SNAP and Diet Quality: An Instrumental Variables Approach

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Abstract

Recent research has shown that the Supplemental Nutrition Assistance Program (SNAP) is effective in reducing food insecurity. Questions remain, however, about whether SNAP also has any effects on the quality of low-income households' diets. These questions have surfaced in the context of the increasing public costs of diet-related illnesses like diabetes, dyslipidemia, and heart disease. Policy recommendations to restrict what can be purchased with SNAP benefits are evidence of these concerns. We use a unique data set that matches state-level SNAP policy variables to individual level data in three waves of the National Health and Nutrition Examination Survey (NHANES). We examine Healthy Eating Index (HEI) scores and intakes of macro-nutrients for low-income households that do and do not participate in SNAP. We find that, after controlling for observed and unobserved factors, SNAP recipients had overall diet quality comparable to their counterparts, although most differences are in the favor of non-participants. While SNAP purchase restrictions could improve diet outcomes, they might do so at the cost of impairing the effectiveness of SNAP at reducing food insecurity.

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Introduction

The Supplemental Nutrition Assistance Program (SNAP, formerly the Food Stamp Program) is the largest food assistance program administered by the USDA, with approximately 46 million persons participating and yearly expenditures of almost $72 billion in 2011. SNAP provides low-income households with resources to purchase food so as to minimize the likelihood that they will experience food insecurity. This is a primary goal of the program and recent research shows SNAP is effective at reducing food insecurity (Yen, Andrews et al. 2008; DePolt, Moffitt et al. 2009; Nord and Golla 2009; Nord and Prell 2011; Ratcliffe, McKernan et al. 2011; Shaefer and Gutierrez 2012). Indeed, some estimates indicate that SNAP has reduced food insecurity by between 33 and 40 percent of total prevalence (Ratcliffe, McKernan et al. 2011; Shaefer and Gutierrez 2012).

Another goal of the program is to improve the quality of low-income families' diets. This aspect of the SNAP program has received public attention recently because of heightened awareness of the high prevalence of obesity, diabetes, dyslipidemia, and other chronic, diet-related illnesses for which the public bears a sizeable cost. Suggestions that SNAP recipients not be allowed to use benefits to purchase some foods perceived to foster the aforementioned conditions--sugar sweetened beverages, for example--highlight these concerns. The Food and Nutrition Service, aware that food assistance programs need to be part of the means to address high obesity prevalence, is also piloting a program that offers financial incentives for the purchase of healthy foods—the Healthy Incentives Pilot. The Wholesome Wave Double Value Coupon Program, which offers SNAP participants incentives to buy from local farmers markets, is another way to address diet quality through SNAP participation.

Although public attention has only more recently focused on the quality of SNAP participants' diets, this question has been the subject of much social science research over the last 30 years(Fox, Hamilton et al. 2004). Much of the literature has found no change in diet quality is associated with SNAP (or Food Stamp Program) participation. A few studies have found that the program is associated with improved intakes (Devaney and Moffitt 1991; Wilde, McNamara et al. 1999) and a few with poorer intakes (Butler and Raymond 1996; Yen 2010).

The policy question is increasingly relevant, however. As mentioned above, recent research has consistently shown that SNAP participation decreases food insecurity. Changes to the basket of foods eligible for SNAP purchase--for example, exclusion of sugar-sweetened beverages--could well change the mix of households who select into the program and alter its effectiveness at reducing food insecurity. At the same time, there is a legitimate question to be asked about whether SNAP does all it could to improve nutritional quality (as well as access to calories): WIC, which offers vouchers for a narrow range of food products, has been shown to improve diet outcomes, especially for children (Yen 2010).

However, getting an unbiased estimate of the effect of SNAP on diet quality has been difficult. It is reasonable to think that households that choose to participate in SNAP are systematically different from similar low income households that do not. These differences are not observed by the researcher, and they are probably correlated with diet quality. For example, households who do participate in SNAP might value food and nutrition more than similar households that do not. In this case, conventional methods for estimating the effect of SNAP on diet quality will overestimate the effects of SNAP because SNAP participants' diets are likely better than similar non-participants' diets anyway. On the other hand, households that participate in SNAP may have preferences for calorie dense foods that do not meet the *Dietary Guidelines for Americans*. In this situation, conventional estimation methods would underestimate the effect of SNAP on diet quality. Although this problem has been understood for some time, solutions to it have been in short supply.

This study uses new data to address this problem directly. It examines the effect of SNAP participation on adults' diet quality, using person level data on Healthy Eating Index (HEI) scores (components and total) as well as macro-nutrient intakes from the National Health and Nutrition Examination Survey (NHANES) data matched to state-level policy data that capture variation in criteria for SNAP eligibility. We use the state-level variables as instruments for SNAP participation; in particular, we use indicators for the adoption of broad-based categorical eligibility, whether biometric information is required to get SNAP, and the length of the income certification period for SNAP households. All of these instruments are strongly related to SNAP participation but not to HEI scores; they offer us the possibility of identifying SNAP participation independent of the unobserved household characteristics that also affect diet quality.

Our results suggest two things about SNAP participation and diet quality: first, after controlling for observed and unobserved factors, SNAP recipients had overall diet quality comparable to their counterparts. While their HEI scores and HEI component scores are lower than non-participants, the differences are small and, while statistically significant, likely not economically so. Our results using macro- and micro-nutrient outcomes corroborate the findings using HEI scores. Second, given the effectiveness of SNAP at reducing food insecurity, while SNAP purchase restrictions could improve diet outcomes, they might do so at the cost of impairing the effectiveness of SNAP at reducing food insecurity.

Background and Previous Research

Studies of the effect of SNAP on diet have examined a wide range of outcomes, including food expenditures, nutrient availability, adherence to USDA dietary guidance, food group servings, nutrients (macro and micro), body weight, source of food (at-home or away-from-home), and summary measures such as HEI. SNAP can be expected to affect all of these outcomes because it increases income available for food-at-home (FAH) purchases for participants. Standard economic theory tells us that such increases in income ought to increase consumption of food, provided that food is a normal good and that the household's SNAP benefit doesn't exceed its food budget.[1]

Whether we should expect the quality of SNAP recipients' diets to be improved with extra income depends on a host of assumptions about everything from the price of "healthy" foods to the effect of SNAP on time spent on food acquisition and preparation. For example, if we assume that "healthy" foods are more expensive on a per-calorie basis than "unhealthy" ones *and* we assume consumers buy and consume food on that basis (ie. price per-calorie), then, all other things equal, SNAP ought to have an unequivocally positive effect on diet quality. (Drewnowski and Specter 2004; Drewnowski and Darmon 2005). On the other hand, it is not clear either that people consume food on this basis, nor that it is a meaningful way to characterize food prices (Burns, Sacks et al. 2010). Moreover, market prices also do not capture the time component of food price, which will be significant for SNAP households subject to work requirements and the time-cost of preparing foods consistent with the Thrifty Food Plan (Davis and You 2010).

A comprehensive review of the literature concerned with the effect of food and nutrition programs (FANP) and SNAP (formerly called the Food Stamp Program) in particular on diet and health outcomes has been completed by researchers in collaboration with the Economic Research Service of the USDA

[1] However, research has consistently found that the marginal propensity to consume (MPC_f) food out of SNAP benefits is higher than out of ordinary income, so anomalies in spending and consumption patterns may be present. For a discussion of the literature on MPC_f, see Meyerhoefer and Yang (2011, pp.308ff.).

(Fox, Hamilton et al. 2004) .[2] The authors of this study examined a wide range of diet-related outcomes and found that, for studies published between 1973 and 2002, there was little evidence of a significant association between SNAP and individual dietary intake. This was true for all of the outcomes they examined.

One study that Fox et. al. highlight in their review is Gleason et al (2000). The authors of this study looked at a broad range of dietary outcomes, comparing SNAP participant and non-participant adults in households that participated in SNAP.[3] The outcome measures examined included food group servings, nutrient and macronutrient intakes, summary indexes (HEI and the Diet Quality Index (DQI)), and the source of foods. In every dimension, the authors found that SNAP participant and non-participant diets were essentially the same. The authors' noted that, due to the sample size, their findings could really only rule out large dietary effects of SNAP, since the small point estimates that they obtained were almost always within the sampling error.

Basiotis et. al (1998) is one of the few studies in the literature that finds an effect of SNAP on diet outcomes. The authors find that the value of SNAP benefits has a significant, positive association with HEI score; each extra dollar is associated with an increase in HEI of .22 points. They also find that participation has a fairly large negative association with HEI: regression estimates suggest that SNAP participants had HEI scores on average about 3.5 points lower than other low-income non-participants. This suggests that, among SNAP recipients, another dollar of benefits did increase the overall HEI score, and that it would take about $15 worth of benefits for the average SNAP recipient to "catch up" to a similar non-participant.

Wilde, McNamara and Ranney (1999) used a seemingly-unrelated-regressions approach to identify the effect of SNAP participation on diet quality. This study's approach allowed the authors to take into account the within-person and between-family-member correlation in food choices. Interestingly, the authors found that SNAP participation increased intakes of meats, added sugars and total fats; moreover, the correlation between fruit consumption and other kinds of food is very low both within person and within a family. The strongest correlation was between fruit consumption and vegetable consumption.

Another study that found a positive effect of SNAP on adult HEI was Kramer-LeBlanc et al (1997). The authors used changes to Welfare rules in the wake of the Personal Responsibility and Work Opportunity Reconciliation Act (PRWORA) as the occasion to look at the effect of SNAP on the diet quality of able bodied adults without children (ABAWDs). As in Basiotis et. al (1998), the authors find that the amount of SNAP benefits matters for HEI scores. They find that each SNAP dollar is associated with a significant increase in HEI score of .68 points for SNAP households as a whole, but that differences in the effect of SNAP for ABAWDs are statistically insignificant.

A more recent study that uses descriptive measures found that SNAP participants had lower HEI scores than income eligible non-participants (Cole and Fox 2008). The authors of this study also examined a HEI-2005 component scores and found, in general, that SNAP participants did about the same or a little less well than income eligible non-participants. The authors also considered a wide variety of diet outcomes, including BMI, source of MyPyramid Equivalents, and prevalence of adequate usual intakes for micronutrients and found SNAP participants did slightly less well or had comparable diet-related outcomes, compared to income-eligible participants.

[2] Throughout, we refer to the Supplemental Nutrition Assistance Program (SNAP) when discussing earlier studies although almost all previous research refers to the Food Stamp Program (FSP).
[3] Gleason et al. (2000) examine differences in intakes for SNAP pre-schoolers and school-aged children as well. We focus on adults.

As mentioned above, the bulk of studies that look at the effect of SNAP on food intakes don't address systematic unobserved differences between SNAP participants and non-participants. One particularly relevant recent study that has done so is Deb and Waehrer (2011). This study used instrumental variables to identify the effect of SNAP participation on food intakes and particularly the mix of convenience foods and other foods consumed away from home, focusing on how SNAP might affect the time available for household food production. The study used data from the American Time Use Survey (ATUS) to estimate the amount of time that SNAP recipients spent on food preparation and stratified the results by employment status. Additionally, the authors used NHANES data to examine intakes of convenience foods (at home and away from home) and carbonated and sweetened beverages (CSB). Their results suggest that, for part-time workers, SNAP increased the amount of time available for household food production, but that these increases did not yield better diet quality. Part-time workers who participated in SNAP consumed significantly more calories from CSBs and fewer calories from fruits and vegetables.

Data

NHANES

We use data from three waves of the National Health and Nutrition Examination Survey (NHANES) for this study: 2003-2004, 2005-2006, and 2007-2008. NHANES is a stratified multistage probability sample of the civilian non-institutionalized U.S. population. NHANES oversamples blacks, Mexican-Americans (Hispanics after 2006), people over 60, and people with low income.[4] The survey consists of a series of initial interviews usually conducted at the participants' household and a subsequent health examination completed at a Mobile Examination Center (MEC). The survey includes design information (primary sampling units and sample weights) to make population-level estimates possible.

Our primary outcome variable is HEI score. The HEI score was developed by researchers at the Center for Nutrition Policy and Promotion (CNPP) and the National Cancer Institute (NCI) (Guenther, Reedy et al. 2007). The index was developed to measure an individual's adherence to the dietary guidance outlined by the 2005 *Dietary Guidelines for Americans* and translated into recommendations by MyPyramid (now MyPlate). The HEI is the sum of scores for 12 dietary elements: total fruit, whole fruit, total vegetables, dark green and orange vegetables and legumes, total grains, whole grains, milk, meat and beans, oils, saturated fat, sodium, and calories from solid fats, alcohol and added sugar (SoFAAS). Scores for all of the food groups (ie. total fruit, vegetables, etc.) and oils are based on intake adequacy on a per-1000-calorie basis: people with no intakes receive a score of zero, while those with intakes that meet or exceed MyPyramid recommendations get the maximum score. Intakes in between zero and MyPyramid recommendations are given scores prorated on a linear basis. Scores for saturated fat, sodium and SoFAAS are scaled according to the recommendations for limiting discretionary calories; as there is not natural value for a zero score, researchers use the 85th percentile value of intakes from the dietary component of NHANES 2001-2002. For example, for saturated fat, respondents get a zero score if they exceed 15 percent of calories from saturated fat; they get a score of 8 if they meet the 2005 dietary guidelines (less than 10 percent of calories) and a score of 10 if they have less than 7 percent of their calories from saturated fat. The maximum score was assigned to those who had intakes below an amount recommended by relevant research. Depending on the component, researchers assigned a value for a score

[4] Some changes to the sampling frame occurred between 2005-2006 and 2007-2008; in the latter wave, the entire Hispanic populations was oversampled instead of just Mexican Americans. In addition, the over sample of pregnant women and adolescents during 2000-2006 was discontinued. For more information, see http://www.cdc.gov/nchs/nhanes/nhanes2007-2008/generaldoc_e.htm.

of eight based on relevant nutrition research and linearly prorated scores between zero and eight and eight and ten.[5] So, for all component scores, higher is better.

Survey respondents in NHANES were assigned a score based on their 24-hour dietary recall data; separate scores were calculated for each of the two days. We use only the first day of the interview because the second day has a higher rate of non-response, and because people consistently report less consumption on the second day, which suggests under-reporting or survey fatigue. Each of the foods reported is matched to nutrient and food group equivalents through the My Pyramid Equivalents Database (MPED). We use the HEI scores that pertain to the first day of the dietary recall interview administered by NHANES.[6]

The independent variable is household SNAP participation. We use household—rather than sample person--SNAP participation because we assume that financial resources are shared across household members. The SNAP participation variable is coded slightly differently across NHANES waves. In the 2003-2004 and 2005-2006 waves, two questions pertain to household SNAP receipt: the number of persons in the household authorized to receive SNAP, and whether the household received SNAP; both variables pertain to the previous 12 months. In the 2007-2008 wave, only the indicator of receipt in the previous 12 months is present. We tested to make sure that, using either the number of persons or the indicator in the earlier waves, we had the same number of (unweighted) food stamp households. There are small differences in the number of cases using these variables, but our results are not sensitive to them. For the main analysis presented below, we used the 12-month household measure of SNAP participation

We restrict the sample to those households at or below 200% of the poverty line. To address sample selection meaningfully, we need to include households that are not already SNAP eligible--below 130% of the federal poverty line--but who might be on the margin of participating.[7] These households help us identify the effect of SNAP by isolating the counterfactual situation of both participating and non-participating households.

Exogenous Variables

As mentioned above, one of the obstacles to getting good estimates of the effect of SNAP on diet outcomes is the selection issue. One method for addressing this issue is an instrumental variables strategy, which we discuss in detail below. The variables that we use for instruments capture state-level policy variation in eligibility criteria for SNAP participation. These data come from the database of SNAP (Food Stamp) eligibility rules compiled by researchers at ERS and linked to geo-coded NHANES data supplied by the National Center for Health Statistics (NCHS). We use variables indicating whether or not biometric information (usually a fingerprint) was required to receive SNAP, whether or not the state used broad based categorical eligibility rules to determine SNAP eligibility, and the length of time (in months) between recertification of SNAP eligibility.

[5] The weighting for each component re-scales the 10-point score based on its importance to the overall view of the dietary recommendations. Total fruit, whole fruit, total vegetables, dark green and orange vegetables and legumes, total grains and whole grains are all worth 5 points in the final scale; milk, meat and beans, oils, saturated fat, and sodium are worth 10 points; SoFAAS is worth 20 points. For more detail on the construction of the HEI scores, see Guenther, Reedy et. al (2007).

[6] There is a significant drop-off in response rates for the second day of the intake diary, so we use only the first day here.

[7] We are aware that between 2002 and 2008 13 states had raised gross income limits above the 130% cutoff (AZ,DE, MD, MA,NC,WA,WI-200%; ME,OR,-185%; MN,TX-165%) using options under the broad based eligibility rules. Nonetheless, there are few households over 200% of the FPL that report SNAP receipt in our sample; and the majority of households are still subject to the 130% of FPL constraint in applying for SNAP.

There is considerable cross-state and cross-time variation in these policies. During the time of this study, 2003-2008, Arizona, California, Massachusetts, New York, and Texas had biometric information policies in place. Broad based categorical eligibility policies vary across states in the extent to which they relax the asset and/or income requirements for SNAP eligibility. In 2003, Delaware, Maine, Maryland, Massachusetts, Michigan, North Dakota, Oregon, South Carolina and Texas had broad based categorical eligibility policies in place. Washington and Wisconsin added them in 2004; Minnesota and Arizona added them in 2006 and 2007, respectively, and Georgia and West Virginia added them in 2008. Between 2003 and 2008, the average certification period rose from about 7.8 months to 8.4 months. Since persons in the NHANES sample are matched to our policy database by state, month, and year, we can capture even part-year variation in all of these policies on a state level for all states.

Methods

In addition to describing the unconditional differences in food intakes for SNAP participants and non-participants below, we estimate two econometric models. First, we show the results of a simple econometric model of the effect of SNAP on a given diet outcome that looks like

$$y_i = X_i\beta + SNAP_i\delta + \varepsilon_i, \quad (1)$$

where *i* indexes a person, *X* is a vector of person and household level attributes, *y* is the diet outcome or HEI component and *SNAP* is an indicator for whether or not a household has participated in SNAP in the previous 12 months. This is the ordinary least squares (OLS) model, which gives us conditional associations between SNAP receipt and diet outcomes. However, as is well understood, in the presence of unobserved factors that are correlated with SNAP receipt, estimates of the coefficient δ will be biased. Because we believe that diets and SNAP participation are chosen together, we additionally estimate the following model:

$$y_i = X_i\beta + SNAP_i\delta + \varepsilon_i$$

$$SNAP_i^* = Z_i\gamma + X_i\theta + u_i, \ (2)$$

where *Z* are instruments for SNAP participation, *SNAP** is a latent index for the probability of enrolling in SNAP (measured by a binary indicator) and ε and *u* have a bivariate normal distribution with covariance matrix

$$\begin{matrix} \sigma^2 & \rho\sigma \\ \rho\sigma & 1 \end{matrix}.$$

We obtain estimates by using maximum likelihood.[8]

While this model is theoretically identified by the specification of functional form which characterizes the joint distribution of ε and *u*, we use instruments, *Z* to identify variation in SNAP participation. In order for the instruments to be valid, they should be correlated with SNAP receipt and uncorrelated with HEI scores. The first condition can be tested: we show the results of tests of the instruments below. The second is not subject to empirical verification; however, it seems unlikely to us that laws that change the cost to access to SNAP would be correlated with individual HEI scores.

The marginal effects (μ_i) of SNAP participation will be

[8] All models and estimates of standard errors take into account survey design information using Stata survey procedures. All models are weighted using the dietary day one sample weight.

$$\mu_i = \delta + \sigma\rho \; \frac{\varphi(Z_i\gamma + X_i\theta)}{\Phi \;\; Z_i\gamma + X_i\theta \;\; *[1-\Phi(Z_i\gamma + X_i\theta)]} \, ,$$

where φ and Φ are the standard normal density function and cumulative distribution function, respectively (Greene 2000). The intuition here is that, absent a selection effect—that is, if the correlation between unobservables in the two equations (ρ) is zero—the marginal effect can be read off of the coefficient δ; in much of the literature that uses participant/non-participant comparisons, this is what is estimated. Here, in order to address the selection effect, we use the coefficient δ plus the expected difference in the expected value of the error terms, conditional on participation status. (For a fuller treatment of this topic, see (Greene 2000).) We calculate the standard errors of the marginal effects using the delta method.[9]

Results

Sample Means for SNAP Participants and Non-Participants

Table Means shows descriptive statistics for SNAP participant and non-participant households. By many of the observed measures in our analysis, SNAP households are significantly more disadvantaged than non-participant households. They are more likely to be non-Hispanic black or of other non-Hispanic ethnic-racial background than they are to be non-Hispanic whites. Sample persons from those households are more likely to be high school dropouts, and less likely to have any college background or a college degree. Respondents from these households are less likely to have been employed in the previous week and more likely to be married; they are younger on average and have higher self-reported weight a year before their interview; the households from which they come have lower annual incomes.

Differences in HEI and HEI Components by SNAP and Food Security Status

Figure 1 shows simple differences in Total HEI score, stratified by SNAP receipt, for sample persons in households with incomes less than 200% of the Federal Poverty Line.[10] Means for those with incomes above this cutoff are not shown, but, as expected, both component and total HEI scores for those households are on average higher than those with incomes below this cutoff. In Figure 1, the mean HEI for households on SNAP are lower than food insecure households that are not SNAP participants. The difference is about 3.5 points, about seven percent of the average for households at this level of income.

Table HEI Means shows the HEI component scores, tabulated by SNAP participation, as well as differences between the scores. The only component scores on which respondents in SNAP participant households do better are saturated fat and sodium, although only the latter is statistically significant. People in SNAP households have statistically significantly lower scores for total fruit, whole fruit, total vegetables, dark green and orange vegetables, total grain, whole grain and SoFAAS. Most of the differences are small—less than one point—although the difference in SoFAAS scores is 1.4 points, which could be expected since it is the largest component score (20) of all.

OLS results

Table OLS shows coefficients from an OLS regression of HEI score or score components on determinants of HEI score: ethnicity (Hispanic, non-Hispanic), race (white, black, other), educational achievement (high school dropout, high school graduate, some college, college graduate), marital status

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[9] Let $\alpha \equiv [\gamma,\theta]$; the standard error of the marginal effects is $\nu_\mu = \overline{\frac{\partial\mu}{\partial\alpha} V \frac{\partial\mu'}{\partial\alpha}}$, where V is variance-covariance matrix of the treatment equation.

[10] All figures, tables, and regression models take sample design information into account.

(married/unmarried), age, annual household income, self-reported weight 1 year ago, employment status (employed/ unemployed), number of times in the last week one has engaged in vigorous physical activity, household size, and state fixed effects.[11] The coefficients are estimates of the association of HEI scores for respondents in SNAP households relative to those not in SNAP households, all of the controls accounted for.[12]

As the table shows, and like the unconditional measures shown in Figure 1 and Table HEI Means, SNAP recipients, have HEI scores lower than non-recipients. In general, we note that controlling for observed factors tends to introduce a good deal of noise into the estimates of the differences between SNAP participants and non-participants. However, like the unconditional means, these measures show that SNAP participation is associated with lower scores on total HEI score and most component scores. Only the scores for total vegetables, dark green and orange vegetables, and meat and beans are significantly lower for participants than non-participants. Sodium, milk, oils, and saturated fat are all HEI components on which SNAP recipients do better, although only the sodium component is significantly different. This result is consistent with other research that finds small changes in diet quality are associated with SNAP receipt (Gleason, Rangarajan et al. 2000). But, as mentioned above, the primary weakness of these results is that they do not address selection into SNAP. We address this question in the results of our preferred models.

Maximum Likelihood Treatment-Effect Results

Treatment Equation

Table MLEa shows coefficients from the selection equation of the model outlined above. The selection equation is a probit equation, so the coefficients let us know the direction of the effect on the probability of SNAP receipt, but the magnitude and significance cannot be read directly off of the coefficients and their standard errors. For all of the diet outcomes, blacks are more likely to be enrolled in SNAP; as we expect, those with less education and income are more likely to participate in SNAP; respondents who were employed in the last week are less likely to be in SNAP households. Married persons are more likely to be enrolled in SNAP; physical activity appears to make no difference in the likelihood of SNAP participation. State level spending on Nutrition Education per poor person significantly increases SNAP participation. Having a higher self-reported weight one year ago increases the likelihood of SNAP participation by a small but statistically significant amount.

The instruments that we use for SNAP participation are strongly correlated with observed participation; expanded categorical eligibility and the median length of the certification period for wage earners both increase the likelihood of participation, as expected; the use of biometric information decreases participation in SNAP, also as expected. Tests of the joint strength of the instruments indicate that they are strong enough to pass the rule-of-thumb for weak instruments test suggested in the literature (Bound, Jaeger et al. 1995); p-values for all of the IV test statistics are less than .001 .

Table MLEa also shows the values of the correlation parameter, ρ, which estimates the association between the unobservables in the treatment and outcome equations. For most models, this parameter is negative: those who have higher (lower) HEI scores are less (more) likely to enroll in SNAP. This suggests that selection into the program is adverse: SNAP participants are worse off from a dietary health

[11] We used the race/ethnicity recode variable in NHANES to assign racial/ethnic status.
[12] Although our main results pertain to person in SNAP households, we use person-level (instead of household-level) weights (WTDRD1, the dietary day one sample weight) in all of the models, since the individual level HEI score is the outcome of interest.

standpoint as they enroll in SNAP. The correlation parameter is statistically significant for models of whole fruit, dark green and orange vegetables, and whole grains.

One difficult aspect of modeling the effect of SNAP on diet outcomes is the role of body weight and/or BMI. It is difficult to argue against the idea that diet choices are informed by one's weight history; on the other hand, there is a large extant literature that looks at the effect of SNAP on BMI, rather than BMI on SNAP. (For reviews of this literature, see Zagorsky (2009) and Ver Ploeg (2008).) We have retained self-reported weight lagged one year in the treatment and outcome equations for two reasons. First, it makes sense to think that current diet choices are affected by one's past weight rather than weight at a point in time; second, our SNAP participation variable is an indicator for participation at any time in the last 12 months: using weight from one year ago, seems appropriate in this context.[13]

Marginal Effects

The marginal effects of SNAP participation are shown in Table MFX. One of the benefits of using maximum likelihood to estimate the parameters of this model—even though it is more complex than OLS—is that it is more efficient, which is reflected in the much more precise estimates of the marginal effects of SNAP on Total HEI and HEI components. In very general terms, SNAP participants do marginally worse on Total HEI than their counterparts: about 1.5 points or 3 percent of the mean for this group. Scores for all of the HEI component scores except milk, oils and sodium are lower, although most by small fractions of a point. Those components that are higher are also higher by only a fraction of a point.

Robustness

In addition to examining HEI score components, we have also examined nutrient intakes for the first day of the food diary. We did this to check to see whether the construction of the indexes according to the guidelines of the *Dietary Recommendations* or *MyPyramid* was producing a spurious correlation in our results. We estimated models for calories, protein, total fat, saturated fat, monounsaturated fat, polyunsaturated fat, cholesterol, carbohydrates, fiber, alcohol, vitamin A, vitamin C, niacin, vitamin B6, folate, vitamin B12, calcium, phosphorous, magnesium, iron, zinc, copper, sodium, and potassium. We also estimated this model for the fraction of calories consumed away from home. We show results in Table Nutrients A and Table Nutrients B.[14]

As for the total and component HEI scores, the marginal effect of SNAP on nutrient intake is generally statistically significant but small. We find that SNAP recipients have slightly lower calorie, protein, cholesterol, and total fat intake, lower intakes of different kinds of fats (saturated, monounsaturated and polyunsaturated), fiber, alcohol, vitamin A, vitamin B6, folate, vitamin B12, phosphorous, magnesium, copper, sodium and potassium. They have higher intakes of carbohydrates, vitamin C, niacin, and calcium. As might have been surmised from the HEI component score, SNAP recipients have slightly lower intakes of sodium. The fraction of calories consumed away from home is about 3 percent less for SNAP participants than non-participants.

One potential difficulty with the estimation method that we present is that SNAP participants are defined as those who have participated at any time in the previous twelve months, while the dietary recall data pertain to a single day, at which time the NHANES sample person may or may not be receiving SNAP benefits. To address this issue we re-estimated the main model above but with SNAP participation redefined: for years 2003-04 and 2005-06, we call someone a recipient if the sample person responds in

[13] Parameters for the treatment equation are shown in Appendix Table A.1.
[14] All of the marginal effects of SNAP in these models are positive, though not all are statistically significant.

the affirmative to the question about being currently authorized to receive SNAP. For the 2007-2008 wave, we say that the sample person is participating if anyone in the household is participating.[15]

The results of these models are shown in Table Robust. The main intuition of the results remains: SNAP participants do less well than their counterparts in terms of total and component HEI scores. However, it is worth noting that the estimates of the effect of SNAP are larger in magnitude than in our main model. For example, the effect of SNAP receipt on total HEI is 2.3 points—about 4.5 percent of the mean for this sub-population. As in the previous models, SNAP recipients do better on milk, and sodium components, and additionally do better with respect to saturated fat. Selection is adverse in most models and the correlation coefficient ρ is significant in models for total HEI, whole fruit and whole grains.

Discussion

How does SNAP affect diet quality?

The results from our study suggest that, for most components of diet measured by the HEI score, recipients are at small, statistically significant disadvantages in terms of diet quality relative to their non-participant counterparts. At the same time, there are aspects of diet that SNAP does improve: consumption of healthy oils, reduction in sodium, and consumption of healthy dairy products, for example. We also note that the correlation coefficient in nearly all of our models is negative, indicating that selection into SNAP is adverse: that is, people who select into SNAP are worse off in a dietary sense to begin with. In theory, not controlling for selection leads to biased estimates of the effect of SNAP; we observe that our MLE estimates are more precise than OLS effects, though of similar magnitudes.

Do these results point to SNAP as *causing* these small deficiencies in diet? Although it is possible that our models do not adequately control for selection, we think that our instruments are valid, and tests of them suggest that they are strong. Moreover, we think that the model is flexible enough to yield good estimates of the parameters and marginal effects we're interested in. It is possible that the distributional assumptions of the model—namely, joint normality of the errors—is not met, however. We have tested models with alternative assumptions, and not found anything different than what we show here.

To some, these results might suggest that restrictions on the foods eligible for SNAP purchase are justified. Of course, the program could always do more to improving recipients' diets. The question is how to change the program without reducing its effectiveness in combating food insecurity. It is entirely possible to reduce food insecurity while incentivizing the purchase of healthier foods, rather than restricting purchases of foods deemed unhealthy. As a first pass at the issue, that approach seems more likely to succeed in improving diets without changing adversely affecting the mix of households that participate in the program. This approach is also supported by empirical evidence that subsidies for healthy foods would be effective for reducing the costs of cardio-vascular disease (Rahkovsky and Gregory).

[15] We have used this scheme because the 2007-2008 NHANES wave does not ask if the sample person is currently participating in SNAP. We have estimated this model using just the 2003-2004 and 2005-2006 waves and got similar results.

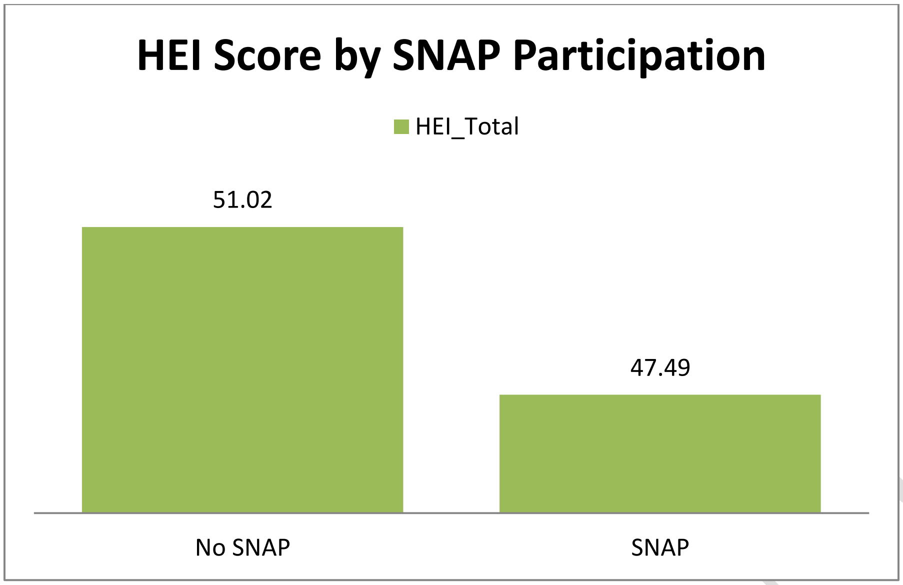
Figures and Tables

Table Means: Sample Means, 200% FPL, Estimation Sample

	No SNAP	SNAP
Hispanic	0.21	0.210
	(0.02)	(0.03)
Black	0.12	0.285***
	(0.01)	(0.03)
Other Race	0.05	0.031**
	(0.01)	(0.01)
HS Drop	0.31	0.431***
	(0.01)	(0.02)
Some College	0.29	0.241**
	(0.01)	(0.01)
College Graduate	0.11	0.035***
	(0.01)	(0.01)
Annual Income ($)	20903.83	15622.28***
	(394.61)	(376.30)
Age	47.06	40.215***
	(0.69)	(0.52)
Married	1.44	1.556***
	(0.02)	(0.02)
Employed	0.53	0.426***
	(0.02)	(0.02)
Vigorous Exercise/Week	1.02	0.976
	(0.07)	(0.17)
Weight 1 Year Ago	172.39	182.142***
	(1.18)	(1.78)
Household Size	3.10	3.684***
	(0.05)	(0.08)
Broad Based Cat Eligibility	0.19	0.24**
	(0.039)	(0.045)
Biometric	0.29	0.232**
	(0.044)	(0.042)
Cert Period	8.52	8.586
	(0.365)	(0.420)
N	3,772	1,333

Note: *p<.10, **p<.05, ***p<.01 denote significance of differences in the sample means between SNAP participant and non-participant households. Standard errors in parenthesis. These are means for the regression estimation sample, for which there are no missing values.

Figure 1. Total HEI Score by SNAP Participation



Total HEI score by SNAP participation. *Source*: Authors' calculations based on NHANES sample, n =5,105. Difference in scores (3.53 points) significant at *p<.01*. Estimates weighted by dietary day one sample weight (WTDRD1).

Table HEI Means

Table HEI Means: Differences in HEI Components by SNAP Participation

	Non-SNAP HH	SNAP HH	Difference
TotalFruit	2.108	1.734	-0.374***
	(0.06)	(0.08)	(0.12)
WholeFruit	1.924	1.371	-0.552***
	(0.06)	(0.06)	(0.10)
TotalVeg	3.009	2.606	-0.403***
	(0.04)	(0.07)	(0.09)
DkGOrVeg	1.209	0.816	-0.393***
	(0.06)	(0.05)	(0.09)
TotGrain	4.213	4.069	-0.143**
	(0.04)	(0.04)	(0.06)
WholeGrain	0.873	0.647	-0.225***
	(0.04)	(0.03)	(0.06)
Milk	4.699	4.387	-0.313*
	(0.09)	(0.12)	(0.17)
MeatBeans	8.160	8.026	-0.133
	(0.08)	(0.09)	(0.14)
Oils	5.432	5.410	-0.023
	(0.10)	(0.12)	(0.18)
SatFat	5.848	5.883	0.035
	(0.10)	(0.12)	(0.17)
Sodium	4.196	4.611	0.416***
	(0.09)	(0.09)	(0.13)
SoFAAS	9.347	7.927	-1.420***
	(0.22)	(0.27)	(0.44)
N		5,105	

*Note: *** p<0.01, ** p<0.05, * p<0.1 that differences are statistically significant, standard errors in parenthesis. Source: Authors' calculations based on NHANES sample below 200% FPL. Estimates weighted by dietary day one sample weight (WTDRD1).*

Table OLS: Marginal effects on HEI and HEI Components.

Table OLS: Marginal Effects of SNAP Participation on HEI Total and Component Scores

	HEI	TotalFruit	WholeFruit	TotalVeg	DkGOrVeg	TotGrain	WholeGrain	Milk	MeatBeans	Oils	SatFat	Sodium	SoFAAS
SNAP	-0.658	-0.018	-0.096	-0.153*	-0.169***	-0.056	-0.027	0.087	-0.197*	0.073	0.008	0.316**	-0.425
	(0.653)	(0.082)	(0.091)	(0.084)	(0.060)	(0.050)	(0.055)	(0.145)	(0.104)	(0.146)	(0.182)	(0.131)	(0.262)
Hispanic	6.207***	0.818***	0.701***	0.141	0.371***	0.323***	-0.177***	-0.432**	0.535***	-0.382**	1.272***	0.445***	2.592***
	(0.921)	(0.128)	(0.124)	(0.093)	(0.088)	(0.062)	(0.065)	(0.202)	(0.132)	(0.154)	(0.174)	(0.169)	(0.499)
Black	-0.701	0.295**	-0.087	-0.182*	0.131	-0.060	-0.129*	-1.676***	0.561***	0.059	0.445***	0.227*	-0.284
	(0.787)	(0.115)	(0.120)	(0.095)	(0.083)	(0.066)	(0.071)	(0.161)	(0.131)	(0.198)	(0.152)	(0.132)	(0.398)
Other Race	2.335	0.496**	0.540**	0.390***	0.159	0.363***	-0.170	-1.188***	0.489**	-0.719**	0.656	-1.140***	2.459***
	(1.441)	(0.222)	(0.222)	(0.142)	(0.158)	(0.088)	(0.124)	(0.330)	(0.248)	(0.343)	(0.402)	(0.341)	(0.764)
HS Drop	-0.601	-0.092	-0.068	-0.138*	0.200***	0.038	-0.110**	-0.118	0.211	-0.520***	0.051	-0.147	0.091
	(0.492)	(0.074)	(0.084)	(0.074)	(0.074)	(0.055)	(0.054)	(0.129)	(0.143)	(0.171)	(0.146)	(0.129)	(0.259)
Some College	0.610	0.016	0.159	-0.140*	0.125*	0.050	0.128**	0.439***	0.027	0.145	-0.325*	-0.271*	0.258
	(0.581)	(0.082)	(0.098)	(0.085)	(0.071)	(0.060)	(0.063)	(0.138)	(0.156)	(0.168)	(0.173)	(0.149)	(0.291)
College Graduate	5.696***	0.658***	0.781***	0.227	0.599***	0.111	0.302***	0.602**	0.313	0.123	0.116	-0.232	2.097***
	(0.938)	(0.130)	(0.139)	(0.156)	(0.137)	(0.092)	(0.109)	(0.267)	(0.211)	(0.289)	(0.281)	(0.200)	(0.366)
Annual Family Income	0.000	0.000	0.000	-0.000	-0.000	0.000**	0.000	0.000**	0.000	-0.000	-0.000	-0.000**	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	0.133***	0.022***	0.027***	0.011***	0.011***	0.004***	0.013***	-0.004	0.007**	0.005	-0.007*	-0.009***	0.054***
	(0.016)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.004)	(0.003)	(0.004)	(0.004)	(0.003)	(0.008)
Married	-1.416**	0.004	0.021	-0.189***	-0.156**	-0.037	-0.018	0.205	-0.279*	-0.263	-0.137	0.069	-0.637**
	(0.566)	(0.086)	(0.098)	(0.071)	(0.061)	(0.042)	(0.055)	(0.149)	(0.149)	(0.170)	(0.159)	(0.132)	(0.258)
Weight 1 Year Ago	-0.008*	-0.002***	-0.002***	-0.001	-0.000	-0.000	-0.000	-0.001	0.006***	0.001	-0.005***	-0.005***	0.002
	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Employed Last Week	-1.342***	-0.245***	-0.220**	0.094	0.149**	0.003	-0.173***	-0.324***	0.132	0.073	-0.028	-0.161	-0.642**
	(0.467)	(0.089)	(0.089)	(0.093)	(0.059)	(0.048)	(0.054)	(0.122)	(0.123)	(0.128)	(0.121)	(0.131)	(0.261)
Vigorous Ex./Wk	0.078	0.029**	0.027**	0.000	0.010	0.011*	0.022**	0.031*	-0.030*	-0.036**	0.027	-0.014	0.002
	(0.070)	(0.014)	(0.011)	(0.010)	(0.012)	(0.006)	(0.010)	(0.019)	(0.016)	(0.014)	(0.027)	(0.016)	(0.038)
Nutrition Education	-0.013	-0.007	-0.001	-0.022	-0.004	-0.011	0.005	-0.060*	0.037*	0.050	0.003	-0.049	0.045
	(0.189)	(0.020)	(0.021)	(0.015)	(0.016)	(0.017)	(0.023)	(0.034)	(0.022)	(0.038)	(0.048)	(0.030)	(0.058)
Household Size	-0.397**	-0.055**	-0.051*	-0.008	0.011	-0.011	-0.065***	-0.034	0.022	-0.017	-0.081**	0.004	-0.112
	(0.202)	(0.028)	(0.029)	(0.021)	(0.026)	(0.017)	(0.014)	(0.046)	(0.028)	(0.055)	(0.041)	(0.044)	(0.096)
N	5,105												

*Note: *** p<0.01, ** p<0.05, * p<0.1, standard errors, adjusted for complex survey design, in parenthesis. Regressions also include state fixed effects. Dependent variable at the top of each column. Estimates weighted by dietary day one sample weight (WTDRD1).*

Table MLE

Table MLE. Parameter of MLE Treatment Equation

	HEI	TotalFruit	WholeFruit	TotalVeg	DkGOrVeg	TotGrain	WholeGrain
Hispanic	-0.030	-0.032	-0.030	-0.039	-0.030	-0.040	0.037
	(0.092)	(0.097)	(0.092)	(0.095)	(0.091)	(0.095)	(0.080)
Black	0.560***	0.561***	0.525***	0.563***	0.459***	0.562***	0.545***
	(0.069)	(0.071)	(0.070)	(0.071)	(0.059)	(0.071)	(0.061)
Other Race	-0.013	-0.028	-0.085	-0.020	-0.031	-0.024	0.121
	(0.147)	(0.152)	(0.136)	(0.152)	(0.102)	(0.152)	(0.123)
HS Drop	0.151**	0.158**	0.149**	0.159**	0.080	0.159**	0.121*
	(0.068)	(0.066)	(0.067)	(0.066)	(0.068)	(0.065)	(0.063)
Some College	-0.115*	-0.113*	-0.086	-0.124*	-0.090	-0.121*	-0.128**
	(0.065)	(0.065)	(0.065)	(0.065)	(0.060)	(0.065)	(0.062)
College Graduate	-0.448***	-0.460***	-0.461***	-0.454***	-0.330***	-0.449***	-0.407***
	(0.128)	(0.129)	(0.121)	(0.125)	(0.116)	(0.128)	(0.113)
Family Income (Yearly)	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	-0.012***	-0.012***	-0.012***	-0.012***	-0.009***	-0.012***	-0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Married	0.266***	0.269***	0.240***	0.268***	0.240***	0.269***	0.259***
	(0.058)	(0.058)	(0.058)	(0.058)	(0.052)	(0.058)	(0.052)
Weight 1 Year Ago	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Employed Last Week	-0.295***	-0.303***	-0.283***	-0.310***	-0.259***	-0.308***	-0.199***
	(0.068)	(0.064)	(0.060)	(0.066)	(0.057)	(0.065)	(0.056)
Vigorous Exercise/Week	-0.008	-0.008	-0.008	-0.008	-0.004	-0.008	-0.015
	(0.011)	(0.011)	(0.011)	(0.011)	(0.008)	(0.011)	(0.011)
BB Cat Eligibility	0.670***	0.606***	0.510**	0.618***	0.483***	0.628***	0.528***
	(0.180)	(0.170)	(0.201)	(0.167)	(0.104)	(0.157)	(0.129)
Biometric	-0.669**	-0.616**	-0.476	-0.627**	-0.555**	-0.640**	-0.405**
	(0.283)	(0.292)	(0.290)	(0.293)	(0.228)	(0.284)	(0.198)
Certification Period	0.042**	0.040*	0.030	0.041*	0.028**	0.041*	0.029**
	(0.021)	(0.022)	(0.020)	(0.022)	(0.013)	(0.022)	(0.015)
Nutrition Education	0.069***	0.068***	0.073***	0.067***	0.050**	0.068***	0.053**
	(0.022)	(0.022)	(0.021)	(0.022)	(0.020)	(0.022)	(0.026)
HH Size	0.254***	0.253***	0.241***	0.254***	0.218***	0.254***	0.210***
	(0.022)	(0.022)	(0.022)	(0.023)	(0.022)	(0.022)	(0.020)
ρ	-0.248	-0.175	-0.797***	0.035	-1.027***	-0.026	-1.057***
	(0.269)	(0.215)	(0.138)	(0.118)	(0.048)	(0.046)	(0.065)
Ln(σ)	2.577***	0.683***	0.824***	0.512***	0.649***	0.139***	0.417***
	(0.028)	(0.017)	(0.025)	(0.008)	(0.020)	(0.021)	(0.026)
N				5,105			

Table MLE (Continued)

Table MLE (Continued): Parameters of MLE Selection Equation						
	Milk	**MeatBeans**	**Oils**	**SatFat**	**Sodium**	**SoFAAS**
Hispanic	-0.040	-0.036	-0.041	-0.041	-0.043	-0.040
	(0.095)	(0.095)	(0.095)	(0.095)	(0.095)	(0.094)
Black	0.562***	0.564***	0.561***	0.563***	0.559***	0.561***
	(0.072)	(0.071)	(0.071)	(0.072)	(0.071)	(0.070)
Other Race	-0.025	-0.021	-0.027	-0.023	-0.024	-0.024
	(0.152)	(0.152)	(0.154)	(0.152)	(0.151)	(0.152)
HS Drop	0.158**	0.157**	0.159**	0.158**	0.160**	0.158**
	(0.065)	(0.064)	(0.065)	(0.065)	(0.065)	(0.066)
Some College	-0.121*	-0.121*	-0.122*	-0.122*	-0.128*	-0.121*
	(0.065)	(0.064)	(0.065)	(0.065)	(0.068)	(0.064)
College Graduate	-0.450***	-0.448***	-0.454***	-0.455***	-0.442***	-0.452***
	(0.128)	(0.127)	(0.127)	(0.128)	(0.128)	(0.127)
Family Income (Yearly)	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	-0.012***	-0.012***	-0.012***	-0.012***	-0.012***	-0.012***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Married	0.270***	0.268***	0.269***	0.268***	0.270***	0.269***
	(0.058)	(0.057)	(0.058)	(0.058)	(0.058)	(0.058)
Weight 1 Year Ago	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Employed	-0.308***	-0.308***	-0.309***	-0.306***	-0.307***	-0.308***
	(0.065)	(0.065)	(0.065)	(0.066)	(0.065)	(0.065)
Vigorous Exercise/Week	-0.008	-0.008	-0.008	-0.008	-0.008	-0.008
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
BB Cat Eligibility	0.630***	0.635***	0.622***	0.638***	0.589***	0.632***
	(0.154)	(0.158)	(0.164)	(0.156)	(0.167)	(0.159)
Biometric	-0.641**	-0.645**	-0.637**	-0.649**	-0.593**	-0.644**
	(0.282)	(0.283)	(0.283)	(0.282)	(0.293)	(0.281)
Certification Period	0.041*	0.041*	0.041*	0.041*	0.038*	0.041*
	(0.022)	(0.022)	(0.022)	(0.022)	(0.023)	(0.022)
Nutrition Education	0.067***	0.067***	0.067***	0.067***	0.067***	0.067***
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
HH Size	0.254***	0.254***	0.254***	0.254***	0.253***	0.254***
	(0.022)	(0.023)	(0.023)	(0.022)	(0.023)	(0.022)
ρ	0.024	-0.063	0.023	-0.038	-0.102	-0.022
	(0.099)	(0.052)	(0.114)	(0.097)	(0.145)	(0.184)
Ln(σ)	1.216***	0.996***	1.278***	1.271***	1.146***	1.869***
	(0.009)	(0.016)	(0.007)	(0.008)	(0.009)	(0.008)
N	5,105					

*Note: *p<.10, **p<.05, ***p<.01. Standard errors, adjusted for complex survey design, in parenthesis. State fixed effects not shown. Estimates weighted by dietary day one sample weight (WTDRD1).*

Table MFX: Marginal Effect of SNAP on HEI Scores and HEI Components: Treatment Effects MLE

	Table MFX: Marginal Effects of SNAP on HEI and HEI Components: 200% FPL												
	HEI Total	TotalFruit	WholeFruit	TotalVeg	DkGOrVeg	TotGrain	WholeGrain	Milk	MeatBeans	Oils	SatFat	Sodium	SoFAAS
μ	-1.562***	-0.115***	-0.456***	-0.137***	-0.472***	-0.064***	-0.302***	0.110***	-0.246***	0.096***	-0.031***	0.225***	-0.466***
v_μ	(0.251)	(0.027)	(0.105)	(0.005)	(0.096)	(0.002)	(0.078)	(0.006)	(0.013)	(0.006)	(0.011)	(0.025)	(0.011)
N	5,105												

*Note: *p<.10, **p<.05, ***p<.01. Marginal effects from two-equation maximum likelihood model, calculated as described in text. Selection and outcome models include race-ethnicity indicators, level of education, age, marital status, self-reported weight 1 year ago, employment status, number of times per week engaged in vigorous exercise, household size, state spending per poor person on Nutrition Education Standard and state fixed effects. Selection equation includes indicators for state SNAP policies: broad based categorical eligibility, biometric, and certification period. Standard errors, calculated by the delta method and adjusted for complex survey design, in parenthesis. N=5,105.*

Table Nutrients A: Marginal Effect of SNAP Participation on Nutrient Intake

	Table MFX Nut: Marginal Effects of SNAP on Nutrient Intake, 200% FPL										
	Energy	Protein	Total Fat	Sat Fat	Mono U Fat	Poly U Fat	Cholesterol	Carbohydrates	Fiber	Alcohol	Vitamin A
μ	-19.78***	-0.047***	-1.810***	-0.221***	-0.939***	-2.086***	-0.106***	0.711***	-0.273***	-1.615***	-221.307*
v_μ	(1.87)	(0.02)	(0.31)	(0.05)	(0.15)	(0.74)	(0.01)	(0.13)	(0.05)	(0.07)	(128.05)
N	5,105										

*Note: *p<.10, **p<.05, ***p<.01. Marginal effects from full model, calculated as described in text. . Selection and outcome models include race-ethnicity indicators, level of education, age, marital status, self-reported weight 1 year ago, employment status, number of times per week engaged in vigorous exercise, household size, state spending per poor person on Nutrition Education Standard and state fixed effects. Selection equation includes indicators for state SNAP policies: broad based categorical eligibility, biometric, and certification period. Standard errors, calculated by the delta method and adjusted for complex survey design, in parenthesis. N=5,105. Energy is measured in kcal, cholesterol in milligrams, Vitamin A in micrograms; all other nutrients measured in grams.*

Table Nutrients B: Marginal Effect of SNAP Participation on Nutrient Intake

	Table MFX Nut (cont'd): Marginal Effects of SNAP on Nutrient Intake, 200% FPL													
	Vitamin C	Niacin	Vitamin B6	Folate	Vitamin B12	Calcium	Phosphorous	Magnesium	Iron	Zinc	Copper	Sodium	Potassium	Frac FAFH
μ	8.220***	0.166***	-0.042***	-0.063***	-1.874	10.103***	-30.021***	-10.079***	-0.303***	-1.336	-0.036***	-0.208***	-6.392**	-0.029***
ν_μ	(0.08)	(0.02)	(0.00)	(0.01)	(1.15)	(1.05)	(0.50)	(0.34)	(0.06)	(1.30)	(0.00)	(0.00)	(3.01)	(0.00)
N	5,105													

*Note: *p<.10, **p<.05, ***p<.01. Marginal effects from full model, calculated as described in text. . Selection and outcome models include race-ethnicity indicators, level of education, age, marital status, self-reported weight 1 year ago, employment status, number of times per week engaged in vigorous exercise, household size, state spending per poor person on Nutrition Education Standard and state fixed effects. Selection equation includes indicators for state SNAP policies: broad based categorical eligibility, biometric, and certification period. Standard errors, calculated by the delta method and adjusted for complex survey design, in parenthesis. N=5,105. Vitamin C, Niacin, Vitamin B6, Calcuim, Phosphorous, Magnesium, Iron, Zinc, Copper, Sodium, and Potassium are measured in milligrams; Folate and Vitamin B12 are measured in micrograms. Frac FAFH is the fraction of calories obtained away from home.*

Table Robust

	Table Robust: Marginal Effects of Current SNAP Participation on HEI Total and Components												
	HEI	TotalFruit	WholeFruit	TotalVeg	DkGOrVeg	TotGrain	WholeGrain	Milk	MeatBeans	Oils	SatFat	Sodium	SoFAAS
μ	-2.371***	-0.301***	-0.570***	-0.059***	-0.019	-0.089***	-0.357***	0.0570***	-0.352***	-0.076***	0.179***	0.337***	-0.712***
ν_μ	(0.60)	(0.09)	(0.14)	(0.01)	(0.02)	(0.01)	(0.10)	(0.00)	(0.02)	(0.00)	(0.01)	(0.03)	(0.14)
N	5,105												

*Note: *p<.10, **p<.05, ***p<.01. Marginal effects from two-equation maximum likelihood model, calculated as described in text. Selection and outcome models include race-ethnicity indicators, level of education, age, marital status, self-reported weight 1 year ago, employment status, number of times per week engaged in vigorous exercise, household size, state spending per poor person on Nutrition Education Standard and state fixed effects. Selection equation includes indicators for state SNAP policies: broad based categorical eligibility, biometric, and certification period. Standard errors, calculated by the delta method and adjusted for complex survey design, in parenthesis. N=5,105.*

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Appendix Table A.1

Appendix Table 1: Parameters of MLE Outcome Equation

	HEI	TotalFruit	WholeFruit	TotalVeg	DkGOrVeg	TotGrain	WholeGrain
SNAP	4.737	0.561	2.479***	-0.252	2.325***	-0.005	1.945***
	(5.918)	(0.714)	(0.396)	(0.354)	(0.095)	(0.104)	(0.085)
Hispanic	6.286***	0.826***	0.739***	0.140	0.407***	0.324***	-0.148*
	(0.943)	(0.128)	(0.134)	(0.092)	(0.102)	(0.062)	(0.076)
Black	-1.532	0.206	-0.484***	-0.166	-0.253***	-0.068	-0.433***
	(1.152)	(0.154)	(0.153)	(0.115)	(0.084)	(0.065)	(0.089)
Other Race	2.398*	0.503**	0.569**	0.389***	0.188	0.363***	-0.148
	(1.445)	(0.220)	(0.225)	(0.141)	(0.160)	(0.088)	(0.142)
HS Drop	-0.844	-0.118	-0.184*	-0.134*	0.088	0.036	-0.198***
	(0.561)	(0.078)	(0.096)	(0.075)	(0.093)	(0.054)	(0.073)
Some College	0.757	0.031	0.229**	-0.143*	0.193**	0.052	0.181**
	(0.615)	(0.084)	(0.116)	(0.085)	(0.082)	(0.061)	(0.078)
College Graduate	6.068***	0.698***	0.958***	0.220	0.771***	0.115	0.438***
	(1.084)	(0.136)	(0.154)	(0.160)	(0.147)	(0.091)	(0.114)
Annual Family Income	0.000	0.000	0.000***	-0.000	0.000***	0.000**	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	0.148***	0.024***	0.035***	0.011***	0.018***	0.004***	0.018***
	(0.023)	(0.003)	(0.003)	(0.002)	(0.003)	(0.001)	(0.002)
Married	-1.728***	-0.029	-0.128	-0.183**	-0.301***	-0.040	-0.132**
	(0.631)	(0.099)	(0.108)	(0.078)	(0.070)	(0.042)	(0.058)
Weight 1 Year Ago	-0.011*	-0.002***	-0.004***	-0.001	-0.002***	-0.000	-0.001**
	(0.006)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Employed	-0.895	-0.197*	-0.007	0.086	0.355***	0.007	-0.010
	(0.699)	(0.116)	(0.109)	(0.100)	(0.078)	(0.051)	(0.063)
Vigorous Exercise/Week	0.087	0.030**	0.031**	0.000	0.014	0.011*	0.025*
	(0.072)	(0.015)	(0.015)	(0.011)	(0.011)	(0.006)	(0.014)
Nutrition Education	-0.105	-0.017	-0.044	-0.020	-0.046**	-0.012	-0.029
	(0.230)	(0.026)	(0.030)	(0.015)	(0.022)	(0.017)	(0.028)
HH Size	-0.749	-0.093	-0.219***	-0.002	-0.152***	-0.015	-0.193***
	(0.459)	(0.058)	(0.046)	(0.034)	(0.032)	(0.018)	(0.019)
N				5,105			

Appendix Table A.1 (Continued)

Appendix Table A.2 (Continued): Parameters of MLE Outcome Equation

	Milk	MeatBeans	Oils	SatFat	Sodium	SoFAAS
HH SNAP Part-12 Months	-0.048	0.089	-0.064	0.240	0.857	-0.186
	(0.598)	(0.234)	(0.741)	(0.678)	(0.798)	(2.035)
Hispanic	-0.434**	0.540***	-0.384**	1.276***	0.452***	2.595***
	(0.202)	(0.133)	(0.156)	(0.175)	(0.173)	(0.498)
Black	-1.655***	0.516***	0.080	0.409**	0.144	-0.321
	(0.201)	(0.141)	(0.217)	(0.175)	(0.193)	(0.493)
Other Race	-1.190***	0.493**	-0.720**	0.659	-1.133***	2.461***
	(0.331)	(0.251)	(0.340)	(0.403)	(0.341)	(0.762)
HS Drop	-0.112	0.198	-0.514***	0.041	-0.171	0.081
	(0.126)	(0.144)	(0.179)	(0.154)	(0.128)	(0.253)
Some College	0.435***	0.035	0.142	-0.319*	-0.256*	0.264
	(0.141)	(0.156)	(0.165)	(0.171)	(0.151)	(0.297)
College Graduate	0.593**	0.332	0.113	0.132	-0.195	2.113***
	(0.271)	(0.211)	(0.292)	(0.281)	(0.224)	(0.426)
Family Income (Yearly)	0.000	0.000	-0.000	0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	-0.005	0.008**	0.004	-0.007	-0.007*	0.055***
	(0.005)	(0.003)	(0.004)	(0.004)	(0.004)	(0.010)
Married	0.213	-0.296**	-0.255	-0.150	0.038	-0.651**
	(0.147)	(0.148)	(0.176)	(0.172)	(0.139)	(0.268)
Weight 1 Year Ago, Self Reported	-0.001	0.006***	0.001	-0.005***	-0.005***	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Employed Last Week	-0.335**	0.156	0.062	-0.009	-0.116	-0.622*
	(0.144)	(0.130)	(0.133)	(0.132)	(0.153)	(0.341)
Times/Wk Vigorous Ex.	0.031	-0.030*	-0.036**	0.027	-0.013	0.002
	(0.019)	(0.016)	(0.014)	(0.028)	(0.017)	(0.038)
Nutrition Education Per Poor Person, Real	-0.057	0.032	0.052	-0.001	-0.058*	0.041
	(0.035)	(0.024)	(0.039)	(0.051)	(0.032)	(0.065)
Household Size	-0.025	0.003	-0.008	-0.096	-0.031	-0.128
	(0.062)	(0.028)	(0.072)	(0.059)	(0.073)	(0.176)
N	5,105					

*Note: *p<.10, **p<.05, ***p<.01. State fixed effects not shown.*