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Re-evaluating associations between the Supplemental Nutrition Assistance Program participation and body mass index in the context of unmeasured confounders

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A B S T R A C T

Objective: To evaluate the association between participation in the Supplemental Nutrition Assistance Program (SNAP) and body mass index (BMI) in the presence of unmeasured confounding.
Methods: We applied new matching methods to determine whether previous reports of associations between SNAP participation and BMI were robust to unmeasured confounders. We applied near-far matching, which strengthens standard matching by combining it with instrumental variables analysis, to the nationally-representative National Household Food Acquisition and Purchasing Survey (FoodAPS, N = 10,360, years 2012–13).
Results: In ordinary least squares regressions controlling for individual demographic and socioeconomic characteristics, SNAP was associated with increased BMI (+1.23 kg/m^2, 95% CI: 0.84, 1.63). While propensity-score-based analysis replicated this finding, using instrumental variables analysis and particularly near-far matching to strengthen the instruments' discriminatory power revealed the association between SNAP and BMI was likely confounded by unmeasured covariates (+0.21 kg/m^2, 95% CI: −3.88, 4.29).
Conclusions: Previous reports of an association between SNAP and obesity should be viewed with caution, and use of near-far matching may assist similar assessments of health effects of social programs.

1. Introduction

Approximately one in seven Americans participate in the Supplemental Nutrition Assistance Program (SNAP, formerly the "Food Stamp Program"), which provides low-income beneficiaries with an electronic debit-type card that can be used to purchase qualified foods. Given the number of participants in SNAP, and the large burden of nutrition-related disease in the United States, epidemiologists have been interested in whether and how the program affects conditions such as obesity. Several previous cross-sectional (Leung et al., 2013; Simmons et al., 2012; Jilcott et al., 2011; Leung and Villamor, 2011) and longitudinal (Schmeiser, 2012; Gibson, 2003), reported associations between SNAP participation and elevated body mass index (BMI), even after adjusting for confounders such as socioeconomic status (see DeBono et al., 2012 for a recent review). Yet many assessments have not addressed unmeasured confounders such as neighborhood factors that may influence both the probability of SNAP participation and obesity risk, such as density and pricing of fresh fruits and vegetables and calorie-dense foods, or additional social and cultural confounders that are difficult to measure (e.g., "local dietary culture"). In addition, previous datasets that have been used to study the SNAP-obesity relationship are limited by lack of administrative confirmation of SNAP participation, which may lead to bias through significant misreporting of SNAP participation status (Kreider et al., 2012).

An ideal experiment to investigate the SNAP-obesity association would be to randomize participation into SNAP, but such an experiment may be unethical (given high food insecurity among

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the SNAP-eligible population, and no natural waiting list or treated control population), illegal (given SNAP is an entitlement for all eligible Americans), and logistically infeasible (given lack of political and administrative support for such research). Therefore two methods of addressing confounding in the absence of a randomized trial have dominated the extant literature: (i) assuming measured confounders can sufficiently block all sources of confounding (ignorability); and (ii) finding an instrumental variable–a variable that effectively encourages individuals into or out of the treatment (SNAP participation) while remaining independent of the outcome (BMI), except through influence on SNAP participation (Baiocchi et al., 2014). Instrumental variable analyses attempt to control for unmeasured confounders by mimicking a randomized trial.

Previous SNAP-BMI studies have generally assumed ignorability–a strong and difficult-to-prove assumption given that SNAP participation and BMI are potentially influenced by many unmeasured factors such as neighborhood poverty (Franco et al., 2008). Alternatively, researchers have used state variations in SNAP enrollment rules as instrumental variables to assess the effect of SNAP on a range of outcomes such as household expenditures (Almada and Nam, 2017), diet quality (Gregory et al., 2012), and food insecurity (Ratcliffe and McKernan, 2010). State variations in SNAP enrollment policies may effectively discourage or encourage individuals from enrolling in SNAP. For example, the requirement of an individual to appear in person and submit a fingerprint may discourage SNAP participation. In FoodAPS, we have access to many of these SNAP policy variables that may vary from state to state ("USDA ERS - Documentation," 2016). A policy variable that is a valid instrument would only be related to BMI through its association with SNAP participation while remaining uncorrelated with any sources of unmeasured confounding in a simple model of BMI as a function of SNAP and other measured confounders, i.e., it is exogenous. Once a valid instrument is identified, researchers typically use it in a two-stage least squares model to estimate the treatment effect of SNAP on BMI.

As with all parametric models, such instrumental variables analysis can produce a treatment effect estimate vulnerable to model specification (i.e., choice of inclusion of different measured covariates), but it is difficult to know if the correct model has been specified (Ho et al., 2007). Instruments can also be "weak" (Todd and Ver Ploeg, 2014); that is, limited in their ability to encourage SNAP participation independent of measured confounders, risking bias (Bound et al., 1995) and sensitivity to unmeasured confounders even with large sample size (Small and Rosenbaum, 2008). 'Weak instrument' bias tends to bias results in the same direction as results from a standard regression approach that adjusts for measured confounders (ordinary least squares, OLS) regression (Pischke, 2016. Chao and Swanson, 2005). Finally, instrumental variable analysis requires parametric adjustment for measured confounders, which may be problematic with skewed data (Ho et al., 2007).

Two recent developments have potentially improved our ability to re-examine the SNAP-BMI relationship. First, the release of the National Food Acquisition and Purchase Survey (FoodAPS) provides a nationally-representative sample of Americans with county-level geocodes and associated covariates, as well as body mass index and administratively-confirmed SNAP participation data. Second, this setting provides an opportunity to test out the relatively new analytical approach of near-far matching (Baiocchi et al., 2010; Rigdon et al., 2017). Prior to fitting any statistical models or conducting any hypothesis tests, near-far matching (Appendix Fig. 1) simultaneously matches groups of participants to be similar in observable characteristics (e.g., age, sex, race, etc.) and maximally different with regard to the level of instrumental variables (e.g., one participant being in a state that encourages SNAP enrollment, and their matched comparator being in a state that discourages SNAP enrollment) (Baiocchi et al., 2010, 2012). The near-far method makes use of instrumental variables' ability to control for unmeasured confounders, while taking advantages of the benefits of matching to examine the distribution of measured confounders. In particular, near-far matching facilitates identification of whether the distributions of measured baseline covariates between treated and untreated subjects are systematically different, which is easier to do than determining whether a model has been correctly specified. Near-far matching can also strengthen 'weak' instruments. Individuals are pair-matched to be near on measured covariates and simultaneously far on the instrument, increasing the chance that within pair differences in treatment assignment are due to differences in the instrument, thus strengthening the instrument. Furthermore, the approach facilitates examination of how changes in the populations selected for analysis by matching can alter the association between treatment and outcome (a sensitivity analysis), and enables nonparametric adjustment for measured confounders through matching (Baiocchi et al., 2010).

Here, we applied near-far matching to the FoodAPS dataset to examine how traditional regression, propensity matching, standard IV analysis, and near-far matching differ in estimating the SNAP-BMI association. This specific case exemplifies a common problem in social epidemiology in which social program exposure and outcomes are potentially explained by unmeasured covariates, and experimental randomization is impossible. We test the hypothesis that associations between SNAP participation and BMI are explained by previously-unmeasured confounders related to county-level covariates.

2. Methods

2.1. Data source

We performed secondary data analyses on the National Household Food Acquisition and Purchase Survey (FoodAPS) released in 2015 by the U.S. Department of Agriculture (USDA). FoodAPS is a cross-sectional national survey representative of non-institutionalized U.S. households conducted in 2012–2013, including subpopulations of SNAP participants, eligible non-participants (household incomes <185% of the federal poverty threshold), and higher-income ineligible non-participants. The FoodAPS survey provides data on SNAP participation; self-reported height and weight (from which body mass index is calculated); demographic and socioeconomic variables including age, sex, race/ethnicity, income and distance to primary store where food is acquired; and county-level geocoded data including poverty rate and urban/rural status. FoodAPS additionally includes state-level SNAP enrollment policy variables commonly utilized as instrumental variables (Appendix Table 1).

2.2. Statistical approach

Our statistical approach proceeded in four steps. Each successive step potentially made a stronger effort to control for unmeasured confounding when assessing the impact SNAP participation on BMI. The four procedures are summarized in Appendix Table 2.

First, we fit a standard ordinary least squares (OLS) model of BMI on SNAP participation (coded as a binary variable – participating or not participating), while adjusting for common measured demographic and socioeconomic covariates to mimic prior epidemiologic studies of the SNAP-obesity association. Demographic and socioeconomic covariates are further defined in Table 1, and include age, sex, race (Black), ethnicity (Hispanic), education level, household size, marital status, and household income (percent of the