Sociodemographic Disparities in Proximity of Schools to Tobacco Outlets and Fast-Food Restaurants

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Objectives. To examine the association of school sociodemographic characteristics with tobacco outlet and fast-food restaurant availability near schools in a national study.

Methods. Business lists and data from the National Center for Education Statistics were used to calculate the numbers of tobacco outlets and fast-food restaurants within 800 meters of public schools in 97 US counties.

Results. More than 50% of schools with a majority of Hispanic students had both a fast-food restaurant and tobacco outlet nearby, compared with 21% of schools with a majority of White students. In adjusted models, each 10% increase in the number of low-income and Hispanic students enrolled in a school led to a 3% to 5% increase in the odds of the school having both a fast-food restaurant and a tobacco outlet nearby.

Conclusions. Low-income and Hispanic students are disproportionately exposed to both tobacco outlets and fast-food restaurants near their schools. Easy access to tobacco products and fast food may influence youth smoking initiation and contribute to poor dietary intake. (*Am J Public Health.* 2016;106:1556–1562. doi:10.2105/AJPH.2016.303259)

Obesity and tobacco use are risk factors for cardiovascular disease and many forms of cancer, and disparities in both of these risk factors exist by socioeconomic status and race/ethnicity[1] (for example, obesity rates are higher among non-Hispanic Black and Hispanic youths than among non-Hispanic White youths[2]). Fast-food consumption has been associated with increased total energy, fat, sodium, and sugar-sweetened beverage intake among both children and adolescents,[3] which may contribute to future obesity and overweight.[4]

In the case of all racial/ethnic groups, smoking initiation rates are highest among lower income youths,[5] and tobacco use rates have been shown to be higher among Hispanic than White middle schoolers.[6] Nearly 90% of adult smokers initiate smoking before the age of 18 years,[7] and thus early interventions targeting vulnerable populations are critical. Furthermore, smoking and poor dietary intake appear to covary,[8] consolidate early,[9] and track together over time.[8–10]

Young people are exposed to retail outlets in school neighborhoods when they walk, drive to and from school, or leave campus during lunch. Evidence suggests that the availability of fast-food restaurants (FFRs) near schools is associated with higher body mass index[11] and that the availability of nearby retail tobacco outlets (TOs) is associated with experimental smoking among young people.[12] Students permitted to leave school during lunch are more likely than students on closed campuses to consume fast food,[13] and exposure to point-of-sale tobacco marketing has been associated with youth smoking initiation, prevalence, and susceptibility as well as pro-smoking attitudes.[14]

Increased availability of FFRs and TOs near schools is a problem for youths not only because of easier access to unhealthy products but also because of increased exposure to point-of-sale marketing of those products. Both fast-food and tobacco companies target low-income, minority, and youth populations with promotions and advertising.[15,16] FFRs in lower income neighborhoods are more likely than those in higher income neighborhoods to offer free prizes with purchases and kids' meals.[17] Similarly, stores selling tobacco products in lower income and racial/ethnic minority neighborhoods have more tobacco marketing,[18] lower cigarette prices,[19] and higher availability of products with youth appeal (e.g., menthol cigarettes, cigarillos).[18]

To our knowledge, no research to date has concomitantly examined both the availability of FFRs and TOs near schools and the extent to which their availability differs according to race/ethnicity and student socioeconomic status. To address this gap, we examined the availability of FFRs and TOs near public schools in a national sample of US counties in association with student race, ethnicity, and socioeconomic status. We hypothesized that schools with higher proportions of Black students, Hispanic students, and students receiving free or reduced-price lunches would have more FFRs nearby, would have more TOs nearby, and would be more likely to have both an FFR and a TO nearby than would schools that were less diverse and had fewer students eligible for free

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or reduced-price lunches. Because older students may have greater autonomy and purchasing power, we also hypothesized that high schools and middle schools would have more FFRs and TOs nearby than would primary schools and would be more likely to have both nearby.

METHODS

As part of a larger study, Advancing Science and Policy in the Retail Environment, we selected a random sample of counties within the contiguous United States in 2011 via a probability proportionate to size method with minimal replacement. Because we selected counties in this manner, larger, more populous counties were more likely to be chosen, resulting in an overall study area with higher proportions of Hispanic and Black residents than the national average. The resulting 97 counties within 40 states comprised 25.7% of the US population. We used secondary data sources to obtain the locations of all public schools, tobacco outlets, and fast-food restaurants within each county. Table 1 lists each data source and corresponding measures.

We identified 18 457 public primary, middle, and high schools within the study counties. We excluded 71 duplicate schools (i.e., identical with respect to school name, address, and student enrollment) and 7 schools that were online-only schools, hospitals, residential treatment centers, or juvenile detention facilities, leaving 18 379 schools for our analyses. Private schools were not included in the sample; however, charter schools were included if they were classified as public schools by the National Center for Education Statistics.

Fast-Food Restaurants and Tobacco Outlets

We purchased FFR data from Dun & Bradstreet using codes consistent with similar studies (Table 1).[20] Food outlet validation studies have shown that commercial sources of such data have at least moderate sensitivity.[21] A national retail tobacco outlet licensing system does not exist; therefore, we used a list of probable tobacco outlets generated for Advancing

Science and Policy in the Retail Environment from Dun & Bradstreet and ReferenceUSA and selected types of establishments likely to sell tobacco products (Table 1).[22] Chains known to not sell tobacco were excluded (e.g., Target), and among pharmacies we retained the top 50 chains to improve the specificity of our list.

We created shapefiles (a vector format for storing the locations, shapes, and attributes of geographic features) using QGIS 2.2.0 and calculated the geographic coordinates of schools, FFRs, and TOs by using NAD 83 Conus Albers projections. Geographic points were joined with census tracts from the 2010 US census and tract-level data on population size and land area for the study counties. We created Euclidean radial buffers 800 meters from each school centroid, a commonly used distance to account for a 10-minute walk.[23] The "count points in polygon" tool in QGIS was used to calculate the total number of FFRs and TOs within each school buffer area. Because our study area included noncontiguous counties, some schools had buffers extending beyond the study area (n = 323). A sensitivity analysis excluding these schools resulted in similar findings, and thus we present the results including all 18 379 schools.

Measures

Dependent variables. Three dependent variables were created within 800-meter radial school buffers: number of FFRs, number of TOs, and a binary outcome indicating whether a school had both an FFR and a TO nearby (vs only 1 or neither an FFR nor a TO).

Independent variables. We used the proportion of students receiving free or reduced-price lunches (low-income students) and the proportion of Black and Hispanic students to assess school sociodemographic characteristics. School level (primary, middle, high) and total student enrollment were employed as covariates. To control for urbanicity, we used population per square mile at the census tract level (similar to another national study[24]) and school urban centric locale (city, suburb, town, rural) as measures of a school's location relative to populous areas.

Data Analysis

We calculated descriptive statistics for schools and the overall study area. The unadjusted average number of FFRs and TOs in each 800-meter buffer was assessed according to quartiles of student demographic characteristics (e.g., income, race/ethnicity). We conducted analyses of variance with Bonferroni pairwise comparisons to compare means across quartiles. We used generalized linear mixed models to estimate associations between FFR and TO counts near schools and student characteristics; we included a random effect at the county level to account for clustering of schools within counties resulting from the sampling design. We included county population size in our adjusted models to account for the sampling design in lieu of sampling weights.

Goodness of fit (χ^2) tests showed that a negative binomial model was a better fit for the data than was a Poisson model because of overdispersion of the count data. We calculated incidence rate ratios (IRRs) and 95% confidence intervals (CIs) based on these models. A generalized linear mixed model with a binary distribution was used to predict the odds of schools having both types of outlets (vs 1 or none) in association with school characteristics. Odds ratios and 95% confidence intervals were based on this model. We used the Markov chain Monte Carlo method of multiple imputation in SAS version 9.3 (SAS Institute Inc, Cary, NC) to impute missing data on the percentage of students receiving free or reduced-price lunches (n = 4955), the percentage of Black students (n = 3), and the percentage of Hispanic students (n = 3). Twenty imputed data sets were generated via PROC MI and modeled via PROC GLIMMIX and PROC MIANALYZE. We also ran models including complete cases (n = 13 421) and the results were similar; therefore, we present the results with the imputed data.

RESULTS

Table 2 shows the characteristics of the schools and study area. A total of 40.3% of schools had at least 1 FFR within 800 meters, and 77.3% had at least 1 TO; 38.2% of schools had both an FFR and a TO within 800

Measure	Source and Inclusion Information
Schools	
Geographic coordinates	National Center for Education Statistics, Elementary/Secondary Information System (2010–2011)
Locale (city, suburb, town, rural area)	Public schools
School level (primary, middle, high)	
No. of students enrolled	
Non-Hispanic Black students, %	
Hispanic students, %	
Students receiving free or reduced-price lunches, %	
Fast-food restaurants	
Geographic coordinates	Dun & Bradstreet Inc. (2011) Chain fast-food and pizza restaurants
Tobacco retail outlets	
Geographic coordinates	Dun & Bradstreet Inc. and ReferenceUSA (merged; 2011) Supermarkets and other grocery stores Convenience stores Tobacco stores Gasoline stations with convenience stores Warehouse clubs and supercenters News dealers and newsstands Beer, wine, and liquor stores Pharmacies and drug stores Discount department stores Other gasoline stations

meters. Schools had an average of 0.9 FFRs (range = 0–29) and 6.4 TOs (range = 0–269) within 800 meters. Schools were composed of, on average, 16.3% Black students, 34.6% Hispanic students, and 35.8% non-Hispanic White students (Table 2). Nearly half of students received free or reduced-price lunches (47.8%). Most schools were primary schools (63.9%), and more than 45% were located in suburban areas; 40% were located in cities, and the remainder were located in towns or rural areas (Table 2).

Bivariate Analyses

Average numbers of FFRs and TOs near schools increased with each increasing quartile of Hispanic students, Black students, and students receiving free or reduced-price lunches. The inverse was true for quartiles of White students (Figure 1). For example, schools comprising the highest quartile of White students had an average of 0.4 FFRs within 800 meters, compared with averages

of 1.3, 1.0, and 1.1 FFRs near schools comprising the highest quartiles of Hispanic students, Black students, and students receiving free or reduced-price lunches, respectively. Similar patterns were observed for TOs, with an average of 2.8 outlets near schools comprising the highest quartile of White students, compared with 9.2, 9.6, and 10.9 near schools comprising the highest quartiles of Hispanic students, Black students, and students receiving free or reduced-price lunches, respectively.

The difference in the average number of FFRs and TOs between the lowest and highest quartiles within each student demographic category was statistically significant ($P < .05$). The percentage of schools that had both an FFR and a TO within 800 meters increased with each increasing quartile of Hispanic students, Black students, and students receiving free or reduced-price lunches but decreased with each increasing quartile of White students. Nearly 53% of schools comprising the highest quartile of Hispanic students, 41% of schools comprising the

highest quartile of Black students, and 46% of schools comprising the highest quartile of students receiving free or reduced-price lunches had both an FFR and a TO within 800 meters, compared with 38% of schools overall and only 21% of schools within the highest White student population quartile (Figure 1).

Multilevel Models

Table 3 presents models focusing on FFR and TO availability after adjustment for school enrollment, school level, school urban locale, and county population size. The number of FFRs within 800 meters of a school increased by 6% for each 10-percentage-point increase in the proportion of Hispanic students in the school and by 3% for each 10-percentage-point increase in the proportion of low-income students (Table 3). The proportion of Black students in a school was not significantly associated with the number of FFRs nearby but was positively associated with number of TOs (IRR = 1.04; 95% CI = 1.03, 1.05). Similarly, the number of TOs within 800 meters of a school increased by 8% and 4% for each 10-percentage-point increase in the proportions of Hispanic and low-income students enrolled in the school, respectively.

The odds of a school having both an FFR and a TO within 800 meters increased by 5% for each 10-percentage-point increase in the proportion of Hispanic students enrolled in the school and by 3% for each 10-percentage-point increase in the school's proportion of low-income students. There was a slight positive but nonsignificant association between the percentage of Black students enrolled in a school and the school's odds of having both types of outlets nearby (Table 3).

We also found a strong association between school level and the availability of FFRs and TOs. High schools had 40% more FFRs and 24% more TOs within 800 meters than did primary schools, and high schools had nearly 1.5 times greater odds of having both an FFR and a TO nearby. There was no significant difference between middle and primary schools in the number of FFRs, TOs, or the odds of having both an FFR and a TO nearby.

TABLE 2—Characteristics of Schools (n = 18 379) and the Overall Study Area: 97 US Counties, 2011

Characteristic	Schools, % or Mean (SD)
School characteristics	
Schools with at least 1 outlet within 800 m	
Fast-food restaurant	40.3
Tobacco outlet	77.3
Both	38.2
No. of outlets within 800 m	
Fast-food restaurants	0.9 (1.6)
Tobacco outlets	6.4 (12.7)
Student composition, %	
Non-Hispanic Black	16.5 (24.5)
Hispanic	36.7 (31.2)
Non-Hispanic White	35.8 (31.5)
Other[a]	4.26 (5.27)
Students receiving free or reduced-price lunches, %	47.8 (31.2)
School level	
Primary	63.9
Middle	17.1
High	19.1
Student body size	669.6 (528.1)
Locale	
Suburb	45.3
City	40.8
Rural area	11.5
Town	2.5
Neighborhood characteristic (census tract)	
Population per square mile[b]	6 650 (117 070)

[a]Asian, American Indian/Alaska Native, or Hawaiian/Pacific Islander; categories do not sum to 100% because reporting did not capture categories comprising multiple races and ethnicities.
[b]From the 2010 US census.

DISCUSSION

We examined the availability of FFRs and TOs near schools in a national sample of US counties in association with student demographic characteristics. More than 40% of all schools had at least 1 FFR within a 10-minute walk (800 m), nearly 80% had at least 1 TO, and approximately 40% had both. Bivariate analyses showed that average numbers of FFRs and TOs and the percentage of schools with both types of outlets within 800 meters increased as concentrations of Hispanic, Black, and low-income students increased. For example, more than half of schools comprising the highest quartile of Hispanic students had both an FFR and a TO within 800 meters compared with only 21% of schools comprising the highest quartile of White students.
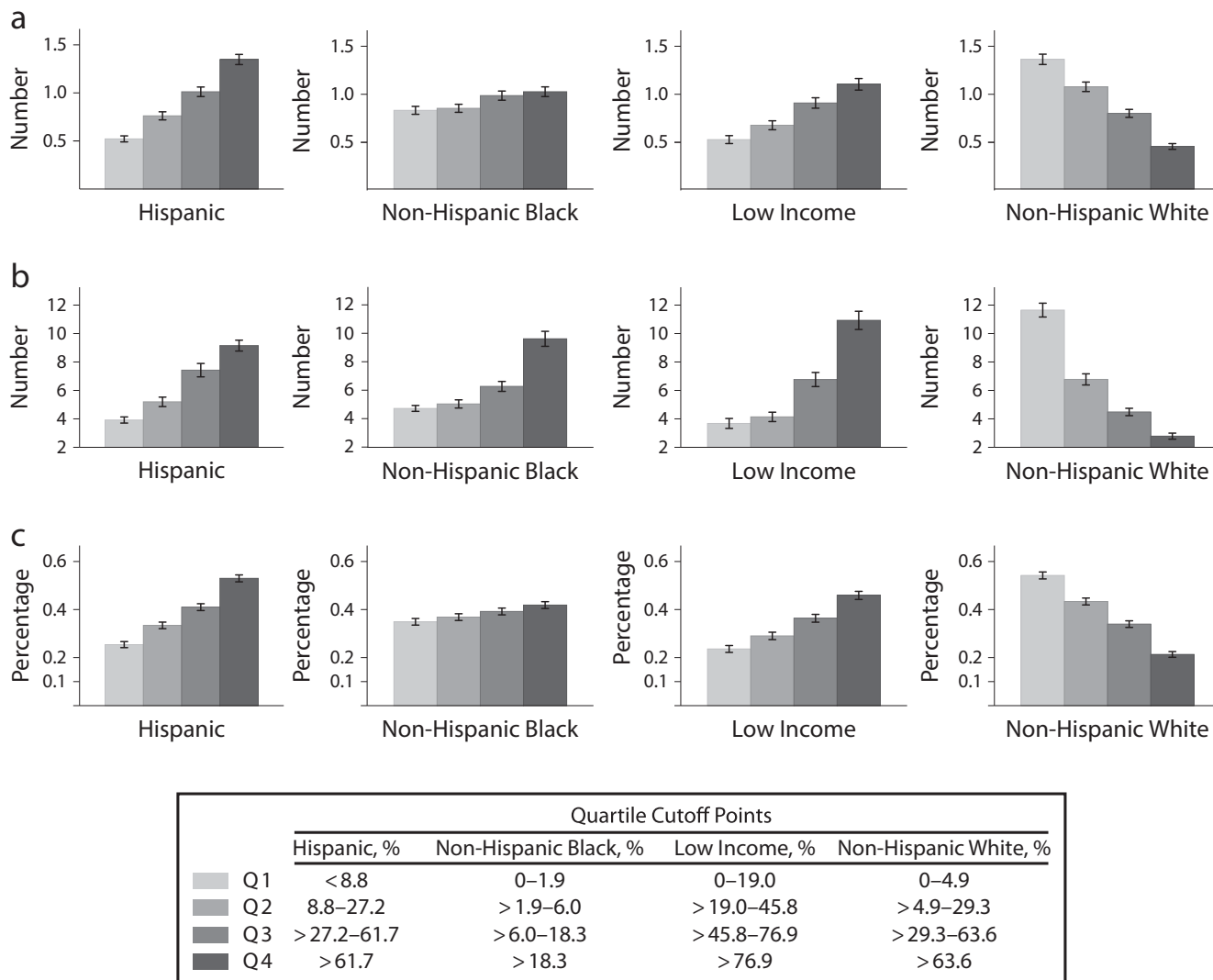
The number of FFRs and TOs near schools was also associated with student race/ethnicity and socioeconomic status in models controlling for school and neighborhood characteristics. Our first hypothesis, which focused on whether student racial/ethnic and socioeconomic compositions were associated with the number of FFRs near schools, was supported for Hispanic and low-income students but not Black students. Our results are similar to those of a pair of US national studies that also controlled for school urban locale. One of these studies revealed a positive association between numbers of FFRs near schools and proportions of Hispanic and low-income students but no association for non–Hispanic Black students.[25] The second study showed that there were more FFRs near schools in low-income than high-income neighborhoods but fewer FFRs near schools in predominantly Black compared with White neighborhoods.[24]

Our second hypothesis was fully supported. We found a higher number of TOs near schools with greater proportions of Black, Hispanic, and low-income students. Similarly, a national study showed that TO density was higher in neighborhoods with more Black and Hispanic residents,[26] and our findings are similar to those of studies that have explicitly assessed the availability of TOs near schools. For example, one investigation showed that California high schools in neighborhoods with at least 5 TOs within a half mile had higher proportions of Hispanic and low-income students.[27] Another study revealed that New York City schools located in neighborhoods with a higher proportion of low-income residents had greater TO density within both a quarter- and a half-mile radius.[28] Unlike our study, TO density near schools has been shown to be inversely associated with the proportion of Black residents in Chicago[29] and not associated with the proportion of Black students in California.[27]

Our third hypothesis was partially supported. We found that schools with higher proportions of Hispanic and low-income students, but not Black students, were more likely to have both an FFR and a TO nearby. There are several possible explanations for our finding of more TOs but not more FFRs near schools with higher numbers of Black students. The growth of the Hispanic population in the United States has led food marketing and advertising companies to target younger, Hispanic audiences,[30] and the fast-food industry is able to reach its audience through television ads.[15] By contrast, the tobacco industry is banned from advertising on television and spends considerably more money than does the fast-food industry at the point of sale,[31] and it has historically targeted low-income Black neighborhoods and youths with point-of-sale marketing and promotions.[16] Chain FFRs represent corporate brands that may use more complex information to determine their locations, such as foot traffic, safety, and consumer demographics, which may lead to FFRs being

	Q	Hispanic, %	Non-Hispanic Black, %	Low Income, %	Non-Hispanic White, %
	Q1	< 8.8	0–1.9	0–19.0	0–4.9
	Q2	8.8–27.2	> 1.9–6.0	> 19.0–45.8	> 4.9–29.3
	Q3	> 27.2–61.7	> 6.0–18.3	> 45.8–76.9	> 29.3–63.6
	Q4	> 61.7	> 18.3	> 76.9	> 63.6

Note. Cutoffs for quartiles are shown in the legend.

FIGURE 1—Average Numbers of (a) Fast-Food Restaurants (FFRs) and (b) Tobacco Outlets (TOs), and (c) Percentages of Schools With Both an FFR and a TO Within 800 Meters, by Student Demographic Quartile: 97 US Counties, 2011

less available in the most deprived areas. By contrast, an independently owned convenience store is likely not subject to the same location constraints.

Differences in the types of outlets included and the commercial business lists used could contribute to inconsistencies between our study and others. We included only chain fast-food and pizza restaurants to capture the major restaurants found in nearly every state, many of which are heavily marketed toward youths. Previous studies in smaller geographic areas have included tobacco licensing lists or single sources of business lists, whereas we

used a systematic process to clean and merge 2 business lists; also, to improve list specificity, we excluded chains known not to sell tobacco products. A field validation involving the same 2 business lists showed that this method correctly identified nearly 90% of all TOs in a 3-county study area.[22] The use of different school buffer areas (network vs Euclidean buffers, for example) and different neighborhood definitions (census tracts vs school buffer areas) could also contribute to variability in study findings.

Finally, similar to another study,[32] we found more FFRs around both high schools

and middle schools than around primary schools. Although the fast-food industry overtly targets both children and adolescents,[15] older children are more autonomous than younger children, more likely to be permitted to walk to a restaurant during or after school, and more likely to have disposable income. We also found that high schools (although not middle schools) had more TOs nearby than did primary schools and were more likely to have both an FFR and a TO nearby. Stores that sell tobacco may target older adolescents who have more purchasing power and can buy a broader

TABLE 3—Incidence Rate Ratios and Odds Ratios for Availability of Fast-Food Restaurants (FFRs), Tobacco Outlets (TOs), and Both Within 800 m of Public Schools: 97 US Counties, 2011

Variable	FFRs, IRR (95% CI)	TOs, IRR (95% CI)	At Least 1 FFR and 1 TO, OR (95% CI)
Student race/ethnicity[a]			
White/other (Ref)	1	1	1
Hispanic	1.06 (1.04, 1.07)	1.08 (1.07, 1.09)	1.05 (1.03, 1.07)
Non-Hispanic Black	1.01 (0.99, 1.02)	1.04 (1.03, 1.05)	1.01 (0.99, 1.03)
Student receipt of free/reduced-price lunches[a]			
No (Ref)	1	1	1
Yes	1.03 (1.02, 1.04)	1.04 (1.03, 1.05)	1.03 (1.01, 1.05)
School level			
Primary school (Ref)	1	1	1
Middle school	1.06 (0.99, 1.13)	1.03 (0.99, 1.07)	1.08 (0.98, 1.18)
High school	1.40 (1.32, 1.50)	1.24 (1.19, 1.30)	1.45 (1.32, 1.60)
Locale			
City (Ref)	1	1	1
Suburb	0.80 (0.76, 0.85)	0.63 (0.60, 0.65)	0.83 (0.77, 0.90)
Town	0.63 (0.52, 0.76)	0.61 (0.54, 0.68)	0.69 (0.53, 0.88)
Rural area	0.15 (0.13, 0.18)	0.20 (0.19, 0.22)	0.16 (0.13, 0.19)

Note. CI = confidence interval; IRR = incidence rate ratio; OR = odds ratio. The sample size was n = 18 379 schools.

[a]Scaled for a 10-percentage-point-increase interpretation; models were adjusted for total number of students enrolled and county population size. Adjustment for tract population density yielded nearly identical results.

range of products, and some may be legally able to purchase tobacco. However, sales to minors are also more likely to occur among older than younger adolescents,[33] and thus the finding of greater availability of tobacco outlets around high schools is troubling. The increased numbers of FFRs, TOs, and both types of outlets around high schools suggests that retailers may be well aware of and ready to take advantage of the autonomy and purchasing power of older youths.

Strengths and Limitations

This is the first study to our knowledge to examine both FFR and TO availability near public schools in association with student race, ethnicity, and socioeconomic status. Our counties were selected proportionate to population size, and therefore the schools in our sample were more suburban and urban than typical and may not be generalizable to all US schools. It is likely that our narrow inclusion criteria (i.e., we included only chain fast-food and pizza restaurants) and extensive list cleaning (to exclude chains known not to sell tobacco) improved the capacity of our lists to accurately capture FFR and TO availability

near schools. However, our list may have included stores that do not actually sell tobacco products or may have involved undercounts or overcounts of the number of actual TOs or FFRs in the study area.

In addition, by not classifying convenience stores as a potential source of unhealthy foods, we underestimated the ways in which convenience stores located near schools might affect the food choices of school-aged youths. Since 2011, changes may have occurred in the retail environment. For example, CVS pharmacy stopped selling tobacco products in 2014, which may have improved the tobacco retail environment near some schools. However, nationally CVS represented only about 2% of tobacco outlets[22] in 2011. Finally, although an 800-meter buffer is a commonly used measure for estimating reasonable walking distances for young people, it may not capture true school neighborhood access.

We used generalized linear mixed models to account for the sampling design and clustering of schools within counties. We did not use a spatial regression model to account for spatial autocorrelation in our dependent variables; however, our use of generalized

linear mixed models with random effects at the county level accounted for the correlation between schools with respect to the dependent variable. Furthermore, adding a spatial component to models involving count data has been found to only marginally improve model fit beyond a standard Poisson or negative binomial regression model.[34] We did not assess individual dietary intake or tobacco use among students. However, identifying differences in the food and tobacco retail environments around schools can inform licensing and zoning policies intended to create sustainable, environmental changes that can have an impact at the population level.[35]

Conclusions

In our sample of US counties, low-income, Hispanic, and high school students were disproportionately exposed to both FFRs and TOs near schools. Licensing or zoning policies restricting the location of fast-food and tobacco retail outlets in school neighborhoods could reduce youth access to fast-food and tobacco products and advertising. However, although there is evidence

linking exposure to tobacco outlets and marketing to youth smoking,[14] more research is needed to disentangle the association of fast-food restaurant availability near schools with dietary intake and subsequent obesity among young people. Studies examining the effects of the built environment on youth health behaviors would benefit from multi-level designs that focus on the relative contributions of home and school neighborhoods and parental and peer factors. Implementing licensing or zoning policies could create sustained environmental change, influence social norms, and improve the health of future generations of children and families. AJPH

HUMAN PARTICIPANT PROTECTION
No protocol approval was needed for this study because no human participants were involved.

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