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Is There a Healthy Foreign Born Effect for Childhood Obesity in the United States?

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Abstract Objective of the study was to explore factors associated with early childhood obesity and assess whether having a foreign born mother is protective against childhood obesity. Data sources include 9 months and 4 years parent interviews and direct assessments of possessive children's weight and height (4 years) or length (9 months) from the Early Childhood Longitudinal Study-Birth Cohort. Subjects were children with anthropometric measures who lived with their mothers ($n = 9{,}700$ at 9 months and 8,200 at 4 years). Overweight is defined as a weight-for-length ratio at or above the 95th percentile at 9 months; obesity is defined as a body mass index at or above the 95th percentile at 4 years. The prevalence of overweight/obesity was 15.4% at 9 months and 18.0% at 4 years. After adjustment for potential confounders, having a foreign-born mother was not associated with the odds of overweight at 9 months or 4 years. At 9 months and 4 years, low birth weight, pre-pregnancy weight and weight gain during pregnancy were protective of overweight. In addition to these factors, at 4 years, excessive weight gain in the first 9 months was the strongest predictors for obesity. Living in a safe neighborhood and ever having breastfed were protective against obesity. Having a foreign born mother is not protective of early childhood obesity. A focus on health of women prior to conception and on women's and infants' health in the perinatal period are key to addressing childhood obesity.

Keywords Childhood obesity · Foreign born · Maternal weight gain · Early weight gain

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Introduction

In the United States, obesity continues to be a major public health concern [1]. The prevalence of overweight among children increased dramatically during the last 30 years. This increase has been marked across all gender, racial and socioeconomic groups [2]. Data from the National Health and Nutrition Examination Surveys (NHANES) show that among pre-school children the prevalence of obesity increased from 5.0 to 13.9% between 1971–1974 and 2003–2004 [3]. Pooled NHANES data from 2003–2006 reveal that 24.4% of children ages 2–5 years in the United States were at or above the eighty-fifth percentile of the 2000 Centers for Disease Control and Prevention (CDC) body mass index (BMI)-for-age growth charts [4]. In 2005, data from the Early Childhood Longitudinal Study-Birth

Cohort (ECLS-B) show the prevalence of obesity among 4 year old children alone was 18.4%. The higher percentages in the ECLS-B study were attributed largely to differences in weight assessment methods and older ages of the children relative to those in NHANES [5].

Early childhood obesity is likely to persist throughout the life span [6–8]. In addition to increasing the risk of obesity and its associated consequences in later life, childhood obesity also is associated with a wide spectrum of serious adverse outcomes including pediatric hypertension [9], type II diabetes mellitus [10], and coronary heart disease [11, 12]. Moreover, obese children experiences psychosocial difficulties such as mood disorders [13] and low self esteem [14].

The foreign-born population, currently representing 12% of the population, is a rapidly growing group in the United States [15]. The proportion of children living with at least one foreign-born parent increased from 12% in 1990 to 22% in 2007 [16, 17]. Immigrants have longer life expectancy, lower BMI, and lower risks of smoking, hypertension, and chronic conditions than the US-born population [18–20]. Immigrants also have better perinatal health; foreign-born women are less likely to have low birth weight babies (<2,500 g), as well as to experience preterm delivery and perinatal mortality [21, 22].

Researchers suggest several explanations for better health among the foreign-born. According to the notion of "healthy immigrant effects" or "positive immigrant selectivity," people immigrating to the United States are thought to be a select group in that they are healthier than those who remain in their countries of origin [23–25]. The second explanation suggests that immigrants are more likely to possess norms and values that are protective of risky behaviors such as smoking, drinking, and unhealthy diets [26–28]. Third, immigrants may have stronger social and familial support and better social integration compared to the US-born population [29].

An acculturation process with regard to health is documented in some studies. Adult immigrants who have lived in the US for more than 10–15 years have health approaching that of native-born Americans [28, 30]. With greater length of residence in the U.S, immigrants are more likely to adopt the diets and lifestyles of residents in the host country, resulting in increasingly similar health outcomes. However, this process appears to differ by education and age at migration. For example, Kaushal and colleagues [31] found that immigrants with a bachelors degree or higher did not experience any change in the risk of obesity with increased duration of stay in the U.S; the risk of obesity, however, increased among those without a bachelors degree and with greater duration of stay. Age at arrival also affects the process of assimilation. Findings from a study by Roshania and colleagues [32] suggest that the relation between duration of residence and overweight or obesity prevalence varied by age at arrival; immigrants who arrive at a relatively young age are more likely to adopt the eating habits and lifestyles of the host country.

Although studies suggest that the prevalence of obesity is lower among immigrants compared with native-born adults, whether or not having a foreign born mother protects against childhood obesity remains unclear. The aim of our study was to explore factors associated with early childhood obesity and assess whether having a foreign born mother is protective for obesity in children.

Methods

Data sources and study sample

The data used in this study are from the Early Childhood Longitudinal Study- Birth Cohort (ECLS-B). ECLS-B is a nationally representative sample of about 10,700 children born in the U.S. in 2001 and followed prospectively. ECLS-B excludes children born to mothers less than 15 years of age and children who died or were adopted before 9 months. Data sources include birth certificates, direct child assessments at 9 months and 4 years, and computer assisted parent interviews at 9 months and 4 years. ECLS-B data also were collected when children were 2 years (range 16–39 months). However, data at 2 years were not used due to different measurements of attained size (length $\leq$24 months; height $\geq$24 months) and, accordingly, different reference populations [33]. Birth certificates provide data on prenatal and neonatal characteristics at the time of the child's birth. Direct child assessments provide information regarding the child's physical growth. Parents reported on family socio-demographic characteristics, maternal education and employment, feeding practices and children's physical and sedentary activities at both times.

At 9 months and 4 years, we included children who had complete data on weight and length and whose biological mothers or other type of mother were interviewed. We also excluded outliers for z values for weight-for-length at 9 months (about 100), weight gain in the first 9 months (about 50), and weight gain after 2 years (about 50). About 9,700 and 8,150 children comprised the final analytic sample at 9 months and 4 years, respectively. The flow charts of the distribution of the samples are presented in Figs. 1 and 2.

Study variables

Dependent variables

Child's weight and length/height were measured by certified interviewers during home visits. Child's length at

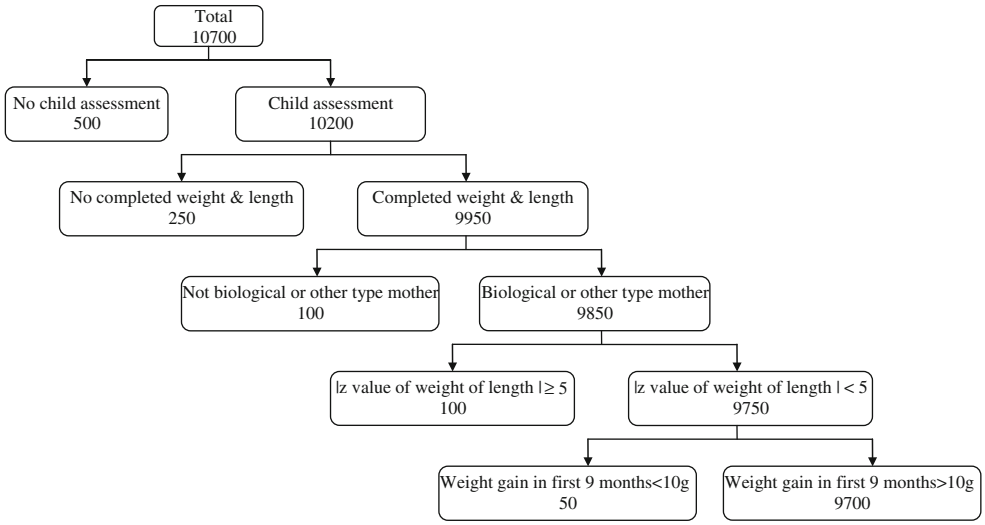

Fig. 1 Identification of study participants at 9 months

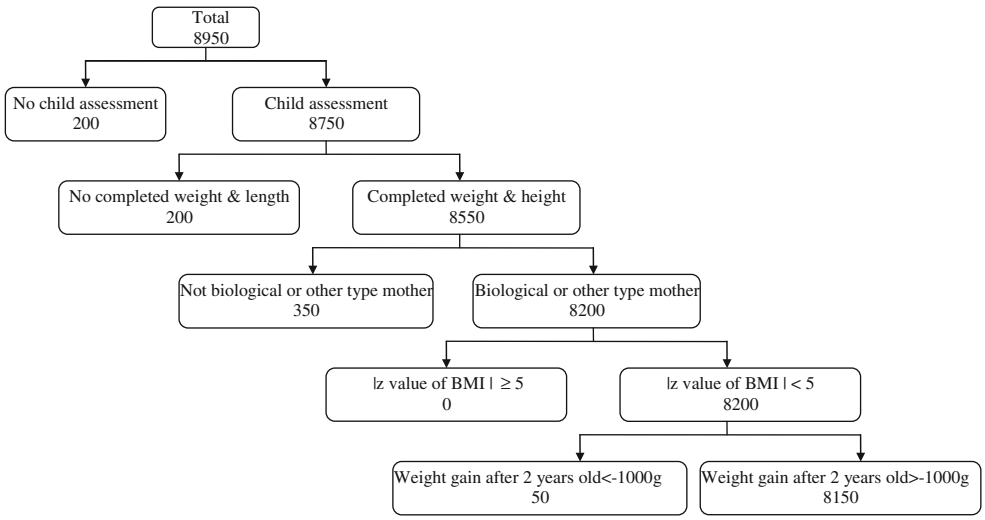

Fig. 2 Identification of study participants at 4 years

9 months was measured with a Measure Mat [34], while height at 4 years was measured with a portable stadiometer [35]. The child's weight was measured with a digital scale at both waves. At 9 months, the mother's weight was subtracted from the combined weights of mother and child. At 4 years, weights for each child were measured directly (for example, the child stood on scale alone). Measurements were taken twice independently and recorded in the Child Assessment Booklet at 9 months and in the computer assisted data entry system at 4 years.

At 9 months, identifiable errors, such as a difference between repeat measurements greater than 5%, were reported to field supervisors who then would follow up with interviewers [33, 34]. Each physical measure was taken twice, and average scores used for differences <5%. For differences greater than 5%, the weight (length) closest to the weighted average weight (length) for the group of children in the sample of the same age and birthweight was used. At 4 years, a third measurement was obtained for differences ≥5%. The two length (height) and weight measurements were highly correlated ($r = 0.81$ for length and weight at 9 months; $r = 0.99$ for height and weight at 4 years).

Normalized (z-score) weight-for-length ratio at 9 months and body mass index (BMI) at 4 years were calculated. Overweight is defined as a weight-for-length ratio at or above the 95th percentile at 9 months; obesity is defined as a BMI at or above the 95th percentile at 4 years for age and sex using the 2000 Centers for Disease Control and Prevention growth charts for the United States.

Independent variables

Independent variables included family (household income, household food security, housing situation, language speak at home, perceived neighborhood safety), maternal (age, foreign-born status, education, employment, pre-pregnancy weight, weight gain during pregnancy, depressive symptoms, first born, plurality, exercise with rapid breathing and heartbeat) and child characteristics (birthweight, sex, race/ethnicity, weight gain during the first 9 months), feeding practices (ever breastfeed, to bed with bottle, >1 serving 100% juice daily, soda/sport/fruit drink daily, 3 daily vegetable servings, weekly fast food, days of eating dinner as a family, days of eating dinner at regular time) and physical activity (daily walk or play outside, organized athletic activity, >2 h daily TV, video and DVD on week days, TV rules/routines, computer use $\geq$3 times/week. Separate variables for household income, housing situation, and maternal education were used to assess the independent effects of different aspects of household socioeconomic status on child obesity.

For mothers not born in the U.S., maternal duration in the U.S. was calculated by subtracting the age she moved to U.S from the current age. We constructed two different categorical variables for maternal foreign-born status. The first one included: (1) not foreign born; (2) foreign-born, U.S stay $\leq$5 years; (3) foreign-born, U.S stay >5 years & $\leq$10 years; (4) foreign-born, U.S stay >10 years & $\leq$15 years; and (5) foreign-born, U.S stay >15 years. The second one grouped maternal foreign born status into (a) not foreign born; (b) foreign-born, U.S stay $\leq$10 years; and (c) foreign-born, U.S stay >10 years. There was no significant difference when we used each variable in the respective analyses. Here we present results using the latter.

Using tertile cut-offs, pre-pregnancy weight and weight gain were categorized into three groups: high, middle, low. Weight gain in the first 9 months was calculated by subtracting weight at birth from weight at 9 months and grouped into 5 categories using quintile cut-offs.

Maternal depressive symptoms were measured by the12-item version of the Center for Epidemiological Studies Depression Scale (CES-D). The CES-D assesses depressive feelings and behaviors during the past week [36]. The CES-D generates a scale 0–36 which was categorized into four groups—no, mild, moderate, and severe depressive symptoms, using 5, 10 and 15 as cut points.

Statistical analyses

Analyses were conducted in Stata 10. Due to the complex sample design [37], sample weights were applied to account for stratification, clustering, and unit non response. In keeping with the restricted-use data license agreement, all unweighted numbers are rounded to the nearest 50.

Bivariate analyses of the relation between each independent variable and the outcomes were performed. Weighted two-way tabulations were conducted to explore associations between possible risk factors and overweight/obesity. To examine the significance of these associations, Pearson chi-square statistics were computed and corrected for the survey design using the second-order correction. Extension of the Wilcoxon rank-sum test [38] was performed to examine the trend across ordered groups. Weighted simple logistic regression models were fit to estimate the unadjusted OR's for each independent variables and outcome. Variables with P-value <0.20 in bivariate analyses were selected for multivariate analyses. After stepwise selection, significant variables for either 9 months or 4 years ($P < 0.05$) and those conceptually relevant and supported in the literature were included in weighted models.

Missingness was not a significant issue. For continuous variables it contributed to less than 3% of the sample while for categorical variables only 1%. For continuous variables, we used medians to impute the missing value; while for categorical variables, ad hoc imputation methods were used [39].

Results

Prevalence of foreign born and overweight/obesity

Among the 26.2% of mothers who were foreign-born, the mean duration in the U.S. was 10.4 years at 9 months (SE = 0.18) (Table 1). At 4 years, among the 24.9% mothers who were foreign-born, the mean duration was 13.7 years (SE = 0.18) (Table 2).

The weighted prevalence of overweight was 15.4% at 9 months. There was no significant difference between children with native-born versus foreign-born mothers, regardless of duration in the U.S. At 4 years, the weighted prevalence of obesity was 18.0% for the full sample, 14.9% for children with native-born mothers, 17.5% for children with foreign-born mothers who had stayed in the U.S. 10 years or less, and 17.3% for children with foreign-born mothers who had stayed in the U.S. more than 10 years. The prevalence of obesity was higher among children with foreign-born rather than native-born mothers ($P < 0.05$); there was no difference in the prevalence of obesity related to duration of stay of foreign-born mothers in the U.S. ($P > 0.05$).

Table 1 Sample characteristics for overweight children at 9 months

Characteristics	Total	Overweight (Unweighted %)	Overweight (Weighted %)	Weighted unadjusted OR (95%CI)
Family characteristics				
Household income				
$ 25,000 or less	3,500	14.9	16.5	1.00
More than $25,000	6,200	12.5	14.8	0.88 (0.75, 1.04)
Household food security				
No	1,250	14.0	16.1	1.00
Yes	8,450	13.3	15.3	0.94 (0.75, 1.18)
Housing situation				
Own home	4,500	12.7	15.4	1.00
Not own home	5,200	14.0	15.4	1.00 (0.86, 1.16)
Language speak at home				
English	7,650	13.0	14.9	1.00
Spanish	950	17.7	19.0	1.35 (1.07, 1.70)*
Other languages	1,100	12.0	14.2	0.95 (0.70, 1.28)
Maternal characteristics				
Age (years)				
15–19	750	13.6	13.8	1.00
20–24	2,350	14.9	16.7	1.25 (0.98, 1.61)
25–29	2,350	12.6	14.9	1.10 (0.85, 1.42)
30–34	2,450	12.4	14.7	1.08 (0.79, 1.48)
≥35	1,800	13.6	15.9	1.18 (0.92, 1.53)
Foreign-born status				
Not foreign born	7,150	13.3	15.0	1.00
Foreign-born, US stay ≤10 years	1,500	13.8	17.2	1.18 (0.94, 1.48)
Foreign-born, US stay >10 years	1,050	13.3	16.5	1.13 (0.86, 1.48)
Education				
Some high school or less	1,850	14.1	15.4	1.00
High school graduate	3,000	14.6	16.9	1.12 (0.90, 1.41)
Some college	2,300	12.7	14.4	0.93 (0.77, 1.12)
College and beyond	2,550	12.1	14.4	0.93 (0.72, 1.19)
Employment				
No	5,000	13.5	15.7	1.00
Yes	4,700	13.3	15.1	0.95 (0.82, 1.11)
Pre-pregnancy weight (Tertiles)				
Low	3,250	11.3	12.9	1.00
Middle	3,400	13.2	15.1	1.20 (0.98, 1.46)
High	3,050	15.9	18.1	1.50 (1.23, 1.78)*
Weight gain during pregnancy (Tertiles)				
Low	3,350	11.6	14.2	1.00
Middle	3,800	13.9	15.6	1.12 (0.95, 1.31)
High	2,550	15.0	16.7	1.22 (0.97, 1.52)
Depressive symptoms				
None	5,800	13.8	15.7	1.00
Mild	2,250	12.3	15.6	1.00 (0.82, 1.21)
Moderate	1,000	14.3	16.3	1.05 (0.79, 1.38)
Severe	650	12.0	10.7	0.65 (0.45, 0.93)*

Table 1 continued

Characteristics	Total	Overweight (Unweighted %)	Overweight (Weighted %)	Weighted unadjusted OR (95%CI)
First born				
No	6,500	13.4	15.2	1.00
Yes	3,200	13.3	15.8	1.05 (0.89, 1.23)
Plurality				
Singleton	8,100	14.1	15.6	1.00
Multiple	1,600	9.8	9.2	0.55 (0.44, 0.67)*
Child characteristics				
Birth weight				
Normal birth weight	7,150	15.2	15.9	1.00
Low birth weight	1,500	8.9	8.8	0.51 (0.41, 0.64)*
Very low birth weight	1,050	7.2	7.3	0.42 (0.31, 0.56)*
Sex				
Male	4,900	14.4	16.1	1.00
Female	4,800	12.4	14.7	0.90 (0.78, 1.04)
Race/ethnicity				
White, non-Hispanic	4,050	12.1	14.3	1.00
Black, non-Hispanic	1,550	14.7	17.7	1.29 (1.03, 1.61)*
Asian, non-Hispanic	1,100	10.2	10.1	0.68 (0.52, 0.88)*
Hispanic	1,950	15.3	17.2	1.25 (1.00, 1.56)
Other	1,050	16.0	15.3	1.09 (0.79, 1.51)
Feeding practices				
Ever breastfeed				
No	3,200	13.7	16.0	1.00
Yes	6,550	13.2	15.1	0.94 (0.81, 1.09)
To bed with bottle				
No	6,650	8.7	14.6	1.00
Yes	3,050	10.4	17.2	1.22 (1.03, 1.44)*
Physical and sedentary activities				
Daily walk or play outside				
No	5,500	8.6	15.4	1.00
Yes	4,200	10.0	15.4	1.00 (0.86, 1.17)
Total	9,700	13.4	15.4	–

* $P < 0.05$

Weights were applied to adjust for stratification, clustering and unit non response

Bivariate analyses

At 9 months, among family characteristics, speaking Spanish at home was significantly associated with higher odds of overweight (Table 1). At 4 years, household income more than $25,000 and food security were protective of obesity; not owning a home, speaking Spanish at home and perception of living in a less safe neighborhood were related to a higher odds of obesity (Table 2).

At 9 months, high pre-pregnancy weight was related to higher odds of overweight. Severe maternal depressive symptoms and multiple births were associated with lower odds of overweight. At 4 years, except for having foreign-born mothers, high pre-pregnancy weight and high weight gain during the pregnancy were strong predictors for obesity. Trend tests suggested that there were positive linear relations between pre-pregnancy weight and weight gain during the pregnancy with the odds of obesity. Higher maternal education and multiple births were protective against obesity.

Birth weight was a strong predictor for overweight at 9 months in bivariate analysis. Being black was associated with higher risk of overweight compared with being white; while being Asian was suggested to be protective. Although there was no association between ever breastfed with overweight, being put to bed with a bottle was related to 20% increase in the odds of overweight at 9 months. At 4 years, in addition to birth weight and being black or

Table 2 Sample characteristics for obese children at 4 years

Characteristics	Total	Obesity (Unweighted %)	Obesity (Weighted %)	Weighted unadjusted OR (95%CI)
Family characteristics				
Household income				
$ 25,000 or less	2,350	18.8	20.8	1.00
More than $25,000	5,800	14.1	16.8	0.77 (0.64, 0.92)*
Household food security				
No	1,000	21.0	23.6	1.00
Yes	7,150	14.7	17.2	0.67 (0.52, 0.86)*
Housing situation				
Own home	4,700	13.0	15.0	1.00
Not own home	3,450	18.9	21.9	1.58 (1.36, 1.83)*
Language speak at home				
English	6,500	14.6	16.8	1.00
Spanish	850	24.1	25.1	1.66 (1.36, 2.02)*
Other languages	800	13.7	16.1	0.95 (0.69, 1.30)
Perceived neighborhood safety				
Very safe	4,700	14.2	15.9	1.00
Less Safe	3,450	17.2	20.7	1.39 (1.22, 1.58)*
Maternal characteristics				
Age (years)				
15–19	50	13.0	16.9	1.00
20–24	1,200	16.6	18.9	1.15 (0.38, 3.45)
25–29	1,900	17.3	19.6	1.20 (0.40, 3.60)
30–34	2,200	15.2	17.3	1.03 (0.34, 3.12)
≥35	2,800	14.0	16.9	1.00 (0.33, 3.05)
Foreign-born status				
Not foreign born	6,150	14.9	17.1	1.00
Foreign-born, US stay ≤10 years	900	17.5	21.0	1.28 (1.03, 1.61)*
Foreign-born, US stay >10 years	1,100	17.3	21.3	1.31 (1.03, 1.67)*
Education				
Some high school or less	1,150	20.5	24.1	1.00
High school graduate	2,400	18.1	19.6	0.77 (0.62, 0.95)*
Some college	2,150	14.6	17.5	0.67 (0.53, 0.84)*
College and beyond	2,450	11.5	13.0	0.47 (0.37, 0.59)*
Employment				
No	3,400	15.5	18.1	1.00
Yes	4,750	15.5	17.8	0.98 (0.82, 1.17)
Pre-pregnancy weight (Tertiles)				
Low	2,800	11.0	13.4	1.00
Middle	2,700	14.7	16.8	1.30 (1.07, 1.59)*
High	2,650	21.0	23.5	1.99 (1.63, 2.44)*
Weight gain during pregnancy (Tertiles)				
Low	2,800	14.4	16.7	1.00
Middle	3,200	14.8	16.9	1.01 (0.86, 1.20)
High	2,150	18.0	21.4	1.36 (1.10, 1.67)*
Exercise with rapid breathing and heartbeat 30 + min, 5 days/week				
No	6,950	15.7	17.9	1.00
Yes	1,200	14.3	18.1	1.01 (0.81, 1.27)

Table 2 continued

Characteristics	Total	Obesity (Unweighted %)	Obesity (Weighted %)	Weighted unadjusted OR (95%CI)
Depressive symptoms				
None	4,750	15.1	17.8	1.00
Mild	2,000	14.8	16.9	0.94 (0.77, 1.14)
Moderate	900	17.4	19.5	1.12 (0.88, 1.42)
Severe	500	18.5	21.3	1.25 (0.90, 1.75)
First born				
No	5,436	15.8	18.5	1.00
Yes	2,731	14.8	16.8	0.89 (0.74, 1.07)
Plurality				
Singleton	6,750	16.6	18.2	1.00
Multiple	1,400	10.0	10.7	0.55 (0.43, 0.67)*
Child characteristics				
Birth weight				
Normal birth weight	6,050	17.3	18.5	1.00
Low birth weight	1,250	10.9	12.1	0.61 (0.49, 0.76)*
Very low birth weight	850	9.6	9.9	0.49 (0.37, 0.64)*
Sex				
Male	4,150	17.3	19.2	1.00
Female	4,000	13.6	16.6	0.88 (0.71, 0.99)*
Race/ethnicity				
White, non-Hispanic	3,600	12.6	15.4	1.00
Black, non-Hispanic	1,250	17.0	19.6	1.34 (1.09, 1.63)
Asian, non-Hispanic	850	11.8	13.7	0.87 (0.64, 1.19)
Hispanic	1,650	19.8	22.3	1.57 (1.31, 1.88)*
Other	900	20.0	21.7	1.52 (1.16, 1.98)*
Weight gain in the first 9 months				
1st quintile (lowest)	1,650	9.1	9.8	1.00
2nd quintile	1,650	10.1	12.6	1.32 (0.94, 1.86)
3rd quintile	1,600	15.0	17.0	1.88 (1.39, 2.56)*
4th quintile	1,650	17.7	21.7	2.56 (1.92, 3.41)*
5th quintile	1,600	25.6	32.6	4.45 (3.33, 5.96)*
Feeding practices				
Ever breastfeed				
No	2,550	18.3	21.6	1.00
Yes	5,600	14.2	16.4	0.71 (0.61, 0.83)*
>1 serving 100% juice daily				
No	4,950	14.6	16.6	1.00
Yes	3,200	16.9	20.0	1.26 (1.06, 1.50)*
Soda/sport/fruit drink daily				
No	5,800	14.3	16.9	1.00
Yes	2,350	18.3	20.6	1.28 (1.06, 1.53)*
Two daily fruit servings				
No	4,750	15.6	17.9	1.00
Yes	3,400	15.3	18.0	1.01 (0.85, 1.19)
Three daily vegetable servings				
No	5,200	15.7	17.8	1.00
Yes	2,950	15.9	18.2	1.02 (0.86, 1.23)

Table 2 continued

Characteristics	Total	Obesity (Unweighted %)	Obesity (Weighted %)	Weighted unadjusted OR (95%CI)
Weekly fast food				
No	2,000	13.7	16.4	1.00
Yes	6,150	16.1	18.4	1.15 (0.93, 1.43)
Daily candy				
No	4,450	15.7	18.0	1.00
Yes	3,700	15.2	18.0	1.00 (0.87, 1.15)
Days of eating dinner as a family, mean (se)	–	5.4 (0.05)	5.3 (0.08)	0.93 (0.89, 0.98)*
Days of eating dinner at regular time, mean (se)	–	4.7 (0.06)	4.7 (0.09)	0.96 (0.93, 1.00)
Physical and sedentary activities				
Daily walk or play outside				
No	4,600	15.6	17.6	1.00
Yes	3,550	15.3	18.5	1.07 (0.90, 1.27)
Organized athletic activity				
No	5,650	16.2	19.2	1.00
Yes	2,500	13.9	15.3	0.76 (0.65, 0.90)*
>2 h daily TV, video and DVD on week days				
No	5,850	14.9	17.1	1.00
Yes	2,300	17.0	20.2	1.23 (1.01, 1.50)*
TV rules/routines				
No	900	18.6	22.3	1.00
Yes	7,250	15.1	17.4	0.74 (0.58, 0.94)*
Computer use ≥3 times/week				
No	6,350	15.4	17.6	1.00
Yes	1,800	15.7	19.4	1.13 (0.94, 1.37)
Total	8,150	15.5	18.0	–

* $P < 0.05$

Weights were applied to adjust for stratification, clustering and unit non response

Hispanic, weight gain during the first 9 months was a strong predictor for obesity; a trend test suggested a dose–response effect of weight gain during the first 9 months on the odds of obesity at 4 years old ($P = 0.000$). Having more than 1 serving of 100% juice daily, consuming soda/sport/fruit drinks daily and watching more than 2 h daily TV/video/DVD on week days were positively associated with obesity at 4 years. Ever breastfed, more days of eating dinner as a family, organized athletic activity, and having TV rules were protective against obesity at 4 years.

Multivariate analyses

After controlling for other covariates, maternal foreign born status was not significantly associated with overweight at 9 months or obesity at 4 years; while maternal pre-pregnancy weight, weight gain during pregnancy, birth weight and plurality were strong predictors for both (Table 3).

At 9 months, having a mother with severe depressive symptoms was associated with a 38% decrease in the odds of overweight, but this effect waned by 4 years. Black children had 33% higher odds of being overweight and Asian children a 34% lower odds than white children. Going to bed with a bottle was associated with a 20% increase in the odds of overweight.

At 4 years, after adjustment for other covariates, a perception of living in a less safe neighborhood was associated with a 20% increase in the odds of obesity. One of the strongest predictors for obesity was weight gain in the first 9 months. Compared with children whose weight gain in the first 9 months was in the first quintile, the odds ratios for those whose weight gain in the first 9 months was in the third, fourth and fifth quintiles were increased by 85, 160 and 350%. Family characteristics, including not owning a home and speaking Spanish at home remained associated with higher odds of obesity after controlling for other variables; however they were only marginally significant (Table 3). The adjusted OR for obesity at 4 years

Table 3 Adjusted association between risk factors and overweight/obesity

Characteristic	Overweight (9 Months)		Obesity (4 years)	
	OR (95%CI)	*P* value	OR (95%CI)	*P* value
Family characteristics				
Housing situation				
Own your home	1.00		1.00	
Not own your home	0.88 (0.75, 1.04)	0.13	1.20 (0.99, 1.45)	0.07
Language speak at home				
English	1.00		1.00	
Spanish	1.35 (0.89, 2.06)	0.16	1.42 (0.96, 2.09)	0.08
Other languages	1.18 (0.76, 1.84)	0.45	1.06 (0.65, 1.73)	0.81
Perceived neighborhood safety				
Very safe	NA	NA	1.00	
Less safe	NA	NA	1.20 (1.03, 1.40)	0.02
Maternal characteristics				
Foreign-born status				
Not foreign born	1.00		1.00	
Foreign-born, US stay >10 years	1.07 (0.74, 1.54)	0.26	1.05 (0.72, 1.52)	0.82
Foreign-born, US stay ≤10 years	1.09 (0.76, 1.57)	0.15	0.97 (0.63, 1.49)	0.90
Education				
Some HS or less	1.00		1.00	
HS graduate	1.21 (0.95, 1.54)	0.12	0.85 (0.68, 1.08)	0.19
Some college	1.02 (0.80, 1.28)	0.89	0.81 (0.61, 1.07)	0.14
College and beyond	1.09 (0.80, 1.48)	0.59	0.68 (0.49, 0.93)	0.02
Pre-pregnancy weight (Tertiles)				
Low	1.00		1.00	
Middle	1.18 (0.96, 1.45)	0.11	1.41 (1.13, 1.75)	.002
High	1.53 (1.26, 1.85)	<0.001	2.19 (1.78, 2.69)	<0.001
Weight gain during pregnancy (Tertiles)				
Low	1.00		1.00	
Middle	1.17 (0.99, 1.38)	0.06	1.12 (0.95, 1.33)	0.17
High	1.32 (1.05, 1.65)	0.02	1.48 (1.16, 1.88)	<0.01
Depressive symptoms				
None	1.00		1.00	
Mild	0.99 (0.82, 1.20)	0.94	0.86 (0.69, 1.08)	0.19
Moderate	1.04 (0.78, 1.38)	0.80	0.96 (0.75, 1.22)	0.74
Severe	0.62 (0.42, 0.91)	0.02	1.07 (0.77, 1.49)	0.69
Plurality				
Singleton	1.00		1.00	
Multiple	0.65 (0.52, 0.83)	<0.01	0.53 (0.40, 0.70)	<0.001
Child characteristics				
Birth weight				
Normal birth weight	1.00		1.00	
Low birth weight	0.57 (0.45, 0.71)	<0.001	0.58 (0.45, 0.75)	<0.001
Very low birth weight	0.46 (0.34, 0.62)	<0.001	0.39 (0.29, 0.53)	<0.001
Race/ethnicity				
White, non-Hispanic	1.00		1.00	
Black, non-Hispanic	1.33 (1.05, 1.69)	0.02	0.87 (0.68, 1.10)	0.23
Asian, non-Hispanic	0.66 (0.43, 0.99)	0.05	1.18 (0.75, 1.86)	0.48
Hispanic	1.07 (0.75, 1.52)	0.72	1.02 (0.77, 1.36)	0.86

Table 3 continued

Characteristic	Overweight (9 Months)		Obesity (4 years)	
	OR (95%CI)	*P* value	OR (95%CI)	*P* value
Other	1.09 (0.78, 1.53)	0.60	1.23 (0.95, 1.60)	0.11
Weight gain in the first 9 months				
1st quintile (lowest)	NA	NA	1.00	
2nd quintile	NA	NA	1.30 (0.92, 1.84)	0.12
3rd quintile	NA	NA	1.85 (1.37, 2.51)	<0.001
4th quintile	NA	NA	2.60 (1.97, 3.42)	<0.001
5th quintile	NA	NA	4.50 (3.35, 6.03)	<0.001
Feeding practices				
To bed with bottle				
No	1.00		NA	NA
Yes	1.21 (1.01, 1.45)	0.04	NA	NA
Ever breastfeed				
No	1.00		1.00	
Yes	0.93 (0.80, 1.12)	0.45	0.76 (0.63, 0.92)	0.01
Days of eating dinner as a family	NA	NA	0.95 (0.91, 0.99)	0.03
Physical and sedentary activities				
Computer use ≥3 times/week				
No	NA	NA	1.00	
Yes	NA	NA	1.21 (0.98, 1.48)	0.07

was 0.76 (95% CI: 0.63–0.92, $P = 0.01$) for ever breastfeeding. Each 1 unit increase in days of eating dinner as a family was associated with a 5% decrease in the odds of obesity ($P = 0.03$).

Discussion

Several studies have documented a lower risk of obesity among adult immigrants in the U.S. [40–42]. Our study, however, is the first to examine the risk of early childhood obesity among children of immigrants compared with children of native born Americans. In our study, the prevalence of obesity was compared between children with foreign-born mothers and those with native-born mothers, using a large, nationally representative sample. There was no evidence that having a foreign born parent is protective of early childhood overweight or obesity.

Prior research suggests that some immigrants experience better health than the U.S. born, possibly due to "positive immigrant selectivity," healthier behaviors or better social support. These factors may not protect their children from obesity. Foreign born immigrants are more likely to have lower family income and to live in low SES neighborhoods [43, 44]. These environmental factors may correlate with increased intake of high-fat, energy-dense food and decreased physical activity among children.

Children's food acceptance and early exposure to fruits and vegetables are shaped by parental behavior [45], and parents' feeding behaviors are influenced by environmental factors. For example, some urban neighborhoods lack places where healthy foods can be purchased, such as supermarkets and outdoor produce stands. Instead, there may be convenience stores and fast food outlets in their neighborhoods, making it difficult for parents to purchase fresh, healthy, and affordable products for their children [46].

Physical activity is another important aspect in childhood obesity which also may be influenced by environmental factors; children who live in neighborhoods with good access to parks and playgrounds tend to have less sedentary activity and reduced risk for obesity [47, 48]. Our findings suggested that parents' perception of less safe neighborhoods was significantly associated with a higher risk of obesity among their children. Similarly, a US study showed that parents living in the inner city were more likely to be concerned about neighborhood safety and have children who were less likely to engage in physical activity than their suburban peers [49]. The reason why children were less physically active may be due to parents' fears for

their children's safety, the key concerns being road safety and harm from strangers [50].

Prior studies have noted disparities between parents' perceptions and their children's risk of obesity [51]. Some parents may not recognize that their children are at risk for increased weight or be convinced of the risks associated with their child being obese; they may believe that their child will shed the excess weight when s/he grows up [52]. Also, some low income mothers indicate a preference for chubbier children and believe that such children are healthier and happier than normal-weight children [53, 54]. Different perceptions of children's size may increase the risk of childhood obesity among immigrants.

Qualitative research has shown that immigrants in the U.S. are more likely to report limited social support and feelings of isolation [55]. The lack of help from friends or other family members may limit their ability to provide healthy meals or allow their children to play outside. Also, lack of social support, as a possible stressor for the mother, may generate behavioral responses including unhealthy eating habits and reduced physical activity among their children, in turn leading to increased risk of obesity [56]. We explored the effect of social support on early childhood obesity in our analyses. However, there was limited information available, and none of the variables used as proxies to measure social support, such as sources of support excluding spouses and number of family members in the community, were related to the risk of obesity.

The results of this study suggested that maternal pre-pregnancy weight, weight gain during pregnancy and early weight gain of infants were strong predictors of early childhood obesity. During the past decade, there has been growing interest in applying a life-course approach in studies about the development of childhood obesity [57, 58]. This approach is well suited for the study of childhood obesity because it conceptualizes the development of chronic disease as a lifelong dynamic process which is caused by genetic, biological, social, and environmental factors [59, 60]. Our results are consistent with the earlier findings about the positive relations between maternal BMI and obesity risk in offspring [58, 61–63], rapid weight gain in infancy and higher rates of overweight and body fat deposition among children [64–66].

We acknowledge some limitations in this study. First, 'foreign born' mothers in this study were those who were born outside the United States, while the U.S. Census Bureau uses this term to refer to those who are not U.S. citizens at birth [67]. Second, ECLS was not designed for the study of obesity. There is limited information on children's nutrition, feeding patterns or physical activity, or on mother's BMI after birth of the child; however the large sample, relative to NHANES and other studies, permits more refined analyses focused on preschool children. Third, there is not sufficient statistical power to perform subgroup analysis of children by the country of origin of their foreign-born mothers. We explored the subgroup of children with foreign born mothers from Mexico, but found no significant association between most independent variables and the odds of obesity. Finally, there were some losses to follow up of respondents between the two waves of data collection reported here which may cause selection bias. Our analysis suggested that children who were overweight at 9 months were more likely to drop out of the study at 4 years.

Despite these limitations, this study has some inherent strengths. To our knowledge, few studies have explored the effect of having foreign born parents on early childhood obesity. Direct measurement of weight and height/length for children in ECLS, a large national data set, provides reliable data about overweight/obesity. ECLS also includes information for the family, child and parents, allowing us to adjust for these factors in our analyses.

Several policy and programmatic implications could be drawn from our findings. It is important to focus on the health of women before conception and in the perinatal period to address childhood obesity. Collaboration between community and health care providers is needed to identify missed opportunities to address childhood obesity. Finally, monitoring childhood obesity among various immigrant groups may provide valuable insights into the role of potentially modifiable social, behavioral, and environmental factors.

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