Adult Obesity and Food Stores' Density – Evidence from State-Level Panel Data

Alessandro Bonanno and Stephan J. Goetz

Alessandro Bonanno is Assistant Professor of Agricultural Economics at Penn State University. Stephan J. Goetz is the Director of The Northeast Regional Center for Rural Development and Professor of Agricultural and Regional Economics at Penn State University.

Selected Paper prepared for presentation at the Agricultural & Applied Economics Association 2010 AAEA,CAES, & WAEA Joint Annual Meeting, Denver, Colorado, July 25-27, 2010

Adult Obesity and Food Stores' Density – Evidence from State-Level Panel Data

By

Alessandro Bonanno and Stephan J. Goetz

Abstract

The association between types of food access and rising adult obesity rates is increasingly recognized, as a complement to the effects of declining physical activity. Previous studies have examined the effects on obesity of only a limited set of store types, such as grocery stores, fast food restaurants and big-box retailers, and they have ignored that certain behavioral factors, such as could play a role in the relationship between food access and obesity. This analysis includes a comprehensive array of food-providing establishments, including limited- and full-service restaurants controlling for fruit-and-vegetables (F&V) consumption (lagged temporally) using a panel data set for the continental U.S. states covering the period 1997-2005. The results show clearly that the density of food stores across the states matters. In addition, important and subtle nuances emerge in the relationships among obesity, F&V consumption and the different types of stores when we allow for interaction effects.

JEL Classification: D12; I19; R23

Introduction

The dramatic increase in American obesity rates has attracted scientists from a variety of disciplines who seek to better understand the physiological, behavioral, and ecological causes of what has been labeled an "epidemic." In the period 2007-2008 the rate of the adult U.S. population being obese, or with a with a body mass index (BMI) equal to or above 30, was 33.8%, while that of overweight and obese population combined (BMI > 25) was 68.0% (Flegal et al. 2010). Within economics, several authors have examined the role of food outlets, primarily fast-food restaurants, as a determinant of the high-caloric intake diets which are at the base of the general increase in the population's BMI (see Philipson and Posner, forthcoming, for a review). The evidence overall is mixed and depends on the type of data used and the geography considered (White 2008).

For example, combining state-level data with individual demographic and weight data from the Behavioral Risk Factor Surveillance Survey (BRFSS) Chou et al. (2004) found a positive, but decreasing effect of restaurants' density on BMI. Using an extensive database from California public schools matched with geo-referenced information from the National Establishment Time Series Database, Currie et al. (2009) found that the nearby presence of fast food restaurants to a school is positively associated with childhood obesity and weight of pregnant women. Similarly, using geo-referenced micro data from the Indianapolis urban area, Chen at al. (2009) found a positive (negative) relationship between the densities of fast food restaurants (grocery stores) and BMI. Conversely, Schafft, Jensen and Hinrichs (2009) find that BMIs of children are higher in those Pennsylvania school districts that are also classified as food deserts – defined as areas with "poor or uneven access to full-service grocery stores" (p.155).

Using food-intake micro data and correcting for endogenous location of establishments, Anderson and Matsa (2009) found no casual link between food consumption at restaurants (both fast-food and full service restaurants) and obesity, suggesting that individuals who consume more meals at restaurants are likely to offset these calories by eating less at other occasions. Dunn (2008) used an IV approach on 2005 Behavioral Risk Factor Surveillance Survey micro data and self-collected data on the density of fast-food restaurants, and found find a positive effect of fast foods' densities on BMI.

Furthermore, the current literature focuses on one, and at most two different types of food outlets, and it ignores the fact that consumers have available and choose among more types. For example, although recently more than 30% of consumers' expenditure for food-at-home are made in non-traditional food retailers (Martinez, 2007), of which 54% occur in supercenters, little research examines the impact of the presence of non-traditional food retailers on the share of overweight or obese population. To that regard Courtemanche and Carden (2010) examined the effect of Wal-Mart Supercenters on obesity rates using individual-level responses to the BRFSS matched geographically to locations and entry dates of the big-box chain, hypothesizing that income and substitution effects lead to consumption of healthier foods that is in turn reflected in lower obesity rates. Using IV estimation and controlling for socio-demographic factors, they find that a greater store density is associated with higher BMIs over the period 1997-2005.

While previous papers have examined the effect of grocery stores, limited service restaurants and big-box retailers on obesity rates, they have ignored the contemporaneous effect that all of them could have on obesity. One exception is Morland et al. (2006) who analyzed the contemporaneous presence of supermarkets, grocery stores, and convenience stores, on the likelihood of being overweight, obese, or of suffering from diabetes and hypertension.[1]

Furthermore, in spite of the relationship between fruit and vegetables consumption and lower BMI has already been established in the literature (see for example Lin and Morrison, 2002), none of the study illustrated above has accounted for the role of consumers' diet in evaluating the impact of food access (or lack thereof) on obesity. As there is evidence that individuals self-select into neighborhoods that would match their propensity to engage in obesogenic lifestyles (Eid at al., 2007),[2] controlling for eating habits (and other behaviors) may mitigate the effect self-selection in assessing the impact of food access on obesity.

In this paper we analyze the relationship between adult obesity rates and the density of grocery stores, fruit and vegetable stores, Wal-Mart Supercenters, and full and limited service restaurants, using a panel of publicly available state-level data from various sources (BRFSS, Bureau of Labor Statistics, Population Estimate Program), accounting for healthy eating habits (the percentage of adults eating at least five servings of fruit and vegetables a day). Our empirical procedure accounts for the endogeneity of the healthy eating habits measure as well as that of Wal-Mart's stores location. We also control for population characteristics and allow for

[1] Morland et al (2006) used the Atherosclerosis Risk in Communities (ARIC) study participants' data matched with census track food-store location data. They found that, while supermarket's presence has a beneficial impact on obesity and overweight, the presence of grocery stores and convenience stores was positively associated with the prevalence of overweight, obesity, diabetes and hypertension.

[2] Eid et al (2007) looked at changed in body weight of individuals that moved to neighborhoods characterized by different levels of urban sprawl using the Confidential Geocode Data of the National Longitudinal Survey of Youth 1979 (nlsy79) of the us Bureau of Labor Statistics. Their findings indicate that higher obesity rates in 'sprawling' areas are due to individuals' self-selection, i.e. that people with a propensity for obesity tend to locate into sprawling neighborhoods.

non-linearities in the relationship between food stores and obesity, and also examine interactions between food stores' density and adults' eating habits.

The results show a strong and negative relationship between adult obesity and healthy eating as well as the density of fruit and vegetables stores and full-service restaurants, while the relationship between obesity rates and Wal-Mart supercenters is positive but weaker than the former. The relationship between adult obesity, grocery stores, limited service restaurants' and full service restaurants' density is and complex. In particular, interacting food-stores' density with the percentage of adults consuming fruits and vegetables five times a day, the results show that most types of food stores density measures are associated with a marginal variation in the adult obesity rate, either when the percentage of adults eating healthy is large (positive, in the case of grocery stores, negative in the case of fruit and vegetables stores and full service restaurant) or very small (and positive in the case of Wal-Mart supercenters), suggesting that a trade-off exists between food access, eating habits and type of food stores.

2. The model

We posit a simple empirical model that builds on the previous literature and is grounded in household utility maximization, taking into account exogenous socio-demographic control variables, relative prices of (or access to) different kinds of foods, and behavioral variables:

$$BMI = f(He, F, B \mid \Omega); \qquad (1)$$

where *BMI* is the body mass index; *He* represents healthy eating habits; *B* is a vector of consumers' socio demographics (including number of children, age, gender and ethnicity) and other behavioral (physical activity and smoking) characteristics[3]; *F* is a vector representing access to alternative food delivery technologies (i.e. food outlets, detailed below) that reflect both different qualities of food and opportunity costs of time related to food preparation; and Ω is a vector of parameters representing the individual's taste for different food outlets (i.e. types of foods) and the quantification of the relationship between habits and socio-demographic characteristics and obesity.

The focus on the variable *He* is crucial to understand the relationship between the built environment (food access) and obesity. Having access to the same assortments of options, consumers who eat healthy may have (*ceteris paribus*) a lower likelihood of becoming obese as they would likely choose the healthier alternatives. This fact has been almost completely disregarded in the literature on obesity and food access which appears, for example, to assume that unhealthy choices are automatic if consumers have access to fast food restaurants.

The most commonly used specification for equation (1) in the literature sees the relationship between obesity and a series of explanatory variables to be linear (see for example Eid et al., 2007; Dunn, 2008; Anderson and Matsa, 2009; Courtemanche and Carden, 2010). In the context of this analysis we specify:

$$BMI_{it} = \alpha + \sum_k \gamma_k B_{kit} + \sum_j \delta_j F_{jit} + \sum_s \nu_s div_s + \sum_t \theta_t T_t + \varepsilon_{it} \qquad (2\text{-a})$$

$$BMI_{it} = \alpha + \beta He_{it-1} + \sum_k \gamma_k B_{kit} + \sum_j \delta_j F_{jit} + \sum_s \nu_s div_s + \sum_t \theta_t T_t + \varepsilon_{it} \qquad (2\text{-b})$$

Where *He, B, F* are described above, α, β, γ and $, \delta_j$ are elements of Ω, *div* and *T* represent regional fixed effects and time dummies respectively, ν_s and $, \theta_t$ are their coefficients

[3] See Table 1 and Section 3 (Data and Estimation) for a description of the socio demographics characteristics and behavioral variables that enter the BMI equation.

and the ε_{it} s are idiosyncratic error terms. Note that a one-period lag of healthy eating is used to avoid reverse causality as the diet could be correlated with unobservables impacting obesity. The other key variables in the model are the *Fs* where *j*=1…5, or grocery stores, fruits and vegetables stores, full-service restaurants, limited service restaurants and non-traditional food retailers (Wal-Mart Supercenters). Models (2-a) and (2-b) will be referred to as the baseline models.

Other analyses have included non-linearity in the relationship between food access and obesity (Chou et al. 2004). As additional empirical tests, quadratic food-access specifications mirroring the baseline models are

$$BMI_{it} = \alpha + \sum_k \gamma_k B_{kit} + \sum_j \left(\delta_j^1 F_{jit} + \delta_j^2 F_{jit}^2 \right) + \sum_s \nu_s div_s + \sum_t \theta_t T_t + \varepsilon_{it} \tag{3-a}$$

$$BMI_{it} = \alpha + \beta He_{it-1} + \sum_k \gamma_k B_{kit} + \sum_j \left(\delta_j^1 F_{jit} + \delta_j^2 F_{jit}^2 \right) + \sum_s \nu_s div_s + \sum_t \theta_t T_t + \varepsilon_{it} \tag{3-b}$$

Models (2-b) and (3-b) only allow eating habits to play a simple role by shifting the average BMI across regions. However the effect of eating habits on obesity may be different depending upon the methods which food is delivered. For example, fruits and vegetables can be "delivered" differently to consumer in different formats (a salad made with fresh greens at home may contain different calories than one purchased at a fast food restaurant, because of particular dressings associated with it). At the same time, the impact of food access of BMI can be different depending upon how consumers are going to use the "technology" at their disposal, i.e. whether or not they engage in healthier eating habits even if they have access to more fresh food. To capture the nature of the interaction between the built environment (i.e. food access), a different specification of the model is:

$$BMI_{it} = \alpha + \sum_k \gamma_k B_{kit} + \sum_j \left(\eta_j + \lambda_j He_{it-1} \right) F_{jit} + \sum_s \nu_s div_s + \sum_t \theta_t T_t + \varepsilon_{it} \tag{4-a}$$

$$BMI_{it} = \alpha + \beta He_{it-1} + \sum_k \gamma_k B_{kit} + \sum_j \left(\eta_j + \lambda_j He_{it-1}\right) F_{jit} + \sum_s \nu_s div_s + \sum_t \theta_t T_t + \varepsilon_{it} \qquad (4\text{-b})$$

where the marginal effects of food access and eating habits (respectively) are:

$$\frac{\partial BMI_{it}}{\partial F_{jit}} = \eta_j + \lambda_j He_{it-1} \text{ and} \qquad (5\text{-a})$$

$$\frac{\partial BMI_{it}}{\partial He_{it-1}} = \beta + \sum_j \lambda_j F_{jit} \qquad (5\text{-b})$$

Furthermore, it is easy to verify that equations (3) and (4) are nested in (2), which allows empirical testing of whether they are statistically equivalent to the baseline model.

3. Data and Estimation

The main data used in the analysis are state-level aggregates from the "Prevalence and Trends Data" of the Center of Disease Control and Prevention's (CDC) Behavioral Risk Factor Surveillance System (BRFSS) survey, available at the CDC website (http://www.cdc.gov/brfss/). The BRFSS is an on-going telephone health survey system, which tracks the health conditions and risk behaviors of the U.S. population and collects data on three types of information: 1) individuals' habits, such as smoking, physical activity, alcohol consumption; 2) health status and health prevention measures, e.g., whether the respondents had high blood pressure, high cholesterol level, access to healthcare etc., and 3) respondents' socio-demographic characteristics such as number of children in the household, age and gender.

Specifically, the BRFSS contains data on height and weight of the respondents, which are used to calculate values of Body-Mass-Index (BMI), dividing weight in kilograms by height squared in meters. In the present study we refer to "adult obesity incidence" as the percentage of adult population, in each state, whose BMI is 30 and above.[4] The BRFSS also contains information on the percentage of "*Adults who have consumed fruits and vegetables five or more times per day*" which is used as proxy for healthy eating habits (referred to as "fruits and vegetables consumption" or "healthy eating" in the remainder of the paper).

Although the BRFSS Prevalence and Trends Data are available starting in 1984, we limit our analysis to the period 1996-2005 to avoid problems arising from changes in the Census' industry classification that occurred in 1997.[5] Data on the number of food outlets are obtained from the U.S. Bureau of Labor Statistic. The industries included are NAICS 4451 – Grocery Stores (establishments primarily engaged in retailing a general line of food products), NAICS 44523 – Fruit and Vegetables Stores (primarily engaged in retailing fresh fruits and vegetables); NAICS 7222 – Limited Service Restaurants[6] and NAICS 722[7] – Food Services and Drinking Places. The number of limited service restaurants is used as proxy for fast food presence while the difference between the number of establishments in NAICS 722 and NAICS 7222 captures the presence of full-service restaurants. The state-level number of Wal-Mart supercenters is obtained from the company's annual shareholder reports. As Wal-Mart is the foremost

---

[4] The CDC classification of BMI is: Below 18.5: Underweight; 18.5 to 24.9 Normal weight; 25 – 29.9 Overweight and above 30 obese.

[5] As the system switched from the SIC 1987 to the NAICS 1997 systems, some of the industries used in this analysis lacked correspondence between the two classification codes.

[6] Official definition: *This industry group comprises establishments primarily engaged in providing food services where patrons generally order or select items and pay before eating. Most establishments do not have waiter/waitress service, but some provide limited service, such as cooking to order (i.e., per special request), bringing food to seated customers, or providing off-site delivery.*

[7] Official definition: *Industries in the Food Services and Drinking Places subsector prepare meals, snacks, and beverages to customer order for immediate on-premises and off-premises consumption. There is a wide range of establishments in these industries. Some provide food and drink only; while others provide various combinations of seating space, waiter/waitress services and incidental amenities, such as limited entertainment.* […] *The industry groups are full-service restaurants; limited-service eating places; special food services, such as food service contractors, caterers, and mobile food services; and drinking places* […].

supercenter representative, its presence is used as proxy of non-traditional food retail outlets. Food access is measured by the state-level number of stores divided by the population. Total population and other demographics (population belonging to different ethnic groups, average age) are from the U.S. Bureau of Census Population Estimates Program.

The data used in the estimation cover the years 1997-2005 for 47 continental states,[8] for a total of 423 observations. As the data on fruits and vegetables consumption and for some of the other regressors included as controls in the models (for example physical activity levels) are not available for all the years, the missing observations are recovered using linear interpolation. The 1996 observations for fruit and vegetable consumption are used to create lags. A summary of the variables that will be used in the estimation is provided in Table 1, along with descriptive statistics; plots of the incidence of adult obesity versus healthy eating habits and the measures of food stores density are reported in Figure 1.

Tests for the endogeneity of fruit and vegetable consumption were performed using a series of Hausman (1978) tests on the different specification of the model, using lagged fruit and vegetables consumption as an instrument. Since current fruit and vegetable consumption was found to be endogenous, its value lagged by one year was used instead in the estimation of the main model. An additional empirical issue that arises is that Wal-Mart's supercenters' location may be endogenous, as the company follows a specific expansion strategy that targets areas where competition is scant and where consumers have larger need for "Wal-Mart-like" stores (Walton and Huey, 1992). Alternatively, Wal-Mart may seek to locate in places with higher obesity rates, as this correlates with socio-demographics such as income or poverty rate. To account for endogeneity of Wal-Mart's supercenter locations we use the fact that the company

[8] Utah was excluded from the sample because of missing observations in the BRFSS data.

has capitalized heavily on the conversion of its mass merchandize format, the Discount Stores into supercenters (Bonanno, 2010). The current number of supercenters is regressed on the lagged number of discount stores state-level fixed effects and year dummies. The predicted number of stores is then divided by total population (in hundreds of thousands) and the variable used in the estimation.[9] Once all the variables are operational and appropriately instrumented, the different versions of the models are estimated including U.S. Census division-level fixed effects and year dummies to help controlling for the panel nature of the data in STATA v. 10.

4. Econometric results

This section is organized into two parts. A discussion of the empirical results of the baseline models (equations 2-a, and 2-b) and the quadratic models (equations 3-a, and 3-b) is presented first, followed by an illustration of the results of the interaction models (equations 5-a and 5-b). The estimates of the linear, quadratic and the interacted specifications are reported, respectively, in tables 2, 3 and 5;[10] the marginal effects of food stores density on adult obesity for the non-linear models are reported in tables 4 and 6. The results of all the models show high levels of goodness of fits (the R-squared exceed 0.9 in all models) and the estimated coefficients jointly differ from 0 at the 1% level.

4.1 Linear and quadratic specification

[9] Detailed results for the OLS regression used to instrumentalize the number of Wal-Mart are omitted for brevity. The R-squared value was 0.94 and the coefficients for the lags of the number of discount stores are significant at the 0.1 % level, while most of the state-level fixed effects and year dummies were significant at the 5% level.

[10] The coefficients for the division fixed-effects and the year dummies are omitted from brevity.

Consistent with previous literature (Lee and Morrison, 2002), the percent of population engaging in healthy eating is negatively related with adult obesity incidence, its coefficients being negative and highly significant in the linear model, while only marginally significant in the quadratic model. The small magnitude of the estimated parameters (-0.0432 and -0.0450, for the baseline and quadratic model, respectively), imply that, in order to decrease the incidence of adult obesity by 1 percentage point, considerable effort would be required in "educating" individuals about the benefits of healthy eating, equal to increasing the percentage of population eating fruit and vegetables five times a day by a percentage close to 21 % (*ceteris paribus*). Alternatively, the relative price reduction needed to induce substitution towards greater consumption of fruits and vegetables would be substantial. This result is consistent with other findings suggesting that public expenditure on nutrition education should increase by 22.73 times to reduce the average BMI in the adult population from 26.66 to 32 Kg/m^2 (McGeary, 2009).

In discussing the impact of the demographic characteristics on adult obesity incidence, notice first that, at the aggregate level, physical activity, smoking, gender composition (percentage female) and average age do not impact adult obesity incidence, or impact it only marginally and with the unexpected sign (see for example the positive and significant parameter for physical activity). Although these variables have been found in several studies to have a significant impact on obesity, their lack of significance (or the "perverse" sign of physical activity) in this analysis may be mostly due to their level of aggregation and to their small coefficient of variation[11] – suggesting that only through more detailed data can one disentangle the relationships between those variables and adult obesity.

[11] The coefficient of variation for the dependent variable is approximately 0.1604; that for age is 0.0323, for the % population being female (male) is 0.0156 (0.0167) and for the percentage population being physically active is 0.0689.

However, other socio-demographics characteristics behave as expected. In particular, per capita income is negatively related with a higher incidence of adult obesity, with an effect indicating that, on average, an increase in per capita income of 10,000 $ is related with a decrease in the incidence of adult obesity varying from -0.9 to -1.2 points, the magnitude of the coefficients being smaller in the baseline models). Education is also negatively related to the incidence of adult obesity, the coefficients being negative and statistically significant at the 1% across specifications. The magnitude of the coefficients vary between -0.1722 and -0.1493. Not having children is also negatively related with adult obesity incidence. Lastly, ethnic composition is also an important determinant of adult obesity. In particular, the coefficients associated with the percentage of African-American population are positive and statistically significant across models while the percentage of population belonging to ethnic groups other than white Caucasian or black is negatively related with it.

In the case of the baseline models, the estimated parameters associated with food outlets' density suggest that, at the aggregate level, the presence of fruit and vegetables stores, full service restaurants, and (marginally) of Wal-Mart supercenters is related to the incidence of adult obesity, and that the estimated coefficients for grocery stores' density and limited service restaurants are not statistically different than 0. With regard to limited service restaurants, this result is in line with Anderson and Matsa's (2009) findings; however, not much empirical support from other literature is available to explain the lack of impact of grocery stores' density.

The results of the linear food access model indicate that adult obesity incidence is negatively related to fruit and vegetables stores' density and if one additional FV store per 100,000 people was opened, one could expect to observe a decrease in the percentage of adult obese by - 0.39 and - 0.42 points. Similarly, states where the presence of full service restaurants is more marked, experience lower levels of adult obesity: an increase of one restaurant per 1,000 individuals is associated with lower adult obesity rates in the order of -0.91 to -1.04 percentage points. Wal-Mart Supercenters' coefficient is only marginally significant in the simplest of the linear specifications, indicating that, at the most, the impact of one Wal-Mart store for every 100,000 people is associated with an in crease of 0.26 % in the rate of adult obesity.

The scenario emerging from the results of the quadratic food access model is more complex. The illustration follows with the estimated parameters reported in table 3-b. The results indicate that the relationship between grocery stores density and adult obesity follows an inverted U shape, with both the linear and quadratic terms being associated with coefficients statistically significant at the 1% level. These results are in line with previous findings: Chen et al. (2009) for example, found in the Indianapolis urban area a negative relationship between the densities of grocery stores and BMI, while several studies have noted that in some urban areas where population density is lower, grocery stores offer lower quality food and are therefore associated with poorer health conditions (e.g., Gittelsohn et al. 2008).

The estimated parameters for limited service restaurants' density show a similar pattern to those illustrated by Chou et al. (2004), with a positive but decreasing relationship with the percentage of adult obese. This result suggests that as limited-services restaurant density increases their positive effect on obesity declines, and eventually turns negative. Conceivably, greater competition among restaurants initially leads to the introduction of healthier alternatives as firms tend to engage in product differentiation. The relationship between full service restaurant density and adult obesity incidence is U-shaped. However, it should be noted that, for most of the range of the data, full service restaurants' density exhibit a negative marginal effect on the adults' obesity incidence.

The estimated coefficients for fruit and vegetable stores' density are not directly interpretable, due to the positive, but not significant coefficient for the linear term and the negative and marginally significant coefficient for the quadratic terms. Similarly, the relationship between Wal-Mart Supercenters and adult obesity is characterized by the linear term negative but not statistically significant, and the quadratic term positive and significant in all specifications (although only at the 10% level in two of them). Table 4 contains estimated marginal effects of store densities on adult obesity measured at the sample minimum values, averages and maximum values. From the values reported in Table 4 it emerges that the presence of fruit and vegetables stores may help lower the adult obesity incidence, but only when their density is large (which could be associated with up to a 1.13 percentage points decrease in the adult obesity rate for every extra fruit and vegetables stores open per 100,000 people). As for the marginal impact of Wal-Mart supercenters, the results show that a small presence of supercenters has no statistically significant effect on adult obesity, while its large presence is associated with a strong positive effect at the sample maximum. As a consequence, in those states where a company is most prevalent, adding one store per 100,000 people is associated with an increase in adult obesity ranging from 1 to 1.56 percentage points.

4.2 Interaction Model

The results of the interaction models are reported in Table 5. It should be noted that F-tests performed on the parameters of the interaction of food stores' density access and fruit and vegetables consumption reject the null of joint non-significance, indicating that the baseline models and the interaction models are not statistically equivalent. The behavior of the estimated coefficients for the socio-demographic variables mirrors that of the linear and quadratic models, in terms of significance, sign and magnitude, with the exception of the lag of fruit and vegetables consumption not interacted with food stores density which appears to be not significant.

The estimated food access coefficients reveal instead the complex nature of the interaction between eating habits, food stores density and adult obesity incidence. In particular, the coefficients associated with fruit and vegetables stores, full service restaurants and Wal-Mart Supercenters show that the presence of these outlets may be playing a role in reducing adult obesity only in areas where a large share of consumers engage in healthy eating. It also emerges that grocery stores' density and limited service restaurants' density is associated with lower levels of adult obesity in areas where less consumers consume 5 or more times a day fruit and vegetables.

Although they depict a complex relationship between eating habits, food access and obesity, the estimated coefficients cannot be easily interpreted and will therefore not be discussed. What should be noticed is that the fruit and vegetables stores, full service restaurant and Wal-Mart supercenters are positively related with obesity only for shares of the population engaging in healthy eating below 21.3%, 20.1%, and 26.5%, respectively.[12] As 21.1% marks the 25th percentile of the percentage of population eating healthy in our data, one can say that, for approximately 75% of the sample, an increase in the number of fruit and vegetables stores and full service restaurants is associated with a decline in adult obesity. However, as the mark of the 75th percentile of the eating healthy is 26.2%, the same would be true in the case of Wal-Mart supercenters for less then 25% of the sample.

---

[12] These values are obtained by dividing, for each food stores' density measure, the estimated coefficient of the linear component by that of the interaction with healthy eating habits, and invert its sign. In the case of the fruit and vegetables stores, one has 1.8705/0.0880 = 21.26 and 1.9201/0.0900 = 21.34. These values should be considered as the incidence of healthy eating for which the direction of the relationship between food stores' density and adult obesity reverses.

Following the same logic, only for (approximately) the lower 25% of the sample (in term of eating habits) could one conjecture a negative association between grocery stores' density and adult obesity (grocery stores' density is negatively associated with adult obesity for percentage of population heating healthy below 21.4%) while for (approximately) the upper 25% of the sample a positive relationship between limited-service restaurants and adult obesity exists (limited service restaurants are associated with an increase in adult obesity when the percentage of population eating healthy is above 26.4).

The marginal effects of a change in food access for a given level of eating habits and (vice versa) that of a change in the share of population eating healthy given a level of food stores' density are reported in Table 6. The overall trend that emerges is that most types of food stores' density are associated with marginal variation in the rate of adult obesity, either when the percentage of adults eating healthy is large (grocery stores, fruit and vegetables stores, full service restaurant) or very small (augmenting effect of Wal-Mart supercenters). This baseline finding suggests that eating habits are a fundamental factor that should be taken into account when evaluating the effect of food access on obesity.

The presence of grocery stores seems to have no effect on the incidence of adult obesity when the F&V consumption is low or at values close to the sample average. Its effect seems to be positive (as in Morland et al., 2006) for large values of F&V consumption (leading to an increase of up to 6.65 to 7.14 points) which may be due to the fact that consumers self-select to shop at other outlets different than grocery stores when they have healthy eating habits, leaving people who have unhealthy eating habits (and therefore more likely to be obese) to shop in those stores (consistently with Eid et al. 2007, hypothesis). Another explanation is that simply, in presence of larger selection of foods (both healthy and unhealthy) even individuals that engage in healthy eating may indulge in overconsumption.

Not surprisingly, having access to fruit and vegetables' specialty stores is negatively associated with adult obesity in areas where there is larger consumption of fruit and vegetables (of a reduction in the incidence of approximately 1.4 percentage points for every store per 100,000 people). Also, consumers who have healthier eating habits benefit from an increased presence of full service restaurants in terms of lower obesity (for a marginal effect of approximately -4.3 points for an increase of one restaurant per 1000 people), while a positive, although only marginally significant effect is present in areas where eating is less healthy. Again, the econometric results fail to provide evidence of an obesity-increasing effect of limited service restaurants (all the estimated marginal effects across levels of fruit and vegetables' consumption are not statistically different from 0). Wal-Mart Supercenters' presence is positively related with the adult obesity rate, but only at low levels of F&V consumption (between a 1.1 and 1.2 points increase in obesity for an increase of one supercenter for 100,000 people). Lastly, the last three rows of table 6 report the marginal effect of an increase in one percent of the adult population eating fruit and vegetables at least 5 times a day, on adult obesity incidence at different sample values of food stores' density. Overall, as food access increases and healthy eating becomes easier a marginal increase in F&V consumption is more effective in reducing obesity (for a marginal effect as large as -0.52).

5. Concluding remarks

This paper contributes to the literature by considering an expanded set of explanatory factors related to adult obesity rates, in state-level panel data set. We find that even after controlling for health behavior, statistically significant community-level factors related to demographics and access to food, where the latter is measured as traditional food outlets, big-box stores and restaurants. Perhaps most importantly density of food and vegetable stores is associated with lower obesity rates, and so is the presence of full-service restaurants. In the case of the former, this suggests that a greater supply or availability of such stores is associated with lower obesity rates, cet. par. The presence of Wal-Mart Supercenters, in sharp contrast, is associated with higher levels of obesity. Thus, the real income-increasing effect of lower prices brought about by the big-box giant is not translated into consumption of healthier foods, on balance.

Additional estimations that include interactions among fruit and vegetable consumption and the different types of stores provide further important insights into the underlying correlates of obesity. Perhaps most remarkably, most types of food stores densities are associated with a marginal variation in the adult obesity rate, either when the percentage of adults eating healthy is large (in the case of grocery stores (+), fruit and vegetables stores (−), full service restaurants (−)) or very small (in this case augmenting the obesity-increasing effect of Wal-Mart supercenters (+)). This underscores the importance of holding constant the percent of population meeting recommended daily fruit and vegetables consumption levels in these kinds of studies.

Future extensions could take one of the following three directions. First, using more refined data and econometrics analysis one could separate the direct and indirect impact of the impact of food outlets on obesity accounting for the trade-off between having access to more food and having access to healthier food. Second, as the relationships considered in this paper are not casual, proper instrumentation of food stores other than Wal-Mart Supercenters could increase the value and the reliability of the results (hard task if one wants to consider several food outlets). Third, different types of food outlets (for example farmers' markets) or more refined measures of healthy eating (considering for example regional variations in diet, and not only the consumption of fruits and vegetables) could be examined.

References

Anderson M., and D. A. Matsa (2009) "Are Restaurants Really Supersizing America?" U.C. Berkeley Northwestern University Working Paper

Bonanno, A. 2010. "An Empirical Investigation of Wal-Mart's Expansion into Food Retailing." *Agribusiness: An International Journal*. 26 (2): 220–243.

Centers for Disease Control and Prevention. 1996-2005. *Behavioral Risk Factor Surveillance System Survey Data.* Atlanta, Georgia: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

Chen, S.E., R.J.G.M. Florax, and S.D. Snyder, (2009). "Obesity, Fast Food, and Grocery Stores: Evidence from Geo-referenced Micro Data," *National Poverty Center Working Paper*, http://www.npc.umich.edu/news/events/food-access/index.php

Chou S., M. Grossman and H. Saffer (2004) "An economic analysis of adult obesity: results from the Behavioral Risk Factor Surveillance System" *Journal of Health Economics* 23:565–587

Courtemanche, C, and A. Carden, (2010) "Supersizing Supercenters? The Impact of Wal-Mart Supercenters on Body Mass Index and Obesity." University of North Carolina, Greensboro and Rhodes College, 49*pp*.

Currie J., S. DellaVigna, E. Moretti, V. Pathania, (2009) The Effect of Fast Food Restaurants on Obesity, NBER Working Paper No. 14721, http://www.nber.org/papers/w14721

Eid J., H. G., Overman, D., Puga and M. A. Tuner (2007) "Fat City: Questioning the Relationship Between Urban Sprawl and Obesity." *University of Toronto Working Paper*.

Flegal, K. M.; M. D. Carroll, C. L. Ogden; and L. R. Curtin, (2010), “Prevalence and Trends in Obesity Among US Adults, 1999-2008” *Journal of the American Medical Association* 303(3):235-241.

Gittelsohn J., Franceschini M.C., Rasooly I., Ries A.V., Ho L.S., Pavlovich W., Santos V.T., Jennings S. and Frick K.D. (2008) “Understanding the food environment in a low income urban setting: Implications for food store interventions,” *Journal of Hunger & Environmental Nutrition*, 2(2/3): 33-50.

Hausman, J.A. (1978). "Specification Tests in Econometrics", *Econometrica*, 46 (6), 1251–1271.

Lin, B. H. and R. M. Morrison (2002) Higher Fruit Consumption Linked With Lower Body Mass Index. *Food Review* 25(3): 28-32.

Martinez, S. W. (2007) “The U.S. Food Marketing System: Recent Developments, 1997-2006” ERR-42. ERS-USDA. http://www.ers.usda.gov/publications/err42/err42.pdf

Mc Geary, A. (2009) “The Impact of State-Level Nutrition-Education Program Funding on BMI: Evidence from the Behavioral Risk Factor Surveillance System” NBER working Paper w15001. Available at http://www.nber.org/papers/w15001 Accessed April 14 2010.

Morland, K., A. V. Diez Roux, and S. Wing (2006). “Supermarkets, Other Food Stores, and Obesity” The Atherosclerosis Risk in Communities Study.” *American Journal of Preventive Medicine*, 30 (4): 333-339.

Philipson, T. and R. Posner (forthcoming) “Economics of Obesity: A Decade of Research," *Journal of Economic Literature*.

Schafft, K., E. Jensen and C. Hinrichs (2009), “Food Deserts and Overweight Schoolchildren: Evidence from Pennsylvania,” *Rural Sociology*, 74(2):153-177.

U.S. Bureau of Census. (1996–2005). Population estimates program: Various years. Retrieved July 16, 2006, from http://www.census.gov/popest/estimates.php.

U.S. Bureau of Census. (1996–2005). Small area income & poverty estimates: Various years. Retrieved October 10, 2006, from http://www.census.gov/hhes/www/saipe/county.html.

U.S. Bureau of Census. (1996–2005). County business patterns database: Various years Retrieved June 20, 2006, http://www.census.gov/epcd/cbp/download/cbpdownload.html

U.S. Bureau of Census. (2001). Gazetteer of counties: Year 2000. Retrieved November 2, 2007, from http://www.census.gov/geo/www/gazetteer/places2k.html.

Wal-Mart Inc. (2008). Shareholders' Annual Reports Various Years. Retrieved September 3, 2008, from www.walmartstores.com.

Walton, S., & Huey, J. (1992). Sam Walton, made in America: My story. New York: Doubleday.

White, M. (2007) "Food Access and Obesity," *Obesity Reviews* 8(1): 99-107.

Table 1. Variables used in the estimation: description, sources, and descriptive statistics

Variable	Description	Source	Mean	St. dev.
% Adult Obese	% of adult population with BMI > 30	BRFSS	21.82	3.50
FV Consumption	% of adult population declaring fruits and vegetables 5 or more times daily	BRFSS	23.44	3.75
% Practicing physical activity	% adults with 30+ minutes of any physical activity five or more days per week	BRFSS	74.50	5.13
% Smoking	% respondents who current smoke	BRFSS	22.57	2.93
% No Children	% responding "None" to the question: *How many children live in your household?*	BRFSS	59.97	3.02
% With College Education (or higher)	% responding "College or higher" to the question: *What is the highest grade or year of school you completed?*	BRFSS	29.05	5.50
% Female	% of respondents being female	BRFSS	51.72	0.80
% Black	African American population divided by total population (%)	PEP	7.38	6.62
% Other ethnicities	Population other than White Caucasian or Black divided by total population (%)	PEP	28.66	2.97
Average Age	Average age	PEP	36.44	1.18
Income	Per capita average income (total income / total population)	ACS / PEP	30.12	5.35
Per Capita Groceries (1,000 ppl)	Grocery Stores Establishments (NAICS 4451) per 1,000 people	BLS / PEP	0.34	0.09
Per Capita FV stores (100,000 ppl)	Fruit and Vegetables Stores Establishments (NAICS 44523) per 100,000 people	BLS / PEP	0.95	0.66
Per Capita Full Serv. Rest. (1,000 ppl)	Full Service Restaurant (NAICS 722 – NAICS 7222) per 1,000 people	BLS / PEP	0.80	0.09
PC Limited Serv. Rest. (1,000 ppl)	Limited Service Restaurant Establishments (NAICS 7222) per 1,000 people	BLS / PEP	1.05	0.26
PC WM SCs (100,000 ppl)	Number of WM Supercenter per 100,000 people	Wal-Mart Inc / PEP	0.49	0.46

Table 3. Econometrics results –Baseline Models

Variable	Equation (2-a)	Equation (2-b)
% Adult Eating > 5 Servings FV Per day(Lag)		-0.0432**
		(0.0219)
% Practicing physical Activity	0.0313	0.0397*
	(0.0217)	(0.0220)
% Smoking	0.0607*	0.0457
	(0.0350)	(0.0357)
% No Children	-0.1455***	-0.1417***
	(0.0339)	(0.0338)
% With College Education (or higher)	-0.1722***	-0.1665***
	(0.0317)	(0.0318)
% Black	0.0872***	0.0849***
	(0.0210)	(0.0209)
% Other ethnicities	-0.1402***	-0.1458***
	(0.0339)	(0.0339)
% Female	0.1742	0.1401
	(0.1777)	(0.1779)
Average Age	-0.0569	-0.0446
	(0.1124)	(0.1122)
Income	-0.0962***	-0.0923***
	(0.0268)	(0.0268)
Per Capita Groceries (1,000 ppl)	1.1372	1.1277
	(1.0792)	(1.0753)
Per Capita FV stores (100,000 ppl)	-0.4211**	-0.3961**
	(0.1736)	(0.1734)
Per Capita Full Serv. Rest. (1,000 ppl)	-0.9053**	-1.0356**
	(0.4133)	(0.4170)
PC Limited Serv. Rest. (1,000 ppl)	-0.5678	-0.5533
	(0.9786)	(0.9750)
PC WM SCs (100,000 ppl; IV)	0.2574*	0.2385
	(0.1467)	(0.1465)
Constant	38.0001***	39.7139***
	(9.2119)	(9.2193)
R-Squared	0.9069	0.9007
P-Value of F test for joint sign	0.0000	0.0000

*Note: *, **, and *** represent 10, 5 and 1% significance levels –*
Standard errors in parenthesis

Table 4-a. Econometrics results – Quadratic Specification– socio - demographics and behavioral characteristics

Variable	Equation (3-a)	Equation (3-b)
% Adult Eating > 5 Servings FV Per day(Lag)		-0.0450***
		(0.0211)
% Practicing physical Activity	0.0416*	0.0522*
	(0.0213)	(0.0318)
% Smoking	0.0473	0.0318
	(0.0349)	(0.0355)
% No Children	-0.1126***	-0.1070***
	(0.0330)	(0.0329)
% With College Education (or higher)	-0.1515***	-0.1493***
	(0.0317)	(0.0316)
% Black	0.0685***	0.0648***
	(0.0213)	(0.0213)
% Other ethnicities	-0.1775***	-0.1855***
	(0.0334)	(0.0334)
% Female	0.0529	0.0240
	(0.1747)	(0.1745)
Average Age	-0.2094*	-0.2061*
	(0.1180)	(0.1175)
Income	-0.1282***	-0.1201***
	(0.0279)	(0.0281)

*Note: *, **, and *** represent 10, 5 and 1% significance levels –*
Standard errors in parenthesis

Table 4-b. Econometrics results – Quadratic Specification – Food Access

Variable	Equation (3-a)	Equation (3-b)
Per Capita Groceries (1,000 ppl)	17.9399***	17.0484***
	(4.5097)	(4.5086)
Per Capita Groceries Squared (1,000 ppl)	-21.5265***	-20.5130***
	(5.3309)	(5.3279
Per Capita FV stores (100,000 ppl)	0.3920	0.4287)
	(0.3878)	(0.3865)
Per Capita FV stores Squared (100,000 ppl)	-0.1976*	-0.1973*
	(0.1055)	(0.1051)
Per Capita Full Serv. Rest. (1,000 ppl)	-8.4685***	-9.6231***
	(2.7472)	(2.7878)
Per Capita Full Serv. Rest. Squared (1,000 ppl)	2.8557***	3.2612***
	(1.0754)	(1.0873)
PC Limited Serv. Rest. (1,000 ppl)	35.4581***	35.4538***
	(8.8615)	(8.8212)
PC Limited Serv. Rest. Squared (1,000 ppl)	-22.0812***	-22.0096***
	(5.1821)	(5.1586)
PC WM SCs (100,000 ppl; IV)	-0.0876	-0.1049
	(0.1857)	(0.1851)
PC WM SCs Squared (100,000 ppl; IV)	0.2430***	0.2408***
	(0.0865)	(0.0861)
Constant	35.5895***	37.9100***
	(10.0907)	(10.1036)
R-Squared	0.9178	0.9118
P-Value of F test for joint sign	0.0000	0.0000

*Note: *, **, and *** represent 10, 5 and 1% significance levels –*
Standard errors in parenthesis

Table 5. Marginal effects – Quadratic Food Access Model

Marginal Effects	Equation (3-a)	Equation (3-b)
Grocery (Sample Min)	10.6029***	10.0569***
	(2.7753)	(2.7745)
Grocery (Smaple Av)	3.1139**	2.9205**
	(1.2705)	(1.2680)
Grocery (Sample Max)	-13.3953***	-12.8115***
	(3.5343)	(3.5289)
FV Stores (Sample Min)	0.3756	0.4123
	(0.3800)	(0.3786)
FV Stores (Sample Av)	0.0160	0.0532
	(0.2248)	(0.2244)
FV Stores (Sample Max)	-1.1282**	-1.0892**
	(0.4926)	(0.4907)
Full Serv. Rest (Sample Min)	7.1368***	7.2244***
	(2.3895)	(2.3790)
Full Serv. Rest (Sample Av)	-0.0391	0.0718
	(1.1355)	(1.1315)
Full Serv. Rest (Sample Max)	-14.8341***	-14.6753***
	(3.1747)	(3.1611)
Limit Serv. Rest. (Sample Min)	-5.2423***	-5.9388***
	(1.5585)	(1.5854)
Limit Serv. Rest (Sample Av)	-2.4594***	-2.7607***
	(0.6209)	(0.6341)
Limit Serv. Rest (Sample Max)	2.5840*	2.9988**
	(1.5100)	(1.5157)
WM Superc. (Sample min.)	-0.0876	-0.1049
	(0.1857)	(0.1851)
WM Superc. (Sample av.)	0.1479	0.1285
	(0.1451)	(0.1447)
WM Superc. (Sample Max)	1.5560***	1.5235***
	(0.4839)	(0.4819)

*Note: *, **, and *** represent 10, 5 and 1% significance levels –*
Standard errors in parenthesis

Table 6-a. Econometrics results – Interaction Model: socio-demographics and behavioral characteristics

Variable	Equation (4-a)	Equation (4-b)
% Adult Eating > 5 Servings FV Per day(Lag)		-0.0350
		(0.0316)
% Practicing physical Activity	0.0265	0.0301
	(0.0217)	(0.0219)
% Smoking	0.0499	0.0511
	(0.0367)	(0.0367)
% No Children	-0.1350***	-0.1323***
	(0.0337)	(0.0338)
% With College Education (or higher)	-0.1600***	-0.1582***
	(0.0323)	(0.0323)
% Black	0.1043***	0.1056***
	(0.0225)	(0.0225)
% Other ethnicities	-0.1404***	-0.1392***
	(0.0354)	(0.0355)
% Female	0.0659)	0.0653
	(0.1802	(0.1802)
Average Age	-0.0267)	-0.0243
	(0.1118	(0.1118)
Income	-0.0957***	-0.0942***
	(0.0277)	(0.0278)

*Note: *, **, and *** represent 10, 5 and 1% significance levels –*
Standard errors in parenthesis

Table 6-b. Econometrics results - Interaction Model – Food Access

Variable	Equation (4-a)	Equation (4-b)
Per Capita Groceries (1,000 ppl)	-8.7109	-9.7669*
	(5.8499)	(5.9252)
Per Capita Groceries * % Adult Eating FV 5*day	0.4142*	0.4558**
	(0.2286)	(0.2316)
Per Capita FV stores (100,000 ppl)	1.8705*	1.9201*
	(1.0327)	(1.0333)
Per Capita FV stores * % Adult Eating FV 5*day	-0.0880**	-0.0900**
	(0.0408)	(0.0408)
Per Capita Full Serv. Rest. (1,000 ppl)	5.0136**	5.1564**
	(2.2516)	(2.2546)
Per Capita Full Serv. Rest. * % Adult Eating FV 5*day	-0.2497***	-0.2562***
	(0.0947)	(0.0949)
PC Limited Serv. Rest. (1,000 ppl)	-5.7479*	-6.3427*
	(3.4826)	(3.5226)
PC Limited Serv. Rest. * % Adult Eating FV 5*day	0.2084	0.2313*
	(0.1306)	(0.1322)
PC WM SCs (100,000 ppl; IV)	1.8434***	1.7161**
	(0.7102)	(0.7192)
PC WM SCs * % Adult Eating FV 5*day	-0.0698**	-0.0646**
	(0.0304)	(0.0308)
Constant	41.9536***	42.2039***
	(9.3681)	(9.3680)
R-Squared	0.9115	0.9207
F tests joint significance (p-val)	0.0000	0.0000

Table7 - Marginal Effects - Interaction Models

Marginal Effects	Equation (5-a)	Equation (5-b)
Grocery (FVcons Min)	-4.9416	-5.6195
	(3.8244)	(3.8718)
Grocery (FVcons Av)	0.9984	0.9165
	(1.1457)	(1.1478)
Grocery (FVcons Max)	6.6561**	7.1418**
	(2.9358)	(2.9674)
FV Stores (FVcons Min)	1.0696	1.1015
	(0.6701)	(0.6705)
FV Stores (FVcons Av)	-0.1926	-0.1886
	(0.1874)	(0.1874)
FV Stores (FVcons Max)	-1.3949***	-1.4174***
	(0.5264)	(0.5267)
Full Serv. Rest (FVcons Min)	2.7410*	2.8245**
	(1.4148)	(1.4164)
Full Serv. Rest (FVcons Av)	-0.8406*	-0.8502**
	(0.4287)	(0.4287)
Full Serv. Rest (FVcons Max)	-4.2519***	-4.3503***
	(1.3730)	(1.3754)
Limit Serv.. Rest (FVcons Min)	-3.8512	-4.2377*
	(2.3654)	(2.3902)
Limit Serv. Rest (FVcons Av)	-0.8622	-0.9206
	(1.0175)	(1.0186)
Limit Serv. Rest (FVcons Max)	1.9847	2.2389
	(1.7940)	(1.8081)
WM Superc. (FV cons min.)	1.2084***	1.1282**
	(0.4430)	(0.4488)
WM Superc. (FV cons av.)	0.2078	0.2018
	(0.1475)	(0.1475)
WM Superc. (FV cons Max)	-0.7453	-0.6805
	(0.4576)	(0.4612)
FV Cons. (Food Access min)	0.1719**	0.1465*
	(0.0750)	(0.0783)
FV Cons. (Food Access av)	-0.0702***	-0.0787***
	(0.0268)	(0.0279)
FV Cons. (Food Access Max)	-0.5190***	-0.5003***
	(0.1319)	(0.1329)

Figure 1. % Adult Obese vs. Healthy Eating and Store Density

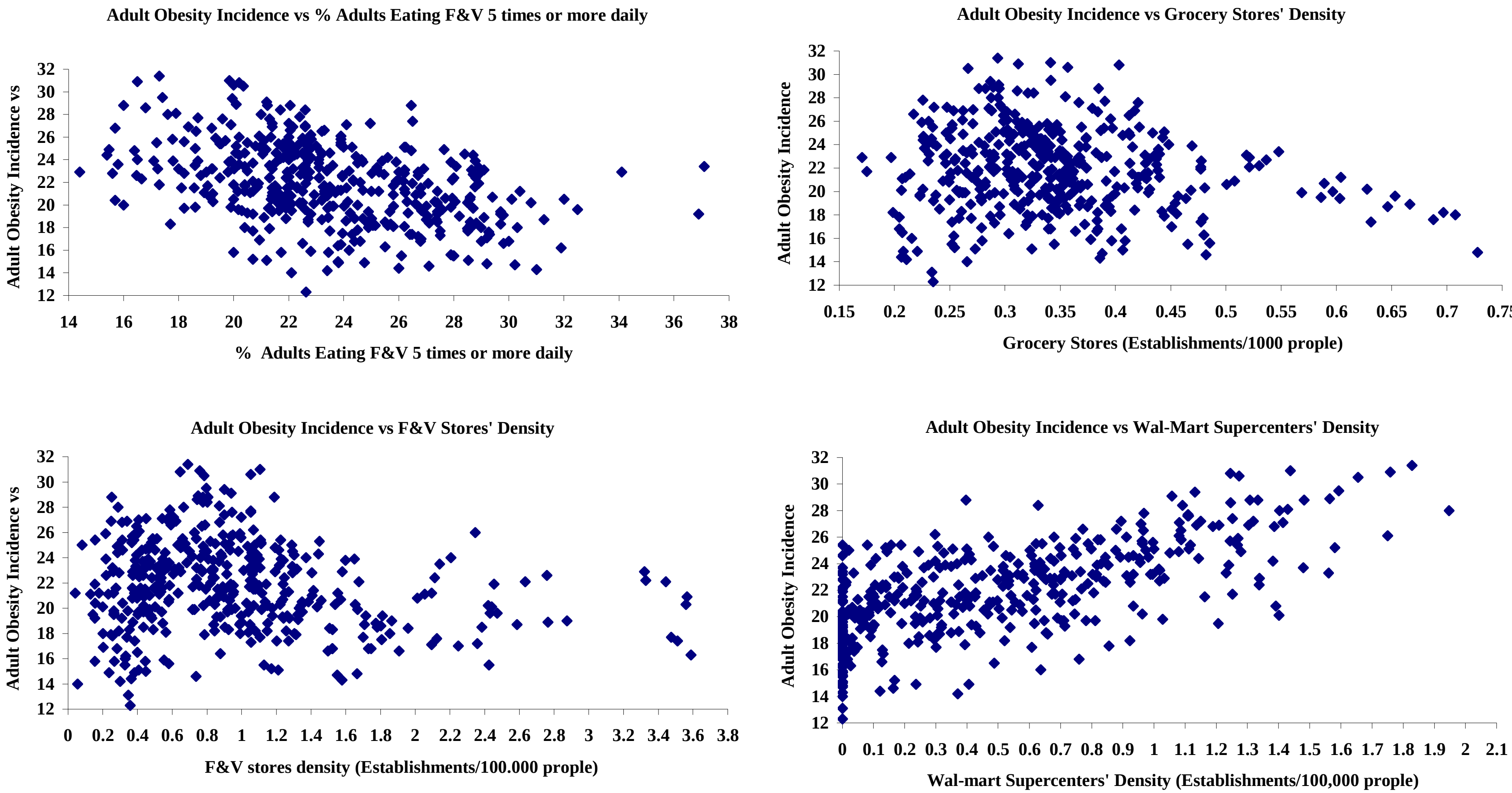

Figure 1. -Continued