Effects of price discounts and tailored nutrition education on supermarket purchases: a randomized controlled trial[1–5]

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ABSTRACT

Background: Traditional methods to improve population diets have largely relied on individual responsibility, but there is growing interest in structural interventions such as pricing policies.

Objective: The aim was to evaluate the effect of price discounts and tailored nutrition education on supermarket food and nutrient purchases.

Design: A 2 × 2 factorial randomized controlled trial was conducted in 8 New Zealand supermarkets. A total of 1104 shoppers were randomly assigned to 1 of the following 4 interventions that were delivered over 6 mo: price discounts (12.5%) on healthier foods, tailored nutrition education, discounts plus education, or control (no intervention). The primary outcome was change in saturated fat purchased at 6 mo. Secondary outcomes were changes in other nutrients and foods purchased at 6 and 12 mo. Outcomes were assessed by using electronic scanner sales data.

Results: At 6 mo, the difference in saturated fat purchased for price discounts on healthier foods compared with that purchased for no discount on healthier foods was −0.02% (95% CI: −0.40%, 0.36%; $P = 0.91$). The corresponding difference for tailored nutrition education compared with that for no education was −0.09% (95% CI: −0.47%, 0.30%; $P = 0.66$). However, those subjects who were randomly assigned to receive price discounts bought significantly more predefined healthier foods at 6 mo (11% more; mean difference: 0.79 kg/wk; 95% CI: 0.43, 1.16; $P < 0.001$) and 12 mo (5% more; mean difference: 0.38 kg/wk; 95% CI: 0.01, 0.76; $P = 0.045$). Education had no effect on food purchases.

Conclusions: Neither price discounts nor tailored nutrition education had a significant effect on nutrients purchased. However, the significant and sustained effect of discounts on food purchases suggests that pricing strategies hold promise as a means to improve population diets. *Am J Clin Nutr* 2010;91:736–47.

INTRODUCTION

Good nutrition is essential for health. Risk factors that have substantial dietary determinants—high blood pressure, high blood cholesterol, overweight/obesity, and low fruit and vegetable intakes— are leading causes of loss of health (1). The potential health gains from reducing these major risk factors are considerable (2) and provide impetus for a growing number of international and national policies to improve population diet and health. Among common strategy recommendations are the provision of nutrition education and fiscal policies (3).

Nutrition education is used frequently to improve dietary behavior of individuals and generally shows positive effects on self-reported outcomes such as fruit and vegetable intakes and total and saturated fat consumption (4). Tailored education, which is designed to reach one specific person on the basis of characteristics unique to that person (5), may be more effective than generic nutrition education. Computer-tailored education shows consistent effects on fat reduction (6), and a recent meta-analysis found that tailored education increased fruit and vegetable intakes by an estimated one-third serving/d and decreased total fat intakes by ≈2% of energy compared with generic education (7). However, methodologic quality and reporting of such trials are frequently suboptimal, and several have relied on self-reported outcome measures, which may lead to overestimation of effects.

The use of fiscal measures as a means to modify behavior recently has received considerable attention (8–11). Although still an emerging research area, reviews suggest that economic incentives positively affect general health-related behavior (12, 13) and dietary behavior (14). Favorable effects have been seen for weight loss (15, 16), purchase of low-fat snacks (17), and self-reported fruit and vegetable consumption (18). However, one meta-analysis failed to find a significant effect of financial incentives on weight loss or maintenance (19). Trials to date, however, have been small, used different types and magnitudes of incentives, assessed different outcomes, and were conducted in different environments and populations. Therefore, although

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[2] The SHOP trial results were presented at the International Society of Behavioral Nutrition and Physical Activity Annual Meeting in Cascais, Portugal, 17–20 June 2009.

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promising, the effect of economic incentives such as price discounts on dietary behavior remains uncertain.

Effects of diet interventions are usually measured by using self-reported dietary assessments, and underreporting of intakes is common (20). However, a large proportion of household food is purchased from supermarkets in many countries (21–23), and routine collection of electronic scanner sales data and the ability to link such data to individual shoppers potentially allow both objective measurement of the effect of interventions on consumer behavior and the capability to deliver automated tailored nutrition education on the basis of usual supermarket food purchases. Supermarkets, therefore, provide an ideal setting for trials of strategies to improve food purchases. The Supermarket Healthy Options Project (SHOP) was a large randomized controlled trial of the effect of price discounts and tailored nutrition education, separately and in combination, on supermarket food and nutrient purchases.

SUBJECTS AND METHODS

Study design

The SHOP was a 15-mo parallel randomized controlled trial. A 12-wk baseline data collection phase was followed by a 24-wk intervention phase and a further 24-wk follow-up phase (no intervention). The trial was conducted in 8 supermarkets in the Lower North Island region of New Zealand (Wellington, Wanganui, and New Plymouth) between February 2007 and February 2009. The study protocol was approved by the University of Auckland Human Ethics Committee (reference 2006/462), and all participants provided written informed consent.

Supermarkets in the trial were members of a retail chain that offered use of a system of handheld barcode scanning terminals that allowed registered customers to scan each item they selected from the supermarket shelf before putting it in their trolley [Shop ’N Go; Foodstuffs (Wellington) Cooperative Society Ltd, Wellington, New Zealand]. The use of the barcode scanner, in conjunction with a personalized scannable card, allowed collection of individualized electronic data on all foods purchased by participants. Shop ’N Go use was essential to measure the effect of the interventions.

A database of supermarket foods and their macronutrient content was created by using 12 mo of retrospective aggregate sales data (2005–2006) from 6 participating stores. Foods and nonalcoholic beverages were ranked on the basis of sales to identify 3000 top-selling products that accounted for the majority of sales volume (78%) and expenditure (65%). Each item was matched to appropriate nutrient content compiled from various sources, including New Zealand food composition databases and product nutrition information panels (24). Categorization of food and beverages as “healthier” and “less healthy” was undertaken by using the Heart Foundation’s Tick program nutrient profiling criteria (25). In total, 1032 database products (35%) met the Tick criteria and were classified as “healthier.”

Participants and recruitment

Our goal was to recruit and randomly assign 1200 participants, of whom one-third would be Māori, one-third Pacific, and one-third non-Māori/non-Pacific individuals. This was to facilitate preplanned subgroup analyses of intervention effects within ethnic groups. Trial eligibility criteria were as follows: age ≥18 y, the main household shopper, a regular shopper at participating stores, and either a registered user of the Shop ’N Go system or willing to sign up and use the system for the duration of the trial.

Recruitment took place over 9 mo beginning in February 2007. Recruitment methods and outcomes have been described in detail previously (26). Strategies used were mail-outs to a random selection of customers who were registered to use the Shop ’N Go system and in-store and community-based recruitment targeted to Māori and Pacific shoppers.

Randomization

Eligible participants were randomly assigned to 1 of the following 4 intervention arms: price discounts on healthier supermarket foods, tailored nutrition education promoting purchase of healthier supermarket foods, a combination of price discounts and tailored nutrition education, or control (no intervention). Computer-generated blocked randomization was used, with stratification by ethnicity (Māori, Pacific, or non-Māori/non-Pacific) and household income pretax (high = >NZ$60,000/y, low = <NZ$60,000/y, or decline to answer). Treatment assignment codes were not available to investigators or research staff at any point during the study.

Interventions

The tailored nutrition education program was developed by using a participatory approach (27), with input from target populations (through focus groups) and Māori and Pacific community health organizations (28). Each month during the 6-mo intervention, participants who were randomly assigned to receive education were mailed a printed package of food-group-specific nutrition information by mail. The package consisted of computer-generated messages and shopping lists tailored by individual shoppers’ usual food purchases (on the basis of 3 mo of their electronic supermarket scanner sales data collected over baseline) and supportive generic resources including recipes and recommended serving sizes. Tailored messages and shopping lists suggested brand-specific healthier alternatives to less-healthy foods usually purchased (29). For example, Brand X reduced-fat milk and Brand Y canned peaches in juice were suggested as healthier alternatives for Brand X full-fat milk and Brand Y canned peaches in syrup, respectively. No formal behavior change theories were used for tailoring. All education materials were printed on culturally appropriate message templates targeted to participants’ ethnicity.

The price discount intervention consisted of an automatic 12.5% price reduction on all eligible healthier food products, and discounts were available only to study participants in the discount intervention groups. Choice of discount level was pragmatic because a 12.5% price discount is equivalent to removal of the goods and services tax (GST), which is applied to all consumer products (including all foods) in New Zealand. Foods eligible for price discounts were core foods (excluding chocolate, potato chips, sports supplements, baby foods, etc) that met Tick program criteria. Participants who were randomly assigned to receive discounts were mailed a printed list of discounted foods at regular intervals throughout the study, and discounts were implemented when Shop 'N Go cards were scanned at checkouts during the intervention period.

Outcomes and data collection

The primary outcome was change from baseline in percentage energy from saturated fat contained in supermarket food purchases at the completion of the 6-mo trial intervention phase. Secondary outcomes were as follows: change from baseline in saturated fat at 12 mo postrandomization, change in other nutrients [total fat (percentage energy), protein (percentage energy), carbohydrate (percentage energy), energy density (MJ/kg), sodium (mg/MJ), and sugars (g/MJ)] at 6 and 12 mo, and change in quantities of healthier foods purchased (by weight; all healthier foods, cereals and cereal products, fats and oils, fruit and vegetables, meat and meat alternatives, and milk and milk products).

Initial contact with potential participants was either by telephone for those who received a mailed invitation to participate in the trial or face-to-face for those who were approached in-store or in the community. A brief registration form was completed comprising information on sex, age, ethnicity, and trial inclusion and exclusion criteria. A participant information sheet, baseline form, and consent form were then mailed or given to registered individuals, which they were asked to return by mail after completion. After consent, 12 wk of prospective electronic scanner sales data were collected on baseline food purchases. Sales data were linked with the SHOP food and nutrient database to allow tailoring of nutrition education and nutrient analysis of purchases. Electronic scanner sales data were collected continuously throughout the 15-mo trial.

Sample size and statistical analysis

The sample size calculation was based on change in percentage energy from saturated fat as the primary endpoint. Saturated fat was chosen as the primary endpoint because potential health gains from lowering population blood cholesterol concentrations are substantial (2). With the assumption of an SD of 6.8% (30), a sample of ≈1200 individuals (300 per intervention arm) was estimated to provide ≥95% power at a 5% level of significance (2-sided) to detect a 2% absolute reduction in saturated fat (% energy) between intervention and control groups at the completion of the 6-mo intervention. This difference in saturated fat approximated that reported in a review of dietary saturated fat interventions (4).

A repeated-measures mixed-model regression analysis was used to evaluate the effect of interventions on primary and secondary endpoints. All randomly assigned participants were included in an intention-to-treat analysis on the assumption that data were missing at random. No imputation was used. Potential interaction between the 2 interventions (price discounts and tailored nutrition education) was tested, and the main effect of each was evaluated separately where the interaction term was not statistically significant. Model-adjusted means, SEs, and 95% CIs were estimated as well as differences between groups with associated *P* values. Prespecified potential confounding factors adjusted for in the regression model were baseline measures of food and nutrients, ethnicity, household income, age, and sex. All analyses were carried out by using SAS, version 9.1.3 (SAS Institute Inc, Cary NC), and R, version 2.8.1 (R Foundation for Statistical Computing, Vienna, Austria); statistical tests were 2-sided with a 5% significance level.

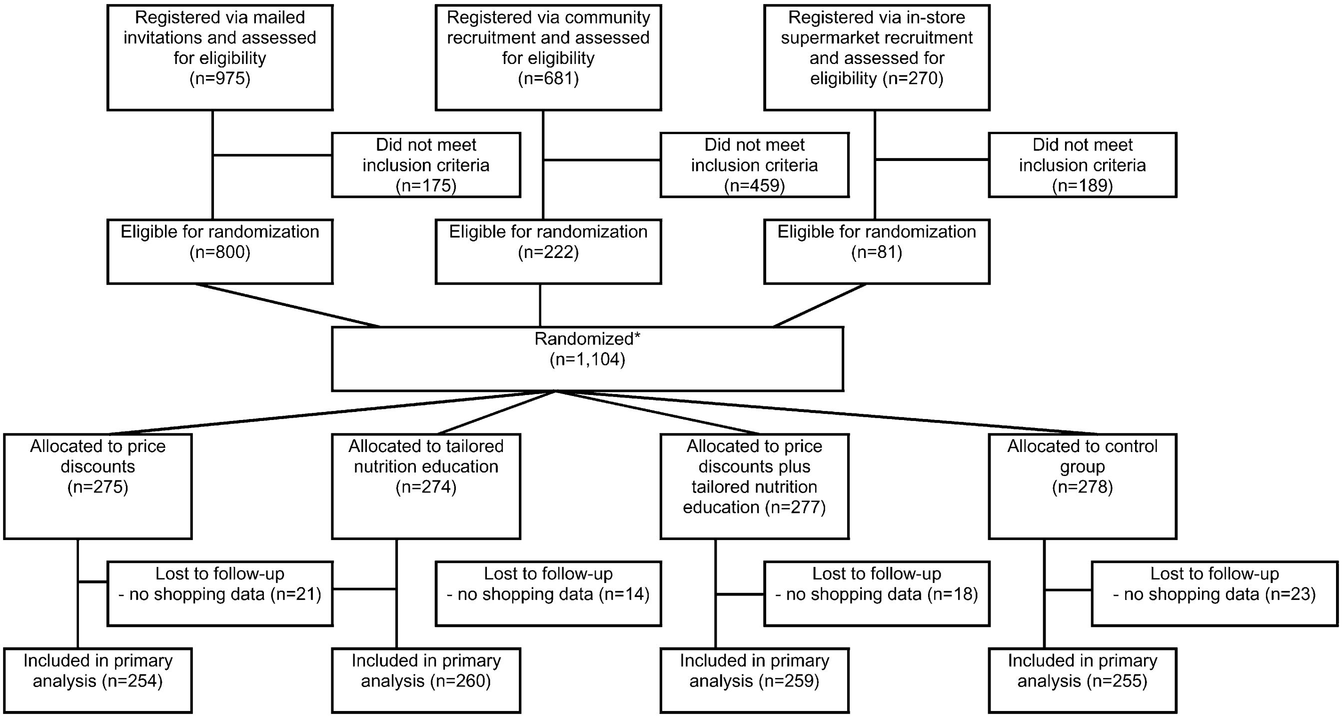

FIGURE 1. Flow of participants through the trial. *A total of 1104 individuals were randomly assigned to the study groups. However, the source of registration/recruitment (mail-out, in-store, or community) was not recorded for one randomly assigned participant. Therefore, numbers registered and numbers eligible for randomization do not include that individual and are thus one less than the totals for each.

TABLE 1
Baseline characteristics of study participants

Characteristic	Price discounts group (*n* = 275)	Tailored nutrition education group (*n* = 274)	Price discounts plus nutrition education group (*n* = 277)	Control group (*n* = 278)	All participants (*n* = 1104)
Age (y)	43 ± 13[1]	45 ± 14	44 ± 14	44 ± 13	44 ± 13
Sex [*n* (%)]					
Female	224 (82)	237 (87)	245 (88)	238 (86)	944 (86)
Male	51 (19)	37 (14)	32 (12)	40 (14)	160 (15)
Ethnicity most identified with [*n* (%)]					
Māori	62 (23)	62 (23)	61 (22)	63 (23)	248 (23)
Pacific	24 (9)	25 (9)	27 (10)	25 (9)	101 (9)
New Zealand European or other	189 (69)	187 (68)	189 (68)	190 (68)	755 (68)
Highest educational qualification [*n* (%)]					
None	38 (14)	45 (16)	50 (18)	52 (19)	185 (17)
Secondary	100 (36)	93 (34)	102 (37)	87 (31)	382 (35)
University/polytechnic degree or diploma	100 (36)	111 (41)	101 (37)	114 (41)	426 (39)
Trade certificate or other	37 (14)	24 (9)	24 (9)	24 (9)	109 (10)
Missing	0	1	0	1	2
Annual household income before tax [*n* (%)]					
<NZ$60,000/y	144 (52)	142 (52)	144 (52)	146 (53)	576 (52)
>NZ$60,000/y	116 (42)	115 (42)	116 (42)	116 (42)	463 (42)
Declined to answer	15 (6)	16 (6)	17 (6)	16 (6)	64 (6)
Missing	0	1	0	0	1
No. of people in household for whom groceries/food are usually bought[2]					
No. of children aged ≤18 y	0 (0, 4)	0 (0, 3)	0 (0, 4)	0 (0, 4)	0 (0, 4)
No. of adults aged ≥19 y	2 (0, 6)	2 (0, 5)	2 (0, 7)	2 (0, 9)	2 (0, 9)
No. of other supermarkets from which household food is also bought in an average month [*n* (%)]					
None	52 (19)	50 (18)	63 (23)	40 (14)	205 (18)
1	101 (37)	127 (46)	114 (41)	117 (42)	459 (42)
≥2	122 (44)	97 (36)	100 (36)	121 (44)	440 (40)
Other types of food outlets from which household food is also bought in an average month [*n* (%)]					
Take-away bars/shops	184 (67)	178 (65)	196 (71)	186 (67)	744 (67)
Dairy or service station	111 (40)	112 (41)	105 (38)	115 (41)	443 (40)
Butchery or bakery	152 (55)	153 (56)	149 (54)	152 (55)	606 (55)
Restaurant or workplace canteen	117 (43)	99 (36)	115 (42)	103 (37)	434 (39)
Markets	100 (36)	115 (42)	113 (41)	106 (38)	434 (39)
Fruit and vegetable shop	121 (44)	106 (39)	102 (37)	117 (42)	446 (40)
Delicatessen	40 (15)	25 (9)	25 (9)	23 (8)	113 (10)
Convenience store or mini-mart	68 (25)	69 (25)	62 (22)	70 (25)	269 (24)
Vending machines	15 (6)	9 (3)	15 (5)	18 (7)	57 (5)
Asian food supply stores	38 (14)	30 (11)	30 (11)	27 (10)	125 (11)
Other	20 (7)	11 (4)	12 (4)	18 (7)	61 (6)
Knowledge about nutrition, food, and healthy eating [*n* (%)]					
Nothing	2 (1)	2 (1)	0 (0)	2 (1)	6 (2)
A little	46 (17)	31 (11)	40 (14)	39 (14)	156 (14)
A moderate amount	147 (54)	167 (61)	161 (58)	163 (59)	638 (58)
A lot	80 (29)	71 (26)	75 (27)	74 (27)	300 (27)
Nutrient purchases					
Saturated fat (% energy)	14.5 ± 3.9	14.9 ± 4.3	14.8 ± 4.4	14.3 ± 4.4	14.6 ± 4.2
Total fat (% energy)	36.2 ± 8.4	36.8 ± 8.8	36.2 ± 7.9	35.6 ± 8.8	36.2 ± 8.5
Protein (% energy)	13.2 ± 4.5	13.0 ± 3.9	13.1 ± 3.5	13.2 ± 5.1	13.2 ± 4.3
Carbohydrate (% energy)	50.3 ± 8.9	49.5 ± 9.3	49.9 ± 7.4	50.8 ± 8.2	50.2 ± 8.5
Energy density (MJ/kg)					
Beverages	3.0 ± 3.8	2.7 ± 3.2	2.7 ± 3.4	2.4 ± 2.7	2.7 ± 3.3
Nonbeverages	7.2 ± 1.8	7.3 ± 2.0	7.3 ± 1.7	7.3 ± 1.8	7.3 ± 1.8

(Continued)

TABLE 1 (*Continued*)

Characteristic	Price discounts group (n = 275)	Tailored nutrition education group (n = 274)	Price discounts plus nutrition education group (n = 277)	Control group (n = 278)	All participants (n = 1104)
Sugars (g/MJ)	14.1 ± 4.9	14.6 ± 5.7	13.8 ± 3.8	14.3 ± 4.5	14.2 ± 4.8
Sodium (mg/MJ)	293.8 ± 101.6	280.6 ± 96.5	281.9 ± 76.3	282.6 ± 75.3	284.7 ± 88.2
Food purchases					
Total food purchases (kg/wk)					
All products[3]	13.78 ± 8.81	13.39 ± 8.37	13.90 ± 7.85	12.72 ± 7.44	13.44 ± 8.13
Less-healthy products only	4.06 ± 3.07	3.83 ± 2.91	4.11 ± 3.13	3.64 ± 2.60	3.91 ± 2.94
Healthier products only	7.30 ± 5.09	7.30 ± 5.12	7.56 ± 4.76	6.82 ± 4.51	7.24 ± 4.88
Cereals and cereal products (kg/wk)					
All products	2.30 ± 1.68	2.07 ± 1.53	2.32 ± 1.58	2.14 ± 1.42	2.21 ± 1.56
Healthier products only	0.68 ± 0.68	0.65 ± 0.67	0.70 ± 0.66	0.69 ± 0.66	0.68 ± 0.67
Fats and oils (kg/wk)					
All products	0.36 ± 0.29	0.39 ± 0.30	0.38 ± 0.28	0.35 ± 0.27	0.37 ± 0.28
Healthier products only	0.13 ± 0.17	0.15 ± 0.18	0.15 ± 0.18	0.13 ± 0.16	0.14 ± 0.17
Fruit and vegetables (kg/wk)					
All products	5.19 ± 3.77	5.12 ± 3.53	5.12 ± 3.27	4.82 ± 3.29	5.06 ± 3.47
Healthier products only	4.81 ± 3.62	4.76 ± 3.44	4.77 ± 3.12	4.49 ± 3.19	4.70 ± 3.35
Meat and alternatives (kg/wk)					
All products	1.52 ± 1.27	1.50 ± 1.13	1.51 ± 1.03	1.38 ± 0.91	1.48 ± 1.09
Healthier products only	0.56 ± 0.59	0.60 ± 0.54	0.63 ± 0.61	0.53 ± 0.43	0.58 ± 0.55
Milk and milk products (kg/wk)					
All products	2.12 ± 1.99	2.21 ± 2.14	2.44 ± 2.34	1.91 ± 1.81	2.17 ± 2.08
Healthier products only	1.09 ± 1.43	1.12 ± 1.56	1.29 ± 1.49	0.97 ± 1.27	1.12 ± 1.44

[1] Mean ± SD (all such values).

[2] Values are medians; ranges (minimum, maximum) in parentheses.

[3] The sum of healthier and less-healthy products is less than the total for all products because some foods that were not directly relevant to trial objectives were classified as neither healthier nor less healthy (eg, sports supplements and baby food).

RESULTS

Recruitment and participant characteristics

Of 1927 individuals registered, 823 (43%) did not meet study inclusion criteria and were excluded before being randomly assigned (**Figure 1**). Those who were not randomly assigned were similar to randomly assigned participants in terms of sex but were younger (mean age: 41 y compared with 44 y; $P <$ 0.001) and differed significantly by ethnicity (not randomly assigned: 46% Māori, 37% Pacific, 18% non-Māori/non-Pacific; randomly assigned: 22% Māori, 9% Pacific, 68% non-Māori/non-Pacific; $P < 0.001$). Detailed trial recruitment results were published previously (26). In total, 1104 individuals were randomly assigned to the following groups: 275 to price discounts, 274 to tailored nutrition education, 277 to a combination of price discounts and tailored nutrition education, and 278 to control (no intervention). Baseline characteristics were similar between participants assigned to the 4 intervention groups (**Table 1**). Seventy-six (7%) had no electronic shopping data for the intervention phase and were considered lost to follow-up at primary analysis (6 mo postrandomization). Those lost to follow-up were younger on average (mean age: 33 y) and differed by ethnicity (70% Maori and Pacific) compared with those who continued to provide shopping data (Table 1).

Saturated fat

There were no significant differences in purchased saturated fat (percentage energy) between those randomly assigned to receive price discounts and those not randomly assigned to receive discounts at 6 mo (mean difference: −0.02%; 95% CI: −0.40%, 0.36%; P = 0.91) or 12 mo (mean difference: −0.12%; 95% CI: −0.51%, 0.27%; P = 0.54). Corresponding differences for tailored nutrition education compared with no education were −0.09% (95% CI: −0.47%, 0.30%; P = 0.66) and −0.21% (95% CI: −0.60%, 0.18%; P = 0.29), respectively (**Table 2**).

Saturated fat at 6 mo postrandomization was similar among participants assigned to price discounts (13.4%), tailored nutrition education (13.4%), the combination of price discounts and tailored nutrition education (13.3%), and the control group (13.2%). Saturated fat also did not differ appreciably between intervention groups at 12 mo postrandomization: 12.4% for those assigned to price discounts, 12.5% for education, 12.5% for discounts plus education, and 12.7% for control (**Table 3**). Change from baseline in saturated fat differed between intervention groups by <0.4% of energy at 6 mo postrandomization and <0.7% at 12 mo postrandomization (Table 3).

Other nutrient outcomes

There were no consistent differences between groups for any nutrients, although a significant effect of price discounts on protein at 12 mo and of tailored education on sodium at 6 mo was noted (Table 2). Given the lack of consistent effects and the number of comparisons, however, it is likely that these differences occurred by chance.

TABLE 2
Estimates of effect of price discounts and tailored nutrition education on mean changes from baseline in nutrient and food purchases[1]

	Price discounts (n = 513) vs no price discounts (n = 515)				Tailored education (n = 519) vs no tailored education (n = 509)			
Purchases	Difference[2]	Lower 95% CI	Upper 95% CI	*P* value	Difference[2]	Lower 95% CI	Upper 95% CI	*P* value
Nutrients								
Saturated fat (% energy)								
6 mo	−0.02	−0.40	0.36	0.91	−0.09	−0.47	0.30	0.66
12 mo	−0.12	−0.51	0.27	0.54	−0.21	−0.60	0.18	0.29
Total fat (% energy)								
6 mo	−0.07	−0.93	0.78	0.86	−0.21	−1.07	0.65	0.63
12 mo	0.05	−0.83	0.94	0.91	−0.09	−0.98	0.79	0.83
Protein (% energy)								
6 mo	0.15	−0.24	0.55	0.44	0.20	−0.19	0.60	0.31
12 mo	−0.42	−0.82	−0.02	0.04	0.03	−0.37	0.43	0.89
Carbohydrate (% energy)								
6 mo	−0.08	−0.95	0.79	0.86	0.33	−0.54	1.20	0.46
12 mo	0.01	−0.88	0.91	0.98	0.25	−0.65	1.14	0.59
Energy density (MJ/kg)								
Beverages								
6 mo	−0.11	−0.41	0.19	0.48	0.18	−0.12	0.48	0.25
12 mo	0.01	−0.31	0.32	0.97	−0.15	−0.46	0.16	0.34
Nonbeverages								
6 mo	−0.07	−0.21	0.07	0.31	−0.07	−0.20	0.07	0.32
12 mo	0.05	−0.09	0.19	0.48	0.11	−0.02	0.25	0.11
Sugars (g/MJ)								
6 mo	0.18	−0.29	0.64	0.46	0.38	−0.09	0.85	0.11
12 mo	0.17	−0.31	0.65	0.48	0.33	−0.15	0.81	0.17
Sodium (mg/MJ)								
6 mo	−0.01	−9.58	9.57	0.99	−9.88	−19.47	−0.30	0.04
12 mo	−1.90	−11.73	7.93	0.71	−8.67	−18.50	1.16	0.08
Foods (kg/wk)								
All foods								
6 mo	0.90	0.29	1.52	0.004	0.09	−0.53	0.71	0.77
12 mo	0.37	−0.26	1.00	0.25	0.02	−0.61	0.65	0.95
All less-healthy products								
6 mo	0.07	−0.15	0.29	0.56	−0.05	−0.27	0.17	0.67
12 mo	0.05	−0.18	0.27	0.67	−0.05	−0.28	0.17	0.65
All healthier products								
6 mo	0.79	0.43	1.16	<0.001	0.07	−0.30	0.44	0.71
12 mo	0.38	0.01	0.76	0.045	−0.01	−0.39	0.37	0.96
Healthier cereals and cereal products								
6 mo	0.05	0.00	0.10	0.04	0.01	−0.04	0.06	0.75
12 mo	0.02	−0.04	0.07	0.56	0.06	0.01	0.11	0.02
Healthier fats and oils								
6 mo	0.01	0.00	0.03	0.08	0.01	0.00	0.03	0.10
12 mo	0.01	0.00	0.03	0.18	0.01	0.00	0.03	0.11
Healthier fruit and vegetables								
6 mo	0.48	0.21	0.75	<0.001	0.03	−0.24	0.30	0.84
12 mo	0.28	0.00	0.56	0.05	−0.06	−0.34	0.22	0.69
Healthier meat and alternatives								
6 mo	0.06	0.02	0.11	<0.001	0.00	−0.04	0.05	0.83
12 mo	0.03	−0.01	0.08	0.15	−0.01	−0.05	0.04	0.74
Healthier milk and milk products								
6 mo	0.21	0.10	0.31	<0.001	0.04	−0.07	0.15	0.46
12 mo	0.06	−0.04	0.18	0.21	0.01	−0.10	0.12	0.90

[1] Model was adjusted for baseline nutrient and food purchase values, ethnicity, income, age, and sex.
[2] Change from baseline with intervention compared with change from baseline without intervention (calculated by using repeated-measures mixed-model regression analysis).

Quantities of healthier foods purchased

There were clear differences in quantities of foods purchased according to intervention group (**Figure 2**). Those subjects who were randomly assigned to receive price discounts bought significantly more healthier discounted foods compared with those not randomly assigned to receive discounts at 6 mo post-randomization (mean increase: 0.79 kg/wk; 95% CI: 0.43, 1.16; $P < 0.001$); this represented an 11% increase compared with

TABLE 3
Nutrient and food purchases according to intervention group at 6 and 12 mo

	Price discounts (n = 254)		Tailored nutrition education (n = 260)		Discounts plus education (n = 259)		Control group (n = 255)	
	Mean ± SD[1]	Change from baseline[2]	Mean ± SD[1]	Change from baseline[2]	Mean ± SD[1]	Change from baseline[2]	Mean ± SD[1]	Change from baseline[2]
Nutrients								
Saturated fat (% energy)								
6 mo	13.4 ± 3.4	−1.2	13.4 ± 3.8	−1.4	13.3 ± 3.8	−1.5	13.2 ± 3.5	−1.1
12 mo	12.4 ± 3.7	−2.1	12.5 ± 3.3	−2.3	12.5 ± 3.5	−2.2	12.7 ± 3.9	−1.6
Total fat (% energy)								
6 mo	34.8 ± 8.0	−1.4	34.8 ± 8.1	−2.0	34.4 ± 7.2	−1.9	34.6 ± 8.2	−1.2
12 mo	32.5 ± 8.1	−3.6	32.6 ± 8.0	−4.1	32.8 ± 8.1	−3.2	32.9 ± 8.3	−3.0
Protein (% energy)								
6 mo	13.3 ± 3.8	0.1	13.2 ± 3.2	0.2	13.4 ± 3.6	0.2	13.1 ± 3.5	0.2
12 mo	12.5 ± 2.9	−0.6	13.1 ± 3.8	−0.2	12.5 ± 3.6	−0.7	13.0 ± 3.9	−0.4
Carbohydrate (% energy)								
6 mo	51.4 ± 8.5	1.1	51.5 ± 8.3	2.0	51.7 ± 6.8	1.9	51.6 ± 7.7	1.0
12 mo	54.1 ± 8.5	3.6	53.8 ± 8.3	4.4	53.8 ± 8.0	3.8	53.6 ± 8.4	3.1
Energy density (MJ/kg)								
Beverages								
6 mo	2.6 ± 2.8	−0.4	2.8 ± 3.0	0.1	2.5 ± 2.5	−0.3	2.3 ± 1.8	−0.1
12 mo	2.8 ± 3.3	−0.3	2.4 ± 2.6	−0.1	2.6 ± 2.7	−0.1	2.5 ± 3.0	0.2
Nonbeverages								
6 mo	6.8 ± 1.5	−0.5	6.8 ± 1.8	−0.5	6.7 ± 1.5	−0.5	6.9 ± 1.5	−0.4
12 mo	6.8 ± 1.7	−0.4	6.9 ± 1.8	−0.4	7.0 ± 1.6	−0.2	6.9 ± 1.6	−0.4
Sugars (g/MJ)								
6 mo	14.4 ± 4.6	0.3	14.8 ± 5.1	0.20	14.5 ± 3.5	0.6	14.1 ± 4.0	−0.1
12 mo	15.2 ± 5.2	1.1	15.6 ± 5.0	1.2	15.7 ± 4.8	1.7	15.3 ± 4.4	1.1
Sodium (mg/MJ)								
6 mo	294.3 ± 115.5	0.3	276.6 ± 72.8	−3.0	277.4 ± 74.1	−5.6	286.4 ± 89.4	2.1
12 mo	289.7 ± 110.9	−2.6	277.8 ± 77.4	−0.3	272.5 ± 73.4	−4.0	272.6 ± 73.4	3.3
Foods (kg/wk)								
All food purchases								
6 mo	13.41 ± 8.37	−0.55	12.27 ± 9.02	−1.21	13.49 ± 7.56	−0.73	11.65 ± 6.98	−1.41
12 mo	12.25 ± 7.94	−1.90	11.63 ± 7.82	−2.08	12.17 ± 7.31	−2.03	10.93 ± 7.14	−2.24
Less-healthy food purchases								
6 mo	3.64 ± 2.57	−0.47	3.35 ± 2.95	−0.51	3.58 ± 2.76	−0.64	3.22 ± 2.41	−0.51
12 mo	3.44 ± 2.70	−0.75	3.14 ± 2.53	−0.77	3.32 ± 2.65	−0.88	2.98 ± 2.33	−0.72
Healthier food purchases								
6 mo	7.61 ± 5.22	0.25	6.92 ± 5.34	−0.42	7.83 ± 4.77	0.19	6.49 ± 4.28	−0.48
12 mo	6.87 ± 4.80	−0.61	6.57 ± 4.78	−0.97	6.94 ± 4.68	−0.78	6.07 ± 4.37	−1.02
Healthier cereals and cereal products								
6 mo	0.64 ± 0.62	−0.05	0.57 ± 0.60	−0.08	0.69 ± 0.61	−0.01	0.63 ± 0.62	−0.07
12 mo	0.59 ± 0.53	−0.12	0.60 ± 0.60	−0.06	0.67 ± 0.57	−0.03	0.60 ± 0.61	−0.12

(Continued)

TABLE 3 (*Continued*)

	Price discounts (n = 254)		Tailored nutrition education (n = 260)		Discounts plus education (n = 259)		Control group (n = 255)	
	Mean ± SD[1]	Change from baseline[2]	Mean ± SD[1]	Change from baseline[2]	Mean ± SD[1]	Change from baseline[2]	Mean ± SD[1]	Change from baseline[2]
Healthier fats and oils								
6 mo	0.12 ± 0.13	−0.01	0.13 ± 0.15	−0.02	0.15 ± 0.16	0.00	0.11 ± 0.15	−0.01
12 mo	0.12 ± 0.13	−0.02	0.13 ± 0.17	−0.02	0.15 ± 0.16	−0.01	0.11 ± 0.14	−0.02
Healthier fruit and vegetables								
6 mo	5.11 ± 3.66	0.26	4.65 ± 3.72	−0.14	4.99 ± 3.07	0.17	4.32 ± 3.00	−0.27
12 mo	4.74 ± 3.45	−0.20	4.43 ± 3.32	−0.48	4.47 ± 3.05	−0.39	4.07 ± 3.09	−0.58
Healthier meat and alternatives								
6 mo	0.59 ± 0.58	0.02	0.55 ± 0.54	−0.05	0.62 ± 0.54	−0.02	0.49 ± 0.38	−0.04
12 mo	0.52 ± 0.50	−0.05	0.52 ± 0.46	−0.11	0.57 ± 0.50	−0.07	0.47 ± 0.42	−0.07
Healthier milk and milk products								
6 mo	1.12 ± 1.45	0.03	0.98 ± 1.26	−0.14	1.35 ± 1.59	0.05	0.91 ± 1.17	−0.09
12 mo	0.88 ± 1.25	−0.22	0.87 ± 1.18	−0.31	1.06 ± 1.42	−0.26	0.80 ± 1.15	−0.23

[1] Unadjusted.
[2] Absolute change in nutrient and food purchases.

baseline (Table 3). The effect of discounts on healthier food purchases was sustained at 12 mo postrandomization (mean difference: 0.38 kg/wk; 95% CI: 0.01, 0.76; P = 0.045) (Table 2). In contrast, purchases of nondiscounted, less-healthy foods did not change significantly at 6 mo (mean difference: 0.07 kg/wk; 95% CI: −0.15, 0.29; P = 0.56) or 12 mo (mean difference: 0.05 kg/wk; 95% CI: −0.18, 0.27; P = 0.67).

Sustained increases were seen in response to price discounts for fruit and vegetable purchases, the largest subgroup of the healthier products category, with a mean increase of 0.48 kg/wk (95% CI: 0.21, 0.75; $P < 0.001$) at 6 mo (a 10% increase from baseline) and an increase of 0.28 kg/wk (95% CI: 0.00, 0.56; P = 0.05) at 12 mo. Positive effects were seen in purchases of most other major food subgroups within the healthier products category, namely cereals and cereal products, meat and meat alternatives, and milk and milk products, although effects were smaller and not sustained at 12 mo (Table 2). In contrast, no effect of tailored nutrition education on foods purchases was evident other than a small increase in healthier cereal purchases at 12 mo, an effect likely to have arisen by chance (Table 2).

Despite a significant increase in quantities of healthier foods purchased by those randomly assigned to receive discounts compared with those not randomly assigned to receive discounts, there was no significant difference in overall food expenditure between groups at 6 mo postrandomization (mean difference: NZ $1.41/wk; 95% CI: −0.87, 3.70; P = 0.23).

Sensitivity analyses

Many participants indicated at baseline that they bought household food from locations other than participating stores, such as other supermarkets (82% of participants), markets (39%), and fruit and vegetable shops (40%). Because participants were not blinded, it is possible that some of the effect of price discounts could have been due to displacement shopping from other locations into intervention supermarkets. Therefore, we conducted sensitivity analyses of the effect of price discounts on healthier food purchases in subgroups of the intervention population that we predicted would be less prone to displacement shopping as follows: *1*) participants who shopped regularly at intervention supermarkets on the basis of electronic sales data, *2*) participants who reported at baseline that they shopped only at participating stores, *3*) participants who reported at baseline that they did not shop at markets and/or fruit and vegetable shops, and *4*) participants who reported at the end of the intervention that they had continued to shop in their usual manner. In all cases, the main study findings were replicated in the predefined "more internally valid" study subgroups, and there were no clear differences in purchases between these subgroups and those more likely to undertake displacement shopping (**Table 4**).

DISCUSSION

In this large randomized trial of interventions to promote healthier supermarket food purchases, neither price discounts nor tailored nutrition education had a significant effect on saturated fat purchases or any nutrient outcome considered. However, price discounts had a significant effect on food purchases at 6 mo, with individuals who were randomly assigned to receive discounts

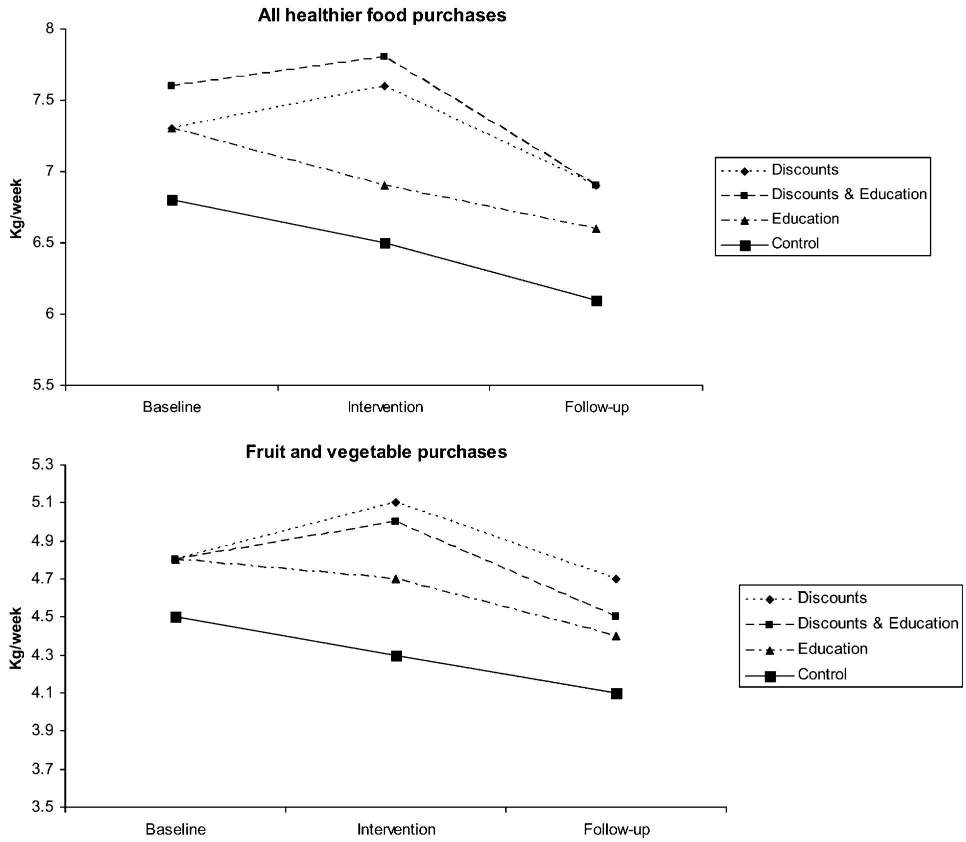

FIGURE 2. Healthier food purchases and fruit and vegetable purchases according to intervention group at baseline, 6 mo, and 12 mo (unadjusted means). Note that the trend in decreasing food purchases over time is likely to reflect changes in product sales, which may have decreased the precision of the trial food and nutrient database.

buying an average of 0.79 kg/wk more healthier products than those not randomly assigned to receive discounts, including 0.48 kg/wk more fruit and vegetables. These effects represent increases of 10–11% from baseline in response to a 12.5% price decrease. Importantly, effects were sustained at 12 mo (although attenuated by approximately half), showing an effect on food purchasing behavior that persisted after cessation of price discounts. In contrast, carefully tailored nutrition education had no effect on food purchases.

The strengths of the SHOP trial include its large sample size, real-life setting, high follow-up data collection rates (93%), and use of electronic scanner sales data as an objective measure of food and nutrient purchases. The population was moderately diverse and included higher proportions of priority populations [Māori (23%) and Pacific (9%)] than would be expected on the basis of their representation in the population (15% and 7%, respectively). Most participants were women (which reflected their frequent role as main household shoppers), and there were approximately equal numbers of participants from high- and low-income households. However, the study population was relatively well educated compared with the general New Zealand population, and a high proportion (85%) self-rated their knowledge of nutrition and healthy eating as "moderate" or "a lot." Thus, although findings should be applicable to a reasonably socioeconomically diverse population, it is likely the study population had a higher level of baseline nutrition knowledge and interest than average.

Study limitations include possible inaccuracies in measurement of food and nutrients. Although scanner sales data provide an objective measure of purchasing behavior and have less response bias relative to self-reported dietary measures (20, 31), they represent household-level purchase data rather than food consumption of individuals within households. Nevertheless, a substudy showed significant positive correlations between household-level purchases and dietary intake by individuals for most macronutrients, including saturated fat ($r = 0.54$; absolute mean difference: $-1 \pm 4\%$; $P = 0.12$) (32). Similar correlations between household food purchases and individual dietary intakes have been reported by others (33, 34).

Most participants purchased food from a number of retail outlets in addition to participating stores. Thus, our findings reflect a proportion of all household food purchases rather than the total. Data from our pilot study suggested that ≈66% of total household food expenditure was undertaken at participating supermarket stores and 51% captured by using Shop 'N Go (35). Our best estimate, therefore, is that scanner sales data reflect about half of all household food purchases.

Another potential weakness was the use of a relatively selective database of supermarket products to assess food and nutrient purchases. The database comprised 3000 top-selling food products (17% of total) sold in participating supermarkets in 2005–2006, and product turnover means that it is possible we did not capture all foods purchased during the trial period (2007–2009). However, the database covered 65% of total sales

TABLE 4
Effect estimates of price discounts on mean changes from baseline in food purchases at 6 mo according to shopping habits[1]

	All healthier foods			Fruit and vegetables[3]		
	Difference in means[2]	Lower 95% CI	Upper 95% CI	Difference in means[2]	Lower 95% CI	Upper 95% CI
		kg/wk			*kg/wk*	
Shopped at participating stores (according to electronic sales data)						
Regular shoppers (n = 172)	1.04	−0.03	2.11	0.37	−0.44	1.17
Nonregular shoppers (n = 901)	0.66	0.31	1.01	0.43	0.17	0.69
Shopped at other supermarkets (self-reported at baseline)						
Only shopped at PNS (n = 199)	0.51	−0.33	1.35	0.33	−0.29	0.96
Shopped at other supermarkets (n = 874)	0.88	0.46	1.29	0.51	0.21	0.82
Only shopped at PNS and up to one other supermarket (n = 650)	0.77	0.33	1.22	0.44	0.10	0.77
Shopped at other supermarkets (n = 423)	0.70	0.07	1.32	0.43	−0.03	0.89
Shopped at markets and fruit and vegetable stores (self-reported at baseline)[3]						
Did not buy from markets or fruit and vegetable stores (n = 425)				0.57	0.16	0.99
Did buy from markets or fruit and vegetable stores (n = 648)				0.45	0.09	0.81
Shopping habits throughout trial (self-reported at follow-up)						
Did not change habits during trial (n = 758)	1.10	0.70	1.51	0.66	0.36	0.96
Did change habits during trial (n = 107)	−0.07	−0.87	0.74	−0.03	−0.60	0.54

[1] PNS, Pak 'N Save [participating stores; Foodstuffs (Wellington) Cooperative Society Ltd, Wellington, New Zealand]. Sensitivity analysis model was adjusted for baseline food purchase values, ethnicity, income, age, and sex.

[2] Change from baseline with price discounts compared with change from baseline without price discounts (calculated by using repeated-measures mixed-model regression analysis).

[3] Effects of price discounts were assessed only for fruit and vegetable purchases, because this was the food group most likely to be affected by participants' use of markets and fruit and vegetable stores.

expenditure and 78% of volume, and it is unlikely that normal product turnover would affect top-selling products substantially. Nevertheless, SHOP was conducted during a period of dramatic increases in global food prices; between January 2006 and July 2008 global food prices rose by 75% (36). Dairy products, a major contributor to population saturated fat intakes (30), were substantially affected, with cheddar cheese prices rising by 65% in New Zealand between 2007 and 2008 (37). It is possible, therefore, that sales of specific products decreased substantially and that our database was no longer as reflective of consumer purchasing. This could account for the decreases in saturated fat observed across all intervention groups (Table 3).

All of the above limitations, however, would likely lead to nondifferential misclassification of outcomes, thus causing a conservative bias toward the null. This could mean that the effect of price discounts on food purchases was somewhat underestimated but would not necessarily account for total lack of effect of interventions on nutrients. The key potential differential bias that could arise due to nonblinding is that shoppers who were randomly assigned to receive price discounts would displace their purchases from other retail outlets into the intervention supermarkets. However, our sensitivity analyses suggest the main study findings are robust.

Some further limitations relate to delivery of study interventions. For example, information on price discounts was provided via a printed mailed list of 1032 eligible products. This unsophisticated method of delivery is likely to have had less effect on shopping behavior than pricing promotions such as in-store signage and "shelf-talkers" (ie, small signs on store shelves that call attention to promoted items) (38). Of the 166 (40%) participants randomly assigned to receive discounts who only sometimes or never bought discounted foods, the reason given by most (52%) was that it took too long to sort through the list. The effect of education may also have been attenuated because most study participants were well informed about healthy eating at baseline, and therefore there may have been less room for improvement in our sample compared with a random sample of the population. Of the 196 (46%) randomly assigned to receive education who found the education slightly or not at all useful, the reason given by most (85%) was that they knew much of the information already.

Finally, the eligibility of foods for price discounts and promotion via education was based on the Heart Foundation's Tick program (25), so effectiveness of interventions was ultimately dependent on the ability of the Tick nutrient profiling model to adequately distinguish between healthy and less-healthy foods to an extent that produces meaningful differences in nutrient profiles. Comparison of the nutrient profile of foods as classified by the Tick model showed average differences between healthier and less-healthy foods of ≈200 kJ/100 g and 4 g saturated fat/100 g (HC Eyles, D Gorton, and C Ni Mhurchu, unpublished data, 14 September 2009). Therefore, the Tick model appears to discriminate foods adequately; however, the relatively small proportion of foods classified as healthier (and therefore eligible for discounts or promotion) (35%) in combination with the modest increase in purchases (11%) may account for the overall lack of effect on nutrient profiles.

To our knowledge, SHOP is the first randomized trial to assess the effect of price incentives on food purchasing behavior in a real-life setting. Previous research on effects of fiscal measures (taxes and subsidies) has often modeled effects on food purchases (8, 39), although natural experiments have also been used (9). Jensen and Smed (39) estimated that a reduction in the value-added tax from 25% to 12.5% would increase fruit and vegetable consumption by 8% and decrease saturated fat consumption by 1%. Although SHOP showed a slightly greater increase in fruit and vegetable purchases (10%) for the same price reduction, no effect was seen on saturated fat. This may be due to variation in cross-elasticities of demand, which we have not examined in detail, or because changes of this magnitude in fruit and vegetable purchases do not substantially effect overall macronutrient purchases. In the real world, it remains unclear what the long-term consequences of pricing policies that favor healthier foods might be. It has been suggested that pricing policies that favor healthier foods, and thus increase their consumption, could ultimately lead to higher market prices for healthier products and lower prices for less-healthy foods (40), which would quite likely alter food purchasing and consumption in ways we could not evaluate in the SHOP trial.

Information or education to promote healthier supermarket food purchases has produced conflicting results. Some studies reported increases in aggregate sales for up to half of targeted items, whereas others showed no effect on sales (41). In an Internet shopping trial, Huang et al (42) found a small positive effect of dietary advice on saturated fat purchased (0.7% less). Overall, it appears that nutrition education does not have an immediate and substantial effect on supermarket purchases, although it is notable that most interventions have been led by health professionals rather than by marketing and retail experts. It seems likely that application of commercial expertise and approaches would lead to bigger effects than those observed to date (38).

This large trial of strategies to promote healthier food purchases showed a significant effect of targeted price discounts on food purchasing behavior. The magnitude of the effect suggests an ≈1:1 relation between food pricing and purchasing. In addition, the effect of pricing on shopping habits was sustained 6 mo after cessation of discounts, although this effect was attenuated. Our findings suggest that structural interventions are more powerful determinants of dietary behavior than those that rely on individual responsibility. Further work is needed to determine how to augment the effect of pricing strategies on healthier food purchases to achieve a corresponding positive effect on nutrient purchases.

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The authors' responsibilities were as follows—CNM, TB, AR, HCE, and YJ: study conception and design; CNM, TB, YJ, and HCE: acquisition of data; YJ, CNM, TB, and AR: analysis and interpretation of data and statistical analysis; CNM, TB, and YJ: drafting of the manuscript; CNM, TB, AR, HCE: critical revision of the manuscript for important intellectual content; CNM, TB, and AR: obtainment of funding; HCE, CNM, and TB: administrative, technical, or material support; and CNM and TB: study supervision. All authors had full access to all data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis and final report. The authors declared that they had no conflicts of interest.

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