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School-Level Body Mass Index Shapes Children's Weight Trajectories

Ashley W. Kranjac

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ABSTRACT

BACKGROUND: Embedded within children's weight trajectories are complex environmental contexts that influence obesity risk. As such, the normative environment of body mass index (BMI) within schools may influence children's weight trajectories as they age from Kindergarten to 5th grade.

METHODS: I use 5 waves of the ECLS-K— Kindergarten Class 1998-1999 data and a series of multilevel growth models to examine whether attending schools with higher overall BMI influences children's weight status over time.

RESULTS: Results show that, net of child, family, and school sociodemographic characteristics, children who attend schools with higher rates of obesity have increased weight compared to children who attend schools with lower rates of obesity, and this effect increases annually.

CONCLUSIONS: Findings indicate that the overall weight status of schools influence child obesity, and further speak to the importance of school-based intervention programs.

KEYWORDS: Child & Adolescent Health; School Health Services; Statistics; Community Health

Children's weight trajectories are embedded within complex familial, social, economic, and environmental contexts that influence obesity risk[1-3]. Several recent studies highlight the significance of contextual[4-6] and social[7,8] influences on weight-related behaviors. For example, children who attend schools of higher socioeconomic status (SES) have greater access to healthier lunches[9-12], more extensive physical education programs[13], and limited access to energy-dense foods and sugar-sweetened beverages[14]. And, administrators in higher SES schools generally adhere to healthier school food practices such as providing nutrition education and limiting the availability of competitive snacks and beverages[15].

Relative to children who attend less affluent schools, children in advantaged institutions are also likely to be positively, rather than negatively, influenced by school sociodemographic composition (eg, body size social norms[8,16-18] and health-related behaviors transmitted through social ties[7,19,20]). Similar patterns are observed in predominantly African American, compared to predominantly non-Latino white, schools[3]. And, concentrated school poverty is linked to overweight in adolescents. For example, Martin and colleagues (2012) found that as school poverty increases, the protective effect of parental education on adolescents' risk of being overweight is significantly reduced[6]. Moreover, solid theoretical evidence links the social environment to several child outcomes[21-25].

Despite the known association between the school environment and obesity in children, existing studies generally use school-level proxy measures such as number of lunches eaten at school or school poverty concentration as indicators of the obesogenic environment within a particular school, without considering the school-level body mass index (BMI) context itself as a relevant factor that influences weight-related outcomes. The current study substantially adds to the literature by uncovering whether the school BMI context is another identifiable risk factor associated with child obesity. To do this, I isolate the impact of the BMI context on children's weight trajectories net of relevant child-, family-, and school-level factors to determine whether schools mean BMI affects a child's weight as they age from Kindergarten to 5th grade. I also investigate whether sociodemographic differences in diverse school BMI environments influence children's weight trajectories.

Influences on Child Weight

Social scientists have long described the connection between social conditions and child health outcomes[26-28]. More recently, we are beginning to better understand the links between specific social contexts and school-aged children's weight status[2,3,6,29]. For example, it has been shown that children who attend schools characterized by disadvantage are subject to under-resourced school meal[30] and activity[2] programs, which increases their risk of overweight and obesity. Moreover, children who attend schools in low income areas are more likely to develop negative weight-related norms and behaviors transmitted through social ties[7,19,20].

These (and other) data imply that child sociodemographic characteristics underlie several factors that influence overweight and obesity. For example, a lack of nutritious food and sufficient play space may strengthen the effect of other school-related risks, such as underfunded physical education programs. And given that children in disadvantaged contexts are disproportionately racial/ ethnic minorities, it is not surprising that relative to their non-Latino white counterparts, children of color are at greater risk of obesity[31-34]. The implication of this is that children's social environmental conditions affect overweight and obesity through mechanisms rooted within structural processes of racial/ ethnic and socioeconomic stratification (eg, culturally specific feeding practices and availability of nutritious, affordable food). Two complementary mechanisms have been identified to understand the ways through which this occurs: (1) differential access to resources; and (2) proximal influences within ones social context.

To demonstrate the first point, it has been shown that differences in economic resources among children can lead to a concentration of racially, culturally, and economically homogenous groups of students within schools, which may explain, in part, why differences in obesity exist by school type[2,3,6]. For example, children attending schools in disadvantaged areas are more likely to endure greater lifetime chronic stress exposure, which increases the risk of overweight and obesity[35]. One chronic stressor is characterized by the concept of concentrated disadvantage, which encompasses community-level deprivation including high rates of poverty, substandard schooling, and high crime rates, to name a few. Concentrated disadvantage also reduces feelings of collective efficacy or social cohesion, which is known to have a protective effect on overweight and obesity through the promotion of health-related behaviors[36]. Area deprivation is also highly segregated. This segregation tends to create concentrated areas of impoverished racial/ ethnic minority children in under-resourced schools, which impacts access to appropriate preventative measures[36] such as nutrition and physical education among children who are already at higher risk of overweight and obesity.

Regarding the second point on social context, because children within a school tend to share specific social characteristics such as parent income-level and educational attainment[25] this in turn may influence overweight and obesity through the production of spatial disparities in obesity prevalence. The internalization of norms and attitudes present within the school context might then serve to inhibit or increase obesity risk. For example, the concentration of children within a school who are overweight or obese may lead to an overarching normative acceptance of increased weight as collective attitudes toward obesity are focused more on living with it than on preventing it. In other contexts, obesity prevalence may serve to increase awareness and encourage preventative measures.

It is likely that a symbiotic relationship between these distal and proximal factors interdependently influence obesity outcomes. Certainly, children's daily exposure to multiple activity spaces (eg, home, extracurricular activities, and after-school programs) coupled with interaction with a culturally diverse set of classmates may uniquely contribute to obesity risk[37-39]. However, in the present analysis I focus only on the child- and school-level effects. Nonetheless, addressing how the school BMI environment influences children's weight status over time uncovers a critical omission in the literature and provides a substantial jumping off point for future researchers interested in other contexts, such as neighborhood-level investigations.

School Environmental Influences on Child Weight

Children's weight trajectories encompass not only family involvement and relevant biological constraints such as genetic predisposition, but also causally distal influences within one's social context including school poverty concentration or school cultural norms. Accordingly, behaviors are driven, in part, by broad contextual factors typically outside of children's immediate control (eg, school-level racial/ ethnic composition) that inform children's health-related behaviors including dietary practices, and ultimately, contribute to the consequences of those behaviors (eg, obesity[40-42]). The internalization of these context-specific social norms motivates certain modes of thinking and behaving[43] that in turn may influence weight-related behaviors such as negative weight evaluations from classmates that may lead to distorted weight perceptions, and may thus motivate changes in dietary practices. Given this, I aim to separate school effects from family effects and quantify the extent to which an observed difference in obesity is a consequence of the school BMI environment (ie, do children weigh more (or less) because of the school they attend).

The current study is the first to investigate the aggregated school BMI context as a potential contributor to child obesity risk. The concept of the aggregated school BMI context represents the overall school-level BMI environment that is a consequence of weight-related attitudes and behaviors for children in that particular school (ie, lower versus higher overall BMI). A better understanding of shared environmental factors that influence weight-related outcomes in children is important in order to implement more effective intervention programs that combat child obesity.

Factors Affecting Child Obesity

I control for a variety of factors known to be associated with child obesity. These factors generally fall into three interrelated areas: child demographic characteristics (age, sex, race/ ethnicity), family characteristics (family structure, parental education and income), and school characteristics (school location, socioeconomic and racial composition).

Child-level Factors

Several demographic characteristics influence child obesity risk. For example, Long et al. (2011) found that advancing age is the single largest predictor of obesity in children[48]. Furthermore, girls (compared to boys) are at increased obesity risk[49-51], with the highest occurrence among African American girls[52]. And, race/ ethnicity is a highly influential factor in child and adolescent obesity, with Hispanic boys at the highest risk[53].

Family-level Factors

During infancy and early childhood, the family and home environment heavily inform health-related behaviors and shape weight-related outcomes[54-56]. Parental SES, comprised of educational attainment and income, influences children's obesity risk, with lower levels of parental education[57] and income[58-62] associated with increased risk. Studies further indicate that a strong positive relationship exists between single-parent households and excess weight in children, particularly in female-headed, African American households[63]. Family structure is included in the analysis, given the strong positive association between single-parent households and excess weight in children[64].

School-level Factors

Distinct sociocultural environments within the school context, such as social influences (eg, classmates' and teachers' dietary/ exercise habits) and broader cultural and environmental characteristics (eg, culturally specific dietary practices, walkability of the school and neighboring community), surround children's weight-related outcomes. It is well documented that children who live in lower socioeconomic conditions have higher rates of obesity (see 52, for review), and Rundle and colleagues (2012) show that the school sociodemographic composition is significantly associated with obesity risk[65]. For example, concentrated school poverty is associated with overweight in adolescents, and, as school poverty increases, the protective effect of parents' education on overweight risk is reduced[6]. Children who participate in food assistance programs at their school[66] and those who consume more meals at school[2] are also at a higher risk of obesity. A wealth of data further indicate that school racial composition influences child obesity risk[3]. Specifically, children who attend schools with a higher concentration of non-white students are at the highest risk[67]. Taken together, racial composition, school location, and socioeconomic conditions are important factors to consider when examining children's weight-related outcomes within the school context.

METHODS

Participants

I use data from the Early Childhood Longitudinal Study—Kindergarten Class 1998-1999, a nationally representative study of kindergartners. The study followed the same children from kindergarten through 8th grade (1998, 1999 – 2007), and contains multiple components including interviews with children in their schools, information collected from parents over the telephone, and teacher/ school administrator completed questionnaires. For a more detailed description of the ECLS-K study design, see 68. The sample size for the entire study was 21,260 children. I use the first 5 waves of data, and include children from kindergarten through 5th grade who have school identification data. I exclude schools with less than 5 children to minimize potential bias[69], producing a sample size of 14,375 children in 867 schools, with an average of 20.91 children per school (SD =2.45).

Inclusion Criteria

I estimate obesity trajectories using maximum-likelihood methods (MLM) that rely on data from children with one or more years of non-missing values to maximize statistical power. The MLM estimation method assumes data are missing at random (MAR), wherein conditional on the covariates missingness is random. This approach maximizes the statistical power for differentiating between BMI trajectories of children with missing data on the outcome for any assessment period. The estimates presented here are statistically similar to findings from analyses where I handled data using listwise deletion, indicating that estimates are robust across different missing data specifications. I include only five of the seven waves of data and exclude children who changed schools (N = 1,029), as data are unavailable for non-sampled schools, and

I, therefore, cannot control for potentially confounding school-level factors. This strategy also isolates the effects of child's weight status when s/ he attend a school in diverse BMI contexts.

Procedure

Of primary interest is the change in children's BMI trajectories over time as a function of the BMI context of the school environment. As such, the key outcome is age- and sex- specific BMI *z*-scores (ie, the number of standard deviation (SD) units that the child's BMI deviates from the age- and sex- normed mean reference value, based on the 2000 Center for Disease Control (CDC) Growth Charts: United States)[70,71]. As shown in Table 1, the average overall BMI is 0.51 SDs above the national reference. However, the majority of children fall at or below the 67th percentile, or in the "Healthy Weight" category.

Time-level Variables

Time is represented by the child's age at each assessment period (Table 1). Time 1 (T1), the fall semester of kindergarten, is considered the baseline. The average BMI z-score increases over the study period, from 0.49 SDs above the mean in the first wave to 0.67 SDs in the 5th wave. At the kindergarten assessment, the average child was 5.70 years old. In the last wave of data (5th grade), the average child was 11.04 years old.

[Table 1 about here]

Child and Family-level Variables

The control variables at the child-level include sex, race, parental education and income, and family structure. Sex is a dichotomous variable, with *Boy* as the reference. Race is a categorical indicator variable and is categorized as *Non-Hispanic White, Black, Hispanic, Asian*, and *Other Race*, with *Non-Hispanic White* as the reference. Parent's education level is an indicator variable representing the highest level of education attained by either parent at any assessment period, and is classified as *No High School Completed*, *High School Graduate*, *Attended Some College*, *College Degree Holder,* and *Advanced Degree Holder*, with *No High School Completed* as the reference category. *Parent's Income* is a continuous measure and represents household income at the baseline assessment period. Income is treated as time invariant due to the relatively short time period between kindergarten and 5th grade[68]. Family structure is a categorical measure representing the child's parent-identified family structure at the first assessment period, and is categorized as households with *One Parent* and *Two Parents*, with *Two Parent Household* as the reference, and step and cohabitating families treated as two parent households. As shown in Table 2, the sample size by key subgroups is as follows: Race: *White*= 8,416 (55%); *Black*= 1,848 (15%); *Hispanic*= 2,622 (18%); *Asian*= 863 (7%); *Other*= 826 (5%). Overall, the average child lived in a two-parent household, except among African American children, wherein 43% lived in two-parent households. To isolate the influence of the school BMI environment explicitly, I treat child- and family-level characteristics as time invariant.

[Table 2 about here]

School-level Variables

ECLS-K staff assessed children's height and weight during each assessment period. School BMI is the average BMI of sample children from the school, averaged across all children in the school and across all assessment periods used in the present study, kindergarten through 5th grade. Based on CDC Growth Charts: United States[70,71], I created age- and sex-specific categorical variables based on BMI (weight [kg/height [m]^2) to determine the proportion of overweight and obese children in a given school, and classified schools as largely underweight, normal weight, overweight, or obese. To examine nonlinear effects and to create an even sample size in each category, schools were then grouped into tertiles based on school-level BMI and categorized as low (Type I), moderate (Type II), and high (Type III) levels of obesity, with Type I as the reference (see Table 3).

The key covariates at the school level include geographic location, percentage of children eligible for free/ reduced lunch, and racial composition. Geographic location is a categorical indicator variable and is categorized as *Rural, Urban,* and *Suburban*, with *Rural* as the reference. Percentage of children eligible for free/ reduced lunch is a continuous measure. Racial composition was aggregated from the student values and is a categorical measure defined as the percentage of *Non-Hispanic White*, *Black*, *Hispanic*, *Asian*, or *Other* race children enrolled in the school.

[Table 3 about here]

Data Analysis

The effect of child/ family characteristics and school BMI on children's BMI z-score trajectories was estimated using multilevel growth curve modeling techniques[69]. The models estimate how BMI trajectories for children in diverse school BMI environments change as a function of sex, race, parental education and income, and family structure. With these models, it is possible to determine if there is increased/ decreased disparity in boy-girl, White-African American-Hispanic-Asian-Other race, higher-lower parental education and income levels, and one-two parent family structures resulting from the school-level BMI environment. The estimated coefficients for child and family characteristics in these models reveal the change in BMI z-scores for children who attend schools of varying BMI environments. All models were estimated using sampling weights provided by ECLS-K to adjust for the unequal probabilities of selection for children in the sample. In the following models, time points are nested within children, and children are nested within schools. Results presented are statistically and substantively similar to findings when I used baseline BMI environment or all-waves-combined BMI environment.

Exploratory analyses indicated that children's BMI is most appropriately captured by a linear growth function. Consequently, I only present estimates from linear growth models. Individual growth trajectories comprise the Level-1 model; the variation in growth parameters among children within a school is captured in the Level-2 model; and, the variation among schools is represented in the Level-3 model. Model 1 is an unconditional means model:

Level 1
$$\text{BMI z} - \text{score}_{tij} = \pi_{0ij} + \varepsilon_{tij}$$

Level 2
$$\pi_{0ij} = \beta_{00j} + r_{0ij}$$

Level 3
$$\beta_{00j} = \gamma_{000} + u_{00j}$$

where π_{0ij} is the mean BMI z- score for wave 1 of student i in school j, and ε_{tij} is the random "time effect", the deviation at time t of child i in school j's score from the mean; these effects are assumed to be normally distributed with a mean of 0 and a variance σ^2. β_{00j} is the mean BMI in school j, and r_{0ij} is a random "student effect", the deviation of child i in school j's mean from the school mean; these effects are assumed normally distributed with a mean of 0 and a variance ι_{π}, γ_{000} is the mean BMI among schools (ie, grand mean). u_{00j} is a random "school effect", the deviation of school k's mean from the grand mean; these effects are assumed normally distributed with a mean of 0 and variances ε_{tij} , r_{0ij} , u_{00j}. I present the results from 5 increasingly saturated models, wherein I add covariates to the preceding model. All analyses were conducted using HLM 7 software[72].

RESULTS

Model 1. Unconditional Means in BMI

The estimated average BMI z-score is 0.53 SDs (Standard Deviations) above the national age- and sex-normed mean for all children (see Table 4). Random effects indicate that children differ in their average BMI, and there is more variation between-children (0.62) than within-children (0.28) or between-schools (0.04). Results indicate that children's BMI tends to vary most between-children within schools rather than within-children over time or between-schools. Fourteen percent of variance is within children, 87% of the variance is between children within schools, and 4% lies between schools.

Model 2. Unconditional Growth in BMI

The average rate of change per year is 0.05 SDs. There is evidence of a relationship between age and BMI ($p < .001$). Of more substantive interest is the decomposition of the variance. The variance of the error (0.22) indicates significant unexplained variation at Level-1. There is significant variation among children in initial BMI z-scores (intercept; 0.64) and rate of change (slope; 0.01) within schools for initial BMI z-scores and for BMI z-scores rates of change. This also tells us there is significant variation between schools in mean initial BMI and in mean BMI rate of change (0.04, 0.01). These results indicate significant variation among children and schools in mean BMI z-scores in kindergarten, as well as in the rates of change over time.

Model 3. Effects of Child and Family Characteristics

Everything held constant, at the first assessment period, Fall/ Spring of kindergarten, Hispanic children have higher BMI z-scores (0.11 SDs, SE = 0.03, $p < .001$) compared to White children. Girls (SE = 0.02, $p < .001$) and Asian children (SE = 0.02, $p < .001$) begin kindergarten with lower BMI z-scores, -0.08 and -0.17 SDs, respectively, relative to boys and White children. Girls (0.05 SDs, SE = 0.01, $p < .001$) and African American children (0.02 SDs, SE = 0.01 p = .04) have higher annual BMI z-score increases, relative to boys and White children, respectively. Children whose parents have earned a college degree (-0.07 SDs, SE = 0.03, $p < .001$) or earn a higher income start out with lower BMI z-scores (-0.0000005 SDs, $p < .001$) and increase less per year (-0.000002 SDs, $p < .001$), compared to children whose parents dropped out of high school and earn less income, respectively.

Model 4. Effects of Individual Characteristics on School-level Body Mass Index

Net of child- and family-level covariates, at the start of kindergarten, the initial gap in BMI is 0.24 SDs higher for children in Type II schools ($p < .001$) and 0.43 SD units for children in Type III schools ($p < .001$), relative to children who attend Type I schools. In other words, children who attend schools with higher rates of obesity have greater weight at baseline compared to children in schools with lower rates of obesity. Children's BMI z-scores are higher over time if they attend Type III schools (0.03 SDs, $p < .001$), compared to children who attend Type I schools. Child- and family-level results are consistent with Model 3.

Model 5. Effects of School-level Characteristics

Racial and ethnic minorities (ie, African American and Hispanic children), those whose parents have less educational attainment, and children whose parents earn less income, start out with higher BMI z-scores at the first assessment period and have higher annual SD units, relative to their counterparts. Results are consistent with Models 3 and 4. I found no statistically significant differences in initial school BMI z-scores or rate of SD unit change and school geographic location, racial composition, or in the proportion of children who receive free/

reduced lunch. However, the White/ Asian gap in initial school BMI z-score is greater in schools with higher percentages of Asians (0.19 SDs, SE = 0.05, p = .01).

At the start of kindergarten, the initial gap in BMI is 0.25 SD units above the mean for children in Type II ($p < .001$) and 0.43 SDs points for children in Type III schools ($p < .001$). In other words, net of child-, family-, and school-level factors, children who attend schools of higher overall BMI start out weighing more compared to children who attend Type I schools. Importantly, as shown in Figure 1, the age slopes are steeper for children in schools with higher average BMI scores. That is, children's BMI z-scores increase faster if they attend Type III (0.02 SDs, SE = .01, $p < .001$) schools, compared to children who attend schools classified as Type I. Roughly estimated, this is equivalent to an annual increase of 1.57 pounds more for children in Type III schools, compared to children who attend Type I schools.

[Figure 1 about here]

[Tables 4 and 5 about here]

DISCUSSION

Child obesity is a public health concern both globally and in the United States[73]. Although the etiology of obesity includes genetic determinants, body weight is strongly influenced by complex contextual factors[2,74,75]. Using 5 waves of the ECLS-K data, I employed a series of multilevel growth models with random effects at the time-, child-, and school-level to examine whether attending a school with higher overall BMI influences children's weight status over time. Results show that, net of child, family, and school characteristics, children who attend schools with higher rates of obesity have greater weight compared to children in schools with lower rates of obesity, and this effect increases annually. Results indicate that the spatial clustering of obesity in schools may, in part, be a derivative of area deprivation that concentrates children of disadvantage into particular school catchment areas.

Notably, I also show that if a child attends a school of higher overall BMI, s/he gains weight at a faster rate compared to a child who attends a school of lower overall BMI. Jencks and Mayer's seminal review (1990) outline several mechanisms through which this might occur[25]. One underlying mechanism is the social modeling of non-parental role models within children's environment. As it relates to the school context, older classmates or school personnel might set and maintain the standards of "normal weight", and act as gatekeepers to "police" overweight and obesity. Consequently, children often do not judge their weight by only comparing themselves to their friends or peers. Rather, they compare their body to that of their most admired schoolmates and/ or teachers. If a child's role model is of average weight status, the child may then hold a more positive opinion toward being "normal weight". However, children who do not share a similar weight with their classmates may either engage in (eg, engender a desire to participate in more physical activity) or reject (eg, incite increased sedentary behaviors and over consumption) similar dietary and physical activity behaviors. In the latter case, attending a school with higher obesity will not only increase their weight, but may also reduce their effort to lose weight. The relative frequency of "engage" and "reject" responses is contingent on a number of not-well-understood factors[76-78], but is associated with socioeconomic and cultural differences[79,80].

Findings provide evidence that children's weight trajectories are influenced by contextual factors given the faster rate of weight gain when children attend a school of higher overall BMI. However, only 4% of the observed variance lies between schools. This is likely due to the fact that students within a school are relatively heterogeneous, and that children are likely to align themselves with others of similar interests, sociodemographic background, and weight status regardless of the school they attend. That is, schools with the highest rates of obesity also have students who are in the "normal weight" range. Similarly, schools with the lowest obesity rates have overweight and obese students. Consequently, the school BMI composition is only one of the many risk factors that combine with other markers to influence children's obesity risk. Given that the school BMI environment does influence children's weight trajectories between kindergarten and 5th grade, however, the magnitude of this effect is likely to increase in adolescence when peers begin to assume an increasingly important role in influencing weight-related behaviors and attitudes[81]. The implication of this trend is significant because it is known that obese children tend to become obese adults[82-84]. Further, the obesogenic environment within a school may have harmful implications for the community at large, given that obesity has been shown to "spread" through social networks[7]. It is also likely, however, that the influence is multi-directional and induction flows from the neighborhood context to the school environment.

To the best of the author's knowledge, this is the first study to use the school BMI environment to understand change in weight trajectories in a nationally representative sample of children. Although these findings are in line with existing literature, and indicate that contextual mechanisms play a role in children's obesity-related outcomes, this study is not without limitations. The present analysis is constrained by the measures available in the publicly accessible ECLS-K data. For example, the socioeconomic context of the school is represented by several available variables (eg, school location, percentage of children eligible for free or reduced lunch, racial/socioeconomic composition), but other measures, such as proximity to fast-food restaurants and parental weight status, are not available. In addition, only about 21 children, on average, attended the same school. Consequently, power to identify complex relationships between children's BMI and school environment is limited.

Further, children who changed schools were excluded from the analysis in order for the sample to be as homogenous as possible, given that children who transfer schools may differ in key factors related to weight status (eg, children who experience divorce), compared to children who remain in the same school. This methodological limitation may attenuate the findings and reduce generalizability to a portion of elementary school children in the 1998-1999 school years. Also, because an individual child is simultaneously contributing to the school BMI context and is potentially being affected by it, aggregation of school BMI with the inclusion of individual children's BMI in the overall measure may further induce correlation. However, I excluded schools with less than 5 children to minimize potential bias. Indeed, the effect in one direction would need to be much stronger than in the other to cause a problem. As a robustness check, I estimated a single-level interaction regression model that ignored nesting, and I excluded child-level BMI for each child from the overall school average BMI, to provide evidence that the inclusion of school-level BMI in a multilevel model that predicts children's BMI z-scores induces correlation but does not have a meaningful influence on findings. Finally, models are based on school BMI environment at later time points, kindergarten – 5th grade, which potentially affects children's BMI at earlier time points. As a final robustness check, I classified schools into tertiles based on BMI environment *at baseline* to examine whether results changed in a meaningful way, either statistically or substantively. Findings were similar when I used either baseline BMI environment or all-waves-combined BMI environment.

IMPLICATIONS FOR SCHOOL HEALTH

Here, I show that changes in children's weight trajectories differ between schools and over time due, in part, to the BMI environment of schools. In light of these findings, school-based obesity interventions such as the BMI surveillance programs (see 85 for review) that broadly target an overall student population may prove crucial to decreasing child obesity, given the significant influence of the BMI environment itself on children's weight trajectories. These findings tell us that other school initiatives such as the BMI screening programs intended to reduce obesity at the individual level may not be as effective in curbing child obesity since they generally target individual children. Instead, school-level health interventions should focus efforts on the entire population of children in an individual school.

HUMAN SUBJECTS APPROVAL STATEMENT

Approval is not required because this study is based on secondary data analyses from the publicly accessible data set of the Early Childhood Longitudinal Study—Kindergarten Class 1998-1999.

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Table 1: Weighted Means and Standard Errors or Standard Deviations for Child-level Time Varying Characteristics, by Wave

	Overall		Wave 1		Wave 2		Wave 3		Wave 4		Wave 5	
Variable	Mean	SE/ SD	Mean	Std Err.	Mean	Std Err.	Mean	Std Err.	Mean	Std Err.	Mean	Std Err.
Dependent Variable												
BMI *z* score (mean ±SD)	0.51	±0.95	0.49	±0.94	0.46	±0.93	0.47	±0.94	0.62	±0.95	0.67	±0.97
Child-level Characteristics												
Age	7.22	(0.01)	5.70	(0.01)	6.22	(0.01)	7.23	(0.01)	9.11	(0.01)	11.04	(0.01)

Source: Data are for American children enrolled in Kindergarten in 1998-1999 through the 5th grade, ECLS-K.

Table 2: Weighted Means and Standard Errors for Child-Level Time Invariant Characteristics, by Race												
	Overall		White		Black		Hispanic		Asian		Other Race	
Variable	Mean	Std Err.	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.
Child-Level Variables												
Boys	0.51	(0.01)	0.51	(0.01)	0.52	(0.02)	0.50	(0.02)	0.47	(0.03)	0.54	(0.03)
Girls	0.49	(0.01)	0.49	(0.01)	0.48	(0.02)	0.50	(0.02)	0.53	(0.03)	0.46	(0.03)
Family-level Variables												
Parent Income	50,350.00	1,179.02	59,064.00	1,366.01	30,891.00	1,620.52	35,770.00	1,517.60	58,345.00	2,752.30	40,715.00	4,423.97
Parent Education												
High School Dropout	0.11	(0.01)	0.04	(0.01)	0.14	(0.01)	0.28	(0.01)	0.09	(0.01)	0.11	(0.01)
High School Graduate	0.28	(0.01)	0.24	(0.01)	0.38	(0.01)	0.32	(0.01)	0.16	(0.01)	0.30	(0.01)
Some College	0.05	(0.01)	0.05	(0.01)	0.06	(0.01)	0.05	(0.01)	0.05	(0.01)	0.07	(0.01)
College Degree Holder	0.17	(0.01)	0.21	(0.01)	0.10	(0.01)	0.08	(0.01)	0.31	(0.01)	0.13	(0.01)
Advanced Degree Holder	0.12	(0.01)	0.17	(0.01)	0.03	(0.01)	0.04	(0.01)	0.24	(0.01)	0.07	(0.01)
Family Structure												
Two Parent	0.76	(0.01)	0.85	(0.01)	0.43	(0.02)	0.76	(0.01)	0.88	(0.02)	0.70	(0.03)
One Parent	0.24	(0.01)	0.15	(0.01)	0.57	(0.02)	0.24	(0.01)	0.12	(0.02)	0.30	(0.03)
N=	14,575		8,416		1,848		2,622		863		826	

Source: Data are for American children enrolled in Kindergarten in 1998-1999 through the 5th grade, ECLS-K.

Table 3: Unweighted Means and Standard Errors for Time Invariant School-Level Characteristics

	Overall	
	Mean	Std. Dev.
School-Level Variables		
School BMI		
Type I (Low proprtion of students obese)	0.33	(0.47)
Type II (Moderate proportion of students obese)	0.33	(0.47)
Type III (High proprtion of students obese)	0.33	(0.47)
School Location		
Rural	0.19	(0.40)
Urban	0.56	(0.50)
Suburban	0.25	(0.43)
School Composition		
Percent eligible for free/ reduced lunch	0.29	(0.26)
Racial Composition		
Percent White	0.57	(0.36)
Percent Black	0.14	(0.25)
Percent Hispanic	0.18	(0.25)
Percent Asian	0.06	(0.12)
Percent Other	0.06	(0.14)
N=	867	

Source : Data are from the ECLS-K (1998-1999), K-5th grade.

Table 4. Estimated Coefficients for Child-, Family-, and School-level Effects on BMI Z-scores

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Coeff	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**
Fixed Effects										
Intercept, γ000	0.53***	0.01	0.54***	0.01	0.59***	0.02	0.36***	0.02	0.38***	0.02
Child Characteristics										
Girl, γ010					-0.08***	0.02	-0.08***	0.02	-0.07***	0.02
Black, γ020					0.06	0.03	0.05	0.03	0.10*	0.04
Hispanic, γ030					0.11***	0.03	0.10***	0.03	0.10**	0.03
Asian, γ040					-0.17***	0.02	-0.14**	0.02	0.19***	0.05
Other, γ050					-0.06	0.04	-0.06	0.04	-0.07	0.05
Family Characteristics										
One-Parent Household, γ060					0.02	0.02	0.02	0.02	0.03	0.02
High School Graduate, γ070					-0.01	0.02	-0.01	0.02	-0.01	0.02
Some College, γ080					0.02	0.04	0.02	0.04	0.02	0.04
College Degree , γ090					-0.07**	0.03	-0.05	0.03	-0.01	0.03
Advanced Degree, γ010					-0.04	0.03	-0.02	0.03	-0.02	0.03
Parent Income, γ0110					-0.00**	0.01	-0.00***	0.01	-0.00	0.00
School Characteristics										
School-level BMI										
Type II							0.24***	0.02	0.24***	0.02
Type III							0.43***	0.03	0.43***	0.03
Location										
Urban									0.02	0.01
Suburban									0.01	0.00
Socioeconomic Composition										
Percent eligible for free/ reduced lunch									0.03	0.01
Racial Composition										
Percent Black									-0.09	0.02
Percent Hispanic									0.00	0.01
Percent Asian									0.00	0.01
Percent Other									0.02	0.01
Age Slope										
Age, γ100			0.05***	0.00	0.05***	0.01	0.04***	0.01	0.04***	0.01
Child Characteristics										
Girl, γ110					0.05***	0.01	-0.01	0.01	-0.01	0.01
Black, γ120					0.02*	0.01	0.02*	0.01	0.02	0.01
Hispanic, γ130					0.01	0.01	0.01	0.01	0.02*	0.01
Asian γ140					0.02	0.01	0.02	0.01	0.03	0.01
Other, γ150					0.01	0.01	0.01	0.01	0.01	0.01
Family Characteristics										
One-Parent Household , γ160					0.01	0.02	0.01	0.02	0.01	0.02
High School Graduate, γ170					0.02**	0.01	0.02**	0.01	0.02**	0.01
Some College, γ180					0.00	0.01	0.00	0.01	0.00	0.01
College Degree , γ190					-0.01	0.01	-0.01	0.01	-0.01	0.01
Advanced Degree, γ1100					-0.01	0.01	-0.00	0.01	-0.00	0.01
Parent Income, γ1110					-0.00***	0.01	-0.00***	0.01	-0.00***	0.01
School Characteristics										
BMI										
Type II							0.01	0.01	0.01	0.01
Type III							0.03***	0.01	0.02***	0.01
Location										
Urban									0.00	0.01
Suburban									0.00	0.00
Socioeconomic Composition										
Percent eligible for free/ reduced lunch									0.01	0.02
Racial Composition										
Percent Black									-0.01	0.02
Percent Hispanic									-0.01	0.01
Percent Asian									-0.01	0.01
Percent Other									0.02**	0.01

Source: Data are from the ECLS-K (1998-1999), K-5th grade.

*Note: * p <0.05 ** p <0.005 ***p < 0.001.*

Table 5. Estimated Random Effects for Child-, Family-, and School-level Effects on BMI Z-scores

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Coeff	Std. Err.	Coeff	Std. Err.	Coeff	Std. Err.	Coeff	Std. Err.	Coeff	Std. Err.
Random Effects										
Level 1 and Level 2										
ε_{it}	0.28		0.22		0.22		0.22		0.22	
Intercept, r0	0.62***	9,030.00	0.64***	8,059.00	0.63***	8,048.00	0.63***	8,048.00	0.63***	8,048.00
Age, r1	--	--	0.01***	8,059.00	0.01***	8,048.00	0.01***	8,048.00	0.01***	8,048.00
Level 3, u00	0.04***	867.00	0.03***	867.00	0.04***	867.00	0.04***	867.00	0.04***	867.00
Age, u10			0.01***	867.00	0.01***	867.00	0.01***	867.00	0.01***	867.00

Source: Data are from the ECLS-K (1998-1999), K-5th grade.

*Note: * p <0.05 ** p <0.005 ***p < 0.001.*

Figure 1: Children's Predicted BMI Z-score by School BMI Environment and Age