Growth Trajectories of Refugee and Nonrefugee Children in the United States

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abstract

BACKGROUND AND OBJECTIVES: Limited data examine longitudinal nutrition outcomes of refugee children after United States resettlement. Among refugee children, our aims were to (1) assess the changes in weight-based nutritional status between baseline (0–3 months) and 10-24 months after arrival and (2) compare the BMI (BMIz) or weight-for-length *z* score (WFLz) trajectories to nonrefugee children for up to 36 months after arrival.

METHODS: We conducted a retrospective study of refugees aged 0-16 years from Washington and Pennsylvania and compared them with an age and sex-matched nonrefugee low-income sample from Washington. Data included anthropometric measurements from the initial screening medical visit and subsequent primary care visits. Multilevel linear mixed-effects regression models evaluated the change in BMIz or WFLz trajectory.

RESULTS: The study included 512 refugee and 1175 nonrefugee children. The unadjusted prevalence of overweight/obesity increased from 8.9% to 20% ($P < .001$) for 2- to 16-year-old refugees from baseline to 10-24 months. Refugees (2–16 years old) had a steeper increase in their BMI*z* per 12 months compared with nonrefugees (coefficient 0.18 vs 0.03; $P < .001$). Refugees <2 years old had a less steep increase in their WFLz per 12 months compared with nonrefugees (coefficient 0.12 vs 0.36, $P = .002$).

CONCLUSIONS: Older refugee children exhibited a higher risk of obesity than nonrefugees, whereas refugees <2 years old exhibited a slower increase in their risk of obesity than nonrefugee children. All age groups experienced increasing obesity prevalence. Targeted and culturally tailored obesity prevention interventions may mitigate health and nutrition inequities among refugee children.

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WHAT'S KNOWN ON THIS SUBJECT: Refugee children are at risk for obesity after US resettlement. It is unknown how their change in nutritional status differs compared with a reference group of nonrefugee US children.

WHAT THIS STUDY ADDS: Refugee children (2–16 years old) had a greater increase in their BMI *z* score after US resettlement compared with low-income, nonrefugee US children, and differences existed among refugee children based on their country of origin.

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Currently there are ~60 million people displaced worldwide due to war and persecution, and half are children.[1] Children comprise 30% to 50% of the ~60 000 refugees annually resettled in >40 states in the United States.[2–4] Refugee children arrive in the United States after a variety of migration experiences that influence their growth and well-being. Before US resettlement, refugee children may experience recurrent stressors including trauma, family separation, food insecurity, malnutrition, obesity, infectious disease, and environmental toxins.[5–9] Medical screening shortly after US resettlement focuses on detecting related health concerns.[7,10–13] However, there is a dearth of evidence establishing the long-term health and nutrition outcomes of refugee children after US resettlement.

Childhood nutritional status has important implications for cognitive development, economic opportunity, mental health, adult weight status, and chronic disease risk.[14–16] Refugee children arrive in the United States with variable nutritional status based on their preresettlement experiences.[9,12,17,18] Although several studies have reported an increase in the prevalence of obesity and obesity-related diseases among adult refugees and an increase in their BMI trajectories after US resettlement, the data among child refugees is limited.[19,20] Two small studies demonstrated a trend toward increasing obesity prevalence among refugee children.[21,22] However, obesity risk has not been examined in a large sample of refugee children.

Additionally, analyses of growth trajectories by country of origin among refugee children is lacking, and such studies are necessary to identify groups most likely to benefit from culturally and linguistically appropriate nutrition interventions, that is, among children from the current largest resettlement countries to the United States.[2,3] Furthermore, no studies have compared the longitudinal growth of refugee children to an age- and sex-matched, low-income cohort of US children. Such comparisons would quantify the extent to which exposure to the US obesogenic environment places newly resettled refugee children at risk for obesity.

The primary aims of our study were to (1) assess the change in weight-based nutritional status of refugee children at baseline (0–3 months after arrival) and time 2 (10–24 months after arrival) and (2) compare the BMI or weight-for-length trajectories of refugee and nonrefugee US children for up to 36 months.

METHODS

Study Population and Design

Refugee Cohort

Refugee children aged 0 to 16 years were identified from 3 primary care sites. Children from site 1 arrived in King County, Washington, from January 1, 2012, to December 31, 2014; had their initial domestic medical screening visit at the Seattle-King County Public Health clinic; and subsequently initiated primary care at HealthPoint, a Federally Qualified Health Center in King County. The data collected from Seattle-King County Public Health was linked with the electronic medical record data from HealthPoint (n = 422).

Children from site 2 included refugees who arrived in Philadelphia, Pennsylvania, from January 1, 2008, to December 31, 2012, and had their initial domestic medical screening visit and subsequent primary care at Jefferson Family Medicine Associates at Thomas Jefferson University (n = 165).

Children from site 3 included refugee children who arrived in Philadelphia, Pennsylvania, from October 1, 2010, to December 31, 2012, and had their initial domestic medical screening visit and subsequent primary care at the Children's Hospital of Philadelphia Refugee Health Clinic (n = 78).

Nonrefugee Cohort

The nonrefugee cohort included children initiating care from HealthPoint from 2008 to 2012. In total, HealthPoint provided care to 32 950 children during that time period, 86% of whom were insured by Medicaid. Low-income children in the United States are at risk for malnutrition, stunting, and overweight/obesity,[23] and previous research describes socioeconomic status as a key confounder in weight outcomes.[24,25] Therefore, we sought to compare the refugee children to nonrefugee children who were low income and received care during the same time period. English-speaking children were assumed to be nonrefugees and were matched to the refugee cohort by age, sex, and year of care initiation at a frequency ratio of ~2:1. Children whose preferred language was not English were excluded from the nonrefugee cohort.

Inclusion and Exclusion Criteria

Children were included in the study if they were between 0 and 16 years old at the time of their initial domestic medical screening visit. Children were excluded if (1) their visit dates were implausible (eg, domestic medical screening visit preceded their overseas medical visit date or their subsequent follow-up preceded their domestic medical screening visit), (2) their country of origin was unknown, (3) if they did not have plausible height and weight measurements available during their first 3 months after resettlement, and (4) if they did not have at least 1 subsequent height and weight measurement available.

Study Measures

Sociodemographics

Age, sex, and country of origin were ascertained from the initial domestic medical screening visit.

TABLE 1 Nutritional Status Category Anthropometric Definitions

Nutritional Status Category	Age <2 y (WHO Definitions)[26]	Age 2–18 y (CDC Definitions)[27]
Wasting	Weight-for-length ≤2.3rd percentile	BMI <5th percentile
Healthy weight	Weight-for-length >2.3rd percentile and <97.7th percentile	BMI ≥5th percentile and ≤85th percentile
Overweight/obese	Weight-for-length ≥97.7th percentile	BMI >85th percentile
Stunting[a]	Length-for-age ≤2.3rd percentile	Height-for-age <5th percentile

The 2.3rd percentile is equal to *z* score of −2.00, 5th percentile is equal to *z* score of −1.64, 85th percentile is equal to a *z* score of 1.04, 95th percentile is equal to a *z* score of 1.64, and 97.7th percentile is equal to a *z* score of 2.00.

[a] Children classified into the wasting, healthy wt or overweight/obese categories, could also be classified into the height/length-for-age category of stunting.

Time

For refugee children, the time since care initiation at the primary care clinic was based on months elapsed since arrival in the United States, up to 36 months. For nonrefugee children, it was based on the time since their first visit initiating care at the primary care clinic.

Anthropometrics

Weight and height/length measurements were obtained at the visits by medical professionals based on clinic protocols as a routine component of the physical examination.[5,26,27] Following World Health Organization (WHO) and Centers for Disease Control and Prevention (CDC) guidelines for measuring anthropometry, standing height was measured for children ≥2 years old and supine length for children <2 years old.[28]

Children were categorized into 1 of 3 weight-based nutritional status categories: wasting, healthy weight, or overweight/obese (Table 1). Children were also categorized into the stunting category based on their age- and sex-appropriate height- or length-for-age *z* score (Table 1). The nutritional status categories are based on anthropometric definitions from the WHO 2006 growth standard definitions for children <2 years of age and from the CDC 2000 definitions for children ≥2 years old, which are the recommended definitions by the CDC for children in the United States.[29] Additionally, the WHO 2006 growth standards for children ≥2 years old were included for reference (Supplementary Table 4). Following CDC guidelines, implausible growth measurements were removed, that is weight-for-length, BMI, or height/length-for-age *z* scores |≥5|.

Study Approval

This study was approved by the Institutional Review Boards of Seattle Children's Hospital, Children's Hospital of Philadelphia, Thomas Jefferson University, and the HealthPoint Research Council, and it was deemed exempt by Washington State.

Analyses

Stata 13.1 (StataCorp LP, College Station, TX) and the program zanthro[30] were used to calculate the height- or length-for-age, weight-for-length and BMI *z* scores.[31] We used χ^2 and Fisher's exact tests for unadjusted comparisons of the nutritional status categories at baseline (0–3 months) and time 2 (10–24 months). The nutritional status category at baseline was based on their earliest available measurement, and time 2 was based on their last available measurement.

Our primary research question was whether the refugee and nonrefugee children demonstrated differential patterns in their BMI or weight-for-length *z* score trajectories for up to 36 months after care initiation. We assessed repeated BMI *z* scores (for 2–16 years old) and weight-for-length *z* scores (for <2 years old) within study subjects. To account for the within-subject correlations, we applied linear mixed effects regression models for our main analysis. We included group category (refugee vs nonrefugee), time (months since care initiation at each weight status assessment), and group-by-time interaction as primary predictors of interest in the models. The group-by-time interaction term estimates and tests whether incremental changes over time in BMI or weight-for-length *z* score were different across groups. In all models, we adjusted for a priori selected covariates: child baseline age, baseline BMI/weight-for-length *z* score, and sex. All models included a subject-specific random effect to account for correlations due to repeated assessments and a site-specific random effect to account for correlation by clinic site. In addition, we conducted subgroup analyses stratified by (1) baseline nutritional status category and (2) country of origin for the 4 most common countries.

RESULTS

Study Population

A total of 512 refugee children and 1175 non-refugee children were included. The proportion of female children was similar between the cohorts (47.1 and 47.6%), whereas children in the refugee cohort were slightly older (mean: 6.8 years vs 6.4 years), and contributed fewer months in follow-up to the cohort (median: 3.8 months vs 5.9 months, Table 2). Children from 4 countries made up 86% of the refugee cohort: Bhutan (23.8%), Burma (21.7%), Iraq (18.0%), and Somalia (22.7%).

TABLE 2 Demographic Characteristics at First Screening Visit for the Refugee Cohort and Care Initiation for the Nonrefugee Cohort

Characteristic	Refugee Cohort (N = 512)	Nonrefugee Cohort (N = 1175)	P
Female, %	47.1	47.6	.85
Age in y,[a] mean (SD)	6.8 (4.4)	6.4 (4.8)	.02
Age categories,[a] %	14.3	16.3	.27
2–5 y	25.0	21.9	
6–10 y	32.6	30.7	
11–16 y	28.2	31.2	
Months of repeated measures in the cohort, median (IQR)	3.8 (1.6–10.2)	5.9 (0.3–14.2)	<.001
Country of origin, %		N/A	N/A
Bhutan	23.8		
Burma	21.7		
Iraq	18.0		
Somalia	22.7		
Other[b]	13.8		
Race, %	N/A		N/A
Asian		12.5	
Black		20.2	
White		46.3	
Other[c]		8.1	
Declined		5.8	
Ethnicity, %	N/A		N/A
Hispanic or Latino		20.9	
Nutritional status category,[a] %			<.001
Wasting	5.3	1.5	
Healthy wt	86.9	66.5	
Overweight	7.8	32.1	
Stunting,[a] %	9.2	1.7	<.001
Wt-for-length z score if <2 y old,[a] mean (SD)	−0.3 (1.4)	−0.4 (1.4)	.10
BMI z score if 2–16 y old,[a] mean (SD)	−0.3 (1.2)	0.7 (1.2)	<.001
Length-for-age z score if <2 y old,[a] mean (SD)	−0.3 (1.3)	0.05 (1.1)	<.001
Height-for-age z score if 2–16 y old,[a] mean (SD)	−0.6 (1.3)	0.2 (1.1)	<.001

IQR, interquartile range.

[a] First available in 0–3 mo after arrival.

[b] Other includes the Democratic Republic of Congo, Eritrea, Ethiopia, Iran, Kenya, Liberia, Sudan, and Togo.

[c] Other includes American Indian/Alaska Native, Native Hawaiian, and Multiracial.

Prevalence of Nutrition Status Categories

A total of 214 refugee children and 610 nonrefugee children aged 2 to 16 years had BMI and height-for-age z scores at both baseline and time 2. Among refugee children, the prevalence of overweight/obesity increased from 8.9% to 21% for the refugee group (P < .001). The prevalence of overweight/obesity increased from 38.9% to 45.7% (P = .02) in the nonrefugee cohort. When the WHO anthropometric definitions (Supplementary Table 4) were applied to refugee children aged 2 to 16 years, the prevalence of overweight/obesity increased from 14.4% to 26.1% (P < .001).

Forty-five refugee children and 117 nonrefugee children <2 years old had weight-for-length and length-for-age z scores at both baseline and time 2. The prevalence of obesity increased from 0% to 16% (P = .003) for the refugee cohort and from 1.7% to 19.7% (P < .001) for the nonrefugee cohort. In the refugee and nonrefugee cohorts, the prevalence of wasting and stunting were not significantly different between baseline and time 2 for 2- 16-year-olds and <2-year-olds.

Growth Trajectory Models

The repeated measures of all 2- to 16-year-old from both cohorts (refugees: n = 439, nonrefugees: n = 985) were included in an adjusted linear mixed effects regression model, in which the refugee cohort had a steeper increase in their BMI z score per 12 months compared with the nonrefugee cohort (coefficient 0.18 vs 0.03; P < .001; Table 3; Fig 1). Similarly using the WHO definitions for children aged 2 to 16 years, the refugee cohort had a steeper increase in their BMI z score per 12 months compared with nonrefugee children (coefficient 0.16 vs 0.02; P < .001; Supplementary Table 5). Among those with healthy weights at baseline, refugee children had a greater increase in their BMI z score per 12 months than nonrefugee children (coefficient 0.17 vs 0.09, P = .02; Table 3; Fig 2). Children that were stunted at baseline had a steeper increase in their BMI z score per 12 months than nonrefugee children (coefficient 0.31 vs −0.33, P < .001; Table 3; Fig 2). Examining trajectories by country of origin, children aged 2 to 16 years from Burma and Somalia had steeper increases in their BMI z scores

TABLE 3 Linear Mixed Effects Regression Models Showing the Change in BMI *z* Score per 12 Months for the Refugee and Nonrefugee Cohort Overall and by Baseline Nutritional Status (Weight and Height Based) for Children Aged 2 to 16 Years

	Refugee Cohort Coefficient (95% CI)	Nonrefugee Cohort Coefficient (95% CI)	*P*
Overall (*n*)	0.18 (0.14 to 0.22) (439)	0.03 (0.01 to 0.06) (985)	<.001
By baseline wt-based nutritional status			
Wasted (*n*)	0.63 (0.36 to 0.90) (23)	0.71 (0.13 to 1.28) (10)	.816
Healthy wt (*n*)	0.17 (0.12 to 0.22) (376)	0.09 (0.06 to 0.13) (603)	.011
Overweight/obese (*n*)	−0.02 (−0.10 to 0.07) (40)	−0.07 (−0.09 to −0.05) (372)	.246
By baseline height-for-age status			
Stunted[a] (*n*)	0.31 (0.13 to 0.49) (45)	−0.33 (−0.50 to −0.16) (18)	<.001

Model adjusted for fixed effects of sex, age in months, baseline BMI *z* score, and subject specific random effects of the individual and site. CI, confidence interval.
[a] Three children were classified in both the overweight and stunting categories, and 5 children were classified in the wasting and stunting categories. The remaining stunted children were in the healthy weight category.

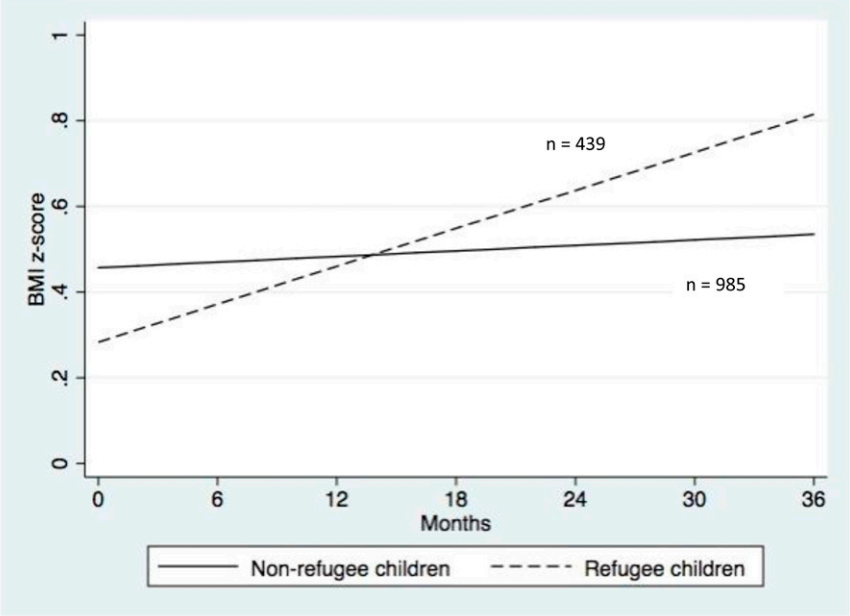

FIGURE 1
Change in BMI *z* score over 36 months after care initiation for children aged 2 to 16 years for the refugee and nonrefugee cohorts.

per 12 months than nonrefugee children (coefficient 0.45 and 0.15, respectively), whereas there was no difference comparing children from Bhutan (0.02) and Iraq (0.07).

In an adjusted linear mixed-effects regression model of children aged <2 years (refugees: *n* = 73, nonrefugees: *n* = 190), refugee children had a less steep increase in their weight-for-length *z* score per 12 months compared with the nonrefugee children (coefficient 0.12 vs 0.36, *P* = .002). Children <2 years old were not evaluated by nutrition status category or country of origin because of the sample size.

DISCUSSION

To our knowledge, this is the first study that examines the longitudinal change in nutritional status of refugee children after US resettlement compared with an age- and sex-matched nonrefugee group of primarily low-income children. Refugee children aged 2 to 16 years had an overall greater increase in their BMI *z* score than non-refugee children after care initiation. Those refugee children with a healthy weight or stunting at baseline had the greatest increases in BMI *z* score compared with nonrefugee children. Among refugee children, the prevalence of overweight and obesity more than doubled within 10 to 24 months from US arrival. By comparison, refugees <2 years old showed a smaller increase in their weight-for-length *z* score compared with nonrefugees, although their prevalence of obesity did increase over the study period. Thus, the risk for obesity appears to steadily increase among refugee children as they reside in the United States. Children aged ≥2 years are at considerably greater risk compared with nonrefugee children to become overweight and obese. Early intervention to prevent childhood obesity is critical due to the health implications of childhood obesity[32–35] and risk for subsequent adult obesity associated chronic disease[16] in this vulnerable population.

This increase in overweight and obesity among 2- to 16-year-old refugees is consistent with a study among 2- to 18-year-old refugee children resettled in Rhode Island,[21] which reported a doubling of the prevalence of overweight and obesity from 17% at arrival to 35% 3 years later. A study in Minnesota (*n* = 69) among 0- to 18-year-old refugee children from sub-Saharan Africa reported that children who were initially underweight gained weight, and 2% of healthy weight children moved into the overweight category (BMI >85th percentile) within 1 year after resettlement.[22] Our results differ from those of the Minnesota study, possibly due to the study time period and/or differences in countries of

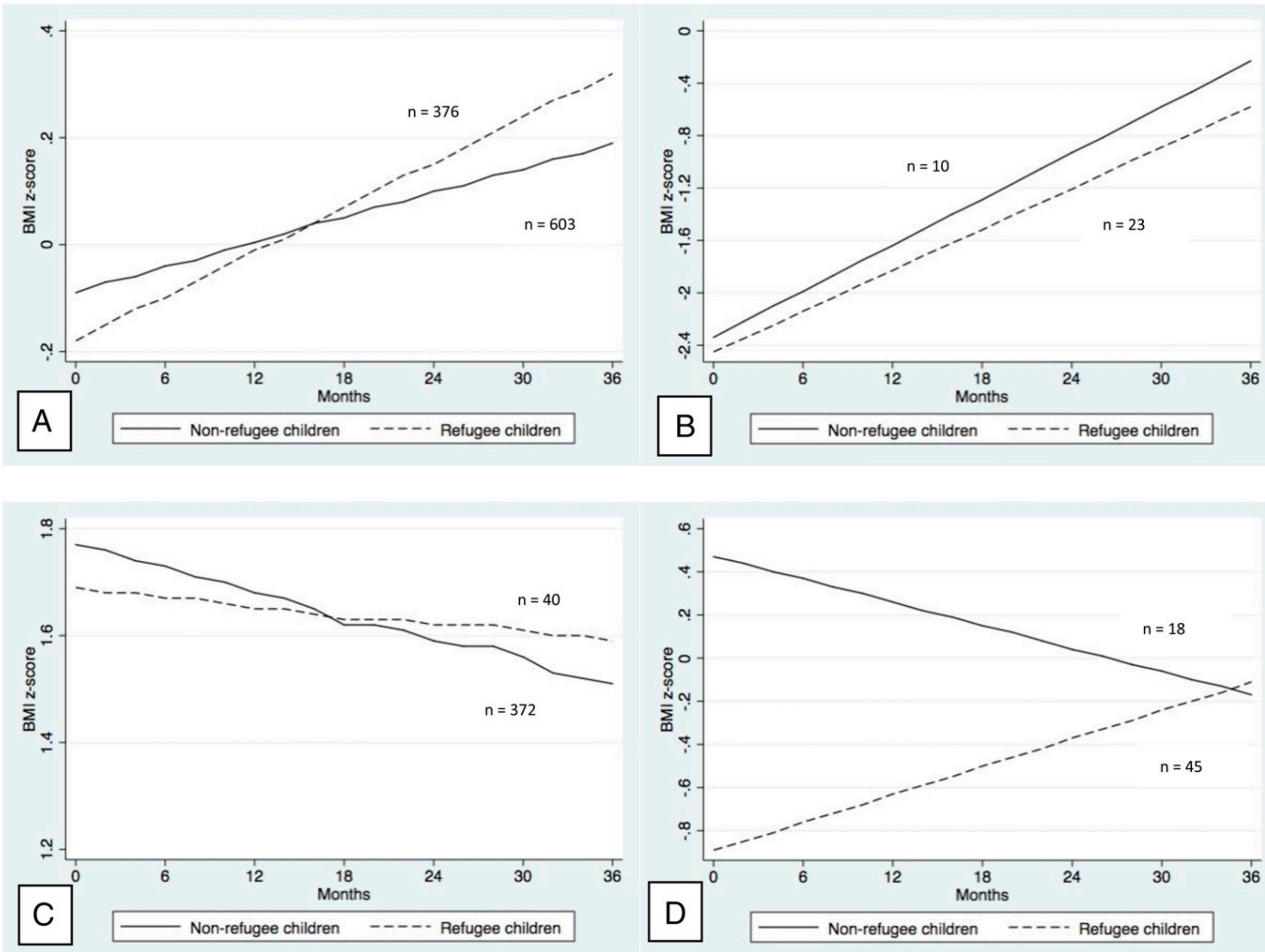

FIGURE 2
Change in BMI *z* score over 36 months after care initiation by nutritional status category for children aged 2 to 16 years for the refugee and nonrefugee cohorts. A, Healthy-weight children. B, Wasted children. C, Overweight/obese children. D, Stunted children.

origin, follow-up duration, or sample size. Given our findings and those of others, obesity prevention should be an important area of focus for refugee children early in their resettlement experience.

In contrast to older refugee children, the young refugee children (<2 years old) had a significantly lower increase in weight-for-length *z* score compared with nonrefugee children, although both demonstrated an increase in obesity prevalence (16% and 19.7%, respectively). One possible explanation for this result may be a higher rate and longer duration of breastfeeding among refugee children. Immigrant populations have higher breastfeeding initiation rates and duration than women born in the United States,[36] and breastfed infants tend to grow more rapidly in the first 2 months of life and less rapidly for the subsequent 3 to 12 months compared with non-breastfed infants.[37] Therefore, higher rates of breastfeeding among refugee infants may be contributing to the smaller incremental change in weight-for-length *z* score observed in this cohort, however, this and other potential explanations require further study.

When the refugee child's country of origin was taken into consideration, children (aged 2 to 16 years) from Burma (coefficient 0.45) and Somalia (coefficient 0.15) had higher gains in BMI *z* score compared with the nonrefugee children (coefficient 0.03; $P < .001$ and $P < .02$, respectively), whereas there was no difference comparing children from Bhutan (0.02) and Iraq (0.07) to the nonrefugee children. These results may capture differences in experiences after resettlement in the US obesogenic food environment.[38] Refugees from different countries of origin may have unique ethnocultural experiences post-US resettlement that may be more or less protective. Although the differences in BMI *z* score between the Bhutanese and Iraqi children and the nonrefugee children were not significantly different, all children demonstrated an increase in their BMI *z* score rather than no change, which would be the ideal. Furthermore, these findings highlight the importance of presenting results by country of origin[11,12] to tailor surveillance and interventions based on the needs of refugee populations.

Refugee children aged 2 to 16 years who were stunted at arrival had the largest increases in their BMI *z* score. Although children's stunting status is defined by their low height-for-age, this increase in BMI *z* score signifies an increase in weight disproportionate to their gain in height. Stunted children living in countries undergoing a nutrition transition (ie, a shift in dietary consumption coinciding with economic changes and urbanization) have an increased risk of obesity, metabolic syndrome and cardiovascular disease in adulthood.[39,40] The coexistence of stunting and overweight has been described in many populations worldwide,[14] and is important to consider among individuals immediately transitioning into the US nutrition environment through migration.

Children in both the refugee and nonrefugee samples who were wasted had an increase in their BMI *z* scores, and children who were wasted and overweight/obese had a decline in their BMI *z* score. Despite the improvement in BMI *z* scores for refugee children who were wasted at arrival, the overall prevalence of wasting did not change from baseline to time 2. This may be because children are gaining weight but do not reach their desired age and sex standards during the study time period or because we did not have a sufficient sample size to detect the difference. Future studies on wasted refugee children may evaluate wasting recovery over a longer time period. Additionally, the prevalence of stunting did not significantly change from baseline to time 2. There is an increased global focus on stunting since the scale up of existing nutrition-specific interventions to prevent malnutrition are estimated to reduce stunting by only 20%.[41] Larger and longer longitudinal studies of stunted refugee children may provide insight into approaches to support stunting recovery, which may influence malnutrition treatment in other global contexts.

This study has several limitations. The nonrefugee cohort of children may include refugee children who arrived before 2012 whose families' preferred language was English. We believe that this potential misclassification would represent a small group of children and would bias results toward the null hypotheses. Second, the birthdate of some of the refugee children may have been unknown to the family and therefore listed as January 1 of a specific year (6.6%). This limited birthdate information could misclassify the child's age and influence his or her nutritional status category. Refugee children were frequency-matched to nonrefugee children from Washington state only (and not from Pennsylvania) due to feasibility. There may be differences in the nutritional context of Washington and Pennsylvania, however, the inclusion of the clinic site in the models accounts for correlation of subjects within study sites. On the basis of the available data, the nonrefugee children were categorized by race/ethnicity and the refugee children by their ethnic country of origin; therefore, we were not able to match the 2 groups by race/ethnicity. Subdivision of children into narrower age categories was limited by our sample size and supports the need for a larger study to evaluate child growth among refugee children. Data on breastfeeding and other dietary factors were not available in this analysis and may influence child weight status.

CONCLUSIONS

Refugee children aged 2 to 16 years resettled in the United States have a steeper BMI increase than their nonrefugee US peers, which differs by country of origin. In contrast, refugee children <2 years old had a less steep weight-for-length increase than their nonrefugee US peers, although the obesity prevalence increased for both groups. Altogether these patterns suggest that protective mechanisms of obesity among refugee children wane over time so that refugee children are at an elevated risk of obesity. Targeted and culturally tailored interventions are necessary to mitigate health and nutrition inequities among refugee children.

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ABBREVIATIONS

CDC: Centers for Disease Control and Prevention
WHO: World Health Organization

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POTENTIAL CONFLICT OF INTEREST: Dr Yun is on the board of the Pennsylvania Immigration and Citizenship Coalition.

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