Price discounts significantly enhance fruit and vegetable purchases when combined with nutrition education: a randomized controlled supermarket trial\textsuperscript{1–3}

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ABSTRACT

Background: Reducing fruit and vegetable (F&V) prices is a frequently considered policy to improve dietary habits in the context of health promotion. However, evidence on the effectiveness of this intervention is limited.

Objective: The objective was to examine the effects of a 50% price discount on F&Vs or nutrition education or a combination of both on supermarket purchases.

Design: A 6-mo randomized controlled trial within Dutch supermarkets was conducted. Regular supermarket shoppers were randomly assigned to 1 of 4 conditions: 50% price discounts on F&Vs, nutrition education, 50% price discounts plus nutrition education, or no intervention. A total of 199 participants provided baseline data; 151 (76%) were included in the final analysis. F&V purchases were measured by using supermarket register receipts at baseline, at 1 mo after the start of the intervention, at 3 mo, at 6 mo (end of the intervention period), and 3 mo after the intervention ended (9 mo).

Results: Adjusted multilevel models showed significantly higher F&V purchases (per household/2 wk) as a result of the price discount (+3.9 kg; 95% CI: 1.5, 6.3 kg) and the discount plus education intervention (+5.6 kg; 95% CI: 3.2, 7.9 kg) at 6 mo compared with control. Moreover, the percentage of participants who consumed recommended amounts of F&Vs (≥400 g/d) increased from 42.5% at baseline to 61.3% at 6 mo in both discount groups ($P$ = 0.03). Education alone had no significant effect.

Conclusions: Discounting F&Vs is a promising intervention strategy because it resulted in substantially higher F&V purchases, and no adverse effects were observed. Therefore, pricing strategies form an important focus for future interventions or policy. However, the long-term effects and the ultimate health outcomes require further investigation. This trial was registered at the ISRCTN Trial Register as number ISRCTN56596945 and at the Dutch Trial Register (http://www.trialregister.nl/trialreg/index.asp) as number NL22568.029.08. Am J Clin Nutr 2013;97:886–95.

INTRODUCTION

Sufficient intake of fruit and vegetables (F&Vs)\textsuperscript{4} forms a principal component of dietary recommendations (1). Nevertheless, F&V intakes are generally far below recommended amounts (2, 3), particularly among people with a lower socioeconomic status (SES) (4–6). Increasing F&V intake up to dietary recommendations could reduce the burden of noncommunicable diseases drastically (7), and effective interventions are urgently needed to accomplish this goal (8). Price discounts are frequently cited as a promising intervention opportunity to stimulate F&V purchases (9, 10). Previous survey-based research indicates that consumers will buy more healthy food if it were cheaper (11, 12). Nevertheless, experimental evidence on the effects of food-pricing strategies is limited (13, 14), and there are even indications for negative consequences (15), such as increased total purchased energy (16, 17).

Food-pricing research lacks good-quality supermarket studies (18, 19). Worldwide, supermarkets are the dominant food-purchasing environment (20, 21), but experimental research in retail settings is limited (22). A recent review showed that only 4 randomized controlled trials (RCTs) in supermarkets have been published to date (23). In addition, some pricing trials have been conducted in laboratories or in computerized supermarket models (16, 17, 24). For example, in an experimental study that used a three-dimensional virtual supermarket, we found that a 25% discount on F&Vs was effective in increasing F&V purchases (25).

Two examples of RCTs that studied the effects of pricing strategies in real supermarkets are the New Zealand Supermarket Healthy Options Project (SHOP) study (26) and a French study examining F&V vouchers (27). SHOP evaluated the effects of a 12.5% discount on healthier foods and nutrition education on supermarket purchases. The authors found that participants receiving price discounts purchased 11% more healthy food items at 6 mo but concluded that further work is needed to determine

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\textsuperscript{4}Abbreviations used: FFQ, food-frequency questionnaire; F&V, fruit and vegetable; MI, motivational interviewing; RCT, randomized controlled trial; SES, socioeconomic status; SHOP, Supermarket Healthy Options Project.

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how to amplify the effect of pricing strategies (26). Similarly, the French study observed positive effects for price discounts on F&V consumption, but a major limitation of this study was a significant loss to follow-up (27).

In conclusion, evidence on the effectiveness of food-pricing interventions is limited. The aim of this study was therefore to examine the effects of a 50% discount on F&Vs or nutrition education or a combination of both on supermarket purchases. The educational component was added because price alone may not improve dietary habits (28, 29). This study focuses on people with a relatively low SES because the burden of noncommunicable disease is largest in this group and financial barriers for F&V purchases mainly apply to these individuals (11, 12, 30). The main hypothesis was that price discounts plus nutrition education would lead to the highest increase in F&V purchases compared with a control.

SUBJECTS AND METHODS

Study design

The present study was a RCT design, with a 6-mo intervention and a 3-mo follow-up period. The trial contained 4 research arms: 1) price discounts on F&Vs, 2) nutrition education, 3) price discounts on F&Vs plus nutrition education, and 4) no intervention. The study was conducted between September 2010 and July 2011 in 4 Dutch supermarkets. The trial was registered with the ISRCTN register (ISRCTN56596945), and the study protocol was approved by the Institutional Medical Ethical Committee, VU University Amsterdam Medical Centre. All participants provided written informed consent.

Selection and recruitment of supermarkets

This study was conducted in collaboration with individual store owners of C1000 and PLUS supermarket chains. These chains had the second- and third-largest market share in the Netherlands, respectively. We recruited supermarkets in areas with no other supermarkets in the vicinity. This approach was used to prevent interference, for example, from competing promotions in other nearby supermarkets. This resulted in an initial list of 7 PLUS and 4 C1000 stores. Owners of these 11 stores were sent a formal letter explaining the rationale of the study. After 1 wk, all of the owners were phoned to inquire about their interest in participation. Four owners could not be reached in time due to holidays. Three owners were not willing or able to participate. Four store owners (2 PLUS and 2 C1000) agreed to participate in the study. The stores were distributed through 4 different provinces and were located in rural areas (population size in villages ranged from 3300 to 6100).

Participants and recruitment

Participants were recruited between July and August 2010. For recruitment we used posters, flyers (handed out by the cashiers), and advertisements in local newspapers. A sample size was calculated by using data on F&V intakes (means and SD) from the Dutch National Food Consumption Survey (31). It was calculated that to detect a significant difference of 65 g of fruit and 50 g of vegetable purchases per person per day, a sample size of $n = 180$ was required. In total, 316 participants registered (see Figure 1). After registration, participants were screened for eligibility. Because this study specifically focused on people with a lower SES, we used educational level as a specific selection

![Consolidated Standards of Reporting Trials flow diagram](https://academic.oup.com/ajcn/article-abstract/97/4/886/4577141)

**FIGURE 1.** Consolidated Standards of Reporting Trials flow diagram. CR, cash receipts.
criterion (eg, excluding participants with a higher educational level and where the maximum level was set at completed intermediate vocational education, which is similar to US community college). Income was not used as an indicator for SES because Dutch people are generally reluctant to provide details about their income. Second, participants had to be frequent shoppers in the participating stores. Finally, participants had to be ≥18 y old and speak Dutch. On the basis of these criteria, 234 participants were registered and sent baseline questionnaires and informed consent forms.

Randomization
A total of 199 (85%) registered participants returned the baseline questionnaire (Figure 1) and were individually randomly assigned by using a Random Number Generator in Microsoft Excel (Microsoft Corporation) into 1 of 4 study conditions. Randomization was stratified by store to make sure there was a balance of subjects in each condition across the 4 stores. The randomization procedure was blinded. Participants were unaware of the aims of this study but not with regard to allocation of the intervention conditions.

Interventions
Nutrition education
Nutrition education comprised provisioning recipe books and telephone counseling. The recipe books were based on a Dutch municipal health service program and provided easy, tasty, and cheap recipes containing large quantities of F&Vs. Participants received 2 recipe books: one containing autumn recipes (at the start of the trial) and one containing winter recipes (halfway through the trial in January).

The telephone counseling consisted of 4 telephone calls conducted by a qualified dietitian (32). At least 3 attempts were made to reach participants for each of these calls, including one evening attempt. If a participant could not be reached, new attempts were made in the next counseling round. Each call lasted ~20 min. The counseling scheme was based on the principles of motivational interviewing (MI). The rounds were divided into 2 phases: 1) building motivation for change and 2) strengthening commitment to change (33). MI uses several specific conversation techniques such as asking open questions and reflective listening with the aim to create an open conversation without any counselor bias. The dietitian received 2 full days of certified training in MI to obtain these skills. Within this MI framework, different theoretical insights were combined to provide a firm education program. Psychosocial determinants of F&V intake were addressed on the basis of on the Theory of Planned Behavior (34). Second, special attention was paid to the misperceptions of one’s own behavior (35). Finally, the self-regulatory process action planning (eg, specifying when and how to act) and coping planning (eg, anticipating personal risk situations and planning coping responses beforehand) were incorporated (36, 37).

Price discounts
The pricing intervention consisted of a 50% price discount on F&Vs. Discount amounts up to 50% could be feasible (38) and are frequently used by retailers. Furthermore, similar discount amounts have been previously used in experimental studies in smaller settings, and it is useful to extrapolate these findings to a real supermarket environment (14, 25, 39). The discounts were provided by coupons. Coupons were used because this has previously been found to be effective (40) and because this system enabled us to offer discounts in all 4 supermarkets without interfering with the nondiscount intervention groups. Participants were sent discount coupons (by mail) for 7 types of vegetables and 5 types of fruit every 2 wk with 2 coupons for each item and with changing discount selections. In addition, apples were discounted throughout the entire intervention period, enabling assessment of the effects of a continuous price reduction. Discounts were chosen in line with seasonal availability. To prevent sharing, each coupon had a maximum amount of produce that could be purchased. Discounted products were mostly fresh produce, but every series also included some canned and frozen products. Discounts were given on F&Vs as a whole product only and not on products such as salads or ready-to-eat meals. Fruit juices, vegetable juices, apple sauce, tomato sauce, and potatoes were also excluded from the discount.

Data collection and outcome measures
Data collection took place at 5 time points: baseline, 1 mo after the start of the intervention, at 3 mo, at 6 mo (end of the intervention period), and 3 mo after the intervention ended (9 mo).

Outcome measures
The main outcome measures were household F&V purchases (combined, measured in grams) and household expenditures on other supermarket items (in €). These measures were based on supermarket cash receipts (from the participating supermarkets) that were collected at each measurement round during a 2-wk period. This method has been previously validated and found to be an effective measure of household food purchases (41). To capture purchases outside the participating supermarkets, participants were additionally asked what proportion of F&Vs was purchased at the participating supermarket. Second, the supermarket owners provided information on the use of discount coupons in each period. Finally, F&V consumption was measured by a shortened food-frequency questionnaire (FFQ), which was specifically developed and validated to measure F&V consumption in the Dutch population (42). Data from this questionnaire were used to detect participants who consumed sufficient (≥400 g/d) or insufficient F&Vs.

Covariates
Participants were asked to report some basic personal characteristics (see Table 1), discount coupon use, and frequency of shopping at the participating supermarket and to evaluate the nutrition education where provided. BMI was measured by self-reported height and weight at baseline. Next, we measured habit strength with regard to F&V purchases by the Self-Report Index of Habit Strength (43). This 12-item index was developed as a direct measure of habit strength and was added because the formation of new behavior may be largely dependent on the strength of current habits (43). Items include, for example, “behavior X is something I do automatically” or “behavior X is something I do without thinking.” The habit score was determined
### TABLE 1
Baseline participant characteristics

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>Price discount (n = 55)</th>
<th>Nutrition education (n = 49)</th>
<th>Price discount + nutrition education (n = 50)</th>
<th>Control (n = 45)</th>
<th>Total sample (n = 199)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>52.6 ± 12.8</td>
<td>48.3 ± 11.4</td>
<td>52.7 ± 12.6</td>
<td>52.6 ± 12.5</td>
<td>51.7 ± 12.4</td>
</tr>
<tr>
<td>21</td>
<td>2.8 ± 1.4</td>
<td>3.3 ± 1.2</td>
<td>3.2 ± 1.3</td>
<td>3.2 ± 1.4</td>
<td>3.1 ± 1.3</td>
</tr>
<tr>
<td>31</td>
<td>3.5 ± 7.1</td>
<td>3.8 ± 0.7</td>
<td>3.6 ± 0.8</td>
<td>3.6 ± 0.9</td>
<td>3.7 ± 0.8</td>
</tr>
<tr>
<td>41</td>
<td>3.6 ± 0.9</td>
<td>4.0 ± 0.8</td>
<td>3.7 ± 0.7</td>
<td>3.6 ± 0.8</td>
<td>3.7 ± 0.8</td>
</tr>
</tbody>
</table>

**Supermarket (n)**

| 1       | 12 | 9  | 9   | 10  | 40  |
| 2       | 21 | 20 | 15  | 14  | 70  |
| 3       | 11 | 10 | 11  | 13  | 45  |
| 4       | 11 | 10 | 15  | 8   | 44  |

**Sex [n (%)]**

| Male    | 46 (93.9) | 37 (94.9) | 44 (97.8) | 39 (97.5) | 166 (96.0) |
| Female  | 3 (6.1)   | 2 (5.1)   | 1 (2.2)   | 1 (2.5)   | 6 (4.0)    |

**Educational level [n (%)]**

| Primary education | 2 (4.2) | —        | 2 (4.8) | 1 (2.5) | 5 (3.0) |
| Lower secondary  | 19 (39.6) | 9 (23.7) | 22 (52.4) | 18 (45.0) | 68 (40.5) |
| Higher secondary | 5 (10.4) | 4 (10.5) | 3 (7.1)  | 1 (2.5) | 13 (7.7) |
| Intermediate vocational | 22 (45.8) | 25 (65.8) | 15 (35.7) | 20 (50.0) | 82 (48.8) |

**Gross income per month [n (%)]**

| Low (<€2000) | 21 (43.8) | 10 (26.3) | 12 (27.3) | 12 (30.8) | 55 (32.5) |
| Medium (€2001–3000) | 3 (6.2) | 6 (15.8) | 7 (15.9) | 4 (10.3) | 20 (11.9) |
| High (>€3001) | 11 (22.9) | 13 (34.2) | 12 (27.3) | 13 (33.3) | 49 (29.0) |

**BMI [n (%)]**

| <25 kg/m² | 26 (53.1) | 17 (43.6) | 16 (37.2) | 22 (55.0) | 81 (47.4) |
| 25 to <30 kg/m² | 17 (34.7) | 18 (46.2) | 19 (44.2) | 12 (30.0) | 66 (38.6) |
| ≥30 kg/m² | 6 (12.2) | 4 (10.3) | 8 (18.6) | 6 (15.0) | 24 (14.0) |

**Ethnicity [n (%)]**

| Dutch | 48 (98.0) | 38 (97.4) | 43 (95.6) | 38 (95) | 167 (96.5) |
| Other | 1 (2.0)   | 1 (2.6)   | 2 (4.4)   | 2 (5) | 6 (3.5) |

**Fresh F&Vs in studied supermarket [n (%)]**

| All | 15 (30.6) | 7 (18.4) | 6 (14.6) | 16 (40.0) | 44 (26.2) |
| Most | 16 (32.7) | 13 (34.2) | 17 (41.5) | 11 (27.5) | 57 (33.9) |
| Half | 5 (10.2) | 11 (28.9) | 11 (26.8) | 6 (15.0) | 33 (19.6) |
| Some | 11 (22.4) | 5 (13.2) | 6 (14.6) | 6 (15.0) | 28 (16.7) |
| None | 2 (4.1) | 2 (5.3) | 1 (2.4) | 1 (2.5) | 6 (3.6) |

**Other F&Vs in studied supermarket [n (%)]**

| All | 19 (39.6) | 17 (43.6) | 12 (30.0) | 16 (40.0) | 64 (38.3) |
| Most | 10 (20.8) | 6 (15.4) | 14 (35.0) | 8 (20.0) | 38 (22.8) |
| Half | 1 (2.1) | 4 (10.3) | 3 (7.5) | 3 (7.5) | 11 (6.6) |
| Some | 8 (16.7) | 7 (17.9) | 6 (15.0) | 3 (7.5) | 24 (14.4) |
| None | 10 (20.8) | 5 (12.8) | 5 (12.5) | 18 (25.0) | 30 (18.0) |

**Grows own vegetables [n (%)]**

| Yes (partially) | 11 (22.4) | 12 (33.3) | 9 (20.0) | 15 (37.5) | 47 (27.7) |
| No | 38 (77.6) | 26 (66.7) | 36 (80.0) | 25 (62.5) | 125 (72.3) |

**Grows own fruit [n (%)]**

| Yes (partially) | 10 (20.4) | 7 (20.5) | 6 (15.6) | 12 (30.0) | 35 (21.4) |
| No | 39 (79.6) | 31 (79.5) | 38 (84.4) | 28 (70.0) | 136 (78.6) |

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1. There were no significant differences in baseline participant characteristics between the 4 study conditions (P < 0.05). F&Vs, fruit and vegetables.
2. The average age in the Netherlands in 2011 was 40.3 y (44).
3. The average household size in the Netherlands in 2011 was 2.20 persons (44).
4. The amount (in g) purchased for the household during 2 wk in the participating supermarkets measured by cash receipts. Range for overall sample = 0–22,172 (minimum–maximum) g.
5. The amount (in g) purchased for the household during 2 wk in the participating supermarkets measured by cash receipts. Range for overall sample = 0–11,650 (minimum–maximum) g.
6. Total expenditures on groceries in the participating supermarket (2 wk) measured by cash receipts.
7. Measured by the index of habits strength (43); minimum = 1 (low habit), maximum = 5 (strong habit).
8. In 2010, 7.6% of the Dutch population had a primary educational level, 19.2% had a lower secondary level, 7% had a higher secondary level, 33% had an intermediate vocational level (comparable to a US community college), 20.5% had a higher vocational level, and 11.7% had a university level (45).
9. The standard (median) gross monthly income for all of the Netherlands in 2011 was €2546 (46).
10. In 2009, 35% of the Dutch adult population was overweight (BMI: 25–29.99) and 11.8% was obese (BMI >30) (47).
11. In 2011, 20.6% of the Dutch population were considered migrants (44).
Incentives

Participants received several small gifts to prevent dropout. First, participants in the discount group received a substantial discount on F&Vs. Second, small gifts were sent to the whole sample, including fridge magnets, tokens for shopping carts, shopping bags, ballpoint pens, and flower seeds. Also, participants received a St Nicholas gift and a Christmas card. At the end of the study, a special meeting was arranged at all 4 supermarkets where participants received a box filled with groceries (value of €40) and a gift coupon (€5) (nondiscount groups) or a discount coupon (€5) only (discount groups).

Statistical analyses

Intervention reach

The discount coupon reach was examined by using supermarket data showing the number of coupons that were redeemed each time period. Also, these data were used to examine differences in general coupon use and the use of apple coupons (consistently provided during the entire intervention). One supermarket was excluded from these analyses because it provided suspicious data: the redeemed coupons for apples totaled >100%, and general return rates were also suspiciously high. Supermarket data were supplemented with descriptive questionnaires to obtain coupon use at the consumer level. The nutrition education reach was examined by tracking the phone calls supplemented with descriptive questionnaires.

Main analyses

All randomly assigned participants with at least cash receipt measures at baseline and one follow-up measure within the intervention period were included in an intention-to-treat analyses (see Figure 1) (44). Differences in F&V purchases (in g) and total expenditures (in €) between the intervention conditions and the control group at all follow-up measurements were analyzed by using multilevel analyses with a random intercept at the subject level and including supermarket as a fixed effect to adjust for clustering of individuals within supermarkets. We analyzed the treatment effects for both outcome measures at each specific time point (1, 3, 6, and 9 mo). This was done by creating a model for each specific time point and by including a time × condition interaction in all models whereby time was modeled as a categorical variable. Therefore, these models yielded treatment effects for every time point separately. In addition, we computed crude and adjusted models for both outcomes. In addition to the abovementioned factors and interaction, the crude models included baseline F&V purchases or total expenditures. The adjusted models were extended by also including demographic characteristics on age, sex, ethnicity, education, household size, and BMI at baseline and finally by adding “proportion of fresh F&V purchased at participating supermarket (all/most/half/some/none),” “proportion of tinned/canned F&V purchased at participating supermarket (all/most/half/some/none),” and baseline habit for F&V purchases to the model. Income was not included in the models because this variable had many missing values. However, sensitivity analysis including income showed similar results. Furthermore, it was examined whether habits specific for F&V purchases modified the effects. We found only one significant dummy interaction term, and therefore it was decided to remove the interaction terms from the models. Next, sensitivity analyses were conducted on participants for whom the cash receipt measures were considered valid. Participants in the lowest 2.5th percentile for total expenditures (<€23) were excluded here. This included a total of 9 participants equally distributed among the study conditions.

Next, it was examined whether the percentage of participants who consumed recommended amounts of F&Vs increased through the intervention period (by using McNemar related-samples tests), and finally cross-price elasticity effects were tested (by using paired-samples t tests). Cross-price elasticity is defined as the percentage change in the quantity demanded of a certain good in response to a given percentage change in the price of another good (49). These effects were tested by comparing expenditures in (non)food categories at baseline and at 1 mo for both discount groups. We used an α of 0.05 for all tests of intervention effects. For the multilevel analyses we used MLWin2.26 (University of Bristol) and for all other analyses we used SPSS version 17.0 (SPSS Inc).

RESULTS

Participant characteristics

Baseline characteristics are shown in Table 1. Some participants provided incomplete baseline data, leading to a sample of n = 173 that could be used in analysis. Most participants were female (96%), and ~80% purchased at least half of their F&Vs in the participating supermarket.

One-hundred eleven (56%) participants provided shopping data for all 4 assessment periods within the intervention period and 151 (76%) participants had sufficient shopping data for the intervention phase and were included in multilevel analyses (see Figure 1). Forty-eight participants were excluded from analyses, of which 24 provided valid baseline data. When comparing these participants with the remaining sample (n = 151) on baseline characteristics, it was found that dropouts differed slightly by supermarket (P = 0.04), that relatively more men dropped out (P < 0.001), and that relatively fewer participants with a high income dropped out (P = 0.004). For the remaining characteristics no significant differences were found.

Intervention reach

Participants in the price discount groups received all discount coupons in line with the intervention protocol. Supermarket data showed that the percentage of coupons that was redeemed throughout the intervention period ranged from 15% to 45% (Figure 2A). The percentage of apple coupons handed in was similar to that of the other coupons (Figure 2B). Data in the questionnaires indicated a maximum of 3 participants who did not use the coupons. Furthermore, 73%, 60%, and 71% of the participants indicated that they used at least half of the coupons, at 1 mo, 3 mo, and 6 mo, respectively. In the education groups, all participants received the 2 recipe books as planned. Furthermore, 54.5% received all 4 counseling calls, 16.2% received
3 calls, 9.1% received 2 calls, 6.1% received one call, and 14.1% were not reached at all. At 6 mo, participants were asked whether they had changed their nutrition behavior due to the calls: 23% answered “a little,” 15% answered “a lot,” and 7% answered “very much.” Overall, participants reviewed the counseling calls positively.

Differences in F&V purchases and total expenditures

Crude multilevel model

As shown in Table 2, participants in the discount and discount plus education group purchased more F&Vs than did the control group. These differences were largest at 6 mo, where the discount group purchased 5.3 kg more F&Vs (P < 0.001) for their household for 2 wk compared with the control group. Similar differences were found in the price discount plus education group. No significant effects of the education alone were observed.

Adjusted multilevel model

The results for the fully adjusted multilevel models are shown in Table 3. Again, participants in the discount and discount plus education groups purchased more F&Vs compared with the control group; however, this was significant only at 6 mo. The largest part of the difference in effects found between the crude and adjusted models was explained by the proportion of purchases that were made in the participating supermarkets (see Supplemental Table S1 under “Supplemental data” in the online issue). At 9 mo, 3 mo after the intervention stopped, the differences between the 4 groups had disappeared.

Sensitivity analyses

Sensitivity analyses that used a subsample of participants who spent at least around €23 at the participating supermarkets yielded results similar to those of the analyses on the total sample (results not shown).

Changes in F&V consumption

The percentage of participants who consumed sufficient amounts of F&Vs increased significantly from 42.5% at baseline

TABLE 2

Crude effects of the price discounts, nutrition education, and price discounts plus nutrition education at all time points compared with control

<table>
<thead>
<tr>
<th>Time and outcome measure2</th>
<th>Price discounts (n = 41)</th>
<th>Nutrition education (n = 31)</th>
<th>Price discounts + nutrition education (n = 43)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Lower 95% CI</td>
<td>Upper 95% CI</td>
</tr>
<tr>
<td>One month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit + vegetables (g)</td>
<td>2386*</td>
<td>87</td>
<td>4685</td>
</tr>
<tr>
<td>Total expenditures (€)</td>
<td>−20</td>
<td>−67</td>
<td>26</td>
</tr>
<tr>
<td>Three months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit + vegetables (g)</td>
<td>1266</td>
<td>−1063</td>
<td>3596</td>
</tr>
<tr>
<td>Total expenditures (€)</td>
<td>−25</td>
<td>−72</td>
<td>22</td>
</tr>
<tr>
<td>Six months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit + vegetables (g)</td>
<td>5252***</td>
<td>2836</td>
<td>7668</td>
</tr>
<tr>
<td>Total expenditures (€)</td>
<td>47</td>
<td>−1.7</td>
<td>96</td>
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<tr>
<td>Nine months</td>
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<tr>
<td>Fruit + vegetables (g)</td>
<td>−826</td>
<td>−3284</td>
<td>1632</td>
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<tr>
<td>Total expenditures (€)</td>
<td>−13</td>
<td>−62</td>
<td>37</td>
</tr>
</tbody>
</table>

1 Results are from crude multilevel analyses (n = 151). Models included a random intercept at the subject level, supermarket as a fixed effect, and an interaction term between intervention and measurement time and the baseline value of the outcome measure. *P = 0.05; ***P < 0.001.
2 Outcomes were measured by cash receipts from the participating supermarkets collected during a 2-wk period.
to 61.3% at 6 mo in the discount groups ($P = 0.03$). For the nondiscount groups, these percentages were 52.7% and 52.5%, respectively ($P = 0.80$).

### Other purchases/cross-price elasticity

Neither of the discount groups showed significant differences between baseline and 1 mo with regard to the following total expenditures or expenditures on nonfood items or food items other than F&Vs (Table 4). This indicated that participants did not use the extra money from the discounts to purchase other supermarket items.

### DISCUSSION

This supermarket RCT studying the effects of F&V price discounts and nutrition education showed significant positive effects of the price and price plus education intervention on F&V purchases. Moreover, the percentage of participants who consumed recommended amounts of F&Vs increased substantially in the discount groups from baseline to 6 mo, whereas no difference was observed in the nondiscount groups. The largest intervention effects were observed at 6 mo (end of the intervention), and the effects disappeared 3 mo after completion of the intervention period. There were no indications that participants spent the money saved from the discounts on other supermarket items. No effects of the education alone were found.

Despite growing consensus that food-pricing strategies are a promising intervention to increase healthy food purchases, supermarket trials examining such interventions are scarce (13, 19, 50). This study is one of the first real supermarket trials in the world and, to our knowledge, the only study that specifically focuses on F&V price discounts. Results showed that, at 6 mo, the price discount plus education group purchased 5.4 kg more F&Vs for their households for 2 wk than did the control group, which corresponds to 124 g/person per day. Because Dutch people consume, on average, only 198 g of F&Vs/d (51), this would suggest a very relevant increase (52). SHOP, the only other large, long-term real supermarket trial, also studied the effects of price discounts and education (26). This study discounted all healthier foods with 12.5% (one-fourth of our discount magnitude) and found that individuals who received discounts purchased, on average, 7 kg more F&Vs per year (53).

### TABLE 4

Mean differences in expenditures at baseline and at 1 mo for participants in the discount groups ($n = 81$)*

<table>
<thead>
<tr>
<th>Expenditure Type</th>
<th>Mean Difference</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total expenditures (€)</td>
<td>-8.44</td>
<td>-25.5</td>
<td>8.55</td>
</tr>
<tr>
<td>Expenditures on vegetables (€)</td>
<td>2.49</td>
<td>0.88</td>
<td>4.09</td>
</tr>
<tr>
<td>Expenditures on fruit (€)</td>
<td>3.25</td>
<td>1.56</td>
<td>4.94</td>
</tr>
<tr>
<td>Fruit (g)</td>
<td>1816***</td>
<td>858</td>
<td>2774</td>
</tr>
<tr>
<td>Vegetables (g)</td>
<td>1327***</td>
<td>654</td>
<td>2001</td>
</tr>
<tr>
<td>Total other expenditures (€)</td>
<td>-7.67</td>
<td>-21.2</td>
<td>5.84</td>
</tr>
<tr>
<td>Expenditures on other food items (€)</td>
<td>-8.34</td>
<td>-20.9</td>
<td>4.22</td>
</tr>
<tr>
<td>Expenditures on nonfood items (€)</td>
<td>2.09</td>
<td>-2.66</td>
<td>6.84</td>
</tr>
</tbody>
</table>

*Values at 1 mo minus values at baseline were determined by using paired-samples $t$ tests. Outcome measures were measured by cash receipts from the participating supermarkets collected during a 2-wk period. **$P < 0.001$.  
*These expenditures were considered the list price of the fruit and vegetables.
average, 0.5 kg more F&Vs than did those not assigned to receive discounts (one-fourth of our effects) (26).

An important finding, however, is that the fully adjusted models showed significant effects for both discount groups only at 6 mo. The effects were substantially smaller at 3 mo. An explanation for the relatively stronger effects at 1 and 6 mo compared with 3 mo may be that these 2 periods profited from “good start” and “good end” effects. Also, participants knew that the discounts would end after 6 mo and might have wanted to profit more from the final coupons. In addition, the 3-mo measurement occurred in the middle of a strong winter, which restricted individuals’ access to the supermarkets. Nevertheless, supermarket data showed that participants redeemed similar numbers of coupons through time. It is therefore important that future studies examine time effects of food-pricing strategies closely (53). Another relevant note is that we tested multiple (24) comparisons, which increases the type I error rate. However, the differences in F&V purchases in both discount groups compared with the control were substantial in the crude and adjusted models, making us confident that the results are accurate.

The adjusted models showed that the effects were larger in the discount plus education group compared with the discount group only. Therefore, education seems like a good strategy to further increase the effects of food-pricing strategies. However, given the large effects of pricing alone, we would recommend focusing on that strategy when designing future interventions or policy; in particular because, at 9 mo, when the interventions were completed, all effects vanished, ascertaining that the price incentive induced behavior change. Moreover, this finding indicates that the price incentive needs to be sustained to result in continued behavior change. Moreover, the wide use of the discount coupons provides further confidence in the successfulness of the pricing intervention strategy. These findings are in line with earlier work that shows that study participants made frequent use of the provided discount coupons and increased their F&V consumption (40, 54).

An important strength of this study was the use of supermarket cash receipts to measure F&V purchases. An advantage of this method over traditional surveys is that the data are objective, unaffected by recall bias, and largely unaffected by over-representation of occasional purchases or social desirability (55, 56). In addition, the use of cash receipts has been validated and been found to be a sufficient measure of household food purchases (41) and to have strong associations with household nutrient intake (55, 57, 58). We did, however, also measure F&V consumption by a shortened FFQ, which was used to determine changes in the percentage of participants who consumed recommended amounts of F&Vs from baseline to 6 mo. FFQs have been found to be valid for making such classifications (42), and the results offer additional support for the positive price-intervention effects observed with the cash receipts. Moreover, these results showed that not only people who already consumed larger amounts of F&Vs increased their purchases but also those individuals who had lower intakes of F&Vs did so.

Furthermore, it is important to consider that the discount coupons may have driven participants in these particular groups to visit the participating supermarkets more frequently than those in the nondiscount groups. This potential bias was minimized by several elements of the study design (26, 27). First, supermarkets were located in areas with no other supermarkets or F&V stores in the vicinity. In addition, only participants who purchased at least half of their F&Vs in the participating supermarkets were included in this study. Furthermore, the purchased proportion of F&Vs at the participating supermarkets was included in the adjusted models as a covariate. Adding this covariate to the model attenuated the intervention effects in the discount groups considerably. This implies that participants in the nondiscount groups may have traveled to other stores to find good F&V offers there. It would therefore be interesting to find out what the effects of discounts that apply to all possible points of purchase would be.

Cross-price elasticity effects were important to consider because people might spend the money saved from the discounts on other (less healthy) food products (16, 17). Results showed that participants did not spend the money saved from the discounts in other supermarket (food) categories. Likewise, in our virtual supermarket experiments, no major cross-price elasticity effects were observed when only F&Vs were discounted (25), as opposed to a general healthy-food subsidy (17). However, large food-price changes can be expected to have effects in domains outside of the supermarket (eg, eating out, cigarettes). Therefore, further research is needed to capture the effects on overall household expenditures (59, 60).

In contrast with a meta-analysis showing moderate effects of MI on dietary changes (61) our study did not find significant effects of the nutrition education intervention alone. The effectiveness of MI could possibly be increased by a more intensive and long-term intervention. Nevertheless, the sustainability and affordability of such education programs may be a barrier to implementation, especially when it is aimed to reach whole populations (62). Still, the results of the present study showed that nutrition education can be helpful in supporting the effects of food-pricing strategies. Similarly, the feasibility of pricing interventions is important to consider. The 50% price discount used in the present study was relatively high. Nevertheless, earlier studies showed that expert panels were uniformly in favor of stimulating healthy-food purchases by an F&V subsidy (63) and favored subsidizing strategies to stimulate healthy eating (38). Nevertheless, implementation and administrative costs need to be examined (13), and the long-term effects of food-pricing strategies and ultimate health outcomes should be carefully monitored (53).

Our study showed that discount coupons offering a 50% price discount on F&Vs led to a substantial increase in F&V purchases. The effects added up to an average additional purchase of 124 g/person per day when combined with nutrition education. Although nutrition education increased the effects of the pricing intervention slightly, there were no effects of education alone. The effects of pricing alone were substantial in all models. Moreover, we found a considerable increase in the percentage of participants who consumed sufficient F&Vs in the groups receiving the price discounts. Therefore, we would recommend focusing on pricing strategies when designing future interventions or policy. Future research is imperative to unravel the long-term effects of pricing strategies as well as the ultimate health outcomes.

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The authors’ responsibilities were as follows—WEW: designed and conducted the research, analyzed the data, and wrote the manuscript; MRdB: performed the statistical analysis and wrote the manuscript; and AJS, ICS, and IHMS: designed the research and wrote the manuscript. None of the authors had any conflicts of interest.

REFERENCES


