Title
Heterogeneity in the Effects of Food Vouchers on Nutrition Among Low-Income Adults: A Quantile Regression Analysis

Journal
American Journal of Health Promotion, 35(2)

ISSN
0890-1171

Authors
White, Justin S
Vasconcelos, Gabriel
Harding, Matthew
et al.

Publication Date
2021-02-01

DOI
10.1177/0890117120952991

Peer reviewed

Heterogeneity in the Effects of Food Vouchers on Nutrition Among Low-Income Adults: A Quantile Regression Analysis

APPLIED RESEARCH BRIEF

Justin S. White, PhD[1,2], Gabriel Vasconcelos, PhD[3], Matthew Harding, PhD[3], Mandy M. Carroll, MPH[4], Christopher D. Gardner, PhD[4], Sanjay Basu, MD, PhD[5,6], and Hilary K. Seligman, MD, MAS[1,7,8]

[1] Philip R. Lee Institute for Health Policy Studies, University of California San Francisco, CA, USA
[2] Department of Epidemiology and Biostatistics, University of California San Francisco, CA, USA
[3] Department of Economics, University of California, Irvine, CA, USA
[4] Stanford Prevention Research Center, Stanford University School of Medicine, CA, USA
[5] Collective Health, San Francisco, MA, USA
[6] Center for Primary Care, Harvard Medical School, MA, USA
[7] Center for Vulnerable Populations, Zuckerberg San Francisco General Hospital, CA, USA
[8] Division of General Internal Medicine, Department of Medicine, University of California San Francisco, CA, USA

Corresponding Author:

Justin S. White, PhD, Philip R. Lee Institute for Health Policy Studies, University of California, San Francisco, 3333 California Street, Box 0936, San Francisco, CA 94118, USA.
Email: Justin.White@ucsf.edu

ABSTRACT

Purpose: To determine whether baseline fruit and vegetable (FV) intake or other predictors are associated with response to food vouchers (change in FV intake) among low-income adults.

Design: Secondary analysis of a randomized, 2x2-factorial, community-based trial.

Setting: San Francisco, California.

Subjects: 359 low-income adults aged ≥21 years old.

Intervention: Participants were mailed $20 of food vouchers monthly for six months, and randomized to one of four arms according to: eligible foods (FV only or any foods) and redemption schedule (weekly or monthly).

Measures: Change in FV intake measured in cup equivalents between baseline and month 6 of the trial, based on 24-hour dietary recalls.

Analysis: Quantile multivariate regressions were employed to measure associations between key predictors and change in FV intake across study arms.

Results: FV-only weekly vouchers were associated with increased FV intake at the 25th percentile (0.24 cups/day, p=0.048) and 50th percentile (0.37 cups/day, p=0.02) of the distribution, but not at lower and higher quantiles. Response to the vouchers diminished 0.10 cups/day for each additional household member (p=0.02).

Conclusion: Response to food vouchers varied along the FV intake distribution, pointing to some more responsive groups and others potentially needing additional support to increase FV intake. Larger households likely need vouchers of higher dollar value to result in similar changes in dietary intake as that observed in smaller households.

Keywords: nutrition intervention, food vouchers, fruit and vegetable intake, quantile regression

PURPOSE

Food insecurity—an inability to reliably afford nutritionally adequate food—is associated with multiple preventable chronic conditions, including obesity, hypertension, and type 2 diabetes.[1] One increasingly common approach to addressing food insecurity is vouchers that subsidize the cost of nutritious foods. Randomized controlled trials (RCTs) conducted among low-income adults suggest that food vouchers promote healthier dietary intake and reduce food insecurity and risk of chronic disease.[2, 3] However, there is limited knowledge about which groups of individuals are responsive to food vouchers. Most voucher-based trials to date have been too small to support adequately powered subgroup analyses.

We implemented a community-based RCT of four voucher designs that varied on which foods could be purchased (fruit and vegetables only or unrestricted) and the allowable redemption schedule (weekly or monthly). The main analyses found no average effect on fruit and vegetable (FV) intake by voucher type,[4] although prior research has shown that voucher effects may differ by subgroup.[5] One important subgroup includes individuals with low baseline FV intake, who have the greatest room for improvement, as supported by research that baseline diet may be an important determinant of dietary changes.[6] To that end, our objectives for this secondary analysis were 1) to test whether response to the intervention differed across the distribution of baseline FV intake and 2) to determine the individual and household characteristics most strongly associated with response to the intervention. This study examined whether some population subgroups are more likely to benefit from a food voucher intervention implemented without additional supports. The findings may inform efforts to meet the needs of population subgroups for whom a voucher alone was insufficient to increase FV intake.

METHODS

Design

This exploratory secondary analysis used data from a randomized, 2x2-factorial, community-based trial. The protocol and main outcomes have been reported elsewhere.[4]

Intervention

Participants were randomly assigned to receive via mail either FV-only or unrestricted vouchers that were redeemable either weekly or monthly. Unrestricted vouchers were redeemable for any food eligible under the Supplemental Nutrition Assistance Program (SNAP), and FV-only vouchers were redeemable for fresh or frozen fruit, vegetables, or herbs without added sugars or fats. Recipients of weekly vouchers received four $5 vouchers valid for a specified week of the month, while recipients of monthly vouchers received four $5 vouchers valid at any time during the month; thus, weekly and monthly vouchers were of equal overall value.

Sample

Major eligibility criteria included residence in San Francisco, California, age ≥21 years old, household (HH) income <250% of the federal poverty level, and fluency in English; complete eligibility criteria have been previously published.[4] Participants were recruited from transit and web advertisements, fliers, and word of mouth.

Measures

The primary outcome was change in FV intake from baseline to 6 months, measured in cup equivalents per day. Registered dietitians blinded to study allocation assessed FV intake four times at baseline and four times at 6 month follow-up using prescheduled 24-hour dietary recalls administered by phone. Multiple dietary recalls conducted at each time point were averaged. Foods were classified using the National Health and Nutrition Examination Survey food grouping scheme.

Independent variables included the randomized study group, baseline FV intake, gender, age, race/ethnicity (non-Hispanic White, non-Hispanic Black, Asian, Hispanic, other/undefined), educational attainment (less than high school degree, high school degree, college or higher), ever redeemed voucher at a farmer's market, and household size (1, 2-3, ≥4).

Analysis

We estimated quantile multivariate regressions for change in FV intake during the 6-month trial conditional on voucher group and as a function of baseline FV intake and (to account for potential non-linearities) baseline FV intake squared. Quantile regression methods allow for estimation of differing relationships at different parts of the distribution of the dependent variable (change in FV intake).[7] Models further adjusted for participant gender, age, education, race/ethnicity, voucher redemption site (farmer's market versus other), and household size. We estimated a separate model for each of the 10th to 90th percentiles, in 5-percentile increments. The end-point quantiles, known to be imprecise and misleading, were omitted. We also performed an inverse analysis using a linear regression of the change in FV intake, in order to identify which individual and household characteristics were the strongest correlates of increased FV intake.

RESULTS

Baseline participant characteristics indicate that the sample is diverse in its racial/ethnic and education composition (Supp. Table S1). Figure 1 shows the quantile regression estimates of the association between the change in FV intake during the trial and baseline intake for the 10th to 90th percentiles. The results suggest an inverted U-shaped association between baseline FV intake and the change in FV intake in the FV-only weekly voucher group, such that FV intake increased in the middle of the distribution (between the 25th and 55th percentiles) but not at lower or higher quantiles. The magnitude of the increase in FV intake was 0.24 cups per day at the 25th percentile (p=0.048) and 0.37 cups per day at the 50th percentile (p=0.02) (Supp. Table S2). We did not observe a significant association for the other voucher groups; they tended to display an inverse U-shaped association as well, although with a smaller magnitude than in the FV-only weekly voucher group (Supp. Figure S1). The change in FV intake was also associated with smaller household sizes at the 50th and 75th percentiles and redemption at farmer's markets at the 50th percentile.

The inverse analysis indicated that baseline FV intake squared and household size were the strongest predictors of change in FV intake in response to the intervention (Supp. Table S3). The negative coefficient on squared baseline intake (-0.09 cups per day, p=0.05) is consistent with the inverse U-shaped association described above. The change in FV intake during the trial decreased with household size (0.10 cups per day, p=0.02), implying that the voucher purchased fewer daily FV cups *per person* when there were more individuals in the household. Figure 2 shows a linear prediction of how household size modifies the relationship between baseline FV intake and change in FV intake. The difference in the voucher effect between a household size of 1 vs. 8 is roughly 0.8 cups per day .

DISCUSSION

Summary

The impact of financial support for food purchases varied in different subpopulations. Participants in the middle quartiles of baseline FV intake were more responsive to the FV-only weekly vouchers, while those in the lowest and highest quartiles were less responsive. Individuals in the lowest quartiles of baseline FV intake may require additional resources beyond financial support—such as transportation support, food preparation skills, cooking equipment, or nutrition education—in order to improve dietary intake. Individuals in the higher quartiles of baseline FV intake may have less room for additional increases. We hypothesize that the heterogeneous effects were concentrated in the FV-only weekly group because more frequent vouchers led to more consistent purchasing and stronger habit formation, and the FV-only vouchers ensured that the subsidies were directed toward FVs, rather than other food items.

Household size was an important predictor of participant response, likely because a fixed subsidy amount is less effective when split across a larger number of individuals.

Limitations

While our results point to cross-group differences in the distribution of treatment effects, we cannot definitively determine why the heterogeneous effects occurred primarily in one voucher group. Limited differences across the four study arms (i.e., all vouchers were redeemable for $20 worth of food per month) may not have been sufficient to produce large cross-group differences. The sample size of nearly 400 participants, selected to detect an overall treatment effect, also may not have been sufficiently large to fully explore heterogeneities in response. Further, quantile regression methods are not able to precisely estimate relationships at the end points of the distribution (in this case, the highest and lowest ends of baseline FV intake).[7]

Significance

Common regression methods measure differences in outcomes at the mean. However, policymakers and clinicians are often interested in group differences across the distribution of outcomes. Food voucher programs might improve their effectiveness by targeting subsidies to subgroups that are likely to be more responsive. For those that are less likely to be responsive, food vouchers may need to be bundled with transportation support, equipment for food storage and preparation, or other supports.

Subsidies for food purchases should be adjusted for household size because food is shared across members of the household. This is important for voucher programs designed to support individuals with diet-sensitive chronic diseases. For example, many produce prescription programs now provide vouchers specifically for adults with diabetes,[8] without accommodating the differing household sizes with whom food is shared. To replicate the consistent positive effects of SNAP benefits on diet quality and food insecurity, voucher programs should factor household size into the dollar amount.

SO WHAT?

What is Already Known on This Topic?

Evidence from randomized trials finds that food vouchers can promote intake of healthier foods, including fruits and vegetables.

What Does This Article Add?

The impact of vouchers on FV intake was greatest among people with baseline intake that is neither very low nor very high, and among people living in the smallest households.

What are the Implications for Health Promotion Practice or Research?

To maximize effectiveness, voucher programs may need to offer additional support to people with very low intake of FV at baseline, and to people living in larger households.

REFERENCES

1. Seligman HK, Laraia BA, Kushel MB. Food insecurity is associated with chronic disease among low-income NHANES participants. *The Journal of Nutrition.* 2010;140(2):304-310.

2. Harnack L, Oakes JM, Elbel B, Beatty T, Rydell S, French S. Effects of subsidies and prohibitions on nutrition in a food benefit program: A randomized clinical trial. *JAMA Internal Medicine.* 2016;176(11):1610-1619.

3. Olsho LE, Klerman JA, Wilde PE, Bartlett S. Financial incentives increase fruit and vegetable intake among Supplemental Nutrition Assistance Program participants: A randomized controlled trial of the USDA Healthy Incentives Pilot. *The American Journal of Clinical Nutrition.* 2016;104(2):423-435.

4. Basu S, Gardner CD, White JS, et al. Effects of Alternative Food Voucher Delivery Strategies on Nutrition Among Low-Income Adults. *Health Aff (Millwood).* 2019;38(4):577-584.

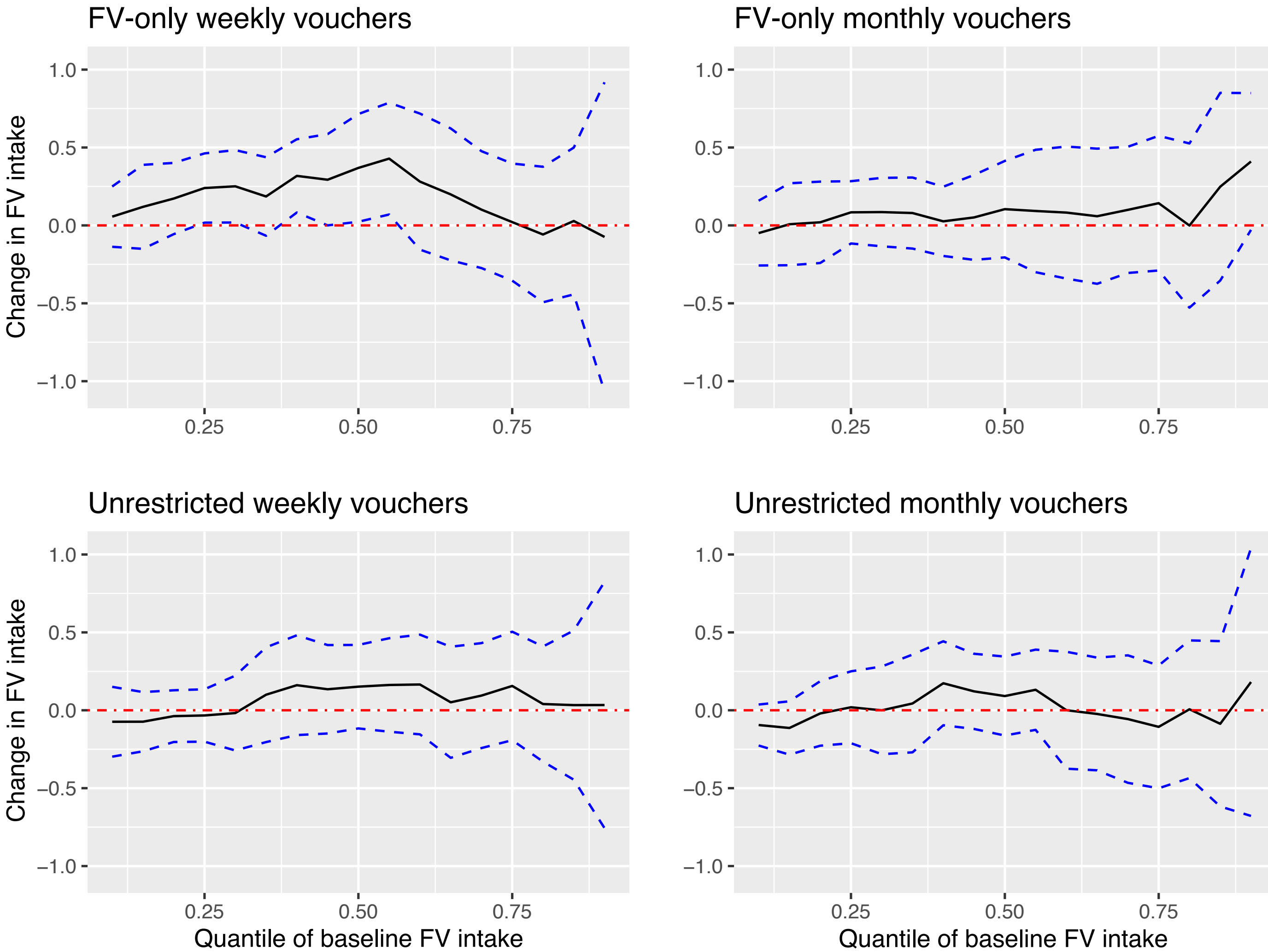
5. Bartlett S, Klerman J, Olsho L, et al. *Evaluation of the Healthy Incentives Pilot (HIP), Final Report*: Prepared by Abt Associates for the U.S. Department of Agriculture, Food and Nutrition Service; 2014.

6. Hut S, Oster E. Changes in Household Diet: Determinants and Predictability. *National Bureau of Economic Research Working Paper Series.* 2018;No. 24892.

7. Koenker R, Hallock KF. Quantile regression. *J Econ Perspect.* 2001;15(4):143-156.

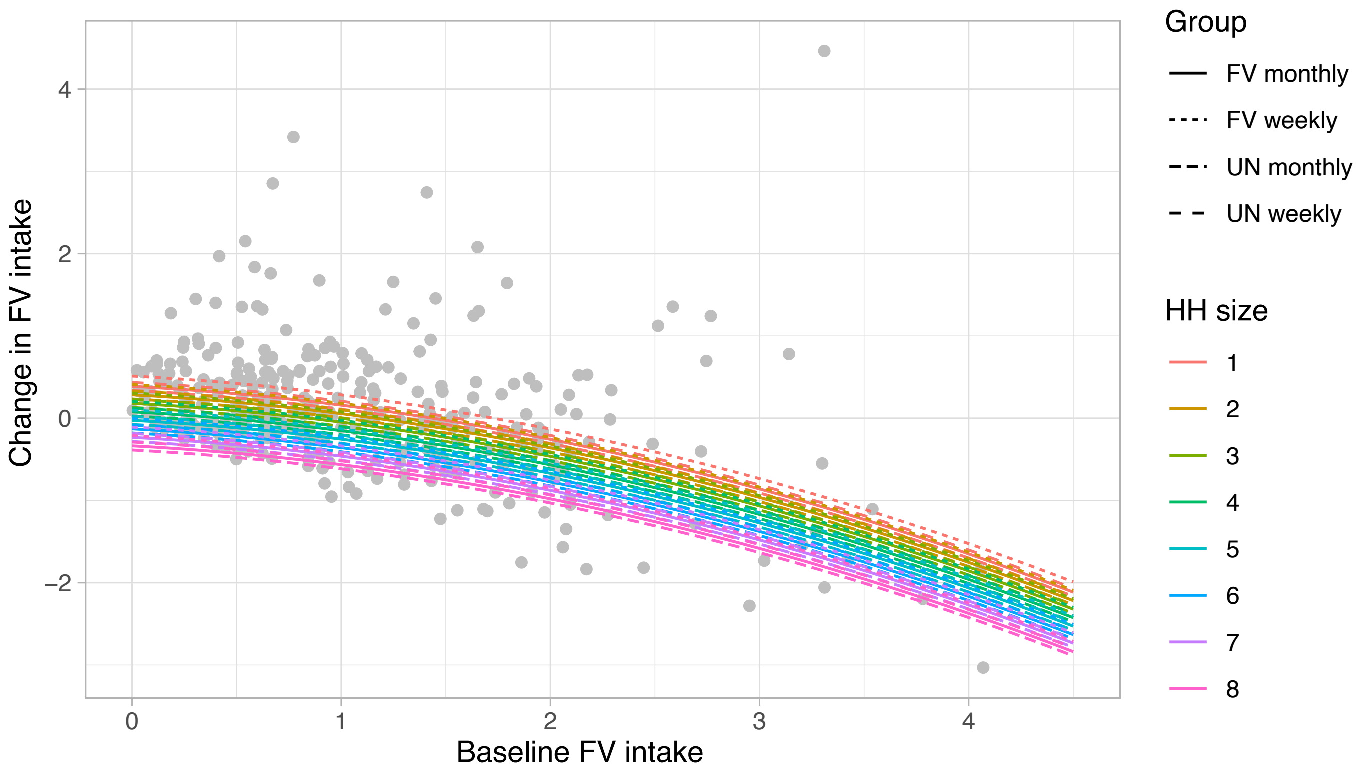
8. US Department of Agriculture. NIFA Announces $41.4 Million in Grants to Encourage Healthy Food Purchases for SNAP Participants: USDA National Institute of Food and Agriculture; 2019.

Figure 1. Association between baseline and change in FV intake, by study group



Note: This figure shows quantile regression estimates (black line) of the association between baseline FV intake and the change in FV intake during the trial. Each panel is a different study group. Error bands (blue dotted lines) represent 95% confidence intervals.

Figure 2. Household size as a modifier of the association between the baseline and change in FV intake



Note: This figure shows the predicted change in FV intake for each baseline intake level associated with different household sizes. Estimates come from a linear regression model of the change in FV intake during the trial, adjusted for baseline intake, baseline intake squared, voucher group, gender, age, typical voucher redemption site (Farmer's market vs. other), and household size.

Supplementary Appendix

Supplement to: "Heterogeneity in the Effects of Food Vouchers on Nutrition Among Low-Income Adults: A Quantile Regression Analysis"

Supplemental Table S1. Baseline characteristics by study group

		Study Group			
	Total (N=359)	FV-only weekly (N = 86)	FV-only monthly (N = 90)	Unrestricted weekly (N = 92)	Unrestricted monthly (N = 91)
Baseline FV intake	1.1 (0.8)	1.0 (0.9)	1.1 (0.7)	1.2 (0.8)	1.0 (0.8)
Study group					
FV-only weekly	86 (24%)				
FV-only monthly	90 (25%)				
Unrestricted weekly	92 (26%)				
Unrestricted monthly	91 (25%)				
Female	236 (66%)	56 (65%)	61 (68%)	62 (67%)	57 (63%)
Age, in years	51.5 (13.5)	52.2 (13.1)	50.7 (13.4)	52.4 (14.1)	50.9 (13.5)
Race/ethnicity					
Non-Hispanic White	133 (37%)	30 (35%)	29 (32%)	37 (40%)	37 (41%)
Non-Hispanic Black	96 (27%)	24 (28%)	26 (29%)	22 (24%)	24 (26%)
Asian	63 (18%)	17 (20%)	18 (20%)	14 (15%)	14 (15%)
Hispanic	56 (16%)	14 (16%)	14 (16%)	13 (14%)	15 (16%)
Other or undefined	11 (3%)	1 (1%)	3 (3%)	6 (7%)	1 (1%)
Education					
Less than high school degree	29 (8%)	7 (8%)	6 (7%)	8 (9%)	8 (9%)
High school degree	205 (57%)	54 (63%)	52 (58%)	54 (59%)	45 (49%)
College or higher	125 (35%)	25 (29%)	32 (36%)	30 (33%)	38 (42%)
Ever redeemed at farmer's market	148 (42%)	33 (39%)	40 (47%)	42 (47%)	33 (37%)
Household size					
1	241 (67%)	53 (62%)	62 (69%)	65 (71%)	61 (67%)
2-3	85 (24%)	21 (24%)	20 (22%)	18 (20%)	26 (29%)
4 or more	33 (9%)	12 (14%)	8 (9%)	9 (10%)	4 (4%)

Note: Data are presented "n (%)" for discrete covariates and "mean (SD)" for continuous covariates.

Supplemental Table S2. Association between study group and the change in FV intake using quantile regression at the 25th, 50th, and 75th percentiles

	Change in FV Intake, by quantile		
	25th percentile	50th percentile	75th percentile
FV-only weekly	0.240**	0.369***	0.021
	(0.001, 0.479)	(0.067, 0.671)	(-0.357, 0.399)
FV-only monthly	0.084	0.104	0.143
	(-0.137, 0.305)	(-0.183, 0.391)	(-0.302, 0.588)
Unrestricted weekly	-0.033	0.152	0.156
	(-0.203, 0.137)	(-0.105, 0.409)	(-0.172, 0.484)
Unrestricted monthly	0.019	0.091	-0.106
	(-0.212, 0.250)	(-0.152, 0.334)	(-0.509, 0.297)

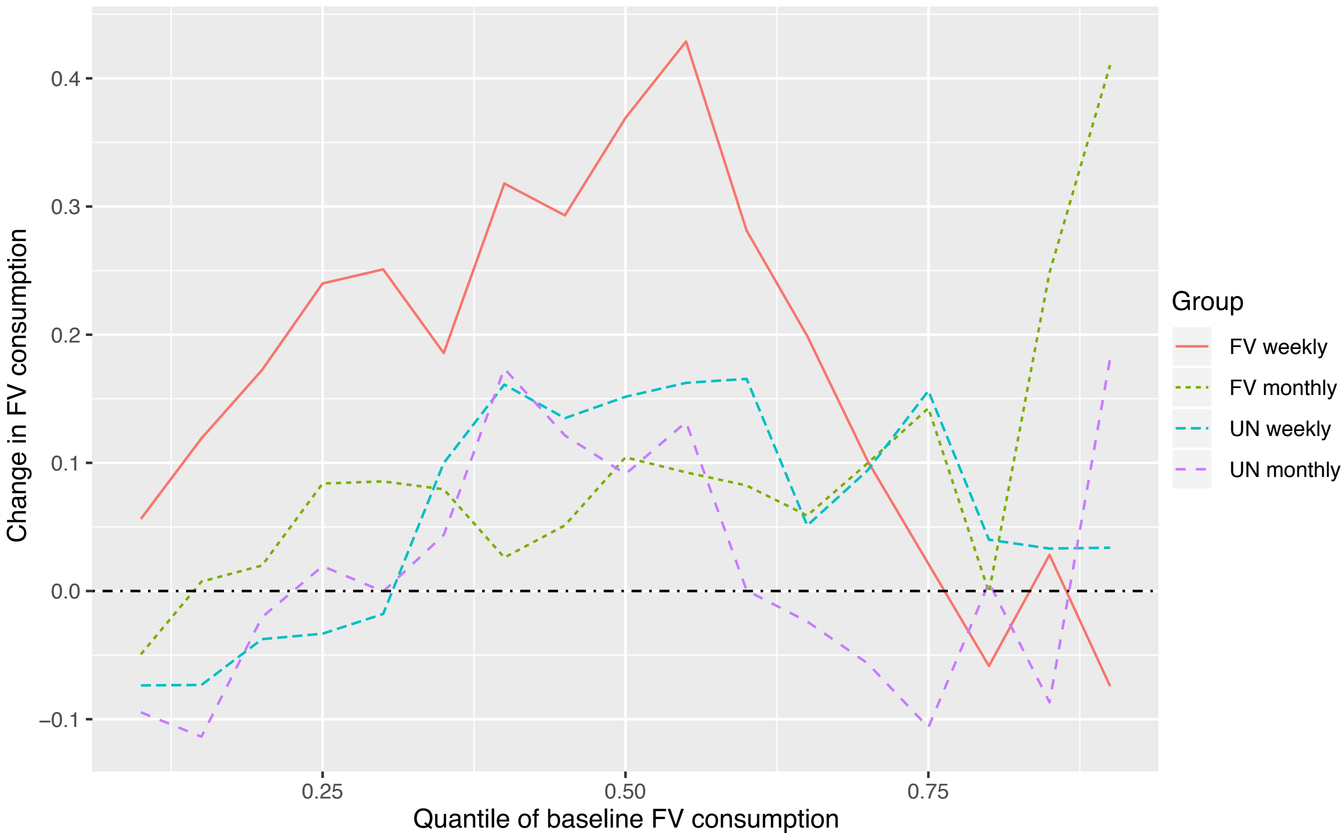
Note: Quantile regression estimates of the change in FV intake at the 25th, 50th, and 75th percentiles. 95% confidence intervals are presented in parentheses. Statistical significance: * $p<0.1$; ** $p<0.05$; *** $p<0.01$.

Supplemental Table S3. Predictors of change in FV intake using OLS and quantile regression

		Quantile regression		
	OLS	25th percentile	50th percentile	75th percentile
	(1)	(2)	(3)	(4)
Baseline FV intake	-0.135	-0.194	0.042	0.068
	(-0.454, 0.184)	(-0.507, 0.118)	(-0.232, 0.315)	(-0.405, 0.541)
Baseline FV intake squared	-0.094*	-0.138**	-0.169***	-0.141
	(-0.188, 0.001)	(-0.255, -0.020)	(-0.263, -0.075)	(-0.375, 0.093)
Voucher group				
FV-only weekly (ref.)				
FV-only monthly	0.124	0.028	0.143	0.067
	(-0.115, 0.364)	(-0.174, 0.230)	(-0.034, 0.320)	(-0.204, 0.338)
Unrestricted weekly	-0.05	0.015	0.011	-0.179
	(-0.281, 0.180)	(-0.149, 0.179)	(-0.143, 0.164)	(-0.421, 0.063)
Unrestricted monthly	0.047	0.055	0.168	-0.1
	(-0.183, 0.277)	(-0.130, 0.241)	(-0.034, 0.369)	(-0.351, 0.151)
Female	-0.081	0.012	-0.039	-0.023
	(-0.262, 0.100)	(-0.141, 0.164)	(-0.174, 0.096)	(-0.196, 0.149)
Age, in years	0.005	0.005	0.002	0.006*
	(-0.002, 0.012)	(-0.001, 0.011)	(-0.004, 0.008)	(-0.001, 0.012)
Race/ethnicity				
Non-Hispanic White (ref.)				
Asian	0.069	0.061	0.085	0.308**
	(-0.177, 0.315)	(-0.180, 0.302)	(-0.118, 0.288)	(0.058, 0.558)
Hispanic	0.044	-0.127	-0.059	0.077
	(-0.213, 0.301)	(-0.362, 0.108)	(-0.229, 0.110)	(-0.146, 0.300)
Non-Hispanic Black	0.005	-0.1	-0.014	0.184**
	(-0.220, 0.230)	(-0.262, 0.062)	(-0.219, 0.190)	(0.011, 0.358)
Other/not available	0.037	0.168	0.057	-0.045
	(-0.511, 0.586)	(-0.145, 0.482)	(-0.266, 0.379)	(-0.355, 0.264)
Education				
< HS degree (ref.)				
HS degree	-0.113	-0.147	-0.182	-0.12
	(-0.423, 0.197)	(-0.431, 0.136)	(-0.458, 0.095)	(-0.275, 0.034)
College or higher	0.136	-0.07	0.004	0.203
	(-0.196, 0.469)	(-0.381, 0.241)	(-0.308, 0.316)	(-0.070, 0.476)
Farmer’s market	0.005	0.010*	0.009***	0.009*
	(-0.005, 0.015)	(-0.001, 0.021)	(0.003, 0.015)	(-0.001, 0.019)
Household size	-0.103**	-0.037	-0.078***	-0.098**
	(-0.187, -0.020)	(-0.111, 0.037)	(-0.133, -0.022)	(-0.176, -0.019)
Constant	0.27	-0.008	0.236	0.348
	(-0.345, 0.885)	(-0.540, 0.524)	(-0.306, 0.777)	(-0.149, 0.846)
Observations	326	326	326	326

Note: 95% confidence intervals are in parentheses. Statistical significance: * p<0.1; ** p<0.05; *** p<0.01

Supplemental Figure S1. Association between baseline and change in FV intake, by study group



Note: This figure shows quantile regression estimates of the association between baseline FV intake and the change in FV intake during the trial.