J. Racial and Ethnic Health Disparities (2016) 3:331–339
DOI 10.1007/s40615-015-0150-7

Two Worlds of Obesity: Ethnic Differences in Child Overweight/Obesity Prevalence and Trajectories

Geraldine Moreno-Black [1] · Jean Stockard [2]

Received: 21 January 2015 / Revised: 17 June 2015 / Accepted: 20 July 2015 / Published online: 15 August 2015

Abstract
Objectives Research on childhood obesity has examined the prevalence of overweight and obesity during childhood and developmental trajectories. This study focuses on the extent to which Hispanic and non-Hispanic white elementary students differ in prevalence of overweight and obesity by grade level, time, gender, and school setting. It also focuses on comparison of the trajectories in weight status for the Hispanic and non-Hispanic white students.
Methods BMI values were examined both using standard scores (*z*-scores) and as categorical variables. Cross-sectional data from 4 years were used to examine prevalence, and panel data across 2-year periods examined trajectories. Descriptive statistics and mixed models, controlling for school setting, were used.
Results Hispanic students began first grade with higher prevalence of obesity and overweight, and the differences were larger in higher grades and later years. The majority of students had stable weight status over the 2-year periods of the trajectory analysis, but Hispanic students began the panel with higher BMI-Z values and were more likely to increase and less likely to decrease BMI-Z.
Conclusions The findings suggest that the degree of childhood overweight/obesity, especially among Hispanics, is substantial and will likely have profound impacts on adult obesity and other associated health issues in the future. Findings confirm the need for early childhood interventions to influence BMI.

Keywords Prevalence overweight/obesity · BMI trajectory · Elementary school children · Ethnic disparities

Electronic supplementary material The online version of this article (doi:10.1007/s40615-015-0150-7) contains supplementary material, which is available to authorized users.

✉ Geraldine Moreno-Black
gmorenob@uoregon.edu

[1] Department of Anthropology, University of Oregon, Eugene, Oregon 97403, USA

[2] Department of Planning, Public Policy and Management, University of Oregon, Eugene, Oregon, USA

Introduction

Childhood overweight and obesity, especially in terms of ethnic differences, continue to be a major concern and focus of public health efforts in the USA [1–4]. Overweight and obesity in childhood, adolescence, and adulthood are complex conditions that can develop from the interaction of genetic, metabolic, social, behavioral, and cultural factors [5, 6]. Recently, a number of research themes have emerged in the childhood obesity domain. Two of these are relevant to the topic of this paper: (1) ethnic differences in the prevalence of overweight and obesity during childhood and (2) ethnic comparisons in the developmental trajectories of overweight/obesity during childhood [7, 8].

Early studies on obesity prevalence suggested that the prevalence of obesity among children could reach 30 % by 2030 [7]. Recent trend analyses suggest the rapid increases in obesity prevalence seen in the 1980s and 1990s did not continue in later decades [3, 9, 10]. While the report of a decline is encouraging, this decline may not be seen across all subgroups of the population. For instance, Ogden et al. [3, 11] indicate increases in obesity prevalence may be occurring among males. Furthermore, trends in overweight/obesity over time among children from low income families as well as children from ethnic minority groups do not follow those of white children [12–18]. Examining such variations in the prevalence of childhood overweight and obesity by ethnicity is a key element of our paper.

A second research theme, closely related to BMI prevalence, focuses on the developmental trajectories of overweight during childhood and adolescence. Such life-course approaches offer valuable insights into heterogeneity in weight gain over the life course and subsequent consequences for related chronic diseases [19–21]. Additionally, information about the timing of weight gain may be helpful for the development of effective interventions [22]. A number of recent studies focusing on BMI change from childhood to adolescence or adolescence to adulthood highlight the importance of understanding growth trajectories [12, 19–21, 23–26].

Fewer studies have focused on BMI growth trajectories solely during childhood. Although they have all identified three or four developmental patterns, each used different terminology to identify the trajectories [2, 22, 27–31]. The trajectory patterns and number of trajectories also varied, reflecting both the differences in analytical methods as well as objectives of the specific study. In general, all of the studies identified one group, regardless of how it was termed, that included those children who had a BMI in the “normal” category and did not change over time. The other categories in each paper reflected some pattern of change, with the majority of students who had experienced change generally moving toward overweight or obesity.

The studies of developmental trajectories have often noted that some groups are more at risk than others are. For instance, Li et al. [4] determined that early-onset overweight was more likely in males, African Americans, those with heavier mothers, those whose mothers had higher pregnancy weight gain, and those with higher birth weight. Balestreri and Van Hook [22] found some evidence that the relationship between socio-economic status and children’s health may operate differently across gender. They also found Hispanic boys, black girls, and children of immigrant parents who have had less exposure to the USA were more likely to experience early and sustained overweight throughout elementary and middle school. Carter et al. [31] found that those living in semi-urban areas were less likely to have increasing weight trajectories, while those in rural areas were more likely to be obese and remain so over time. Additionally, other important risk factors for the high-stable weight group included obesity status of the mother, smoking during pregnancy, and overeating behaviors. Magee et al. [28] found that socio-demographic factors such as parent overweight/obesity, education, and smoking, and childbirth weight were significantly related with these trajectories. They propose their results suggest there may be some commonalities in BMI/obesity trajectories in different samples of children and that interventions could be tailored specifically toward these at-risk trajectories.

This paper adds to the literature by looking at variations in the prevalence of obesity and overweight and BMI growth trajectories of elementary-aged Hispanic and Non-Hispanic white students over a 3-year period in a medium-sized western city with a substantial number of Hispanics with Mexican and Central American origins. Our first research question focuses on the prevalence of overweight and obesity in this sample. Using a large cross-sectional sample, we examine the extent to which differences in prevalence between the ethnic groups varies by grade level, time, gender, and school setting. Our second research question focuses on developmental trajectories. Using a sub-sample of the total group with panel data, we look at variations in individual students’ BMI growth trajectories over a 2-year period and factors related to these variations for both Hispanic and non-Hispanic white students. In both analyses, we examine the extent to which our conclusions are replicated with different measures of obesity and overweight (categorical versus continuous measurements). In the final section, we contrast our results with those obtained with national samples and describe the implications of our work, especially for those concerned with developing effective interventions for local and regional communities and understanding variations in BMI growth trajectories by ethnicity.

Methods

Participants

The sample for the analysis came from 18 elementary schools in two school districts in western Oregon. The districts are part of the same metropolitan area and separated by only a few miles. Three small rural schools were omitted from the analysis because there was very little data available. The omitted schools had a total of 82 students, only four of whom were of Hispanic origin. There were no indications that these schools differed from others in the sample in key variables in the analysis other than the representation of Hispanic students. (see Table A-1 in the Appendix.)

Students with ethnicities other than Hispanic or non-Hispanic white, such as Asian-American, American Indian, or African American, were approximately equally represented but, taken together, comprised only 7 % of the total sample. Because they were such a small proportion of the total group and because the nature of weight-related risk factors vary substantially from one group to another, these students were omitted from the analysis, thus providing a more homogeneous population for comparisons by ethnicity.

To address our first research question regarding factors related to the prevalence of overweight and obesity among Hispanic and non-Hispanic students, we focused on the total population of 1st, 3rd, and 5th grade students in the 18 schools across a 4-year period (fall 2005 to fall 2008). This group is called the cross-sectional sample in the discussion below and is especially well suited for the examination of changing trends in prevalence within the total group. It was comprised of 1164 Hispanic students and 5169 non-Hispanic students, equally distributed among the three grade levels and the two sex groups. There was a tendency, however, for Hispanics to be more highly represented among the two later years of the analysis, when they were 20 % of the sample, than in the first year, when they comprised only 13 % of the total group.

To address our second research question regarding developmental trajectories, we focused on subsamples of students for whom data were available from grade 1 to grade 3 or from grade 3 to grade 5. Using information on students' birth date, gender, ethnicity, and school, we developed unique identifiers for each student and matched data for an earlier year (2005 or 2006) with that for 2 years later (2007 or 2008). Data for multiple years were available for 11 of the 18 schools, and we were able to match about half of the students in these schools. Of the 583 students in first grade in these schools in 2005 or 2006, 288 (49.4 %) had data for third grade in 2007 or 2008. Of the 399 students in third grade in these schools in 2005 or 2006, 222 (55.6 %) had data for fifth grade in 2007 or 2008. These two groups, which we refer to as panel samples, did not differ significantly from the larger group in BMI-Z values at any of the times of assessment (see Table A-8 in the Appendix).

Procedure

The data for this paper were obtained through voluntary provision of height and weight information by schools in one county in Oregon. Students' height and weight were measured at the start of each school year from 2005 through 2008 as part of in-school health screenings. The 2005 data were obtained through a request for baseline county data made by the county Health Department and a local child health and obesity coalition. A letter from these organizations was sent to all school districts in the county. Administrators or staff (primarily school nurses) who were interested in participating sent data from their health screening to one of the researchers for analysis. Some schools were interested in continuing to receive analysis from their screenings and voluntarily supplied the information to the researcher during the 2006–2007 through the 2008–2009 periods. Each school was responsible for its own data collection, and no attempt was made to standardize collection procedures or demographic categories (e.g., ethnicity) throughout the district. The 2008–2009 data in one of the districts was collected by one of the researchers as part of a separate NIH project focusing on child obesity in that district. Student IDs were not included in the material sent from the schools for analysis and project ID numbers were assigned to each child, ensuring student confidentiality. Data included gender, ethnicity, date of screening, birth date, grade level (not specific class), height, and weight. All of the data were entered into the EPI Info NutStat [32] program for calculation of BMI values. This study was determined to be exempt by the Committee on the Protection of Human Subjects at the researchers' university.

Data Analysis

Data on each student's height, weight, gender, and age were used to calculate their body mass index (BMI). For this analysis, the BMI values were translated into standard scores (*z*-scores), which provide a measure of children's weight relative to the national means for their age and sex. In the description below, these standardized comparisons to national means are referred to as BMI-Z values [33]. The use of *z*-scores was important in allowing comparisons across grade levels and over time and avoids the problem of unequal intervals that would occur with the use of BMI-for-age percentiles [33–35]. Extreme outliers (BMI-Z values greater than or equal to |3.0|) were omitted from the analysis. This involved less than 1 % of the cases.

We also examined students' weight status as a categorical variable. In the cross-sectional analysis of prevalence, with a relatively larger sample size, three categories (normal, overweight, and obese) were examined. Fewer than 2 % of the students were underweight. Given this very small sample and the strikingly different health risks this group faces, they were omitted from the analysis. For the analysis of panel data, which followed students over time and had a smaller sample, BMI-Z values were classified into a simple dichotomy (overweight or obese = 1, other = 0). Results were substantively identical when the three categories were used.

To examine the first research question regarding variations in the prevalence of obesity and overweight for the two ethnic groups by grade, time, sex, and setting, we first calculated simple descriptive statistics on weight status. We then used a multivariate, mixed model analysis, regressing students' weight status on each of these independent measures. School was entered as a random effect (intercept), and the percentage of free and reduced lunch was used as a school-level explanatory variable to control for the context of school poverty. A series of models was examined, focusing on the independent effect of each independent measure and all possible two-way interaction effects with ethnicity. Because the number of significant interaction effects was relatively large, we supplemented this analysis with a comparison of results within each ethnic group. The multivariate analyses were conducted with both the BMI-Z values and the categorical measure of weight status as dependent measures, using the STATA programs xtmixed and xtmelogit. To conserve space, only the results for the continuous measure and the most parsimonious explanatory models are included in the text. Model fit statistics for both analyses and coefficients for the categorical dependent measure are in Tables A-4, 5, and 6, and the correlation matrix for the cross-sectional sample is in Table A-3.

A similar procedure was used to examine our second research question regarding developmental trajectories of obesity and overweight within the two ethnic groups. We first calculated descriptive statistics regarding overweight and obesity within the two panel samples, focusing on the extent to which students maintained their initial weight status or had a lower or higher weight status over the 2-year interval. We then used mixed models to examine variables related to variations in changes in weight status over the 2-year panel period by regressing the measures of weight status at time 2 on status at time 1, ethnicity, gender, and school context, again beginning with a simple intercept only model and testing the fit of incrementally more complex models including interactions of initial weight status, gender, and school context with ethnicity. To control for the impact of age on the results, analyses were conducted separately for the two panel samples (grades 1 to 3 and grades 3 to 5). Details on statistical analyses that were excluded from the text to conserve space are provided in Tables A-9 and A-10.

Results

Summary information about the schools' socio-demographic characteristics was obtained from the Oregon Department of Education and is given in Table 1. It indicates substantial variation in the sample. For instance, the schools ranged in size from less than 100 to over 700 students, with an average of 382. There was also substantial variation in the percentage of Hispanics in the schools and the percentage of students receiving free or reduced lunch (FRL), our proxy measure of school-level SES. The schools ranged from having about 2 % to over 30 % of their students being of Hispanic heritage (mean = 18.3 %). The percentage receiving free or reduced lunch varied from 26 to 83 %, with an average of 56. The percentage receiving FRL and the percentage of Hispanic students were essentially collinear (r = 0.94). Finally, there was substantial variability in average BMI-Z values and weight status across schools in the sample. This variation indicates the importance of including a school-level measure in the analysis.

Ethnic Differences in Changing Prevalence of Overweight and Obesity over Time (Research Question One—the Cross-Sectional Sample)

Table 2 reports the average BMI-Z score of Hispanic and non-Hispanic white students for the total group, within each grade, year, and sex. In all comparisons, the Hispanic students had higher average BMI-Z scores. However, the difference (in the last column of the table) was substantially smaller for first graders than for those in the two higher grades. The difference was also substantially smaller for the first year of data collection than the last, when the average BMI-Z score of Hispanic students was almost half of a standard deviation greater than that of the non-Hispanic white students. The difference was slightly larger for males than for females. Descriptive statistics for the categorical measure of overweight and obesity for the cross-sectional sample show an identical pattern and are in Table A-2 in the Appendix.

Table 3 reports the results of the mixed model analyses for the cross-sectional sample, regressing BMI-Z values on measures of ethnicity, year, grade, sex, and the school-level poverty (FRL). The results in the first set of columns, in which only main effects are included, show a strong association of ethnicity with BMI-Z. The coefficient of 0.36 is similar to the unadjusted difference between the groups shown in Table 2. The results in the second set of columns include the interaction effects of ethnicity with each of the other variables. Model fit statistics (in Table A-4 in the Appendix) indicate that the model with interactions provides a significantly better fit to the data. The coefficients in Table 3 show that there were significant interactions of ethnicity with each of the other variables—year, grade, sex, and school-level poverty. Moreover, when these interaction effects were included, the coefficient associated with ethnicity increased markedly, to a value of 0.76. In other words, the association of year, grade, sex, and

Table 1 Characteristics of schools ($n = 18$)

Statistic	Enrollment	% FRL	% Hispanic	BMI-Z	% Overweight or obese
Mean	382.3	56.4	18.2	0.67	38.0
Minimum	67.5	25.9	2.2	0.16	26.1
Maximum	724.0	82.8	33.8	0.94	49.8
St. dev.	158.6	19.7	10.1	0.18	6.45

FRL free and reduced lunch

Note: Data on enrollment and % FRL were obtained from the Oregon Department of Education. Data on ethnic composition and BMI-Z scores were obtained from the data set analyzed in this paper. Descriptive statistics were calculated with schools as the unit of analysis

Table 2 Average BMI-Z scores of Hispanic and non-Hispanic white students, by grade, year, and sex, cross-sectional sample

	Hispanic students		Non-Hispanic white students		
	Mean	*N*	Mean	SD	Difference
Total group	1.05	1164.00	0.67	5169	0.38
By grade					
Grade 1	0.92	389	0.65	1608	0.27
Grade 3	1.06	402	0.63	1912	0.43
Grade 5	1.16	373	0.73	1649	0.43
By year					
2005	0.87	165	0.64	1109	0.23
2006	1.14	236	0.76	1070	0.38
2007	0.92	306	0.61	1178	0.31
2008	1.15	457	0.66	1812	0.49
By sex					
Female	0.97	588	0.64	2476	0.33
Male	1.12	576	0.69	2693	0.43

Note: The difference column is the difference of the average BMI-Z value of the Hispanic and non-Hispanic white students. A two-way analysis of variance of the BMI-Z values yielded the following results: For grade: F (grade) = 8.68, p = .0002; F (ethnicity) = 144.03, $p < .0001$; F (interaction) = 2.74, p = .06. For year, F (year) = 8.43, $p < .0001$; F (ethnicity) = 108.68, $p < .0001$; F (interaction) = .03. For sex, F (sex) = 9.13, p = .002; F (ethnicity) = 145.49, $p < .0001$; F (interaction) = 2.77, p = .10. As would be expected, standard deviations for all BMI-Z scores were within rounding difference of 1.0

school context with BMI-Z values differed significantly between the two ethnic groups and the impact of these differential associations was an increased estimate of the discrepancy in overweight and obesity between the two ethnic groups.

To better illustrate the different patterns within the two ethnic groups, Table 4 displays the coefficients obtained from mixed models regressing time, grade, sex, and school poverty on BMI-Z values for both the Hispanic and non-Hispanic

Table 3 Mixed model regressions of BMI-Z on ethnicity, time, grade, sex, FRL, main effects only. and with interactions with ethnicity, cross-sectional sample

	Only main effects		Including interactions with ethnicity	
	b	*Z*	*b*	*Z*
Hispanic	0.36	11.09***	0.76	4.56***
Year 2006	0.03	1.03	0.30	2.87**
Year 2007	0.12	3.78***	0.04	0.38
Year 2008	0.14	3.09***	0.28	3.17**
Grade 3	−0.04	−1.03	−0.004	−0.11
Grade 5	0.05	1.26	0.08	2.37*
Male	0.06	2.55*	0.04	1.58
FRL (school level)	0.002	1.08	0.002	1.45
Hispanic * year 2006	–	–	−0.004	−2.21*
Hispanic * year 2007	–	–	−0.17	−1.58
Hispanic * year 2008	–	–	−0.08	−0.78
Hispanic * grade 3	–	–	−0.28	−2.93**
Hispanic * grade 5	–	–	−0.12	−1.85
Hispanic * male	–	–	−0.16	−2.07*
Hispanic * FRL	–	–	−0.18	−2.30*
Constant	0.45	4.31***	0.47	4.46***

Note: There were 18 schools in the analysis. The number of students per school ranged from 26 to 706 with an average of 352 students per school. Less than 2 % of the total variance in BMI-Z scores was between schools

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 4 Coefficients in mixed models, cross-sectional sample, Hispanic and non-Hispanic white students, and differences

	Hispanic	Non-Hispanic white	Difference
FRL (school)	−0.002	0.002	−0.004
Year 06	0.272**	0.133**	0.139
Year 07	0.058	−0.044	0.102
Year 08	0.292**	0.001	0.290***
Grade 3	0.158*	−0.006	0.164**
Grade 5	0.257***	0.080*	0.180**
Male	0.154**	0.041	0.113
Constant	0.772***	0.471***	0.301

Note: For both ethnic groups there were 18 schools. The average number of students per school was 65 for the Hispanic group and 287 for the non-Hispanic white group. Values given in the first two columns are the regression coefficients and the final column is the difference of the two coefficients

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

white students. The final column reports the difference in the two coefficients. All of the differences, except that associated with school poverty, were positive in nature, indicating that the impact of time, grade, and sex was stronger for the Hispanic students than for the non-Hispanic students. Substantively identical results were obtained when the categorical variable of weight status was used.

In all of the cross-sectional analyses, the percentage of variance related to differences between schools was minimal, ranging from only 1.2 to 1.5 %. The rate of free or reduced lunch, our measure of school poverty, was not significant in any of the models. Thus, the vast majority of variability in the cross-sectional sample was between individual students and unrelated to school context.

Trajectories of Overweight and Obesity (Research Question No. 2—the Panel Samples)

As noted above, two sets of panel data were available, one that tracked changes from grade 1 to grade 3 and another that tracked changes from grade 3 to grade 5. Table 5 summarizes the changes in weight status over time for the Hispanic and non-Hispanic white students in each panel group, differentiating four categories: (1) normal weight status at both time periods, (2) moving from the normal category to overweight or obese, (3) moving from the overweight or obese category to normal, and (4) overweight or obese status at both time periods. The results from the two panel samples were very similar. There was substantial stability in weight status over time. Fewer than 20 % of the students in either panel or ethnic group changed weight status over the 2-year period. Yet, the Hispanic students were much more likely than the non-Hispanic white students to be in the overweight or obese category at baseline. In addition, they were far less likely to move from the overweight or obese category to a normal weight. Only one of the Hispanic students in either of the two panels moved from the overweight and obese category to the normal group. The differences between the ethnic groups were statistically significant for both panel groups. Similar results appeared with the BMI-Z values, and these are summarized in Table A-7 in the Appendix.

Table 5 Weight trajectories by ethnicity, panel samples

Panel 1: grade 1 to grade 3		
	Hispanics (%)	Non-Hispanic whites (%)
Stable, normal weight	33	56
Increased from normal	11	8
Decreased to normal	0	10
Stable, overweight or obese	56	26
Total	100	100
N	45	231
Chi-square	18.56, df = 3, $p < 0.001$	
Panel 2: grade 3 to grade 5		
	Hispanics (%)	Non-Hispanic whites (%)
Stable, normal weight	35	53
Increased from normal	12	9
Decreased to normal	2	9
Stable, overweight or obese	51	30
Total	100	101
N	43	169
Chi-square	9.13, df = 3, $p = 0.03$	

Table 6 gives the results of the mixed model analyses for the panel sample, where the BMI-Z scores at the end of the period (third grade for the grade 1 to grade 3 panel and fifth grade for the grade 3 to grade 5 panel) were regressed on initial BMI-Z scores, ethnicity, and the school-level measure of poverty. None of the interaction effects was significant, and the results with the continuous and dichotomous dependent

Table 6 Mixed model results, panel samples, regressing ending BMI-Z on baseline BMI-Z, ethnicity, sex, and school-level poverty

	Panel 1: grade 1 to grade 3		Grade 3 to grade 5 panel	
Variables	*b*	*z*	*b*	*z*
Baseline BMI-Z	0.85	23.09***	0.81	22.48***
Hispanic	0.21	1.99*	0.35	3.89***
Male	0.12	1.80	0.01	0.17
FRL	0.01	1.97*	−0.01	−0.16
Constant	−0.28	−1.94*	0.11	0.56

Note: For the grade 1 to grade 3 panel, $n = 276$ students from 11 schools. The number of students per school ranged from 6 to 63 with an average of 25. For the grade 3 to grade 5 panel, $n = 212$ students from 8 schools. The number of students per school ranged from 10 to 68 with an average of 26

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

variables were substantively identical. The results confirm those shown in the descriptive analyses. For both panel groups, students' BMI-Z scores at the beginning of the period were the strongest predictor of their BMI-Z score 2 years later. However, the increase over time was significantly greater for the Hispanic students. At the end of the panel period, the BMI values of the Hispanic students were predicted to be from 0.21 to 0.35 of a standard deviation higher than those of non-Hispanic white students who had identical BMI-Z values at the start of the period, net of school context, and sex. The impact of ethnicity was stronger for the older panel than for the younger panel, perhaps reflecting the increased differences by ethnicity over the grades observed in the cross-sectional analyses.

In contrast to the results with the much larger cross-sectional sample, the school-level measure of poverty was statistically significant in the analysis of the younger panel, with higher predicted BMI-Z values in grade 3 for students from higher poverty schools and almost 5 % of the total variance in third grade panel scores related to between-school variation. Virtually none of the variance in fifth grade BMI-Z values was between schools (the between group SD was $0.09*10^{-9}$; see Table A-9).

Discussion

In this study, using both descriptive and multivariate analyses of data from a western Oregon community, we found substantial differences between non-Hispanic white and Hispanic elementary students. The prevalence of overweight (18 %) and obesity (21 %) among the elementary non-Hispanic white school children in the sample was higher than would be expected by the established norms, but this prevalence did not substantially change over the 4-year period of the study. The prevalence of both overweight and obesity was substantially higher for the Hispanic children. The ethnic difference was large at first grade and then increased over time. Although recently decreases in the prevalence of obesity have been reported in some populations of youth in the USA [36, 37], the stability in our non-Hispanic white sample is consistent with some recent literature that point to no significant changes in obesity prevalence in youth [11, 38–40]. The increasing prevalence among the Hispanic students is consistent with other studies [17, 40–43].

The data showing that overall rates of overweight and obesity remain high and ethnic disparities seem to be widening are important. The elimination of health disparities has been a national priority for years, but as seen in our study, as well as previous research, disparities in child overweight and obesity by race/ethnicity have not improved over the past decade but have, at least for this population, worsened. These findings suggest that the degree of childhood overweight/obesity, especially among Hispanics, is substantial and will likely have profound impact on adult obesity and other associated health issues in the future.

Findings in our study are consistent with the general patterns seen in the few recent studies that focus on ethnic disparities in elementary-aged children [41, 43–50]. First, they indicate a fair amount of stability in weight status over time. Over four fifths of the students who were initially either classified as being in the normal BMI category or in the overweight/obese category were in that category 2 years later. However, movement patterns from one category to another were markedly different for students in the two ethnic groups. The Hispanic students consistently remained in the overweight/obese category while about one fourth of the non-Hispanic students who were in the overweight/obese category at baseline had moved to the normal weight category 2 years later. The non-Hispanic students were also less likely than the Hispanic students to move from the normal category to obese or overweight. This type of ethnic disparity in which Hispanic children begin heavier and continue to be overweight/obese throughout childhood is consistent with results of other studies [14, 15, 17, 22, 38].

The strength of our conclusions is bolstered by the replication of results with different methodological approaches as suggested by Rossen et al. [47]. In our study, similar conclusions appeared with a cross-sectional analysis and panel analyses with two different age groups. Similar conclusions also appeared when BMI-Z values were measured continuously and categorically. We suggest that it is important to include both types of measures, especially when examining subjects with high initial rates of obesity and overweight. Although not the case in our study, such subjects might appear to have a stable trajectory, when looking at a categorical measure; however, either a decreased or increased risk would become apparent with the use of a continuous measure.

Our results represent one community in the Northwest, a community where the Hispanic population has Mexican or Central American heritage, is clearly a numerical minority, and has a relatively high rate of poverty. As suggested by Hoelscher [49], our focus on a local-level, community-based sample of children highlights the importance of this type of approach for providing evidence to local and state decision-makers and for supporting policy change at the school, local, and state level. Future research could, of course, build on and extend our findings. For example, we had limited data on the individual characteristics of students in our sample and no data on individual poverty status. More extensive data on students' individual characteristics would be an important addition to future research.

Our findings are not only consistent with those of other studies but, in fact, the differences are stronger. Additionally, our sample findings are important because of the focus on the elementary school level and the documentation of increasing ethnic differences and how they are present at the start of school and increase as children age. This type of analysis at the local and state level is valuable because it provides important information for program development that is appropriate in the local community. Such analyses are especially important for Hispanics, given the large variability among Hispanics in terms of background characteristics, including socioeconomic status, region of origin, and time in the USA.

It would be important to replicate the analysis in other communities, especially in those in which the Hispanic population is more diverse in cultural and economic characteristics and in which there was, potentially, more variability among school populations. It also would be important to examine variations in prevalence and trajectories over time for a variety of ethnic groups. As noted in the introduction to this paper, there have been reports of a recent stabilization and even decline in the prevalence of obesity and overweight. Given our results, it seems important to determine if this improvement is limited only to certain socio-demographic groups.

Finally, the convergence of results using different analytical methods highlights the importance of considering life-course changes when developing interventions and policies. Like Schuster et al. [48], we suggest that school environments still have high potential for obesity prevention interventions and programs, especially when BMI data is collected longitudinally on all grades. However, the very high level of early establishment of obesity and overweight, especially among the Hispanic students in our sample, suggests that school-based interventions could be especially important in the first 3 years of elementary school, a time when physical activity programs and nutrition education are not always present or consistent in the schools in the sample. Implementing interventions, especially parent-based programs, during these early school years and even before the beginning of elementary school could be very effective [51]. In a recent review and analysis of child and adolescent obesity prevention programs, Haynos and O'Donohue conclude the field of universal childhood obesity prevention is far from having identified empirically supported prevention programs [51]. Their review suggested that outcomes are generally modest across all age groups and there were few replications of any program. Information from both prevalence and trajectory data can be particularly valuable for the development of prevention programs. Approaches that involve assessments of both local school environments and neighborhood conditions and the relationship of school interventions to family-level and community interventions could also be especially valuable.

Acknowledgments The authors appreciate the assistance of the county health department and the staff and administrators of the school districts. The authors especially appreciate the work of Alisha Perry, Aiden Holpuch and Caitlin Turnbull for their assistance with data entry and management, and all of the children who participated in the screening. We also thank the reviewers of the paper for their very helpful comments.

Conflict of Interest The authors declare that they have no competing interests.

Informed Consent This study was determined to be exempt by the Committee on the Protection of Human Subjects at the researchers' university.

Compliance with Ethical Standards .

References

1. Koopman LP, Mertens LL. Impact of childhood obesity on cardiac structure and function. Curr Treat Options Cardiovasc Med. 2014;16(11):1–20.
2. Li C, Goran MI, Kaur H, Nollen N, Ahluwalia JS. Developmental trajectories of overweight during childhood: role of early life factors. Obesity. 2007;15:760–71.
3. 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.
4. Shankaran S, Bann C, Das A, et al. Risk for obesity in adolescence starts in early childhood. J Perinatol. 2011;31(11):711–6.
5. Niclasen BVL, Petzold MG, Schnohr C. Overweight and obesity at school entry as predictor of overweight in adolescence in an Arctic child population. Eur J Pub Health. 2006;17(10):17–20.
6. Huang DYC, Lanza HI, Wright-Volel K, Anglin MD. Developmental trajectories of childhood obesity and risk behaviors in adolescence. J Adolesc. 2013;36:139–48.
7. Wang YC, Gortmaker SL, Taveras EM. Trends and racial/ethnic disparities in severe obesity among US children and adolescents, 1976–2006. Int J Pediatr Obes. 2011;6:12–20.
8. Cunningham SA, Kramer MR, Narayan KV. Incidence of childhood obesity in the United States. N Engl J Med. 2014;370(5):403–11.
9. CDC [Centers for Disease Control and Prevention]. Obesity in K–8 students—New York City, 2006–07 to 2010–11 school years. MMWR. 2011;60:1673–8.
10. Gee S, Chin D, Ackerson L, Woo D, Howell A. Prevalence of childhood and adolescent overweight and obesity from 2003 to 2010 in an integrated health care delivery system. J Obes. 2013;3:1–8.
11. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of childhood and adult obesity in the United States, 2011-2012. JAMA. 2014;311(8):806–14.
12. Lohrman DA, YoussefAgha A, Jayawardene W. Trends in body mass index and prevalence of extreme high obesity among Pennsylvania children and adolescents, 2007–2011: promising but cautionary. Am J Public Health. 2014;104:62–8.
13. Skinner AC, Skelton JA. Prevalence and trends in obesity and severe obesity among children in the United States, 1999–2012. JAMA Pediatr. 2014 doi:10.1001/jamapediatrics.2014.21.
14. Freedman DS, Khan LK, Serdula MK, Ogden CL, Dietz WH. Racial and ethnic differences in secular trends for childhood BMI, weight, and height. Obesity. 2006;14(2):301–8.
15. Karlsen S, Morris S, Kinra S, Vallejo-Torres L, Viner RM. Ethnic variations in overweight and obesity among children over time: findings from analyses of the health surveys for England 1998–2009. Pediatr Obes. 2014;9(3):186–96.

16. Reed M Childhood obesity policy: implications for African American girls and a nursing ecological model. Nurs Sci Q. 2013;26(1):86–95.
17. Taveras EM, Gillman MW, Kleinman KP, Rich-Edwards JW, Rifas-Shiman SL. Reducing racial/ethnic disparities in childhood obesity: the role of early life risk factors. JAMA Pediatr. 2013;167(8):731–8.
18. Weeden AE, Ang SC, Zeman CL, Darden PM. Obesity prevalence in low-income preschool children in Oklahoma
19. Chen X, Brogan K. Developmental trajectories of overweight and obesity of US youth through the life course of adolescence to young adulthood. Adolesc Health Med Ther. 2012;3:33–342.
20. Hoekstra T, Barbosa-Leiker C, Koppes LL, Twisk JW. Developmental trajectories of body mass index throughout the life course: an application of latent class growth (mixture) modeling. Longit Life Course Stud. 2011;2(3):319–30.
21. Østbye T, Malhotra R, Landerman LR. Body mass trajectories through adulthood: results from the National Longitudinal Survey of Youth 1979 cohort (1981–2006). Int J Epidemiol. 2011;40:240–50.
22. Balistreri KS, Van Hook J. Trajectories of overweight among US school children: a focus on social and economic characteristics. Matern Child Health. 2011;15(5):610–9.
23. Nonnemaker JM, Morgan-Lopez AA, Pais JM, Finkelstein EA. Youth BMI trajectories: evidence from the NLSY97. Obesity. 2009;17(6):1274–80.
24. Potter CM, Ulijaszek SJ. Predicting adult obesity from measures in earlier life. J Epidemiol Community Health. 2013;67(12):1032–7.
25. Reilly M, Bonataki M, Leary S. Progression from childhood overweight to adolescent obesity in a large contemporary cohort. Int J Pediatr Obes. 2011;6:e138–43.
26. Rzehak P, Heinrich J. Development of relative weight, overweight and obesity from childhood to young adulthood. A longitudinal analysis of individual change of height and weight. Eur J Epidemiol. 2006;21(9):661–72.
27. Lane SP, Bluestone C, Burke CT. Trajectories of BMI from early childhood through early adolescence: SES and psychosocial predictors. Brit J Health Psychol. 2013;18(1):66–82.
28. Magee CA, Caputi P, Iverson DC. Identification of distinct body mass index trajectories in Australian children. Pediatr Obes. 2012;8:189–98.
29. YoussefAgha AH, Lohrmann DK, Jayawardene WP. Use of data mining to reveal body mass index (BMI): patterns among Pennsylvania schoolchildren, pre-K to grade 12. J Sch Health. 2013;83(2):85–92.
30. Pryor LE, Tremblay RE, Boivin M, et al. Developmental trajectories of body mass index in early childhood and their risk factors: an 8-year longitudinal study. Arch Pediatr Adolesc Med. 2011;165(10):906–12.
31. Carter MA, Dubois L, Tremblay MS, Taljaard M, Jones BL. Trajectories of childhood weight gain: the relative importance of local environment versus individual social and early life factors. PLoS One. 2012;7(10):e47065. doi:10.1371/journal.pone.0047065.
32. NutStat (2000) Centers for Disease Control and Prevention, Atlanta, Georgia EpiInfo http://wwwn.cdc.gov/epiinfo/.
33. Barlow SE and the Expert Committee. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. Pediatrics 2007; 120 Supplement 4:S164—S192.
34. CDC [Centers for Disease Control and Prevention] 2015 Basics about childhood obesity. http://www.cdc.gov/obesity/childhood/basics.html.
35. Must A, Anderson S. Body mass index in children and adolescents: considerations for population-based applications. Int J Obes. 2006;30:590–4.
36. CDC [Centers for Disease Control and Prevention]. Vital signs: obesity among low-income, preschool-aged children—United States, 2008-2011. MMWR Morb Mortal Wkly Rep. 2013;62(31):629–34.
37. Wen X, Gillman MW, Rifas-Shiman SL, Sherry B, Kleinman K, Taveras EM. Decreasing prevalence of obesity among young children in Massachusetts from 2004 to 2008. Pediatrics. 2012;129(5):823–31.
38. Bailey-Davis L, Horst M, Hillemeier MH, Lauter A. Obesity disparities among elementary-aged children: data from school-based BMI surveillence. Pediatrics. 2012;130(6):1101–9.
39. Skinner, A C, Skelton J A. Prevalence and trends in obesity and severe obesity among children in the United States, 1999-2012. JAMA Pediatr 2014 doi:10.1001/jamapediatrics.2014.21
40. Wang Y, Beydoun MA, Liang L, Caballero B, Kumanyika SK. Will all Americans become overweight or obese? Estimating the progression and cost of the US obesity epidemic. Obesity. 2008;16(10):2323–30.
41. Martinson ML, McLanahan S, Brooks-Gunn J. Race/ethnic and nativity disparities in child overweight in the United States and England. Ann Amer Acad Pol and Soc Sci. 2012;643:219–38.
42. Rundle A, Richards C, Bader MDM. Individual- and school-level sociodemographic predictors of obesity among New York City public school children. Amer J Epidemiol. 2012;176(11):986–94.
43. Schuster MA, Elliott MN, Kanouse DE. Racial and ethnic health disparities among fifth-graders in three cities. N Engl J Med. 2012;367(8):735–45.
44. Bisset S, Fournier M, Pagani L, Janosz M. Predicting academic and cognitive outcomes from weight status trajectories during childhood. Int J Obes. 2013;37:154–9.
45. Garden FL, Marks GB, Simpson JM, Webb KL. Body mass index (BMI) trajectories from birth to 11.5 years: relation to early life food intake. Nutrients. 2012;4(10):1382–98.
46. Xie B, Ishibashi K, Lin C, Peterson DV, Susman EJ. Overweight trajectories and psychosocial adjustment among adolescents. Prev Med. 2013;57:837–43.
47. Rossen LM, Schoendorf KC. Measuring health disparities: trends in racial-ethnic and socioeconomic disparities in obesity among 2- to 18-year old youth in the United States, 2001–2010. Ann Epidemiol. 2012;22:698–704.
48. Schuster MA, Elliott MN, Kanouse DE. Racial and ethnic health disparities among fifth-graders in three cities. N Engl J Med. 2012;367(8):735–45.
49. Hoelscher DM, Kelder SH, Pérez A, et al. Changes in the regional prevalence of child obesity in 4th, 8th, and 11th grade students in Texas from 2000–2002 to 2004–2005. Obesity. 2010;18(7):1360–8.
50. Rendall MS, Weden MM, Fernandes M, Vaynman I. Hispanic and black US children's paths to high adolescent obesity prevalence. Pediatr Obes. 2012;7:423–35.
51. Haynos AF, O'Donohue WT. Universal childhood and adolescent obesity prevention programs: review and critical analysis. Clin Psych Rev. 2012;32(5):383–99.