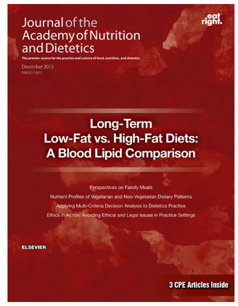
Journal Pre-proof



Trends in quick-service restaurants near public schools in the United States: Differences by community, school and student characteristics

Deborah A. Olarte, PhD, RDN, Joshua Petimar, ScD, Peter James, ScD, Kristen Cooksey Stowers, PhD, Sean B. Cash, PhD, Eric B. Rimm, ScD, Christina D. Economos, PhD, Jeffrey C. Blossom, MA, Marlaina Rohmann, MPH, Yuting Chen, PhD, Rinki Deo, PhD, Juliana F.W. Cohen, ScD

PII: S2212-2672(23)00057-6

DOI: https://doi.org/10.1016/j.jand.2023.01.016

Reference: JAND 55630

To appear in: *Journal of the Academy of Nutrition and Dietetics*

Received Date: 11 July 2022

Revised Date: 12 January 2023

Accepted Date: 31 January 2023

Please cite this article as: Olarte DA, Petimar J, James P, Stowers KC, Cash SB, Rimm EB, Economos CD, Blossom JC, Rohmann M, Chen Y, Deo R, Cohen JFW, Trends in quick-service restaurants near public schools in the United States: Differences by community, school and student characteristics, *Journal of the Academy of Nutrition and Dietetics* (2023), doi: https://doi.org/10.1016/j.jand.2023.01.016.

Title of the manuscript: Trends in quick-service restaurants near public schools in the United States: Differences by community, school and student characteristics

Keywords: Childhood nutrition; School health; Quick-service restaurants; Geographic information systems; Race and income

Abstract word count: 328

Text word count: 3837

Author contact information:

Deborah A. Olarte, PhD, RDN

- Postdoctoral Research Fellow, Merrimack College, School of Health Sciences, Department of Nutrition and Public Health, Center for Health Inclusion, Research and Practice, 315 Turnpike Street, North Andover, MA 01845, USA, olarted@merrimack.edu
- ORCID: 0000-0003-0133-4793

Joshua Petimar, ScD

- Research Scientist, Department of Population Medicine, Harvard Medical School and Harvard Pilgrim Health Care Institute, 401 Park Drive, Suite 401, East Boston, MA 02215, USA, jsp778@mail.harvard.edu
- ORCID: 0000-0002-3025-5931

Peter James, ScD

- Associate Professor, Department of Population Medicine, Harvard Medical School and Harvard Pilgrim Health Care Institute, 401 Park Drive, Suite 401, East Boston, MA 02215, USA, peterjames7@gmail.com
- Assistant Professor, Department of Environmental Health, Harvard T.H. Chan School of Public Health, 677 Huntington Avenue, Boston, MA 02115, USA, pjames@hsph.harvard.edu
- ORCID: 0000-0002-2858-1973

Kristen Cooksey Stowers, PhD

- Assistant Professor, Allied Health Sciences, Rudd Center for Food Policy and Health, University of Connecticut, One Constitution Plaza, Suite 600, Hartford, CT 06103, USA, kristen.cooksey@uconn.edu
- ORCID: 0000-0001-7988-8011

Sean B. Cash, PhD

- Associate Professor, Friedman School of Nutrition Science and Policy, Tufts University, 150 Harrison Avenue, Boston, MA 02111, USA, Sean.Cash@tufts.edu
- ORCID: 0000-0002-7561-3392

Eric B. Rimm, ScD

- Professor, Departments of Epidemiology and Nutrition, Harvard T.H. Chan School of Public Health, 677 Huntington Avenue, Boston, MA 02115, USA, erimm@hsph.harvard.edu
- Channing Division of Network Medicine, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, 75 Francis Street, Boston, MA 02115, USA, erimm@hsph.harvard.edu
- ORCID: N/A

Christina D. Economos, PhD

- Professor, Friedman School of Nutrition Science and Policy, Tufts University, 150 Harrison Avenue, Boston, MA 02111, USA, Christina.Economos@tufts.edu
- ORCID: N/A

Jeffrey C. Blossom, MA

- GIS Services Manager, Center for Geographic Analysis, Harvard University, 1737 Cambridge Street, Cambridge, MA 02138, USA, jblossom@cga.harvard.edu
- ORCID: N/A

Marlaina Rohmann, MPH

- Research Assistant, Department of Nutrition and Public Health, Merrimack College, 315 Turnpike Street, North Andover, MA 01845, USA, rohmannm@merrimack.edu

- Department of Nutrition, Harvard T.H. Chan School of Public Health, 677 Huntington Avenue, Boston, MA 02115, USA, mrohmann@hsph.harvard.edu
- ORCID: N/A

Yuting Chen, PhD

- GIS Services, Center for Geographic Analysis, Harvard University, 1737 Cambridge Street, Cambridge, MA 02138, USA, yutingchen@link.cuhk.edu.hk
- ORCID: 0000-0002-3384-8062

Rinki Deo, **PhD**

- GIS Services, Center for Geographic Analysis, Harvard University, 1737 Cambridge Street, Cambridge, MA 02138, USA rinkideo@gmail.com
- ORCID: N/A

Juliana F.W. Cohen, ScD

- Associate Professor, Department of Public Health and Nutrition, School of Health Sciences, Merrimack College, 315 Turnpike Street, North Andover, MA, 01845, USA, T: 978-837-5456, cohenj@merrimack.edu
- Adjunct Associate Professor**,** Department of Nutrition, Harvard T.H. Chan School of Public Health, Harvard University, Boston, MA, USA, T: 978-604-5896; F: 617-432-2435, jcohen@hsph.harvard.edu
- ORCID: 0000-0002-3145-6014

Author contributions:

JFWC and MR conceived this study. MR, PJ, JP, and ER developed the study design. JB, YC and RD collected the data. JFWC and DAO conducted the analysis and JP and PJ assisted with interpretation of the data. DAO led the writing. JFWC, JP, PJ, KCS, SC, ER, CE, JB, MR, YC, and RD provided critical feedback on the manuscript.

Corresponding Author/Reprint Contact: Deborah A. Olarte, PhD, RDN

Funding/Financial Disclosures: This study was funded by a grant (K01DK107810) from the National Institutes of Health (Cohen). The study sponsors did not have any role in the study design; collection, analysis and interpretation of the data; writing the report; and the decision to submit the report for publication. The authors have no financial disclosures.

Conflict of interest disclosures: The authors have no conflicts of interest.

RESEARCH SNAPSHOT

Research Question: Has the number of quick-service restaurants (QSRs) in proximity to United States public schools changed over time by community, school, and student-level characteristics?

Key Findings: This study examined trends in QSR proximity to public schools from 2006-2018. Over time, the number of QSRs increased near schools with high school students, near schools with a higher percentage of Black or African American and Hispanic or Latino students and near schools with a higher percentage of students from low-income backgrounds.

Trends in quick-service restaurants near public schools in the United States: Differences by community, school, and student characteristics

ABSTRACT

Background. More than a third of children and adolescents consume foods from quick-service restaurants (QSRs) daily, which is associated with an increased risk of diet-related adverse health conditions.

Objective. To examine trends in the proximity of top-selling QSR chains to all public schools across the United States (US) between 2006-2018 by community, school, and student-level characteristics.

Design. This longitudinal study examined changes in the number QSRs between the 2006-2007 and 2017-2018 school years using data from National Center for Education Statistics, Infogroup US Historical Business Data, and the US Department of Agriculture's Economic Research Service.

Statistical analyses performed. A mixed-model ANOVA using census tract as a random effect and accounting for repeated measures by school was used to examine the proximity of QSRs near schools. Models adjusted for demographic and census tract population density. Data were analyzed in 2021.

Results. In 2006, 9% of schools had QSRs within 400m, and 25% of schools in the most populated areas had at least one QSR within 400m. There were more QSRs near schools with a high percentage of poverty (12%), and near schools with high school students with the highest population of Black or African American (16%) and Hispanic or Latino (18%) students. By 2018, the percent of QSRs within 400m of all public schools increased to 12%. The increase over

time was greater near schools with a high percentage of poverty (16%) and near schools with high school students with the highest population of Black or African American students (22%) and Hispanic or Latino (23%) students.

Conclusions. This is the first nationwide study to examine trends in QSR proximity to all public schools. QSRs were most likely to be located near schools with high school students, near schools with a high percentage of poverty, and near schools with a higher proportion of racial and ethnic minority students. Over time, there were greater increases in QSRs near these schools which may have important implications for children's health and diet-related disparities.

INTRODUCTION

Over the last half century, consumption of fast food from quick-service restaurants (QSRs) has increased, paralleling rates of overweight and obesity among children and adults.[1-4] Because many children, especially adolescents, purchase food outside of school, the proximity of QSRs to schools may play a role in contributing to the obesity epidemic. A recent systematic review and meta-analysis found that greater access to QSRs was associated with children and adolescents' consumption of fast food.[5] On any given day, more than a third of children and adolescents ages 2-19 years consume ultra-processed foods that are engineered to be hyper-palatable, profitable and convenient, such as pizza, fries, desserts, and sugar-sweetened beverages.[1, 4-8] Food items such as these may contribute to an increased risk of childhood obesity and a lifetime risk of chronic diseases.[9,10] Furthermore, school proximity to QSRs is associated with greater BMI and poorer dietary patterns among children.[11-14]

Preliminary studies in urban areas (i.e., Los Angeles, New York City, and Boston) have found roughly a quarter of public schools have at least one QSR within 400m, although little is known about other cities or schools in suburban or rural regions.[11,12,15] However, environments that are laden with unhealthy food choices influence children's eating habits.[16] Students with QSRs within a half-mile radius (800m) from school (an approximate 10-minute walk) are more likely to be overweight and eat fewer fruits and vegetables compared to students in schools that are not near QSRs.[13,14] On any given day, consumption of food from QSRs is associated with a greater net caloric intake in children and adolescents' by an average of 126 and 301 calories, respectively.[17]

Children and adolescents are influenced by their surrounding food environments and the demographic make-up of a community dictates the exposure to healthy or unhealthy environments.[16,18-20] Historically marginalized populations (i.e., students from low-income and/or from predominantly racial and ethnic minority areas) have greater exposure to empty-calorie, low-nutrient foods due to greater geographic proximity to QSRs, compared to students who are White or from a high-income background.[19-23] The risk of obesity and chronic diseases, such as type 2 diabetes and heart disease is higher in these populations.[3,24] Adolescents are particularly at risk from the potentially close proximity of QSRs near their schools as they frequently eat at those establishments.[14,19-23,25,26]

Few studies have assessed QSRs proximity to schools outside of major United States (US) cities. Moreover, few have compared trends over time. Only one study examined the food environments that surround public middle and high schools in the US.[25] Additionally, there is limited research examining the proximity of QSRs to schools with a greater proportion of students from low-income and/or predominantly racial and ethnic minority areas. Therefore, the purpose of this study was to examine changes in the number of QSR establishments (based on the top ten QSR chains in the US) in proximity to all public schools between 2006-2018 by school- and community-level characteristics. It was hypothesized that there would be an increase in QSRs from baseline, particularly among schools with greater poverty levels and/or a greater percentage of students who were racial or ethnic minorities.

METHODS

Study Sample

School Data

Using data from the National Center for Education Statistics (NCES) the number of all schools across the US and their respective demographics over 12 school years (2006-2007 through 2017-2018) were examined. [27] Information on the grade levels categorizing school type (i.e., elementary, middle, kindergarten through twelfth grade [K-12], middle/high school, and primary/middle school [K-8]), school geographic coordinates, their respective lowest and highest grades, and basic demographics for public schools in the US were compiled.[27] Private schools, juvenile detention centers, schools that were missing identifying information, and schools with values that were considered implausible or potentially unreliable were excluded (i.e., schools listed with a population density of zero or schools with a percent poverty change of 20% or higher in less than three years during the study period). Out of the total number of schools examined (N=81,633) in the 2006-2007 school year, a total of 1,535 schools were excluded. In the analyses examining the change in QSRs over time, a total of 634 schools that closed during this time were excluded.

Food Establishment Data

Infogroup US Historical Business Data compiles all business names and their respective latitudinal and longitudinal coordinates throughout the US and is updated on a yearly basis. [28] Each business is classified by a North American Industry Classification System (NAICS) code.[29] NAICS codes were used to extract the nation's top-ten QSRs with the highest national sales between 2007-2018 (i.e., McDonalds, Burger King, Starbucks, Dunkin Donuts, Pizza Hut, Subway, Taco Bell, KFC, Chick-Fil-A, and Wendy's [NAICS code 722513]). [29] These 10 QSRs represented approximately 51.6% of all QSRs in 2018.[30,31] For the twelve school years, all school locations and QSRs were mapped using ArcGIS Pro version 2.2 (ESRI Redlands, CA).[32]

Measures

Rural-Urban Commuting Area Codes

Rural-Urban Commuting Area (RUCA) Codes were acquired from the US Department of Agriculture's Economic Research Service. RUCA Codes classify US census tracts through measures of population density, urbanization, and commuting and are published in tabular format. The RUCA table was linked to census tract shapefiles downloaded from the National Historic GIS.[33] A spatial join overlay analysis was applied from each school to the census tracts, determining the tract the school fell into and the related RUCA code.

Demographic Variables

The percentage of the student population by race and ethnicity was calculated using data provided by NCES. NCES classifies students by both ethnicity (i.e., Hispanic or Latino and non-Hispanic) and race (i.e., Asian, Native Hawaiian or Other Pacific Islander, Black or African American, American Indian or Alaska Native, White, or more than one race). Students whose ethnicity was classified as Hispanic or Latino were not included in the race categories for this study. Due to the small percentage of students who were classified as Native Hawaiian or Other Pacific Islander (<1%), this category was combined with the percentage of students who were classified as Asian. Similarly, because less than 1% of students in the dataset were classified as having more than one race, they were not included in the final dataset. Social Explorer was used to download and identify the socioeconomic characteristics of the communities surrounding the schools, including poverty data (i.e., the percentage of families at or below the poverty level within a given year) from the US Census Bureau, American Community Survey at the census tract level.[34] The poverty data were matched to each school for each school year. This study was determined exempt by the XX Institutional Review Board.

Statistical Analysis

Descriptive statistics were used to characterize all US public schools at baseline (2006-2007) including school type (e.g., elementary, middle, high, etc.) and student race and ethnicity, as well as census tract characteristics of the area surrounding the schools (i.e., urbanicity, poverty and population density). The percentage of schools with QSRs within 400m was also calculated. Quartiles by the percentage of students' race and ethnicity and family poverty were calculated with the highest quartile (Q4) having the greatest percentage. States were separated into four regions based on the US Census Bureau, Census Regions and Divisions.[35] Multi-level ANOVA accounting for clustering of observations (census tract as a random effect using SAS PROC MIXED) was used to examine cross-sectional differences in the number of QSRs in proximity to public schools by race and ethnicity, poverty, and school type for the 2006-2007 school year. Population density and urbanicity were examined as covariates in the models; due to multicollinearity (assessed by examining the variance inflation factor [VIF]), urbanicity was not included in the final models.

To examine changes in the number of QSR locations near schools over time between 2006 and 2018, a mixed model ANOVA was used, with census tract as a random effect and accounted for repeated measures by school (using SAS PROC MIXED). Models were adjusted for school demographics (i.e., racial and ethnic composition of schools and percent poverty within the school) and census tract population density. Students' racial and ethnic composition in schools was adjusted for (specifically the percentage of students who were Black or African American and Hispanic or Latino) because prior research has suggested that there are more QSRs located closer to certain racial and ethnic groups, in comparison to schools with a predominantly White student body and communities surrounding schools.[36,37] An interaction term between year and percent poverty, as well as between year and race and ethnicity were also examined in secondary analyses. Multilevel model assumptions (functional form, normality, and homoscedasticity) were tested and there was no evidence of a violation of such assumptions.[38] P-values were considered significant at the 0.05 level. The analyses were conducted using SAS version 9.4, SAS Institute, Cary, NC.[39]

RESULTS

Table 1 shows the demographic characteristics by school type for the 2006-2007 school year (n=80,098). Most schools were in urban areas. The mean percentage of families at or below the poverty level within a given year ranged from approximately 11% (± 10%) to 14% (± 12%). On average, 53% (± 38%) to 69% (± 34%) of students in the public schools included in the study were classified as White. During the 2006-2007 school year there was a mean of 0.1 (± 0.5) to 0.2 ± (0.8) QSRs within 400m of public schools. Additionally, during the same school year, there was a mean of 0.5 (± 1.2) to 0.7 (± 1.6) QSRs within 800m of public schools.

The results of the cross-sectional analysis for the 2006-2007 school year are presented in Table 2. The Northeast region of the US had the highest mean number of QSRs within 800m of schools (0.71; [SE: 0.03]). Race and ethnicity were statistically significantly associated with the number of QSRs in proximity to schools. Schools in the highest quartile of percentage of Hispanic or Latino students had on average more QSRs within 400m compared with schools in the lowest quartile (0.18 vs. 0.15 [SE: 0.01]; p=.0003), and on average more QSRs within 800m (0.68 vs. 0.57 [SE: 0.02 vs. 0.57]; p<.0001). Among schools with the highest proportion of Black or African American students, no statistically significant differences were observed in the mean number of QSRs within 400m or 800m compared with schools in the lowest quartile. Additionally, schools with high school students had statistically significantly more QSRs compared to elementary schools. Specifically, high schools had a mean of 0.19 more QSRs within 400m of schools [SE: 0.01; p<.0001] and a mean of 0.70 more QSRs within 800m of schools [SE:0.01; p<.0001]) within their respective 400m and 800m buffer zones compared with elementary schools.

In secondary analyses examining the percent of schools with QSRs within 400m during the 2006-2007 school year, 9% of all schools were located near QSRs (range 0-24). Specifically, 8% of elementary schools were near QSRs and 10% of schools with high school students (K-12, middle/high, and high schools) were near QSRs during the 2006-2007 school year (Figure 1). Twelve percent of schools in high poverty areas were within 400m of QSRs compared with 8% of schools in the lowest poverty areas. Additionally, 25% of schools in areas with the highest population density were located near QSRs compared with less than 1% of schools in the least dense areas (0.9%). When examining differences by race/ethnicity, 13% of schools with the highest proportion of Hispanic or Latino students, and 12% of schools with the highest proportion of Black or African American students were near QSRs compared with 6% of schools with the lowest proportion of students who were racial or ethnic minorities. When specifically examining schools with high school students, 18% of schools with a higher proportion of Hispanic or Latino students and 16% of schools with a higher proportion of Black or African American students were within 400m of QSRs compared with 6% of schools with the lowest proportion of students who were Black or African American or Hispanic or Latino.

Table 3 shows the annual change in the number of QSRs near schools throughout the US from the 2006-2007 school year through the 2017-2018 school year. There was a mean of 0.003 (95% CI: 0.003-0.004; p<.0001) more QSRs within 400m of all public schools per year (i.e., a mean increase of 0.036 QSRs over the twelve-year time period). When examining differences by region, there was a mean difference of 0.03 to 0.06 fewer QSRs per year within 400m of schools during this time period in the Midwest, South, and West compared with the Northeast. Race and ethnicity continued to be associated with the number of QSRs in proximity to schools over time. There were on average 0.008 (95% CI: 0.002-0.01; p=.004) more QSRs per year within 400m of schools in the highest quartile of percentage of Black or African American students in the schools compared to schools in the lowest quartile of percentage of Black or African American students. Similarly, over this time period there was a mean of 0.05 (95% CI: 0.04-0.06; p<.0001) more QSRs per year within 400m of schools in the highest quartile of percentage of Hispanic or Latino students in the schools compared to schools in the lowest quartile (0.01 [95% CI: 0.008-0.02; p<.0001]). Additionally, compared with elementary schools, there were more QSRs within 400m of middle schools, K-8, K-12, middle/high schools and high schools. Specifically, near high schools, there were on average, 0.11 (95% CI: 0.10-0.11; p<.0001) more QSRs within 400m. There were no statistically significant differences observed between the lowest and highest quartiles of poverty.

In secondary analyses examining the change in percentage of schools with QSRs within 400m over this time, there was a 3-percentage point increase in the percent of schools near QSRs (i.e., 12% of schools in 2017-2018 compared with 9% in 2006-2007 [data not shown]). There was a 4-percentage point increase in QSRs near schools in the highest poverty areas (i.e., 16% of schools were within 400m of QSRs in 2017-2018), and a 9-percentage point increase in QSRs near schools in areas with the greatest population density (i.e., 34% of schools were within 400m of QSRs in 2017-2018).

Online Supplementary Table 4 examines the interaction between time and race and ethnicity and poverty. Overall, there were statistically significant interactions by race and ethnicity and percent poverty ($p<.0001$). The mean annual increase was greater for schools in the highest quartile of Black or African American students (0.002 QSRs per year [95% CI: 0.0008-0.003; $p=.0006$]) and Hispanic or Latino students (0.006 QSRs per year [95% CI: 0.004-0.007; $p<.0001$]) compared to schools in the lowest quartile of percentage of Black or African American and Hispanic or Latino students. By the 2017-2018 school year, 17% of schools with the highest percentage of Black or African American and Hispanic or Latino students were within 400m of QSRs, representing an overall 5-percentage point increase (compared with 12% of these schools in 2006-2007) and an overall 4-percentage point increase among schools with the greatest percentage of Hispanic or Latino students (compared with 13% of these schools in 2006-2007). Conversely, during this time, there was only a 2-percentage point increase among schools with the greatest percentage of White students (7% in 2017-2018 versus 5% in 2006-2007). Similar differences by race and ethnicity were observed when limiting to only high school students

(Figure 2). There was a 6-percentage point increase among schools with a higher proportion of Black or African American high school students (22% of schools in 2017-2018 compared with 16% of schools in 2006-2007) and a 5-percentage point increase among schools with a higher proportion of Hispanic or Latino high school students (23% of schools in 2017-2018 compared with 18% in 2006-2007). During this same time period, there was only a 2-percentage point increase among schools with the highest percentage of White students during this same time period (7% in 2017-2018 versus 7% in 2006-2007).

Additionally, in these analyses there was a statistically significant interaction in the quartile with the highest poverty (0.002 [95% CI: 0.001-0.003; p=.0001]) highlighting that the mean increase in QSRs within 400m of schools was greater in communities with high poverty. There was a 4-percentage point increase in the percent of schools near QSRs in the highest poverty areas (16% of schools in 2017-2018 versus 12% in 2006-2007) compared with a 2-percentage point increase in schools in the lowest poverty areas (10% of schools in 2017-2018 versus 8% in 2006-2007). When specifically examining schools with high school students, there was a 6-percentage point increase in the percent of schools near QSRs in the highest poverty areas (20% of schools in 2017-2018 versus 14% in 2006-2007) compared with a 3-percentage point increase in schools in the lowest poverty areas (13% of schools in 2017-2018 versus 10% of schools in 2006-2007).

DISCUSSION

This study examined the change in the number of QSRs in proximity to all US public schools by region, community and school-level and student characteristics. In cross-sectional models, there were on average more QSRs near schools with adolescents (e.g., high schools and K-12 schools) and schools with a greater percentage of students who were Hispanic or Latino. Over time, there was an increase in the number of QSRs within 400m of schools from 2006 to 2018. This increase is a 3-percentage point increase in the percent of US schools near QSRs, with over 1 in 10 public schools within 400m of QSRs by the 2017-2018 school year. Importantly, these increases were even greater in high poverty areas (i.e., an average 4-percentage point increase) and in areas with higher population densities (i.e., an average 9-percentage point increase) with over a third of schools in areas with the highest population density near QSRs.

Disparities by race and ethnicity also were observed during this time period with an average 5-percentage point increase in the percentage of schools with a greater proportion of Black or African American or Hispanic or Latino students near QSRs. By 2017-2018, nearly 1 in 5 schools with a higher proportion of Black or African American high school students and almost 1 in 4 schools with a higher proportion of Hispanic or Latino high school students were within 400m of QSRs. This poses meaningful, real-world implications as the data indicate an increase of QSRs near schools, particularly in underserved neighborhoods; this may have the potential to influence the eating habits of children and adolescents and contribute to dietary disparities.

These results are consistent with a previous study conducted by James and colleagues that analyzed the changes in the food environment over 40 years (1971-2008) using data from the Framingham Heart Study in four Massachusetts towns.[40] Over this period, most food establishments increased. There were increases in density and proximity of QSRs to homes and workplaces and access to fast food increased over time for those in low poverty census tracts. The results are also consistent with studies that have previously examined food environments that surround schools and examined associations between race and ethnicity, socioeconomic status and QSR proximity to schools in a few larger US cities.[15,19,23,40,41] A study conducted in Los Angeles estimated that 23% of public schools had at least one QSR within 400m and 65% of schools had at least one QSR within 800m.[15] There was also a greater density of QSRs near high schools than middle and elementary schools. Similarly, in New York City, at least 25% of public schools had one QSR within 400m and in Boston, 84% of schools had at least one QSR within 800m.[19,42] Additionally, three studies found that Hispanic or Latino students are more likely to attend schools in proximity to QSRs.[23,24,37] QSRs may be locating near schools with older students, as adolescents have some financial resources, freedom in their food choices and ability to visit QSRs, in comparison to younger students.[43,44]

Previous research suggests that QSRs use targeted food marketing techniques to influence children who are from predominantly low-income and/or racial and ethnic areas.[45,46] In 2017, US food companies spent over $1 billion to advertise their food products to historically marginalized populations.[47] Black or African American and Hispanic or Latino children and those from low-income backgrounds have viewed more QSR food advertisements than their White peers and QSRs in these areas have more unhealthy items on their children's menus.[46] This study found that students who are adolescents, and/or in a low-income and/or predominantly racial and ethnic minority area are more likely to attend school near a QSR. This could have important health implications because previous research suggests that QSRs may be associated with unhealthy eating habits and health disparities among the nation's youth.[1,4,7,8]

This study had several strengths. The 400m or 800m proximity of QSRs to school is about a 5–10-minute walk and most children could walk to these establishments. The time period covers twelve school years and is longer than any similar study to date. This study also relied on data from the ten largest QSR chains in the US. These ten are consistently available in all 50 states, represent over half of all QSR locations across the country and had the highest national sales between 2007 and 2018.[30,31] The use of buffer zones allowed for greater accuracy in modeling the food establishments and their distances from schools. Also, the rich within-school data was able to account for school- and community-level characteristics. Lastly, this study was nationally comprehensive in that it analyzed changes in all school districts across the US for over a decade.

This study also had limitations. The 400m and 800m proximity was based solely on distance from a school. It did not consider street networks. The dataset combined Asian with Native Hawaiian or Other Pacific Islander. As Native Hawaiian or Other Pacific Islanders have been recognized as a separate racial group, future studies should examine differences in the number of QSRs in these communities. This study did not include all regional chains and local/independent QSRs across the US. This study did not include schools' open or closed-campus lunch policies or student purchasing data. Additionally, this study did not account for impact on students' diets and related health outcomes, and future research should examine these outcomes.

CONCLUSION

This study examined the trends in the number of QSRs in proximity to nearly all public schools in the US across twelve school years (2006-2007 through 2017-2018). This study found that the number of QSRs has increased near schools with high school students, near schools with higher poverty levels, and near schools in areas with high proportions of racial and ethnic minorities. These results may have an important impact on childhood diet and health outcomes over time and highlight the need to address inequitable food environments and health disparities that continue to exist.

Future studies should examine inequitable food environments surrounding schools, open and closed-campus lunch policies, the rate of student frequency at QSRs in proximity to their schools and impact of QSR food consumption during the school day on students' diet and health outcomes over time. Future studies should also consider all QSRs near schools including regional, local and independent establishments and examine the impact of other proximal store types (i.e., grocery and convenience stores) on student health outcomes. Lastly, future research should examine the impact of zoning regulations that limit the number of QSRs near schools or regulations that limit QSRs marketing to children.

REFERENCES

1. Vikraman S, Fryar CD, Ogden CL. Caloric intake from fast food among children and adolescents in the United States, 2011-2012. U.S. Department of Health and Human Services, CDC, National Center for Health Statistics. *NCHS Data Brief* No. 213; 2015.
2. Fryar CD, Carroll MD, Afful J. Prevalence of overweight, obesity, and severe obesity among children and adolescents aged 2–19 years: United States, 1963–1965 through 2017–2018. NCHS Health E-Stats; 2020. https://doi.org/10.1037/e582042012-001
3. Skinner AC, Ravanbakht SN, Skelton JA, et al. Prevalence of Obesity and Severe Obesity in US Children, 1999–2016. *Pediatrics.* 2018;141(3). https://doi.org/10.1002/oby.21497
4. Fryar CD, Carroll MD, Ahluwalia N, et al. Fast food intake among children and adolescents in the United States, 2015-2018. *NCHS Data Brief*; 2020:(375):1–8. Accessed February 25, 2022. https://stacks.cdc.gov/view/cdc/ 92755.
5. Jia P, Luo M, Li Y, et al. Fast-food restaurant, unhealthy eating, and childhood obesity: a systematic review and meta-analysis. *Obes Rev;* 2021:22 (S1):e12944. https://doi.org/10.1111/obr.12944
6. Monteiro CA, Cannon G, Levy RB, et al. Ultra-processed foods: what they are and how to identify them. *Public Health Nutr*. 2019:(5):936 941. https://doi.org/10.1017/s1368980018003762
7. Wang L, Martínez Steele E, Du M, et al. Trends in Consumption of Ultra-processed Foods Among US Youths Aged 2-19 Years, 1999-2018. *JAMA;* 2021:326(6):519–530. doi:10.1001/jama.2021.10238. https://doi.org/10.1093/cdn/nzaa061_131

8. Poti JM, Slining MM, Popkin BM. Where are kids getting their empty calories? Stores, schools, and fast-food restaurants each played an important role in empty calorie intake among US children during 2009-2010. *J Acad Nutr Diet;* 2014:114: 908-917. https://doi.org/10.1016/j.jand.2013.08.012

9. Braithwaite I, Stewart AW, Hancox RJ, et al. Fast-food consumption and body mass index in children and adolescents: an international cross-sectional study. *BMJ Open;* 2014. 4:e005813. doi:10.1136/bmjopen-2014-005813. https://doi.org/10.1136/bmjopen-2014-005813

10. Bowman SA, Gortmaker SL, Ebbeling CB, et al. Effects of fast-food consumption on energy intake and diet quality among children in a national household survey. *Pediatrics*; 2004:113(1 Pt 1):112–18. https://doi.org/10.1542/peds.113.1.112

11. Rummo PE, Wu E, McDermott ZT, et al. Relationship between retail food outlets near public schools and adolescent obesity in New York City. *Health Place*; 2020:65:102408. https://doi.org/10.1016/j.healthplace.2020.102408

12. Oreskovic NM, Winickoff JP, Kuhlthau KA, et al. Obesity and the built environment among Massachusetts children. *Clin Pediatr;* 2009:48(9) 904-912. https://doi.org/10.1177/0009922809336073

13. Davis B, Carpenter C. Proximity of fast-food restaurants to schools and adolescent obesity. *Am J Public Health*; 2009:99(3):505-510. https://doi.org/10.2105/ajph.2008.137638

14. Howard PH, Fitzpatrick M, Fulfrost B. Proximity of food retailers to schools and rates of overweight ninth grade students: An ecological study in California. *BMC Public Health*; 2011:11:68. https://doi.org/10.1186/1471-2458-11-68

15. Simon PA, Kwan D, Angelescu A, et al. Proximity of fast food restaurants to schools: do neighborhood income and type of school matter? *Prev Med; 2008:*47(3):284-8. https://doi.org/10.1016/j.ypmed.2008.02.021

16. Boehm R, Cooksey Stowers K, Schneider GE, et al. Race, Ethnicity, and Food Environment Are Associated with Adolescent Sugary Drink Consumption During a 5-Year Community Campaign. *J Racial Ethn Health Disparities*; 2021:1-12. https://doi.org/10.1007/s40615-021-01074-9

17. Powell LM & Nguyen BT. Fast-food and full-service restaurant consumption among children and adolescents. *JAMA Pediatr*; 2013:167(1): 14-20. https://doi.org/10.1001/jamapediatrics.2013.417

18. Cubbin C, Jun J, Margerison-Zilko C, et al. Social inequalities in neighborhood conditions: spatial relationships between sociodemographic and food environments in Alameda County, California. *J Maps*; 2012:8(4): 344-348. https://doi.org/10.1080/17445647.2012.747992

19. Kwate NOA & Loh JM. Separate and unequal: The influence of neighborhood and school characteristics on spatial proximity between fast food and schools. *Prev Med*; 2010:51:153-156. https://doi.org/10.1016/j.ypmed.2010.04.020

20. Chen HJ, Wang Y. Changes in the neighborhood food store environment and children's body mass index at peripuberty in the United States. *J Adolesc Health*. 2016 Jan 1;58(1):111-8. https://doi.org/10.1016/j.jadohealth.2015.09.012

21. Fleming-Milici F, and Harris JL. Television food advertising viewed by preschoolers, children and adolescents: contributors to differences in exposure for black and white

youth in the United States. *Pediatr Obes*; 2018:13:103-110. https://doi.org/10.1111/ijpo.12203

22. Richmond TK, Spadano-Gasbarro JL, Walls CE, et al. Middle school food environments and racial/ethnic differences in sugar-sweetened beverage consumption: Findings from the Healthy Choices study. *Prev Med*; 2013:57: 735-738. https://doi.org/10.1016/j.ypmed.2013.09.001
23. Elbel B, Tamura K, McDermott ZT, et al. Disparities in food access around homes and schools for New York City children. *PloS ONE*; 2019:14(6):e0217341. https://doi.org/10.1371/journal.pone.0217341
24. Skinner AC, Perrin EM, Moss LA & Skelton JA. Cardiometabolic risks and severity of obesity in children and young adults. *N Engl J Med*; 2015: 373(14), pp.1307-1317. https://doi.org/10.1056/NEJMoa1502821
25. Sturm R. Disparities in the food environment surrounding US middle and high schools. *Public Health*; 2008:122(7): 681-690. https://doi.org/10.1016/j.puhe.2007.09.004
26. Forsyth A, Wall M, Larson N, et al. Do adolescents who live or go to school near fast-food restaurants eat more frequently from fast-food restaurants. *Health Place*; 2012:18:1261-1269. https://doi.org/10.1016/j.healthplace.2012.09.005
27. U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics.
28. Infogroup, Inc. Infogroup US Historical Business Data. 2016. V10. Harvard Dataverse. https://doi.org/10.7910/DVN/PNOFKI
29. U.S. Department of Commerce. North American Industry Classification System. 2017. https://www.census.gov/naics/

30. America's 50 Biggest Fast-Food Chains. QSR website. https://www.qsrmagazine.com/content/americas-50-biggest-fast-food-chains. Accessed November 18, 2022.

31. Number of quick service restaurants in the United States from 2011 to 2020 with a forecast for 2021. Statista website. https://www.statista.com/statistics/196619/total-number-of-fast-food-restaurants-in-the-us-since-2002/. Accessed November 18, 2022.

32. Esri Inc. (2020). ArcGIS Pro (Version 2.5). Esri Inc. https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview.

33. Manson S, Schroeder J, Van Riper D, Kugler T, Ruggles S. IPUMS National Historical Geographic Information System: Version 16.0 [Census Tract Polygons 2000, 2010]. Minneapolis, MN: IPUMS. 2021. http://doi.org/10.18128/D050.V16.0

34. ACS Census Data Prepared by Social Explorer. https://socialexplorer.com. Accessed in December of 2020

35. Census Regions and Divisions of the United States. US Census Bureau website. https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf. Accessed May 2022.

36. Chen HJ, Wang Y. The changing food outlet distributions and local contextual factors in the United States. *BMC Public Health*. 2014:14:1-1. https://doi.org/10.1186/1471-2458-14-42

37. Sanchez-Vaznaugh EV, Weverka A, Matsuzaki M, Sánchez BN. Changes in fast food outlet availability near schools: unequal patterns by income, race/ethnicity, and urbanicity. *Am J Prev Med*. 2019 Sep 1;57(3):338-45. https://doi.org/10.1016/j.amepre.2019.04.023

38. Singer J, Willett J. Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence. New York, NY: Oxford University Press; 2003.

39. SAS version 9.4, SAS Institute, Cary, NC

40. James P, Seward M, O'Malley AJ, et al. Changes in the food environment over time: examining 40 years of data in the Framingham Heart Study. *Int J of Behav Nutr Phys Act*; 2017:14:84. https://doi.org/10.1186/s12966-017-0537-4

41. James P, Arcaya MC, Parker DM, et al. Do minority and poor neighborhoods have higher access to fast-food restaurants in the United States? *Health Place*; 2014:29:10-17. https://doi.org/10.1016/j.healthplace.2014.04.011

42. Walker RE, Block J, Kawachi I. The spatial accessibility of fast food restaurants and convenience stores in relation to neighborhood schools. *Appl. Spat Anal Policy*; 2014:7:169-182. https://doi.org/10.1007/s12061-013-9095-6

43. Cohen JFW, Rimm EB, Davison KK, et al. The role of parents and children in meal selection and consumption in quick service restaurants. *Nutrients; 2020:*12.3: 735. https://doi.org/10.3390/nu12030735

44. Ziegler AM, Kasprzak CM, Mansouri TH, et al. An Ecological Perspective of Food Choice and Eating Autonomy Among Adolescents. *Front Psychol;* 2021:12:654139. https://doi.org/10.3389/fpsyg.2021.654139

45. Grier SA, Kumanyika S. Targeted marketing and public health. *Annu Rev Public Health*; 2010:31:349–369. https://doi.org/10.1146/annurev.publhealth.012809.103607

46. Cohen JFW, Cooksey Stowers K, Rohmann M, et al. Marketing to Children inside quick service restaurants: differences by community demographics. *Am J Prev Med*; 2021:61(1): 96-10. https://doi.org/10.1016/j.amepre.2021.01.035

47. Harris JL. Targeted food marketing to Black and Hispanic consumers: the tobacco playbook. *Am J Public Health*; 2020:110(3):271-2. https://doi.org/10.2105/ajph.2019.305518

Table 1. School-level, community, and regional characteristics of US public schools and the proximity to quick-service restaurants (QSRs) during the 2006 – 2007 school year (N = 80,098)

Measures	Elementary (n=40,383)	Middle (n=14,050)	K – 8 (n=5,359)	K – 12 (n=2,315)	Middle/High (n=4,276)	High (n=13,715)
Urbanicity, %[a]						
Urban	63.2	56.7	50.3	45.9	36.1	51.9
Suburban	10.7	12.4	11.1	9.9	12.9	12.4
Large rural	11.9	12.5	11.9	14.5	15.4	12.6
Small town/rural	14.2	18.5	26.5	29.7	35.7	23.2
Poverty, %[b], Mean ± SD[c]	10.8 ± 10.3	10.9 ± 10.1	13.8 ± 12.2	13.2 ± 11.2	12.1 ± 10.2	11.3 ± 10.3
Population Density[d], Mean ± SD	3630 ± 8376	3066 ± 8643	5614 ± 12141	2859 ± 8936	2288 ± 8765	3060 ± 8598
Race & ethnicity, %[e] Mean ± SD						
American Indian or Alaska Native	1.4 ± 6.7	1.9 ± 8.2	3.7 ± 12.3	7.9 ± 25.5	2.3 ± 9.8	2.5 ± 9.8

Asian or Native Hawaiian or Other Pacific Islander	4.7 ± 9.3	3.7 ± 7.7	3.3 ± 8.3	2.6 ± 8.6	1.5 ± 5.0	3.3 ± 7.4
Black or African American	14.4 ± 22.4	13.8 ± 21.1	20.3 ± 31.1	14.2 ± 22.5	13.5 ± 23.1	13.8 ± 22.1
Hispanic or Latino	19.5 ± 26.3	16.4 ± 23.8	20.1 ± 27.2	12.6 ± 19.2	11.5 ± 20.8	15.2 ± 22.9
White	59.9 ± 33.4	63.9 ± 31.6	52.6 ± 37.8	56.4 ± 35.1	68.9 ± 33.7	63.2 ± 33.1
QSRs[f] in 400m, Mean ± SD	0.1 ± 0.5	0.1 ± 0.5	0.2 ± 0.6	0.2 ± 0.6	0.1 ± 0.6	0.2 ± 0.8
QSRs in 800m, Mean ± SD	0.5 ± 1.2	0.5 ± 1.2	0.7 ± 1.6	0.6 ± 2.0	0.5 ± 1.6	0.7 ± 1.9
QSRs by Region, %[g]						
Northeast	16.0	15.7	19	11.7	13.7	15.1
Midwest	24.3	24.9	23.3	19.3	37.5	25.8
South	35.9	38.3	26.3	35.5	30.8	35.2
West	23.9	21.1	31.5	33.5	18	24

[a] Urbanicity is derived from the RUCA codes measuring urbanization. Urbanization was based on a classification scale from 1-10 (ranging from urban to rural) and further broken down into a scale of 1-4, where 1 = urban; 2, 3 = suburban, 4, 5, 6 = large rural; and 7, 8, 9, 10 = small town/rural.[33]

[b] The percentage of poverty in the community surrounding the school was obtained from data from Social Explorer at the census tract level.[34]

[c] SD, Standard Deviation.

[d] Population density is the census tract population density per square mile surrounding each school.

[e] The percentage of race and ethnicity of students within each school was calculated from data from NCES. [27] The race category 'Black or African American' excluded students who were also classified as Hispanic or Latino.

[f] QSRs, quick-service restaurants.

[g] Regions are based on the U.S. Department of Commerce Economics and Statistical Administration US Census Bureau: Census Regions and Divisions of the United States.[35]

Table 2. Association between the mean number of QSRs[a] near public schools in the US by region, school type and school- and community-level demographics for the 2006-2007 school year[b]

Variables	Mean number of QSRs within 400m[c] (SE)[d]	p-value	Mean number of QSRs within 800m (SE)	p-value
Region[e]				
Northeast (Ref)[f]	0.20 (0.01)		0.71 (0.03)	
Midwest	**0.16 (0.01)**	**0.0006**	**0.63 (0.02)**	**0.006**
South	**0.15 (0.01)**	**<.0001**	**0.58 (0.02)**	**<.0001**
West	**0.15 (0.01)**	**<.0001**	**0.60 (0.02)**	**0.002**
School Type				
Elementary (Ref)	0.12 (0.004)		0.52 (0.01)	
Middle	**0.14 (0.01)**	**<.0001**	**0.58 (0.01)**	**<.0001**
K – 8	**0.14 (0.01)**	**0.002**	0.55 (0.02)	0.08
K – 12	**0.22 (0.01)**	**<.0001**	**0.76 (0.03)**	**<.0001**
Middle/High	**0.17 (0.01)**	**<.0001**	**0.66 (0.02)**	**<.0001**
High	**0.19 (0.01)**	**<.0001**	**0.70 (0.01)**	**<.0001**
Percent Race and ethnicity (Quartiles)[g]				
Black or African American				
Q1(Ref)	0.16 (0.01)		0.61 (0.01)	
Q2	0.16 (0.01)	0.53	0.61 (0.01)	0.82
Q3	0.17 (0.01)	0.85	**0.65 (0.01)**	**0.003**
Q4[h]	0.17 (0.01)	0.43	0.64 (0.02)	0.05

Hispanic or Latino				
Q1(Ref)	0.15 (0.01)		0.57 (0.01)	
Q2	**0.16 (0.01)**	**0.01**	**0.60 (0.01)**	**0.008**
Q3	**0.17 (0.01)**	**0.0003**	**0.67 (0.02)**	**<.0001**
Q4	**0.18 (0.01)**	**0.0003**	**0.68 (0.02)**	**<.0001**
Percent Poverty[i]				
Q1(Ref)	0.16 (0.01)		0.60 (0.02)	
Q2	**0.17 (0.01)**	**0.009**	**0.64 (0.01)**	**0.002**
Q3	0.17 (0.01)	0.08	**0.66 (0.01)**	**<.0001**
Q4	0.16 (0.01)	0.23	0.62 (0.01)	0.25

[a] QSR, quick-service restaurant.

[b] Results are calculated using a multi-level model, including census tract as a random effect, and adjusted for population density and school demographics.

[c] Calculated using Least Squares Means.

[d] SE, Standard Error.

[e] Regions are based on the U.S. Department of Commerce Economics and Statistical Administration US Census Bureau: Census Regions and Divisions of the United States.[35]

[f] Ref, reference group.

[g] The percentage of race and ethnicity of students within each school was calculated from data from NCES.[27] The race category 'Black or African American' excluded students who were also classified as Hispanic or Latino.

[h] Q4 has the highest percentage of student race and ethnicity per school and percentage of poverty per community.

[i] The percentage of poverty in the community surrounding the school was obtained from data from Social Explorer at the census tract level.[34]

Table 3. The mean annual change in QSRs [a] within 400m of public schools by school type and school- and community-level characteristics (2006-2018)[b]

Variables	β-coefficient (95% CI) [c]	p-value
QSR (overall)	**0.003 (0.003 to 0.004)**	**<.0001**
Region[d]		
Northeast	Reference	
Midwest	**-0.03 (-0.05 to -0.008)**	**0.007**
South	**-0.05 (-0.07 to -0.03)**	**<.0001**
West	**-0.06 (-0.08 to -0.04)**	**<.0001**
School Type		
Elementary	Reference	
Middle	**0.03 (0.02 to 0.03)**	**<.0001**
K-8	**0.02 (0.02 to 0.03)**	**<.0001**
K-12	**0.14 (0.14 to 0.15)**	**<.0001**
Middle/High	**0.09 (0.08 to 0.09)**	**<.0001**
High	**0.11 (0.10 to 0.11)**	**<.0001**
Percent Race and ethnicity[e]		
Black or African American		
Q1	Reference	
Q2	-0.003 (-0.007 to 0.001)	0.18
Q3	0.0005 (-0.004 to 0.005)	0.84
Q4[f]	**0.008 (0.002 to 0.01)**	**0.004**

Hispanic or Latino		
Q1	Reference	
Q2	**0.01 (0.008 to 0.02)**	**<.0001**
Q3	**0.03 (0.02 to 0.03)**	**<.0001**
Q4	**0.05 (0.04 to 0.06)**	**<.0001**
Percent Poverty[g]		
Q1	Reference	
Q2	0.004 (-0.00002 to 0.007)	0.05
Q3	**0.01 (0.005 to 0.014)**	**<.0001**
Q4	-0.002 (-0.006 to 0.003)	0.50

[a] QSR, quick-service restaurant.

[b] Results are calculated using mixed-model ANOVA, including census tract as a random effect and school as a repeated measure and adjusted for population density and school demographics.

[c] β-coefficient is the mean annual change in the number of QSRs within 400m of schools (e.g., for every year, the mean number of QSRs increased by 0.003. Over the twelve-year study, the mean increase in QSRs within 400m of schools was 0.036).

[d] Regions are based on the U.S. Department of Commerce Economics and Statistical Administration US Census Bureau: Census Regions and Divisions of the United States. [35]

[e] The percentage of race and ethnicity of students within each school was calculated from data from NCES.[27] The race category 'Black or African American' excluded students who were also classified as Hispanic or Latino.

[f] Q4 has the highest percentage of student race and ethnicity per school and percentage of poverty per community.

[g] The percentage of poverty in the community surrounding the school was obtained from data from Social Explorer at the census tract level. [34]

Supplementary Table 4. The mean annual change in QSRs [a] within 400m of public schools by yearly increase for race and ethnicity and poverty (2006-2018)[b]

Variables	β-coefficient (95% CI)[c]	p-value
Percent race and ethnicity[d]		
Black or African American		
Q1	Reference	
Q2	-0.003 (-0.007 to 0.001)	0.18
Q3	0.0005 (-0.004 to 0.005)	0.84
Q4[e]	**0.008 (0.002 to 0.01)**	**0.004**
Hispanic or Latino		
Q1	Reference	
Q2	**0.01 (0.008 to 0.02)**	**<.0001**
Q3	**0.03 (0.02 to 0.03)**	**<.0001**
Q4	**0.05 (0.04 to 0.06)**	**<.0001**
Percent Poverty[f]		
Q1	Reference	
Q2	0.004 (-0.00002 to 0.007)	0.05
Q3	**0.01 (0.005 to 0.014)**	**<.0001**
Q4	-0.002 (-0.006 to 0.003)	0.50
School Type		
Elementary	Reference	
Middle	**0.03 (0.02 to 0.03)**	**<.0001**

K-8	**0.02 (0.02 to 0.03)**	**<.0001**
K-12	**0.14 (0.14 to 0.15)**	**<.0001**
Middle/High	**0.09 (0.08 to 0.09)**	**<.0001**
High	**0.11 (0.10 to 0.11)**	**<.0001**
Region		
Northeast	Reference	
Midwest	**-0.03 (-0.05 to -0.008)**	**0.007**
South	**-0.05 (-0.07 to -0.03)**	**<.0001**
West	**-0.06 (-0.08 to -0.04)**	**<.0001**
Interactions		
Q1 Hispanic or Latino * Year	Reference	
Q2 Hispanic or Latino * Year	-0.0005 (-0.002 to 0.0005)	0.34
Q3 Hispanic or Latino * Year	**0.001 (0.0002 to 0.002)**	**0.03**
Q4 Hispanic or Latino * Year	**0.006 (0.004 to 0.007)**	**<.0001**
Q1 Black or African American * Year	Reference	

Q2 Black or African American * Year	-0.0001 (-0.001 to 0.0009)	0.80
Q3 Black or African American * Year	-0.00002 (-0.001 to 0.001)	0.97
Q4 Black or African American * Year	**0.002 (0.0008 to 0.003)**	**0.0006**
Q1 Poverty * Year	Reference	
Q2 Poverty * Year	**-0.002 (-0.003 to -0.0008)**	**0.0005**
Q3 Poverty * Year	0.0008 (-0.0002 to 0.002)	0.13
Q4 Poverty * Year	**0.002 (0.001 to 0.003)**	**0.0001**

[a] QSR, quick-service restaurant.

[b] Results are calculated using mixed-model ANOVA, including county as a random effect and school as a repeated measure and adjusted for population density and school demographics.

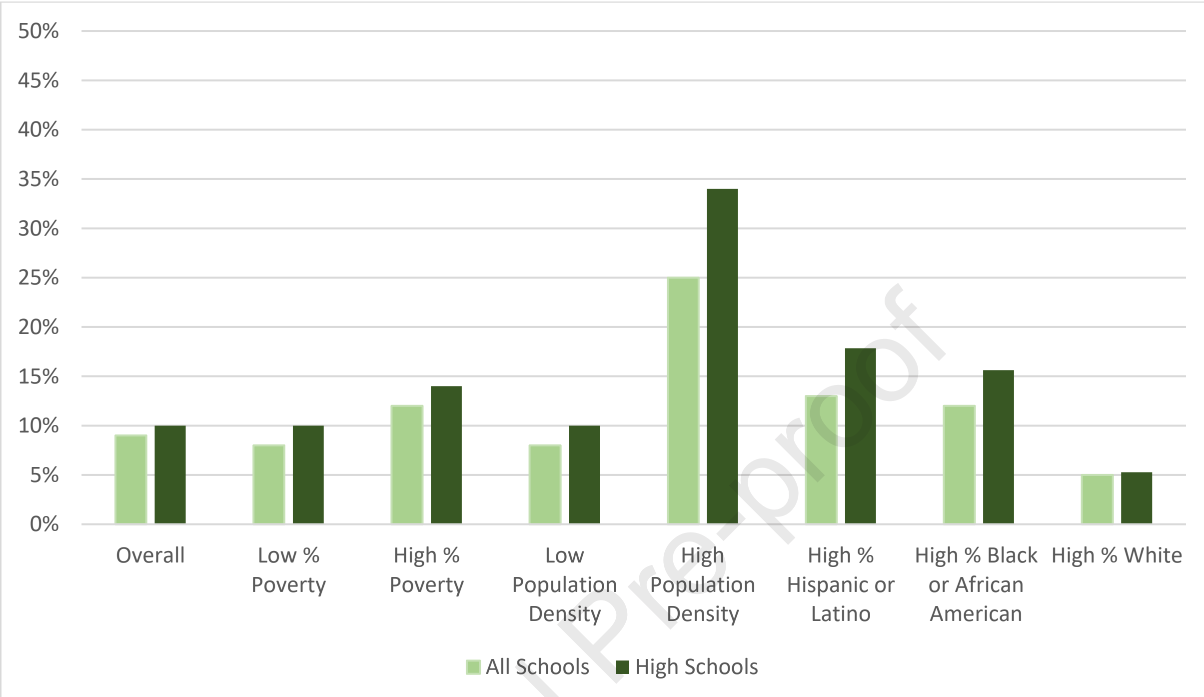
[c] β-coefficient is the mean annual change in the number of QSRs within 400m of schools.

[d] The percentage of race and ethnicity of students within each school was calculated from data from NCES.[27] The race category 'Black or African American' excluded students who were also classified as Hispanic or Latino.

[e] Q4 has the highest percentage of student race and ethnicity per school and percentage of poverty per community.

[f] The percentage of poverty in the community surrounding the school was obtained from data from Social Explorer at the census tract level. [34]

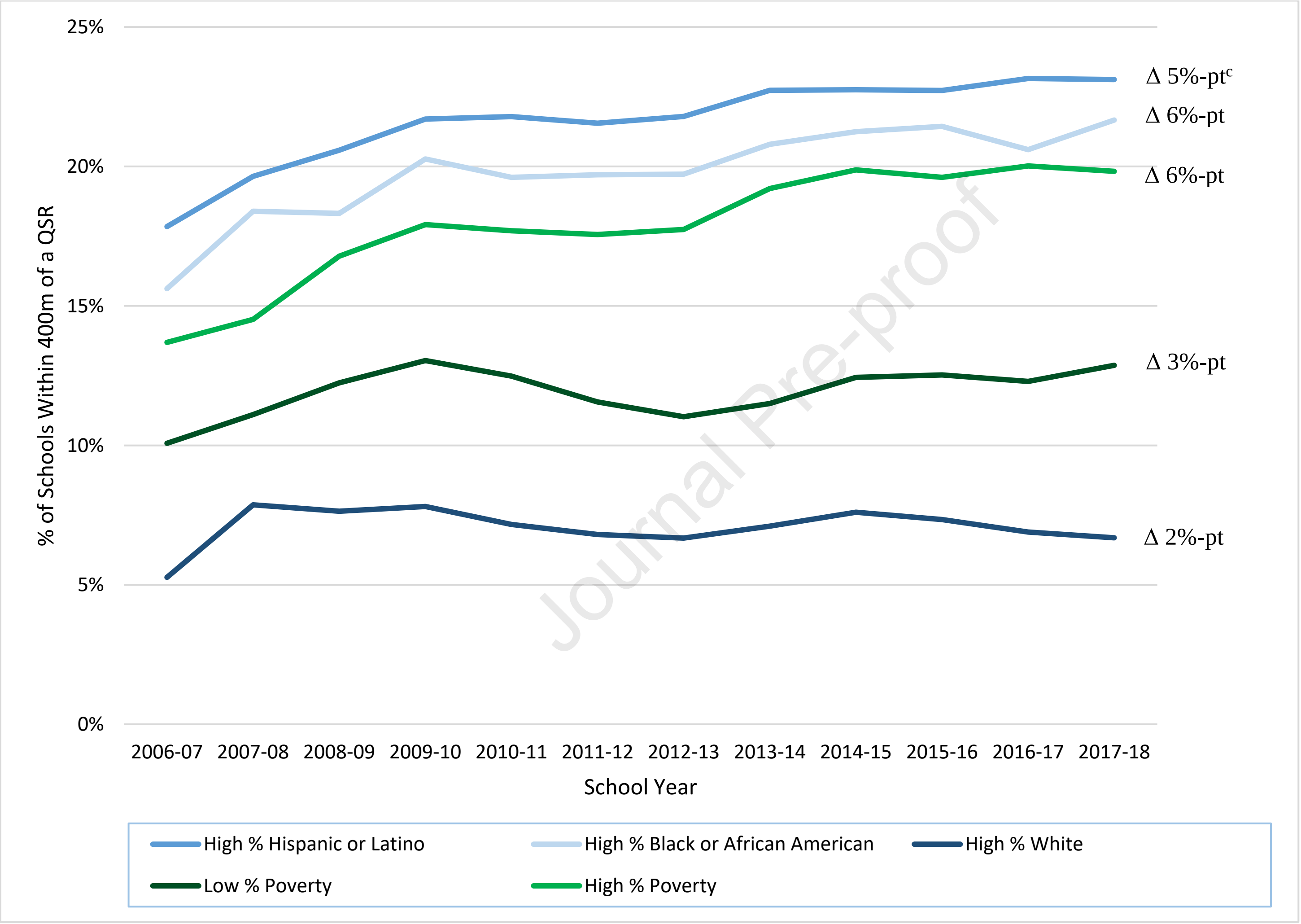
Figure 1. The percent of schools[a] with quick service restaurants (QSRs) within 400m during the 2006-2007 school year by poverty levels, population density, race, and ethnicity[b].



[a] "All schools" includes elementary, middle, K-12, middle/high, and high schools; "High schools" include includes K-12, middle/high (grades 6-12) and high schools (grades 9-12).

[b] Examining the schools within the highest proportion of Black or African American, Hispanic or Latino, and White students and the highest and lowest proportion of families at or below the poverty level (based on quartiles) and schools in areas with the highest and lowest population densities (based on deciles). The percentage of race and ethnicity of students within each school was calculated from data from NCES.[27] The race category 'Black or African American' excluded students who were classified as Hispanic or Latino.

Figure 2. Change in the percentage of schools with high school students[a] within 400m of quick service restaurants (QSRs) by race, ethnicity, and poverty levels[b] (2006-2018)



[a] Includes K-12, middle/high and high schools.

[b] Examining the schools within the highest proportion of Black or African American, Hispanic or Latino, and White students and the highest and lowest proportion of families at or below the poverty level (based on quartiles). The percentage of race and ethnicity of students within each school was calculated from data from NCES.[27] The race category 'Black or African American' excluded students who were classified as Hispanic or Latino.

[c] %-pt, percentage point