Obesity and malnutrition among Hispanic children in the United States: double burden on health inequities

Celia Iriart,[1] *Blake Boursaw,*[2] *Gabriela P. Rodrigues,*[1] *and Alexis J. Handal*[1]

Suggested citation Iriart C, Boursaw B, Rodrigues GP, Handal AJ. Obesity and malnutrition among Hispanic children in the United States: double burden on health inequities. Rev Panam Salud Publica. 2013;34(4):235–43.

ABSTRACT

Objective. *To examine important micronutrient deficiencies related to child health and growth outcomes for all weight statuses to 1) better understand other potential nutritional problems and inequities that may be masked by focusing solely on BMI percentiles and overweight/obesity, and 2) draw attention to the need for more studies focused on the nutritional well-being of children at all weight statuses, including healthy weight.*

Methods. *A sample of children (ages 2–19 years) old from the National Health and Nutrition Examination Survey (NHANES) 2003–2010 was analyzed. Prevalence of stunting, folate, vitamin D, iron, iodine, and anemia, was considered. Comparisons were conducted between non-Hispanic whites and Hispanics, and within Hispanics, based on socio-demographic and economic characteristics.*

Results. *Hispanic children experienced significantly higher prevalence of stunting (6.1% versus 2.6%), and the prevalence of stunted Hispanic children in the healthy weight category was higher than those in the overweight/obese category. Comparable percentages were observed by ethnicity for most analyzed micronutrients, although girls had consistently higher prevalence of nutritional deficiencies than boys, especially girls reaching reproductive age.*

Conclusions. *The results of this article draw attention to the need for more specific and differentiated analyses of child obesity and nutritional status among and within ethnic, sex, and age groups. Appropriate public health interventions need to consider the entire range of weight statuses and micronutrient deficiencies to eliminate inequities among minority children, especially girls.*

Key words Health inequalities; malnutrition; Hispanic Americans; obesity; child welfare; United States.

In the United States, research on childhood obesity tends to focus on weight—using the body mass index (BMI) percentile as the sole indicator—and the inequity-oriented analysis tends to focus on weight differences across race/ethnicity, sex, and age categories (1). This focus limits the capacity to understand the complexity of childhood obesity, including nutritional deficiencies and the social determinants of health inequities. Few recent studies in the United States analyzed other nutritional problems, such as chronic malnutrition and deficiencies in micronutrients, which particularly affect disadvantaged children (2). Understanding these other nutritional problems is important due to their negative effects on child development and growth, which can also result in a higher risk of obesity (3–5). A poor-quality diet consisting of high-calorie foods that lack the micronutrients needed for optimal neurobehavioral development and growth can contribute to the development of obesity and severe diet-related chronic diseases as well as deficits in learning capacities

[1] Department of Family and Community Medicine, Public Health Program, University of New Mexico, Albuquerque, New Mexico, United States of America. Send correspondence to: Alexis Handal, AJHandal@salud.unm.edu

[2] College of Nursing, University of New Mexico, Albuquerque, New Mexico, United States of America.

(6). The seemingly contradictory relationship between chronic malnutrition, micronutrient deficiency, and the risk of obesity is known as the "nutritional double burden" and has been examined in previous studies, most of which were conducted in developing countries (4). In the United States, study and analysis of the impact of this double burden on children's health is lacking.

Due to the cumulative effects of chronic malnutrition, growth deficits can occur over time and manifest as stunting. Stunting is an indicator of inequities in living conditions, health care access, and nutrition, because all racial/ethnic groups have similar growth potential (7). There is strong evidence that micronutrient deficits in early life play an important role in linear growth and may result in stunting (8, 9). This may be particularly true for Hispanic populations in the United States, especially immigrant populations who confronted prior nutritional challenges in their home countries (10). According to a recent study, approximately 13% of Latin American children suffer from chronic malnutrition manifested as stunting (11). While a handful of studies have examined the prevalence of stunting concurrent with obesity, the majority of them have been conducted in developing countries and few have focused on the role of micronutrient deficiencies (12).

To help fill the data gap for this important area of research in the United States, the authors of the current study recently published findings based on the 2007–2008 National Health and Nutrition Examination Survey (NHANES), focusing on chronic malnutrition measured as stunting in overweight children, and the inequities that disproportionally affect Hispanics in the United States (13). The results of the analysis reinforced the authors' initial concerns that the focus on overweight/obesity and use of BMI percentiles as the sole measure may be masking chronic malnutrition, especially in immigrant Hispanic and other disadvantaged children. The authors found that Hispanic children categorized as having a healthy weight experience chronic malnutrition at higher proportions than overweight/obese children. Overall, these findings underscored the importance of broadening the focus on the childhood obesity problem beyond a simple analysis of weight to include an analysis of nutritional deficits.

In this report, the authors present new analyses of the combined 2003–2010 NHANES cycles that expand on their previous findings on chronic malnutrition inequities. These analyses examine important micronutrient deficiencies related to child health and growth outcomes for all weight statuses to 1) better understand other potential nutritional problems and inequities that may be masked by focusing solely on BMI percentiles and overweight/obesity, and 2) draw attention to the need for more studies focused on the nutritional well-being of children at all weight statuses, including healthy weight.

MATERIALS AND METHODS

For the current study, the authors combined the 2003–2010 NHANES cycles for study participants aged 2–19 years at the time of the physical examination. The NHANES is a program of studies designed to monitor and assess the health and nutritional status of individuals in the United States, administered by the National Center for Health Statistics (NCHS) as part of the Centers for Disease Control and Prevention (CDC), and conducted since 1971, with two-year cycles of data reported since 1999. The survey design is a stratified, multistage probability sample of the civilian, noninstitutionalized U.S. population. The NHANES program combines interviews with physical examinations and laboratory studies.

For the current analyses, the authors focused on comparisons between Hispanics and non-Hispanic whites.[3] A final sample size of 14 710 was obtained after excluding a small number of participants who 1) had very low birth weight, 2) did not have appropriate height and weight measures, and/or 3) were identified as pregnant. The overall unweighted examination response rate for children 2–19 years old exceeded 80% for all two-year cycles from 2003–2010.

[3] In the NHANES, Hispanics are divided into two main categories: "Mexican-Americans" and "Other Hispanics." These categories were first implemented in 2007, when all Hispanics were oversampled (previous cycles oversampled only Mexican-Americans). The authors decided to analyze both categories together after observing that there were few if any values in the "Other Hispanics" category for some independent variables. All data for the NHANES racial/ethnic subcategories ("Hispanic," "non-Hispanic white," "non-Hispanic black," and "Other, including multiracial") are self-reported. Details about the NHANES methodology are available at http://www.cdc.gov/nchs/nhanes.htm (14).

For the current analyses, the authors applied the same methodology used in their previous study to determine stunting and weight status and to identify and measure pertinent independent variables (shown in Table 1) (13). Sampled participants were classified as "healthy weight," "overweight," or "obese" using BMI percentiles for age and sex. As indicated by the 2000 CDC growth charts, the BMI is weight in kilograms divided by height in meters squared, with "healthy weight" defined as a BMI ≥ the 5th percentile and < the 85th percentile; "overweight" as a BMI ≥ the 85th percentile and < the 95th percentile; and "obesity" as a BMI ≥ the 95th percentile (7). According to the CDC, children with stunted growth are those who fall below the fifth percentile in the height-for-age-and-sex growth chart. Based on the current authors' literature review, folate, vitamin D, iron, anemia, iodine, and zinc intake deficiencies were identified as the micronutrient deficiencies linked to child development problems, chronic malnutrition, and potentially obesity (4, 8, 15). The authors used lab cut-off values for malnutrition indicators from a recent CDC report to assess folate, vitamin D, iron, and iodine deficiencies (16). To assess anemia, they used lab cut-off values for serum hemoglobin levels by age and gender published in a previous CDC report (17). Despite the importance of zinc to health, the authors chose not to include it in their analysis because the only available measures of zinc intake in the NHANES are from a two-day dietary recall survey.

Stata 12.1 (18) was used to perform statistical analysis. Sample weights and stratification and clustering of the survey design were incorporated in all analyses, including logistic regression models for vitamin D deficiency and stunting, and design-adjusted Rao-Scott chi-square tests of independence to assess significant bivariate associations between categorical variables (13). Multicollinearity for regression models was assessed through post-estimation calculation of variance inflation factors (VIFs). For analysis of deficiencies in all micronutrients except iodine, sample weights were taken from the NHANES mobile examination center component, combined across cycles. As iodine measures were only taken for one-third of the examination center sample for some cycles, specific NHANES-created sub-

TABLE 1. Demographic and socioeconomic characteristics of the study sample (children ages 2–19 years), their family/household, and the household reference person, NHANES,[a] United States, 2003–2010

Characteristic	Total study population n = 14 710[b]			Hispanics n = 5 409[b]			Non-Hispanic whites n = 4 350[b]		
	No.	%	CI[c]	No.	%	CI	No.	%	CI
Child									
Sex									
Male	7 539	51.4	(50.3, 52.6)	2 734	50.9	(49.4, 52.5)	2 265	52.0	(50.3, 53.7)
Female	7 171	48.6	(47.4, 49.7)	2 675	49.1	(47.5, 50.6)	2 085	48.0	(46.3, 49.7)
Age (years)[d]									
2–5	3 493	21.3	(20.3, 22.3)	1 312	25.3	(23.9, 26.8)	1 110	19.8	(18.5, 21.3)
6–11	4 468	33.0	(31.8, 34.2)	1 690	33.7	(32.0, 35.5)	1 295	32.3	(30.5, 34.1)
12–19	6 749	45.7	(44.1, 47.2)	2 407	40.9	(38.8, 43.1)	1 945	47.9	(45.6, 50.3)
Country of birth[d]									
United States	13 441	93.8	(92.9, 94.6)	4 498	84.2	(82.2, 86.0)	4 228	97.3	(96.5, 97.9)
Other	1 263	6.2	(5.4, 7.1)	905	15.8	(14.0, 17.8)	122	2.7	(2.1, 3.5)
Length of time in United States[e]									
< 5 years	551	41.7	(36.9, 46.5)	402	46.7	(40.3, 53.1)	48	36.3	(27.4, 46.2)
≥ 5 years	665	58.3	(53.5, 63.1)	461	53.3	(46.9, 59.7)	72	63.7	(53.8, 72.6)
U.S. citizenship status[d]									
U.S. citizen	13 725	95.9	(95.1, 96.5)	4 615	87.0	(85.0, 88.8)	4 288	98.6	(98.0, 99.0)
Non-U.S. citizen	970	4.1	(3.5, 4.9)	779	13.0	(11.2, 15.0)	62	1.4	(1.0, 2.0)
Food security category[d,f,g]									
Full food security	7 843	82.6	(80.5, 84.4)	2 578	68.2	(65.1, 71.2)	2 552	88.9	(86.8, 90.7)
Less than full food security	2 613	17.4	(15.6, 19.5)	1 239	31.8	(28.8, 34.9)	414	11.1	(9.3, 13.2)
Family/household									
Food security category[d,f]									
Full food security	7 029	73.6	(71.2, 75.9)	2 119	53.6	(49.9, 57.4)	2 462	82.3	(79.7, 84.6)
Less than full food security	4 035	26.4	(24.1, 28.8)	1 867	46.4	(42.6, 50.1)	686	17.7	(15.4, 20.3)
Number of people in household[d]									
1–3 (small household)	3 274	23.3	(22.0, 24.6)	797	16.0	(14.3, 18.0)	1 082	24.3	(22.6, 26.0)
4–5 (medium household)	7 472	56.8	(54.8, 58.7)	2 615	49.1	(46.5, 51.8)	2 536	61.8	(59.0, 64.5)
≥ 6 (large household)	3 964	19.9	(18.1, 21.9)	1 997	34.8	(32.0, 37.8)	732	13.9	(11.5, 16.7)
Family income-to-poverty ratio (IPR)[d,h]									
< 1 (i.e., income below poverty level)	4 609	23.0	(21.1, 25.0)	2 010	39.7	(37.0, 42.5)	861	14.2	(11.8, 17.0)
1–2.5 (income near poverty level)	4 892	31.9	(30.2, 33.6)	1 955	38.7	(36.9, 40.6)	1 296	28.6	(26.0, 31.3)
> 2.5 (income not near poverty level)	4 290	45.2	(42.4, 48.0)	987	21.6	(19.3, 24.1)	2 017	57.2	(52.9, 61.4)
Language of family interview[d]									
English	12 874	94.1	(93.0, 95.0)	3 639	69.2	(66.2, 72.1)	4 324	100	NA[i]
Spanish	1 701	5.9	(5.0, 7.0)	1 701	30.8	(27.9, 33.8)	0	0	NA
Household reference person									
Country of birth[d]									
United States	9 987	80.1	(77.4, 82.5)	1 912	38.0	(34.1, 42.0)	3 976	94.8	(93.3, 96.0)
Other	4 226	19.9	(17.5, 22.6)	3 294	62.0	(58.0, 65.9)	239	5.2	(4.0, 6.7)
Education level[d]									
Less than high school	4 490	20.6	(19.0, 22.3)	2 655	48.4	(45.2, 51.6)	538	10.2	(8.5, 12.3)
High school or above	9 657	79.4	(77.7, 81.0)	2 513	51.6	(48.4, 54.8)	3 670	89.8	(87.7, 91.5)

[a] National Health and Nutrition Examination Survey.
[b] Some categories sum to less than sample total due to missing data.
[c] 95% confidence interval.
[d] $P < 0.001$ for comparison to non-Hispanic whites.
[e] Includes only foreign-born participants.
[f] Includes only respondents from 2003–2008.
[g] Only applies to households with at least one child ≤ 17 years old.
[h] Based on U.S. Department of Health and Human Services poverty guidelines.
[i] Not applicable.

sample weights were used to analyze iodine deficiencies.

RESULTS

Table 1 shows the characteristics of the study sample, their families/households, and the household reference persons. As expected, Hispanic children and their households tended to have substantially different values than non-Hispanic white children and their households for demographic and socioeconomic measures, particularly for the language, immigration, food security, household size, income, and education attainment measures.

As shown in Table 2, Hispanic children were significantly more likely to be overweight/obese than non-Hispanic white children. Across all categories of ethnicity and sex, children 2–5 years old were much less likely to be overweight/obese than older children.[4] While stunting for all ethnicities could be considered low (3.5%), Hispanic children consistently experienced significantly a higher

[4] Data not shown are available from the corresponding author (AH) upon request.

TABLE 2. Weight status by race/ethnicity and sex and stunting prevalence by weight status and race/ethnicity and sex among children ages 2–19 years, NHANES,[a] United States, 2003–2010

	Overweight/obese prevalence			Stunting prevalence: all weight statuses			Stunting prevalence: healthy weight			Stunting prevalence: overweight/obese		
Race/ethnicity (sex) (*n*)	No.	%	CI[b]	No.	%	CI	No.	%	CI	No.	%	CI
Hispanic (all) (5 409)	2 057	38.2[c]	(36.4, 39.9)	343	6.1[c]	(5.4, 6.9)	233	6.8[c]	(5.7, 7.8)	89	4.6[c]	(3.5, 5.7)
Non-Hispanic white (all) (4 350)	1 292	29.8	(27.7, 32.0)	119	2.6	(2.1, 3.1)	82	2.7	(2.1, 3.3)	21	1.6	(0.9, 2.4)
All ethnicities (all) (14 710)	5 058	31.9	(30.5, 33.4)	618	3.5	(3.1, 3.9)	418	3.7	(3.2, 4.2)	153	2.5	(1.9, 3.0)
Hispanic (boys) (2 734)	1 086	40.0[c]	(37.8, 42.2)	162	5.6[c]	(4.6, 6.6)	113	6.6[c]	(5.2, 8.1)	38	3.8[d]	(2.1, 5.4)
Non-Hispanic white (boys) (2 265)	686	31.0	(28.5, 33.6)	66	2.7	(2.0, 3.5)	44	2.8	(1.9, 3.8)	10	1.3	(0.4, 2.3)
All ethnicities (boys) (7 539)	2 581	32.8	(31.1, 34.6)	315	3.5	(3.0, 4.1)	216	3.8	(3.1, 4.5)	69	2.2	(1.4, 2.9)
Hispanic (girls) (2 085)	971	36.2[c]	(33.9, 38.6)	181	6.7[c]	(5.5, 7.8)	120	6.9[c]	(5.5, 8.2)	51	5.5[e]	(3.1, 7.9)
Non-Hispanic white (girls) (1 994)	606	28.6	(26.2, 31.1)	53	2.4	(1.8, 3.1)	38	2.5	(1.6, 3.4)	11	2.0	(0.8, 3.1)
All ethnicities (girls) (7 171)	2 372	32.0	(30.3, 33.7)	303	3.5	(2.9, 4.0)	202	3.6	(2.8, 4.3)	84	2.8	(1.9, 3.7)

[a] National Health and Nutrition Examination Survey.
[b] 95% confidence interval.
[c] $P < 0.001$ for comparison to non-Hispanic whites.
[d] $P < 0.05$ for comparison to non-Hispanic whites.
[e] $P < 0.01$ for comparison to non-Hispanic whites.

prevalence of stunting than non-Hispanic white children across all weight statuses, as shown in Table 2. Moreover, the prevalence of stunted Hispanic children in the healthy weight category was higher than those in the overweight/obese category. The prevalence of stunting in Hispanic girls was higher than for their non-Hispanic white counterparts in both the healthy weight and overweight/obese categories.

For most of the micronutrient deficiencies studied, the authors observed generally comparable percentages for Hispanics and non-Hispanic whites, although some differences were apparent between sexes. Anemia percentages were similar between Hispanics and non-Hispanic whites, and were generally under 4% in all weight categories. Folate deficiency for Hispanics and non-Hispanic whites also had a low prevalence for all weight categories (0.6% and 0.4% respectively). Table 3 shows vitamin D, iodine, and iron deficiencies, which were more prevalent than anemia and folate. The study results indicated a relatively low overall prevalence of vitamin D deficiency within the study population (5.6%), but Hispanic children had a significantly higher prevalence than non-Hispanic white children. For deficiencies in that micronutrient, girls had almost double the prevalence compared to boys for all weight categories, with the biggest differences by sex in the overweight/obese category. Hispanic girls had significantly higher prevalence compared to non-Hispanic white girls, and almost double prevalence when compared with Hispanic boys. In contrast, iodine deficiency was relatively common across all groups and was more prevalent among healthy weight children than overweight/obese children. Girls were more affected by iodine deficiency than boys, especially Hispanic girls. For Hispanics overall, iodine deficiency was significantly higher for healthy weight 12–19 year olds than for 6–11 year olds with that weight status (26.2% with a 95% confidence interval (CI) of 22.6–29.8 versus 17.2% with a CI of 12.9–21.5). Across age and sex categories, iron-deficiency prevalence was generally higher than anemia prevalence, with similar percentages for both analyzed ethnic categories. Girls 12–19 years old had the highest prevalence of iron deficiency for all weight statuses and for both ethnic categories, with Hispanic girls having higher (albeit not significantly higher) proportions than non-Hispanic white girls.

Consistent with the authors' prior work, some important demographic and socioeconomic impacts on stunting prevalence among Hispanic children were found (Table 4). For instance, the prevalence of stunting was significantly higher among healthy weight boys versus overweight/obese boys ($P < 0.05$) and among older children (12–19 years old) versus younger ones ($P < 0.001$). Foreign-born or non-U.S.–citizen Hispanic children had much higher stunting percentages than their Hispanic counterparts of the same weight status. In addition, being simultaneously stunted and overweight/obese was more common among recent-immigrant Hispanic children (those who had lived in the United States for less than five years) versus longer-term immigrants. In addition, prevalence of stunting increased for children with a foreign-born household reference person, albeit to a lesser extent than in cases where the child herself/himself was foreign-born. The prevalence of stunting was also significantly higher in households with a reference person who had less than a high school education. Finally, the observed differences in stunting prevalence between healthy weight children and overweight/obese children appeared to be affected by the income-to-poverty ratio (IPR), with smaller differences occurring in families who were more economically secure.

TABLE 3. Prevalence of vitamin D, iodine, and iron deficiency by weight status and race/ethnicity among children ages 2–19 years, NHANES,[a] United States, 2003–2010

		All weight statuses[b]			Healthy weight			Overweight/obese		
Deficiency	Race/ethnicity (*n*)	No.	%	CI[c]	No.	%	CI	No.	%	CI
Vitamin D[d]	Hispanic (2 478)	200	5.7[e]	(4.0, 7.4)	101	4.8[e]	(3.1, 6.6)	94	7.1[e]	(4.8, 9.4)
	Boys (596)	68	4.0[e]	(2.5, 5.5)	33	3.3[e]	(1.9, 4.8)	33	5.0[f]	(2.5, 7.5)
	Girls (576)	132	7.5[e]	(4.8, 10.1)	68	6.3[e]	(3.8, 8.8)	61	9.8[f]	(5.7, 13.8)
	Non-Hispanic white (1 835)	19	1.0	(0.5, 1.5)	6	0.5	(0.1, 0.9)	12	1.9	(0.5, 3.3)
	Boys (938)	6	0.5	(0.0, 1.0)	2	0.3	(0.0, 0.6)	4	1.0	(0.0, 2.0)
	Girls (897)	13	1.6	(0.7, 2.5)	4	0.8	(0.0, 1.8)	8	3.0	(0.5, 5.5)
	All ethnicities (6 921)	837	5.6	(4.2, 7.0)	428	4.3	(3.1, 5.6)	389	8.0	(5.8, 10.3)
	Boys (3 524)	343	4.2	(2.9, 5.5)	188	3.4	(2.2, 4.7)	145	5.7	(3.9, 7.6)
	Girls (3 397)	494	7.2	(5.5, 8.9)	240	5.3	(3.7, 6.9)	244	10.6	(7.5, 13.7)
Iodine[g]	Hispanic (1 870)	393	20.7	(18.4, 22.9)	241	22.2	(19.4, 25.0)	134	17.8	(14.2, 21.5)
	Boys (943)	175	18.3	(15.0, 21.5)	103	19.2	(15.3, 23.2)	64	16.4	(11.6, 21.3)
	Girls (927)	218	23.2	(19.8, 26.6)	138	25.2	(20.7, 29.7)	70	19.4	(13.4, 25.4)
	Non-Hispanic white (1 438)	293	20.9	(18.3, 23.5)	198	23.0	(19.4, 26.5)	85	17.0	(12.2, 21.8)
	Boys (745)	111	14.9	(11.5, 18.3)	77	17.7	(13.3, 22.1)	30	10.0	(4.6, 15.4)
	Girls (693)	182	27.5	(23.0, 32.0)	121	28.4	(22.8, 33.9)	55	25.9	(19.0, 32.7)
	All ethnicities (5 004)	1 167	22.1	(20.5, 23.8)	726	23.8	(21.3, 26.2)	404	19.4	(16.4, 22.5)
	Boys (2 545)	497	17.3	(15.0, 19.6)	312	19.2	(16.3, 22.0)	171	14.2	(10.3, 18.2)
	Girls (2 459)	670	27.4	(24.6, 30.1)	414	28.4	(24.8, 32.1)	233	25.5	(21.6, 29.4)
Iron	Hispanic (1 856)[h]	36	7.5	(5.0, 10.0)	23	7.2	(4.4, 9.9)	13	8.8	(3.9, 13.7)
	Boys 2–5 years old (403)	27	5.9	(2.8, 9.0)	17	5.4	(1.2, 9.5)	10	7.5	(2.8, 12.3)
	Girls 2–5 years old (400)	113	9.7	(7.5, 12.0)	75	10.6	(7.8, 13.5	34	7.7	(4.7, 10.6)
	Girls 12–19 years old (1 053)	176	8.3	(6.7, 9.9)	115	8.4	(6.4, 10.4)	57	7.8	(5.6, 10.0)
	Non-Hispanic white (1 439)[h]	19	5.0	(2.4, 7.5)	13	4.8	(2.0, 7.6)	6	6.1	(0.9, 11.3)
	Boys 2–5 years old (351)	13	4.6	(1.7, 7.5)	7	3.7	(0.5, 7.0)	6	9.0	(0.0, 18.2)
	Girls 2–5 years old (292)	63	7.8	(5.5, 10.0)	40	6.8	(4.0, 9.5)	21	9.6	(4.3, 14.9)
	Girls 12–19 years old (796)	95	6.7	(5.0, 8.4)	60	5.8	(3.9, 7.6)	33	8.7	(4.6, 12.9)
	All ethnicities (4 937)[h]	72	5.3	(3.8, 6.8)	47	5.0	(3.3, 6.7)	24	6.4	(3.4, 9.4)
	Boys 2–5 years old (1 108)	51	5.3	(3.3, 7.3)	29	4.7	(2.2, 7.2)	22	8.1	(3.7, 12.5)
	Girls 2–5 years old (997)	293	8.9	(7.3, 10.5)	175	8.3	(6.3, 10.2)	109	9.8	(6.6, 13.0)
	Girls 12–19 years old (2 832)	416	7.5	(6.3, 8.7)	251	6.8	(5.4, 8.1)	155	8.8	(6.4, 11.2)

[a] National Health and Nutrition Examination Survey.
[b] The overall numbers include underweight participants as well as healthy weight and overweight/obese participants, so the sums of the raw healthy weight and overweight/obese frequencies do not equal the overall frequencies.
[c] 95% confidence interval.
[d] Includes only participants from 2003–2006.
[e] $P < 0.001$ for comparison to non-Hispanic whites.
[f] $P < 0.01$ for comparison to non-Hispanic whites.
[g] Includes only participants 6–19 years old.
[h] Includes only participants in listed age/sex categories.

To better understand the nature of the stark disparities by ethnicity observed for stunting and vitamin D deficiency, the authors ran logistic regression models. As shown in Table 5, the predictor variables for the models included the sex/race/ethnicity/weight status variables considered in Tables 2 and 3 as well as the possible confounding variables of age and country of birth. For both outcomes, Hispanic ethnicity remained a significant predictor. For vitamin D deficiency in particular, healthy weight Hispanic boys had almost 16 times the odds of experiencing vitamin D deficiency versus their non-Hispanic white counterparts, with the lower bound of the CI for this estimate at 3.7. With the exception of the simultaneous impact of being both Hispanic and female on stunting, the interaction terms included in the models were generally not significant, suggesting relatively consistent impact of ethnicity across other categories. However, this finding should be interpreted with caution due to the high degree of multicollinearity exhibited by the interaction terms. Older age also emerged as a strong predictor of vitamin D deficiency risk, with a striking odds ratio, partially due to the relatively low prevalence (less than 1%) of vitamin D deficiency among children ages 2–5 years. With regard to stunting, the results indicated that being born abroad, being older, being Hispanic, and being healthy weight were all risk factors.

DISCUSSION

The results of the current analysis support the authors' hypothesis that Hispanic children are suffering from chronic malnutrition at a higher proportion than non-Hispanic children and that this racial/ethnic inequity persists in analyses that incorporate obvious confounders. The results also attest that this important health condition is present even among children categorized as healthy weight when using BMI percentiles as the sole indicator of health. While the prevalence of stunting for all ethnicities is low, these findings serve as an important indicator of inequities in child nutrition between non-Hispanic whites and Hispanics in the Unites States and

TABLE 4. Prevalence of stunting among Hispanic children ages 2–19 years by demographic and socioeconomic characteristics, NHANES,[a] United States, 2003–2010

Characteristic	All weight statuses[b] (*N* = 5 409; *n*, stunted = 343)			Healthy weight (*N* = 3 196; *n*, stunted = 233)			Overweight/obese (*N* = 2 057; *n*, stunted = 89)		
	No.	%	CI[c]	No.	%	CI	No.	%	CI
Child									
Sex									
Male	162	5.6	(4.6, 6.6)	113	6.6	(5.2, 8.1)	38	3.8	(2.1, 5.4)
Female	181	6.7	(5.5, 7.8)	120	6.9	(5.5, 8.2)	51	5.5	(3.1, 7.9)
Age (years)									
2–5	33	2.6[d]	(1.6, 3.6)	25	2.7[d]	(1.5, 3.8)	6	2.3[d]	(0.3, 4.2)
6–11	70	3.8	(2.9, 4.7)	63	6.2	(4.7, 7.8)	2	0.3	(0.0, 0.6)
12–19	240	10.2	(8.5, 11.9)	145	10.2	(7.9, 12.6)	81	9.3	(6.7, 11.9)
Country of birth									
United States	226	4.9[d]	(4.2, 5.7)	151	5.4[d]	(4.3, 6.4)	61	3.8[e]	(2.9, 4.7)
Other	117	12.6	(9.8, 15.4)	82	13.9	(9.8, 18.1)	28	8.8	(4.7, 13.0)
Length of time in the United States[f]									
< 5 years	52	12.3	(7.7, 17.0)	39	12.8	(7.4, 18.1)	12	11.3	(3.0, 19.6)
≥ 5 years	58	12.2	(8.9, 15.4)	38	14.5	(9.0, 19.9)	14	6.8	(2.5, 11.0)
U.S. citizenship status									
U.S. citizen	240	5.1[d]	(4.4, 5.9)	160	5.6[d]	(4.5, 6.6)	65	4.0[e]	(3.0, 5.0)
Non-U.S. citizen	101	12.6	(9.6, 15.6)	71	14.2	(9.9, 18.4)	24	8.8	(4.2, 13.4)
Food security category[g,h]									
Full food security	162	6.1	(5.0, 7.2)	112	6.8	(5.2, 8.3)	41	4.5	(2.8, 6.2)
Less than full food security	74	5.5	(4.1, 6.8)	50	5.9	(4.7, 7.1)	20	4.1	(1.5, 6.7)
Family/household									
Food security category[g]									
Full food security	147	6.5	(5.1, 7.9)	102	7.2	(5.2, 9.1)	38	5.1	(3.0, 7.3)
Less than full food security	115	6.0	(4.7, 7.3)	78	6.9	(5.1, 8.6)	29	4.0	(2.0, 6.0)
Number of people in household									
1–3 (small household)	66	8.3[e]	(6.1, 10.4)	41	8.8	(5.5, 12.0)	20	6.7	(4.0, 9.5)
4–5 (medium household)	125	4.7	(3.6, 5.8)	90	5.3	(3.9, 6.8)	28	3.3	(1.5, 5.0)
≥ 6 (large household)	152	7.2	(5.9, 8.6)	102	7.9	(5.8, 9.9)	41	5.4	(3.7, 7.0)
Family income-to-poverty ratio (IPR)[i]									
< 1 (i.e., income below poverty level)	141	6.8	(5.3, 8.2)	105	8.4[j]	(6.4, 10.5)	28	3.6	(1.9, 5.3)
1–2.5 (income near poverty level)	118	5.7	(4.4, 6.9)	81	6.6	(5.0, 8.2)	28	3.2	(1.8, 4.7)
> 2.5 (income not near poverty level)	42	4.3	(2.5, 6.2)	28	4.0	(2.1, 6.0)	12	5.0	(1.1, 8.9)
Language of family interview									
English	214	5.7	(4.8, 6.7)	146	6.5	(5.2, 7.8)	54	4.0	(2.8, 5,2)
Spanish	125	6.9	(5.7, 8.1)	86	7.5	(5.9, 9.2)	32	5.1	(3.1, 7.1)
Household reference person									
Country of birth									
United States	95	4.6[j]	(3.4, 5.8)	69	5.4	(3.9, 6.8)	19	3.0	(1.1, 4.9)
Other	223	6.9	(5.9, 7.9)	145	7.4	(6.0, 8.8)	65	5.4	(4.2, 6.6)
Education level									
Less than high school	193	7.6[e]	(6.5, 8.8)	123	8.3[j]	(6.6, 10.0)	59	6.1[j]	(4.7, 7.6)
High school or above	119	4.5	(3.3, 5.6)	87	5.2	(3.7, 6.6)	23	2.8	(1.2, 4.4)

[a] National Health and Nutrition Examination Survey.
[b] The overall numbers include underweight participants as well as healthy weight and overweight/obese participants, so the sums of the raw healthy weight and overweight/obese frequencies are not equal to the overall frequencies.
[c] 95% confidence interval.
[d] $P < 0.001$ for within-column comparison.
[e] $P < 0.01$ for within-column comparison.
[f] Includes only foreign-born participants.
[g] Includes only respondents from 2003–2008.
[h] Only applies to households with at least one child ≤ 17 years old.
[i] Based on U.S. Department of Health and Human Services poverty guidelines.
[j] $P < 0.05$ for within-column comparison.

indicate the need for further analysis of micronutrient deficiencies among and within ethnic groups. Although stunting typically occurs in early childhood and is irreversible, understanding the interrelation between this condition and childhood weight status and micronutrient deficiencies is critical, especially when assessing the impact on older girls, as stunting in mothers increases the risk of this condition for their children, potentially perpetuating inequities over generations (19).

To fully understand the "nutritional double burden," researchers must assess not only weight status based on BMI measurements and growth deficits but also the possibility of the presence of micronutrient deficiencies. Nutrition plays a fundamental role in linear growth and development, and deficiencies can impair cell proliferation and DNA synthesis functions, leading to permanent metabolic and physiologic changes affecting fat oxidation and energy intake as well as brain development (3, 8, 20). Moreover, stunting can result from chronic

TABLE 5. Logistic regression models for predictors of vitamin D deficiency and stunting among Hispanic and non-Hispanic white children ages 2–19 years, NHANES,[a] United States, 2003–2010

	Vitamin D (n = 4 313)		Stunting (n = 9 753)	
Independent variable	OR[b]	CI[c]	OR	CI
Hispanic	15.7[d]	(3.7, 66.2)	2.0[d]	(1.3, 2.9)
Female	3.7	(0.3, 39.6)	0.8	(0.5, 1.3)
Overweight/obese	3.5[e]	(1.0, 11.7)	0.4[f]	(0.2, 0.8)
Hispanic*female[g]	0.5	(0.0, 6.0)	1.4	(0.8, 2.5)
Hispanic*overweight/obese[g]	0.4	(0.1, 1.7)	1.4	(0.6, 3.4)
Female*overweight/obese[g]	0.9	(0.1, 9.8)	2.0	(0.7, 6.0)
Hispanic*female*overweight/obese[g]	1.3	(0.1, 14.2)	0.7	(0.2, 3.0)
Age 6–11 years[h]	10.4[e]	(1.2, 90.9)	1.3	(0.8, 2.0)
Age 12–19 years[h]	57.6[d]	(7.4, 450.8)	1.8[e]	(1.1, 2.8)
Born outside United States	1.0	(0.6, 1.7)	1.7[d]	(1.3, 2.3)
Constant	0.0[d]	(0.0, 0.0)	0.0[d]	(0.0, 0.0)

[a] National Health and Nutrition Examination Survey.
[b] Odds ratio.
[c] 95% confidence interval.
[d] $P < 0.001$.
[e] $P < 0.05$.
[f] $P < 0.01$.
[g] Asterisk indicates interaction term.
[h] Reference category is age 2–5 years.

inadequate intake of one or more micronutrients, including iron, zinc, folate, vitamin D, and iodine (4, 9, 21, 22).

Anemia is also associated with reduced cognitive development and stunted growth. Consistent with the literature, the results of the current study did not indicate substantially higher proportions of anemia in Hispanic children versus non-Hispanic white children (14). However, Hispanic girls, particularly overweight/obese girls, experienced the highest proportions of anemia. Research suggests iron deficiency, which is more prevalent than anemia, increases infant mortality, decreases mental and physical development and cognitive function, and is associated with stunting (8, 23). Overall, between 1971 and 2000, mean iron intakes increased in all groups except adolescent girls (24). Despite these increases, a recent report indicates that iron deficiency continues to be one of the most common forms of nutritional deficiency in the United States, particularly among females and Mexican-Americans (16). In the current study, the authors found that iron deficiency affected Hispanic and non-Hispanic white children in similar percentages, but that, consistent with the referenced report, older girls were more affected.

Iodine plays an important role in the thyroid function, the production of thyroid hormones, and the production of growth factors. Deficiency in this nutrient can lead to hypothyroidism and, in severe cases, goiter. Iodine deficiency is associated with stunted growth and, in severe cases, mental retardation, in the form of cretinism (25). In the current study sample, iodine deficiency significantly affected more girls than boys, regardless of ethnicity, and in both sexes, healthy weight children were more affected than overweight/obese children.

For both adults and children, folate is important for normal red blood cell production and to prevent anemia. Folate deficiency can also lead to fatigue and poor growth. Prior studies have shown a positive response in population serum folate levels to folate supplementation in grain foods but have been limited by a focus on the impacts of folate deficiency on obesity among non-Hispanic whites (26, 27). In the current study, following the same trend observed for other micronutrients, folate deficiency affected more girls than boys in both ethnic groups, with older girls displaying a higher prevalence, and overweight/obese girls affected more than healthy weight girls.

Vitamin D deficiency has been linked to musculoskeletal problems, obesity, autoimmune diseases, adult heart disease, cancer risk, decreased immunological function, growth retardation, and bone development (21, 28). In the current study, while vitamin D deficiency was generally low for all groups, the highest prevalence was found among Hispanics, with Hispanic girls affected more than boys, especially those in the overweight/obese category. Results from the logistic regression model were consistent with these observed prevalence patterns and highlighted the magnitude of the association between age and race/ethnicity and risk for this micronutrient deficiency.

Several important findings emerged from the current analysis. Overall, in addition to observed differences across the two different ethnic groups, the authors observed that for most of the micronutrient deficiencies analyzed, girls were more affected than boys, and Hispanic girls were generally the most affected group, particularly for the oldest age group (12–19 years). This highlights the importance of considering ethnic inequities as well as sex inequities in analyzing malnutrition and obesity. In addition, while the authors generally found a higher prevalence of micronutrient deficiencies among the overweight/obese children, they also found micronutrient deficiencies among the healthy weight children. This is a key finding because it supports the need to focus public health efforts not only on weight reduction but also on nutritional status, for all weight categories.

This study highlights the importance of analyzing micronutrients and chronic malnutrition in an effort to unmask critical nutritional problems disproportionally affecting certain ethnic, age, and sex categories. It also draws attention to the need for analyses of differences within ethnic groups to understand how demographic and socioeconomic conditions affect some children more than others, and how these differences play out in the various weight categories. The analyses conducted for the current study allowed for the following author observations: 1) Hispanics who are foreign-born and non-U.S. citizens presented a higher prevalence of stunting; 2) Hispanic girls were more likely to be stunted than Hispanic boys; and 3) older children were more likely to be stunted than younger ones. The authors also noted that stunting prevalence increases among healthy weight Hispanic children below the poverty level, and among Hispanic children living in households where the survey respondent was foreign-born or had less than a high school education. These results indicate the need for studies that consider immigrant health in a more nuanced fashion. Currently, Hispanic im-

migrants and their descendants constitute the youngest and fastest growing racial/ethnic group in the United States, accounting for 16.3% (50.5 million) of the total U.S. population, and growing 43% in a decade (29). The results of the current study suggest that children from immigrant families, including those born in the United States, may not be reaching their growth potential. Immigrant children in the United States may suffer from lack of access to nutritious food due to poverty, language barriers, and legal status, among other factors (30). Because of these social and economic barriers and challenges, food consumed by Hispanic children from disadvantaged families may be highly caloric but poor in nutritional value, which could result in stunted children gaining weight but remaining undernourished. As observed in the current study, this phenomenon is of particular concern when it affects girls, because the same problem could be transmitted to the next generation, thus contributing to an intergenerational transfer of poor health and continued disadvantage.

Limitations

This study had several limitations. First, the use of secondary data (the NHANES results) restricted the scope of the research to specific types of variables. For example, the use of the NHANES data restricted the IPR data to self-reported income, which may not indicate socioeconomic status as reliably as a wealth-based measure, and due to the cross-sectional nature of the NHANES, there were no life-course data, so the authors could not infer the causes of stunting, weight status, and micronutrient deficiencies. In addition, because NHANES does not survey homeless people or migrant workers and their families—populations that are more likely than others to experience chronic malnutrition and micronutrient deficits—the prevalence of these deficiencies may be underestimated.

Conclusions

The aim of this analysis was to draw attention to the need for 1) more specific and differentiated analyses of child obesity and nutritional status among and within different ethnic, sex, and age groups, and 2) consideration of the entire range of weight statuses (including healthy weight), as well as potential micronutrient deficiencies, to create more appropriate public health interventions. Another objective was to highlight the risk of obesity and malnutrition among girls, and the fact that their nutritional deficits could perpetuate nutritional problems among their future descendants. Understanding and eliminating micronutrient deficiencies, especially those that affect girls, could have important positive consequences for future generations. Although child growth and development are affected by multiple factors at the individual, family, and community levels, the results of this analysis suggest that tackling potential child development problems from a nutritional perspective, across generations, might be a particularly effective means of improving academic and social performance for the most disadvantaged children living in the United States.

Acknowledgments. The authors thank Robert Valdez and the Robert Wood Johnson Foundation Center for Health Policy at the University of New Mexico, for support of this research; their colleagues, Laura Nervi and Betty Skipper, who provided invaluable comments during the preparation of the manuscript; and Alison McGough-Maduena, for her invaluable input during the early stages of development of the manuscript.

Conflicts of interest. None.

REFERENCES

1. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity and trends in body mass index among US children and adolescents, 1999–2010. JAMA. 2012;307(5):483–90.
2. Lewit EM, Kerrebrock N. Population-based growth stunting. Future Child. 1997;7(2): 149–56.
3. Hoffman DJ, Sawaya AL, Verreschi I, Tucker KL, Roberts SB. Why are nutritionally stunted children at increased risk of obesity? Studies of metabolic rate and fat oxidation in shantytown children from São Paulo, Brazil. Am J Clin Nutr. 2000;72(3):702–7.
4. Uauy R, Kain J, Mericq V, Rojas J, Corvalán C. Nutrition, child growth, and chronic disease prevention. Ann Med. 2008;40(1):11–20.
5. Bove I, Miranda T, Campoy C, Uauy R, Napol M. Stunting, overweight and child development impairment go hand in hand as key problems of early infancy: Uruguayan case. Early Hum Dev. 2012;88(9):747–51.
6. Eckhardt C. Micronutrient malnutrition, obesity, and chronic disease in countries undergoing the nutrition transition: potential links and program/policy implications. Washington: International Food Policy Research Institute; 2006. (FCND Discussion Paper No. 213).
7. Kuczmarski RJ, Ogden CL, Guo SS, Grummer-Strawn LM, Flegal KM, Mei Z, et al. 2000 CDC growth charts for the United States: methods and development. National Center for Health Statistics. Vital Health Stat. 2002;11(246):1–190.
8. Rivera JA, Hotz C, González-Cossio T, Neufeld L, Garcia-Guerra A. The effect of micronutrient deficiencies on child growth: a review of results from community-based supplementation trials. J Nutr. 2003;133(11 Suppl 2):4010S–4020S.
9. Branca F, Ferrari M. Impact of micronutrient deficiencies on growth: the stunting syndrome. Ann Nutr Metab. 2002;46 Suppl 1:8–17.
10. Singh GK, Kogan MD, Yu SM. Disparities in obesity and overweight prevalence among US immigrant children and adolescents by generational status. J Community Health. 2009;34(4):271–81.
11. Duran P, Caballero B, de Onis M. The association between stunting and overweight in Latin American and Caribbean preschool children. Food Nutr Bull. 2006;27(4):300–5.
12. Popkin BM. The nutrition transition and obesity in the developing world. J Nutr. 2001;131(3):871S–873S.
13 Iriart C, Handal A, Boursaw B, Rodrigues G. Chronic malnutrition among overweight Latino children: understanding health disparities. J Immigr Minor Health. 2011;13(6):1069-75. doi 10.1007/s10903-011-9464-7.
14. Centers for Disease Control and Prevention (US). National Center for Health Statistics: surveys and data collection systems: National Health and Nutrition Examination Survey [Internet]. Hyattsville, MD: U.S. Department of Health and Human Services, CDC; 2012. Available from: http://www.cdc.gov/nchs/nhanes.htm Accessed 5 May 2012.
15. Nead KG, Halterman JS, Kaczorowski JM, Auinger P, Weitzman M. Overweight children and adolescents: a risk group for iron deficiency. Pediatrics. 2004;114(1):104–8.
16. Centers for Disease Control and Prevention (US). Second national report on biochemical indicators of diet and nutrition in the U.S.

population 2012. Atlanta: CDC; 2012. Available from: http://www.cdc.gov/nutritionreport/report.html Accessed 12 June 2012.
17. Centers for Disease Control and Prevention (US). Recommendations to prevent and control iron deficiency in the United States. MMWR Recomm Rep. 1998;47(RR-3):1–29.
18. StataCorp. Stata statistical software: release 12. College Station, TX: StataCorp LP; 2011.
19. Sawaya AL, Roberts S. Stunting and future risk of obesity: principal physiological mechanisms. Cad Saude Publica. 2003;19 Suppl 1:S21–8.
20. Georgieff MK. Nutrition and the developing brain: nutrient priorities and measurement. Am J Clin Nutr. 2007;85(2):614S–620S.
21. Holick MF. The vitamin D deficiency pandemic: a forgotten hormone important for health. Public Health Rev. 2010;32(1):267–83.
22. Caldwell KL, Makhmudov A, Ely E, Jones RL, Wang RY. Iodine status of the U.S. population, National Health and Nutrition Examination Survey, 2005–2006 and 2007–2008. Thyroid. 2011;21(4):419–27.
23. Lozoff B. Iron deficiency and child development. Food Nutr Bull. 2007;28(4 Suppl):S560–71.
24. Briefel RR, Johnson CL. Secular trends in dietary intake in the United States. Annu Rev Nutr. 2004;24(1):401–31.
25. Wan Nazaimoon WM, Osman A, Wu LL, Khalid BA. Effects of iodine deficiency on insulin-like growth factor-I, insulin-like growth factor-binding protein-3 levels and height attainment in malnourished children. Clin Endocrinol (Oxf). 1996;45(1):79–83.
26. Ganji V, Kafai MR. Trends in serum folate, RBC folate, and circulating total homocysteine concentrations in the United States: analysis of data from National Health and Nutrition Examination Surveys, 1988–1994, 1999–2000, and 2001–2002. J Nutr. 2006;136(1):153–8.
27. Gallisti S, Sudi K, Mangge H, Erwa W, Borkenstein M. Insulin is an independent correlate of plasma homocysteine levels in obese children and adolescents. Diabetes Care. 2000;23(9):1348–52.
28. Javaid MK, Crozier SR, Harvey NC, Gale CR, Dennison EM, Boucher BJ, et al. Maternal vitamin D status during pregnancy and childhood bone mass at age 9 years: a longitudinal study. Lancet. 2006;367(9504):36–43.
29. Passel JS, Cohn D, Lopez MH. Hispanics account for more than half of nation's growth in past decade. Washington: Pew Research Center; 2011. Available from: http://pewhispanic.org/files/reports/140.pdf Accessed 18 April 2012.
30. Morrison SD, Haldeman L, Sudha S, Gruber KJ, Bailey R. Cultural adaptation resources for nutrition and health in new immigrants in Central North Carolina. J Immigr Minor Health. 2007;9(3):205–12.

Manuscript received on 7 November 2012. Revised version accepted for publication on 21 October 2013.

RESUMEN

Obesidad y desnutrición en niños hispanos de los Estados Unidos: doble carga en materia de desigualdades de salud

Objetivo. Analizar las carencias importantes de micronutrientes relacionadas con la salud del niño, y los resultados de crecimiento para las distintas situaciones en cuanto a peso, con objeto de 1) comprender mejor otros posibles problemas y desigualdades nutricionales que podrían quedar ocultos al adoptar un enfoque exclusivo en los percentiles de *índice de masa corporal*, y el sobrepeso y la obesidad, y 2) hacer hincapié en la necesidad de llevar a cabo más estudios que se centren en el bienestar nutricional de los niños en las distintas situaciones en cuanto al peso, incluido el peso saludable.
Métodos. Se analizó una muestra de niños (de 2 a 19 años) de la Encuesta Nacional de Salud y Nutrición (NHANES) 2003–2010. Se consideraron las prevalencias del retraso en el crecimiento, de las deficiencias de folato, vitamina D, hierro y yodo, y de la anemia. Se establecieron comparaciones entre blancos no hispanos e hispanos, y entre los mismos hispanos, con base en las características sociodemográficas y económicas.
Resultados. Los niños hispanos mostraron una prevalencia significativamente mayor de retraso en el crecimiento (6,1 frente a 2,6%), y la prevalencia del retraso en el crecimiento en los niños hispanos clasificados como de peso saludable fue mayor que en los incluidos en las categorías de sobrepeso u obesidad. Se observaron porcentajes comparables por grupos étnicos en cuanto a los micronutrientes más analizados, aunque las niñas mostraron sistemáticamente una mayor prevalencia de carencias nutricionales que los niños, especialmente las que se acercaban a la edad fecunda.
Conclusiones. Los resultados hacen hincapié en la necesidad de llevar a cabo estudios más específicos y diferenciados sobre la obesidad y el estado nutricional de los niños entre y dentro de los distintos grupos étnicos, de sexo y de edad. Las intervenciones de salud pública, para que resulten apropiadas, deben considerar las distintas situaciones en cuanto a peso y las carencias de micronutrientes, con objeto de eliminar las desigualdades en niños de grupos minoritarios, especialmente en niñas.

Palabras clave Desigualdades en la salud; desnutrición; hispanoamericanos; obesidad; bienestar del niño; Estados Unidos.