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Effects of Subsidies and Prohibitions on Nutrition in a Food Benefit Program
A Randomized Clinical Trial

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IMPORTANCE Strategies to improve the nutritional status of those participating in the Supplemental Nutrition Assistance Program (SNAP) are of interest to policymakers.

OBJECTIVE To evaluate whether the proposed policy of incentivizing the purchase of fruits and vegetables and prohibiting the purchase of less nutritious foods in a food benefit program improves the nutritional quality of participants' diets.

DESIGN, SETTING, AND PARTICIPANTS Lower income participants (n = 279) not currently enrolled in SNAP were randomized to 1 of 4 experimental financial food benefit conditions: (1) incentive (30% financial incentive for fruits and vegetables purchased using food benefits); (2) restriction (not allowed to buy sugar sweetened beverages, sweet baked goods, or candies with food benefits); (3) incentive plus restriction (30% financial incentive on fruits and vegetables and restriction of purchase of sugar sweetened beverages, sweet baked goods, or candy with food benefits); or (4) control (no incentive or restrictions on foods purchased with food benefits). Participants in all conditions were given a study-specific debit card where funds were added every 4 weeks for a 12-week period. Outcome measures were collected at baseline and in the final 4 weeks of the experimental period.

MAIN OUTCOMES AND MEASURES Primary outcomes (from 24-hour dietary recalls) included intake of energy, discretionary calories, and overall diet quality.

RESULTS A number of favorable changes were observed in the incentive plus restriction condition that were significantly different from changes in the control condition. These included (1) reduced intake of energy (−96 kcal/d, standard error [SE], 59.9); (2) reduced intake of discretionary calories (−64 kcal/d, SE 26.3); (3) reduced intake of sugar sweetened beverages, sweet baked goods, and candies (−0.6 servings/d, SE 0.2); (4) increased intake of solid fruit (0.2 servings/d, SE 0.1); and (5) improved Healthy Eating Index score (4.1 points, SE 1.4). Fewer improvements were observed in the incentive only and restriction only arms.

CONCLUSIONS AND RELEVANCE A food benefit program that pairs incentives for purchasing more fruits and vegetables with restrictions on the purchase of less nutritious foods may reduce energy intake and improve the nutritional quality of the diet of participants compared with a program that does not include incentives or restrictions.

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About 1 in 7 Americans participated in the Supplement Nutrition Assistance Program (SNAP) at some point in 2015.[1] The Supplement Nutrition Assistance Program, formerly known as the Food Stamp program, provides funds to low-income families for purchasing food. Benefits are provided on an electronic benefits transfer (EBT) card that is used like a debit card at stores. The funds are meant to supplement (assist) households in purchasing food. In 2015 the average monthly benefit per household was $257.[1]

There is interest in identifying ways SNAP may better meet its objective to help families buy the food they need for good health because lower income families in the US are disproportionately obese, with poor diet quality contributing to this health disparity.[2-7] A variety of program modifications have been proposed,[8-15] including offering financial incentives for the purchase of fruits and vegetables and prohibiting the purchase of less nutritious foods, such as sugar sweetened beverages with program funds.

Offering an incentive for the purchase of nutritious foods might support the purchase and consumption of more healthful foods, but may not necessarily reduce the purchase or consumption of less nutritious foods. Several studies have found that incentives increase purchasing and/or consumption of incented foods.[16-20] But, the purchase and consumption of unhealthy food may not change[17,18,20] or may increase.[16,19]

Prohibiting the purchase of less nutritious foods with SNAP benefits (eg, soft drinks, candies) is a controversial proposal that has been discussed and debated by public health advocates and policy makers.[8-15] It is unclear whether excluding these types of foods from SNAP would improve the nutritional quality of the diet because personal funds may be used to buy foods prohibited from purchase using SNAP benefits.

To our knowledge no experimental studies have been conducted to evaluate whether prohibiting the purchase of less nutritious foods with SNAP benefits improves the nutritional quality of foods purchased and consumed. Likewise research is lacking on the effect of pairing restrictions with incentives.

Methods

This study was conducted to address these important, potentially far-reaching policy-relevant questions using a randomized trial design. The primary dietary outcomes were energy intake and discretionary calories (defined as calories from added sugars, solid fats, and alcohol above moderate consumption level). Other dietary outcomes included intake of added sugars, solid fats, fruits and vegetables, foods restricted, and overall diet quality as measured using the Healthy Eating Index (HEI)-2010.[21] Household food security was examined as a secondary outcome and body mass index (BMI), calculated as weight in kilograms divided by height in meters squared, as an exploratory outcome.

All aspects and procedures of this study were approved by the University of Minnesota institutional review board for the protection of human research subjects. Written informed consent was obtained for all participants, and incentives (gift cards to a discount retailer) were provided for completion of study measures. The trial protocol is included in Supplement 1.

Study Design

Lower income adults not currently enrolled in SNAP were recruited into a 2×2 randomized factorial experiment. After baseline measures were completed, participants were randomized to 1 of 4 financial benefit funds experimental conditions: (1) incentive (30% financial incentive on fruits and vegetables purchased using food benefits); (2) restriction (not allowed to buy sugar sweetened beverages, sweet baked goods, or candies with food benefits); (3) incentive plus restriction (30% financial incentive on fruits and vegetables and not allowed to buy sugar sweetened beverages, sweet baked goods, or candies with food benefits); or (4) control (no incentive or restrictions on foods that are purchased with food benefits). Participants in all conditions were given a study-specific debit card where funds were added every 4 weeks for a 12-week period. Follow-up measures were collected in weeks 9 through 12 of the experimental period.

Eligibility Criteria and Recruitment

Households in the Minneapolis-St Paul, Minnesota metropolitan area were recruited into the study. Individual level measures (eg, height, weight, dietary recalls) were collected from the adult in the household most responsible for food shopping.

For legal reasons it is currently not possible to alter the practices of the actual SNAP program. Accordingly, study eligibility criteria were established with the aim of recruiting adults in households that were near eligible for SNAP or eligible for SNAP but not currently participating. Criteria included: (1) not currently participating in SNAP; (2) household income less than or equal to 200 percent of the federal poverty level, or participating in a government program, such as the Diversionary Work Program, which automatically qualifies household for SNAP in Minnesota; and (3) adult in household most responsible for food shopping is able to read and speak English and is willing to participate. An asset test like that used to determine SNAP eligibility in Minnesota (eg, ascertaining value of any vehicles owned) was not applied. In addition, some other eligibility criteria for SNAP participation (eg, US citizenship, no felony drug conviction, etc) were not applied.

Our initial target sample size was 320 households. For our power calculation we assumed an analytic sample size of 300, and estimated that we could minimally detect a linear trend of 4.5% declining change in energy intake per condition with 80% power and 2-tailed 5% α error, and prepost test correlation of 0.8. This is a small effect size of 0.19. Owing to reductions in the study budget the target was revised to 280 households (70 per condition). Therefore, power may be somewhat lower than our initial estimate.

Recruitment was carried out in the Minneapolis-St Paul, Minnesota metropolitan area by posting study fliers in community locations in neighborhoods with a high poverty rate; distributing fliers through food pantries; and referrals from organizations that serve lower income households. Respondents were screened for eligibility and scheduled for a clinic visit if eligible and interested in participating.

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Table 1. Description of Experimental Conditions

Food Purchase Rule	Experimental Condition			
	Incentive	Restriction	Incentive Plus Restriction	Control
Not allowed to purchase alcoholic beverages, restaurant foods, and dietary supplements with debit card (same exclusion criteria as SNAP)	Yes	Yes	Yes	Yes
Not allowed to purchase sugar sweetened beverages (water-based beverages with added sugar such as soft drinks, fruit drinks, energy drinks, and sports drinks), candy (all types), and prepared sweet baked goods (eg, pies, cakes, cookies, donuts) with debit card	No	Yes	Yes	No
30% Incentive on eligible fruits and vegetables; incentive amount calculated weekly from food purchase receipts and added to debit card. Text/email sent notifying participant of amount added as incentive[a]	Yes	No	Yes	No

Abbreviation: SNAP, Supplemental Nutrition Assistance Program.

[a] Fruits and vegetables not eligible for 30% incentive include fruit juices; fruits canned, frozen, or dried with sugar/syrup; vegetables canned or frozen with a sauce; pickled vegetables; and white potatoes.

Baseline Measures

At a baseline clinic visit, participants were consented and given a questionnaire to assess demographics and household food security (US Household Food Security Survey Module: 6 Item Short Form[22] modified to ask about past the 30 days). Participant height was measured to the nearest 0.1 cm using a stadiometer and weight was measured to the nearest 0.1 kg on a calibrated digital scale following standard protocols.[23] Body mass index was calculated as weight in kilograms divided by height in meters squared. During the visit participants were instructed to collect food purchase receipts for all foods purchased for the 4 week baseline period and each week of the experimental period.

Within 21 days following the baseline visit 3 unannounced 24-hour dietary recalls were collected over the telephone by trained and certified interviewers using the Nutrition Data System for Research.[24]

Follow-up Measures

In the final 4 weeks of the experimental period (weeks 9-12 following randomization) 3 dietary recalls were collected and a follow-up clinic visit was scheduled during which baseline measures were repeated.

Incentives (gift cards to a discount retailer) were provided as follows: $15 for each clinic visit; $40 for each set of 3 dietary recalls (prorated to encourage completion of all 3); and $30 for every 4 weeks of receipt collection.

Experimental Procedures

Those who completed the baseline measures and remained eligible (SNAP EBT card usage not detected on baseline food purchase receipts) were randomized to 1 of 4 experimental conditions (**Table 1**).

Restriction: sugar sweetened beverages, candies, and sweet baked goods were selected for restriction in the restriction and the incentive plus restriction arms because these food categories are leading contributors to discretionary calories in the American diet and contribute minimally to vitamin and mineral intake.[25-29]

Financial incentives: fruit and vegetable intake is insufficient for 44% and 42% of SNAP participants respectively,[3] hence these food categories were selected for incentivizing in the incentive and incentive plus restriction arms. The incentive was 30% of purchase price, and the amount was based on previous research.[30]

After random assignment to condition, a meeting was scheduled to orient the participant to his or her assigned experimental arm. While complete blinding was impossible, we did not share the experimental details of the study with participants; they were blind to other conditions. The participant was given a debit card and told the dollar amount to be added to the card every 4 weeks over the 12-week experimental period (3 deposits). The amount placed on the card every 4 weeks was the average benefit amount provided by SNAP in Minnesota's Hennepin and Ramsey counties to those with the same household size as the participant ($152 monthly for a household of 1, $277 monthly for household of 2, $401 monthly for household of 3, etc). Verbal and written instructions were provided regarding allowable and nonallowable purchases. The food purchase receipt collection procedures (weekly submission of all food purchase receipts) were reviewed, with a focus on the role they play in monitoring compliance with food purchase rules and determining the incentive amount. On a weekly basis the amount of incentive earned for purchasing eligible fruits and vegetables was calculated from the receipts; the incentive amount was added to the participant's debit card; and a text or email was sent to the participant notifying her or him of the incentive amount added to their card.

Compliance in use of the study debit card in accord with experimental procedures was encouraged by explaining appropriate use (training), informing participants of errors made (feedback), and termination of debit card for repeated or flagrant misuse (consequences).

Compliance was monitored using the food purchase receipts submitted by participants in conjunction with transaction information (date, dollar amount, and location) available through the bank that administered the debit cards.

A set of criteria were used to determine when noncompliance with experimental procedures warranted termination of debit card funds (withdrawal of funds from the debit card and discontinuation of addition of funds). Consistent with an intent to treat approach to trial design and analysis, follow-up measures were sought from those terminated.

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Table 2. Demographic Characteristics of 265 Participants at Baseline by Experimental Condition

Characteristic	No. (%)			
	Incentive (n = 68)	Restriction (n = 64)	Incentive Plus Restriction (n = 67)	Control (n = 66)
Age, mean (SD), y	42.2 (12.4)	44.5 (14.6)	46.3 (12.8)	44.9 (12.9)
Sex				
Male	13 (19.1)	12 (18.8)	13 (19.4)	13 (19.7)
Female	55 (80.9)	52 (81.3)	54 (80.6)	53 (80.3)
Ethnicity				
Hispanic/Latino	9 (13.2)	6 (9.4)	6 (9.1)	6 (9.2)
Not Hispanic/Latino	59 (86.8)	58 (90.6)	60 (90.9)	59 (90.8)
Race				
White	17 (25.0)	14 (21.9)	26 (39.4)	20 (30.3)
Black	38 (55.9)	38 (59.4)	30 (45.5)	33 (50.0)
Biracial	9 (13.2)	7 (10.9)	7 (10.6)	12 (18.2)
Other	4 (5.9)	5 (7.8)	3 (4.6)	1 (1.5)
Marital status				
Single, never married	35 (51.5)	34 (53.1)	28 (43.1)	22 (33.3)
Married or partnered	13 (19.1)	16 (25.0)	21 (32.3)	23 (34.9)
Separated/divorced/widowed	20 (29.4)	14 (21.9)	16 (24.6)	21 (31.8)
Household size (debit card benefiter 4-week period)				
1 person ($139)	15 (22.1)	15 (23.4)	21 (31.3)	13 (19.7
2 people ($233)	11 (16.2)	17 (26.6)	15 (22.4)	16 (24.2)
3 people ($350)	17 (25.0)	10 (15.6)	12 (17.9)	21 (31.8)
4 people ($421)	12 (17.7)	9 (14.1)	9 (13.4)	7 (10.6)
5 or more ($493)	13 (19.1)	13 (20.3)	10 (14.9)	9 (13.6)
Education level				
High school graduate or less	18 (26.5)	23 (35.9)	17 (25.8)	16 (24.2)
Some college/associate's degree	42 (61.8)	32 (50.0)	33 (50.0)	34 (51.5)
College graduate or higher	8 (11.8)	9 (14.1)	16 (24.2)	16 (24.2)
Food security				
High or marginal	8 (11.8)	12 (18.8)	15 (22.4)	18 (27.3)
Low	30 (44.1)	22 (34.4)	20 (29.9)	18 (27.3)
Very low	30 (44.1)	30 (46.9)	32 (47.8)	30 (45.5)
Body weight[a]				
Normal weight	12 (17.7)	10 (16.1)	14 (21.5)	12 (19.1)
Overweight	14 (20.6)	18 (29.0)	17 (26.2)	13 (20.7)
Obese	42 (61.8)	34 (54.8)	34 (52.3)	38 (60.3)

[a] Body mass index (calculated as weight in kilograms divided by height in meters squared) of less than 25 classified as normal weight; 25-29.9 classified as overweight; and more than 30 classified as obese.

Statistical Analysis

Because loss to follow up was low overall and for each of the conditions, the analytic sample was restricted to those with baseline and follow-up measures (n = 265).

A measure of usual intake for each food and nutrient of interest at baseline and follow-up was estimated by averaging intake estimates from the multiple 24-hour dietary recalls collected from each person at each measurement period. Those with only 1 dietary recall at baseline or follow-up (n = 14) were excluded from analyses in which food or nutrient intake was the outcome of interest because a single recall is a poor representation of usual intake owing to high day-to-day variation in diet.

Means and frequencies were calculated for the demographic and health characteristics of those in each experimental condition. General linear regression models[31] were used to evaluate differences in outcomes at follow-up by experimental condition. Outcome measures (eg, change in energy intake from baseline to follow-up) were separately regressed on an experimental condition indicator. Participants with extreme studentized residuals as identified in SAS statistical software proc GLM (version 9.3, SAS Institute) were excluded (n = 0 to 6 depending on nutrient/food group). Because no confounding was expected as a result of randomization and the distribution of potential confounders appeared to be similar across experimental conditions (**Table 2**) no covariates were included in the final models.

All analyses were planned a priori and all outcomes examined are reported herein. A *P* value of less than .05 was the criterion for statistical significance.

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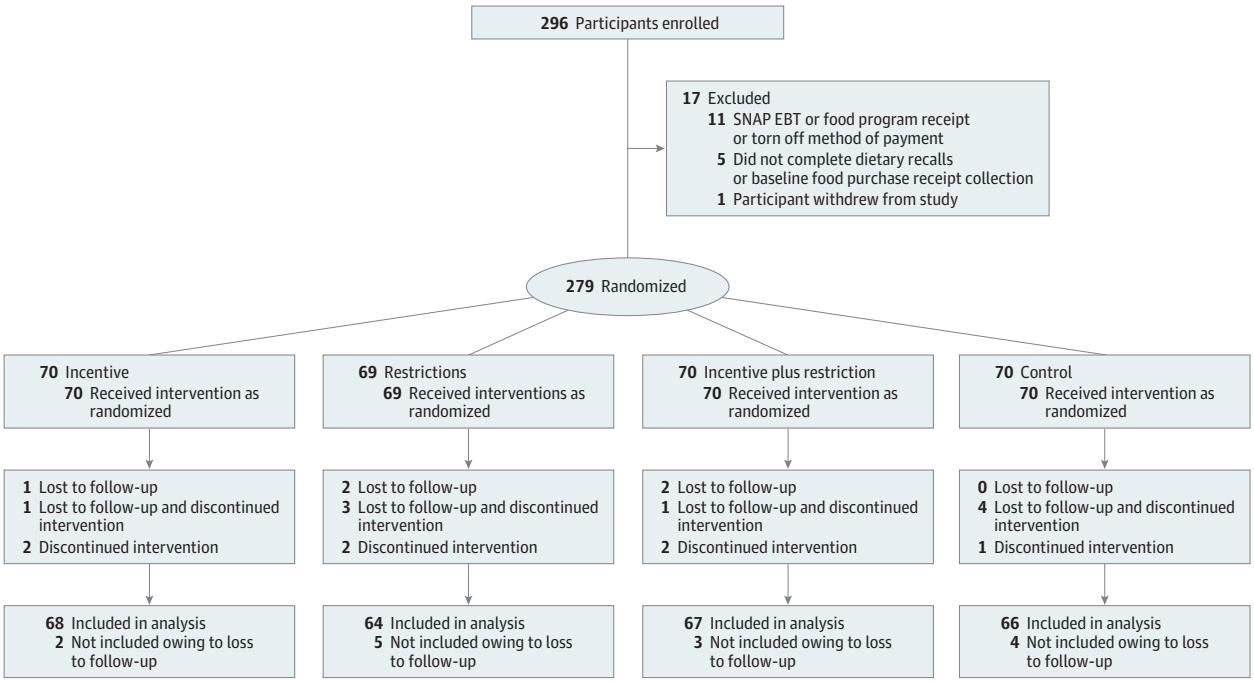
Figure. Flow of Study Participants: Incentives and Restrictions in a Food Benefit Program



Results

Between August 2013 and May 2015, 279 participants completed baseline measures and were randomized to 1 of the experimental conditions (**Figure**). Most (95%; n = 265) completed the follow-up measures. Completion rates were similar across experimental conditions (93%-97%). The demographic characteristics of those who completed follow-up measures were similar to those who did not with 1 exception. Those who completed follow-up measures were significantly more likely to have some education beyond high school (72%) compared with those who did not (43%).

Sixteen participants (6%) had their debit card funds discontinued owing to noncompliance with experimental procedures. Similar numbers were discontinued from each experimental condition (incentive arm, n = 3; restriction arm, n = 5; incentive plus restriction arm, n = 3; and control arm, n = 5). Reasons for discontinuation included use of the debit card to purchase nonfood items (n = 9); SNAP EBT card use detected on food receipts (n = 6); and use of debit card to purchase ineligible foods to the extent that the infraction limit was exceeded (n = 1). Seven of the 16 participants completed follow-up measures.

Those in the incentive and incentive plus restriction arms received incentives on eligible fruit and vegetable purchases that totaled, over the 12-week intervention period, an average of $41.25 and $44.69 respectively (eTable 1 in Supplement 2).

Most participants were female with an average age of 44.5 years. African Americans comprised 52.7% (n = 139) of the sample followed by those who self-identified as white (29.2%; n = 77) or biracial (13.3%; n = 35). Most were either overweight (24.0%; n = 62) or obese (57.4%; n = 148). Household food security was low (34.0%; n = 90) or very low (46.0%; n = 122) for most. Ten percent of participants reported currently participating in WIC. Thirty-seven percent reported using an emergency source of food (eg, food pantry) in the past month. About one-half reported participating in SNAP in the past. Demographic factors were similar across experimental conditions (Table 2).

Differences (changes) in food and nutrient intake between baseline and follow-up by experimental condition are presented in **Table 3**.

Change in energy intake was found to differ significantly between the restriction (−105 kcal/d; SE, 87.5) and incentive plus restriction (−96 kcal/d; SE, 85.4) arms compared with the control arm (80 kcal/d; SE, 61.1).

Change in energy from discretionary calories for the incentive plus restriction arm (−64 kcal/d; SE, 38.6) was significantly different from the control arm (13 kcal/d; SE, 27.5). For discretionary calories as a percent of total energy, changes differed between the incentive plus restriction (−2.8%; SE, 1.7%) and the restriction (1.0%; SE, 1.7%) arms.

Change in sugar sweetened beverage intake was found to differ between those in the incentive (−0.3 servings/d; SE, 0.2) and incentive plus restriction (−0.3 servings/d; SE, 0.2) arms compared with those in the control arm (0.2 servings/d; SE, 0.1).

In comparing change in consumption of all the foods targeted for restriction in the restricted and incentive plus restriction conditions (sugar sweetened beverages, candies, and sweet baked goods) 2 statistically significant differences between conditions were found. Change in servings of

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Table 3. Comparison of Change (Difference) in Food and Nutrient Intake From Baseline to Follow-up by Experimental Condition

Food/Nutrient	Experimental Condition, Mean (SE)				*P* Value[a]
	Incentive	Restriction	Incentive Plus Restriction	Control	
Energy, kcal/d (n = 249)					
Baseline	1840 (79.8)	1865 (82.8)	1890 (89.6)	1647 (75.3)	.12
Follow-up	1811 (84.2)	1761 (93.4)	1794 (78.8)	1727 (81.6)	
Difference[b]	−28.8 (84.7)	−105 (87.5)	−96 (85.4)	80 (61.1)	
Discretionary calories, kcal/d (n = 250)					
Baseline	562 (34.0)	576 (41.8)	558 (37.3)	504 (32.8)	.13
Follow-up	568 (41.3)	530 (37.2)	494 (34.1)	517 (31.6)	
Difference[c]	5.5 (38.2)	−46 (39.7)	−64 (38.6)	13 (27.5)	
Discretionary calories, % energy (n = 251)					
Baseline	29.8 (1.1)	29.1 (1.3)	29.2 (1.0)	29.6 (1.3)	.13
Follow-up	28.9 (1.1)	30.1 (1.3)	26.4 (1.2)	29.6 (1.3)	
Difference[d]	−0.9 (1.6)	1.0 (1.7)	−2.8 (1.7)	−0.1 (1.2)	
Added sugar, g/d (n = 250)					
Baseline	59.5 (5.4)	57.2 (5.3)	60.7 (5.1)	55.5 (4.6)	.38
Follow-up	56.9 (5.8)	52.5 (4.9)	49.9 (4.0)	53.8 (3.9)	
Difference	−2.6 (5.7)	−4.7 (5.9)	−10.8 (5.7)	−1.6 (4.1)	
Added sugar calories, % energy (n = 251)					
Baseline	12.9 (0.9)	11.8 (0.8)	12.8 (0.8)	13.2 (0.9)	.19
Follow-up	11.6 (0.8)	12.2 (0.9)	10.9 (0.7)	13.5 (1.2)	
Difference	−1.3 (1.3)	0.4 (1.3)	−1.9 (1.3)	0.3 (0.9)	
Solid fats, g/d (n = 250)					
Baseline	35.6 (2.1)	36.5 (2.8)	32.3 (1.9)	30.8 (2.1)	.53
Follow-up	36.1 (2.6)	34.8 (2.5)	30.6 (2.3)	32.9 (2.5)	
Difference	0.5 (2.9)	−1.8 (3.1)	−1.6 (3.0)	2.1 (2.1)	
Solid fats, % energy (n = 251)					
Baseline	17.0 (0.6)	16.8 (0.8)	16.0 (0.6)	16.2 (0.7)	.72
Follow-up	17.1 (0.8)	17.3 (0.7)	15.1 (0.8)	16.1 (0.8)	
Difference	0.1 (1.2)	0.6 (1.2)	−0.8 (1.2)	−0.1 (0.9)	
Sugar sweetened beverages, servings/d (n = 249)					
Baseline	1.2 (0.2)	1.1 (0.2)	1.2 (0.2)	0.9 (0.1)	.01
Follow-up	1.0 (0.2)	1.0 (0.2)	0.9 (0.1)	1.1 (0.2)	
Difference[e]	−0.3 (0.2)	−0.1 (0.2)	−0.3 (0.2)	0.2 (0.1)	
Restricted foods, servings/d (n = 249)[f]					
Baseline	1.7 (0.2)	1.7 (0.2)	1.9 (0.2)	1.5 (0.2)	<.01
Follow-up	1.6 (0.2)	1.6 (0.2)	1.3 (0.2)	1.7 (0.2)	
Difference[g]	−0.1 (0.2)	−0.1 (0.2)	−0.6 (0.2)	0.3 (0.2)	
Total fruit, servings/d (n = 245)					
Baseline	0.6 (0.1)	0.6 (0.1)	0.6 (0.1)	0.8 (0.1)	.07
Follow-up	1.0 (0.1)	0.7 (0.1)	0.9 (0.1)	0.8 (0.1)	
Difference[h]	0.4 (0.2)	0.1 (0.2)	0.3 (0.2)	0.0 (0.1)	

(continued)

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Table 3. Comparison of Change (Difference) in Food and Nutrient Intake From Baseline to Follow-up by Experimental Condition (continued)

Food/Nutrient	Experimental Condition, Mean (SE)				*P* Value[a]
	Incentive	Restriction	Incentive Plus Restriction	Control	
Solid fruit, servings/d (n = 241)					
Baseline	0.4 (0.1)	0.3 (0.1)	0.4 (0.1)	0.5 (0.1)	.06
Follow-up	0.6 (0.1)	0.4 (0.1)	0.6 (0.1)	0.5 (0.1)	
Difference[i]	0.2 (0.1)	0.1 (0.1)	0.2 (0.1)	0.0 (0.1)	
Total vegetables, servings/d (n = 251)					
Baseline	1.3 (0.1)	1.3 (0.1)	1.4 (0.1)	1.2 (0.1)	.99
Follow-up	1.3 (0.1)	1.3 (0.1)	1.3 (0.1)	1.2 (0.1)	
Difference	0.0 (0.1)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	
Vegetables, no potatoes, servings/d (n = 249)					
Baseline	1.0 (0.1)	1.0 (0.1)	1.1 (0.1)	1.0 (0.1)	.99
Follow-up	1.0 (0.1)	1.1 (0.1)	1.1 (0.1)	1.0 (0.1)	
Difference	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.1 (0.1)	
Total fruits and vegetables, servings/d (n = 251)					
Baseline	1.9 (0.1)	1.9 (0.2)	2.0 (0.2)	2.1 (0.2)	.43
Follow-up	2.3 (0.2)	2.0 (0.2)	2.3 (0.2)	2.1 (0.2)	
Difference	0.4 (0.2)	0.1 (0.2)	0.2 (0.2)	0.1 (0.2)	
Fruits and vegetables, no juice or potatoes, servings/d (n = 248)					
Baseline	1.3 (0.1)	1.4 (0.1)	1.6 (0.2)	1.5 (0.1)	.68
Follow-up	1.6 (0.1)	1.6 (0.2)	1.8 (0.2)	1.6 (0.2)	
Difference	0.3 (0.2)	0.2 (0.2)	0.1 (0.2)	0.1 (0.1)	
HEI-2010 score (n = 251)					
Baseline	50.5 (1.4)	52.1 (1.7)	49.6 (1.7)	51.3 (1.6)	<.01
Follow-up	52.2 (1.5)	49.8 (1.8)	53.7 (1.7)	51.0 (1.8)	
Difference[j]	1.6 (1.9)	−2.3 (2.0)	4.1 (1.9)	−0.2(1.4)	

Abbreviation: HEI, Healthy Eating Index.

[a] *P* value calculated from F test for equality of means.

[b] Differences are significantly different (*P*<.05) between the restriction and control groups and the incentive plus restriction and control groups.

[c] Differences are significantly different (*P*<.05) between the incentive plus restriction and control groups.

[d] Differences are significantly different (*P*<.05) between the restriction and incentive plus restriction groups.

[e] Differences are significantly different (*P*<.05) between the incentive and control groups and the incentive plus restriction and control groups.

[f] Sugar sweetened beverages, candies, and sweet baked goods.

[g] Differences are significantly different (*P*<.05) between the incentive and incentive plus restriction groups and the incentive plus restriction and control groups.

[h] Differences are significantly different (*P*<.05) between the incentive and control groups.

[i] Differences are significantly different (*P*<.05) between the incentive and control groups and the incentive plus restriction and control groups.

[j] Differences are significantly different (*P*<.05) between the incentive and restriction groups; the restriction and incentive plus restriction groups; and the incentive plus restriction and control groups.

Table 4. Comparison of Change (Difference) in Percent With Low or Very Low Food Security Status From Baseline to Follow-up by Experimental Condition in 265 Participants

Low or Very Low Food Security	Experimental Condition, No. (%)				*P* Value[a]
	Incentive (n = 68)	Restriction (n = 64)	Incentive Plus Restriction (n = 67)	Control (n = 66)	
Baseline	60 (88.2)	52 (81.3)	52 (77.6)	48 (72.7)	.18
Follow-up	19 (27.9)	16 (25.0)	16 (23.9)	27 (40.9)	
Difference[b]	−60.3	−56.3	−53.7	−31.8	

[a] *P* value from χ^2 test.

[b] Differences are significantly different (*P*<.05) between the incentive and control groups; the restriction and control groups; and the incentive plus restriction and control groups.

restricted foods differed between those in the incentive plus restriction arm (−0.6 servings/d; SE, 0.2) compared with those in the incentive (−0.1 servings/d; SE, 0.2) and control (0.3 servings/d; SE, 0.2) arms.

Change in total fruit intake was significantly different between those in the incentive arm (0.4 servings/d; SE, 0.2) compared with those in the control arm (0 servings/d; SE, 0.1). Findings for solid fruit were somewhat different, with change in intake different for both the incentive (0.2 servings/d; SE, 0.1) and incentive plus restriction (0.2 servings/d; SE, 0.1) arms compared with the control arm (0 servings/d; SE, 0.1).

The HEI-2010 is an index designed to assess the extent to which an individual's diet is consistent with the 2010 Dietary Guidelines for Americans. Index scores may range from 0 to 100, with a higher score indicative of a diet that is more consistent with dietary recommendations. In the study total HEI-2010 score changes were significantly different between those in the incentive plus restriction arm (4.1 points; SE, 1.9) compared with the control (−0.2 points; SE, 1.4) and the restriction (−2.3 points; SE, 2.0) arms. Furthermore, the change in total HEI-2010 score was significantly different between those in the incentive (1.6 points; SE, 1.9) and restriction (−2.3 points; SE, 2.0) arms.

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Reductions in the percent of households that reported low or very low food security were observed in all experimental arms (**Table 4**). The magnitude of change was significantly smaller for the control arm (−31.8%) compared with the other arms (−53.7 to −60.3).

No statistically significant group differences in change in BMI were observed (eTable 2 in Supplement 2).

We present results unadjusted for type I error rates for multiple testing because all hypotheses were identified a priori (no post hoc analyses or *P* value dependent analyses were conducted), and as such maintain the nominal error rate for the family of tests. In addition, we present results for all outcomes examined (reporting is not selective). If an adjustment is made for type I error rates using a Bonferonni correction (*P* = .05 divided by 128 tests), the threshold of significance is .0004. Using this threshold none of the results are statistically significant.

Discussion

A number of favorable changes in diet were observed in the incentive plus restriction condition that were significantly different from changes in the control condition. These included reduced energy intake; reduced intake of discretionary calories; reduced intake of sugar sweetened beverages, sweet baked goods, and candies; increased intake of solid fruit; and improved HEI-2010 score. To our knowledge, this is the first study to examine the effects of pairing food purchase financial incentives with restrictions on food and nutrient intake.

Improvements in diet quality were also observed in the incentive relative to the control condition. Intake of sugar sweetened beverages decreased and intake of fruit increased (0.4 servings/d; SE, 0.2 for total fruit and 0.2 servings/d; SE, 0.1 for solid fruit). These findings are largely consistent with the results of the USDA Healthy Incentive Pilot (HIP) study.[20] In that study fruit and vegetable consumption was 0.32 servings per day more among SNAP participants receiving a 30% financial incentive for purchasing fruits and vegetables compared with SNAP participants not receiving this incentive (*P* < .001). Most of the difference between means was attributable to higher fruit intake in the group receiving the incentive (0.23 servings/d; *P* < .001). Consistent with our findings, the HIP study found similar intakes of energy, added sugars, solid fats, and discretionary calories between those in the incentive and no-incentive groups.

The only statistically significant difference in diet observed in the restricted arm compared with the control arm was a decrease in energy intake. This finding suggests that prohibiting the use of food benefits to purchase sugar sweetened beverages, candies, and sweet baked goods may decrease energy intake, thus potentially addressing concerns related to overweight and obesity. However, the nutritional quality of the diet may otherwise be unaffected. Although these findings cannot be compared with those of other experimental studies because ours is the first, econometric modeling studies suggest that restrictions on food items eligible for purchase in a food benefit program such as SNAP could result in small decreases in expenditures for restricted items.[32]

The proportion of households with low or very low food security decreased markedly between baseline and follow-up in all 4 experimental arms, which is consistent with studies that have evaluated the effect of SNAP on household food security.[33,34] It is unclear why the proportion of households with low or very low food security was reduced less in the control arm compared with the other conditions. Increased food purchasing power is a potential explanation for the arms in which a financial incentive was provided, but does not explain the differences in change in food security between the restriction and control arms.

Limitations

Study limitations include the representativeness of our sample with respect to the target population. Actual SNAP participants may respond differently, and the external validity of findings may therefore be limited. In addition, only the diet of the adult in the household most responsible for food shopping was assessed. Consequently, the effects on other household members such as children are unknown. Owing to the large number of statistical comparisons carried out (n = 128) it is likely that some of the 20 statistically significant results are attributable to type I error. Other limitations include reliance on a self-report measure of diet (as opposed to biomarkers), a short experimental period, and use of a debit card to mimic food benefits received through SNAP.

Study strengths include use of a randomized factorial trial design. Food and nutrient intake was measured using multiple dietary recalls collected at baseline and follow-up. Although this method has shortcomings, it is among the best self-report methods for assessing diet in free-living populations.[35]

The greatest strength of the study may be its innovativeness and importance to public policy. In recent years California, Nebraska, Illinois, Pennsylvania, Michigan, Maine, Vermont, and Texas have either requested permission or urged Congress to grant states more flexibility to set standards for what can and cannot be purchased with SNAP benefits. For example, in 2015 Maine proposed banning the purchase of soft drinks and candy with SNAP benefits.[15] These requests have been made in the absence of research on the potential effect of restrictions on nutrition and health. In 2010 New York City proposed evaluating the health effects of a ban on the purchase of sugar sweetened beverages with SNAP benefits in that city.[36] The US Department of Agriculture (USDA) denied the request for several reasons including operational issues related to implementing such a program change and concerns about the scientific integrity of the evaluation to be conducted.[14,37] Our study aimed to circumvent the operational concerns raised by the USDA. In addition, we were able to carry out random assignment to experimental condition, thus overcoming a major methodological issue inherent in evaluating policy changes that occur at the population level.

These results suggest that a food benefit program that pairs financial incentives for the purchasing of fruits and vegetables with restrictions on the purchase of less nutritious foods may reduce energy intake and improve the nutritional quality of the diet of program participants in comparison with a food benefit program that does not include incentives and restrictions.

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ARTICLE INFORMATION

Correction: This article was corrected online on December 5, 2016. The footnotes that explain the statistically significant difference between groups in Tables 3 and 4 were corrected.

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Author Contributions: Dr Harnack had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Concept and design: Harnack, Oakes, Elbel, Beatty, French.
Acquisition, analysis, or interpretation of data: Harnack, Oakes, Elbel, Rydell, French.
Drafting of the manuscript: Harnack, Oakes.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Harnack, Oakes, Elbel, Rydell.
Obtaining funding: Harnack, Oakes, Beatty, French.
Administrative, technical, or material support: Beatty, Rydell, French.
Study supervision: Harnack, Rydell.

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