Variation in Obesity Among American Secondary School Students by School and School Characteristics

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Background: Body mass index (BMI) is known to vary by individual characteristics, but little is known about whether BMI varies by school and by school characteristics.

Methods: Nationally representative samples of United States schools and students are used to determine the extent to which BMI and percent of students at or above the 85th percentile of BMI vary by school and by school characteristics. Data from the 1991–2004 Monitoring the Future (MTF) study were analyzed in 2006 and 2007.

Results: A relatively small proportion of variance in BMI lies between schools; intraclass correlations are on the order of 3%. Still, this is sufficient variation to provide very different environments for students attending schools that are low versus high in average BMI. There is some modest variation by school type (public, Catholic private, non-Catholic private); school size (number of students in the sampled grade); region of the country; and population density. There is more variation as a function of school socioeconomic status (SES) and racial/ethnic composition of the school. School SES in particular was negatively associated with BMI levels, even after controlling individual-level SES and racial/ethnic status.

Conclusions: The residual differences in BMI by school suggest that some characteristic of the school and/or community environment—perhaps cultural factors or peer role modeling or differences in school food, beverage, or physical education policies—facilitate obesity in schools with a high concentration of lower socioeconomic students, beyond individual-level factors.

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Introduction

The distribution of obesity among American adolescents is known to vary by important individual factors, including gender and race/ethnicity.[1–4] Little is known, however, about the extent to which obesity varies by school factors, and this represents an important gap for scientific and policy-related purposes. This article focuses on a description of: (1) the extent to which student obesity (measured by body mass index [BMI]) and the percentage of students who are at or above the 85th percentile (that is, overweight or at risk of overweight) vary among American secondary schools, and (2) how BMI and percentage of students at or above the 85th percentile vary by certain key characteristics of the schools. That is, this article describes the extent to which these problems cluster by school and by particular characteristics of the school, thereby providing indications of the potential importance of contextual factors in the school and community.

This study focuses on broad-based school characteristics, including school type (public, Catholic private, non-Catholic private); school size (measured by number of students in the sampled grade); school socioeconomic status (SES, as indicated by average parental education reported by students); and racial/ethnic composition (derived from student self-identification). Two other contextual characteristics that vary between schools (but not within schools) are also considered—the region of the country and the population density of the community in which they are located.

The extent to which obesity varies by school is an important issue because it sets outer limits to how much school-level factors could "explain" variations in individual-level obesity at the point in time at which measurement occurs. The degree of variation among schools could change over time to the extent that independent and/or dependent characteristics such as school policies about cafeteria offerings, vending machines, or required physical education become more or

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less homogeneous. The extent to which obesity varies by school characteristics is of interest primarily in a descriptive sense. Knowing whether obesity clusters by certain school characteristics can serve to focus future attention and resources on understanding the mechanisms by which these characteristics contribute to obesity in young people and to develop interventions that target these characteristics in order to prevent and reduce obesity.

Methods

Fourteen years of data (1991–2004) were examined from 8th-, 10th-, and 12th-grade students who participated in the University of Michigan's Monitoring the Future (MTF) project, sponsored by the National Institute on Drug Abuse. Data analyses were conducted in 2006 and 2007.

Design

The design and methods are summarized briefly below; more detailed descriptions are available elsewhere.[5,6] The study employs a multistage sampling design to obtain nationally representative samples of 8th-, 10th-, and 12th-grade students from the 48 contiguous states. Data have been collected annually from 12th graders since 1975 and from 8th and 10th graders since 1991. The sampling procedures involve three stages: first, geographic regions are selected; second, schools are selected—approximately 420 each year; third, between 42,000 and 49,000 students are sampled each year from within those schools. Schools are invited to participate in the study for a 2-year period, and most do. For each school that declines to participate, a similar school (in terms of size, geographic area, urbanicity, for example) is recruited as a replacement for that "slot." From 1991 to 2004, an average of 55% of the original schools agreed to participate, and either an original school or a replacement school was obtained in 98% of the sample units, or slots. University of Michigan representatives collect the data from the students, who complete a self-administered, machine-readable questionnaire during a normal class period. Student response rates have averaged 90%, 86%, and 84% for 8th, 10th, and 12th graders, respectively, during the study. Absence on the day of data collection was the primary reason that students were missed; it is estimated that fewer than 1.5% of students refused to complete the questionnaire.

Measures: School Characteristics

School characteristics used in this study were: (1) school type (public, Catholic private, non-Catholic private); (2) school size (number of students enrolled in the grade that participated in the MTF survey); (3) race/ethnicity of the student body; (4) average parental education (a proxy for socioeconomic status); (5) region, determined by the geographic region of the country where the school is located (Northeast, North Central, South, and West); and (6) population density, determined by the United States Census Bureau's classification of the area in which the school is located: within a large metropolitan statistical area (MSA), other metropolitan statistical area, or nonmetropolitan statistical area. Two measures—race/ethnicity and parental education—are based on an aggregate measure of the individual answers provided by the students.

Measures: Student Characteristics

Students were characterized by their BMI, racial/ethnic group, and parental education. Students report their height (in feet and inches) and weight (in pounds), using pre-coded close-ended response alternatives. BMI was calculated by dividing weight (in kilograms) by height (in meters) squared. The questions about height and weight (used to calculate BMI) were asked of a random half of the 8th- and 10th-grade students and a random sixth of the 12th-grade students, so the numbers of cases available for analysis are less than the total numbers surveyed. The numbers of available cases are further reduced by missing data, which is somewhat above average because the height and weight questions are located toward the end of the questionnaire. Age- and gender-specific growth curves produced by the Centers for Disease Control and Prevention (CDC) were used to determine whether each student's BMI was greater than or equal to the 85th percentile.[7,8] These growth curves were originally normed on data from several national health examination surveys conducted by the National Center for Health Statistics between 1963 and 1994; more recent data, such as the data analyzed here, show that more than 15% of respondents exceed the 85th percentile because of the considerable increase in BMI in recent decades. Racial/ethnic group for each student was measured by the question: How do you describe yourself? The respondent was instructed to answer only one category. The present analysis distinguishes among African-American; Hispanic (which included answers of Mexican-American or Chicano, Cuban-American, Puerto Rican, and other Latin-American students); and white. All other answers were categorized into an "other" category due to limited sample sizes. Parent education is the average of father's and mother's educational attainment (with one missing data case permitted); this individual-level measure is aggregated to the school level, and schools are categorized into three levels. Educational attainment was coded as follows: 1=completed grade school or less, 2=some high school, 3=completed high school, 4=some college, 5=completed college, 6=graduate or professional school after college.

Analysis

SAS PROC MIXED[9] was used to estimate the percentage of variation in BMI and in the proportion of students who are at or above the 85th percentile that lies between and within schools. SAS PROC SurveyReg was used to estimate the bivariate and multivariate generalized least squares models for BMI, and SAS PROC SurveyLogistic was used to estimate the bivariate and multivariate logistic regressions for the dichotomous measure of above the 85th percentile. Sample weights are assigned to each student to take into account variations in selection probabilities that may have occurred at different stages of sampling.

Results

Table 1 shows mean BMI and the proportion at or above the 85th percentile for each grade for each year

Table 1. Trends from 1991 to 2004 in mean BMI and proportion at or above 85th percentile, by grade level

	8th grade		10th grade		12th grade	
Year	Mean	SE	Mean	SE	Mean	SE
1991	20.60	0.07	21.77	0.08	22.31	0.09
1992	20.83	0.09	21.94	0.08	22.55	0.12
1993	20.83	0.08	21.99	0.07	22.66	0.11
1994	21.04	0.11	22.15	0.08	22.62	0.09
1995	21.17	0.11	22.09	0.07	22.68	0.09
1996	21.12	0.09	22.09	0.08	22.95	0.12
1997	20.89	0.09	22.32	0.09	22.88	0.11
1998	21.10	0.09	22.33	0.09	23.14	0.12
1999	21.18	0.09	22.45	0.07	23.07	0.12
2000	21.27	0.09	22.47	0.09	23.22	0.14
2001	21.33	0.10	22.69	0.10	22.97	0.14
2002	21.31	0.10	22.79	0.09	23.19	0.14
2003	21.36	0.09	22.72	0.08	23.29	0.13
2004	21.38	0.07	22.91	0.09	23.70	0.11
	Proportion	**SE**	**Proportion**	**SE**	**Proportion**	**SE**
1991	0.197	0.009	0.187	0.006	0.143	0.009
1992	0.215	0.009	0.200	0.009	0.171	0.013
1993	0.205	0.008	0.197	0.007	0.189	0.012
1994	0.230	0.010	0.215	0.009	0.178	0.012
1995	0.232	0.010	0.215	0.007	0.185	0.010
1996	0.236	0.008	0.212	0.008	0.194	0.013
1997	0.212	0.009	0.234	0.008	0.197	0.009
1998	0.240	0.008	0.224	0.008	0.218	0.013
1999	0.241	0.008	0.239	0.008	0.215	0.012
2000	0.251	0.009	0.244	0.009	0.239	0.014
2001	0.249	0.009	0.257	0.010	0.208	0.012
2002	0.241	0.008	0.273	0.009	0.233	0.013
2003	0.261	0.008	0.261	0.008	0.223	0.014
2004	0.260	0.007	0.270	0.008	0.246	0.010

SE, standard error.

from 1991 to 2004. There is a clear general upward trend in both measures, as reported in more detail elsewhere.[10] Table 2 provides the percentage of variance, also called the intraclass coefficient (ICC), that is between schools for BMI and for being at or above the 85th percentile, separately for grades 8, 10, and 12 from 1991 to 2004. Calculations were performed separately for each year, then averaged; Table 2 shows minimum, maximum, and averages. Average ICCs were slightly higher for BMI than for being at or above the 85th percentile. The ICC values for individual years on BMI ranged from 1.3% to 6%, averaging 3.0% across all grades and years. There was no ordinal relationship by grade level, the ICCs being larger in 8th and 12th grades than in 10th grade for both BMI and percentage at or above the 85th percentile. Clearly, most of the variation in these measures lies within schools—that is, most schools have nearly the full range of height-by-weight combinations.

Table 2. BMI and percent at or above 85th percentile: Average percent variance (intraclass correlation coefficient) between schools, 1991–2004

	Grade		
	8th	10th	12th
BMI (%)			
Minimum	2.0	1.9	1.3
Maximum	4.5	3.3	6.0
Average	3.0	2.3	3.6
Percent at or above 85th percentile			
Minimum	1.5	1.2	0.7
Maximum	3.8	3.0	6.7
Average	2.6	2.0	3.3
Number of schools per year, average	151	132	136
Number of students per year, average	7234	7263	2193

BMI, body mass index.

The amount of variation that does lie between schools is not trivial. Even with a low ICC, schools show considerable variation. For example, in 8th grade, the 2003 ICC for BMI was 3.0%. In the 10% of schools (weighted by number of students) with the lowest BMIs, the average BMI was 19.76; in the 10% of schools with the highest BMIs, the average BMI was 23.21. This is a difference of 3.45 scale points, or about 75% of a standard deviation (which is 4.56). Thus, even though the ICC is only 3.0%, a student in one of the low-BMI schools is in an environment with a considerably lower average BMI than a student in one of the high-BMI schools. Similarly, the 2003 ICC for being at or above the 85th percentile was 2.9% for 8th grade. In the 10% of these schools (weighted by number of students) with the lowest average proportion of students who were at or above the 85th percentile, the average percent at that level was 10.2%, whereas in the 10% of schools with the highest proportion of students at or above the 85th percentile, the average percent at that level was 43.6%. Again, even though the ICC is relatively low, the school environment in terms of the proportion of students who are overweight or at risk of overweight is quite different (by a factor of about 4) for a student in the low-BMI schools as opposed to a student in the high-BMI schools.

There was no evidence of any systematic trending in ICC values over time in any of the three grades. Thus, in spite of an important increase in BMI that has been occurring in recent years,[10–12] there is no concurrent tendency for schools to become more similar or dissimilar on this dimension.

School Characteristics

The second objective of this study was to provide information on how student BMI and the percentage at or above the 85th percentile vary by selected school characteristics, including school type (public, Catholic private, non-Catholic private); school size (number of students in the sampled grade); school SES (as indicated by an average of parents' education levels, reported by students); racial/ethnic composition (derived from student self-identification); region of the country; and population density.

Table 3 shows the mean BMI and percentage of students at or above the 85th percentile, separately for 8th, 10th, and 12th graders, by various school characteristics. Data for the years 2001 through 2004 are combined to provide a greater number of cases. The columns labeled "Biv" provide for each school characteristic the statistical significance associated with the characteristic in a bivariate model that uses the characteristic by itself, that is, with no other variables predicting to the outcome measure, except for dummy variables indicating year of measurement; asterisks indicate the statistical significance level. The columns labeled "Mult" provide the statistical significance associated with the characteristic in a multivariate model that uses all the school-level variables simultaneously, and dummy variables indicating year of measurement; plus signs indicate the statistical significance level.

Bivariate Results

School type is significantly associated with both BMI and percent at or above the 85th percentile on BMI in all three grades, with the public schools averaging slightly higher on both dimensions than the private schools. The overall standard deviation is about 4.5, so the differences in 8th grade, for example, are on the order of about 14% of a standard deviation.

School size, as measured by the number of students in the grade being surveyed, is marginally significantly ($p<0.05$) associated with BMI and percentage at or above the 85th percentile only for 8th grade, with smaller and larger schools being slightly lower on both measures, compared to mid-sized schools.

School SES, as measured by average parental education at the aggregate level, is very significantly associated with both overweight indicators, with lower SES schools having a distinctly greater proportion of overweight students. The differences are rather impressive, with, for example, low-SES schools averaging 31% of students at or above the 85th percentile, while high-SES schools average 20% in 8th grade. The differences are even larger in 10th and 12th grades.

The racial/ethnic composition of the schools also is significant in terms of BMI and percentage at or above the 85th percentile, with majority African-American and majority Hispanic schools having higher values on both measures in all three grade levels. The differences are particularly strong for 10th graders: 38% of students in majority Hispanic schools and 33% in majority African-American schools are at or above the 85th percentile, compared with 24% of predominantly white schools and 27% of remaining schools. (As noted below, this is more a matter of race/ethnicity as an individual characteristic rather than a school population characteristic.)

Regional differences are strongly significant ($p<0.001$) for both BMI and percentages of students at or above the 85th percentile in 8th grade, with schools in the West being slightly lower than schools in the other regions on both outcome dimensions. Regional differences are slightly significant ($p<0.05$) in the 10th grade, with schools in the South and West being somewhat higher on both measures than schools in the Northeast and North Central regions. Regional differences in 12th grade are not significant.

Variations by population density are significant for both BMI and percentage of students at or above the 85th percentile in 8th grade, with schools in non-MSAs (that is, more rural areas) having a higher percentage of students who are high on both indicators. In this case the same pattern is also evident in both 10th and 12th grades but reaches statistical significance in only the 12th grade.

Multivariate Results

The multivariate analyses shown in Table 3 generally do not differ from these bivariate findings, with the major exception that the school-type variations become nonsignificant. The variable that accounts for virtually all of the reduction of school-type differences to nonsignificance is school SES. Public schools are much more

Table 3. BMI and percent at or above 85th percentile by grade and school characteristics, 2001–2004 (combined)

	Number of cases			Mean BMI									Percent at or above 85th percentile								
				8th grade			10th grade			12th grade			8th grade			10th grade			12th grade		
	8th grade	10th grade	12th grade		Biv	Mult		Biv	Mult		Biv	Mult		Biv	Mult		Biv	Mult		Biv	Mult
School type					***	ns		***	ns		*	ns		***	ns		***	ns		**	ns
Public	24,510	25,019	7037	21.41			22.85			23.36			25.9			27.2			23.2		
Catholic private	1,661	1,429	601	20.74			22.29			22.82			21.3			22.1			18.2		
Non-Cath. private	974	1,070	169	20.79			21.80			22.94			19.6			18.6			14.0		
School size					*	ns		ns	ns		ns	ns		*	ns		ns	ns		ns	ns
<75	6,101	2,857	957	21.24			22.83			23.29			24.3			27.7			23.7		
75-225	9,509	9,993	3213	21.50			22.89			23.44			26.7			26.8			23.5		
>225	11,536	14,668	3637	21.28			22.70			23.20			24.9			26.3			21.5		
SES (parental education)					***	+++		***	+++		***	+++		***	+++		***	+++		***	+++
Low (<3.5)	4,225	5,161	1527	21.97			23.56			23.94			31.4			34.1			28.6		
Medium (3.5-4.2)	14,006	14,085	4137	21.56			22.85			23.36			26.9			27.3			23.4		
High (>4.2)	8,915	8,272	2143	20.73			22.18			22.77			20.2			20.8			16.9		
Majority race/ ethnicity					***	+++		***	+++		***	++		***	+++		***	+++		***	ns
≥66% white	14,777	16,710	4892	21.22			22.56			23.25			24.1			24.5			21.9		
≥ 50% African-American	1,843	1,826	433	22.20			23.56			24.17			32.6			32.7			29.4		
≥50% Hispanic	1,001	1,757	393	22.15			23.98			23.76			33.7			38.1			26.0		
Other racial composition	9,525	7,225	2089	21.30			22.81			23.20			25.0			27.2			22.4		
Region					***	+++		*	ns		ns	ns		***	+++		*	++		ns	ns
Northeast	4,795	5,245	1362	21.28			22.64			23.46			25.5			25.2			22.3		
North Central	7,086	7,569	2080	21.35			22.67			23.24			24.6			25.2			22.4		
South	9,898	9,297	2781	21.63			22.94			23.37			27.7			28.3			23.8		
West	5,366	5,406	1584	20.89			22.80			23.19			21.9			27.1			21.1		
Population density					*	ns		ns	ns		ns	ns		**	++		ns	ns		*	ns
Large MSA	7,591	7,928	2240	21.21			22.62			23.16			24.1			25.7			21.6		
Other MSA	12,749	13,461	3559	21.24			22.81			23.29			24.2			26.6			22.1		
Non-MSA	6,806	6,129	2008	21.70			22.93			23.52			28.9			27.9			24.7		

Note: Bivariate association models use one independent variable at a time, plus year dummy variables; multivariate association models use all independent variables simultaneously, plus year dummy variables.

*$p<0.05$; **$p<0.01$; ***$p<0.001$ (bivariate associations).

$^{+}p<0.05$; $^{++}p<0.01$; $^{+++}p<0.001$ (multivariate associations).

BMI, body mass index; ns, not significant.

likely than private schools to be in the lowest SES category, and when SES is included in the model, the school-type effect becomes nonsignificant at all three grade levels. School size, which has some marginally significant bivariate variation at 8th grade, becomes nonsignificant in the multivariate case; it is nonsignificant in both the bivariate and multivariate cases for 10th- and 12th-grade students.

Additional multivariate analyses (not shown) were conducted in which individual-level SES and race/ethnicity were included as predictors. These two variables are known to be associated with BMI.[2,13] With these two variables added, the racial/ethnic composition of the school was no longer significantly associated with BMI or being at or above the 85th percentile (with the sole exception that the percentage at or above the 85th percentile remained significant at a diminished level for 10th grade), suggesting that individual characteristics, and not differences in school environment associated with race/ethnicity, account for most of the differences observed at the aggregate level. With only minor exceptions, the significances of the other school characteristics were generally unchanged (those that were significant remained significant and those that were not significant remained so). The effect of school SES, though it remained significant with the sole exception of 12th-grade BMI ($p=0.08$), was substantially diminished but not eliminated.

Discussion

Although at present the great majority of the variation in BMI resides within schools, there remains enough variation between schools for school characteristics and school policies and programs to have had important effects on their students' BMI. This is about equally true at all three grade levels included in this study. Although the ICC for BMI is only about 3%, it remains true that schools could have substantially more influence in the future. The figure of 3% reflects the maximum impact that policy differences between schools may have had in the interval from 1991 to 2004. Policies that did not differ by school (e.g., policies that encourage drinking of high-calorie soft drinks) could still be having major effects. If all schools were to adopt policies that encourage good nutritional practices, that also could have major effects (in reducing both BMI and between-school variation in BMI). On the other hand, if there were considerable variation in how schools react to the extensive activity that is occurring at the national, state, and local levels regarding childhood obesity, that could produce more heterogeneity among schools.

A major conclusion from this study is that obesity is quite prevalent today among students in all types of schools, but that schools with a high concentration of students from low-SES households are most likely to have higher proportions of overweight students. Public schools and schools with majority racial/ethnic-minority enrollment have higher average BMI, but this appears to be due mostly to the concentration in those schools of students of lower SES, which is strongly correlated with both BMI and race/ethnicity.[2,14] Most, but not all, of the association between school-level SES is also accounted for by individual-level SES. The residual difference suggests that something about the school environment, perhaps differences in school food and beverage policies or in cultural factors or peer role modeling, facilitates obesity in schools with a higher concentration of lower-SES students, beyond individual-level factors. It is also possible that the single measure used here to indicate SES—the average education level of the parents—does not fully correct for individual SES, and that the aggregate measure for the school in essence improves on the accuracy of the individual-level measure.

Limitations

A limitation of this study is its reliance on self-reports for two key variables: BMI and parent education. However, the literature, as described below, shows that both of these have sufficient validity for the present purposes. With respect to BMI, the values used in this study were calculated from students' self-reported height and weight. A number of studies have investigated the use of self-reports of height and weight, and have generally reported that, although there may be modest biases associated with self-reports, they are certainly adequate for research purposes. Brener et al.[15] obtained both objective and self-reported data on height and weight for over 2000 students in grades 9 through 12, and found that ". . . self-reported values of height, weight, and BMI were highly correlated with their measured values." They also noted that surveillance systems can yield "valuable results by using self-reported height and weight to assess trends in the prevalence of obesity." Goodman et al.[16] analyzed data from over 10,000 respondents in the National Longitudinal Study of Adolescent Health, with both self-reported and objectively measured height and weight. They report that "correlations between measured and self-reported anthropomorphic indices (height and weight) were very strong." They conclude that "findings from other studies that have used self-reported BMI should be considered valid, and future studies can use self-reported data to understand adolescent obesity, its correlates, antecedents, and sequelae." To address the question of possible gender and racial differences in biases, Strauss[17] examined self-report and measured data on height and weight from over 1600 adolescents in the National Health and Nutrition Examination Survey Cycle III. They concluded that the influences of gender and racial biases in reporting of height and weight were relatively small, and that self-reports "were extremely reliable for . . . predicting obesity related morbidities and behaviors."

Although it would clearly be preferable to have a more extensive measure of family SES than students' reports of parent education, the fact is that valid measurement of more extensive indicators is very difficult to obtain in large-scale epidemiologic studies that rely on student reports.[18,19] Parent education is one measure (perhaps the only one in this set) that can be reasonably validly measured. Although there is no direct evidence on the validity of the students' reports of parent education, there are a number of indicators that the measure has reasonable validity. It should be noted that the measure used in the MTF study was based to a considerable extent on our experience in an earlier study called Youth in Transition. In that study, a national sample of young men from the high school class of 1969 was extensively interviewed by professional interviewers. Extensive information was obtained about indicators of family SES, including parental education. Analyses of the various indicators led to the conclusion that student reports of parental education were the best measures that could be obtained in group-administered questionnaires, and that those reports were of acceptable reliability and validity.[20]

Three other factors support the validity of this measure: first, respondents are given an explicit response option of "don't know or does not apply," so those respondents who do not know a parent's education level would be able to say so. Only about 8% failed to provide parent education data. Thus, the great majority appeared comfortable with reporting parent education. Second, this measure has shown trends over time consistent with the (rising) educational level of the adult population in the country and by racial/ethnic groups. Moreover, 8th-grade students reported having parents with higher education than youth in 12th grades, as would be expected given the rising level of education in the adult population. Finally, the measure correlates well in expected directions with (1) students' educational plans, (2) actual college attendance, and (3) several other educational outcomes.

An important limitation of the analyses presented here is that there was no attempt to conduct a full multilevel analysis of all the various factors acting at various levels that affect BMI. Thus, there was no attempt to determine how much between-schools variance in BMI is due strictly to school-related factors as opposed to other factors that vary between schools, including neighborhood factors (including some that are the subject of other articles in this issue) or local- or state-level policies. In effect, the analyses here present descriptive information on how schools vary, and how they vary according to selected school characteristics, but the analyses cannot support causal interpretations of school effects.

Conclusion

Although a fair amount is known about how individual characteristics relate to BMI among adolescents, less is known about the extent to which BMI varies by school and by school characteristics. This study shows that although most variation in BMI lies within schools, there is sufficient between-school variation to be of interest to policymakers. School SES is shown to be of some importance, even after controlling for individual-level SES and race/ethnicity. In sum, the school one attends has implications for one's likelihood of being overweight. This is both good and bad news, but in either case, it suggests that schools can have a direct impact on improving the health of our young people.

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