Neighborhood Convenience Stores and Childhood Obesity: A Panel Data Instrumental Variable Approach

Di Zeng*, research associate, Department of Agricultural Economics and Agribusiness, University of Arkansas.

Michael R. Thomsen, associate professor, Department of Agricultural Economics and Agribusiness, University of Arkansas.

Rodolfo M. Nayga Jr., professor and Tyson Endowed Chair, Department of Agricultural Economics and Agribusiness, University of Arkansas, and adjunct professor, Norwegian Agricultural Economics Research Institute and Korea University.

Heather L. Rouse, director of Health Policy Research, Arkansas Center for Health Improvement, and assistant professor, University of Arkansas for Medical Sciences.

*Corresponding author. Tel: 540-553-4568. Fax: 479-575-5306. Email: dizeng@uark.edu

While the impacts of the commercial food environment on childhood obesity are receiving increasing attention, little is known about the possible impacts of neighborhood convenience stores, an important food retail format throughout the United States. This study helps bridge this gap using a panel data set of measured BMI screenings for Arkansas public schoolchildren and geo-referenced locations of children's residences and convenience stores. We consider the choice nature of store location decisions and account for possible endogeneity using an instrumental variable approach, with proximity to the nearest US highway as the instrument. We find that access to convenience stores slightly increases BMI of schoolchildren. This finding is consistent across alternative measures of convenience store access after controlling for potential confounders such as access to fast food restaurants. Moreover, it is robust to alternative radii that define convenience store access. We find no evidence for disproportionately larger impacts among children from low-income families or children residing in areas with limited access to healthy foods.

Key Words: convenience store, impact, childhood obesity, panel data, instrumental variable

Childhood obesity is a major public health issue in the United States. Nearly one in five children are now obese (Ogden et al. 2010), putting them at much higher risk for adulthood obesity and related health problems throughout life (Serdula et al. 1993; Biro and Wien 2010). This makes childhood obesity a tremendous fiscal burden for the whole nation (Trasande and Chatterjee 2009). Due to its significance, there have been urgent calls for a better understanding of obesogenic factors for children since this will assist in the development and defense of policy initiatives designed to address high rates of childhood obesity (National Research Council 2010; Institute of Medicine 2012).

While childhood obesity is clearly the consequence of numerous factors (Anderson and Butcher 2006), policies can be most effective by targeting common aspects faced by most of the population. One such focus is the commercial food environment. There is increasing evidence that access to healthy foods, or exposure to unhealthy foods, can affect children's body weight outcomes. Earlier work has addressed the impact of grocery stores (especially supermarkets), which provide healthy foods like fresh fruits and vegetables (Schafft, Jensen and Hinrichs 2009; Thomsen et al. 2014), and fast food restaurants, which offer energy-dense food options (Currie et al. 2010; Alviola et al. 2014). There is however a need to extend this literature into the possible impacts of other pervasive store formats such as convenience stores.

Convenience stores are a major type of food retail outlet throughout the United States. They generally carry a larger proportion of convenience foods (Morland, Diez Roux and Wing 2006). Such foods, usually processed and served in large portion sizes, sacrifice nutritional quality for convenience purposes, including loss of fiber, vitamins, minerals, and phytonutrients, as well as addition of sugars, fillers, preservatives, hydrogenated or saturated fats, sodium, artificial colors and flavors (Rosenkranz and Dzewaltowski 2008). As convenience foods are increasingly consumed at home (Nestle 2003), ready access to such foods may be one factor that contributes to childhood obesity.

Convenience stores are also an interesting case to examine because many of them have been approved to accept Supplemental Nutrition Assistance Program (SNAP) benefits, and so may be important sources of foods for lower-income families, especially when access to grocery stores is limited. Hence, SNAP benefits, if used for unhealthy foods, could result in unintended body weight gains among recipients (Chen, Yen and Eastwood 2005; Meyerhoefer and Pylypchuk 2008). In fact, 47 percent of all SNAP recipients are children and over 70 percent of SNAP benefits go to households with children (Keith-Jennings 2012). Moreover, it has been found that children from low-income households are also vulnerable to unhealthy foods due to overeating and night eating (Dammann and Smith 2010), and it is possible that convenience stores can play a substantial role in this regard. Therefore, the possible obesogenic impacts of convenience stores on low-income children may be disproportionately high.

A few studies have examined the impact of convenience stores on body weight outcomes. These studies have found mixed results, with some suggesting significant body weight increases (Morland, Diez Roux and Wing 2006; Bodor et al. 2010) while others seeing no significant change (Wang et al. 2007; Morland and Evenson 2009). These studies focus on either adults or adolescents but not children. Also, none of them have explicitly considered the endogeneity issues involved in the relationship between the commercial food environment and body weight outcomes. Given the ubiquity of convenience stores, empirical evidence on their possible impacts on childhood obesity is urgently needed and highly policy relevant.

Our study helps fill these gaps through an evaluation of the obesogenic impacts of neighborhood convenience stores on children. We use a unique individual-level panel dataset of schoolchildren in Arkansas, where the childhood obesity rate is among the highest in the country (Arkansas Center for Health Improvement 2010). These data are merged with geo-referenced food store locations and community socioeconomic indicators. We construct different measures of access to convenience stores from the residence of each child, including: (i) a binary measure indicating the existence of neighborhood convenience store(s) within a specified radius, (ii) the count of convenience stores within such radius, and (iii) the distance from the child's home to the nearest convenience store. We then use an instrumental variable approach, where the distance from the residence to the nearest highway is employed as the excluded instrument. We find that access to convenience stores slightly increases the BMI of schoolchildren. This result is consistent across alternative measures of convenience store access after controlling for potential confounders such as access to fast food restaurants and robust against alternative radii that define the convenience store access. Finally, we re-estimate our model using children of low-income families and those residing in areas with limited access to supermarkets that contain healthy foods, and find no evidence for disproportionately larger impacts among these disadvantaged subgroups.

Our contribution is threefold. First, we provide the first population-wide evidence of the obesogenic impacts of convenience stores on Arkansas schoolchildren and therefore complement the growing literature on the commercial food environment and childhood obesity. Second, we explicitly control for confounding factors such as access to other food store formats and address concerns for possible impact heterogeneity among different socioeconomic groups. Finally, given our unique data discussed in detail below, we are able to jointly employ the exact measures of both BMI outcomes and access to convenience stores in a statewide panel data setting, thereby reaching more credible estimates.

Data Description

Annual BMI screenings of public school children in Arkansas started in the 2003/2004 academic year in partial fulfillment of the requirements of Act 1220, passed in 2003 by the Arkansas General Assembly to combat high rates of childhood obesity. All public school children were screened for BMI from the 2003/2004 through 2006/2007 academic years, while only those in even-numbered grades from kindergarten through tenth grade were measured in subsequent academic years. The screening process is supervised by the Arkansas Center for Health Improvement (ACHI) and is implemented by trained personnel within public schools. Statewide protocols ensure uniformity in measurement procedures and equipment (Justus et al. 2007). BMI is computed based on children's height and weight measures, and converted to age-gender-specific z-scores in our analyses according to the guidelines provided by the Centers for Disease Control and Prevention (CDC 2013).[1]

Our study uses a subset of the Arkansas childhood BMI database, which provides BMI measures of schoolchildren during seven academic years (2003/2004 to 2009/2010). Also recorded for each child are gender, age in months, race and school meal status (whether the child is eligible for free or reduced-price school lunch). Our focus is on younger children, namely those from kindergarten through 144 months (12 years). We focus on this age group for three reasons. First, most children within this age range follow the development stage of adiposity rebound when increasing BMI after early childhood is generally observed (Boonpleng, Park and Gallo 2012). Understanding obesogenic factors at this stage is important. Second, few existing studies have investigated the impacts of convenience stores on the body weight outcomes of younger children. As over 70 percent of SNAP benefits go to households with children (Keith-

Jennings 2012), the possible obesogenic impacts of convenience stores as a potential source of daily foods especially for low-income children is especially policy-relevant. Third, younger children have limited ability to obtain foods away from home and their diets are more likely dictated by their caregivers. Therefore, the possible impacts of neighborhood convenience stores can be more accurately evaluated and potential interventions targeting home food consumption may also be more effective.[2]

Our food store location data come from geo-referenced business lists purchased from Dun and Bradstreet, Inc. (D&B). These data are commonly used in the literature to characterize food environments (Powell et al. 2007; Zick et al. 2009; Bader et al. 2010). Specifically, we obtained archival data for the years 2004 to 2010 to match the period of time covered by the BMI records. Convenience stores were identified based on the following standard industrial classification (SIC) codes: 5541(Gasoline Service Stations), 54110200 (Convenience Stores), and 54110202 (Convenience Stores, Independent). However, it was clear that many convenience stores were contained within the general 5411 SIC code for Grocery Stores. Consequently, we inspected company names and/or trade names to check their accuracy and identify additional convenience stores from this category. We also used street-view images in the Google search engine to verify store formats. Regardless of primary SIC classification, we found that most of the convenience stores in our sample also sold gasoline.

The residential addresses of schoolchildren in the Arkansas BMI dataset were geocoded by ACHI personnel, thereby allowing the number of convenience stores to be measured around each residence. These residences were also matched to the 2009 American Community Survey (ACS) summary files by census block group. The 2009 ACS provides neighborhood-level demographic and socioeconomic statistics averaged over the period of 2005-2009 and therefore is centered on the 2004 to 2010 period covered by our study. Using census defined places, we classified each residence as urban or rural based on its census block.

We construct several measures of access to convenience stores. First, we introduce a dummy indicator that takes the value of one if there is at least one convenience store within a half mile of an urban residence or within two miles of a rural residence. Second, we consider the counts of convenience stores within the half-mile and two-mile radii for urban and rural residences, respectively. Third, we measure the radial distance from the residence of each child to the nearest convenience store. The chosen radius cutoffs for convenience store access are not arbitrary. Our data show that in urban areas, 22.43%, 51.42% and 85.24% of the observations have access to convenience stores within one quarter mile, one half mile, and one mile. In rural areas, 19.80%, 40.98% and 81.02% of the observations have access to convenience stores within one mile, two miles, and five miles. Thus, a half mile for an urban residence and two miles for a rural residence serve as reasonable midpoints for the sake of variation. That said, we also implement robustness checks using different combinations of these radii, as discussed below. The chosen radii also reflect the fact that convenience stores are more ubiquitous than supermarkets. Longer distances of one and ten miles in urban and rural areas, respectively, have been proposed to define measures of supermarket access (Economic Research Service, United States Department of Agriculture 2013).

While our emphasis is on the relationship between convenience stores and childhood body weight, we acknowledge that other features of the food environment could also be important and so all our models include a control for fast-food restaurants around the child’s home. Analogous to our measurement of convenience stores, we construct measures of fast food restaurants from the D&B business lists based on SIC code, company name and/or trade style. In addition, we conduct follow-up analyses where we examine children in food desert residences separately. For purposes of this study, we follow Thomsen et al. (2014) who, using criteria similar to USDA's Food Desert Atlas (Economic Research Service, United States Department of Agriculture 2013), classified a residence as a food desert if it is located in a low-income census block group and it is more than one mile (ten miles) from the nearest supermarket in an urban (rural) census block. Low-income block groups are defined as those where the median household income is less than 80 percent of the state median or at least 20 percent of the population below the poverty line (Thomsen et al. 2014).

Table 1 presents summary statistics for the variables used in the empirical analyses. Throughout the years in our study period, 48% of the children are exposed to neighborhood convenience stores within a half mile (two miles) in urban (rural) areas. The average count of convenience stores within the same radii is 0.924, suggesting that on average the 48% of children residing close to convenience stores as defined by these criteria have access to roughly two stores. Similar patterns are observed for access to fast food restaurants. Finally, only nine percent of the total observations were observed in food desert residences.

Modeling Procedure

Our baseline model is specified as:

$$(1) \qquad BMI_{it} = \beta_0 + \beta_1 D_{it} + \boldsymbol{\gamma} \boldsymbol{X_{it}} + \mu_i + \varphi_t + \epsilon_{it}$$

where BMI_{it} is the BMI z-score of child *i* at time *t*; D_{it} is the measure of convenience store access; $\boldsymbol{X_{it}}$ is a vector of control variables with coefficients, $\boldsymbol{\gamma}$; μ_i is an individual fixed effect; φ_t is a year fixed effect; and ϵ_{it} is the stochastic error term. $\boldsymbol{X_{it}}$ includes age, age squared, dummy indicators of school meal status (either free lunch or reduced-price lunch), and a set of community characteristics from 2009 ACS as reported in Table 1. Also included in $\boldsymbol{X_{it}}$ is the count of fast food restaurants within the half mile (one mile) radius for urban (rural) areas, which aims to capture possibly confounding obesogenic impacts of these restaurants. In addition to individual fixed effects, we also include year fixed effects to capture any potential upward trend in BMI over time as well as broad macroeconomic dynamics that may affect health outcomes (Ruhm 2000).

Among all the coefficients, the one of primary interest is the marginal effect of convenience store access on BMI outcome, measured by β_1. Direct estimates of β_1, however, may be biased and inconsistent if convenience store access is endogenous. Household location decisions may be based in part on preferences for healthfulness, and convenience stores are likely to make strategic location decisions to maximize the number of customers. It is for these reasons that we use an instrumental variable approach. Specifically, we employ road distance from the residence to the nearest United States numbered highway or interstate highway (US highway hereafter) as the excluded instrument. The rationale is that convenience stores are likely to cluster near highways to capture sales from traveling customers. Therefore proximity to highways substantially facilitates access to convenience stores. We use US highway in addition to interstate highways because the interstate system only serves a limited portion of Arkansas and US numbered highways are major arterial roads connecting population centers within the state (Alviola et al. 2014).

Instrument Validity

Highway proximity has been successfully employed in previous literature to identify obesogenic impacts of fast food restaurants (Dunn 2010; Anderson and Matsa 2011; Alviola et al. 2014).

These studies present extensive evidence in support of the validity of this instrument. Similarly, the use of highway proximity as the excluded instrument in the context of convenience stores needs to be carefully considered. One obvious concern is the possible confounding impacts of fast food restaurants that also tend to cluster near highways. To address this issue, we explicitly control for fast food restaurant counts within the half mile and one mile radii for urban and rural areas, respectively. Moreover, we test whether the estimated impacts of convenience stores are robust to alternative controls for fast food restaurants, which, in addition to restaurant counts, include a binary indicator for the presence of a restaurant and the distance to the nearest restaurant, and find that they are.

Another concern is the potential for systematic differences among the characteristics of children living close to and further from highways that may also contribute to the estimated impacts, thereby leading to biased results. To address this concern, we implement a series of OLS balancing test regressions where each explanatory variable is regressed against the instrument, a procedure suggested by and commonly used in the earlier literature (Dunn 2010; Alviola et al. 2014). Our results are similar to these studies in that only a limited number of correlations are found significant but all coefficient magnitudes are small.[3] Thus, such differences are not likely to invalidate our main impact estimates.

Finally, the same instrument may not be equally valid for different subgroups of the population. For instance, health preferences and travel costs may differ by income status, and children of disadvantaged households may observe disproportionately higher obesogenic impacts due to the exposure to convenience stores for reasons discussed above. Consequently, we separately analyze subsamples consisting of children from low-income families and children living in food desert residences. As shown below, we find no disproportionately higher impacts among these groups, confirming the appropriateness of our instrument.

Results

Our empirical analyses progress as follows. First, we carry out baseline estimation of equation (1) using all observations with repeated BMI measures. We then interpret the main results in the real world context by checking the actual weight gains of an average child in Arkansas due to the exposure to convenience stores. Finally, we re-estimate the model with alternative radius measures and using children of low-income families and those living in food deserts for the dual purpose of checking the robustness of our main results and investigating the potential disproportionate impacts felt by the disadvantaged groups.

Table 2 presents our baseline estimation results. Three specifications are estimated, each employing a different access measures: (i) a dummy indicator of presence of neighborhood convenience store(s), (ii) the count of neighborhood convenience stores, and (iii) the distance from the residence to the nearest convenience store, respectively. The baseline OLS and simple 2SLS models were also estimated in a pooled cross-sectional setting, as well as a fixed-effects model without an instrumental variable. These models (not reported) provide numerically close coefficient estimates, but are rejected by test statistics presented in the lower panel of table 2. Specifically, our tests provide evidence against zero fixed effects for either individual or year, against exogeneity of convenience store location, and against weak identification and underidentification. Therefore, only the panel instrumental variable results are presented.

The measures of convenience store access are of primary interest and are statistically significant in all specifications. Specification (1) suggests that children living close to neighborhood convenience stores have a BMI z-score that is 0.144 standard deviations higher on average than those without such access. Alternatively, specification (2) suggests that one more neighborhood convenience store is associated with a 0.076 standard deviation increase in BMI z-scores on average. The former impact estimate is approaching twice the size of the latter, which is consistent with the fact that the average number of convenience stores for children exposed to at least one store is around two. This suggests that the count of convenience stores matters at the margin. Finally, specification (3) shows that a one-mile increase in the distance to the nearest convenience store reduces BMI z-score by 0.012 standard deviations, further confirming the positive obesogenic impacts of proximity to convenience stores. This last impact estimate is smaller in magnitude when compared to the previous estimates and can be explained by the positive skewness of the distance measure. Even so, the estimate for distance is still highly significant. These results provide fairly strong evidence of the obesogenic impacts of neighborhood convenience stores on children. Beyond convenience store access, the coefficient estimates for the remaining covariates are smaller in magnitudes and their statistical significances vary across the alternative specifications.

The convenience store effect we measure is not large, but it needs to be placed into some context. The average age in our sample is 8.5 years. A girl of this age with a stature of 130 centimeters (roughly the center of the age for height growth chart) and a weight of 29.8 kilograms would have a BMI z-score 0.68, which is very close to the sample average. Our estimate is that the impact of any exposure to convenience stores within the specified radii causes of 0.144 standard deviation increase in the z-score. This translates into weight gain for this child (assuming no change in stature or age) of 0.7 kilograms.[4] To provide further context an 8.5 year-old girl with stature of 130 centimeters and weight of 27.1 kilograms would be at the center of the reference distribution (BMI z-score of zero). She would be classified as overweight (85th percentile of the distribution) if her weight was 31.6 kilograms, and she would be considered obese (95th percentile of the distribution) if her weight was 36.0 kilograms. In other words, a gain of 4.5 kilograms and 8.9 kilograms would move this child from the center of the reference distribution into the overweight category and obese category, respectively. When placed in this context, the impact of convenience stores may not be trivial.

We now turn to several robustness checks. The first assesses the appropriateness of the radii used to measure convenience store access. It can be argued that the impacts can be fairly local, which may disappear quickly over distance between the home and the store. To see if such spatial heterogeneity exists, we re-estimate the model with convenience store access measured on alternative radial distance cutoffs surrounding the children's residence. Impact estimates are reported in the top two panels of table 3. It is seen that the estimated convenience store impacts exhibit little change with increases in the radii. Overall, the main findings are robust to the radii used to define convenience store access.

Next we re-estimate the models with disadvantaged subsamples, where larger obesogenic impacts of convenience stores may exist for the reasons described above. We estimate one set of regressions for children in low-income families and another for children living in food desert areas. Although household income is not observed, the child's school meals status is a good proxy for family income that is available in the BMI database. According to the United States Office of Management and Budget, children qualify for free school lunch if household income is below 130% of the federal poverty threshold. In our case, we define the low-income subsample in terms of children that were qualified for free school lunches during each year of observation. The definition of food desert is consistent with earlier literature on the subject. Specifically, food desert residences are located in low-income census block groups with no supermarket access within one mile (ten miles) of the child's residence in an urban (rural) census block. Again, we restrict the sample to children who were observed in a food desert area each time they appeared in the BMI data.

The third panel of table 3 reports the convenience store impacts on low-income children. Estimates across all specifications are numerically close to the main results reported in table 2, suggesting that the obesogenic impacts of neighborhood convenience stores on low-income children are not meaningfully different from the population of Arkansas schoolchildren in general. In other words, there is no evidence in our data that convenience stores have a disproportionate effect on lower-income children. It is possible that children who qualify for the free school lunches have less financial resources, and this may crowd out the role of convenience stores as a food source to a large extent.

Finally, estimated convenience store impacts on children living in food deserts are reported in the last panel of table 3. Again, no meaningful differences are found between these results and our main results. Two complementary logics may possibly explain such pattern. First, as food deserts are low-income communities, price sensitivity can surpass convenience incentives and encourage people to obtain foods at lower prices from remote grocery stores even if they are exposed to neighborhood convenience stores (only 5.36% of the residents of these communities do not own a vehicle). Second, children from low-income households are again likely to qualify for free school lunch. Thus, although it is widely argued that disadvantaged populations are more vulnerable to unhealthy food environments, our results suggest that the impact of convenience stores on children may be an exception. In sum, we conclude that there is no evidence of disproportionately larger obesogenic impacts of neighborhood convenience stores on low income children in general or for children residing in food deserts.

Concluding Remarks

We evaluate the impacts of neighborhood convenience stores on childhood obesity using a unique statewide panel data set of Arkansas schoolchildren containing exact measures of both BMI outcomes and convenience store access. We provide some first evidence for the hypothesized obesogenic impacts of convenience stores and thereby extend the literature on the effects of commercial food environment to cover this pervasive store format. Impact estimates are robust against varying radius cutoffs used to measure convenience store access. While the impact of convenience stores on weight gain appears to be small, the exposure to neighborhood convenience stores may translate into more than one pound of weight gain for an average Arkansas schoolchild in our sample. Such evidence suggests that convenience stores matter and that they may be one contributor to childhood obesity.

Concerning specific vulnerability of children of disadvantaged households as well as the appropriateness of using US highway as our instrumental variable to uncover possibly heterogeneous obesogenic impacts of convenience stores, we further estimate our model using children from low-income families and those residing in food desert areas. We find no evidence of larger impacts among these subsamples. It is reassuring that these children do not appear to be disproportionately affected by neighborhood convenience stores.

Since childhood obesity has become an important issue in the United States, appropriate interventions are needed as we start to understand the obesogenic impacts of neighborhood convenience stores on children. Policy makers may want to incentivize convenience store operators to introduce healthy food options, such as fresh fruits and vegetables. Potential policy instruments may include possible revisions of SNAP coverage as well as tax benefits for store operators. As convenience store counts matter, it is also important for policy makers to understand the commercial food landscape, especially at the local level, and invest special attention to communities with wider exposure in educational interventions. While our findings do not speak directly to the merits of such policies, the estimates we report provide useful evidence that contribute to a more informed decisions involving these or other potential policies that may impact access to convenience stores.

Notes

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[1] BMI is computed as a ratio: weight in kilograms / (height in meters)^2.

[2] It is arguable that older children, or adolescents, are also an important focal group because they are able to visit convenience stores on their own without parental supervision. Due to reasons discussed above as well as noticeable behavioral differences between these two age groups, the possible obesogenic impacts of neighborhood convenience stores on older children is not investigated in the current study but worth further investigation.

[3] Detailed results are available from authors upon request.

[4] The effect for an 8.5 year old boy with stature of 130 centimeters and BMI z-score of 0.68 would be similar at 0.6 kilograms. BMI z-scores are age and gender specific.

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Table 1. Summary Statistics (n=855,138)

Variable	Measure	Mean	Std. Dev.
BMI	z-score	0.677	1.067
Age	Months	102.9	23.60
Female	Dummy	0.498	0.500
African American	Dummy	0.206	0.411
Hispanic	Dummy	0.075	0.097
Free school lunch	Dummy	0.432	0.493
Reduced price lunch	Dummy	0.095	0.106
Convenience store dummy	Dummy	0.480	0.500
Convenience store count	Count	0.924	1.339
Convenience store distance	Miles	1.550	2.074
High school	Proportion[a]	0.355	0.109
Some college	Proportion[a]	0.215	0.073
College and above	Proportion[a]	0.179	0.131
Working mother	Proportion[b]	0.683	0.218
Married household	Proportion[b]	0.721	0.179
Single female-headed household	Proportion[b]	0.213	0.162
No vehicle	Proportion[c]	0.042	0.046
Fast food restaurant count	Count	0.878	1.455
Food desert	Dummy	0.090	0.287
Distance to nearest US highway	Mile	2.034	3.165

[a] Proportion of population over age 25 within the block group of residence from the 2009 ACS.
[b] Proportion of all children under 18 within the block group of residence from the 2009 ACS.
[c] Proportion of occupied housing units within the block group of from the 2009 ACS.

Table 2. Baseline IV Fixed-Effects Regression Results (n=703,416)[a, b]

	Specification (1)	Specification (2)	Specification (3)
Convenience store dummy	0.144*** (0.030)		
Convenience store count		0.076*** (0.016)	
Convenience store distance			-0.012*** (0.003)
Age	-0.001 (0.000)	-0.001 (0.000)	-0.001 (0.000)
Age square	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Free school lunch	0.001 (0.003)	0.002 (0.003)	0.001 (0.003)
Reduced price lunch	-0.000 (0.003)	0.000 (0.003)	-0.000 (0.003)
High school	-0.008 (0.016)	-0.022 (0.017)	0.012 (0.016)
Some college	0.017 (0.019)	0.045** (0.021)	-0.003 (0.019)
College and above	0.024 (0.016)	0.051*** (0.017)	-0.003 (.016)
Working mother	-0.007 (.005)	-0.008 (0.005)	-0.012** (0.005)
Married household	0.005 (0.020)	-0.023 (0.018)	-0.020 (0.018)
Single female-headed household	0.006 (0.019)	-0.004 (0.019)	-0.009 (0.019)
No vehicle	-0.001** (0.000)	-0.001*** (0.000)	-0.000 (0.000)
Fast food restaurant count	-0.012*** (0.003)	-0.027*** (0.006)	-0.001 (0.001)
Individual fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Endogeneity test[3]	23.18***	18.98***	27.44***
F-test of excluded IV in 1st stage	830.47***	647.37***	3401.54***
Underidentification test[4]	856.91***	656.20***	2991.81***

[a] The dependent variable is BMI z-score in all specifications. Heteroskedasticity-robust standard errors are reported in parentheses.

[b] *, **, *** indicate statistical significance at 10%, 5% and 1% levels, respectively.

[c] Davidson-Mackinnon test statistic is reported.

[d] Kleibergen-Paap rank Lagrange multiplier statistic is reported.

Table 3. Robustness Check Results of Convenience Store Impacts[a, b]

	Specification (1)	Specification (2)	Specification (3)
Alternative radii: one mile (urban) and two miles (rural) (n=703,416)			
Convenience store dummy	0.132*** (0.044)		
Convenience store count		0.071***(0.017)	
Convenience store distance			--
Alternative radii: half mile (urban) and five miles (rural) (n=703,416)			
Convenience store dummy	0.129*** (0.030)		
Convenience store count		0.064***(0.016)	
Convenience store distance			--
Children with free school lunch status (n=242,038)			
Convenience store dummy	0.118*** (0.038)		
Convenience store count		0.067*** (0.022)	
Convenience store distance			-0.012*** (0.004)
Children living in food deserts (n=96,558)			
Convenience store dummy	0.130* (0.072)		
Convenience store count		0.076* (0.042)	
Convenience store distance			-0.009* (0.005)

[a] The dependent variable is BMI z-score in all specifications. Individual and year fixed-effects are included in all specifications. Heteroskedasticity-robust standard errors are reported in parentheses.

[b] *, **, *** indicate statistical significance at 10%, 5% and 1% levels, respectively.