Proximity of Fast-Food Restaurants to Schools and Adolescent Obesity

Brennan Davis, PhD, and Christopher Carpenter, PhD

Objectives. We examined the relationship between fast-food restaurants near schools and obesity among middle and high school students in California.

Methods. We used geocoded data (obtained from the 2002–2005 California Healthy Kids Survey) on over 500 000 youths and multivariate regression models to estimate associations between adolescent obesity and proximity of fast-food restaurants to schools.

Results. We found that students with fast-food restaurants near (within one half mile of) their schools (1) consumed fewer servings of fruits and vegetables, (2) consumed more servings of soda, and (3) were more likely to be overweight (odds ratio [OR]=1.06; 95% confidence interval [CI]=1.02, 1.10) or obese (OR=1.07; 95% CI=1.02, 1.12) than were youths whose schools were not near fast-food restaurants, after we controlled for student- and school-level characteristics. The result was unique to eating at fast-food restaurants (compared with other nearby establishments) and was not observed for another risky behavior (smoking).

Conclusions. Exposure to poor-quality food environments has important effects on adolescent eating patterns and overweight. Policy interventions limiting the proximity of fast-food restaurants to schools could help reduce adolescent obesity. (*Am J Public Health.* 2009;99:505–510. doi:10.2105/AJPH.2008.137638)

The marketing of food to children is in the national spotlight as rates of childhood obesity rise in the United States. More than 9 million US children and adolescents are obese, and just as many are at risk of becoming obese.[1] The consequential health risks include asthma, hypertension, type 2 diabetes, cardiovascular disease, and depression.[2] Fast food consumption by 2- to 18-year-olds increased 5-fold from 1977 to 1995; by the latter year, fast food was consumed at 9% of eating occasions and comprised 12% of daily caloric intake.[3] Almost one third of all youths now eat at fast-food restaurants on any given day.[4] One study reports that weekly consumption of fast food by young adults is directly associated with a 0.2-unit increase in body mass index (BMI).[5]

Despite the possibility that proximity of fast-food restaurants to schools affects children's health, research has not yielded consensus on this issue. Multiple studies have found that fast-food restaurants are systematically concentrated within a short walking distance of schools, giving children greater access to low-quality food, but these studies do not make an explicit connection between proximity to fast-food restaurants and diet-related outcomes.[6,7] Studies that have examined possible associations between the density of fast-food outlets and outcomes such as food consumption and weight status among youths have not found a relationship.[8,9] Our study revisits these questions using new detailed data on youths in California.

METHODS

Our empirical approach related the presence of fast-food restaurants near schools to youths' weight status and food consumption. We used information from individual-level student responses to the 2002–2005 California Healthy Kids Survey (CHKS).[10] The CHKS is an anonymous, school-based survey consisting of a core set of questions and several topical modules that focus on specific health-risk behaviors. The California Department of Education requires middle schools and high schools in California to administer the CHKS for compliance with provisions of the No Child Left Behind Act of 2001 (Pub L No. 107-110), and the sampling is designed to produce estimates that are representative at the district level. Consequently, the CHKS provides very large sample sizes; our data include information on over a half million students.

Our primary outcome of interest was BMI (defined as weight in kilograms divided by height in meters squared). We also considered binary outcomes for overweight and obesity. The obesity measurements of those younger than 19 years were based on percentiles by age and gender reference group, according to the BMI-for-age percentiles chart published by the Centers for Disease Control and Prevention (CDC).[11] A child at or above the 85th percentile of BMI distribution by age and gender was considered overweight. A child at or above the 95th percentile was considered obese (and overweight).

We also created an indicator variable for drinking any soda in the last 24 hours. Similar variables were created as indicators for the consumption of any vegetables, juice, fruit, and fried potato foods. We also measured the number of servings of each food type that a youth reported consuming in the past 24 hours.

To measure the proximity of fast-food outlets to schools, we used (1) a database of latitude–longitude coordinates and other school information for middle and high schools from the California Department of Education,[12] (2) a database of restaurants in California in 2003 with latitude–longitude coordinates from Microsoft Streets and Trips (Microsoft Corporation, Redmond, WA), and (3) a list of restaurant brands classified as "top limited-service restaurants" by Technomic Inc, a food industry consulting firm.[13]

Using these data, we created the following indicator: a youth who attended a school located within one half mile of at least 1 restaurant whose brand was on the list of top limited-service restaurants was considered near a fast-food restaurant. Previous research has also used the one half mile measure of proximity.[6,7] A person can walk this distance in 10 minutes. We also created the variable "near other restaurant" to indicate that the student's school was near a restaurant not on Technomic's list of top limited-service restaurants. Most restaurants in this latter category were probably nonchain, limited-service restaurants or smaller-chain, limited-service restaurants whose total US sales were not high enough to be on the list of top limited-service restaurants but that probably catered to youths in a manner similar to that of the larger fast-food chain restaurants. Given our inability to precisely identify the type of these other restaurants, however, we have focused on the results for being near a fast-food restaurant.

We estimated standard multivariate regression models that linked adolescent obesity outcomes to variables measuring the proximity of fast-food establishments to the student's school. The dependent variables were BMI, overweight, various food consumption outcomes, and obesity. For the BMI outcome, we estimated ordinary least squares regression models; for the dichotomous overweight and obesity outcomes, we used logistic regression and present adjusted odds ratios. The independent variables we controlled for included indicator variables for the following: female gender, age category (≤12, 13, 14, 15, 16, or ≥17 years), grade (≤7, 8, 9, 10, 11, or 12), and race/ethnicity (White, Asian, Black, Hawaiian, Hispanic, American Indian, multiple race, or other).

We also controlled for various measures of the youth's physical activity and exercise regimen (number of days in the previous week the respondent engaged in vigorous physical activity and number of days of muscle-strengthening activities), which should be directly associated with weight status outcomes. In addition, we controlled for school and other contextual characteristics, including indicators for school type (high school vs middle school), the proportion of students eligible for free or reduced-price meals, school enrollment, indicators for school location types (separate indicators for large, medium, and small urban locations; large, medium, and small suburban locations; town location; and rural location), and county indicators. In all models, we also included controls for the survey wave (2002–2003, 2003–2004, or 2004–2005).

All analyses were performed with Stata 10.0 software (StataCorp LP, College Station, TX), which takes the complex sampling design and differential respondent weights into account when calculating standard errors. We allowed for the arbitrary correlation of errors across students within a school by correcting our standard errors at the school level with Stata's CLUSTER correction. In addition to the baseline models with the full set of controls already described, we also investigated effects for specific demographic subgroups such as racial and ethnic minorities.

Being near a fast-food restaurant was chosen to be consistent with previous research.[6,7] To examine the sensitivity of our results to other plausible ways of measuring proximity, we also performed additional tests. For example, we tested the association between students' BMI and proximity of the nearest fast-food restaurant to their schools with the following mutually exclusive categories of proximity: (1) within one quarter of a mile (400 m), (2) between one quarter and one half mile, and (3) between one half mile and three quarters of a mile. We also considered, as an alternative measure of proximity, the distance between the youth's school and the closest fast-food restaurant among youths whose school was within 3 miles of a fast-food establishment (if proximity to a fast-food restaurant affects weight status, we would expect lower BMI measures at schools farther from fast-food restaurants). Finally, we examined the number of fast-food restaurants within a half-mile radius of the youth's school.

Our measures of food consumption outcomes in the CHKS came from questions that asked about the student's reported intake of 5 food types: vegetables, fruit, juice, soda, and fried potatoes. For each food type, we estimated logit models of the likelihood of consuming that food type on the day before the interview, and we also estimated the number of servings of that food type on the day before the interview by using a negative binomial model. For these food consumption outcomes, we controlled for all of the student and school characteristics, as well as the school location variables and county indicators. For the logit models, we present the adjusted odds ratios for being near a fast-food restaurant, and for the negative binomial models, we report the marginal effect estimated at the sample means.

As a set of additional tests for our main weight status models, we examined the sensitivity of being near a fast-food restaurant to additional controls for other types of establishments such as gas stations, motels, and grocery stores. We identified the presence of these establishments using Microsoft Streets and Trips in the same way that we identified the proximity of restaurants to schools. We estimated models of weight status outcomes that were identical to the baseline models except that being near a gas station, near a motel, and near a grocery store were added as additional controls. Finally, we estimated similarly specified models for a placebo outcome—past-month tobacco consumption—that should not be directly affected by proximity to a fast-food restaurant in the same way as weight status. Specifically, we considered an indicator of any past-month cigarette smoking as the outcome of interest (in a logit model in which adjusted odds ratios are presented), and we controlled for the detailed student and school characteristics, as well as the variables for being near a gas station, near a motel, and near a grocery store.

RESULTS

Table 1 shows the basic CHKS descriptive statistics. The average BMI for students in the sample was 21.7 kg/m^2, which the CDC considers a healthy weight for boys and girls aged at least 12.5 years.[11] About 27.7% of our sample was overweight, and 12% was obese (obese children are also considered to be overweight). Slightly over half of the students were girls, and the racial/ethnic composition was largely White and Hispanic. About 30% of our sample was in middle school. Over one third (38%) of the students attended schools in large suburban areas. Over half of all students (55%) attended schools near (i.e., within one half mile of) a fast-food restaurant.

Table 2 presents our main results, showing that youths who attended schools located near fast-food restaurants were heavier than were other students with similar observable characteristics who attended schools not located near fast-food restaurants. Models predicting youths' overweight (model 1) and obesity (model 2) show that a youth had 1.06 times the odds of being overweight (95% confidence interval [CI]=1.02, 1.10) and 1.07 times the odds of being obese (95% CI=1.02, 1.12) if the youth's school was near a fast-food establishment; both estimates were statistically significant. In model 3, attending a school within one half mile of a fast-food establishment was associated with a 0.10-unit increase in BMI (95% CI=0.03 kg/m^2, 0.16 kg/m^2) compared with youths whose

TABLE 1—Descriptive Statistics of Key Variables: California Healthy Kids Survey, 2002–2005

	% or Mean (SD)
Outcomes	
BMI	21.66 (3.96)
Weight	
Overweight	28
Obesity	12
No. of servings in past 24 h	
Vegetable	1.69 (1.52)
Fruit	1.79 (1.60)
Juice	1.71 (1.64)
Soda	1.60 (1.62)
Fried potato	1.21 (1.39)
Any serving in past 24 hours	
Vegetable	75
Fruit	74
Juice	70
Soda	68
Fried potato	62
Primary predictors	
% of establishments near school	
Fast-food restaurant	55
Other restaurant	25
Gas station	51
Motel	31
Grocery store	53
Individual-level covariates	
Gender	
Boy	47
Girl	53
Grade	
≤7th	30
8th	2
9th	34
10th	2
11th	30
12th	1
Age, y	
≤12	21
13	11
14	24
15	12
16	23
≥17	9
Race/ethnicity	
White	31
Asian	10
Black	4
Hawaiian	2
Hispanic	31
American Indian	1
Multiple	14
Other	7
Physical activity, no. days out of past 7	3.21 (2.35)
Exercise, no. days out of past 7	4.03 (2.20)
School-level covariates	
School type	
High school	68
Middle school	32
Students eligible for free/reduced-price meals	34
School year	
2002–2003	21
2003–2004	44
2004–2005	35
School enrollment	1864.13 (883.08)
School location type	
Large urban	15
Midsize urban	10
Small urban	11
Large suburban	38
Midsize suburban	7
Small suburban	4
Town	8
Rural	9

Note. Data are weighted to be representative at the district level through use of sample weights provided by the California Department of Education.[10]

schools were not near a fast-food restaurant, after we controlled for detailed observable characteristics. Given a mean height and weight of 5 feet 3 inches and 110 pounds for youths aged 14 years (the mean age of this population), a 0.10-unit increase in BMI translates to 0.56 lb. Models 1 through 3 also give estimates for being near other restaurants. As expected, we found a smaller relationship between this indicator and a youth's weight status, and the estimates were statistically significant. Across all outcomes, our models can explain 5% to 10% of the variation in a youth's weight status.

To preserve space, we present results only for the BMI outcome (the analyses for overweight and obesity, which produced similar results, are available upon request). Model 4 in Table 2 shows that for fast-food restaurants within one quarter mile (400 m) of a school and between one quarter and one half mile of a school, estimates are similar in magnitude to the effects seen in model 3 and are statistically significant. The third measure, within one half mile to three quarters of a mile of a school, was not significant. Model 5 shows that replacing the indicator for being near a fast-food restaurant with the measure of distance to the nearest fast-food establishment was consistent with the original result: there is a direct relationship between the proximity of fast-food restaurant to a school and a students' BMI. Finally, in model 6, there is no statistically significant relationship between the number (4 vs 3) of fast-food restaurants within one half mile of a school and a students' BMI, suggesting that the density of fast-food restaurants near schools may not be relevant to youths' obesity.

We examined reported consumption of vegetables, fruit, juice, soda, and fried potatoes. Youths attending schools located near a fast-food restaurant had significantly lower odds of reporting that they consumed vegetables or juice on the day prior to the survey than did other youths (Table 3), and they also reported consuming significantly fewer servings of vegetables, fruits, and juice than did students at schools that were not located near a fast-food restaurant, after we controlled for detailed observable characteristics. Table 3 shows results for the arguably less-healthy food types—soda and fried potatoes. We found that attending a school near a fast-food restaurant was associated with significantly higher odds of reporting soda consumption on the day before the survey, after we controlled for detailed observable characteristics. We did not find differences in fried potato consumption associated with the proximity of a fast-food outlet, although when we restricted our attention to limited-service restaurants that Technomic classified as "burger" establishments, we found a significantly higher likelihood of reporting fried potato consumption (odds ratio [OR]=1.02; 95% CI=1.00, 1.04; data not shown; available upon request).[13]

TABLE 2—Association Between a School's Proximity to a Fast-Food Restaurant and Overweight, Obesity, and Body Mass Index (BMI) Among Its Students (N=529 367): California Healthy Kids Survey, 2002–2005

Indicator	Model 1: Overweight, AOR (95% CI)	Model 2: Obese, AOR (95% CI)	Model 3: BMI, b (95% CI)	Model 4: BMI, b (95% CI)	Model 5: BMI, b (95% CI)	Model 6: BMI, b (95% CI)
Fast-food restaurant within 0.5 miles of school (among the top LSR establishments)	1.06*** (1.02, 1.10)	1.07*** (1.02, 1.12)	0.10*** (0.03, 0.16)			
Other restaurant within 0.5 miles of school (not among the top LSR establishments)	1.04** (1.01, 1.08)	1.04* (1.0, 1.09)	0.08** (0.01, 0.14)			
Fast-food restaurant 0–0.25 miles from school				0.12*** (0.04, 0.20)		
Fast-food restaurant 0.25–0.5 miles from school				0.14*** (0.06, 0.23)		
Fast-food restaurant 0.5–0.75 miles from school				0.06 (-0.04, 0.16)		
Distance to nearest fast-food restaurant					-0.03*** (-0.05, -0.01)	
No. of nearby fast-food restaurants						0.00 (0.00, 0.00)
R^2	0.05	0.06	0.10	0.10	0.10	0.10

Note. CI = confidence interval; AOR = adjusted odds ratio; LSR = limited-service restaurants. We estimated logit models for overweight (model 1) and obese (model 2) youths, and for these models we present AORs. In model 1, obese youths were also considered to be overweight. We used ordinary least squares for the BMI outcome in models 3 through 6. CIs were adjusted for clustering at the school level. In addition to the variables shown, all models also included controls for the following student characteristics: a female indicator, grade indicators, age indicators, race/ethnicity indicators, and physical exercise indicators. All models also included indicator variables for school location type, including large urban, midsize urban, small urban, large suburban, midsize suburban, small suburban, town, and rural. A full set of parameter estimates is available from the author upon request.
**P*<.10; ***P*<.05; ****P*<.01.

Table 4 shows the observed relationship between proximity of fast-food restaurants and adolescent weight status after control for nearby gas stations, motels, and grocery stores. We found no relationship between the presence of any of these types of businesses near the student's school and youths' BMI, likelihood of being overweight, or likelihood of being obese. Moreover, even with these establishments added to the models, the relationship between proximity to fast-food restaurant and weight status remained. The estimates indicate that attending a school located near a fast-food restaurant was associated with a statistically significant 0.13-unit increase (95% CI=0.05, 0.20) in BMI after we controlled for the presence of nearby gas stations, motels, and grocery stores, in addition to the standard control variables.

The results from our test of the placebo outcome of past-month cigarette smoking are shown in Table 4. There was a much smaller estimated association between being near a fast-food restaurant and cigarette smoking compared with the associated relationships for the overweight and obese indicators, and the relevant estimate was not statistically significant.

We also investigated whether the estimated relationship between proximity of fast-food restauraunts and weight status differed by students' or schools' observable demographic characteristics. We found that among Black students (but no other racial/ethnic minorities), the associations between being near a fast-food restaurant and BMI (b=0.20; 95% CI=0.04, 0.36) were larger than were baseline associations representing all students. We also found that associations

TABLE 3—Logit and Negative Binomial Models of Association Between a School's Proximity to a Fast-Food Restaurant and Nutritional Intake Measures Among Its Students (N=529 367): California Healthy Kids Survey, 2002–2005

Nutritional Intake Measure	Negative Binomial Model, b (95% CI)	Logit Model, AOR (95% CI)	R^2
Any vegetables yesterday		0.97* (0.93, 1.00)	0.04
No. of vegetable servings yesterday	-0.02** (-0.03, 0.00)		0.06
Any fruit servings yesterday		0.97 (0.93, 1.02)	0.04
No. of fruit servings yesterday	-0.02** (-0.04, 0.00)		0.08
Any juice yesterday		0.97* (0.94, 1.00)	0.02
No. of juice servings yesterday	-0.02*** (-0.03, 0.00)		0.05
Any soda yesterday		1.05** (1.00, 1.11)	0.02
No. of soda servings yesterday	0.02 (-0.01, 0.04)		0.06
Any fried potato servings yesterday		1.01 (0.98, 1.05)	0.02
No. of fried potato servings yesterday	0.00 (-0.02, 0.02)		0.04

Note. CI = confidence interval; AOR = adjusted odds ratio. Because parameter estimates from negative binomial models are not directly interpretable, we report the associated marginal effects from being near a fast-food restaurant. CIs were adjusted for clustering at the school level. In addition to the variables shown, all models also included controls for the following student characteristics: a female indicator, grade indicators, age indicators, race/ethnicity indicators, and physical exercise indicators. All models also included indicator variables for school location type, inlcuding large urban, midsize urban, small urban, large suburban, midsize suburban, small suburban, town, and rural.
**P*<.10. ***P*<.05. ****P*<.01.

TABLE 4—Association Between a School's Proximity to Other Types of Establishments and Weight Status of Students, With Student Smoking Added as a Placebo: California Healthy Kids Survey, 2002–2005

Indicator	BMI, b (95% CI)	Overweight, AOR (95% CI)	Obese, AOR (95% CI)	Smoker, AOR (95% CI)
School near fast-food restaurant	0.13*** (0.05, 0.20)	1.08*** (1.03, 1.13)	1.11*** (1.04, 1.18)	1.04 (0.97, 1.11)
School near gas station	−0.03 (−0.08, 0.03)	0.99 (0.97, 1.02)	0.98 (0.94, 1.01)	0.99 (0.94, 1.04)
School near motel	0.01 (−0.04, 0.06)	0.99 (0.97, 1.02)	0.99 (0.96, 1.03)	1.03 (0.97, 1.08)
School near grocery	−0.04 (−0.09, 0.01)	0.98 (0.95, 1.01)	0.97 (0.94, 1.01)	1.00 (0.96, 1.05)
R^2	0.10	0.08	0.08	0.05

Note. AOR = adjusted odds ratio; CI = confidence interval. We estimated models using ordinary least squares or logit; for the logit models, we present the adjusted odds ratio. CIs were adjusted for clustering at the school level. In addition to the variables shown, all models also included controls for the following student characteristics: a female indicator, grade indicators, age indicators, race/ethnicity indicators, and physical exercise indicators. All models also included indicator variables for school location type, inlcuding large urban, midsize urban, small urban, large suburban, midsize suburban, small suburban, town, and rural.
***$P<.01$.

between proximity of a fast-food restauraunt and weight status for students at urban schools (b= 0.16; 95% CI = 0.06, 0.25) were larger than were baseline associations representing all students.

DISCUSSION

We found that students in California were heavier and more likely to be overweight or obese if their school was located within one half mile of a fast-food restaurant, after control for student demographic characteristics, school characteristics, and detailed controls for the type of community in which the school was located. This main finding still held when other definitions of nearby (i.e., other than within 0.5 mile) were used and was not observed for other types of business establishments also commonly found near schools. Finally, we show that nearness to fast food was unrelated to smoking. We also addressed the concern that fast-food proximity may simply be a proxy for other unobserved characteristics about locations that are independently correlated with weight status, such as the degree of economic development around a school. Overall, our patterns are consistent with the idea that fast food near schools affects students' eating habits, overweight, and obesity.

Limitations

There were a few limitations to our study. BMI has been criticized as a measure of obesity in part because the height and weight used to calculate it are self-reported. However, research with self-reported measures of BMI combined with actual measures of BMI has shown the 2 to be highly correlated.[14]

The CHKS is compulsory for all California middle and high schools; however, as with any school-based survey, students were not included if (1) the parents did not provide consent for them to take the survey, (2) they were absent on the day the survey was administered, or (3) they had dropped out of school by the day of the survey. Although it is unlikely that data from missing respondents would affect the findings, concerns remain about generalizability and external validity. Student absence from school may be caused by illness, which could be more prevalent among overweight youths. If so, our results may understate the relationship between a school's proximity to fast-food restaurants and weight status. We also found that the results for the youngest students in the survey were consistent with the overall results, reducing concerns that student dropout might have biased our estimates.

One of our measures for unhealthful consumption was soda intake, which did not account for whether the soda was sugar based or diet soda. Some may argue that soda consumption is an invalid measure of unhealthful dietary intake, because it may include diet soda consumption; however, such potential measurement error would tend to mask (rather than enhance) the association between fast-food consumption and childhood overweight. A measure of solely sugar-based soda consumption would only strengthen our results. In addition, recent research has shown that diet soda consumption may be associated with obesity because the sweet taste encourages the consumption of other high-calorie foods.[15]

Other dimensions of the school environment that we did not observe could be important. For example, it would be useful to know whether students were allowed to leave school for lunch, because our observed relationship should be stronger for those youths. In addition, we controlled throughout for an extensive set of variables related to socioeconomic status, ethnicity, gender, and age; socioeconomic status, however, was controlled at the school level but not at the individual level.

It is also unclear how well our results generalize beyond California. Children living in the South, for example, are more likely than are children in the West to be obese.[4] Future work with large samples of students in other states would be useful. Finally, we do not know the causal directions of the associations between proximity to fast-food restaurants and overweight among youths. If fast-food restaurants are sufficiently savvy about locating near youths who will consume their products, there might be a positive association between proximity of fast-food restaurants and adolescent overweight even if such proximity did not directly cause the weight status outcome. We present only associations between nearby fast-food restaurants and adolescent obesity from data that are cross-sectional.

Conclusions

Despite these limitations, our results can be used to inform current debates over school eating policies. Our results suggest that it might be useful to consider policies such as providing adolescents with alternatives to fast-food restaurants. In addition, more research is needed on how public policy might target demographically identifiable subgroups for interventions related to proximity to fast-food restaurants.

A more drastic public policy measure would be for local governments to restrict commercial permits for fast-food restaurants within walking distance of a school.[16] Policymakers could also consider restrictions on the menus of restaurants that already exist within those zones, especially during lunch times and immediately before and after school. Alternatively, officials could consider ways to encourage vendors of healthful food to locate near schools.

Regardless of which option policymakers choose, the need for intervention is clear. The United States spends 12.7% of its gross domestic product on health care, and obesity is one of the most costly medical conditions.[17] The sheer magnitude of the problem of childhood obesity demands attention. ■

About the Authors

At the time of the study, Brennan Davis was with the School of Business and Management, Azusa Pacific University, Azusa, CA. Christopher Carpenter is with the Paul Merage School of Business, University of California, Irvine.

Requests for reprints should be sent to Brennan Davis, PhD, Hankamer School of Business, Baylor University, One Bear Place 98007, Waco, Tx 76798 (e-mail: marketing_department@baylor.edu).

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Contributors

B. Davis originated the study and completed the analysis. C. Carpenter supervised the study. Both authors helped to conceptualize the ideas, interpret findings, and write and review drafts of the article.

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Human Participant Protection

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