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Obese Peers' Influence on Students' BMI: Heterogeneity in Race and Sex

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Abstract

Objectives: In this study, we investigate peer influence on obesity, with a focus on race and sex.

Methods: We conducted econometric analysis of longitudinal health data of 277,566 public school students, ages 5–13 years.

Results: A percentage point increase in the proportion of obese students within the same grade increased a student's BMI z-scores by about 4 one-thousandths of a standard deviation. On racial peers, the standard deviation increase in BMI z-score is 3.9 one-thousandths for Hispanics or Caucasians and 4.9 one-thousandths for African Americans. Influence of obese peers is nearly identical for boys and girls.

Conclusions: Such a small magnitude of obese peers' estimate suggests that classroom peers do not play a substantial role in weight gain or loss in elementary schools.

Keywords

childhood obesity; race and health; sex and health; social networks

There is growing evidence that individuals in a network can significantly influence the behavior of one another.¹ If peers influence health behaviors, then policies to encourage healthier choices in food and physical activities by actively engaging peers could yield greater benefits via a social multiplier effect. Peer groups may support and reinforce the

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Conflict of Interest Disclosure Statement

The authors declare that they have no conflict of interest.

Human Subjects Approval Statement

The research reported in this study was approved by the Institutional Review Board, University of Arkansas, Fayetteville, USA under protocols # 10–11-235 and # 14–07-026. The procedures of this study are in accordance with ethical standards for human research.

determination to attain or maintain healthy weight, and also complement various interventions aimed at improving health behaviors.^{2–4} Most of the research on peer effects, however, has focused on substance-abuse and other health behaviors.

Peers may influence obesity outcomes through attitudes and behaviors that can in turn influence choices which play a role on obesity development. Eating habits, for example, are one possible mechanism through which peers influence an individual's food habits.⁵ Another is physical activity. Barkley et al⁶ find that children, in the presence of a friend with access to the same activities, exhibit greater physical activity participation.

The issue of peer influence on obesity received much attention with the publication of a number of studies on peer effects.^{2,7–10} However, all of these have focused on adults or adolescents. Whereas adolescence is a stage when peers may have a large impact, pre-adolescence is a good stage to inculcate healthier lifestyles.¹¹ Interventions targeting environments such as elementary schools, where students are beginning to learn and adopt behaviors related to diet and physical activity, could be especially effective at preventing future occurrences of obesity.

Our study contributes to the literature on peer effects and obesity in several ways. First, this study is among the first few studies to analyze peer influence among elementary school children, an important stage when habits are malleable.^{12,13} Gwozdz et al¹⁴ analyzed peer effects among children ages 2–9 years from 2 selected regions that covers 8 European countries. Nie, Sousa-Poza and He examine peer effects among children in a community, as opposed to within a grade or school, for ages 3–18 years.¹⁵ Second, we control for the commercial food environment around the child's residence and the school using precise geographic data. There is growing evidence that the food environment around schools may affect obesity rates among all students in a grade within a school.^{16–18} This factor has been largely ignored in previous literature on peer effects and obesity. Third, in contrast to several past studies, the BMI data we use are based on height and weight measurements taken by trained personnel, as opposed to being self-reported. This is important because several studies use BMI calculated from self-reported height and weight. Such self-reported measures are prone to measurement errors which can lead to biases in certain empirical specifications such as fixed effects models.¹⁹ Fourth, we specifically examine the role of sex and race on peer influences.

Previous studies of peer effects on obesity focus on the influence of friends' within a network.^{2,7} Whereas the social network plays an important role in behavior, a school setting provides a unique environment where students interact with peers on most weekdays during a school year in a variety of ways that could influence food consumption and physical activity. Hence, we follow the same definition adopted in the education literature, which generally defines peers at a grade-level within a school.²⁰ The student and peers all interact and spend time in the same environment, and a school provides a unique environment where the shared goal is that of academic progress. Peers within a class or grade almost always have common schedules for meals and physical activities. Studying peer effects within a school also has some practical advantages.²¹ Identifying peer groups outside of school can take a great deal of effort, and social networks may not be stable over time. In contrast, peers

within a grade in a school are relatively more stable, and if peer effects are significant and sizeable, such effects should be taken into consideration while designing effective school-level policies and programs targeting childhood obesity related issues.

This study reports change in the BMI z-score of a student in response to a change in the proportion of obese peer students. The peers are defined as all other students in the same grade within a school. One objective of this study is to estimate peer effects in general, and the other is to examine if peer effects vary by race and sex. Shedding more light on the difference in peer-influences by race and sex is especially important because obesity prevalence and rates of obesity increase could vary by racial group and by sex.^{22,23} Differences across race and sex have been reported in other health behaviors.²⁴ Existing literature, Parsons' theory in particular, suggests 2 possible ways that peer influence can differ across race and sex.^{25,26} First, peers' influence on attitudes towards foods could be greater among friends with solidarity. Second, the degree of trust affects a student's vulnerability to influence. Both, solidarity among friends and vulnerability to influences could be more among peers of similar background, including race and sex. Robinson and Higgs²⁷ found liking towards a food among study participants from a college were influenced by information about liking of other group members. Finnerty et al²⁸ observed that peers have a significant effect on physical activity levels among children.

With respect to sex, it has been found that girls are more body image conscious than are boys.²⁹ Interestingly, this has been observed even in elementary school. For example, 2 studies report that body image problems are spilling over to dietary choices as early as third grade.^{30,31} An earlier study had reported that 'girls demonstrated significantly higher levels of body dissatisfaction and lower levels of self-esteem than boys.'²⁹ In general, boys are more physically oriented than girls, and also interact differently with male peers compared to female peers.^{32–35}

Aside from same-grade peers, students could also be influenced by students in other grades in the same school.²³ Asirvatham, Nayga and Thomsen show that the obesity prevalence in the highest grade in an elementary school is strongly associated with obesity rates in the lower grades.²¹ Failing to consider peers from other grades within the same school simultaneously could bias the same-grade peer-effects estimate. We address this by including a variable that represents the proportion of obese students among peers in other grades but within the same school.

Data Source

Our dataset provides BMI outcomes for the population of elementary schoolchildren in Arkansas. Arkansas is an interesting state to study because it has one of the nation's highest childhood obesity rates at 21% and it was the first state to require BMI screenings for public schoolchildren. These screenings began in the 2003–2004 school-year and were required under Act 1220, passed by the Arkansas General Assembly in 2003. Child weight and height data are collected by trained personnel in the public schools according to standard protocols and are then converted to age-sex specific z-scores according to the US Centers for Disease Control and Prevention (CDC) guidelines.³⁶ Arkansas enacted Act 1220 of 2003. Among a

series of community- and school-based interventions, the Act requires each public school student to have his/ her body mass index (BMI). Given the panel data methods used in this study, only those students with at least 2 observations are included in our analysis. Throughout this study, we categorize students into 4 mutually exclusive categories based on CDC reference growth chart – obese, overweight, normal, and underweight.

A second type of data we bring into the analysis reflect the commercial food environment around schools and residences. Historic business lists on the geographic locations food stores were obtained from Dun & Bradstreet. These lists provide geographic coordinates for food stores as they existed during each year represented in the sample. The models we estimate include controls for fast-food restaurants (chain quick-service formats and local non-chain fast-food establishments), sandwich shops and delis, pizzerias, other restaurants (primarily full-service restaurants), supermarkets and grocery stores, and convenience stores. Classification of food stores into these categories was based on company name, trade description, standard industrial classification (SIC) code, and Internet searches for street-view images and restaurant menus. These data were matched geographically to the locations of schools and student residences. Models include the radial distance, in miles, from the child's home to the nearest food store of a given type and density of food stores around schools at one-third, two-thirds and one mile of the school.

The analytic sample consists of 277,566 students between ages 5 and 13 years enrolled in grades K through 6 whose residential addresses could be geocoded. Our empirics are based on a panel dataset covering the years 2004 to 2010. One problem we confronted in assembling the data set is that state policy relating to the frequency of BMI measurement changed during our study period. From 2004 to 2007, the BMI of all school children was measured annually for grades K-12. Thereafter, BMI was measured and reported only for children in even grades through the 10th grade (K, 2, 4, 6, 8 and 10). Thus, we have BMI prevalence rates for all grades from 2004 through 2007, but only for even grades after 2007. The non-reporting of obesity prevalence in odd grades after 2007 should not bias our estimates because the decision to stop measuring the BMI of children in odd-numbered grades was exogenous in that it was not made by the child, the child's family, or the child's school. However, this change in reporting does affect our ability to take into account BMI changes in a consistent fashion over time.

METHODS

The peer effects model in a panel framework estimated is written as follows:

$$Y_{igkt} = \beta_0 + \beta_1 Y_{-igkt} + \beta_2 X_{igkt} + \beta_3 X_{-igkt} + \beta_4 Z_{kt} + \beta_5 Z_{it} + U_{it} \quad (1)$$

where Y_{igkt} is the BMI z-score of the i^{th} student in grade g of school k at time t ; Y_{-igkt} is a vector of peer-student proportions in 3 mutually exclusive weight categories (ie, underweight, overweight and obese). Specifically, these represent the proportions of students other than student i in the same grade g in the same school k at time t ; X_{igkt} is a vector of student i 's characteristics; X_{-igkt} is a vector depicting averages of peer characteristics in

grade g other than student i ; Z_{kt} is a vector of observed factors at school k , which includes the food environment surrounding the school; Z_{it} is the vector of commercial food environment around the residence of student i ; and U_{it} is the error term which equals $\mu_i + \epsilon_{it}$, where μ_i is the unobserved time invariant component and ϵ_{it} is the spherical error term.

Three mutually exclusive weight categories are introduced into the model to test if heavier peers have an increasing effect and if lighter peers have a decreasing effect in a monotone fashion. Even though many elementary schools in Arkansas are large enough to require multiple classrooms for students in single grade, the grade within an elementary school is the ideal level to represent the peer effects. When there are multiple classrooms for the same grade, students still share common recess and lunch times and it is common to group students across home room classes based on ability for subjects like math and reading. Thus, there is ample opportunity for interactions among peers across classrooms within the same grade.

As mentioned in the introductory section, race has both social and economic connotations. We examine how race plays a role in peer effects. Specifically, we examine whether the race of a student makes him or her more affected by the proportion of obese or overweight peers. To answer this question, we interact the proportion of obese students with the race of the i^{th} student. The specification is now,

$$Y_{igkt} = \beta_0 + \beta_1(Y_{-igkt} * D_r) + \beta_2X_{ight} + \beta_3X_{-ight} + \beta_4Z_{kt} + \beta_sZ_{it} + U_{it}. \quad (2)$$

All variables are the same as in equation (1) except that each of the peer proportions under different weight categories (Y_{-igkt}) is now interacted with each of the dummy variables (D_r), subscript 'r' denotes the student's race.

Other than race, peer effects could also vary due to sex composition of obese peers because persons of different sex could view their peers differently. Similar to race, we ask if the sex of a student makes him or her more affected by peers. The specification is similar to equations (2) presented above except that now it is for the 2 sex types instead of race categories. Thus, Y_{-igkt} in equation (2) is now interacted with the student's sex. Even though race and sex do not vary over time, the peer variable varies for each student within a year depending on the composition of race or sex of the rest of the classmates in the same grade within the same school. Thus, the peer variable defined by race or sex does not get dropped off in the fixed effects model.

Some studies have found that students across grade might also influence one another's behavior, especially with regard to diet and physical activity. Leatherdale and Papadakis³⁷ and Asirvatham, Nayga and Thomsen²¹ show evidence of higher graders impacting lower graders within a school. Hence, we also look into alternative specifications that include obesity prevalence rates among students in other grades within the same school. Specifically, we include a variable that indicates student proportions under different weight categories among all students other than the i^{th} student's grade.

The panel nature of the data and the amount of information on students, schools and food environment allow us to control for individual and peer characteristics. Even though we control for several student and peer characteristics, environmental features, and other observables, our analysis may not fully eliminate all potential biases due to the possible presence of unobservable factors that could be correlated with outcomes of peers. Better education of parents, for example, is correlated with lower prevalence of obesity.^{38,39}

To control for time invariant unobservables, we employ fixed effects (FE) models. Table 1 also reports random effects estimates to assess any difference due to the unobserved time invariant factors. To account for stage year-to-year changes in the BMI, we also estimate a 2-way FE model by adding binary variables for each of the years.

RESULTS

Table 1 presents peer effect estimates for different weight proportions and corresponding standard errors clustered at the school-level. All regressions control for student age, race, sex, rural or urban area of residence, participation in school free or reduced-price lunch program, and the food environment around the child's residence. Table 1 includes results from pooled OLS, random effects, one-way FE and 2-way FE without school-level food environment measures, and from a 2-way FE model that includes school-level food environment measures. The school-level food environment is presented in a separate regression because it sheds light on the impact of a characteristic that is shared among all the peers. A comparison across estimates of the different peer-weight categories in Table 1 reveals that the peer effect monotonically increases according to the proportion of peers in increasingly heavier body-weight classifications. That is, the effect of obese peers is significantly higher than that of overweight peers. Given the low prevalence of underweight (ie, about 2% in the sample), we primarily focus on the obese and overweight peers. The prevalence of overweight and obese is similar.

The pooled OLS estimates for the obese category presented in Table 1 suggest a 7 one-thousandths standard deviation increase in BMI z-score in response to a percentage point increase in the proportion of obese peers in the same grade. Interestingly, the random effects estimate is about one-third less than that of the OLS estimate. In the fixed-effects models, the estimate for the obese category drops to less than 5 one-thousandths of a standard deviation. Thus, whereas the effects are statistically significant, the peer effect is small. The similarity between the random effects and fixed effects estimates suggest that the bias resulting from the correlation between individual time invariant factors and the weight of peers is relatively unimportant. Including year dummy variables to the fixed-effects model reduces the magnitude of the estimates. These reductions in magnitude are offset by the inclusion of additional controls for the food environment around schools. Thus, we find some influence of the food environment surrounding schools on an individual student's BMI z-score. However, the impact of the food environment on the peer-effect estimate is not substantial.

The effect of overweight peers is nearly the same as the effect of obese peers, a coefficient of 0.41 as compared to 0.44. In all results that follow, the models include binaries for year and controls for food environment around both the residence and school of the child.

Peer Influence and Race

Table 2 presents the estimates of the peer effect with the obese proportion interacted with the student's own race. These estimates can be used to examine if peer effects vary by the student race. We focus on Caucasians, African Americans, and Hispanics because there are many schools that do not have students of other races. Results from the 2-way fixed effects suggest that African Americans are the most responsive to the body weight of obese or overweight peers followed by Hispanics, and then, Caucasians. Aside from this finding, it is worth pointing out the differences across models by race. The pooled OLS results show that the z-scores of Caucasian students increase by roughly 8 one-thousandths of a standard deviation in response to a percentage point increase in the proportion of obese peers. The magnitude of the FE estimate for Caucasian students is less than half that of the OLS, whereas the FE model estimate is about 15% smaller than the random effects estimate. Peers' effect on Hispanic students follows a similar pattern; that is, the magnitude decreases when the bias resulting from time invariant unobserved is addressed. The estimate for African Americans is different, in that the magnitude varies only marginally across the models. Moreover, the 2-way FE estimates for both African Americans and Hispanics are not statistically different from the OLS estimates. Thus, we do not observe the same significant correlation between the unobserved factors and the peer effect for these 2 racial categories compared to the Caucasian category.

Peer Influence and Sex

Table 3 presents peer effect estimates obtained by interacting the student's own sex with the proportion of students under the different weight categories, and is a sex analog to the results by race presented in Table 2. Pooled OLS estimates indicate that a percentage point increase in the proportion of obese girls and boys is associated with 6.5 and 7.5 one-thousandths of a standard deviation increase, respectively, in a student's BMI z-score. The 2-way fixed-effects' estimates, however, are nearly identical across sex. A similar lack of a meaningful difference between boys and girls is observed in the overweight and underweight category as well.

Placebo Test

In this subsection, we test the validity of the peereffects estimate by testing if there is an influence of peers from a neighboring school. To test this, we substitute the proportion of obese peers in the original specification (ie, equation 1) with the proportion of obese students' from the nearest school but from the same grade. We do this for all weight categories, and run 2 modified specifications. The first uses proportions from the nearest school that has the same grade composition. For example, if the student in question is from a K-4 school, the proportions will be taken from the nearest K-4 school. The second specification uses proportions from the nearest school with the same grade regardless of what other grades are offered in that school.

Table 4 shows that models controlling for individual student fixed effects show no effect of peers from neighboring schools in either of these specifications. Thus, we can assert that the peer effects observed in this study are valid.

DISCUSSION

We conducted this study to analyze peer effects among elementary students in public schools, and further examine if peer influence varies by race and sex. We find evidence that peer effects differed by race but not sex. In general, our results indicate that a percentage point increase in the proportion of obese students within the same grade increased the student's BMI z-scores by just over 4 one-thousandths of a standard deviation. On racial peers, the standard deviation increase in BMI z-score is in the order of 3.9 one-thousandths if the student was Hispanic or Caucasian and 4.9 one-thousandths if the student was an African American. The effect of obese peers is nearly identical for boys and girls. It's important to note that this study did not administer different treatments across peer groups. Studies have found that students respond differently to treatment based on their sex.⁴⁰

We addressed several of the biases that typically plague peer-effect studies by using different estimation methods, including student fixed effects to estimate the impact of peer effects. We find that peer effects are robust to alternative specifications, and that these effects differ by race but not sex. Using a falsification test, we also show that the peer effects exist only within schools, and thus, occur due to interactions among classmates.

IMPLICATIONS FOR HEALTH BEHAVIOR OR POLICY

Our findings generally suggest that peer effects in obesity among classroom peers, although statistically significant, are of little economic or practical significance in elementary schools. Thus, these findings provide little evidence that the weight status of same-grade peers plays a meaningful role within a school setting. We acknowledge, however, that peer effects may be important in health-related behaviors, some of which may impact body weight. Similarly, there is evidence that peer effects could be important in the context of a childhood obesity intervention.⁴⁰

There are 2 notable limitations of the data used for this study. First, we did not have data on children's actual networks and social networks that influence childhood obesity could extend beyond the school environment. Social networks outside of the school could not be addressed with our data. Second, it was only possible to identify children to the grade level but not classrooms within a grade. Social interactions may be stronger among children who interact in the same classrooms in comparison to children who are in the same school in the same grade.

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References

1. Cunningham SA, Vaquera E, Maturro CC, Narayan KMV. Is there evidence that friends influence body weight? A systematic review of empirical research. *Soc Sci Med*. 2012;75(7):1175–1183. [PubMed: 22749656]
2. Christakis NA, Fowler JH. The spread of obesity in a large social network over 32 years. *N Engl J Med*. 2007;357(4):370–379. [PubMed: 17652652]
3. Halliday TJ, Kwak S. Weight gain in adolescents and their peers. *Econ Hum Biol*. 2009;7(2):181–190. [PubMed: 19497795]
4. Carrell SE, Hoekstra M, West JE. Is poor fitness contagious? Evidence from randomly assigned friends. *J Public Econ*. 2011;95(7):657–663.
5. Fortin B, Yazbeck M. Peer effects, fast food consumption and adolescent weight gain. *J Health Econ*. 2015;42:125–138. [PubMed: 25935739]
6. Barkley JE, Salvy SJ, Sanders GJ, et al. Peer influence and physical activity behavior in young children: an experimental study. *J Phys Act Health*. 2014;11(2):404–409. [PubMed: 23359051]
7. Cohen-Cole E, Fletcher JM. Is obesity contagious? Social networks vs. environmental factors in the obesity epidemic. *J Health Econ*. 2008;27(5):1382–1387. [PubMed: 18571258]
8. Trogdon JG, Nonnemaker J, Pais J. Peer effects in adolescent overweight. *J Health Econ*. 2008;27(5):1388–1399. [PubMed: 18565605]
9. Yakusheva O, Kapinos K, Weiss M. Peer effects and the freshman 15: evidence from a natural experiment. *Econ Hum Biol*. 2011;9(2):119–132. [PubMed: 21216679]
10. Yang M, Huang R. Exposure to obesity and weight gain among adolescents. *East Econ J*. 2013;40(1):96–118.
11. Kelder SH, Perry CL, Klepp KI, Lytle LL. Longitudinal tracking of adolescent smoking, physical activity, and food choice behaviors. *Am J Public Health*. 2013;84(7):1121–1126.
12. Nyberg G, Sundblom E, Norman A, Elinder LS. A healthy school start - parental support to promote healthy dietary habits and physical activity in children: design and evaluation of a cluster-randomised intervention. *BMC Public Health*. 2011;11:185–2458-11–185. [PubMed: 21439049]
13. Wardle J, Cooke L. Genetic and environmental determinants of children's food preferences. *Br J Nutr*. 2008;99(S1):S15–S21. [PubMed: 18257946]
14. Gwozdz W, Sousa-Poza A, Reisch LA, et al. Peer effects on obesity in a sample of European children. *Econ Hum Biol*. 2015;18:139–152. [PubMed: 26115518]
15. Nie P, Sousa-Poza A, He X. Peer effects on childhood and adolescent obesity in China. *China Econ Rev*. 2015;35(Suppl C):47–69.
16. Alviola PA 4th, Nayga RM Jr, Thomsen MR, et al. The effect of fast-food restaurants on childhood obesity: a school level analysis. *Econ Hum Biol*. 2014;12:110–119. [PubMed: 23827821]
17. Currie J, DellaVigna S, Moretti E, Pathania V. The effect of fast food restaurants on obesity and weight gain. *Am Econ J Econ Policy*. 2010;2(3):32–63.
18. Davis B, Carpenter C. Proximity of fast-food restaurants to schools and adolescent obesity. *Am J Public Health*. 2009;99(3):505–510. [PubMed: 19106421]
19. Johnston J, DiNardo J. *Econometric Methods*. 4th ed. Singapore: McGraw-Hill; 1997.
20. Hoxby C. Peer effects in the classroom: learning from gender and race variation. 2000; NBER Working Paper 7867. Available at: <http://www.nber.org/papers/w7867.pdf>. Accessed August 14, 2018
21. Asirvatham J, Nayga RM Jr., Thomsen MR. Peer-effects in obesity among public elementary school children: a grade-level analysis. *Appl Econ Perspect Policy*. 2014;36(3):438–459.
22. Baskin ML, Ahluwalia HK, Resnicow K. Obesity Intervention among African-American children and adolescents. *Pediatr Clin North Am*. 2001;48(4):1027–1039. [PubMed: 11494636]

23. Wang Y, Beydoun MA. The obesity epidemic in the United States – gender, age, socioeconomic, racial/ethnic, and geographic characteristics: a systematic review and meta-regression analysis. *Epidemiol Rev.* 2007;29(1):6–28. [PubMed: 17510091]
24. Simons-Morton B, Farhat T. Recent findings on peer group influences on adolescent smoking. *J Prim Prev.* 2010;31(4):191–208. [PubMed: 20614184]
25. Parsons T On the concept of influence. *Public Opin Q.* 1963;27(1):37–62.
26. Hallinan MT, Williams RA. Students' Characteristics and the peer-influence process. *Sociol Educ.* 1990;63(2):122–132.
27. Robinson E, Higgs S Liking food less: the impact of social influence on food liking evaluations in female students. *PLoS One.* 2012;7(11):1–7.
28. Finnerty T, Reeves S, Dabinett J, et al. Effects of peer influence on dietary intake and physical activity in schoolchildren. *Public Health Nutr.* 2010;13(3):376–383. [PubMed: 19719887]
29. Wood KC, Becker JA, Thompson JK. Body image dissatisfaction in preadolescent children. *J Appl Dev Psychol.* 1996;17(1):85–100.
30. Wal JSV, Thelen MH. Eating and body image concerns among obese and average-weight children. *Addict Behav.* 2000;25(5):775–778. [PubMed: 11023018]
31. Frost J, McKelvie S. Self-esteem and body satisfaction in male and female elementary school, high school, and university students. *Sex Roles.* 2004;51(1–2):45–54.
32. Markovits H, Benenson J, Dolenszky E. Evidence that children and adolescents have internal models of peer interactions that are gender differentiated. *Child Dev.* 2001;72(3):879–886. [PubMed: 11405588]
33. Wilkinson IAG, Fung IYY. Small-group composition and peer effects. *Int J Educ Res.* 2002;37(5):425–447.
34. Phares V, Steinberg A, Thompson JK. Gender differences in peer and parental influences: body image disturbance, self-worth, and psychological functioning in preadolescent children. *J Youth Adolesc.* 2004;33(5):421–429.
35. Bailey R, Wellard I, Dismore H. Girls' Participation in Physical Activities and Sport: Benefits, Patterns, Influences and Ways Forward. Berlin, Germany; World Health Organization; 2005 Available at: <https://www.icsspe.org/sites/default/files/Girls.pdf>. Accessed August 14, 2018.
36. Justus MB, Ryan KW, Rockenbach J, et al. Lessons learned while implementing a legislated school policy: body mass index assessments among Arkansas's public school students. *J Sch Health.* 2007;77(10):706–713. [PubMed: 18076417]
37. Leatherdale S, Papadakis S. A multi-level examination of the association between older social models in the school environment and overweight and obesity among younger students. *J Youth Adolesc.* 2011;40(3):361–372. [PubMed: 20013351]
38. Greenlund KJ, Liu K, Dyer AR, et al. Body mass index in young adults: associations with parental body size and education in the CARDIA Study. *Am J Public Health.* 2013;86(4):480–485.
39. Chen E, Martin AD, Matthews KA. Understanding health disparities: the role of race and socioeconomic status in children's health. *Am J Public Health.* 2013;96(4):702–708.
40. Li Y, Palma AM., Towne SD, et al. Peer effects on childhood obesity from an intervention program. *Health Behav Policy Rev.* 2016;3(4):323–335.

Table 1:
Impact of Proportion of Underweight, Overweight, and Obese Peers on Students' BMI z-Scores (N = 753,381)

Peer proportion	Panel Methods			
	OLS	Random-Effects	One-way FE	2-way FE with Food Environment
Underweight	-1.17*** (0.10)	-1.34*** (0.09)	-1.37*** (0.10)	-1.37*** (0.10)
Overweight^a	0.48*** (0.02)	0.43*** (0.02)	0.41*** (0.02)	0.41*** (0.02)
Obese	0.71*** (0.03)	0.50*** (0.02)	0.45*** (0.02)	0.44*** (0.02)

*** Significant at .01

** Significant at .05

* Significant at .10

Note.

Regressors in each regression model include student age, race, sex, rural or urban area of residence, participation in school free or reduced-price lunch program, and food environment around residence. The one-way fixed effects (FE) model includes student fixed effects; and the 2-way FE model includes year dummy variables in addition to the student fixed effects. 'Food Environment' stands for the commercial food environment around schools. Clustered standard errors at school-level are reported in parentheses.

^aThis effect is statistically different from the obese proportion only in the OLS and random-effects model. The p-values of F-tests are .00, .00, .09, .17, and .11 for each model listed by column in Table 1.

Table 2:

Impact of Proportion of Obese Peers on BMI z-Score by Race (N = 753,381)

Race categories	OLS	Random-Effects	2-way FE
Caucasian			
Underweight	-1.89 *** (0.09)	-1.28 *** (0.08)	-1.29 *** (0.09)
Overweight	0.48 *** (0.03)	0.39 *** (0.02)	0.38 *** (0.02)
Obese	0.76 *** (0.03)	0.46 *** (0.02)	0.39 *** (0.02)
African-American			
Underweight	-1.22 *** (0.02)	-1.49 *** (0.18)	-1.54 *** (0.21)
Overweight	0.47 *** (0.05)	0.54 *** (0.04)	0.49 *** (0.03)
Obese	0.58 *** (0.04)	0.61 *** (0.03)	0.60 *** (0.04)
Hispanic			
Underweight	-0.95 *** (0.02)	-1.52 *** (0.25)	-1.58 *** (0.02)
Overweight	0.42 *** (0.09)	0.46 *** (0.05)	0.46 *** (0.06)
Obese	0.52 *** (0.07)	0.43 *** (0.02)	0.39 *** (0.06)

*** Significant at .01

** Significant at .05

* Significant at .10

Note.

Regressors in each regression model include student age, race, sex, rural or urban area of residence, participation in school free or reduced-price lunch program, year dummies, and food environment around each student's residence and around school. The 2-way FE model includes year dummy variables in addition to the student fixed effects. Clustered standard errors at school-level are reported in parentheses.

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Impact of Proportion of Underweight, Overweight, and Obese Peers across Sex on Students' BMI z-Scores (N = 753,381)

Table 3:

Sex	OLS	Random-Effects	2-way FE
Male			
Underweight	-1.31 *** (0.11)	-1.37 *** (0.10)	-1.39 *** (0.12)
Overweight	0.48 *** (0.03)	0.42 *** (0.02)	0.41 *** (0.02)
Obese	0.75 *** (0.03)	0.51 *** (0.02)	0.45 *** (0.02)
Female			
Underweight	-1.04 *** (0.12)	-1.31 *** (0.09)	-1.35 *** (0.01)
Overweight	0.47 *** (0.03)	0.43 *** (0.02)	0.42 *** (0.03)
Obese	0.65 *** (0.02)	0.48 *** (0.02)	0.44 *** (0.03)

*** Significant at .01

** Significant at .05

* Significant at .10

Note.

Regressors in each regression model include student age, race, sex, rural or urban area of residence, participation in school free or reduced-price lunch program, year dummies, and food environment around each student's residence and around school. The 2-way FE model includes year dummy variables in addition to the student fixed effects. Clustered standard errors at school-level are reported in parentheses.

Table 4:

Impact of Proportion of Peers by Different Weight Categories from Nearest Schools on a Student's BMI z-score (N=753,381)

Sex	OLS	Random-Effects	2-way FE	2-way FE with School Environmental Features
Neighboring school				
Underweight	-0.05 (0.06)	-0.02 (0.04)	-0.01 (0.05)	-0.02 (0.05)
Overweight	0.10*** (0.03)	0.01 (0.02)	0.00 (0.02)	0.00 (0.02)
Obese	0.15*** (0.02)	0.04*** (0.01)	0.02 (0.02)	0.02 (0.02)
Neighboring school of same type				
Underweight	-0.05 (0.06)	-0.01 (0.04)	-0.00 (0.05)	-0.01 (0.05)
Overweight	0.10*** (0.03)	0.02 (0.02)	-0.00 (0.02)	-0.00 (0.02)
Obese	0.15*** (0.02)	0.04*** (0.01)	0.02 (0.02)	0.02 (0.02)

Significant at .01**
Significant at .05*
Significant at .10

Note.

Regressors in each regression model include student age, race, sex, rural or urban area of residence, participation in school free or reduced-price lunch program, year dummies, and food environment around each student's residence and around school. The 2-way FE model includes year dummy variables in addition to the student fixed effects. Clustered standard errors at school-level are reported in parentheses.