Local Food Impacts on Health and Nutrition

Myra Clarisse R. Ferrer
Department of Agricultural and Applied Economics
University of Georgia, Athens, GA 30605-7509
E-mail: mferrer@uga.edu

Esendugue Greg Fonsah
Department of Agricultural and Applied Economics
University of Georgia, Tifton, GA 31794-0748
E-mail: gfonsah@uga.edu

Octavio Ramirez
Department of Agricultural and Applied Economics
University of Georgia, Athens, GA 30605-7509
E-mail: oramirez@uga.edu

Cesar L. Escalante
Department of Agricultural and Applied Economics
University of Georgia, Athens, GA 30605-7509
E-mail: cescalan@uga.edu

Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2011 AAEA & NAREA Joint Annual Meeting, Pittsburgh, Pennsylvania, July 24-26, 2011

Introduction

The increasing prevalence of local food system across United States and other parts of the world for the recent years is deemed to be one of the major answers to several food issues. One of which is the relationship of human health and food intake. Several studies show evidence of links between food intake and numerous diseases such as cancer (Kushi *et al*., 2006 and Buiatti *et al*., 1989), diabetes (Bantle *et al*., 2006 and Bidlack, 1996), obesity (Drewnowski and Popkin, 1997 and Mirmiran and Mirbolooki, 2002), and hypertension (Reddy and Katan, 2004). These findings prompted various food policy implications and directed several institutions, for instance, the American Dietetic Association, American Cancer Society, National Institutes of Health and others, to offer dietary change recommendations.

Researchers have found that food choices are influenced by a variety of factors, these includes the knowledge of the causative and preventive effects of certain foods, the cost of food and the availability of different foods (Morland, Wing, and Roux, 2002). This study will focus on the last factor, particularly on the availability of local foods to consumers and see its relationship with two specific diet-related diseases namely, obesity and diabetes. Since there is an increasing trend of local food systems across United States, it is intuitive to think that healthier foods are now available to consumers. Indeed, Morland, Wing and Roux found some positive association between the local food environment and residents meeting dietary recommendations. Accessibility to healthier food options could potentially lead to improved health conditions thus the expected effect is decreased rates of diet-related diseases.

Numerous studies have highlighted the associations between food environment, health, and food intake. Most of these literature looks at the food environment in terms of fast food locations, types of food stores and presence of grocery stores and supermarkets. Some of these studies were discussed to mention a few.

Morland and Evenson (2008) conducted a study that looks at the disparity in access to healthy foods in the southern region of the United States. With a sample of 1296 adults, they found out that obesity rates were lower in regions with supermarkets and higher in regions with small grocery stores or fast food restaurants implying that types of food stores and restaurants influence food choices and subsequently, diet-related outcomes. Austin *et. al* (2005) used spatial statistical methods to examine the concentration of fast food restaurants in areas proximal to schools where they would be highly accessible to students. The locational patterns of fast-food restaurants in Chicago showed that fast-food restaurants are statistically significantly clustered in areas within short walking distance with a median of 0.52 km from schools. Seventy-eight percent of school samples had at least 1 fast-food restaurant within the 800 m radius exposing children to poor-quality food environments. Another study suggested that stores (supermarkets and grocery stores) offering more healthful and lower-cost food selections were outnumbered by convenience stores offering lower availability of more healthful foods at higher prices (Liese, 2007). The same study also concluded that the healthful version of a food was typically more expensive than the less healthful version.

Researchers have proven that food environment plays a crucial role on making food choices and consequent diet-related diseases. However, fewer studies have demonstrated the link between food environment as characterized by local food systems and diet-related health outcomes. This is where the goal of this study comes into play. It intends to look at the measurable impact of local foods on health and food intake as reflected on diet-related diseases such as diabetes and obesity rates.

Data and Methodology

Since the relationship of the availability of local foods to two diet-related diseases is being studied, two equations will be estimated and are displayed as follows:

$$pct\_diabet = \alpha_0 + \alpha_1{'}\overline{Diet} + \alpha_2{'}\overline{LF} + \alpha_3{'}\overline{Env} + \alpha_4{'}\overline{Educ} + \alpha_5{'}\overline{Dem} + \mu \qquad (1)$$

$$pct\_obese = \beta_0 + \beta_1{'}\overline{Diet} + \beta_2{'}\overline{LF} + \beta_3{'}\overline{Env} + \beta_4{'}\overline{Educ} + \beta_5{'}\overline{Dem} + \varepsilon \qquad (2)$$

The dependent variable in equation (1), the diabetes model, is the adult diabetes rate per county across the US (PCT_DIABET). It is defined as percentages of persons age 20 and above with diabetes. Similarly, adult obesity rate (PCT_DIABTE) is defined as percentages of persons age 20 and above that are obese and have a body mass index of at least 30 kg/m^2. It is the dependent variable in the obesity model, equation (2). The nature of the equations appears that they are not related but the correlation across errors in both equations can provide links that can be exploited in estimation (Wooldridge, 2002). In fact, a simple correlation measure validates the relationship between the error terms of the two equations. Seemingly-unrelated regression (SUR) estimation was performed and estimates were compared to the ordinary least squares (OLS) estimation equation by equation results. The coefficient values were identical between the two methods with standard errors from the SUR estimation having smaller values. The differences on standard errors however were minuscule and insignificant thus results of the OLS estimation were presented in the results table. Besides, the OLS results are more efficient since the regressors used in both equations are identical.

According to preceding literature, obesity has been considered as a major risk factor causing diabetes (Lazar, 2005 and NIH, 2007). To account for this fact, a two-stage least squares (2SLS) with a single endogenous explanatory variable estimation was performed. Obesity is now considered as an endogenous explanatory variable to diabetes. The obesity equation was used as the reduced form equation and the diabetes equation is the structural equation for the 2SLS estimation. After re-writing equations (1) and (2) for the 2SLS approach, they are now defined as follows,

$$pct\_diabet = \alpha_0 + \alpha_1 pct\_obese + \alpha_2{}'\overline{Diet} + \alpha_3{}'\overline{LF} + \alpha_4{}'\overline{Env} + \alpha_5{}'\overline{Educ} + \alpha_6{}'\overline{Dem} + u_1 \qquad (3)$$

$$pct\_obese = \beta_0 + \beta_1{}'\overline{\overline{SocEcon}} + \beta_2{}'\overline{Diet} + \beta_3{}'\overline{LF} + \beta_4{}'\overline{Env} + \beta_5{}'\overline{Educ} + \beta_6{}'\overline{Dem} + u_2 \qquad (4)$$

In equation (4), socio-economic factors were used as instruments to obesity rate in the diabetes model estimation. This is to follow previous findings that socio-economic factors were established to be related to being overweight (Sobal and Stunkard, 1989; National Center for Health Statistics, 1998). However the same relationship does not hold with diabetes. Hence, these variables were used as instruments in the analysis. $\overline{\overline{SocEcon}}$ is a 2 x 1 vector of socio-economic-related variables specifically median household income (MEDIAN_INC) and poverty rate (PCT_POVERTY). The soundness of these instruments was verified through simple correlation with the endogenous variable and error term and they were found to be valid.

To determine the major objective of this research, three variables on local food systems were incorporated in the model. The 3 x 1 vector $\overline{LF}$ is consist of local food-related variables namely value of direct farm sales per capita (PC_DIRSALES), number of farmer's markets (FMRKT), and the number of harvested vegetable acres per 1,000 county residents (VEGACRESP1T). These variables have very wide ranges characterizing how broad the difference of the extent of exposure of local foods across counties (Table 1.).

The rest of the exogenous variables are detailed as follows. Evidently, since diabetes and obesity are diet-related and are very close to each other, results of previous studies showed similar factors affecting their occurrence. Such factors are unhealthy eating habits, sedentary lifestyle, family history/genetics, increased age and other related diseases. This explains why most of the exogenous variables between the two equations are the same. Among the factors mentioned, the first two are the major contributors thus variables relating to them are included in the analysis. Besides, data on the other three factors are hard to find. $\overline{Diet}$ is a 5 x 1 vector that constitutes factors related to eating habits and food prices. These variables are as follows: pounds per capita of fruit and vegetable consumption (PC_FRUVEG), pounds per capita of meat consumption (PC_MEAT), pounds per capita of fat consumption (PC_FATS), relative price ratio of low-fat milk to soda (MILK_SODA), and soda sales tax (SODA_STORE). Furthermore, $\overline{Env}$ is a 4 x 1 vector of environment and physical activity-related variables such as the number of recreation and fitness facilities per 1,000 population (REC_FAC_P1T), the percent of adult meeting activity guidelines (PCT_ADULTPA), the percent of households with no vehicle and lives more than a mile to a store (PCT_HHNV1), and the number of grocery stores and supermarkets in a county (GROC).

Though not the main focus of this study, responsiveness of diabetes and obesity rates on educational level, gender and race were included in the analysis as base variables. Education is considered in particular because it has a crucial role in making conscious food choices. $\overline{Educ}$ is a 4 x 1 vector of education-related variables given as percentages of the population that attended some high school (PCT_LESS_HS), finished high school (PCT_HS), attended some college (PCT_SOME_COLLEGE) and finished college (PCT_COLLEGE). Gender and race were both under $\overline{Dem}$, the 7 x 1 vector of demographic-related variables which includes five classified races, namely White American (WA), Black or African American (BA), American Indian and Alaskan Native (IA), Asian (AA) and Native Hawaiian or Other Pacific Islander (NA), and the genders (TOT_MALE and TOT_FEMALE). More information on the variables used could be found in the summary statistics in Table 1. The stochastic errors of the diabetes and obesity models were represented by u and ε respectively.

Data came from the Economic Research Service – U.S Department of Agriculture (ERS-USDA). The frequencies of all the data used in this study are on a county level across the United States with counties from Alaska and Hawaii excluded. The analysis was performed under the cross-section assumption on time being fixed between the years 2006-2008. This is a very important postulation since the data comes in different years ranging from 2006-2008. Yet the stochastic characteristic of each variable across this time period is consistent making the assumption practical.

Empirical Results

Results from the OLS and 2SLS estimation were summarized in Table 2. Due to the use of a number of variables in estimation, only the significant results were discussed.

Findings suggest that most of the local food variables in the model are significant and can diminish diabetes and obesity rates both under the OLS and 2SLS approaches. For instance, for every additional farmer's market in a county, obesity and diabetes rates decrease by around 0.07% and 0.03%, correspondingly. In addition, increasing the direct farm sales per capita by $1,000 will reduce obesity and diabetes rates by 0.01%. The number of vegetable acres planted per 1,000 county residents was insignificant to obesity and though significant to diabetes, the size of the coefficient is very close to zero. By and large, the coefficient estimates of the local food variables even though significant are quite small. Nevertheless, it should be noted that diabetes rates only range from 3.2 to 17.4 percent while obesity has 12.5 to 43.5 percent for the entire US. Therefore, the coefficients even though small have comparative impacts relative to the overall distribution of disease frequency. Even though the significant results showed positive impacts of local foods to the reduction of diet-related diseases, the evidence provided by this study were still weak and do not provide a strong indication that the said impacts are substantial.

Looking at the other exogenous variables, all of the diet and price related variables are significant in both estimation schemes except for PC_FATS which was found to be only significant to obesity by the OLS method. Findings show that increased per capita fat consumption could lead to higher obesity rates by about 0.32%. Similarly, increased per capita meat consumption not only results into elevated obesity rates (0.04%) but also diabetes rates (0.02%). On the other hand, every additional pound of fruits and vegetables consumed per capita reduces obesity and diabetes rates by about 0.02 and 0.01 percent, respectively. These results are consistent with earlier outcomes that healthy foods are useful in nutritional change (Epstein *et. al*, 2001) while increased intake of fats and meat are vastly associated with higher risks of diabetes and obesity (Van Dam *et. al*, 2002; Appleby *et. al.*, 1998).

The price variables showed insightful consequence as well. According to the results, increased soda sales tax in retail stores could lead to a considerable decrease on the diet-related diseases under investigation. This is the classic quantity and price relationship in demand theory. As price increases brought by increased tax rates, quantity demanded (consumed) goes down and successive reduction in diet-related diseases occurs. The impacts on obesity could range from a reduction of 14-15%, while for diabetes it was 6-8%. Note that the impacts of soda sales tax are enormous as compared to the other variables. This is because sugar-sweetened soft drinks contribute 7.1% of total energy intake and represent the largest single food source of calories in the US diet (Apovian, 2004). Because of this, the same study by Apovian concluded that the odds ratio of becoming obese increased 1.6 times for each additional sugar-sweetened drink consumed every day along with the higher prevalence of implicating diabetes. The same intuition could be derived from the MILK_SODA coefficient where a relative price increase of milk to soda would lead to higher diabetes and obesity rates.

The environmental and physical-activity related factors produced somewhat mixed results. Presence of recreational facilities is significant for obesity rates both under OLS and 2SLS and contributes to the reduction of its prevalence by 1.8- 2.3%. Alternatively, it was only significant to diabetes rates under the 2SLS estimation showing an opposite effect of 0.62%. This result is quite unusual and no study in the literature has supported this outcome. The percentage of adults meeting activity guidelines illustrated negative effects to diabetes and obesity on both estimation approaches. Its impacts could range from 0.08 to 0.25%. PCT_HHNV1 and GROC variables demonstrated perceptive effects. The impact of the prior variable means, as the population of households with no car that lives more than a mile from a store increases; there is a big chance that diabetes and obesity rates also increase. This could be explained by consumer's tendency to purchase ready-to-eat or prepared foods in bulk and stack them at home since they cannot make many trips to the store. Also, often than not, they tend to purchase food that would have longer shelf-life such as canned goods and other processed products. These circumstances lead to unhealthy food choices thus diet-related diseases rises. On the contrary, increasing prevalence of grocery stores help lessen the incidences of diabetes and obesity. This is consistent with previous studies where supermarkets and grocery stores are more inclined to offer healthier food selections with lower costs than smaller stores such as convenience stores at gas stations (Liese, 2007).

Education was found not have any effect on the rates of diet-related outcomes however most of the gender and race factors were found to have significant effects. Both genders have positive relationships with obesity rates under OLS and 2SLS techniques. Not much intuition could be derived from this result for the reason that as the sample size increases, the probability of people having diabetes or obesity also increases. This implies that both males and females have tendencies to be obese however the coefficient on TOT_FEMALE is larger than that of TOT_MALES indicating that the later has lower tendencies of getting obese. For diabetes, females seem to have higher propensity to implicate the disease.

Most of the gender variables are significant with the exception of Native Hawaiians and Pacific Islanders on diabetes under the 2SLS method. This result could be biased and possibly caused by the elimination of the counties from Alaska and Hawaii in the analysis. Notice that even though the variable IA is significant in the 2SLS estimation, it was only significant at the 10% size of test. Nonetheless, it should also be noted that diet between Alaska, Hawaii and the contiguous US are vastly different. Therefore, this result might as well be a consequence of differences in diet. The overall result on race implies that all races in the US have the same tendencies to be obese or diabetic. Some previous studies showed difference of obesity and diabetes rates across genders however having any of these diseases is a major function of unhealthy eating habits and fit lifestyle.

The instrumental variables, MEDIAN_INC and PCT_POVERTY, were both significant in the obesity model under the 2SLS estimation. The coefficient of MEDIAN_INC showed a positive relationship with obesity rates however is effectively small to have any momentous effect. In contrast, every percent increase in poverty rate could lead to a 0.25% increase in obesity rates. In fact, the highest rates of obesity occur among population groups with the highest poverty rates (Drewnowksi and Specter, 2004). This is because poverty is associated with lower food expenditure, low fruit and vegetable intake and lower-quality diets. Most food products that are affordable to the low income population have high sugar content and most of the time unhealthy. This exposes this population with poor food options and may be deterring them to make intelligent food choices.

After instrumentation, inclusion of obesity rates as an endogenous variable to diabetes produced consistent results. Normally, there is loss in efficiency however the standard errors in the 2SLS approach were smaller for some variables while larger for the others as compared to OLS (Table 2). As hypothesized, obesity rates are positively related to diabetes confirming the causality of the prior to the latter.

Summary and Conclusions

This study primarily looks at the impacts of local food systems to health and nutrition in terms of prevalence of two diet-related diseases namely obesity and diabetes. Other variables were included in the analysis as well in order to provide additional evidence to previous findings. Ordinary least squares and two-stage estimation techniques were employed to measure the impacts of 25 factors included in the model. These factors were categorized into 5 major groups specifically diet-, local food-, environment-, education- and gender-related factors. Diet- and environment-related variables provide the most perceptive findings. Local food variables, the major concern of this research, presented significant however weak evidence of positive impacts to health and nutrition. There is still no clear indication of its substantial impacts. Though it should be noted that information relating to local foods are still not extensively collected and available thus future studies could still find more definitive results.

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Table 1. Variable Description and Summary Statistics (N=3108 counties)

Variable	Description	Mean[a]	Min	Max
PCT_DIABET	Adult diabetes rate (age ≥ 20)	9.65 (2.0056)	3.2	17.4
PCT_OBESE	Adult obesity rate (age ≥ 20), obesity defined as BMI ≤ 30 kg/m^2	28.28 (3.6140)	12.5	43.5
PC_FRUVEG	Fruit & vegetables purchased per resident (in lbs)	172.79 (19.2537)	143	252
PC_MEAT	Meat & poultry purchased per resident (in lbs)	70.38 (12.6935)	31	120
PC_FATS	Solid fats purchased per resident e.g. butter and margarine (in lbs)	18.65 (2.2899)	13	24
MILK_SODA	Relative price ratio of low-fat milk to soda	1.05 (.1270)	0.75	1.32
SODA_STORE	Additional tax on soda at retail stores (in percentage points)	0.03 (.0284)	0	0.07
PC_DIRSALES	Value of direct farm sales per capita (in $1,000)	7.30 (12.6936)	0	274.51
FMRKT	Number of farmer's markets in a county	1.65 (3.9497)	0	94.00
VEGACRESP1T	Vegetable acres harvested per 1,000 county residents	35.21 (194.2152)	0	4596.10
REC_FAC_P1T	Number of recreation and fitness facilities per 1,000 county residents	0.09 (.0938)	0	1.193
PCT_ADULTPA	Percent of adults ≥ 18 that meets activity guideleines	3.49 (1.0428)	1	7
PCT_HHNV1	Percentage of households with no vehicle and lives > 1 mile to store	3.98 (2.6025)	0	27.91
GROC	Number of grocery stores and supermarket in a county	20.47 (77.0984)	0	2084
MEDIAN_INC	Median household income	44034.07 (11375.57)	19182	111582
PCT_POVERTY	Poverty rate	15.27 (6.0513)	3.1	54.4
PCT_LESS_HS	Percent population that did not complete high school	22.66 (8.7275)	3	65.3
PCT_HS	Percent population that complete high school	34.70 (6.5603)	10.9	53.2

PCT_SOME_COLL	Percent population that attended at least some years in college	26.12 (5.6331)	9.9	44.9
PCT_COLLEGE	Percent population that completed college	16.51 (7.8002)	4.9	63.7
TOT_MALE	Total male population (in 1,000 people)	47.49 (152.9086)	0.027	4824.22
TOT_FEMALE	Total female population (in 1,000 people)	48.90 (157.1110)	0.027	4910.48
WA	White population (in 1, 000 people)	77.23 (231.198)	0.054	7206.82
BA	Black or African American population (in 1,000 people)	12.44 (56.2091)	0	1360.09
IA	American Indian and Alaskan Native population (in 1, 000 people)	.9412 (3.9092)	0	95.152
AA	Asian population (in 1,000 people)	4.1083 (32.9230)	0	1292.99
NA	Native Hawaiian or Other Pacific Islander population (in 1,000 people)	.1382 (.9764)	0	33.477

[a] Numbers in parentheses are standard deviations

Table 2. Summary of Estimation Results for OLS and 2SLS

	OLS		2SLS	
VARIABLES	(1)	(2)	(3)	(4)
PC_FRUVEG	-0.00865***	-0.0199***	-0.00569***	-0.0250***
	(0.00204)	(0.00423)	(0.00190)	(0.00419)
PC_MEAT	0.0236***	0.0431***	0.0172***	0.0463***
	(0.00309)	(0.00640)	(0.00301)	(0.00617)
PC-FATS	0.0251	0.319***	-0.0223	0.373***
	(0.0157)	(0.0326)	(0.0166)	(0.0322)
MILK_SODA	2.995***	1.385***	2.789***	1.872***
	(0.232)	(0.480)	(0.210)	(0.465)
SODA_STORE	-8.373***	-14.35***	-6.237***	-15.21***
	(0.808)	(1.673)	(0.824)	(1.625)
PC_DIRSALES	-0.00908***	-0.0135***	-0.00708***	-0.00881**
	(0.00177)	(0.00367)	(0.00162)	(0.00355)
FMRKT	-0.0367***	-0.0709***	-0.0261***	-0.0757***
	(0.0100)	(0.0208)	(0.00916)	(0.0200)
VEGACRESP1T	-0.000153	0.000282	-0.000195*	0.000268
	(0.000116)	(0.000239)	(0.000103)	(0.000230)
REC_FAC_P1T	0.285	-2.266***	0.622***	-1.782***
	(0.248)	(0.514)	(0.230)	(0.495)
PCT_ADULTPA	-0.115***	-0.252***	-0.0774***	-0.247***
	(0.00614)	(0.0127)	(0.00895)	(0.0123)
PCT_HHNV1	0.208***	0.295***	0.164***	0.187***
	(0.0114)	(0.0237)	(0.0131)	(0.0242)
GROC	-0.00630***	-0.0125***	-0.00443***	-0.0131***
	(0.000993)	(0.00206)	(0.000952)	(0.00198)
MEDIAN_INC				9.44e-05***
				(8.50e-06)
PCT_POVERTY				0.247***
				(0.0156)
PC_LESS_HS	0.130	0.546	0.0492	0.232
	(0.375)	(0.776)	(0.334)	(0.747)
PC_HS	0.146	0.585	0.0587	0.341
	(0.375)	(0.776)	(0.334)	(0.747)
PC_SOME_COLL	0.112	0.553	0.0294	0.301
	(0.375)	(0.776)	(0.334)	(0.747)
PC_COLLEGE	0.0600	0.414	-0.00160	0.0993
	(0.374)	(0.776)	(0.334)	(0.746)
TOT_MALE	0.0344*	0.182***	0.00732	0.131***
	(0.0208)	(0.0431)	(0.0192)	(0.0416)
TOT_FEMALE	0.125***	0.231***	0.0901***	0.197***
	(0.0210)	(0.0436)	(0.0198)	(0.0420)
WA	-0.0800***	-0.208***	-0.0490***	-0.165***
	(0.0202)	(0.0419)	(0.0189)	(0.0403)

BA	-0.0772***	-0.196***	-0.0481**	-0.153***
	(0.0202)	(0.0419)	(0.0188)	(0.0403)
IA	-0.0694***	-0.189***	-0.0413*	-0.164***
	(0.0234)	(0.0486)	(0.0215)	(0.0468)
AA	-0.0781***	-0.206***	-0.0474**	-0.162***
	(0.0204)	(0.0424)	(0.0191)	(0.0408)
NA	-0.172**	-0.652***	-0.0755	-0.458***
	(0.0845)	(0.175)	(0.0774)	(0.169)
PCT_OBESE			0.149***	
			(0.0281)	
Constant	0.780	-16.92	3.297	1.743
	(37.47)	(77.64)	(33.36)	(74.68)
Observations	3,108	3,108	3,108	3,108
R-squared	0.637	0.520	0.713	0.556

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1