British Food Journal

Food taxes and calories purchased in the virtual supermarket: a preliminary study

Maartje Poelman, Willemieke Kroeze, Wilma Waterlander, Michiel de Boer, Ingrid Steenhuis,

Food taxes and calories purchased in the virtual supermarket: a preliminary study

Maartje Poelman
Universiteit Utrecht, Utrecht, The Netherlands
Willemieke Kroeze
Vrije Universiteit Amsterdam, Amsterdam, The Netherlands
Wilma Waterlander
National Institute for Health Innovation, University of Auckland, Auckland, New Zealand, and
Michiel de Boer and Ingrid Steenhuis
Vrije Universiteit Amsterdam, Amsterdam, The Netherlands

Received 25 August 2016
Revised 12 March 2017
Accepted 13 March 2017

Abstract

Purpose – The purpose of this paper is to examine the effectiveness of three food taxation schemes on energy (kcal), saturated fat (gram) and sugar (gram) purchased in the virtual supermarket.

Design/methodology/approach – Based on the literature, three food taxation schemes were developed (sugar tax, saturated fat tax and a nutrient profiling tax) and implemented in the three-dimensional virtual supermarket. A randomized control trial was conducted to determine the differences in the amount of energy (kcal), saturated fat (gram) and sugar (gram) purchased for a one-week food basket.

Findings – In total, 191 Dutch adults were randomly assigned to a sugar-tax condition ($n = 48$), a saturated fat-tax condition ($n = 37$), a nutrient profiling-tax condition ($n = 62$) and a control (no-tax) condition ($n = 44$). Fully adjusted models indicated that compared to the no-tax condition, no significant effects of a sugar-tax condition (B: −2,041 kcal (95% CI −5,350 to 1,914)), saturated fat-tax condition (B: −2,717 kcal (95% CI −6,596 to 1,163)) or nutrient profiling-tax condition (B: −1,124 kcal (95% CI −4,538 to 2,292)) were found on the amount of energy purchased. Also, none of the taxation schemes showed significant effects on saturated fat or sugar purchased.

Originality/value – This is one of the first randomized controlled trials testing the effectiveness of a variety of food taxes in the virtual supermarket. This preliminary study provides important directions for future research (the design, results, as well as the lessons learned with respect to recruitment, incentives and technology).

Keywords Public health, Computer software, Consumer purchasing decisions, Food policy, Supermarkets, Prices

Paper type Research paper

Introduction

In response to the increased prevalence of obesity and non-communicable diseases (NCDs) over the past decades, national governments and health organizations are seeking for effective prevention strategies. In 2011, the United Nations General Assembly high-level meeting on NCDs advocated the use of fiscal strategies (e.g. food taxes or subsidies) to improve human diet and health (United Nations, 2011). Already, several studies have been conducted showing the beneficial effects of food taxes on food purchases (Thow *et al.*, 2014; Andreyeva *et al.*, 2010; Epstein *et al.*, 2012; Eyles *et al.*, 2012; Cabrera Escobar *et al.*, 2013; Nakhimovsky *et al.*, 2016; Backholer *et al.*, 2016).

Andreyeva *et al.* (2010) conducted a review study on food price elasticity ("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)) and indicated that consumer behavior is affected by changed food prices. Especially, food consumed away from home, soft drinks, juices, meats and fruits had the highest price elasticity. A review by Epstein *et al.* (2012) on

British Food Journal
Vol. 119 No. 12, 2017
pp. 2559-2570

0007-070X
DOI 10.1108/BFJ-08-2016-0386

experimental studies in different settings (e.g. in laboratories, cafeteria's, vending machines) showed that, in all settings, the purchase of less healthy foods reduced when prices increased. A review by Thow *et al.* (2014) showed that different types of food taxes can be effective to improve dietary intake although differences in effectiveness have been indicated. For example, a sugar-sweetened beverage (SSB) tax ranging from 5 to 30 percent decreased the intake of SSBs by 4-48 percent. A (saturated) fat tax of 5-17.5 percent would reduce (saturated) fat consumption by 0-3 percent, especially from certain high-fat foods (e.g. chips). A review on simulation modeling studies assessed the effects of SSB tax and saturated fat tax. A price increase of 1 percent of SSBs would lead to a decrease of 0.93 percent of energy intake derived from these drinks, and the modeled reduction in energy consumption was −0.02 percent for each 1 percent increase in price. The reduction in saturated fat would lead to a decrease of 12.8 percent of the total intake of saturated fat, corresponding to a modeled reduction of −0.02 percent in saturated fat, for each 1 percent increase in price (Eyles *et al.*, 2012). A meta-analysis by Cabrera Escobar *et al.* (2013) also suggested that an elevation in SSB price is associated with a lower consumption of SSBs (price elasticity: −1.299 (95% CI: −1.089 to −1.509)). SSB taxes have either similar effects on reductions in body weight among individuals with different socio economic positions (SEP) or greater effects for individuals with lower SEP as compared to individuals with higher SEP (Backholer *et al.*, 2016). In middle-income countries, similar results of SSB taxes as in high-income countries are reported (PE = −0.6 to −1.2, corresponding to a decrease of 5-9 kJ/pp/d given a price increase of 10 percent (Nakhimovsky *et al.*, 2016). Overall, these reviews outline the beneficial effects of taxes on the healthiness of food purchases.

Notwithstanding the importance of these studies and outcomes, most evidence is built upon simulating modeling studies and evidence from randomized controlled trials is lacking. From modeling studies, it is hard to gain good insight in cross-price elasticity or compensatory purchasing behaviors (Eyles *et al.*, 2012): a large number of studies only determine the effect of a particular food tax on the corresponding nutrient (e.g. the impact of a sugar tax on purchased sugar) and overlook its effectiveness on other nutrients (e.g. the impact of a sugar tax on purchased saturated fat). More recently, it has also been suggested that tax salience – the visibility/notification of the tax – might be an important factor in behavioral response to food taxes and could strengthen the taxation effect (Chetty *et al.*, 2009; Chen *et al.*, 2015).

Randomized controlled trials on the effectiveness of a variety of food taxes and tax salience in a retail setting are scarce (Epstein *et al.*, 2012). A potential explanation for this lack of experimental evidence is that such studies are challenging to conduct. First, the implementation of different taxation schemes (e.g. saturated fat-tax, sugar-tax, no-tax (control condition)) under systematically comparable environmental conditions (i.e. well-controlled environments) is a challenge. Second, it is challenging to engage retailers in such trials as the proposed strategies might negatively influence profits. To overcome these challenges, (online) virtual environments may provide a solution. Virtual environments allow for objective observations (participants' shopping behavior), behavioral measures (e.g. measures on food purchases) and, most importantly, for controlled environmental manipulations in an environment that closely resembles the real-life experience.

As part of the investigation undertaken by the DEDIPAC project (the Knowledge Hub on the DEterminants of DIet and Physical Activity, which is the first Research Action of the European Union's Joint Programming Initiative on healthy diet for healthy life) (Lakerveld *et al.*, 2014), the present manuscript provides insight into a preliminary study that uses a virtual reality setting to examine the effectiveness of three food taxation schemes on energy (kcal), saturated fat (gram) and sugar (gram) purchased in the virtual supermarket. Results of a small sample study are presented as well as the lessons learned. Also, the input and directions for future research using a virtual setting to test food taxes are presented.

Methods

Study design and setting

This study was conducted in the virtual supermarket, which is a unique three-dimensional software application closely resembling a real supermarket (Figure 1). The virtual supermarket was validated against real-life shopping behavior in a recent New Zealand study (Waterlander *et al.*, 2015). In virtual environments, participants can experience and interact intuitively in real time (Nichols *et al.*, 2000). The virtual supermarket is designed in the image of an existent branch of the Dutch market leader supermarket. The shopping procedures in the virtual supermarket closely mirror a real-life supermarket experience where participants navigate a trolley along supermarket aisles and select products by a single mouse click. The stock was based on an existing supermarket. In total, the virtual supermarket contained 512 different food products (see Waterlander *et al.*, 2012a), including 71 different types of beverages, modeling the actual distribution of store products and categories. The main features of the software are described in more detail elsewhere (Waterlander *et al.*, 2011).

In the virtual supermarket, food prices can be adapted for each test condition in the study. In the case of this study, the prices varied for four different conditions to which study participants were randomly assigned: an experimental condition with a 25 percent tax on products rich in fat; an experimental condition with a 25 percent tax on products rich in sugar; an experimental condition with a 25 percent tax on "unhealthy" products, based on a nutrient profiling model; and a control condition with regular prices conforms the prices of the two Dutch supermarket leaders in 2014. A tax level of 25 percent was chosen because previous studies indicated that a price increase of at least 20 percent on unhealthy products is needed to be effective to decrease the demand for calories (Mytton *et al.*, 2012). Alcoholic drinks were exempt from taxes because they are already taxed in the Netherlands.

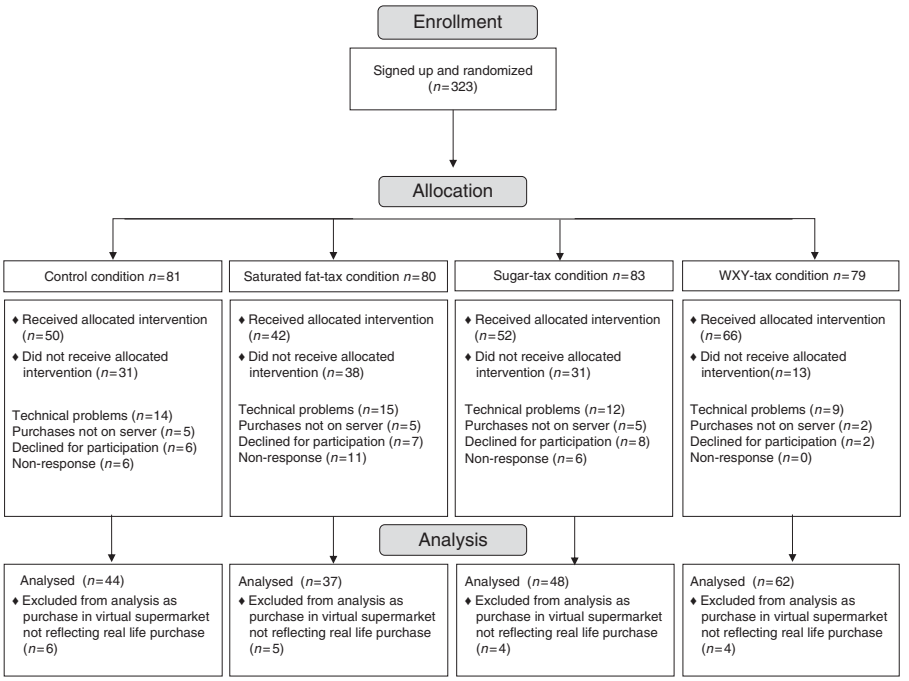

Figure 1.
Flow diagram of participants

Tax salience and taxation schemes

To reflect a realistic situation in which taxes are introduced (Chetty *et al.*, 2009; Chen *et al.*, 2015), the experimental groups were informed about the taxation before entering the supermarket by means of the following notification tailored to each of the conditions: "In the virtual supermarket, unhealthy/fat-rich/sugar-rich products are taxed. Therefore, the prices of, unhealthy/fat-rich/sugar-rich products are 25 percent more expensive. This tax aims to support healthy eating and thereby lower the chances of obesity or chronic diseases such as a diabetes type 2 or coronary heart disease." The control group did not receive a notification. The following taxation schemes were used.

Nutrient profiling tax. The taxation for "unhealthy" products was based on the British WXY nutrient profiling scheme (Quinio *et al.*, 2007). This scheme allocates positive and negative points based on the nutritional content per 100 g of a product. The overall score for the product is calculated in three steps and includes the following nutrient characteristics: energy (kilojoules (kJ)), saturated fat, total sugars, sodium, fiber, protein, fruit and vegetables (Rayner *et al.*, 2007). The total score ranges from −12 to 21, where a lower value indicates a healthier product. Based on the WXY nutrient profiling scheme, foods with $\geqslant 4$ points and drinks with $\geqslant 1$ point were classified as "unhealthy," and were taxed at a 25 percent level. In total, 282 (55 percent) products were taxed, including 244 foods and 38 drinks.

Sugar tax. A sugar tax was implemented using cut-off values for high and low total sugar content as used in the WXY nutrient profiling model (Rayner *et al.*, 2007). As foods products in the Netherlands most often only provide product information of the "total" sugar content of the product rather than the amount of "added" sugar, total sugar was used. Here, foods containing $\geqslant$13.5 g/100 g of total sugar and drinks containing $\geqslant 4.5$ g/100 g of total sugar were taxed with 25 percent. In total, 157 (31 percent) products were taxed, including 110 foods and 47 drinks.

Saturated fat tax. The saturated fat tax was based on the Danish fat tax (October 2011-January 2013) where the prices of products containing $\geqslant$2.3 g/100 g saturated fat were taxed, corresponding with a price increase of €2.14 per kilogram saturated fat. Empirical evidence revealed that household food purchases reduced products as butter, blends, oils, margarines by 10-15 percent (Jensen and Smed, 2013) and led to an average decrease in saturated fat consumption by 4 percent (Smed *et al.*, 2016). In the current study, products with $\geqslant 2.3$ g/100 g saturated fat were taxed with 25 percent. In total, 186 (36 percent) products were taxed, including 174 foods and 12 drinks.

No tax – control condition. In the control condition, regular prices were used. Moreover, no notification about prices was communicated before entering the supermarket.

Recruitment and procedures

A ~450 kcal decrease in calorie purchases per day for an average three-person household was determined to be a minimal relevant effect. A priori sample size estimation indicated that 700 participants (175 per group) would be required to detect a difference of 3,150 kcal (SD 10,000) per one-week food basket with a two-sided 5 percent significance level and a power of 80 percent. The study followed the standards of the institutional medical ethical committee.

Participants were recruited through advertisements in newspapers (two national, six local), social media (Twitter, Facebook), the website of the Netherlands Nutrition Centre Foundation and by a message on a local radio station. Inclusion criteria were as follows: being 18 years of age or older, familiar with the Dutch language and being the household gatekeeper (responsible/shared responsibility for doing the groceries). Two €100 and thirty €10 vouchers were raffled among the participants that completed the study. Also, a donation of €1.00 for every registered participant was provided to a health charity.

Following registration, participants were randomized via a computer-generated list containing pre-determined log-in codes for the virtual supermarket. These log-in codes corresponded with random allocation to either the control or one of the experimental conditions. Participants in the tax conditions were aware of the taxation scheme due to the tax salience. Participants received an e-mail explaining the study details and the link to the virtual supermarket. When entering the supermarket, each participant was asked to conduct a typical shopping trip for his/her household for one week. Before entering the virtual supermarket, participants were told that the experiment was virtual, the taxation message was displayed (except for the control group), and all participants were informed that they would not receive the groceries for real. Participants were asked about their household size and composition which was used to allocate a household-specific shopping budget minimally needed for weekly food consumption according the National Institute for Family Finance Information (Nibud, 2014). Next, participants were able to enter the virtual supermarket and do their groceries. When finished shopping, participants moved to the cash register and were directed to a closing questionnaire.

Measures

The primary outcome measure was the difference in energy (kilocalories) purchased between the tax conditions and the control condition. Secondary outcome measures were saturated fat (gram) and sugar (gram) purchased between the tax conditions and the control condition. Moreover, questions on potential confounders and effect modifiers were included. First, the following sociodemographic characteristics were measured: household size, level of responsibility for groceries, age, sex, gross income, educational level and BMI. Moreover, questions (15 items) regarding price perception (Lichtenstein *et al.*, 1993) and questions (15 items) measuring impulsivity (Spinella, 2007) were assessed because these were hypothesized to be strong predictors of the outcomes. Third, one question about understanding of the virtual supermarket and two questions about participants' notice of prices in the virtual supermarket were included. Fourth, participants were asked if their purchases in the virtual supermarket reflected a shopping trip comparable to real life with one item on a scale from 1 to 7: "The products I purchased in the Virtual Supermarket are a fair representation of what I regularly buy in a supermarket" with a response option ranging from 1 (totally not) to 7 (totally yes). Finally, the intervention conditions were asked if they had read the notification about the concerned tax in the virtual supermarket.

Statistical analyses

Participants indicating that their purchases in the supermarket reflected a fair representation of what they regularly bought in real life ($\geqslant 4$ out of 7) were included in the analysis. Mean (SD) and frequencies of the outcome measures were determined and tested for a normal distribution. Successively, mean differences in the main outcome measures between the conditions were analyzed using a one-way ANCOVA analysis. Both crude and adjusted analyses were conducted. The crude analysis was only adjusted for household size. The adjusted analysis included both participant characteristics (household size, sex, gross net income, educational level and BMI) and theoretically expected strong predictors of the outcomes (impulsiveness and price perception). Regression coefficients were presented for the tax conditions in comparison to the control condition. Afterward, a sensitivity analysis was conducted including all participants that completed the study, regardless of the real-life representativeness of their purchases. All tests were two sided and the level of significance was set at 0.05. Analyses were conducted using SPSS statistical software (version 21.00, IBM SPSS Inc., Chicago, IL).

Results

Participants

Recruitment ran for five months but had to be halted afterward because of (staffing) budget restraints. In total, 323 participants signed up for the study during this time. Of these, 113 (35 percent) dropped out: 50 (15.5 percent) because of technical problems with the virtual supermarket; 46 (14.2 percent) because they declined (e.g. lack of time, incentive wanted) or did not respond after signing up (following two reminder emails); and 17 (5.3 percent) because their purchases in the virtual supermarket were not processed properly by the website server. As such, 210 (65 percent) participants completed the study. Because of this dropout, numbers of participants in each condition were not evenly allocated. Of the 210 participants, 191 (91 percent) reported that their shopping behaviors were comparable to real-life purchases and were included in the analysis (Figure 1). Table I presents an overview of the participants' characteristics. In all conditions, household size was fairly similar, most participants were female, had a healthy weight and a high educational status.

	Group and number of participants (n)	Control condition ($n = 44$)	Fat-tax condition ($n = 37$)	Sugar-tax condition ($n = 48$)	Nutrient profiling-tax condition ($n = 62$)
Household size	Mean (SD)	2.47 (1.25)	2.19 (1.24)	2.25 (1.12)	2.74 (1.44)
% of HHS above 14 y	%	87.65 (20.93)	92.70 (15.98)	91.60 (19.25)	2.74 (1.44)
		$n = 39$	$n = 31$	$n = 44$	$n = 58$
Household income (gross monthly in €)[a]	% low (0-2,000)	23.1	32.3	27.3	32.8
	% mid (2,000-3,000)	28.2	29.0	20.5	19.0
	% high (3,000+)	48.7	38.7	52.2	48.3
Virtual shopping budget	€ Mean (SD)	91.75	83.86 (37.02)	81.85 (24.45)	92.81 (34.79)
Percentage spent	% Mean (SD)	83.62 (16.67)	88.09 (14.84)	89.23 (12.35)	86.05 (16.27)
Sex	% Female	79.5	73.0	83.3	87.1
Age	% 18-31	27.3	21.6	20.8	35.5
	% 32-46	31.8	32.4	20.8	38.7
	% 47-61	22.7	27.0	39.6	21.0
	% 62+	18.2	19.0	18.8	4.8
Education	Low	6.8	13.5	18.8	8.1
	Medium	31.8	40.5	20.8	29.0
	High	61.4	46.0	60.4	62.9
		$n = 42$	$n = 36$	$n = 47$	$n = 62$
Body mass index (BMI)	Mean (SD)	24.5 (3.97)	23.7 (3.50)	25.1 (4.24)	24.0 (3.66)
BMI $\leqslant 25$	%	66.7	77.8	57.8	70.0
BMI $\geqslant 25$	%	33.3	22.2	42.2	30.0
Price perception score[b]	Mean (SD)	4.23 (0.82)	4.42 (0.90)	4.36 (0.74)	4.17 (0.79)
Impulsiveness score[c]	Mean (SD)	1.89 (0.34)	1.85 (0.35)	1.79 (0.23)	1.85 (0.25)
Understanding supermarket[d]	Mean (SD)	5.52 (1.30)	5.97 (0.99)	5.67 (1.15)	5.84 (1.18)
Price awareness in during virtual shopping[e]	Mean (SD)	3.50 (1.79)	3.55 (1.67)	3.65 (1.74)	3.65 (1.85)
Awareness of taxation[f]	% yes	–	89.2	95.8	93.5

Notes: [a]The standard gross monthly income in the Netherlands in 2014 was €2.695 (MODAAL); [b]measured by 15 items (seven-point Likert Scale) from the seven "price perception construct scale items" (Lichtenstein); [c]measured by 15 items (four-point Likert Scale) of the shortened version of the Barratt Impulsiveness Scale (barratt/spinolla); [d]measured by one item on the virtual supermarket software; [e]measured by two items about the awareness of the price in the virtual supermarket; [f]measured by one item about the notification of the implemented tax

Table I. Participant characteristics

On average, participants spent over 80 percent of the budget that they received in the virtual supermarket. In the taxation conditions, around 90 percent of the individuals were aware of the food tax present in the supermarket (Table I).

Kilocalories (kcal) purchased

The amount of kilocalories, saturated fat (g) and sugar (g) purchased were normally distributed. Mean (SD) calories purchased were 35,213 (12,222) per household per week in the control condition, 30,988 (10,997) in the saturated fat-tax condition, 32,239 (11,967) in the sugar-tax condition and 35,666 (15,509) in the nutrient profiling-tax condition. Primary outcomes indicated that there were no significant effects of any of the three taxation schemes compared to the control condition on the total amount of calories purchased (saturated fat tax: $b = -2{,}009$ (95% CI −5,802 to 1,783); sugar tax: $b = -1{,}226$ (95% CI −4,772 to 2,320); WXY tax: $b = -1{,}582$ (95% CI −4,934 to 1,770)). The observed effects became somewhat stronger in the adjusted models saturated fat tax: −2,717 (95% CI −6,596 to 1,163); sugar tax: −2,041 (95% CI −5,695 to 1,612), except for the WXY condition: −1,124 (95% CI −4,538 to 2,292) where they became weaker. Although the differences between the taxation conditions and the control group remain statistically insignificant, the outcomes appear to be in the expected direction. The sensitivity analysis including the entire study sample ($n = 210$) showed similar results.

Saturated fat and sugar (gram) purchased

Similar to the primary outcome, an analysis on the secondary outcomes (amount of saturated fat and sugar purchased) also did not show statistically significant effects for any of the experimental conditions (Tables II (b) and (c)). Again, similar effects were observed in the sensitivity analysis including the entire study sample ($n = 210$).

Discussion

The observed effects of the three taxation schemes on food purchases compared to control were statistically insignificant. This lack of a statistically significant effect is likely due to the small sample sizes included, which resulted from recruitment challenges during the study. However, the outcomes were in the expected direction (i.e. less calories, saturated fat and sugar purchased) and the results of this preliminary study suggest a potential effect of the taxes on calorie purchases (primary outcome) because 3,150 kcal anticipated in the power calculation lies within the 95% confidence interval (−6.596 to 1.163). However, the current study is unable to provide firm conclusions on the effectiveness of food taxes on calories purchased. Succeeding this preliminary study, in future, more studies are needed to provide robust experimental evidence on the effects of food taxes. Moreover, future simulation modeling studies would benefit from determining different food tax approaches.

The non-significant effects were indeed in the same direction as the outcomes of previous modeling studies (Thow, 2014; Eyles, 2012). However, in line with our results, previous studies in virtual supermarket settings also did not find significant effects of taxes on overall calories purchased (Waterlander *et al.*, 2012b; Epstein *et al.*, 2015), although including an appropriate sample size. A study by Waterlander *et al.* (2012b) that combined food tax (20 percent) on unhealthy foods with a small (5 percent) discount on fruit and vegetables did not significantly discourage unhealthier food or calories purchased. A more recent experimental study by Epstein *et al.* (2015) also did not find an effect of taxation (12.5 and 25 percent) on high-energy dense foods on the overall calories purchased. However, purchases of the taxed foods decreased statistically significant. Also, another study using the virtual supermarket methodology revealed that a price increase of 12.4 percent of SSB would result in a statistically significant decrease of 168 kcal pp/week as a result from the decrease in

	B	SE	95% CI 95% low	95% high	*p*
(a) Effects of taxation schemes on kilocalories purchased					
Saturated fat tax model 1	−2,009	1,922	−5,802	1,783	0.30
Saturated fat tax model 2	−2,527	1,964	−6,403	1,348	0.20
Saturated fat tax model 3	−2,717	1,966	−6,596	1,163	0.17
Sugar tax model 1	−1,226	1,797	−4,772	2,320	0.50
Sugar tax model 2	−1,718	1,840	−5,350	1,914	0.35
Sugar tax model 3	−2,041	1,851	−5,695	1,612	0.27
Nutrient profiling tax 1	−1,582	1,699	−4,934	1,770	0.35
Nutrient profiling tax 2	−1,147	1,727	−4,555	2,260	0.51
Nutrient profiling tax 3	−1,124	1,731	−4,538	2,292	0.52
(b) Effects of taxation scheme on sat fat purchased (gram)					
Saturated fat tax model 1	−52.34	35.71	−122.78	18.09	0.14
Saturated fat tax model 2	−56.76	36.00	−127.82	14.30	0.12
Saturated fat tax model 3	−59.90	36.02	−131.07	11.28	0.09
Sugar tax model 1	−46.75	33.38	−112.60	19.11	0.16
Sugar tax model 2	−55.15	33.75	−121.75	11.45	0.10
Sugar tax model 3	−60.51	33.97	−127.55	6.52	0.08
Nutrient profiling tax 1	−35.30	31.56	−97.56	26.96	0.27
Nutrient profiling tax 2	−22.00	31.66	−84.49	40.48	0.49
Nutrient profiling tax 3	−21.05	31.75	−83.72	41.61	0.51
(c) Effects of taxation scheme on sugar purchased (gram)					
Saturated fat tax model 1	54.97	162.62	−265.85	375.79	0.74
Saturated fat tax model 2	9.18	156.56	−297.37	282.43	0.96
Saturated fat tax model 3	15.97	168.20	−316.00	347.94	0.92
Sugar tax model 1	−151.97	152.05	−451.93	147.98	0.32
Sugar tax model 2	−136.86	156.56	−445.84	172.12	0.38
Sugar tax model 3	−125.47	158.42	−438.44	187.20	0.43
Nutrient profiling tax 1	−4.07	143.74	−287.64	279.51	0.98
Nutrient profiling tax 2	−7.47	146.89	−297.37	282.43	0.96
Nutrient profiling tax 3	−3.51	148.08	−295.78	288.76	0.94

Notes: Model 1: corrected for household size; Model 2: corrected for household size and sociodemographic variables; Model3: corrected for household size, sociodemographic variables and impulsiveness and price perception

Table II.
The effect of the taxation schemes on the amount of kilocalories (a), grams of sugar (b) and saturated fat (c) purchased

purchases of these SSBs (Waterlander, Ni Mhurchu and Steenhuis, 2014). Future studies should not only reveal effects on overall purchased calories but also on the effectiveness of the taxed products specifically.

Besides the lack of an adequate sample size, another explanation of the insignificance of the results could be the design of the tax instrument used in this experiment. Comparable to previous studies (Waterlander *et al.*, 2012b; Waterlander, Ni Mhurchu and Steenhuis, 2014), fixed cut-off values were used to tax products in this experiment; for example, both semi-fat (5 g sat. fat/100 g) and high-fat products (15 g sat. fat/100 g) were taxed equally (by 25 percent). This might be less of an incentive for individuals to substitute high-fat products to lower-fat alternatives that now are also taxed if more than 2.3 g fat/100 g. Moreover, using a relative "price change," higher priced products are more heavily taxed (in absolute sense) and may lead to perverse substitution effects if higher priced products are healthier or of higher quality. Yet, as showed in a previous study, more expensive products are not necessarily of better nutritional quality (Waterlander, van Kouwen and Steenhuis, 2014). Future studies – but also policy makers – should consider the design of the tax instrument carefully.

An innovative aspect of the study setting was that tax salience was introduced, to reflect a more real-life situation. However, this study did not specifically examine the effect of the tax salience. In future, experimental studies need to be conducted to determine the effectiveness of the tax salience itself. Chen *et al.* (2015) showed that individuals decrease the intake of calories, fat, carbohydrates and sodium in a cafeteria setting due to visibility of food taxes. Future studies testing different food taxes and policy makers need to keep in mind that a disadvantage of nutrient-based taxes is that they may apply on both foods that are recommended by dietary guidelines (e.g. dairy, meat, fish) and on unhealthier foods (snacks, soft drinks). Therefore, rather than taxing nutrients, the taxation of certain foods is more often considered, like taxing snack foods or soft drinks (Cabrera Escobar *et al.*, 2013). This corresponds to the current regulation on alcohol and tobacco (Leiceser and Windmeijer, 2004; Thow *et al.*, 2014). Also, rather than focusing solely on health promotion, taxes that are focused on sustainability-based decisions may be of interest and may indirectly effect the healthiness of purchases positively (Wirsenius *et al.*, 2011).

Several strengths of this initial experiment should be acknowledged. To best knowledge of the authors, this is one of the first studies testing a range of food taxes in one experiment. The taxing schemes were applied in the same highly controlled setting, providing strong internal validity. In addition, compensatory purchasing and cross-price elasticity were taken into account by analyzing the effects on the total amount of calories, saturated fat and sugar purchased as opposed to only measuring the purchases of products that were taxed. Although virtual reality settings provide great potential for taxation studies, it should be kept in mind that results of virtual supermarket studies reflect hypothetical purchasing decisions. Although the virtual supermarket was validated against real-life purchases (Waterlander *et al.*, 2015), it is unclear to what extent these self-reported data reflect real-world decision; and studies in more ecological valid settings would strengthen the literature on food taxes.

The study also faced few weaknesses, and "lessons learned" with respect to recruitment, incentives and technology can be obtained from the current study. First, major challenges in recruitment were experienced that were not expected, based on previous studies with the virtual supermarket (i.e. Waterlander, 2012a, b). In the current study, however, much effort was put in recruiting participants (national newspapers, websites and social media) for approximately a five-month period. Though a large number of participants ($n = 323$) were recruited, a longer recruitment period (at least $\geqslant 6$ months) and a more intensive recruitment strategy (e.g. via personal e-mail or telephone or via the use of existing consumer panels) are needed to include a sufficient number of participants. Second, the incentives in the study were not guaranteed (e.g. chance to win money) or not addressed to the participants (donation to charity). This might indicate that the used incentive was not appropriate to motivate individuals to participate initially or could explain why a considerable number of participants (14.2 percent) did not start the study after initially signing up. This confirms previous insights that a guaranteed incentive may be more beneficial than a lottery incentive (Leung *et al.*, 2002). However, studies did indicate that altruism is an important motivator to participate (Stunkel and Grady, 2011) and therefore a larger number of individuals were expected to participate using a donation to charity as an additional incentive. Finally, a larger number of the participants than anticipated experienced problems with the virtual tool (20.8 percent), which is contradictory with our previous studies using the virtual supermarket. We experienced that compatibility with all different computer systems was a challenge, that respondents were not able to install the program themselves or gave up on/were not motivated to install the virtual tool. This shows that it is important to continue investing in this technology and making sure it is up-to-date with most recent computer systems.

Conclusions

This study explored the impact of three taxation schemes (saturated fat tax, sugar tax and nutrient profiling tax) on food purchases in the virtual supermarket. Virtual environments allow for objective observations and controlled manipulations in a "laboratory" setting, while simulating real-life environments. Non-significant effects of the tested food taxes were observed on the purchases of calories, sugar and saturated fat compared to the control group. Yet, the outcomes were in the expected direction and our study provides useful tools for the design of future food pricing trials, such as specific data on required sample size, recruitment strategies and the use of virtual reality.

Acknowledgments

The authors thank Frédérique Rongen for her assistance in the recruitment of the participants for this study.

Financial support: the preparation of this paper was supported by the DEterminants of DIet and Physical ACtivity (DEDIPAC) knowledge hub. This work is supported by the Joint Programming Initiative "Healthy Diet for a Healthy Life." The Dutch funding agency funding this work was The Netherlands Organisation for Health Research and Development (ZonMw).

References

Andreyeva, T., Long, M.W. and Brownell, K.D. (2010), "The impact of food prices on consumption: a systematic review of research on the price elasticity of demand for food", *American Journal of Public Health*, Vol. 100 No. 2, pp. 216-222.

Backholer, K., Sarink, D., Beauchamp, A., Keating, C., Loh, V., Ball, K., Martin, J. and Peeters, A. (2016), "The impact of a tax on sugar-sweetened beverages according to socio-economic position: a systematic review of the evidence", *Public Health Nutrition*, Vol. 19 No. 17, pp. 3070-3084.

Cabrera Escobar, M.A., Veerman, J.L., Tollman, S.M., Bertram, M.Y. and Hofman, K.J. (2013), "Evidence that a tax on sugar sweetened beverages reduces the obesity rate: a meta-analysis", *BMC Public Health*, Vol. 13 No. 1, p. 1072, available at: https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-13-1072

Chen, X., Kaiser, H.M. and Rickard, B.J. (2015), "The impacts of inclusive and exclusive taxes on healthy eating: an experimental study", *Food Policy*, Vol. 56, pp. 13-24.

Chetty, R., Looney, A. and Kroft, K. (2009), "Salience and taxation: theory and evidence", *American Economic Review*, Vol. 99 No. 4, pp. 1145-1177.

Epstein, L.H., Jankowiak, N., Nederkoorn, C., Raynor, H.A., French, S.A. and Finkelstein, E. (2012), "Experimental research on the relation between food price changes and food-purchasing patterns: a targeted review", *American Journal of Clinical Nutrition*, Vol. 95 No. 4, pp. 789-809.

Epstein, L.H., Finkelstein, E., Raynor, H., Nederkoorn, C., Fletcher, K.D., Jankowiak, N. and Paluch, R.A. (2015), "Experimental analysis of the effect of taxes and subsides on calories purchased in an on-line supermarket", *Appetite*, Vol. 95, pp. 245-251, available at: https://ac.els-cdn.com/S019566631500313X/1-s2.0-S019566631500313X-main.pdf?_tid=c6f7e03c-bb0c-11e7-8360-00000aab0f27&acdnat=1509105101_cf38f44148d7aad8d5cb5ee672a2d7a0

Eyles, H., Mhurchu, C.N., Nghiem, N. and Blakely, T. (2012), "Food pricing strategies, population diets, and non-communicable disease: a systematic review of simulation studies", *PLoS Medicine*, Vol. 9 No. 12, available at: http://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1001353

Jensen, J.D. and Smed, S. (2013), "The Danish tax on saturated fat – short run effects on consumption, substitution patterns and consumer prices of fats", *Food Policy*, Vol. 42, pp. 18-31, available at: www.sciencedirect.com/science/article/pii/S0306919213000705

Lakerveld, J., van der Ploeg, H.P., Kroeze, W., Ahrens, W., Allais, O., Andersen, L.F., Cardon, G., Capranica, L., Chastin, S., Donnelly, A., Ekelund, U., Finglas, P., Flechtner-Mors, M., Hebestreit, A., Hendriksen, I., Kubiak, T., Lanza, M., Loyen, A., MacDonncha, C., Mazzocchi, M., Monsivais, P., Murphy, M., Nöthlings, U., O'Gorman, D.J., Renner, B., Roos, G., Schuit, A.J., Schulze, M., Steinacker, J., Stronks, K., Volkert, D., van't Veer, P., Lien, N., De Bourdeaudhuij, I. and Brug, J. (2014), "Towards the integration and development of a cross-European research network and infrastructure: the DEterminants of DIet and Physical ACtivity (DEDIPAC) Knowledge Hub", *International Journal of Behavioral Nutrition and Physical Activity*, Vol. 11 No. 1, p. 143.

Leiceser, A. and Windmeijer, F. (2004), "The 'fat tax': economic incentives to reduce obesity", Briefing Notes No. 49, The Institute for fiscal studies, doi: 10.1920/bn.ifs.2004.0049.

Leung, G.M., Ho, L.M., Chan, M.F., Johnston, J.M. and Wong, F.K. (2002), "The effects of cash and lottery incentives on mailed surveys to physicians a randomized trial", *Journal of Clinical Epidemiology*, Vol. 55 No. 8, pp. 801-807.

Lichtenstein, D.R., Ridgway, N.M. and Netemeyer, R.G. (1993), "Price perceptions and consumer shopping behavior: a field study", *Journal of Marketing Research*, Vol. 30 No. 2, pp. 234-245.

Mytton, O.T., Clarke, D. and Rayner, M. (2012), "Taxing unhealthy food and drinks to improve health", *British Medical Journal*, Vol. 344, available at: http://user37685.vs.easily.co.uk/wp/wp-content/uploads/2013/10/mytton2012.pdf

Nakhimovsky, S., Feigl, A., Avila, C., Spranca, M., O'Sullivan, G. and Macgreggor-Skinner, E. (2016), "The effectiveness of using taxes on sugar-sweetened beverages to reduce obesity in middle income countries: a systematic review", *Annals of Global Health*, Vol. 82 No. 3, p. 545.

Nibud (2014), "What do you spend on food?", available at: www.nibud.nl/consumenten/wat-geeft-u-uit-aan-voeding/ (accessed September 8, 2014).

Nichols, S., Haldane, C. and Wilson, J.R. (2000), "Measurement of presence and its consequences in virtual environments", *International Journal of Human-Computer Studies*, Vol. 52 No. 3, pp. 471-491.

Perloff, J.M. (2007), *Microeconomics*, Pearson Education, Boston, MA.

Quinio, C., Biltoft-Jensen, A., De Henauw, S., Gibney, M.J., Huybrechts, I., McCarthy, S.N., O'Neill, J.L., Tettens, I., Turrini, A. and Volatier, J.L. (2007), "Comparison of different nutrient profiling schemes to a new reference method using dietary surveys", *European Journal of Nutrition*, Vol. 46 No. 2, pp. 37-46.

Rayner, M., Scarborough, P., Stockley, L. and Boxer, A. (2007), "Nutrient profiles: further refinement and testing of model SSCg3d", Final Report 2005, available at: www.food.gov.uk/multimedia/pdfs/npreportsept05.pdf (accessed September 10, 2014).

Smed, S., Scarborough, P., Rayner, M. and Jensen, J.D. (2016), "The effects of the Danish saturated fat tax on food and nutrient intake and modelled health outcomes: an econometric and comparative risk assessment evaluation", *European Journal of Clinical Nutrition*, Vol. 70 No. 6, pp. 681-686.

Spinella, M. (2007), "Normative data and a short form of the Barratt impulsiveness scale", *International Journal of Neuroscience*, Vol. 117 No. 3, pp. 359-368.

Stunkel, L. and Grady, C. (2011), "More than the money: a review of the literature examining healthy volunteer motivations", *Contemporary Clinical Trials*, Vol. 32 No. 3, pp. 342-352.

Thow, A.M., Downs, S. and Jan, S. (2014), "A systematic review of the effectiveness of food taxes and subsidies to improve diets: understanding the recent evidence", *Nutrition Reviews*, Vol. 72 No. 9, pp. 551-565.

United Nations (2011), "Political declaration of the high-level meeting of the general assembly on the prevention and control of non-communicable diseases", available at: www.who.int/nmh/events/un_ncd_summit2011/political_declaration_en.pdf?ua=1 (accessed November 16, 2015).

Waterlander, W.E., Ni Mhurchu, C. and Steenhuis, I.H. (2014), "Effects of a price increase on purchases of sugar sweetened beverages. Results from a randomized controlled trial", *Appetite*, Vol. 78 No. C, pp. 32-39, available at: https://ac.els-cdn.com/S0195666314001275/1-s2.0-S0195666314001275-main.pdf?_tid=15af2028-bb0d-11e7-8364-00000aacb361&acdnat=1509105233_44dcfcf5114a6b4540253485b052ad8f

Waterlander, W.E., van Kouwen, M. and Steenhuis, H.M. I. (2014), "Are diets healthier when they contain branded foods?", *British Food Journal*, Vol. 116 No. 10, pp. 1522-1532.

Waterlander, W.E., Jiang, Y., Steenhuis, I.H.M. and Mhurchu, C.N. (2015), "Using a 3D virtual supermarket to measure food purchase behavior: a validation study", *Journal of Medical Internet Research*, Vol. 17 No. 4.

Waterlander, W.E., Scarpa, M., Lentz, D. and Steenhuis, I.H. (2011), "The virtual supermarket: an innovative research tool to study consumer food purchasing behaviour", *BMC Public Health*, Vol. 11 No. 1, p. 589.

Waterlander, W.E., Steenhuis, I.H., de Boer, M.R., Schuit, A.J. and Seidell, J.C. (2012a), "The effects of a 25% discount on fruits and vegetables: results of a randomized trial in a three-dimensional web-based supermarket", *International Journal of Behavioral Nutrition and Physical Activity*, Vol. 9 No. 11, available at: https://ijbnpa.biomedcentral.com/track/pdf/10.1186/1479-5868-9-11?site=ijbnpa.biomedcentral.com

Waterlander, W.E., Steenhuis, I.H., de Boer, M.R., Schuit, A.J. and Seidell, J.C. (2012b), "Introducing taxes, subsidies or both: the effects of various food pricing strategies in a web-based supermarket randomized trial", *Preventive Medicine*, Vol. 54 No. 5, pp. 323-330.

Wirsenius, S., Hedenus, F. and Mohlin, K. (2011), "Greenhouse gas taxes on animal food products: rationale, tax scheme and climate mitigation effects", *Climatic Change*, Vol. 108 Nos 1-2, pp. 159-184.

Corresponding author
Maartje Poelman can be contacted at: m.p.poelman@uu.nl