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Hispanic and black US children's paths to high adolescent obesity prevalence

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Summary

Objective—The study aims to identify the ages contributing most to the development of higher obesity prevalence in the 8th grade (approximately age 14) among Hispanic and black children than among non-Hispanic white children in the United States.

Methods—Using the nationally representative Early Childhood Longitudinal Study (ECLS-K), a sample of 17 420 children in kindergarten in 1999, followed in 1st, 3rd, 5th and 8th grades through 2007, was analysed. First, 'normal', 'overweight' and 'obese' weight-status categories in each grade were assigned from US Centers for Disease Control body mass index percentiles. Second, probabilities of being in each of the three weight-status categories in kindergarten and of transitioning between categories after kindergarten were estimated by logistic regression. These probabilities were then used as parameters of a weight-status trajectory simulation model from which a decomposition analysis was performed.

Results—Obesity prevalence in the 8th grade was equally high among Hispanic (25.0%, 95% confidence interval [CI]: 22.3, 27.8%) and black children (25.1%; 95% CI: 20.9, 29.6%) compared to white children (17.4%; 95% CI: 15.9, 19.0%). As much as 73% of the Hispanic–white 8th grade obesity disparity was generated by 3rd grade and 44% by kindergarten. In contrast, only 15% of the black–white obesity 8th grade disparity was generated by kindergarten, whereas 75% was generated between the 3rd and 8th grades and 53% between the 5th and 8th grades.

Conclusions—Although adolescent obesity is equally prevalent among Hispanic and black children, obesity emerges and is sustained earlier in Hispanic children. Diagnosis and prevention strategies should be designed accordingly.

Keywords

Adolescent; body mass index; health disparities; minority health

Introduction

The prevalence of child obesity in the United States is higher among Hispanic and black than white children (1), and these racial/ethnic disparities have widened with the development of the child-obesity epidemic (2). A strong tracking of childhood obesity into obesity in adulthood among minority children (3,4) and unfavourable links between obesity

and other health problems (5) underscore the importance of reducing minority children's obesity for reducing minority health disadvantages more generally.

Little is known, however, about racial and ethnic differences in the trajectories of childhood weight status (6). One prior national cohort study found that black, but not Hispanic children, were more likely to experience early-onset and later-onset obesity than were white children (7). More prevalent early-onset child obesity among Hispanic than white children, however, is a consistent finding in more recent nationally representative surveys (1,8,9). Other trajectory comparisons by race/ethnicity typically have not used national probability samples (3,10–16) and typically have not considered transitions out of obesity during childhood even though these have been found to be frequent (7,17–19). Previous studies of weight status trajectories have also been limited in the ages analysed (12,15,16,20,21) or have not drawn contrasts between white children and both Hispanic and black children (3,4,9–13, 15,22,23).

The present study uses a nationally representative, prospective sample to analyse differences in weight-status trajectories between black and Hispanic children relative to white children. Transitions between normal, overweight and obese weight statuses are analysed beginning in spring of kindergarten (modal age 6) and extending through to spring of 8th grade (modal age 14). Our goal is to identify the ages at which racial/ethnic differences in transitions into and out of overweight and obesity contribute most to Hispanic–white and black–white disparities in adolescent obesity prevalence.

Methods

Data on Hispanic, non-Hispanic black and non-Hispanic white children were obtained from the Early Childhood Longitudinal Study, Kindergarten 1999 cohort (ECLS-K) (24). The ECLS-K is designed as a nationally representative cohort of US kindergartners in the 1998/1999 school year, followed prospectively in survey waves of between 6 months and 3 years apart through to 8th grade of the 2006/2007 school year. The baseline kindergarten sample was selected using a three-stage probability sampling design. Counties or groups of counties were first sampled as primary sampling units (PSUs), then schools within these PSUs and finally students within schools. The stratified sample design ensures national and regional geographical representativeness, and the dual public and private school sampling frame ensures representativeness by school type. Sample numbers may be reported only to the nearest 10 under ECLS-K conditions of use.

An overall unweighted response rate of 65% was achieved for the baseline (kindergarten) child assessment of 17 420 children (25). The main source of non-response was the non-participation of 26% of sampled schools, leaving 1010 schools participating in the baseline sample. All schools continued to participate in the 1st, 3rd, 5th and 8th grades that constituted the study's follow-up observations, and new schools were recruited to enable children who changed schools to be followed. The ECLS-K followed all children who remained in the same school and all children between the 5th and 8th grades regardless of whether they changed schools. For children who changed schools between kindergarten and 1st grade, 1st grade and 3rd grade, and 3rd grade and 5th grade, approximately 50% were retained by random subsampling. Between 1st and 3rd grades and between 3rd and 5th grades, children from households in which the parents did not speak English as a first language ('Language-Minority' students) were subsampled for retention at higher rates. Approximately half of the Hispanic children in the ECLS-K are classified as Language-Minority.

Child assessments were conducted for 88% of eligible kindergartners, and for 92%, 86%, 93% and 78%, respectively, of eligible 1st, 3rd, 5th and 8th graders, resulting in overall (cumulative) unweighted response rates of 60%, 51%, 48% and 37%, respectively, in 1st, 3rd, 5th and 8th grades. Due both to the random subsampling of children who changed schools and to sample attrition, the analytic sample sizes fell over the course of the follow-up phases of the study from 13 390 Hispanic, black and white children that were observed in both kindergarten and 1st grade, 11 070 observed at both 1st and 3rd grades, down to 7390 that were observed in both the 5th and 8th grades. Only 6550 children were observed in all grades from kindergarten through 8th grade (see Table 1).

Attrition bias was assessed by the data collector and found to be small but nevertheless present by 8th grade (25). We minimize the impact of attrition bias in two ways. First, we apply the ECLS-K's longitudinal sampling weights. These sampling weights adjust both for differential attrition and for the multistage sampling design and sample augmentation in 1st grade. Second, our transition-probability approach allows us to include in the model estimation every child's weight-status trajectory up to the point that the child was last observed. This may be 8th grade, or it may be any previous grade in the cases of attrition or subsampling of children who changed schools.

Race and ethnicity were reported by the parent in response to Census-based categories provided. We used the study's composite race/ethnicity variable from the parent's most recent report of the child's race and ethnicity. We omitted the 50 children for whom race/ethnicity was not reported. A child assessment was conducted at each grade after obtaining parental consent for the child's continued participation in the study. Trained assessors collected two measurements of standing height using a Shorr Board and of weight using a digital scale. Children were measured and weighed in their own clothing, with shoes and heavy items such as jackets removed. The weight and height variables in the ECLS-K are the average of the two measurements taken of height and weight. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Weight status was categorized using US Centers for Disease Control and Prevention (CDC) sex-specific BMI-for-age growth charts as obese (≥95th percentile), overweight (85th and <95th percentiles) or normal (<85th percentile) (26). Comparisons were also made to obesity prevalence at 8th grade measured using the International Obesity Task Force (IOTF) standard (27). Our analyses were determined to be exempt from human subjects review by the RAND Institutional Review Board.

Analysis

A transition-probability decomposition method (28) was used to identify the age pattern by which black and Hispanic children developed a higher prevalence of obesity in 8th grade compared to white children. Compared to the continuous-time latent trajectory modelling methods used in previous child-obesity trajectory studies (7,9), our transition-probability method uses more fully the data from children who attrited from the study before its final wave or who were not observed in one or more wave. Additionally, our transition-probability method allows for quantification of the relative importance of different ages in the trajectory through a subsequent decomposition analysis. Decomposition is a method commonly employed by demographers to apportion the relative contributions of factors to differences in an outcome between two populations (29). It involves the following steps: first, an outcome is expressed as a function of parameters that generate it; second, that function (model) is estimated separately for two population groups being compared on the outcome; and third, the values of parameters in one of the populations are substituted systematically for the values of the parameters in the other population to assess those parameters' contributions to the total difference in outcome value between the two populations. For the transition-probability decomposition employed in the present study, 8th

grade obesity prevalence is the outcome, and the parameters generating the outcome are the distributions of weight-status categories in kindergarten (proportions obese, overweight and normal) and the transition probabilities between these three weight-status categories from kindergarten to 1st grade, 1st grade to 3rd grade, 3rd grade to 5th grade and 5th grade to 8th grade.

Because our study's objective is to identify the ages at which the black–white and Hispanic–white disparities in child obesity prevalence emerge, we group together the parameters into five age-defined sets. These sets are the five vector and matrix terms on the right hand side of:

$$P_{s(8)} = P_{s(k)} \cdot P_{s(k),s(1)} \cdot P_{s(1),s(3)} \cdot P_{s(3),s(5)} \cdot P_{s(5),s(8)} \quad (1)$$

In this equation, weight-status distribution at 8th grade $P_{s(8)}$ is the outcome. It is a 3×1 vector of proportions of children that are, respectively, normal, overweight and obese. It is generated from kindergarten weight-status distribution $P_{s(k)}$ matrix-multiplied sequentially by 3×3 matrices of weight-status transition probabilities $P_{s(t),s(u)}$. The transition probability elements of these matrices are each defined as:

$$P_{s(t),s(u)}(x, y) = \Pr\{s(u)=y | s(t)=x\} \quad (2)$$

where t and u represent consecutive time points of varying interval lengths, and x and y represent an individual's weight-status category at those points. Equation (1) is referred to as a Markov process (30) whose transition intervals are 1 year (kindergarten to 1st grade), 2 years (1st to 3rd and 3rd to 5th grades) and 3 years (5th to 8th grade). Each of the three race/ethnic groups has unique kindergarten weight-status vector $P_{s(k)}$ and transition-probability matrices $P_{s(t),s(u)}$ that generate a weight-status distribution at 8th grade $P_{s(8)}$.

The decomposition procedure begins from the values for the minority group (black or Hispanic) in all the right hand-side terms of Equation (1) and, in five incremental steps, successively substitutes the white children's values of $P_{s(k)}$ and of the four matrices $P_{s(t),s(u)}$. At each step, a new set of values of the 8th grade weight-status distribution $P_{s(8)}$, is simulated. The substitution process is cumulative, such that after the final step in which white 5th grade to 8th grade weight-status transition probabilities are substituted in, the white children's distribution of weight status at 8th grade is generated. In results not reported here, the simulation findings were found to be insensitive to order of substitution. The 'total' difference in the proportion-obese component of $P_{s(8)}$ between the minority group and white children is then decomposed into the five incremental changes (reductions) in proportion obese at 8th grade when first the kindergarten weight-status distributions of white children are substituted in, then transformed into percentages of the difference already existing at kindergarten and percentages generated between each of the consecutively observed grades from kindergarten to 8th grade.

Although the Markov modelling framework allows for any number of weight-status categories, we restricted them to only three (normal, overweight and obese) to ensure that there were sufficient observations of transitions between each pair of weight-status categories at each grade for each race/ethnic group. Estimation of the proportions ('state probabilities') in the vector $P_{s(k)}$, and of the transition probabilities in the matrices $P_{s(t),s(u)}$, is from the observations of weight statuses of the ECLS-K sample children. The estimation was conducted in a series of multinomial logistic regression equations in which the response variable was the three-category weight status and the only predictor variables were indicators for race/ethnicity. For the weight-status transition-probability models, a separate regression was run for each of the normal, overweight and obese origin states (weight

statuses, respectively, at kindergarten, 1st, 3rd and 5th grades). The sizes of the ECLS-K samples for these regressions are shown in Table 1. The regression to predict obesity prevalence in kindergarten uses a sample of all 17 420 with observed height and weight in the spring kindergarten wave. The transition-probability regression models have sample sizes given by the 'Total' row for the particular origin-state column (normal, overweight, obese). This requires observation only in the two waves delimiting the transition. As examples, 8070 1st grade 'normal' weight-status children were observed also in 3rd grade and were therefore used in the regression predicting transitions into overweight and obese weight statuses over that transition interval, and 1480 'obese' children were observed in both kindergarten and 3rd grade and were therefore used in the regression predicting transitions into overweight and normal-weight statuses over that same transition interval. The losses in sample sizes due to attrition and the subsampling of children who changed schools are seen to reduce sample sizes from wave to wave. The 'normal' category is reduced proportionately more than the 'overweight' and 'obese' categories due to the increase in the cohort's proportion overweight and obese with increasing age. The Hispanic samples are reduced less than the black samples due to the higher rate of subsampling retention of Language-Minority children. The smallest samples are those of children observed in every wave (bottom panel of Table 1). These samples are used only for the 'observed' prevalence estimates of Fig. 1, against which the simulated prevalence trajectories are compared. The regressions were performed using the SAS 9.1 PROC SURVEYLOGISTIC command (SAS Institute, Cary, NC, USA), which adjusts the standard errors to account for the ECLS-K's stratified and clustered sample design.

Equation (1) describes a 'first-order' Markov process in which only weight status in the present period (age) influences weight statuses in the next period; weight status before the present period is assumed to have no additional, lingering impact on the weight status in the next period. Statistical tests were conducted for ('second-order') dependence additionally on weight status two periods before, by including those weight statuses as additional regressors in the multinomial logits for 3rd grade, 5th grade and 8th grade weight-status transitions. These tests failed to reject the first-order Markov model specification (results not shown).

All simulations of Equation (1) to generate obesity proportions in 8th grade were conducted in Stata version 10.0 (StataCorp, College Station, TX, USA). Confidence intervals (CIs) about these proportions were estimated by using Stata's bootstrap function to generate 2000 replications of the entire regression estimation and Markov simulation routine. For each race/ethnic group, we also output the simulated proportions obese at kindergarten, 1st grade, 3rd grade, 5th grade and 8th grade, and their bootstrapped CIs. These simulated proportions obese were compared to the observed trajectory of proportions obese for the subsets of the ECLS-K samples of white, black and Hispanic children whose weight statuses were observed at all study waves from kindergarten through 8th grade.

Results

In Fig. 1, the trajectories of proportions obese by race/ethnicity are presented both for the sample of children observed at all study waves from kindergarten through 8th grade and as simulated in the Markov model of Equation (1). Observed obesity prevalence was 16.2% for non-Hispanic white 8th graders, 24.8% for Hispanic 8th graders and 24.6% for black 8th graders. Using the multi-country IOTF standard (27), observed 8th grade obesity prevalence was lower but in a similar pattern of race/ethnic contrasts: 12.6% of white 8th graders, 19.7% of Hispanic 8th graders, and 22.4% of black 8th graders were classified as obese (results not shown). All results described below use the US CDC standard, and refer to the simulated series unless otherwise noted. Similar patterns are seen between the simulated and the observed series estimated for those children observed in all grades from kindergarten

through 8th grade, and each group's simulated obesity prevalence CI includes the observed obesity prevalence at each grade. There are greater fluctuations, however, in the observed series. Because of the specification of the weight-status trajectory as a first-order Markov model, and because the transition-probability parameters of the model are estimated by a fully non-parametric (saturated) regression model, the greater smoothness of the simulated series is entirely due to the larger sample sizes available to estimate individual transition probabilities than are available on individuals with complete observation through 8th grade.

Simulated obesity prevalence in 8th grade was 17.4% (95% CI: 15.9, 19.0%) for white children, but as high as 25.0% (95% CI: 22.3, 27.8%) for Hispanic children, and 25.1% (95% CI: 20.9, 29.6%) for black children. The magnitudes of the obesity prevalence disparities to be explained are therefore 7.6% (25.0% minus 17.4%) for Hispanic vs. white children and 7.7% (25.1% minus 17.4%) for black vs. white children.

For non-Hispanic whites, the greatest growth in obesity prevalence occurs between 1st grade (11.3%; 95% CI: 10.6, 12.1%) and 3rd grade (16.4%; 95% CI: 15.5, 17.4%). A similarly strong growth in obesity prevalence between 1st and 3rd grades is seen for Hispanic children, but from a 1st grade level (17.5%; 95% CI: 16.0, 19.1%) much higher than for non-Hispanic white children. Growth in obesity prevalence between 1st and 3rd grades is less marked among black children. For black children alone, obesity prevalence continues to grow between the 5th and 8th grades, albeit more slowly than between previous grades.

These differences in trajectories are quantified through sets of counterfactual simulations of Hispanic and black obesity prevalence in 8th grade (Fig. 2). The percentage contributions of each grade interval to the obesity prevalence disparities in 8th grade are shown in Table 2. In the 'Kindergarten' simulation (second bar in Fig. 2), the 8th grade Hispanic children's obesity prevalence drops appreciably to 21.7% (95% CI: 19.3, 24.2%). This implies that differences in weight statuses in kindergarten explain almost half (43.7%) of the total Hispanic-white disparity in obesity prevalence at 8th grade (Table 2). A further 12.4% of the total disparity is attributable to Hispanic children's weight-status transition probabilities between kindergarten and 1st grade, and 16.5% to their weight-status transition probabilities between 1st and 3rd grades. Therefore, almost three quarters (72.6%) of Hispanic children's higher obesity prevalence in 8th grade emerges by 3rd grade.

Black 8th graders' higher obesity prevalence than white 8th graders is seen to be due less to differences in early childhood than to differences in their middle-childhood and adolescent weight-status transitions. Their obesity prevalence in 8th grade is reduced relatively little in the simulations that respectively substitute white children's kindergarten weight-status distributions, kindergarten to 1st grade weight-status transition probabilities and 1st grade to 3rd grade weight-status transition probabilities. Instead, three quarters (74.7%) of the black-white disparity in obesity prevalence at 8th grade is generated by differences between black and white children's weight-status transition probabilities in the grade intervals from 3rd and 8th grades. More than half (53.4%) is contributed by differences in black and white children's weight-status transition probabilities between 5th and 8th grades. This is seen (Fig. 2 penultimate bar) in the still high simulated 8th grade obesity prevalence among black children even after substituting white probabilities for all but the 5th to 8th grade weight-status transitions (21.5%; 95% CI: 18.4, 24.9%).

Disparities in obesity prevalence may be generated by a greater likelihood of movement into the obese category (either from the normal or overweight category) or by a lesser likelihood of movement out of the obese category, or both. In Table 3, we present odds ratios (ORs) of *upward* weight-status transitions to overweight and obese in periods from kindergarten through 8th grade, together with the ORs of being overweight or obese already in

kindergarten. Hispanic children's odds of being obese in kindergarten were almost twice (OR: 1.84; 95% CI: 1.58, 2.13) those of white children. Black children's odds of being obese in kindergarten were also higher than those of white children (OR: 1.26; 95% CI: 1.07, 1.48). Black kindergartners' odds of being obese, however, were only 0.68 as high (95% CI: 0.57, 0.82) as those of Hispanic kindergartners. Combining the periods between kindergarten and 3rd grade, normal-weight Hispanic kindergartners faced odds of being obese in 3rd grade that were 1.80 (95% CI: 1.28, 2.54) times those for normal-weight white kindergartners. Normal-weight black kindergartners' odds of being overweight (BMI percentile between 85 and 95) in 3rd grade were 1.26 times (95% CI: 1.00, 1.57) greater than for white children.

The relative odds of black children's moving into either an overweight or obese status were especially high after 3rd grade. Normal-weight black 3rd graders faced odds of being obese in 5th grade that were 3.52 times (95% CI: 1.35, 9.19) higher than for normal-weight white 3rd graders. Normal-weight black 3rd graders faced odds of being obese in 8th grade that were 3.67 times (95% CI: 1.94, 6.93) higher than for white 3rd graders, and 2.90 times (95% CI: 1.31, 6.45) higher than for normal-weight Hispanic 3rd graders.

The smaller sample sizes at risk of moving downwards from overweight and obese categories than of moving upwards from the normal category (see again Table 1) reduces statistical power to detect real differences by race/ethnicity in downward weight-status transition probabilities. We found no statistically significant racial/ethnic differences in the probability of making downward weight-status transitions from one observed grade to the next observed grade, and therefore show (Table 4) results only for the kindergarten to 3rd grade and 3rd grade to 8th grade intervals. We also increase statistical power by alternately combining the overweight and obese categories. Overweight-or-obese Hispanic kindergartners were only 0.60 times (95% CI: 0.42, 0.86) as likely to move back to a normal-weight status by 3rd grade as were overweight-or-obese white kindergartners. Additionally, overweight-or-obese black kindergartners were 1.51 times (95% CI: 1.04, 2.19) more likely than overweight-or-obese Hispanic kindergartners to move back to a normal-weight status by 3rd grade. Both Hispanic and black overweight-or-obese 3rd graders faced odds of moving back to normal-weight statuses by 8th grade that were only half the odds for overweight-or-obese white 3rd graders (OR: 0.40; 95% CI: 0.29, 0.55, and OR: 0.52; 95% CI: 0.33, 0.84, respectively). Similarly, overweight Hispanic and black 3rd graders had much lower odds of moving back to normal-weight status in 8th grade than did white overweight 3rd graders (OR: 0.35; 95% CI: 0.21, 0.58, and OR: 0.49; 95% CI: 0.26, 0.89, respectively). In part, this can be attributed to overweight white children being less overweight, at a median 1.16 BMI points above the 85th percentile threshold, compared to a median 1.38 and 1.30 BMI points above the 85th percentile threshold, respectively, for overweight Hispanic and black 3rd graders (results not shown). White, Hispanic and black children, however, made downward weight-status transitions between 3rd and 8th grades from similar distances above the 85th percentile cut-off: from respectively 0.93, 0.97 and 0.88 median BMI points above that cut-off.

Discussion

The primary contribution of our study is its finding in a nationally representative US cohort sample of distinct trajectories between Hispanic and black children in their development of higher prevalence of obesity at 8th grade than non-Hispanic white children. One in four Hispanic and black children was estimated to be obese in 8th grade, a prevalence level almost 50% higher than that estimated for (non-Hispanic) white 8th graders. Using a novel transition-probability simulation and decomposition method, we estimated that almost half of the 8th grade obesity disparity between Hispanic and white children had already emerged

by kindergarten. In contrast, three quarters of the greater 8th grade obesity of black than white children was estimated to have been generated between 3rd and 8th grades, a period across which black children experienced a continued growth in obesity prevalence while prevalence among white children levelled off. This latter finding reinforces that of a three-city study (12) in which greater BMI growth was seen among adolescent black than white girls after controlling for differences in age at menarche, and further suggests that early adolescence may be a critical period in the development of black children's obesity.

Our finding of an earlier emergence of obesity in Hispanic children is similar in character to that obtained in a previous study (9) that used a different methodology to analyse the same ECLS-K sample that we analysed here. In another previous study that compared children's weight-status trajectories in a national probability sample (the National Longitudinal Study of Youth, NLSY-79), black but not Hispanic children were found to be more likely to experience early-onset and later-onset obesity during childhood than were white children, after controlling for factors expected to influence obesity trajectories (7). That study, however, analysed the offspring of a sample of young adults from the late 1970s, predating the arrival in the United States of the parents of a large fraction of the present study's Hispanic children. Other national studies analysing broader groups of Hispanic children found at least as high or higher early-childhood obesity prevalence among Hispanic than among black children (1,8,9), as did studies comparing prevalence of obesity among Hispanic and black pre-school children in largely low-income urban birth cohorts (31) or participating in publicly funded health and nutrition programmes (32).

A second contribution of our study is its finding of fewer 'downward' transitions from overweight and obese statuses back to normal-weight status among Hispanic children than among either white or black children in early childhood, and fewer downward transitions among Hispanic and black than among white children in later childhood. For example, not only did normal-weight status black 3rd graders face odds of becoming obese in 8th grade that were twice those of white 3rd graders, but also black 3rd graders who were already overweight or obese faced odds of being back in a normal-weight status in 8th grade that were only half the odds for overweight-or-obese white 3rd graders. Previous investigations of racial/ethnic differences in trajectories that allowed for movement out of obesity lacked statistical power to detect such reverse movements (9,13). Small sample sizes of racial/ethnic minorities may also be responsible for other prospective studies' being unable to detect racial/ethnic differences in weight-status trajectories more generally (3,10,11).

Our study nevertheless has important limitations. Firstly, BMI is an imperfect comparative measure of adiposity change due to differences in body composition by race/ethnicity, gender and developmental age (11,33). Although relatively small differences only in body fatness have been found in children and adolescents in obese and non-obese BMI categories (34), higher BMI has been found to correspond less strongly to higher fat composition for black than for Hispanic and non-Hispanic white adolescents (35). Secondly, because we used a non-parametric method with multiple transition intervals between kindergarten and 8th grade, we lacked the statistical power needed to model transitions between finer weight-status categories or to conduct separate analyses of boys and girls. Evidence from previous studies is mixed on the extent and nature of gender differences in levels and trajectories of obesity between racial/ethnic groups (1,8,9,14,36). Thirdly, sample attrition was relatively high. Caution is warranted especially in interpreting the finding of the much greater likelihood of becoming obese for black than white children between 3rd, 5th and 8th grades, as cumulative attrition was at its highest at these grades. Finally, our transition models considered only age, race/ethnicity and previous weight status. Neither diet and physical activity nor their proximate determinants in the family and broader environment were examined.

This study's primary conclusions of an earlier emergence of high obesity prevalence among Hispanic than black children and of a rapid growth in obesity prevalence among black children compared to white children entering their teens provide an additional developmental perspective to the general guidance that child-obesity prevention strategies should take into account race and ethnicity (23,37,38). Given the observation of a cohort at multiple pre-kindergarten ages, future work of this type might additionally investigate which pre-kindergarten ages contribute most to the already much higher Hispanic than white obesity prevalence in kindergarten. More data, moreover, may allow for the contributions of race/ethnic differences in downward weight-status transitions (e.g. from overweight to normal) to be estimated separately from the contributions race/ethnic differences in upward weight-status transitions (e.g. from overweight to obese). Further, as the roles of environmental factors and gene–environment interactions on change in adiposity between specific ages are established quantitatively, the simulation methods of the present study may be elaborated to compare the likely pay-offs of different interventions at different ages for arresting the development of childhood and adolescent obesity especially among disadvantaged racial/ethnic groups. Much work remains to be done to understand these aetiological roles as they apply to the black and Hispanic children of our study. Hispanic children may be more likely to be at risk of early-onset obesity due to higher rates of gestational diabetes (39), and possibly due to feeding practices that encourage children to eat past satiety (40). The prevalence and duration of breastfeeding, however, are also greater for Hispanic than for black children (41), and this should protect against early-onset obesity. Black children have been found to have longer television viewing hours in the school ages than Hispanic children, but also higher rates of active play (42). As these examples suggest, causal factors and potential interventions will often differ according to stage of childhood. Therefore, much may be gained by methods that integrate analysis of determinants at specific ages with the modelling of weight-status changes as a complete trajectory over childhood.

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What is already known about this subject

- The prevalence of child obesity in the U.S. is higher among Hispanic and black than white children.
- Racial/ethnic disparities have widened with the development of the child-obesity epidemic.
- Obese minority children are at greater risk of being obese also as adults.

What this study adds

- By 8th grade, Hispanic and black children are both 50% more likely to be obese than are non-Hispanic white children.
- High obesity emerges more strongly by Kindergarten age among Hispanic children than among black children.
- Overweight and obese Hispanic and black children are less likely to return to normal weight levels than are overweight and obese white children.

Figure 1.

Obesity prevalence of Hispanic, Black and White children, simulated and observed. CI, confidence interval. Source: Authors' calculations from the Early Childhood Longitudinal Study, Kindergarten 1999 cohort (ECLS-K).

Notes: 95% confidence intervals about the simulated prevalence estimates are indicated by the vertical lines extending above and below the bars. They are computed applying the bootstrap method to the source data.

Figure 2.

Hispanic and black children's 8th grade obesity prevalence after successively eliminating their differences from white children's kindergarten weight-status distributions and from white children's subsequent weight-status transition probabilities.

Source: Authors' calculations from the Early Childhood Longitudinal Study, Kindergarten 1999 cohort (ECLS-K).

Notes: All simulations employ a Markov model to estimate the prevalence of obesity in 8th grade (equation 1 in the text). Simulation (1) retains the minority (Hispanic or black) racial/ethnic group's kindergarten weight-status distribution and weight-status transition probabilities, producing their simulated 8th grade obesity prevalence shown in Fig. 1; Simulation (2) substitutes in the kindergarten weight-status distribution of white children; Simulation (3) additionally substitutes in the kindergarten-to-1st grade weight-status transition probabilities of white children; Simulation (4) additionally substitutes in the 1st-to-3rd grade weight-status transition probabilities of white children; Simulation (5) additionally substitutes in the 3rd-to-5th grade weight-status transition probabilities of white children; and Simulation (6) additionally substitutes in the 5th-to-8th grade weight-status transition probabilities of white children, producing white children's simulated 8th grade obesity.

Sample sizes for weight-status probabilities in kindergarten in 1999 and for transition probabilities from kindergarten through 8th grade in 2007

Table 1

Race/Ethnicity	Kindergarten	Kindergarten and 1st grade			
		Weight status at kindergarten			
		Normal	Overweight	Obese	Total
Hispanic	3,450	1,720	420	410	2,550
Black	2,940	1,510	350	250	2,110
White	11,030	6,700	1,190	840	8,730
Total	17,420	9,930	1,960	1,500	13,390

1st and 3rd grades				
Weight status at 1st grade				
Hispanic	1,430	350	390	2,170
Black	1,060	230	270	1,560
White	5,580	940	820	7,340
Total	8,070	1,520	1,480	11,070

Kindergarten and 3rd grades				
Weight status at kindergarten				
Hispanic	1,560	360	380	2,300
Black	1,140	270	210	1,620
White	5,810	1,040	740	7,600
Total	8,510	1,670	1,330	11,520

3rd and 5th grades				
Weight status at 3rd grade				
Hispanic	1,110	360	490	1,950
Black	710	200	250	1,170
White	4,250	960	950	6,160
Total	6,070	1,520	1,690	9,280

5th and 8th grades				
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Race/Ethnicity	Kindergarten	Kindergarten and 1st grade		
		Weight status at kindergarten		
		Normal	Overweight	Obese
Total				
Weight status at 5th grade				
Hispanic		710	290	400
Black		470	150	230
White		3,370	870	900
Total		4,550	1,310	1,530
7,390				
3rd and 8th grades				
Weight status at 3rd grade				
Hispanic		760	240	350
Black		500	130	170
White		3,520	790	780
Total		4,780	1,160	1,300
7,220				
Observed kindergarten, 1st, 3rd, 5th and 8th grades				
Weight status at 3rd grade				
Hispanic		660	210	290
Black		440	120	150
White		3,250	720	710
Total		4,350	1,050	1,150
6,550				

Note: Child weight-status is categorized using the Centers for Disease Control age- and sex-specific body mass index (BMI) percentiles: normal and overweight is <85th BMI percentile; overweight is 85th BMI percentile and <95th BMI percentile; obese is ≥95th BMI percentile.

Source: Authors' calculations from the Early Childhood Longitudinal Study, Kindergarten 1999 cohort (ECLS-K), Spring observation in K, 1st, 3rd, 5th and 8th grades. All samples are rounded to the nearest 10 in conformity with ECLS-K conditions of use.

Table 2

Decomposition results: Percentage of the Hispanic–white and black–white difference in 8th grade obesity prevalence contributed by Hispanic–white and black–white differences in weight-status distributions at kindergarten and in probabilities of weight-status transitions in four subsequent grade intervals

Grade interval	Hispanic-white	Black-white
Kindergarten	43.7	15.3
Kindergarten to 1st grade	12.4	9.5
1st to 3rd grade	16.5	0.6
3rd to 5th grade	14.5	21.3
5th to 8th grade	12.8	53.4
Total	100.0	100.0

Notes: These decomposition results are derived from the simulations presented in Fig. 2.

Source: Authors' calculations from the Early Childhood Longitudinal Study, Kindergarten 1999 cohort.

Table 3

Odds ratios for transitions from normal to overweight weight status and from normal to obese weight status from multinomial logistic regressions by race/ethnicity, 1999 to 2007

Transition type	School grades between which the observations of transition occur				
	Kindergarten (K) *	K to 1st	1st to 3rd	3rd to 5th	5th to 8th
<i>Odds ratio[†] (95% CI)</i>					
Normal to obese					
Hispanic vs. White	<i>1.84</i> (1.58, 2.13)	1.66 (0.99, 2.80)	1.48 (0.97, 2.26)	1.30 (0.51, 3.30)	1.12 (0.46, 2.73)
Black vs. White	<i>1.26</i> (1.07, 1.48)	1.49 (0.89, 2.47)	1.08 (0.65, 1.78)	<i>3.52</i> (1.35, 9.19)	2.59 (0.79, 848)
Black vs. Hispanic	<i>0.68</i> (0.57, 0.82)	0.89 (0.47, 1.71)	0.73 (0.38, 1.38)	2.71 (0.97, 7.57)	2.31 (0.62, 8.66)
Normal to overweight					
Hispanic vs. White	<i>1.31</i> (1.14, 1.50)	<i>1.36</i> (1.07, 1.73)	1.16 (0.93, 1.45)	1.33 (0.93, 1.89)	1.50 (0.99, 2.27)
Black vs. White	<i>1.21</i> (1.04, 1.40)	1.06 (0.79, 1.43)	1.11 (0.88, 1.42)	1.35 (0.98, 1.88)	<i>2.28</i> (1.46, 3.57)
Black vs. Hispanic	0.92 (0.77, 1.09)	0.78 (0.59, 1.04)	0.96 (0.71, 1.30)	1.02 (0.64, 1.62)	1.52 (0.90, 2.58)
Normal to overweight/obese					
Hispanic vs. White	<i>1.53</i> (1.37, 1.71)	<i>1.40</i> 1.10, 1.77)	<i>1.22</i> (1.00, 1.49)	1.33 (0.93, 1.88)	1.45 (0.99, 2.14)
Black vs. White	<i>1.23</i> (1.08, 1.39)	1.12 (0.87, 1.43)	1.11 (0.89, 1.37)	<i>1.58</i> (1.18, 2.11)	<i>2.32</i> (1.54, 3.50)
Black vs. Hispanic	<i>0.80</i> (0.70, 0.92)	0.80 (0.63, 1.02)	0.90 (0.70, 1.17)	1.19 (0.78, 1.81)	1.60 (0.99, 2.58)

* Kindergarten odds ratios are independent of any earlier weight status.

[†] Bold italic odds ratios indicate significantly different from 1.00 with $P < 0.05$.

Source: Authors' calculations from the Early Childhood Longitudinal Study, Kindergarten 1999 cohort (ECLS-K), Spring observation in K, 1st, 3rd, 5th and 8th grades. Sample sizes are given in Table 1's 'normal' column in the 'Total' row corresponding to each pair of grade observations.

Table 4

Odds ratios for weight-status transitions from obese and overweight statuses between kindergarten and 8th grade by race/ethnicity, 1999 to 2007

Transition type	<u>School grades between which the observations of transition occur</u>	
	K to 3rd odds ratio* (95% CI)	3rd to 8th odds ratio* (95% CI)
Obese to normal		
Hispanic vs. White	0.63 (0.26, 1.52)	0.74 (0.36, 1.52)
Black vs. White	0.98 (0.41, 2.30)	0.73 (0.26, 2.11)
Black vs. Hispanic	1.55 (0.49, 4.89)	0.99 (0.34, 2.86)
Overweight to normal		
Hispanic vs. White	0.79 (0.50, 1.25)	0.35 (0.21, 0.58)
Black vs. White	1.05 (0.66, 1.67)	0.49 (0.26, 0.89)
Black vs. Hispanic	1.33 (0.79, 2.24)	1.38 (0.74, 2.59)
Overweight-or-obese to normal		
Hispanic vs. White	0.60 (0.42, 0.86)	0.40 (0.29, 0.55)
Black vs. White	0.91 (0.64, 1.29)	0.52 (0.33, 0.84)
Black vs. Hispanic	1.51 (1.04, 2.19)	1.31 (0.82, 2.09)
Obese to overweight		
Hispanic vs. White	0.98 (0.56, 1.73)	1.06 (0.65, 1.72)
Black vs. White	1.01 (0.54, 1.89)	0.57 (0.26, 1.27)
Black vs. Hispanic	1.03 (0.55, 1.94)	0.54 (0.23, 1.28)
Overweight to obese		
Hispanic vs. White	1.09 (0.80, 1.50)	0.99 (0.55, 1.78)
Black vs. White	1.29 (0.84, 2.00)	1.20 (0.52, 2.76)
Black vs. Hispanic	1.18 (0.72, 1.93)	1.21 (0.48, 3.04)

* Bold italic odds ratios indicate significantly different from 1.00 with $P < 0.05$.

Source: Authors' calculations from the Early Childhood Longitudinal Study, Kindergarten 1999 cohort (ECLS-K), Spring observation in K, 1st, 3rd, 5th and 8th grades. Sample sizes are given in Table 1's 'overweight' or 'obese' columns in the 'Total' row corresponding to the 'Kindergarten and 3rd Grade' and '3rd and 8th Grades' panels.