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Ending SNAP Subsidies For Sugar-Sweetened Beverages Could Reduce Obesity And Type 2 Diabetes

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ABSTRACT To reduce obesity and type 2 diabetes rates, lawmakers have proposed modifying Supplemental Nutrition Assistance Program (SNAP) benefits to encourage healthier food choices. We examined the impact of two proposed policies: a ban on using SNAP dollars to buy sugar-sweetened beverages; and a subsidy in which for every SNAP dollar spent on fruit and vegetables, thirty cents is credited back to participants' SNAP benefit cards. We used nationally representative data and models describing obesity, type 2 diabetes, and determinants of food consumption among a sample of over 19,000 SNAP participants. We found that a ban on SNAP purchases of sugar-sweetened beverages would be expected to significantly reduce obesity prevalence and type 2 diabetes incidence, particularly among adults ages 18–65 and some racial and ethnic minorities. The subsidy policy would not be expected to have a significant effect on obesity and type 2 diabetes, given available data. Such a subsidy could, however, more than double the proportion of SNAP participants who meet federal vegetable and fruit consumption guidelines.

About one in seven Americans (more than forty-six million people) receive benefits from the food stamp program—now known as the Supplemental Nutrition Assistance Program (SNAP).[1] Low-income populations, including those in SNAP, consume a high number of calories from sugars and eat few vegetables and fruits. They also experience higher rates of obesity and type 2 diabetes than higher-income groups.[2,3] Recent proposals have suggested that reductions in obesity and type 2 diabetes in the United States could be achieved by modifying SNAP policy to encourage healthier food choices. One such policy would be to ban the use of SNAP dollars for sugar-sweetened beverage purchases. Another policy option would be to subsidize vegetable and fruit purchases made with SNAP dollars.[4–7] The US Department of Agriculture (USDA) has initiated a Healthy Incentives pilot study in which SNAP participants receive an incentive of thirty cents for every SNAP dollar spent on targeted fruits and vegetables. The money is credited back to participants' SNAP benefit cards and can be spent on any SNAP-eligible food and beverages.[8]

While proposals to tax or subsidize food have been advanced for the general US population,[9,10] the rationale for directing interventions specifically toward SNAP participants is twofold. First, since low-income Americans have a disproportionately higher prevalence of obesity and type 2 diabetes than other Americans, SNAP policy changes may disproportionately benefit populations most affected by the health consequences of poor nutrition.[11] Second, since SNAP is a federally funded program, taxpayers pay for SNAP program costs as well as downstream health care expenditures (such as through Medicaid) and indirect economic costs from future lost work

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productivity attributable to obesity, type 2 diabetes, and cardiovascular disease.[12]

Here we address a critical gap in knowledge about the proposed SNAP policy changes: How much could policies directed through SNAP affect population-level disease outcomes, particularly obesity and type 2 diabetes? To address this gap in the existing literature, we estimated the population-level health implications of two proposed policies over a multiyear time period—a task that is difficult to capture through pilot studies and trials and, therefore, requires methods from econometrics and epidemiological modeling. We estimated the potential implications of the proposed policy changes on eating behaviors and, in turn, on health outcomes (obesity and type 2 diabetes) among SNAP participants.

Study Data And Methods

OVERVIEW We calculated how changes in price or policy would be expected to affect the consumption of food among SNAP participants, and we then integrated these data into a validated microsimulation model of body mass index and type 2 diabetes risk. The methodological details are provided with all parameters, data sources, and model equations in the online Appendix.[13]

CONSUMPTION BEHAVIORS We characterized actual food consumption (not just changes in food purchased) in kilocalories (one kilocalorie is what the American public generally refers to as a calorie) per person per day among SNAP users, using twenty-four-hour dietary recall data from SNAP participants sampled in the National Health and Nutrition Examination Survey (NHANES).[14] To identify how food price changes affect food consumption among SNAP participants, we linked NHANES data to price data among thirty-five market areas using the USDA Quarterly Food-at-Home Price Database augmented by the Nielsen Homescan Panel Database,[14,15] which describes consumer prices paid for food (including fresh vegetables and fruit).

Using these linked databases, we estimated the effects of price changes on consumption (price elasticity) with the Quadratic Almost Ideal Demand System (QUAIDS). This system of equations captures how changes in consumption are dependent on both price and income, controlling for the impact of demand on price and correcting for the skewed nature of price and consumption distributions.[16,17] It provides estimates of how a change in the price of a food affects consumption of that food (own-price elasticity), and how a change in the price of that food affects substitution of that food with other foods (cross-elasticity).

We also estimated the "marginal propensity to consume" among SNAP participants. The marginal propensity to consume is an estimate of how much SNAP participants reduce their consumption given a reduction in effective SNAP purchasing power (such as from a sugar-sweetened beverage ban), after accounting for baseline consumption, income, and demographics. This captures how much change in sugar-sweetened beverage consumption would be expected to occur if SNAP participants were restricted from purchasing such beverages with SNAP dollars but also ended up spending some of their disposable income to purchase the very same kinds of beverages. (See the Appendix for an example.)[13]

Consumption was analyzed for each of twenty food groups, using standard USDA food codes.[18] To capture potential differences in glycemic load among certain food groups, sugar-sweetened beverages were categorized separately from 100 percent fruit juice, and potatoes were categorized separately from other vegetables. Glycemic load captures the amount of carbohydrate in a food, how much that carbohydrate affects glucose levels in the blood stream, and subsequent risks of insulin resistance and type 2 diabetes.[19,20]

SIMULATED HEALTH EFFECTS OF POLICY CHANGE We integrated the estimates of how price affects consumption (price elasticities) and how reductions in purchasing power affect consumption (marginal propensity to consume) into a microsimulation computer model that simulates how changes in food consumption alter body mass index and risk of type 2 diabetes. (See Appendix Exhibit 1 for a detailed model diagram.)[13]

In the model we simulated the population of SNAP participants defined by demographic variables of age, sex, race or ethnicity, and income. We simulated the population during the period 2015–26, choosing a ten-year simulation period to be consistent with policy planning horizons.[21] As illustrated in Appendix Exhibit 1,[13] each simulated individual consumed a number of kilocalories from each food group, specific to his or her demographic cohort.

To simulate a ban on purchasing sugar-sweetened beverages with SNAP dollars, we simulated two effects: First, sugar-sweetened beverage consumption among SNAP recipients was lowered based on the marginal propensity to consume such beverages (accounting for both reduced purchases using SNAP dollars and compensatory increased purchases using disposable income); and, second, the SNAP dollars no longer spent on sugar-sweetened beverages were distributed among other food groups based on the cross-elasticities between such beverages and other foods (substitution). The portion of overall sug-

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ar-sweetened beverage consumption paid for through SNAP dollars was estimated as the ratio of SNAP benefits to total food expenditures. The ban covered all sugar-sweetened beverages, including sports drinks (not just carbonated sodas), but it excluded 100 percent fruit juice, in line with current proposals.[6,7]

Next, to simulate a thirty-cents-per-dollar subsidy on vegetable and fruit purchases (to match the USDA's Healthy Incentive pilot program)[8] we simulated two effects: increased vegetable and fruit purchases as a result of the effectively lower price among the proportion of such purchases that are made with SNAP dollars (based on own-price-elasticity); and potential changes in consumption of other foods because of the additional effective purchasing power and lower price of vegetables and fruit purchased with SNAP benefits (based on cross-elasticities). To match the USDA Healthy Incentives pilot program, the subsidy was applied to all vegetables and fruit except for nuts, legumes, seeds, potatoes, and juice (fruit and nonpotato vegetables that are fresh, frozen, canned, or dried were eligible for the subsidy).[8]

We simulated two major outcomes: obesity and type 2 diabetes. Body mass index changes were estimated using a validated set of equations derived by the National Institutes of Health,[22,23] which convert kilocalorie consumption changes into kilogram changes in body mass, using starting weight and height data from NHANES. The model assumed no change in physical activity from the simulated policies. We also calculated changes to type 2 diabetes incidence using relative risk measurements that account for the impact of obesity[24] and glycemic load[25] on type 2 diabetes risk, using a standard hazard model[26,27] incorporating incidence rate data from the Centers for Disease Control and Prevention (CDC).[28,29]

SENSITIVITY AND UNCERTAINTY ANALYSES We varied all parameters across their uncertainty ranges to estimate the impact of variation in parameter values on modeled outcomes. We also performed 10,000 repeated replications of the model, repeatedly sampling from the input parameter distributions to generate 95 percent confidence intervals around the modeled results. Statistics on input data were performed in the statistical software Stata, version MP-12.1, and modeling was performed in the software MATLAB, version R2013b.

LIMITATIONS As with any analysis based on statistical and modeling techniques, our assessment relied on assumptions; no model can capture all aspects of reality or predict the future. Our assessment of SNAP participants' consumption behavior relied on data from a validated twenty-four–hour dietary recall strategy and a food security questionnaire in NHANES.[30] Despite its extensive use, the survey is subject to recall biases that typically lead to underestimates of consumption and may include misreporting of SNAP participation. We constructed the model such that these biases would tend to underestimate the impact of the simulated policies, producing a conservative, lower-bound estimate of impact.

SNAP participants consume almost twice as many calories from sugar-sweetened beverages as they do from vegetables and fruit.

Second, our model relied on estimated changes in food consumption to estimate changes in obesity prevalence and type 2 diabetes incidence. The model assumes that physical activity will not change from the simulated policies. The model also relied on estimates of the type 2 diabetes risk associated with both obesity and glycemic load, which may not capture all exposures relevant to diabetes risk. The model is limited to a ten-year simulation period, to be consistent with policy planning horizons as well as to minimize longitudinal uncertainty in the estimates. Yet given the long time course of onset for type 2 diabetes, and potentially other nutritional factors related to diabetes risk, our estimates of effect may again be considered conservative, lower-bound projections.

Third, our assessment did not estimate the potential impact of the simulated policies on food security or other important nutritional outcomes besides obesity and type 2 diabetes. Sugar-sweetened beverage consumption is not thought to mitigate food insecurity, but increased fruit and vegetable consumption may do so.[31]

Fourth, our statistical and mathematical assessment could not capture real political, social, and administrative barriers to implementation of the proposed policies. In addition to political opposition to sugar-sweetened beverage purchasing restrictions from industry lobbyists

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The subsidy would be expected to more than double the proportion of SNAP participants who meet federal recommendations for daily vegetable and fruit intake.

and some anti-hunger groups, the policies may also confer administrative and cost burdens on the USDA and local SNAP programs that could not be captured in our analysis.

Study Results

CURRENT CONSUMPTION BEHAVIOR BEFORE POLICY CHANGES Three notable observations on food consumption among SNAP participants emerged from our analyses.

First, sugar-sweetened beverage consumption among SNAP participants averaged 157 kcal per person per day (95% confidence interval: 0, 500; 7.6 percent of overall calorie consumption; $N = 19,388$), as compared to 140 kcal per person per day among matched nonparticipants (95% CI: 0, 425; 6.0 percent of overall consumption; $N = 120,130$). For reference, one can of regular carbonated soda contains an average of 138 kcal.[32] Most sugar-sweetened beverages were consumed at home (71 percent among SNAP participants, 61 percent among nonparticipants; see Appendix Exhibit 4).[13]

Second, calories from vegetable and fruit consumption were lower than calories from sugar-sweetened beverage consumption among SNAP participants as well as matched nonparticipants. Vegetable and fruit consumption averaged 91 kcal per person per day among SNAP participants (95% CI: 1, 329; only 1.3 percent of participants met federal vegetable and fruit servings per day recommendations), compared to 70 kcal per person per day among matched nonparticipants (95% CI: 1, 274; 1.4 percent met recommendations, consistent with prior independent analyses).[33,34] Most of the vegetables and fruit were consumed at home (68 percent among SNAP participants, 58 percent among nonparticipants). These estimates include potatoes but exclude fruit juice, to match federal recommendations for vegetable and fruit servings per day that include potatoes. Approximately 52 percent of calorie consumption from vegetables and fruit was made up of potatoes or refined potato products among SNAP participants, compared to 49 percent among matched nonparticipants. Excluding potatoes, SNAP participants consumed 44 kcal per day of vegetables and fruit (95% CI: 1, 158), versus 36 kcal per day among matched nonparticipants (95% CI: 1, 150).

Third, SNAP participants' consumption was significantly sensitive to SNAP benefit changes and food price variations. With each one-dollar reduction in effective SNAP benefit purchasing power, SNAP participants reduced their food purchasing by thirty-three cents (95% CI: 0.24, 0.43—the "marginal propensity to consume"). Price changes in food products also resulted in significant consumption changes. A 1 percent price increase in sugar-sweetened beverages was associated with a 1.5 percent consumption decrease (95% CI: 1.2, 1.7), with fruit juice being the most common substitute (a 0.5 percent increase in consumption of fruit juice for each 1 percent increase in sugar-sweetened beverage price; 95% CI: 0.4, 0.6). By comparison, a 1 percent decrease in the price of fruit was associated with only a 0.7 percent consumption increase (95% CI: 0.5, 0.8); similarly, a 1 percent decrease in the price of vegetables was associated with a 0.6 percent consumption increase (95% CI: 0.5, 0.7). Our estimates of consumption changes following price changes (see Appendix Exhibit 5)[13] were consistent with findings of a recent systematic review.[35]

SIMULATED HEALTH EFFECTS OF POLICY CHANGE

▶**SUGAR-SWEETENED BEVERAGE BAN:** A ban on sugar-sweetened beverage purchases would be expected to reduce kilocalorie intake from these beverages by a net average of 24.2 kcal per person per day among SNAP participants (95% CI: 22.8, 25.5)—a 15.4 percent decline in calorie consumption from sugar-sweetened beverages, according to our model. This estimate incorporated the effect of compensatory purchasing using non-SNAP disposable income once SNAP dollars were banned from use to purchase sugar-sweetened beverages. The redistribution to alternative food items of SNAP dollars previously used to purchase sugar-sweetened beverages would include a significant increase in juice consumption of 12.3 kcal per person per day, on average (95% CI: 10.8, 13.8)—a 17.1 percent increase. The ban would be expected to reduce net kilocalorie intake by 11.4 kcal per person per day—a 0.6 percent decrease—and net

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EXHIBIT 1

Comparative Effectiveness Of A Simulated Ban On Using Supplemental Nutrition Assistance Program (SNAP) Dollars To Buy Sugar-Sweetened Beverages Versus A Subsidy To Use SNAP Dollars To Purchase Fruit And Vegetables, 2015–26

	Sugar-sweetened beverage ban		Fruit/vegetable subsidy	
Outcome	Change	95% CI	Change	95% CI
Total daily caloric intake compared to baseline (kcal/person/day)	−11.4**	(−8.4, −14.5)	1.8	(−0.6, 3.0)
Proportion meeting veg/fruit intake guidelines compared to baseline (percent)	—[a]	—[a]	2.1**	(1.8, 2.4)
Glycemic load (grams/person/day)	−2.7**	(−2.4, −3.1)	−0.03	(−0.16, 0.09)
Obesity prevalence compared to baseline (percent)	−0.89**	(−0.41, −1.37)	0.14	(−0.02, 0.31)
Type 2 diabetes incidence compared to baseline (per 100,000)	−8.5**	(−2.4, −14.6)	0.03	(−4.7, 2.7)

SOURCE Authors' analysis. **NOTE** 95 percent confidence intervals (CIs) are calculated from 10,000 repeated replications of the model. [a]Not applicable. **$p < 0.05$

glycemic load by 2.7 grams per person per day. Exhibit 1 displays projected outcomes from this policy.

Given this decline in net kilocalorie intake, overall obesity rates declined over the simulated period. The average reduction in weight per person was 0.52 kg (1.15 lbs.) over the ten-year simulation, which translated into a decline in the obesity prevalence rate of 0.89 percentage point, which is a 2.4 percent decline from current obesity prevalence rates among SNAP participants (approximately 422,000 people; Exhibit 1). The largest relative effects were observed among adults ages 18–65, who would be expected to experience a 1.12-percentage-point decline in obesity prevalence (281,000 people; 95% CI: 0.48, 1.77), as compared to a 0.41-percentage-point decline among children ages 5–18 (141,000 children; 95% CI: 0.26, 0.55). Nonblack and non-Mexican racial and ethnic minorities (predominantly other Latinos and Asians) would be expected to experience a 1.24-percentage-point decline in obesity prevalence (95% CI: 0.79, 1.70). The anticipated decrease in type 2 diabetes incidence averaged 8.5 per 100,000—a 1.7 percent decline in the incidence rate among SNAP participants, or approximately 240,000 people. When accounting for baseline type 2 diabetes rate differences among cohorts, our model estimated that the largest type 2 diabetes incidence decline would be expected among adults ages 18–65, who would be expected to experience an incidence rate decline of 17.2 per 100,000 (95% CI: 4.0, 30.5)—a 2.3 percent decline (see Appendix Exhibit 6).[13]

▶**VEGETABLE AND FRUIT SUBSIDY:** The proposed vegetable and fruit subsidy of thirty cents per dollar was observed to significantly increase the number of vegetable and fruit servings per day among SNAP participants by 0.24 cup-equivalents per day, on average (95% CI: 0.20, 0.28), increasing the percent of SNAP participants meeting vegetable and fruit consumption recommendations by 2.1 percentage points. Our results were similar to those of a recent USDA pilot study of the vegetable and fruit subsidy in Massachusetts, which revealed a 0.22 cup-equivalent increase in vegetable and fruit consumption per day.[8] Accounting for substitutions of other products for vegetables and fruit and the use of additional SNAP dollars to purchase other food products, the policy was not observed to have a significant impact on net kilocalorie intake (mean net intake +1.8 kcal per person per day) or glycemic load (−0.03 grams per person per day; Exhibit 1). The subsidy policy also did not have a significant impact on overall obesity prevalence or type 2 diabetes incidence among SNAP participants, after the uncertainty range in the input parameters to the model was accounted for (Appendix Exhibit 6).[13]

SENSITIVITY ANALYSES The model was more sensitive to changes in price elasticity (the change in consumption per a change in price) than to changes in any other parameter. If the cross-elasticities between vegetables and fruit and other food products increased significantly, meaning that SNAP participants substituted vegetables and fruit more readily for other products when vegetable and fruit prices decreased, the impact of the vegetable and fruit subsidy would be amplified. See Appendix Exhibit 8 for complete sensitivity analyses on the model's input parameters.[13]

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Our model is intended to help policy makers systematically analyze the health implications of complex policies at a population level.

Discussion

More than forty-six million low-income Americans currently participate in SNAP. Among low-income Americans, obesity and type 2 diabetes have been a subject of national concern.[3] In this study we evaluated the potential efficacy of recent proposals to ban the use of SNAP dollars for sugar-sweetened beverage purchases or to further subsidize vegetable and fruit purchases made with SNAP dollars.[4–7] We combined data from a nationally representative dietary survey and a price database of nearly 20,000 children and adults in SNAP to simulate the proposed policies using a combination of economic and epidemiological modeling techniques. These data reveal that SNAP participants consume almost twice as many calories from sugar-sweetened beverages as they do from vegetables and fruit but are sensitive to changes in SNAP benefits and food prices.

MIXED OUTCOMES A policy to ban sugar-sweetened beverage purchases made with SNAP dollars is likely to significantly reduce obesity prevalence and type 2 diabetes incidence, according to our model. The largest effects in the model were observed among adults ages 18–65 and among nonblack, non-Mexican ethnic minorities such as other Latinos and Asians, although the effects remained significant for children and white populations as well. Obesity prevalence would be expected to decline by over 281,000 adults and 141,000 children under this policy.

However, in our model simulations incorporating potential uncertainties in consumption behaviors and metabolism, the vegetable and fruit subsidy had a nonsignificant effect on obesity or type 2 diabetes. Nevertheless, the subsidy would be expected to significantly increase vegetable and fruit consumption and to more than double the proportion of SNAP participants who meet federal recommendations for daily vegetable and fruit intake.

CONTRIBUTIONS TO THE LITERATURE Our analysis makes several important contributions to the existing literature on fiscal strategies to improve nutrition. Prior models have estimated the potential impact of sugar-sweetened beverage taxes on obesity and type 2 diabetes rates but have been criticized for ignoring how much consumers substitute some foods for others or assuming arbitrary levels of substitution.[36] Our model incorporates the effects of substitution through a direct estimation method rather than through assumptions alone and matched the results of a recent USDA pilot trial of vegetable and fruit subsidies conducted in a limited population in Massachusetts, which revealed an increase in vegetable and fruit consumption among SNAP users provided with a subsidy.[8] Our study is also the first analysis, to our knowledge, to examine specifically how population-level health outcomes may be altered by fiscal policies directed through SNAP. This subject is of major national interest given that the program is taxpayer funded. The logic behind SNAP policy changes is that taxpayers are potentially subsidizing unhealthy food consumption and paying for its downstream health consequences.[6]

A key implication, however, of using mathematical models to investigate these policies is that models and their data require careful interpretation. In addition to the limitations noted earlier, a key issue to consider is that the indirect effects of SNAP restrictions on food security, such as SNAP benefit restrictions that discourage eligible beneficiaries from enrolling in SNAP, are not possible to anticipate. In particular, as a result of the recent farm bill, about 4 percent of SNAP participants are expected to experience a benefit reduction over the next decade, which does not affect our input parameters to the model but could worsen food insecurity among SNAP participants.[37]

Another issue requiring further investigation is that benefits of a vegetable and fruit subsidy may accrue in terms of averting nutritional deficiencies or other health risks, not just averting obesity or type 2 diabetes, although a standardized method is not yet available to quantify nutritional deficiency frequency in the US population. Conversely, a vegetable and fruit subsidy may have unintended consequences such as increased consumption of unhealthy food (for example, SNAP participants spending the same amount on cheaper vegetables and fruits as before the subsidy and spending the saved SNAP dollars on less healthy options). Our model attempted to capture these complex behavioral patterns given historical consumption data in-

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corporating SNAP benefit and food price fluctuations, but no model can predict the future.

NEED FOR MORE RESEARCH Our model is intended to help policy makers systematically analyze the health implications of complex policies at a population level. A logical next step, given our findings, is to initiate a randomized controlled trial paralleling the Healthy Incentives pilot trial, testing a sugar-sweetened beverage ban.

Future research on SNAP benefit restrictions should also address how consumption behaviors differ among groups within the SNAP participant population. Given the large and diverse number of Americans currently participating in SNAP, it is likely that there are complex interactions among location (urban versus rural, for example), accessibility of food choices such as fresh produce, and consumption behaviors, not just the price variations we accounted for here.

The question of how the "food stamp cycle" alters behavior is particularly important to evaluate, as the monthly cycle of benefits appears to increase consumption soon after SNAP dollars are received by households. This cycle may predispose people toward purchasing less healthy food items in bulk as opposed to healthier (but perishable) fresh produce.[38]

Conclusion

Given currently available data, we find that a policy to ban sugar-sweetened beverage purchases made with SNAP dollars is more likely to significantly reduce obesity prevalence and type 2 diabetes incidence than a policy to subsidize vegetable and fruit purchases using SNAP dollars. Yet a vegetable and fruit subsidy could significantly increase the proportion of SNAP participants who meet federal vegetable and fruit consumption guidelines, given data on the current behavioral responses of SNAP participants to food price declines. ■

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