Higher densities of fast-food and full-service restaurants are not associated with obesity prevalence

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ABSTRACT

Background: The obesity epidemic in the United States has been mirrored by an increase in calories consumed outside of the home and by expansions in the numbers of, and portion sizes at, both fast-food restaurants (FFRs) and full-service restaurants (FSRs), leading some to blame the epidemic on the restaurant industry. If this were indeed true, one would predict that greater per capita densities of FFRs and FSRs would lead to greater obesity prevalence.

Objective: We evaluated the population-level association between both FSRs and FFRs and the prevalence of obesity and calculated the proportion of calories consumed in these establishments.

Design: In this ecological cross-sectional study, we used county-level data (aggregate-level data) for obesity prevalence across the mainland United States in 2012 and matched these data to county-level per capita densities of FFRs and FSRs in the same year. Multiple linear regression was used to determine the relation between the prevalence of obesity and the densities of FFRs and FSRs after adjustment for confounding factors.

Results: Contrary to expectations, obesity prevalence was highly significantly negatively related to the densities of both FFRs and FSRs (combined-effect \( R^2 = 0.195 \)). This was principally because greater numbers of both FFRs and FSRs were located in areas in which individuals were on average wealthier and more educated. When we normalized for these factors (and additional socioeconomic variables), the associations between restaurant densities and obesity effectively disappeared (pooled \( R^2 = 0.008 \)). Our calculations showed that the percentage of total calories consumed in FFRs and FSRs is a mean of only 15.9% of the total intake (maximum: 22.6%).

Conclusions: Variations in the densities of FFRs and FSRs are not linked to the prevalence of obesity in the United States, and food consumed in these establishments is responsible for <20% of total energy intake. This finding has implications for policy decisions regarding how we aim to tackle the obesity epidemic. *Am J Clin Nutr* 2017;106:603–13.

Keywords: fast-food restaurants, full-service restaurants, obesity, total energy intake, county level

INTRODUCTION

Obesity is one of the greatest health issues currently facing the world and is a predisposing factor for several chronic diseases, including cardiovascular disease, hypertension, type 2 diabetes, and cancer (1, 2). Weight gain is a consequence of sustained energy imbalance in which caloric intake exceeds expenditure (3, 4). Whether the primary cause is increasing sedentariness in modern society facilitated by labor-saving devices, increased television viewing and computer use (5, 6), or elevated food consumption (7, 8) has been much debated. Demonstrations that the level of energy expenditure has hardly changed over the course of the epidemic (9) and that the energy gap sufficient for causing the epidemic can be explained by national-level changes in food supply (10) strongly implicate elevated food intake rather than reduced expenditure.

Meals consumed in fast-food restaurants (FFRs) and full-service restaurants (FSRs) are sources of calories that have generated particular interest (11–13). Several lines of evidence implicate this sector of the food industry in the epidemic. The increase of the obesity rate in the United States has been mirrored by an explosion in the number of fast-food establishments (14). Portion sizes in both FFRs and FSRs have similarly increased over time (15), as has the proportion of income spent on eating out of the home (16, 17). Meals consumed outside of the home are significantly larger and contain more calories, more fat (18, 19), and fewer nutrients (20). The high caloric:protein ratio of these foods has been suggested to be a key factor in promoting the overconsumption of calories (21).

Supported by a World Academy of Sciences scholarship from the Chinese government (to MM) and a 1000 Talents Professorship of the Chinese Government and a Wolfson professorship by the Royal Society (to JRS).

The funders took no part in the design, implementation, analysis, or interpretation of the data.

Supplemental Figures 1–4, Supplemental Tables 1 and 2, and Supplemental Material are available from the “Online Supporting Material” link in the online posting of the article and from the same link in the online table of contents at http://ajcn.nutrition.org.

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Abbreviations used: DLW, doubly labeled water; ERS, Economic Research Service; FFR, fast-food restaurant; FSR, full-service restaurant; NAICS, North American Industry Classification System.

Received December 23, 2016. Accepted for publication May 5, 2017.

In addition, it has been suggested that poorer and less educated individuals with a lower socioeconomic status are more likely to choose less healthy options among takeaway foods (22–25), and this dietary pattern has been invoked to explain why there are strong associations between socioeconomic status and obesity (26–28). Adults with a lower educational status have particularly been reported to consume “unhealthy” rather than “healthy” options at fast-food outlets (23, 24), leading to a greater contribution of such foods to their energy and fat intake. Other studies have suggested that individuals with a lower educational status visit fast-food outlets more often than those with a higher educational status (25), but this has not been universally observed. These educationally related differences in consumption have been implicated in the greater prevalence of adiposity among less educated groups (26, 27). Several studies have noted an association between the consumption of fast food and obesity (29–31). Previous studies have also suggested that there is a strong positive association between the availability of fast-food outlets and consumption of fast food (32). Moreover, neighborhood exposure to fast-food outlets has been associated with the greater purchasing (33) and consumption (34–36) of fast foods.

If the restaurant industry is indeed culpable in the obesity epidemic, then given studies that have suggested greater accessibility to such outlets promotes greater consumption, one would predict higher per capita densities of FFRs and FSRs would be associated with a greater prevalence of obesity. Indeed, a previous study (37) indicated that such an association exists at the state level between obesity prevalence and densities of the top 2 fast-food outlets. Moreover, if the associations between poverty and education and obesity are mediated via fast-food consumption, any link of obesity to FFR density would be predicted to disappear when obesity rates are normalized for such factors. We have extended the previous state-level analysis by performing tests of these predictions with the use of the county-level data for obesity prevalence across the United States derived from the behavioral risk-factor surveillance system operated by the CDC combined with data on poverty, education, ethnicity, employment and health insurance status, household income, and recreational facilities from the US census. These data were compared with data on the densities of FFRs and FSRs from USDA Economic Research Service (ERS). In addition, we estimated the contribution of meals consumed at FFRs and FSRs to the total annual calorie intake.

METHODS

Population

The preparation, definition, downloading, and sorting of data on the prevalence of obesity, poverty, and ethnicity have been explained elsewhere (38). Briefly, we downloaded the county-level data on the age-adjusted prevalence of obesity from the CDC website (https://www.cdc.gov/www.cdc.gov). The prevalence of obesity in this database is estimated with the use of data from the CDC behavioral risk-factor surveillance system, which is a monthly state-based telephone survey of a nationally representative sample of adults aged ≥20 y. Because it is a telephone-based survey it excludes individuals living in care homes or those without a telephone. More than 400,000 individuals are contacted annually to take part in the survey, which has been running since 1984. In the telephone interview, individuals report their height and weight in response to the questions “About how much do you weigh without shoes?” and “About how tall are you without shoes?” that are then converted if necessary to kilogram and meters before calculating the BMI (in kg/m²). A BMI >30 is then classed as obese with the use of the WHO standard for Caucasians (39). This is applied independent of actual ethnicity. Individuals normally overestimate their own height and underestimate their own weight in a self-reported setting (40, 41), and hence these estimates are likely to be conservative. However, this bias is unlikely to vary in relation to restaurant density. Obesity prevalence data in 2012 were available for 3138 counties or county equivalents from the continental United States, reflecting a population of ~170 million adults. A previous variogram analysis (38) showed that the county-level data are a suitable spatial scale at which to seek disease associations for obesity prevalence. Previous studies have used the same database to study factors that influence obesity prevalence (42).

Data on employment and health insurance status, household income, and recreational facilities were obtained from County Health Rankings and Roadmaps (www.countyhealthrankings.org), which is a collaboration of the Robert Wood Johnson Foundation and the University of Wisconsin Population Health Institute. This organization compiles data at the county level from several national government sources, including health behaviors, clinical care, socioeconomic factors, and aspects of the physical environment.

FFR and FSR definition

The densities of FFRs and FSRs in 2012 were obtained from the USDA ESR (https://www.ers.usda.gov). The density of the FFRs was defined as the number of FFRs in the county per 1000 county residents. Limited-service restaurants [defined by North American Industry Classification System (NAICS) code 722211] include establishments primarily engaged in providing food services (except snack and nonalcoholic beverage bars) where patrons generally order or select items and pay before eating. Food and drink may be consumed on the premises, taken out, or delivered to the customer’s location. Some establishments in this industry may provide these food services in combination with alcoholic beverage sales. FSRs (defined by NAICS code 722110) include establishments primarily engaged in providing food services to patrons who order and are served while seated (i.e., waiter or waitress service) and pay after eating. These establishments may provide this type of food service to patrons in combination with selling alcoholic beverages, providing takeout services, or presenting live nontheatrical entertainment.

There were 2 counties with much higher numbers of restaurants per capita. We performed the analysis to include or exclude these counties, and this approach had no impact on the findings. Thus, we have included these data in the final analysis. Because some counties contained either no FFRs (n = 44) or FSRs (n = 145), the data were severely nonnormal. We therefore eliminated data for counties in which these values were 0 and normalized the data for the remaining densities with the use of log transformation. Because we had eliminated the counties in which FFRs and FSRs were absent, we performed an additional analysis that compared the levels of obesity (adjusted for poverty, education, and ethnicity) between counties in which FFRs...
and FSRs were either present or absent with the use of 2 sample t tests.

Covariates

Records of county-level poverty (percentage poverty and mean income) and ethnicity were obtained from 2010 US Census Bureau data (www.census.gov/2010census). The distributions of ethnicity data showed heteroscedasticity in the variance. We tried various transformations to remove this heteroscedasticity, but none was completely successful. Fortunately, the outcome of the final analysis was robust in relation to the type of data transformation used. Data on employment status, household income, recreational facilities, and health insurance status were obtained from County Health Rankings and Roadmaps.

Calculation of the contribution of meals consumed at FFRs and FSRs to total calorie intake

To estimate the contribution of meals consumed at FFRs and FSRs to the total annual calorie intake, we combined the state-level data on the annual spent in these establishments with typical costs of meals purchased in the same establishments. This gave us an estimate of the numbers of meals that individuals eat per year in the 2 types of restaurants. We combined these estimates with the estimated energy contents of the meals to obtain an estimate of the calories consumed by the average person in each state in FFRs and FSRs over the course of a year. This was then expressed as a percentage of the total energy intake, which was obtained from the mean energy expenditure derived from doubly labeled water (DLW) measurements divided by the estimated food assimilation efficiency.

In the case of the FFRs, we downloaded the prices of typical meals served in the top 5 fast-food chains (by numbers of locations) that together in 2010 had 38,545 outlets across the United States (http://www.fastfoodmenuprices.com). The estimated example meal prices for these chains were as follows: KFC (2-piece combo meal: $5.99); McDonald's (Big Mac meal: $5.99); Taco Bell (burrito supreme combo meal: $5.79); Wendy's (single burger with cheese combo meal: $6.19); and Burger King (Whopper meal: $6.49). These estimates yielded a mean estimate of $6.09/meal. We then divided the state-level mean expenditures at FFRs by this value (prices of typical meals served in the top 5 fast-food chains) to obtain the number of fast-food meals consumed by the average person in each state in a typical year. We also downloaded data on the mean energy content of these meals from the respective company websites [KFC (690 kcal or 2887 kJ); McDonald's (940 kcal or 3933 kJ); Taco Bell (820 kcal or 3430 kJ); Wendy's (1160 kcal or 4853 kJ); and Burger King (1200 kcal, 5021 kJ)] (mean: 962 kcal or 4025 kJ) (43).

We performed the same calculations for FSRs. The mean price for a meal in an FSR was $9.95 (http://www.ers.usda.gov); dividing this price by the state-level total values of the annual expenditure in FSRs gave the mean number of meals per year consumed at FSRs in each state. The energy obtained from a typical meal (entrée plus sides) in an FSR in the United States is ~1327.0 kcal (5552 kJ) (44).

The mean estimated energy expenditure based on 529 DLW measurements of adults aged 18–96 y (45) living in the Netherlands was 12.4 MJ/d (mean: 14.1 MJ/d for men and 10.7 MJ/d for women) (equivalent to 2964 kcal). Similarly, 319 measurements of adults aged 18–64 y living in affluent communities suggested a mean energy expenditure 11.65 MJ/d (13.2 MJ/d for men and 10.1 MJ/d for women) (46). A review of 13 studies of 393 adults living in the United States gave a mean of 11.95 MJ/d (14.0 MJ/d for men and 9.9 MJ/d for women) (9).

Sensitivity analysis

These estimates depended on several assumptions and were prone to various potential sources of error and bias. We had insufficient data to assess whether energy demands differed across the United States and hence had to assume uniform requirements. Because energy demands depend on body weight, it is likely that mean energy demands are higher in counties and states that have higher prevalence of obesity. If this were the case, then the calculated contribution of restaurant-based food intake to total energy demands would be overestimated in these states. In addition, estimates of energy expenditure were based on a review of DLW studies conducted before 2008. We assumed that there has been no change in the mean level of energy expenditure since that time (consistent with the fact that levels of expenditure have not changed over the previous 25 y) (9). We assumed that the entire annual amount spent at FFRs was divided by the mean price of a fast-food meal across the top 5 fast-food outlets in the United States.

There is, however, a wide range of additional fast-food outlets in the United States and meal sizes, and prices may deviate considerably from the top 5. Moreover, in the absence of data to the contrary, we had to assume that the portion sizes and pricing at these 5 outlets were uniform across the 48 states. For FSRs, we used the energy content of a typical meal (entrée plus sides) based on a study in Boston that suggested a mean meal energy content of 1327 kcal (44). A more recent survey that included a more nationally representative sampling suggested a lower figure of 1205 kcal (47). Thus, the figure we used may be conservative. Again, however, meals differ in both their energy content and pricing. If we take the minimum meal price of $7.99 from http://www.ers.usda.gov and the largest energy content per meal (Italian food: 1755 kcal/meal) (44), this provides a maximal estimate.

Statistical analysis

All variables were tested for normality and normalized where necessary with the use of log or arcsine transformation. We combined the estimated prevalence data for obesity with the density of the FFR and FSR records for each county (identified by the federal information–processing standard code, which is a 5-digit code that allows counties and county-equivalent units to be uniquely identified), and the records of county-level poverty (percentage in poverty), ethnicity (percentage African American), and educational status (percentage with a bachelor’s degree or higher). We investigated the relations between the densities of the 2 restaurant types and the levels of poverty, education, and ethnicity with the use of simple linear regression. We then adjusted the obesity prevalence data for these 3 factors and repeated the regression analysis with FFR and FSR densities as predictors. Finally, we adjusted the obesity rate for several other factors that indicate affluence of an area, specifically unemployment levels, mean household income, availability of recreational facilities,
and health insurance status, and repeated the multiple-regression analysis with FFRs and FSRs as the predictors. The densities of FFRs and FSRs were weakly correlated across counties ($R^2 = 0.059$), but not to an extent that would create major issues of collinearity (variance inflation ratio: 1.15). The natural logarithm of FFRs and FSRs (both +1) were taken to normalize the data. The previously discussed analyses matched obesity prevalence in a given county with the numbers of restaurants in the same county. However, people may dine in restaurants outside their own county, particularly in the neighborhood of their work location. To investigate whether this wider accessibility of restaurants affected the relation, we performed an analysis for the state of Georgia that explored the links of obesity not only to the immediate county but also to neighboring counties (Supplemental Material). All analyses were performed with the use of SPSS version 11.5 (IBM). $P \leq 0.05$ was considered statistically significant.

**RESULTS**

Contrary to our a priori predictions, there was a significant negative relation between the age-adjusted prevalence of obesity and the per capita densities of both FFRs (Figure 1A) and FSRs (Figure 1B). Together, FFRs and FSRs explained 19.5% of the variation of obesity prevalence (FFRs—$b = -2.348$; 95% CI: $-4.49, -2.28$; $t = -6.75$; $P < 0.001$) (FSRs—$b = -7.63$; 95% CI: $-8.32, -6.94$; $t = -21.61$; $P < 0.001$) (overall $F_2, 2975 = 360.7; P < 0.001$) (Figure 1A, B, Table 1). Both FFRs and FSRs were more frequently found in areas in which the population was wealthier (Figure 2A, B) and more highly educated (Figure 2C, D) and for FSRs had a lower proportion of African Americans (Figure 2E, F). When we adjusted the prevalence of obesity for these 3 factors (poverty, ethnicity, and education), FFRs and FSRs together explained only 2.6% of the variation in obesity prevalence (FFRs—$b = -0.04$; 95% CI: $-0.24, 0.23$; $t = -0.031$; $P = 0.975$) (FSRs—$b = -0.691$; 95% CI: $-0.85, -0.52$; $t = -0.27$; $P < 0.001$) (overall $F_2, 2973 = 39.8; P < 0.0001$) (Figure 3A, B, Table 1). We further adjusted the prevalence of obesity to account for other factors linked to affluence, including percentage unemployment, mean household income, numbers of recreational facilities, and percentage of the population that had health insurance. Once these factors were also taken into account, FFRs and FSRs together explained only 0.8% of the spatial variation in obesity prevalence, although because of the very large sample size, this was still statistically significant (overall $F_2, 2950= 11.3; P < 0.001$) (Figure 3C, D). When we compared the obesity prevalence in counties in which FFRs or FSRs were present or absent, there was no significant difference (FFRs: $t = -0.801$; $P = 0.423$) (FSRs: $t = -0.269$; $P = 0.788$) (Figure 4A, B, Table 1), suggesting that the absence of a relation was not because of the densities always being above a threshold at which there is no marginal impact.

Because of grade effects, it is possible for a national survey that combines data across states to obscure trends that are evident at the state level. To evaluate whether this was the reason for the very low $R^2$ in the previously discussed analysis, we repeated the analysis for each state separately (Supplemental Table 1). This
analysis revealed that in the vast majority of states (n = 33 of 48), both FFRs and FSRs were not significantly associated with obesity prevalence. In 11 states, the effect of FFRs was not significant, but FSRs had a significant negative effect. FSRs in 3 states were not significant, but FFRs had a significant positive effect, and in another single state FSRs had a significant negative association, whereas FFRs had a significant positive effect. Hence, inappropriate pooling of data across states cannot explain the effective absence of an association of FFR and FFR densities with obesity prevalence at the national level. Furthermore, there was a significant weak negative relation between the adjusted prevalence of obesity and per capita density of FFRs at the state level (R² = 0.020; P = 0.001) (Figure 1A). We divided the state-level mean expenditures at FFRs by $6.09 (estimated example meal prices in 5 top FFRs). The mean annual expenditure in FFRs in the United States was $628.79, thus suggesting that a typical citizen eats 66.9 fast-food meals/y (~1 meal every 3.5 d). We also downloaded data on the mean energy content of these meals at those FFRs (mean: 962 kcal or 4025 kJ) and thus could calculate for each state the annual energy intake at FFRs, which across all states was a mean of 99.4 Mcal (415.8 MJ). We performed the same calculation for FSRs. Nationally, the mean annual amount spent at FSRs was $655.91, which indicated a mean consumption of 65.9 meals at FSRs/y (just >1 time/wk). These data suggest that in a typical week an average US citizen consumes ~2 fast-food meals outside of the home and 1 full-service meal. Because we already knew that energy obtained from a typical meal (entrée plus sides) in an FSR in the United States is ~1327.0 kcal (5552 kJ), we multiplied the state-level numbers of FSR meals consumed per year to obtain the total energy intake per year from FSRs for each state. The mean national consumption was 87.4 Mcal (365.9 MJ).

With the use of 11.95 MJ/d (2856 kcal/d) as a mean estimated energy expenditure for a typical US adult across the life span and assuming the assimilation of food is 90% efficient, this indicates a mean daily energy intake of 13.27 MJ/d (3173 kcal/d) and gives a mean total annual energy intake of 1158 Mcal (4844 MJ). We applied this value to each state to obtain the percentage contribution of FFR- and FSR-derived intakes to total energy intake. Nationally, the figures suggest 8.58% annual energy is sourced at FFRs and 7.55% at FSRs, together constituting 15.9% (statewide data shown in Supplemental Table 2).

If we take the fast-food meal that provides the greatest amount of energy per dollar spent (Wendy’s: 187 kcal/US dollar), this gives a total annual intake at FFRs of 117.6 Mcal/y (492 MJ/y). This is 10.2% of the annual food intake. If we take the minimum meal price of $7.99, that leads to an intake of 82 full-service meals/y; when combining this intake amount with the largest energy content per meal (Italian food: 1755 kcal/meal), that yields 143 Mcal/y (602.1 MJ/y), which is 12.4% of the annual energy requirements and—combined with the maximal FFR estimate—comes to 22.6% of the total energy intake. This is probably a maximal estimate for the contribution of restaurant food to total annual intake.

**DISCUSSION**

Our a priori prediction that FFRs and FSRs would be positively linked to obesity prevalence was not supported. Indeed, we observed the opposite relation for the unadjusted prevalence, primarily because FFRs and FSRs were more likely to be located in areas in which the population was more affluent and more educated. However, these characteristics were negatively associated with obesity prevalence (38). Although high obesity among the poor and less educated has often been blamed on the high consumption of foods from FFRs, some previous studies have suggested that people in the middle-income range consumed the most calories from FFRs compared with those in the low- and high-income categories (48, 49). In both Australia and the United States, the consumption of fast food has been associated with higher incomes (50–52), and in the latter being employed was also positively associated with more fast-food consumption (30, 31). In the light of these trends it makes sound commercial sense for restauranteurs to locate their premises in areas with more affluent populations that also on average have lower mean obesity prevalence, leading to the negative association we observed. Previous work with the use of census tract data has also indicated that middle-income neighborhoods had the highest number of both FFRs and FSRs and that both types of restaurants were much less prevalent in areas with high African American populations (53). This negative association between total restaurant availability was
also shown in a previous analysis of county-level data that included a smaller subset \( (n = 554) \) of the total number of counties \( (54) \). This negative association was because of such confounding variables, and when we removed the confounding effects of affluence and ethnicity on obesity this effectively completely removed any association between the density of both restaurant types and obesity prevalence (the pooled \( R^2 \) decreased from 0.195 to 0.008).

These findings differ from the results of a previous study that found that obesity prevalence at the state level (adjusted for age, ethnicity, fruit and vegetable consumption, and physical inactivity) was linked to the per capita FFR density \( (37) \). We also analyzed the country-level data pooled together at the state level, and this analysis recapitulated our findings at the county level that there was a weak negative association (Figure 5). Hence, the difference between the studies was not because of some intrinsic difference in the spatial scales at which the analyses were performed. The source of the data for obesity prevalence was the same (CDC) for both the previous studies and those presented herein, although there was a difference in the timing of the surveys that were included in the analysis. The main difference

**FIGURE 2** Associations between FFR and FSR densities with percentage of poverty (A and B), educational status (C and D), and percentage of African Americans (E and F) across the mainland United States. The log-transformed numbers per 1000 population (+1) for FFRs and FSRs are shown in panels A, C, and E and B, D, and F, respectively. FFR, fast-food restaurant; FSR, full-service restaurant.
between our study and this previous work was the source of data for the numbers of FFRs per capita. In our study, these data were obtained from the USDA ERS and include all establishments that met the NAICS-defined criteria for the given establishments in 2012. The previous study, however, concerned only the numbers of restaurants in the top 2 fast-food chains that were obtained from listings in the Yellow Pages. In 2004, these numbers constituted 59.7% of the top 10 chain outlets and must therefore have been a much smaller percentage of all outlets, including small local chains and outlets with no chain affiliation. In fact, the mean per capita density of these outlets in 2004 (0.08 restaurants/1000 people) was only 14.5% of the mean density of all FFRs reported here (0.55 restaurants/1000 people). The previous association for the restricted subset of restaurants may not then be reflective of the overall pattern when all outlets are included.

The absence of an effect of FFRs and FSRs on obesity rates might have come about for several different reasons, apart from the possibility that there is no actual association. First, our analysis matches the densities of restaurants in a given county with the prevalence of obesity in individuals that are residents of that county. However, individuals may consume foods at

**FIGURE 3** Associations between FFR and FSR densities with adjusted prevalence of obesity across the mainland United States. Plots show the county-level data \((n = 2994)\) for obesity prevalence adjusted for age, ethnicity, poverty, and educational status (A and B) and obesity prevalence adjusted for age, ethnicity, poverty, educational and employment status, household income, insurance status, and recreational facilities (C and D), respectively, against log-transformed numbers per 1000 population (+1) of FFRs (A and C) and FSRs (B and D). FFR, fast-food restaurant; FSR, full-service restaurant.
FFR and FSR establishments in the vicinity of their places of work as much as in the neighborhood of their homes. Hence, if individuals routinely worked outside their own county, this could obscure any trends between FFR and FSR densities and obesity prevalence. We tested whether this was a possible explanation by analyzing data from the state of Georgia, where we examined the association between obesity prevalence (adjusted for poverty, ethnicity, and education) and the densities of FFRs and FSRs (Supplemental Figures 1 and 2), and in this case the pooled and individual effects were not significant (overall $F_{2, 147} = 1.8; \ P = 0.162$). We then repeated the analysis, but in this second analysis we compared the level of obesity in a target county with the numbers of FFRs and FSRs in that county plus all the immediate neighboring counties. We obtained the same result in this analysis that the overall effect and individual FFR and FSR effects were also not significant (Supplemental Figures 3 and 4) (overall $F_{2, 109} = 2.3; \ P = 0.111$). Hence, the absence of a relation in the national data is probably not because people routinely dine outside their own county, notably when working, but rather because the distances that people commute to work is on average less than the radius of the average US county. For example, if we assume that counties are roughly circular, then given the mean county area across the United States of 622.0 square miles (1610 km$^2$) (http://www.census.gov/main/www/cen2000.html), then this gives a mean radius of 22.6 km. Data on commuting distances suggest that a mean of 83% of the commutes from home to work in the United States is less than this distance (55).

A second potential reason is the opposite problem—that county-level data may obscure associations at smaller spatial scales. In other words, if FFRs and FSRs are not evenly distributed throughout each county, then clusters of restaurants may be spatially associated with localized clusters of larger numbers of people with obesity. Several previous studies have looked at the food environment surrounding the homes of focal individuals with the use of various radii (3–2 miles (3.2 km) to see whether there is an association between the local numbers of FFRs and individual BMIs. Most of these studies showed no association (56–58), extremely weak positive associations (59, 60), or associations only in certain groups [e.g., low-income individuals (61)]. Similarly, studies that used zip code areas as the sampling unit (generally zip code areas are smaller than counties) have failed to find associations between local fast-food establishment density and obesity (62, 63). Nevertheless, some studies have reported small area–positive associations between FFR densities and BMIs (64) or adolescent BMIs and the proximity of their schools to FFRs (65), although in these latter cases confounding factors included greater soda consumption of children attending schools near FFRs. On balance, although the evidence is mixed, it does not point strongly to an association between obesity and FFR density at a smaller spatial scale than the county. This is also consistent with a recent review of such studies that concluded

FIGURE 4 Comparison of obesity prevalence in US counties with or without FFRs (A) and FSRs (B) adjusted for age, poverty, ethnicity, and educational status. FFR, fast-food restaurant; FSR, full-service restaurant.
that most associations were not significant (66). Moreover, it has been suggested in another systematic review of fast-food access studies (67) that based on the heterogeneity between our studies, further work is needed to understand whether and how fast-food access affects dietary intake and health outcomes.

A third potential reason is that increasing FFRs and FSRs may stimulate increased obesity prevalence, but at some point adding further restaurants does not further stimulate the consumption of food out of the home. Hence, there may be no relation because across the United States densities of both FFRs and FSRs may be above this critical limit. This effect might be exacerbated by the analysis we performed. Because of issues with the normality of the data, we eliminated from the analysis any counties in which there were no FFRs (n = 145) or FSRs (n = 44). We did not have access to county-level financial expenditure data to test whether the expenditure and intake in FFRs and FSRs increase in relation to the number of local restaurants. Previous studies have indicated such an association (32–35), but this finding is not universal (68).

The absence of an association between both FFR and FSR densities and obesity prevalence is therefore possible because these restaurants represent only a small percentage of the obesity problem. Similar conclusions were recently reached with respect to the contribution of fast foods from the West to the growing obesity epidemic in China (69). How can these conclusions be reconciled with evidence that has shown that eating food away from the home in the United States has increased enormously while portion sizes in such outlets have also increased (48, 70)? We used the data from mean annual individual expenditures in such restaurants at the state level (USDA ESR) with the mean price of fast-food and full-service meals and the mean calories in such meals as models for the mean annual consumption of energy at both FFR and FSR establishments. Our estimate for FFR meals was similar to but slightly lower than the number of fast-food meals reported to be consumed each week (mean: 2.46) in a national direct survey of 13,000 young adults living across the United States (68). We then compared these data to the mean annual consumption of energy based on a review of DLW measurements made across the United States (9). These calculations indicate that the consumption of fast-food comprises only a mean of 8.58% of the total annual food consumption, whereas FSRs contribute 7.6%. Hence, across the entire United States, food consumed at FFRs and FSRs accounts for a mean of only 15.9% of the total consumption of calories. A sensitivity analysis suggested that this could be maximally 22.6% of the total intake. These estimates are consistent with reports that on days when individuals ate fast food it provided >33% of the calories for that day but that a mean of 25% of the individuals in the same survey reported eating fast food on the survey days, indicating that the contribution of fast-food calories was only a mean of 8.25% over all days when fast food was consumed or not (71). Such calculations provide a context for understanding why the densities of FFRs and FSRs are not linked to obesity prevalence and suggest the main driver of obesity is probably calories consumed away from these establishments, which makes up by far the larger percentage of total caloric consumption.

In this study, we evaluated the association of obesity prevalence among US adults with both FSRs and FFRs and adjusted for a wide range of the socioeconomic factors to decrease the chance of residual bias. The data sources we used in the primary analysis were all from well-established and respected US government departments, including the CDC for the obesity prevalence data and USDA for the densities of FFRs and FSRs defined with the use of NAICS criteria. County demographics used as covariates were derived from the US Census or from the County Health Rankings and Roadmaps, which itself generates information primarily from government sources. Although these sources are independent and unimpeachable, some of the data are potentially prone to error; e.g., the measures of obesity (BMI) were based on self-reported heights and weights, which are likely to be conservative. In the secondary analysis we used data from the DLW method, which is the gold standard of energy measurement, to estimate the percentage of total daily intake that is derived from FFR and FSR sources. However, the findings of our study should be considered within the context of some clear limitations. This study was cross-sectional and like all such studies has problems in defining exposure-outcome temporal relations. Moreover, with the use of aggregated ecological data such as these, it is not possible to infer individual-level behavior. In particular, it is important to emphasize that the absence of a relation at the population level...
between obesity prevalence and the restaurant densities shown here does not mean that a given individual could eat large amounts of meals served in FFRs and FSRs without health consequences.

Nevertheless, these data do have broad implications for how governments attempt to tackle the obesity epidemic. FFRs and FSRs are easy targets for imposing taxes to provide negative incentives for dining in these establishments. However, because we show that a relatively small proportion of total calories are consumed in these establishments (~15.9%), this may not be the most effective strategy for curbing total energy intake. This is because a relatively large change in consumer behavior at these locations would be necessary to produce a modest reduction in total energy consumption. For example, on average, these figures imply that to reduce total energy consumption by 4% would require a mean reduction of food consumption in FFRs and FSRs by 25%. Focusing attention on reducing calories consumed away from these establishments may then be a more effective strategy.

The authors’ responsibilities were as follows—MM: collected, analyzed, and interpreted the data and drafted the manuscript; JRS: conceived and designed the study, interpreted the data, and critically revised the manuscript; and both authors: read and approved the final manuscript. Neither author declared any competing financial interests, conflicts of interest, or direct association with the fast-food or full-service restaurant food industries. JRS has historically had several links with food industries, none of which were directly involved with fast-food or full-service provision: He was formerly a member of the Scientific Advisory Board of the Waltham Centre for Pet Nutrition (WCPN), a subsidiary of the Mars corporation, and was remunerated for that role. He spoke twice at Waltham symposia on issues relating to energy balance and was also paid for these presentations. Between 1993 and 2006, he was also the recipient of several grants from WCPN and co-supervised several students who worked on issues relating to pet nutrition (grant total of <$500,000). JRS has made invited presentations at the headquarters of 2 major suppliers of beverages that are supplied in fast-food outlets—PepsiCo (Houston, TX) and The Coca-Cola Company (Atlanta, GA)—both times on the role of energy expenditure in the obesity epidemic, and was paid expenses for both of these presentations. JRS is also a shareholder in the iDiet company (shareholding <$100,000).

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