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Introducing taxes, subsidies or both: The effects of various food pricing strategies in a web-based supermarket randomized trial

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ABSTRACT

Objective. Fiscal policies may form a solution in improving dietary intake. This study aimed to examine the effectiveness of varying taxing and subsiding schemes to stimulate healthier food purchases.

Methods. A randomized controlled trial with three levels of price reduction on healthy foods (no; 25%; 50%) × three levels of price increase on unhealthy foods (5%; 10%; 25%) factorial design was used. 150 participants were randomized into one of nine conditions and were asked to purchase groceries at a web-based supermarket. Data were collected in the Netherlands in January–February 2010 and analyzed using analysis of covariance.

Results. Subjects receiving 50% discount purchased significantly more healthy foods than subjects receiving no (mean difference = 6.62 items, $p<0.01$) or 25% discount (mean difference = 4.87 items, $p<0.05$). Moreover, these subjects purchased more vegetables (mean difference = 821 g; $p<0.05$ compared to no discount). However, participants with the highest discount also purchased significantly more calories. No significant effects of the price increases on unhealthy foods were found.

Conclusion. Price decreases are effective in stimulating healthy food purchases, but the proportion of healthy foods remains unaffected. Price increases up to 25% on unhealthier products do not significantly affect food purchases. Future studies are important to validate these results in real supermarkets and across different countries.

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Introduction

Overconsumption and excessive intakes of sugar and saturated fats contribute largely to the growing prevalence of non-communicable diseases including cardiovascular disease, type-2 diabetes and obesity (Joint WHO/FAO Expert Consultation, 2003; Schmidhuber and Traill, 2006; World Health Organization, 2009). Fiscal policies form one solution in improving dietary intake (Caraher and Cowburn, 2005; Finkelstein et al., 2004; Leicester and Windmeijer, 2004; Waterlander et al., 2010a). Broadly, three types of strategies can be considered: 1) increasing unhealthy food prices, 2) lowering healthy food prices, and 3) a combination of both.

With respect to taxes on high-calorie foods there is evidence from two experimental studies showing that these are effective in lowering calorie purchases (Epstein et al., 2010; Giesen et al., 2011a). However, both studies were limited to a restricted food selection making it hard to extrapolate the conclusions into broader food environments. Recently, Nederkoorn and colleagues published a comparable study using a web-based supermarket. They found that a calorie tax was effective in decreasing the purchase of high energy-dense products, but not in decreasing calories from fat. Moreover, they found that people tended to replace more expensive energy-dense products with cheaper alternatives (Nederkoorn et al., 2011). Also Mytton and colleagues found that reactions to price increases were not linear by showing that fruit purchases tended to fall as a result of taxation on milk and cream (Mytton et al., 2007). These complex reactions to pricing measures may have important implications for public health outcomes (Mytton, et al., 2007; Tiffin and Arnoult, 2011).

Similar concerns apply to thin subsidies (lowering the price of healthier products). To date only a couple of experimental studies examining these types of strategies in retail environments are available, including a New Zealand supermarket trial (Ni Mhurchu et al., 2010) and a Dutch trial in a computerized retail environment (Waterlander et al., 2012). Both studies found that the reduced prices of healthier

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Fig. 1. Impression of the 3-D web-based supermarket, The Netherlands 2010.

foods led to higher purchases of these products. Recently, Andreyeva and colleagues published a review on the price elasticity[1] of food. They concluded that food is elastic and that the highest price elasticity was found for food away from home, soft drinks, juice, meats, and fruit (Andreyeva et al., 2010). These results show that thin subsidies are promising to stimulate healthier food purchases. Nevertheless, studies also reported that discounting healthy foods leads to more calorie purchases (Epstein et al., 2010) or is counterproductive because consumers used the saved money to buy unhealthier products (Giesen et al., 2011b).

Previous studies show that both taxing and subsidizing strategies have positive (e.g., more healthy food purchases), but also potentially negative side effects (e.g., more calories, lower fruit purchases). Therefore, the best suggestion may be to combine both strategies (Ni Mhurchu, 2010; Nnoaham et al., 2009; Powell and Chaloupka, 2009). Therefore, this study aimed to examine both single and combined effects of lowering the prices of healthier foods and (simultaneously) increasing the prices of unhealthier foods on food purchases. It is hypothesized that the most favorable nutrient purchases will be found when combining the greatest discounts on healthier foods with the greatest tax increase on unhealthier foods.

Methods

The 3-D web-based supermarket

This study used a unique 3-D web-based supermarket (Fig. 1). The main features are described below; additional information can be found elsewhere (Waterlander et al., 2011).

The web-based supermarket was designed in the image of an existent branch of the Dutch market leader supermarket. Photographs of genuine products were used to compose product images and prices were made available through shelf labeling. Food prices were based on the prices of the two Dutch market leaders, and the stock was also based on an existing supermarket. It was decided to create a representative product selection based on the 38 different food categories as used on the website of the market leader supermarket (Albert Heijn Online Shop, 2010). Within each product category, a sample representing around 10% of the regular assortment was selected by choosing popular and frequently consumed products. In total, the web-based supermarket contained 512 different food products modeling the actual distribution of store products and categories (Table 1). The stock did not take in specific brands or different package sizes.

Study design

A randomized controlled trial with three levels of price reduction on healthy foods and three levels of price increases on unhealthy foods was conducted. Participants were randomly assigned to one of nine conditions by using the Random Number Generator in Excel by three research assistants who were blinded with regard to the contents of each condition. Discount levels were: no discount; 25%; and 50%; and price increases were: 5%; 10%; and 25% (Fig. 2). This design was chosen to enable studying the effects of smaller and larger price changes, thereby expanding the results of previous experimental (French, 2003) and economic modeling studies (Nnoaham et al., 2009). Price increases were kept relatively low, because these have been suggested to be more feasible to implement (Waterlander et al., 2010a). Discount levels up to 50% do seem to be practicable (Waterlander et al., 2010a) and are frequently used by retailers. The base condition was set on no discount on healthier foods combined with a 5% price increase on unhealthier foods; which could basically be seen as a control condition.

In determining experimental price levels (e.g., in distinguishing healthy and unhealthy products) product criteria of the Choices front of pack nutrition logo were used (Roodenburg et al., 2011). These criteria are based on the international World Health Organization (WHO) recommendations regarding saturated fat, trans fat, sodium, and added sugar (Dotsch-Klerk and Jansen, 2008). The criteria are set separately for different food categories, where the criteria for non-basic foods are generally stricter than for basic foods. All products in the web-based supermarket were judged against these criteria and, if they complied, they were eligible for price reduction. Prices of products not meeting the criteria were increased (Table 1).

Participants and recruitment

A sample size was determined using delta-values as effect size. Delta-values are denoted by the difference between the smallest and the largest means, in units of the within-cell standard deviation. Values of delta = 0.25, 0.75 and

[1] Price elasticity of demand is defined as the percentage change in the quantity demanded in response to a given percentage change in price, at a particular point in the demand curve (Perloff, 2007).

Table 1
Number of healthy food products within the 38 food categories in the web-based supermarket, the Netherlands (2008–2009).

	Food category	Total products (n)	Healthy products (n)[a]
1	Potatoes and potato products	10	7
2	Fruits	10	10
3	Vegetables	41	41
4	Ready to eat meals	19	4
5	Meat/fish/poultry[b]	29	13
6	Meat products[b]	18	4
7	Salads (e.g., crab salad, egg salad, etc.)	8	3
8	Appetizers/snacks	6	1
9	Cheese	19	3
10	Dairy drinks (e.g., milk, yogurt drink, etc.)[b]	15	8
11	Desserts[b]	21	4
12	(Whipped) cream	5	–
13	Butter	6	2
14	Eggs	2	–
15	Bread[b]	15	6
16	Pastry	14	4
17	Snacks/refreshments	12	3
18	Frozen snacks	10	–
19	Ice (cream)	8	1
20	Frozen pastry	2	–
21	Coffee	7	–
22	Evaporated milk/sugar/sweeteners	9	2
23	Baking products	13	4
24	Sweet sandwich fillings[b]	10	3
25	Breakfast products	13	6
26	Pasta/rice/noodles[b]	12	4
27	Mixes for sauces	12	1
28	Seasonings	9	1
29	Herbs and spices	10	–
30	Oils/sauces and pickles	26	9
31	Soups	12	2
32	Canned foods (excluding fruits and vegetables)	10	3
33	Beverages (excluding soda)	6	3
34	Soda[b]	24	14
35	Alcoholic beverages	19	–
36	Candy	14	3
37	Chocolate	20	–
38	Crisps/nuts/toast	16	3
	Total	512	172 (33.6%)

[a] Healthy products are defined following the Choices front-of-pack nutrition label criteria which are based on the international WHO recommendations regarding saturated fat, trans fat, sodium, and added sugar (Roodenburg, et al., 2011).
[b] These product categories were selected for *within* category analyses.

Table 2
Participant characteristics, The Netherlands (2010).

		Total n = 117 n (%)	p[a]
Sex	Female	100 (85.5)	0.81
Age	18–31	13 (11.1)	0.85
	32–46	34 (29.1)	
	47–61	52 (44.4)	
	62+	18 (15.4)	
Grocery responsibility	Totally responsible	74 (63.2)	0.80
	Largely responsible	24 (20.5)	
	Partly responsible	19 (16.2)	
Education level	Low (primary/lower secondary)	21 (17.9)	0.75
	Medium (higher secondary/ intermediate vocational)	66 (56.4)	
	High (high vocational/University)	30 (25.7)	
Employment status	Employed	55 (47.0)	0.66
	Other	62 (53.0)	
Household income (€ gross monthly)[b]	Low (0–2000)	23 (19.7)	0.88
	Medium (2000–3000)	31 (26.5)	
	High (3000+)	63 (53.8)	
Household weekly food expenditures (€)	20–60	36 (30.8)	0.39
	60–100	65 (55.6)	
	100+	16 (13.6)	
Household size		Mean (SD) 2.9 (1.5)	0.53
Price perception [c]		63.3 (11.9)	0.72
Habit score [d]		52.5 (10.1)	0.27
Appreciation score Virtual Supermarket [e]		58.8 (8.6)	0.36
Attention to prices in Virtual Supermarket [f]		17.4 (6.8)	0.92
Budget in virtual supermarket		72.4 (24.6)	0.41
% of budget spent		93.0 (12.3)	0.08

Data were measured in January–February 2010 in the Netherlands. Participants included a community sample (n = 117).
[a] Indicates the p-value for chi^2 tests and ANOVA analysis comparing the nine research conditions.
[b] The standard gross monthly income in the Netherlands (2010) was € 2508 (Central Planning Office (Centraal Planbureau (CPB)), 2010).
[c] Measured by fifteen items on a 7-point Likert scale (min = 15; max = 105) from the seven "price perception construct scale items" (Lichtenstein et al., 1993).
[d] Measured by twelve items on a 7-point Likert scale (min = 12; max = 84) self-report index of habit strength (Verplanken et al., 2003).
[e] Measured by eleven items on a 7-point Likert scale (min = 11; max = 77) on the Virtual Supermarket software.
[f] Measured by four items on a 7-point Likert scale concerning attention to prices in the Virtual Supermarket (min = 4; max = 28).

≥1.25 correspond to small, medium and large effect sizes respectively (Cohen, 1988). For this study it was determined that a sample size of n = 108 would be sufficient to demonstrate an effect size of 0.50 (level of significance 0.05, power >0.90, fixed effects, equal sizes in all treatment cells assumed).

The study was conducted in the Netherlands. Participants were recruited as part of a broader range of studies by using newspapers in October–November 2009. n = 658 people signed up and were checked for eligibility (Fig. 2). For this study, the main interest was in participants with a lower socio-economic status (SES) since they have the largest burden of diet-related disease and financial barriers in taking up a healthy diet mainly applies to them (Darmon and Drewnowski, 2008; Steenhuis et al., 2011; Waterlander et al., 2010b). Because Dutch people are reluctant in providing their income, inclusion criteria were set on having completed a medium secondary vocational education or lower and/or being unemployed. Furthermore, participants had to be ≥18 years, speaking the Dutch language, and running their own household. Participants were not aware of the research aims and were blinded with regard to assignment of the research conditions. The study procedures were in accordance with the standards of the institutional medical ethical committee.

Procedure

Participants were sent a USB-device with the web-based supermarket software, instructions and a personal log-in code by post. Every participant was asked to conduct a typical shop for their household for one week. The shopping procedure was experimental and participants did not receive their groceries for real. After logging on to the application, participants were asked about their household composition which was used to allocate a specific shopping budget. Next, participants were able to walk around the web-based supermarket and purchase products by a single mouse click. Also, participants could obtain nutritional information about each product; see also Waterlander et al. (2011). When they finished shopping, participants moved to the cash register and, if the budget was not exceeded, they were directed to a closing questionnaire.

Measures

Main outcome measures were purchases of healthy and unhealthy food items (number and percentage); fruit and vegetables (gram); healthy products outside fruits and vegetables (number and percentage); budget spending and calories. As secondary outcome measure we calculated the proportion of healthier products purchased within specific product categories (Table 1). In addition, some background variables were assessed (Table 2). Finally, participants were asked to complete several questionnaires after shopping by assessing price perception (Lichtenstein et al., 1993); habit strength (Verplanken and Orbell, 2003); understanding and rewarding of the web-based supermarket and notice of prices (Table 2). Answers were all measured on a 7-point Likert Scale, and total scores were calculated from summing up the individual items.

Table 3
Purchased amounts of (un)healthier food items within the nine research conditions, the Netherlands (2010)[a].

Item		5% increase		10% increase		25% increase		Total per discount	
		Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Healthy food items (n)	No discount	23.9	(7.0)	23.8	(5.7)	26.2	(8.1)	**24.6**	(**6.9**)
	25% discount	29.4	(12.1)	24.9	(9.7)	27.7	(10.4)	**27.2**	(**10.6**)
	50% discount	30.4	(11.9)	33.5	(9.0)	32.3	(15.0)	**32.0**	(**11.9**)
	Total per price increase	**27.9**	(**10.7**)	**27.3**	(**9.3**)	**28.6**	(**11.4**)	–	–
Unhealthy food items (n)	No discount	23.8	(10.9)	22.7	(12.7)	20.8	(9.5)	**22.4**	(**10.9**)
	25% discount	24.9	(12.1)	22.9	(11.5)	26.5	(11.6)	**24.7**	(**11.5**)
	50% discount	32.1	(14.3)	24.6	(9.0)	25.4	(8.8)	**27.5**	(**11.4**)
	Total per price increase	**27.1**	(**12.8**)	**23.4**	(**10.9**)	**24.2**	(**10.1**)	–	–
Total products (n)	No discount	47.7	(16.0)	46.4	(16.0)	47.0	(9.6)	**47.1**	(**13.8**)
	25% discount	54.3	(23.1)	47.8	(18.0)	54.2	(18.1)	**51.8**	(**19.4**)
	50% discount	62.5	(20.2)	58.1	(12.4)	57.8	(9.7)	**59.6**	(**18.3**)
	Total per price increase	**55.1**	(**20.4**)	**50.7**	(**16.2**)	**52.8**	(**17.4**)	–	–
Healthy excl. food items (n)[b]	No discount	14.8	(6.8)	13.9	(3.8)	16.8	(6.4)	**15.2**	(**5.8**)
	25% discount	19.3	(8.3)	15.6	(6.4)	18.5	(7.1)	**17.2**	(**7.3**)
	50% discount	19.9	(9.5)	21.6	(6.6)	19.8	(9.7)	**20.4**	(**8.5**)
	Total per price increase	**18.1**	(**8.4**)	**17.1**	(**6.6**)	**18.3**	(**7.7**)	–	–
Purchased calories (kcal)	No discount	34,936	(16,467)	38,091	(16,611)	38,027	(10,645)	**36,990**	(**14,456**)
	25% discount	43,874	(20,358)	38,328	(15,692)	46,913	(21,338)	**42,782**	(**18,949**)
	50% discount	52,805	(18,255)	47,835	(13,180)	47,081	(18,741)	**49,387**	(**16,654**)
	Total per price increase	**44,101**	(**19,398**)	**41,347**	(**15,507**)	**43,926**	(**17,533**)	–	–
Vegetables (gram)	No discount	3682	(1021)	3433	(1268)	3771	(1765)	**3634**	(**1359**)
	25% discount	3625	(1977)	3353	(1363)	4196	(2236)	**3708**	(**1854**)
	50% discount	4491	(1481)	4646	(1470)	4853	(2561)	**4654**	(**1831**)
	Total per price increase	**3955**	(**1542**)	**3797**	(**1463**)	**4258**	(**2187**)	–	–
Fruit (gram)	No discount	2308	(1066)	2583	(907)	2748	(1940)	**2545**	(**1367**)
	25% discount	2685	(1775)	2200	(1536)	1692	(1575)	**2181**	(**1630**)
	50% discount	2654	(1314)	3442	(1225)	3396	(2535)	**3145**	(**1750**)
	Total per price increase	**2548**	(**1375**)	**2719**	(**1351**)	**2591**	(**2107**)	–	–
% of budget spent	No discount	97.2	(4.9)	96.4	(4.9)	95.0	(10.8)	**96.2**	(**7.3**)
	25% discount	88.6	(22.2)	94.3	(9.8)	95.2	(4.9)	**92.9**	(**13.7**)
	50% discount	83.3	(18.4)	94.6	(7.3)	92.8	(11.5)	**90.0**	(**14.1**)
	Total per price increase	**89.5**	(**17.3**)	**95.0**	(**7.7**)	**94.4**	(**9.3**)	–	–
Total expenditures (€)	No discount	65.9	(18.0)	66.0	(23.2)	70.0	(13.7)	**67.3**	(**18.2**)
	25% discount	66.5	(29.2)	58.3	(20.8)	69.6	(20.5)	**64.4**	(**23.5**)
	50% discount	67.1	(24.4)	62.8	(13.7)	69.2	(24.2)	**66.3**	(**21.0**)
	Total per price increase	**66.5**	(**23.3**)	**62.1**	(**19.4**)	**69.6**	(**19.3**)	–	–

Data were measured in January–February 2010 in the Netherlands. Participants included a community sample (n = 117).
[a] Crude effects.
[b] Healthy excl. means amount of healthy products excluding fruits and vegetables.

Statistical analysis

First, outcome measures were tested for an adequately normal distribution. Second, mean values for the main outcome measures were analyzed. Next, mean differences (B) between conditions were tested using two-way factorial ANCOVA, where factor 1 indicated the level of discount and level 2 the level of price increase. Analysis were conducted by including standard factors (e.g., sex, education level, spending budget (low/high) and grocery responsibility) and theoretically expected strong predictors of the outcomes (e.g., score on price perception, habit strength, appreciation of the web-based supermarket and notice of prices) in the model. These covariates were included because they explained a major part of the error variance and enlarged the power of the model. For each outcome measure it was then tested whether the interaction between the level of discount and price increase was significant, whereby the level of significance was set at 0.10. Non-significant interaction terms were then removed from the model. For significant interaction terms it was planned to present the results separately for every discount and price increase combination. Analyses were conducted using SPSS statistical software (version 17.00, SPSS Inc, Chicago, IL).

Results

Participant characteristics

n = 125 (83%) participants completed the study. Compared to the final study sample, non-responders were older (Δ = 7.42 years) and had a smaller household size (Δ = 0.82 persons). From this sample, participants who were barely responsible for groceries in real life (n = 1) or with a low appreciation score of the Virtual Supermarket (n = 6) were excluded. A low appreciation score was set on the fifth percentile, which included participants with a score ≤42 (range = 27–77; mean = 58, SD = 9.6). Also, n = 1 person was excluded due to missing data. The final study sample included n = 117 participants (Fig. 3; Table 2).

Understanding and appreciation of the 3-D web-based supermarket

Ninety-one percent of the participants scored ≥5 (1 = lowest; 7 = highest) on comprehension of the software. Furthermore, 85% scored ≥5 on the question asking whether their experimental groceries corresponded with their regular groceries and 94% scored ≥5 on the question asking whether the products in the web-based supermarket were good and recognizable.

Description of differences in food purchases

Participants with the highest discount on healthier foods purchased the most products within this category (32.0 items), compared to the other discount conditions (27.2 and 24.6 items respectively) and also purchased the most fruits and vegetables. However, this group also purchased the highest number of calories. This was especially apparent in the conditions with the lowest price increase on unhealthier foods (Table 3).

Table 4a
Effects of varying price *discount* levels on food purchases in the web-based supermarket, The Netherlands (2010)[a].

Discount		Level 1 = No			Level 2 = 25%			Level 3 = 50%		
	Ref. level	B[c]	Lower 95% CI	Upper 95% CI	B	Lower 95% CI	Upper 95% CI	B	Lower 95% CI	Upper 95% CI
No. of unhealthy food	1	–	–	–	1.75	−2.06	5.55	3.78‡	−0.12	7.68
	3	−3.78‡	−7.68	0.12	−2.03	−5.91	1.84	–	–	–
No. of healthy food	1	–	–	–	1.75	−2.30	5.80	6.62**	2.47	10.78
	3	−6.62**	−10.78	−2.47	−4.87*	−9.00	−0.75	–	–	–
Total items	1	–	–	–	3.50	−2.32	9.31	10.40**	4.44	16.37
	3	−10.40**	−16.37	−4.44	−6.91*	−12.83	−0.99	–	–	–
No. of healthy food excl.[b]	1	–	–	–	1.87	−1.08	4.82	4.94**	1.91	7.96
	3	−4.94**	−7.69	−1.91	−3.07*	−6.07	−0.06	–	–	–
Purchased calories (kcal)	1	–	–	–	4669	−1305	10,642	10,505**	4376	16,635
	3	−10,505**	−16,635	−4376	−5836	−11,920	247	–	–	–
% of healthy food	1	–	–	–	−1.07	−6.09	3.94	0.59	−4.55	5.74
	3	−0.59	−5.74	4.55	−1.66	−6.77	3.44	–	–	–
% of healthy food excl.[b]	1	–	–	–	1.02	−2.83	4.87	2.04	−1.92	5.99
	3	−2.04	−5.99	1.92	−1.01	−4.94	2.91	–	–	–
Vegetables (gram)	1	–	–	–	52.0	−665	769	821*	85.1	1556
	3	−821*	−1556	−85.1	−768 *	−1498	38.2	–	–	–
Fruit (gram)	1	–	–	–	−382	−1105	341	420	−322	1163
	3	−420	−1163	322	−803*	−1539	−66.4	–	–	–
% of budget spent	1	–	–	–	−3.67	−8.95	1.60	−5.20‡	−10.61	0.22
	3	5.20‡	−0.22	10.61	1.52	−3.85	6.90	–	–	–

Data were measured in January–February 2010 in the Netherlands. Participants included a community sample (n = 117).
[a] Adjusted effects for two-way factorial ANCOVA analyses. Adjusted for: sex, education level, spending budget (low/high), grocery responsibility, price perception, habit strength, appreciation of the web-based supermarket and notice of prices.
[b] Healthy excl. means amount of healthy products excluding fruits and vegetables.
[c] B = mean difference between groups.
‡ Borderline significant at p = 0.06.
* Significant at p < 0.05.
** Significant at p < 0.01.

Effects of price discount × price increase

There were no significant interactions between price increase and discount level for any outcome measure. This means that the effects of the discounts were irrespective of price increase level and vice versa. This could however be due to our small sample size. Interaction terms were therefore removed from the model, and results of the ANCOVA will be presented at discount and price increase levels separately.

Effects of the discounts

Participants with a 50% discount purchased significantly more healthy foods than participants with no discount (Δ = 6.62, p = 0.002) or a 25% discount (Δ = 4.87, p = 0.02) (Table 4a). Furthermore, participants with a 50% discount purchased 821 g more vegetables for their household for a week (p = 0.03) compared to no discount and 768 g more compared to the 25% discount conditions (p = 0.04). However, participants in the highest discount condition

Table 4b
Effects of varying price *increase* levels on food purchases in the web-based supermarket, The Netherlands (2010)[a].

Price increase		Level 1 = 5%			Level 2 = 10%			Level 3 = 25%		
	Ref. level	B[c]	Lower 95% CI	Upper 95% CI	B	Lower 95% CI	Upper 95% CI	B	Lower 95% CI	Upper 95% CI
No. of unhealthy food	1	–	–	–	−1.66	−5.47	2.15	−1.99	−5.82	1.85
	3	1.99	−1.85	5.82	0.33	−3.51	4.17	–	–	–
No. of healthy food	1	–	–	–	0.48	−3.58	4.54	1.03	−3.05	5.11
	3	−1.03	−5.11	3.05	−.55	−4.63	3.54	–	–	–
Total items	1	–	–	–	−1.18	−7.00	4.65	−0.96	−6.82	4.90
	3	0.96	−4.90	6.82	−0.22	−6.08	5.65	–	–	–
No. of healthy food excl.[b]	1	–	–	–	−0.42	−3.38	2.53	0.45	−2.53	3.42
	3	−0.45	−3.42	2.53	−0.87	−3.85	2.10	–	–	–
Purchased calories (kcal)	1	–	–	–	313	−5676	6302	816	−5209	6841
	3	−816	−6841	5209	−503	−6530	5524	–	–	–
% of healthy food	1	–	–	–	2.17	−2.85	7.20	1.93	−3.12	6.99
	3	−1.93	−6.99	3.12	0.24	−4.82	5.30	–	–	–
% of healthy food excl.[b]	1	–	–	–	0.74	−3.12	4.60	1.89	−2.00	5.77
	3	−1.89	−5.77	2.00	−1.15	−5.04	2.74	–	–	–
Vegetables (gram)	1	–	–	–	121	−598	840	368	−355	1091
	3	−368	−1091	355	−247	−970	477	–	–	–
Fruit (gram)	1	–	–	–	304	−421	1029	83.2	−646	813
	3	−83.2	−813	646	221	−508	951	–	–	–
% of budget spent	1	–	–	–	4.43	−.86	9.72	4.21	−1.11	9.53
	3	−4.21	−9.53	1.11	0.23	−5.10	5.55	–	–	–

Data were measured in January–February 2010 in the Netherlands. Participants included a community sample (n = 117).
[a] Adjusted effects for two-way factorial ANCOVA analyses. Adjusted for: sex, education level, spending budget (low/high), grocery responsibility, price perception, habit strength, appreciation of the web-based supermarket and notice of prices.
[b] Healthy excl. means amount of healthy products excluding fruits and vegetables.
[c] B = mean difference between groups.

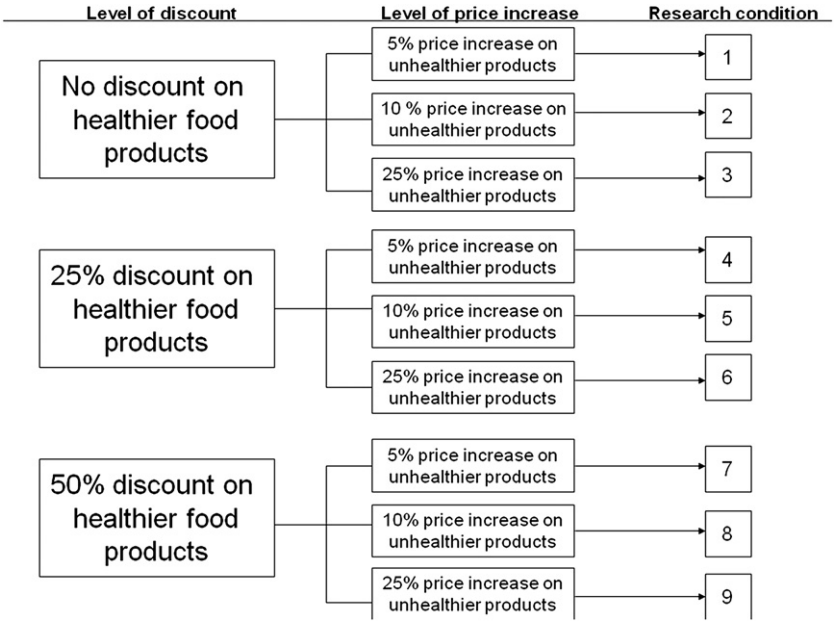

Fig. 2. Study design, The Netherlands 2010.

also purchased significantly more items in total (Δ = 10.40, p = 0.001) compared to no discount, and significantly more calories (Δ = 10,505 kcal, p = 0.001) compared to no discount. The discounts had no statistically significant effects on the proportion of healthier products purchased within each of the eight most popular food categories (Table 1 and Table A.1), but effects were generally in the same direction as for the overall analyses.

Effects of the price increases

Participants with higher taxes purchased somewhat fewer unhealthy food items than participants presented with a lower tax, but this was not statistically significant. Furthermore, the price increases did not significantly limit the total number of products or calories bought (Table 4b). Within specific food categories, including soda, dairy drinks, or desserts, no significant effects of the price increases on unhealthier food purchases were found either (Table A.2). The only statistically significant effect was observed within the category 'meat products' where participants in the 10% price increase group purchased a higher percentage of healthier products compared to the 5% price increase group (Table A.2).

Discussion

This study examined the effects of varying combinations of price increases on unhealthy products and price discounts on healthy products on food purchases. Results indicate that higher discount levels were associated with higher purchases of fruit and vegetables

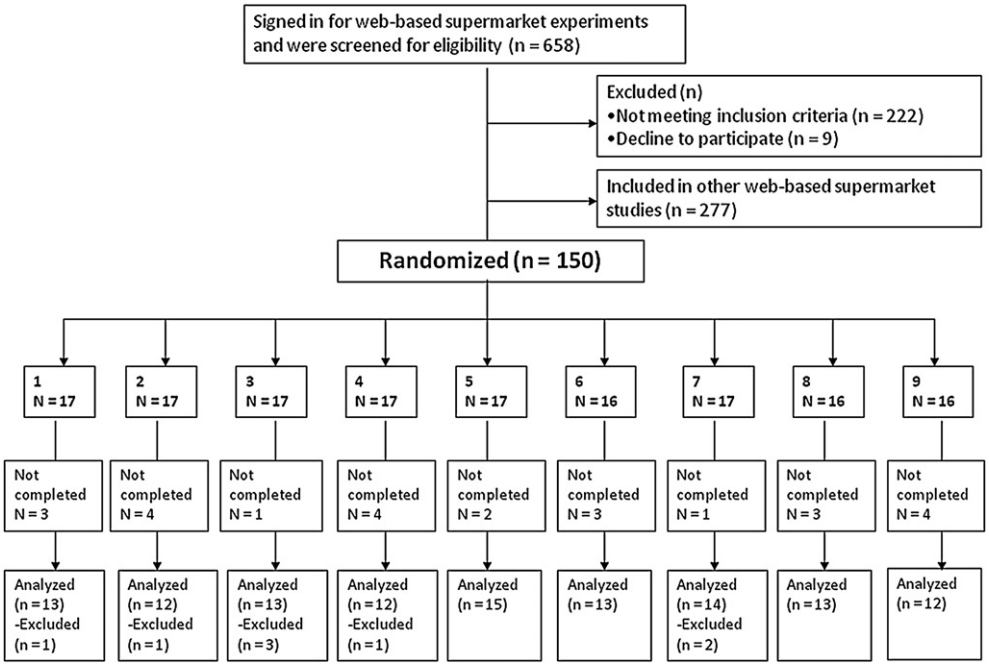

Fig. 3. CONSORT flow diagram, The Netherlands 2010.

and a higher number of healthy foods overall. However, the discounts also lead to a higher *total* number of items purchased, meaning that the proportion of healthy products was not higher. Furthermore, higher price discounts were associated with a higher number of calories purchased. The effects of the discounts were found on the product range in general and not within specific food categories including meat products, bread or soda. There were no significant effects of price increases. Also, the rise in total food items purchased due to the discounts was not significantly balanced by the price increases. The results apply specifically to the Dutch situation and the generalizability to other settings is unknown.

To our knowledge, this is the first study examining both separate and simultaneous effects of multiple price discounts and price increases in a retail environment. Different authors have emphasized the importance of such studies (Andreyeva, et al., 2010; Ni Mhurchu, 2010). Results revealed that the effects of price changes are multifaceted. Firstly, it was found that discounts are effective in stimulating healthy food purchases in general and also specifically in stimulating fruit and vegetable purchases. At the 50% discount level an average increase of 821 g in vegetable and 420 g in fruit purchases was found as compared to the no discount level. This indicates a difference of 40 g and 21 g per person per day respectively. As the Dutch Food Consumption Survey showed that people consumed on average 121 g of vegetables and 77 g of fruit per day (van Rossum et al., 2011), this would implicate a major shift in fruit and vegetable purchases which seem very relevant for public health.

Secondly, however, it was found that the discounts also led to higher food purchases in total and to higher calorie purchases. Therefore, the proportion of healthy foods was not higher due to the discounts. These results are in line with a laboratory experiment by Epstein et al. (2010) and a simulation modeling study on the effects of tax reforms designed to increase whole grain consumption (Nordstrom and Thunstrom, 2009). One suggested solution is combining lower prices of healthier products with tax increases on unhealthier food products (Nordstrom and Thunstrom, 2009).

Epstein found that a price increase of high-caloric foods was effective in decreasing the purchase of these items while increasing the purchase of low-caloric foods. Giessen and colleagues also concluded that a >25% tax rise on high-caloric foods is effective in decreasing the demand for calories (Giesen et al., 2011a, 2011b). The current study, however, does not provide support for increasing unhealthier food prices. In addition, results of the study could not confirm the hypothesis that discounts on healthier food products are most effective when supported by price increases of unhealthier products, nor that higher energy purchases may be prevented using such a combination of strategies. Nordström et al. found similar results in a simulation modeling study where the increase in fat consumption remained prevalent in simulations combining a subsidizing measure with a tax on unhealthier products (Nordstrom and Thunstrom, 2011). Nevertheless, the current study found that price increases lowered the amount of unhealthy food purchases to some extent. The absence of significant interaction effects may be due to a power problem; our sample size was not specifically powered for these interaction effects. Moreover, our power calculations were based on quite large effect sizes, meaning that our sample size was likely too small to detect smaller effects of the price increases. It is therefore important to study the combined effects of taxes and subsidies further in larger populations. Moreover, the price increase levels in this study were relatively low whereas the price discounts ran up to 50%. We opted for these levels based on the results of a previously conducted Delphi study where it was found that subsidies are more politically feasible than taxes (Waterlander et al., 2010a). Nevertheless, higher tax increases can be feasible when considering the revenue they bring, especially given the current budget deficits many governments are facing. We therefore propose that increased taxes on unhealthier food products could be effective when they are high and prevent shifting to cheaper (unhealthier) alternatives.

Another important aspect to consider is that our results may be an underestimation of price strategies in practice, because the pricing strategies were silent. Normally, when products are sold at lower prices, effort is made in drawing people's attention toward this by using signs or advertisements (Anderson and Simester, 1998; Blattberg et al., 1995). This may apply to price increases; it may be more important to tell people that products are taxed than to actually tax it (Lacaniloa et al., 2011). This discussion is referred to as 'tax salience' in the economic literature; in which salience has indeed been found to have large effects on behavioral responses on tax changes (Chetty et al., 2009). Nevertheless, the evidence is currently limited to theoretical analysis (Chetty et al., 2009) and experimental studies are needed to gain insight into this topic. The web-based supermarket could be a useful tool in conducting such experiments and in finding out how taxing schemes should best be addressed to consumers.

Alongside the effectiveness of price manipulations, it is of importance to consider practical issues as well. A recent study found that an expert panel was uniformly in favor of a subsidy on fruits and vegetables, which is promising (Faulkner et al., 2011). Nevertheless, the discounts in the current study were found to be most effective in stimulating healthy food purchases when these were set at 50%. Such high levels of price change may not be realistic and there seems to be little consensus on who should pay for that (McLaughlin, 2004; Waterlander et al., 2010a). One potential solution lies in designing subsidizing schemes specifically targeting the lower socio-economic groups (who are most in need for such interventions), for example by providing discount coupons within food assistance programs. A focus at specific target groups is also relevant with regard to the distributional effects of food pricing strategies. A population wide fiscal policy could worsen economic inequality wherefore strategies that target specific vulnerable populations are more appropriate (Tiffin and Salois, 2011).

A merit of this study is the use of the 3-D web-based supermarket which closely images a real shopping experience. Still, the assortment is not as extensive as a real supermarket. Also, this supermarket does not provide insight into how people may shift to non-food items as a consequence of the price changes. The results do not give insight into effects at other points of purchase settings. Nevertheless, people buy most of their food at supermarkets (Main Trading Organisation Retail Trade, 2011) which thus seems the most obvious environment for interventions (Hawkes, 2008; Vorley, 2003). Another limitation is that people may behave differently in an authentic shopping situation, involving real money. However, a large majority of the participants stated that their web-based purchases resembled their regular food purchases accurately. Moreover, there is evidence showing that peoples' virtual behavior images their actual behavior very well (Sharpe et al., 2008). Finally, compared to previous studies where a supermarket environment was modeled using 60 products (Epstein et al., 2010) or using online drop-down lists (Nederkoorn et al., 2011), our application is regarded as a high-quality research instrument. Nevertheless, it remains important to validate the results in a real shopping environment. Another limitation is that the price changes in our study applied to a wide product range (healthy versus unhealthy). At this time, various governments are considering more specific strategies such as a fat tax or a tax on sugar sweetened beverages. Our results do not provide insight into the effects of such specific measures. Finally, it should be mentioned that our study population had a relatively high income level and also that it is unknown whether our results are generalizable outside the Dutch setting. Future research is warranted to validate our results in real supermarkets and among different populations.

Conclusion

This study provides new evidence into the effectiveness of varying price discounts and price increase schemes on food purchases within a Dutch web-based supermarket. Results revealed that decreasing healthy food prices is effective in stimulating the purchase of these products. However, these manipulations also resulted in higher food and calorie purchases overall. This effect was not equilibrated by supplementing the price decreases with taxing unhealthier foods up to 25%. Also, these increased taxes did not significantly discourage unhealthier food purchases. This implicates that the studied pricing strategies do not improve overall diet quality. Future research is required to examine the effects of the studied pricing strategies outside the Dutch situation.

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Conflicts of interest
The authors declare that there are no conflicts of interest.

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