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Effectiveness of Subsidies in Promoting Healthy Food Purchases and Consumption: A Review of Field Experiments

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Abstract

Objective: To systematically review evidence from field interventions on the effectiveness of monetary subsidies in promoting healthier food purchases and consumption.

Design: Keyword and reference search were conducted in 5 electronic databases: Cochrane Library, EconLit, MEDLINE, PsycINFO, and Web of Science. Studies were included based on the following criteria – intervention: field experiments; population: adolescents 12-17 years old or adults 18 years and older; design: randomized controlled trials, cohort studies, or pre-post studies; subsidy: price discounts or vouchers for healthier foods; outcome: food purchases or consumption; period: 1990-2012; and language: English. Twenty-four articles on 20 distinct experiments were included with study quality assessed using predefined methodological criteria.

Setting: Interventions were conducted in 7 countries: USA (*n* 14), New Zealand (*n* 1), France (*n* 1), Germany (*n* 1), Netherlands (*n* 1), South Africa (*n* 1), and United Kingdom (*n* 1). Subsidies applied to different types of foods such as fruits, vegetables, and low-fat snacks sold in supermarket, cafeteria, vending machine, farmers' market, or restaurant.

Subjects: Interventions enrolled various population subgroups such as school/university students, metropolitan transit workers, and low-income women.

Results: All but one study found subsidies on healthier foods to significantly increase the purchase and consumption of promoted products. Study limitations include small and convenience samples, short intervention and follow-up duration, and lack of cost-effectiveness and overall diet assessment.

Conclusions: Subsidizing healthier foods tends to be effective in modifying dietary behavior. Future studies should examine its long-term effectiveness and cost-effectiveness at the population level and its impact on overall diet intake.

Introduction

Poor diet quality is among the most pressing health challenges in the U.S. and worldwide, and is associated with major causes of morbidity and mortality, including cardiovascular disease, hypertension, type 2 diabetes, and some types of cancer[(1)]. The U.S. National Prevention Strategy, released in June 2011, considers healthy eating a priority area and calls for increased access to healthy and affordable foods in communities[(2)].

High prices remain a formidable barrier for many people, especially those of low socioeconomic status, to adopt a healthier diet[(3)]. A 2004-2006 survey of major supermarket

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chains in Seattle found foods in the bottom quintile of energy density cost on average $4.34 per 1,000 kJ, compared with $0.42 per 1,000 kJ for foods in the top quintile[4]. The large price differential between nutrient-rich, low-energy-dense foods such as fruits and vegetables and nutrient-poor, energy-dense foods might contribute to poor diet quality and various sociodemographic health disparities[4-7].

Increasing attention has been paid to the use of economic incentives in modifying individuals' dietary behavior. Fiscal policies (i.e., taxation, subsidies, or direct pricing) to influence food prices "in ways that encourage healthy eating" have been recommended by the World Health Organization[8,9]. In September 2011, Hungary imposed a 10 forint (approximately $0.04) tax on packaged foods high in fat, sugar or salt[10]. One month later, Denmark implemented a tax of 16 Danish Krone (approximately $2.80) per kg saturated fat on domestic and imported foods with a saturated fat content exceeding 2.3%[11]. By 2009, 33 U.S. states had levied sales taxes on sugar-sweetened soft drinks with an average tax rate of 5.2%[12]. In addition, the Food, Conservation, and Energy Act of 2008 (Public Law H.R. 6124, also known as the Farm Bill)[13] required a U.S. Department of Agriculture pilot project to examine the effectiveness of a 30% price discount on fruits, vegetables, and other healthier foods in changing dietary behavior among low-income residents enrolled in the Supplemental Nutrition Assistance Program[14]. Preliminary results may be available in 2013.

In this study, we review current evidence from field interventions subsidizing healthier foods on their effectiveness in modifying dietary behavior. A field intervention refers to an experiment conducted in the real world rather than in the laboratory. The review focuses on the findings related to the following issues: Are subsidies effective in promoting healthier food purchases and consumption? What level of subsidies is required to be effective? Is there evidence of a dose-response relationship? Does the effectiveness differ across population subgroups? Are subsidies more or less effective than other intervention strategies? Does the impact maintain after the withdrawal of the incentive? Admittedly, it is unrealistic to address all these issues in a single review article as answers to those issues remain tentative, incomplete, or even contradictory sometimes. Nevertheless, it serves as a starting point in the direction to synthesize relevant findings.

Four recent review articles are particularly relevant to our study. Kane et al. (2004) reviewed the role of economic incentives on a wide range of consumers' preventive behaviors such as healthy diet, physical exercise, and immunization[15]. Wall et al. (2006) reviewed randomized controlled trials (RCTs) that used monetary rewards to incentivize healthy eating and weight control[16]. Thow et al. (2010) reviewed empirical and modeling studies on the effectiveness of subsidies and taxes levied on specific food items on consumption, body weight, and chronic diseases[17]. Jensen et al. (2011) reviewed the effectiveness of economic incentives in modifying dietary behavior among school children[18].

Our study contributes to the literature by systematically reviewing most recent scientific evidence on the effectiveness of monetary subsidies in promoting healthier food purchases and consumption. To synthesize data from a reasonably homogeneous body of literature with relatively rigorous study design, we exclusively focus on: (1) prospective field interventions with a clear experimental design; (2) monetary subsidies in the form of price discount or voucher for healthier foods; and (3) food purchases and intake among adolescent and adult population.

Methods

Study selection Criteria

Studies which met all of the following criteria were included in the review: (1) intervention type: prospective field experiments; (2) study population: adolescents 12-17 years old or adults 18 years and older; (3) study design: RCTs, cohort studies, or pre-post studies; (4) subsidy type: price discounts or vouchers for healthier foods; (4) outcome measure: food purchases or consumption; (5) publication date: between January 1st 1990 and May 1st 2012; and (6) language: articles written in English.

Arguably, children 11 years and younger consist of an important population for dietary intervention. Even so, we decided not to include them in this review due to the following reasons. Children largely depend on their parents to pay their expenses. Therefore, most of the dietary interventions on children focus on free provision of healthier meal or fruit/vegetable, nutrition education, role model, and promotion of physical activities, while children-targeted interventions using price discount or voucher worth a certain amount of money exchangeable for healthier foods remain scarce. Moreover, there has already been a systematic review on the effectiveness of economic incentives in modifying nutritional behavior among school children by Jensen et al. (2011)[18].

Search Strategy

We searched 5 electronic bibliographic databases – Cochrane Library, EconLit, MEDLINE, PsycINFO, and Web of Science, using various combinations of keywords such as "subsidy", "discount", "voucher", "food", and "diet". A complete search algorithm for MEDLINE is reported in Table 1. Algorithms for other databases are either identical or sufficiently similar. Titles and abstracts of the articles identified through the keyword search strategy were screened against the study selection criteria. Potentially relevant articles were retrieved for evaluation of the full text.

We also conducted a reference list search (i.e., backward search) and cited reference search (i.e., forward search) from full-text articles meeting the study selection criteria. Articles identified through this process were further screened and evaluated using the same criteria. We repeated reference searches on all newly-identified articles until no additional relevant article was found.

Data Extraction and Synthesis

A standardized data extraction form was used to collect the following methodological and outcome variables from each included study: intervention country, intervention duration, follow-up duration, intervention strategy, intervention setting, study design, economic incentive, eligible product, targeted population, targeted behavior, sample size, outcome measure, study results, and intervention effectiveness.

Ideally, a formal meta-analysis should be conducted to provide quantitative estimates of the effect of subsidies in promoting healthier diet. This requires intervention type and outcome measure across studies to be sufficiently homogeneous. However, among the twenty interventions included in this review, few adopted the same experiment strategy, and the type of food purchase/intake also substantially differed. The dissimilar nature of intervention strategy and outcome measure precludes meta-analysis. This study was thus limited to a narrative review of the included studies with general themes summarized.

Study Quality Assessment

Following Wu et al. (2011)[19], the quality of each study included in the review was assessed by the presence or absence of 10 dichotomous criteria: (1) a control group was included; (2) baseline characteristics between control and intervention groups were similar; (3) the intervention period was at least 5 weeks; (4) the follow-up period was at least 3 weeks; (5) an objective measure of food purchases or intake was used; (6) the measurement tool was shown to be reliable and valid in previously published studies; (7) participants were randomly recruited with a response rate of 60% or higher; (8) attrition was analyzed and determined not to significantly differ by respondents' baseline characteristics between control and intervention groups; (9) potential confounders were properly controlled in the analysis; and (10) intervention procedures were documented in detail in the article. A total study quality score ranging from 0 to 10 was obtained for each study by summing up these criteria. Quality scores helped measure the strength of the study evidence and were not used to determine the inclusion of studies.

Results

Study Selection

A total of 8,036 articles were identified in the keyword and reference search, among which 7,963 were excluded in title/abstract screening. The remaining 73 articles were further evaluated in full text against the study selection criteria. Among them, 13 were controlled laboratory experiments[20-24], computer simulations[25,26], or modeling exercises[27-32] rather than field interventions; 6 exclusively enrolled children participants 11 years and younger[33-38]; 10 were cross-sectional observational studies without clear experimental or quasi-experimental designs[39-48]; 7 provided fruits and vegetables in school or other settings for free rather than using price discount or voucher[49-55], 7 used economic incentives unrelated to healthier foods (i.e., financial rewards for weight loss[56-60] or subsidies on staple or other basic food necessities[61,62]; 4 used weight loss rather than food purchases or consumption as the outcome measure[63-66]; and 2 were published before 1990[67,68]. Excluding the above articles yielded a final pool of 24 studies[69-92] with reported outcomes from 20 distinct field interventions. Figure 1 shows the study selection process.

Basic Characteristics of the Included Studies

Table 2 summarizes the studies included in the review. The 20 interventions were conducted in 7 countries: a majority of them (*n* 14) in the U.S., and the remaining 6 in New Zealand, France, Germany, Netherlands, South Africa, and United Kingdom. Fourteen interventions provided price discounts for healthier food items, and the other 6 used vouchers worth a certain amount of money exchangeable for healthier foods. Subsidies (i.e., price discounts and vouchers) applied to various types of healthy foods and beverages sold in supermarkets (*n* 6), cafeterias (*n* 5), vending machines (*n* 5), farmers' markets (*n* 2), restaurants *(n* 1), or organic food stores (*n* 1). Eligible foods mainly consist of fruits/vegetables and low-fat snacks, and eligible beverages mainly consist of fruit juice, vegetable soup, and low-fat milk. Interventions enrolled different population subgroups such as school or university students, metropolitan transit workers, and low-income women. RCTs were the most common study design (*n* 9), followed by pre-post studies (*n* 8) and cohort studies (*n* 3). The difference between pre-post and cohort studies is that the latter not only had an intervention group as in the former but also a control group which was followed before and during the intervention.

Intervention Effectiveness

All but one study found subsidies on healthier foods to significantly increase the purchase and consumption of promoted products. The only null finding, reported in Kristal et al. (1996), was likely due to its small financial incentive – a voucher worth $0.50 toward the purchase of any fruit or vegetable[73]. As noted in their conclusion, "more powerful interventions are probably necessary to induce shoppers to purchase and consume more fruits and vegetables."

The level of subsidies varied substantially across interventions. The price discounts ranged from 10% to 50%, and the monetary values of vouchers were largely between $7.50 and $50, except for the $0.50 voucher in Kristal et al. (1996)[73]. The lower bounds (i.e., 10% price discount and $7.50 voucher) could serve as a conservative estimate for the minimal level of subsidies required to induce a meaningful increase in healthier food purchases or consumption.

There is some preliminary evidence from price discount interventions that the demands for fruits and low-fat snacks are price elastic – a 1% decrease in price is associated with a larger than 1% increase in quantity demanded. Jeffery et al. (1994) documented a twofold increase of fruit purchases in a university cafeteria when price was reduced by half[69]. French et al. (1997b) reported the fruit sales in high school cafeterias increased fourfold following a 50% price reduction[72]. Lowe et al. (2010) reported an increase of fruit intake by about 30% in hospital cafeterias when price was lowered by 15-25%[88]. French et al. (1997a) found a 50% price reduction for low-fat snacks sold in university vending machines to be associated with a 78% increase in sales[71]. French et al. (2010a) reported a fourfold increase in sales of low-fat snacks sold in worksite vending machines when prices decreased by 50%[86]. Evidence for price elasticities of other foods is less consistent. For example, given a 50% price reduction of salad sold in cafeteria, Jeffery et al. (1994) documented a twofold increase in sales[69] while French et al. (1997b) reported none[72].

Most studies adopted a fixed subsidy level that did not vary across groups or over time, so that the dose-response relationship could not be examined. Two exceptions were French et al. (2001) and An et al. (2013) which both confirmed a dose-response relationship between the level of price discount and sales/consumption of subsidized foods. In French et al. (2001), price reductions of 10%, 25%, and 50% on low-fat snacks sold in school and worksite vending machines were associated with an increase in sales by 9%, 39%, and 93%, respectively[75]. An et al. (2013) reported a 10% and 25% discount on healthier food purchases were associated with an increase in daily fruit/vegetable intake by 0.38 and 0.64 servings, respectively[92].

Evidence on the differential effect of subsidies across different populations remains sparse. Blakely et al. (2011) is the only study that examined the differential effect of price discount on food purchases across ethnic and socioeconomic groups[90]. No variation in intervention effect was identified by household income or education, and the evidence for differential effects of price discounts across ethnicities was weak.

A few studies compared subsidies with alternative intervention strategies, namely nutrition education, product labeling, promotional signage (e.g., posters in cafeteria), and stimulation (i.e., a text message to remind/encourage action) or health message (i.e., a text message to introduce the health benefit of nutritious food intake). The results are largely inconclusive. Anderson et al. (2001)[74] and Bihan et al. (2010, 2012)[84,85] found that vouchers and nutrition education both significantly increased fruit and vegetable consumption (with similar effect sizes), and Anderson et al. (2001) reported the combination of the two had the largest effect. Conversely, Burr et al. (2007)[81], Ni Mhurchu et al. (2010)[89], and Blakely et

al. (2011)[90] found no impact of nutrition education on fruit or other healthier food purchases. No effects on healthier food sales were found for health message[78], and some but limited effects were reported for product labeling[88,91], promotional signage[75], and stimulation message[76].

Seven interventions included a follow-up period to assess changes in dietary behavior after the withdrawal of incentives, but their findings diverged. Three found sustained improvement after the intervention – the effect remained the same in the 6-month follow-up reported in Herman et al. (2006, 2008)[79,80], increased by about twofold in the 5-week follow-up in Michels et al. (2008)[82], and decreased by half in the 6-month follow-up in Ni Mhurchu et al. (2010)[89]. Conversely, the other 4 interventions[69,71,72,88] found no extended effect in the follow-up period.

Study Quality

Table 3 reports the results of study quality assessment. On average, studies included in the review met 6 out of 10 quality criteria, but the distribution of qualification differed substantially across criteria. Almost all studies included an objective measure of food purchases or intake, used a measurement tool that was shown to be reliable and valid in previously published studies, and documented intervention procedures in detail. In contrast, nearly none recruited participants randomly with a response rate of 60% or higher.

Discussion

The high price of nutrient-rich, low-energy-dense foods relative to nutrient-poor, energy-dense foods might prevent individuals, especially those who are low-income, from adopting a healthier diet. In this study, we systematically reviewed evidence from field interventions on the effectiveness of monetary subsidies in promoting healthier food purchases and consumption. Improved affordability was associated with significant increases in the purchase and consumption of healthier foods.

Economic theory suggests that when the price of healthy diets drops, individuals will substitute healthy foods for unhealthy ones, but as their real income increases due to price reduction, they may spend more on food overall, including unhealthy foods. Among the interventions included in this review, the amount of subsidies relative to personal income appears to be small. In this case, the income effect is unlikely to play a major role, and the study estimates suggest an unambiguous effect on improved patterns of healthier food purchases and consumption.

The evidence on the effectiveness of subsidies is to some extent compromised by a few major limitations in the reviewed studies. Arguably, the biggest limitation is the external validity of study outcomes. Almost all studies included in this review were limited in scale, had a small or convenience sample rather than a population representative sample, and were implemented in very specific settings (e.g., one or a few supermarkets, cafeterias, vending machines, farmers' markets, or restaurants), which have substantially limited the generalizability of study results beyond the sample. Moreover, the intervention duration was usually limited to a few weeks, and a majority of the studies did not incorporate a follow-up period after the intervention. Therefore, the long-term trends and effectiveness of subsidies cannot be evaluated, and whether the effect will sustain after the withdrawal of incentive remains questionable. Separating the effects of subsidies from those of other intervention elements (e.g., prompting, product sampling, increasing the number of healthier food choices) was often infeasible due to the integrated study design. Policy makers are not well informed of the potential for large-scale application of subsidies on healthier foods because none of the reviewed studies explicitly measured cost-effectiveness of the interventions or

evaluated the potential impact on the food industry. No study targeted overall diet quality, and thus little is known about the impact of subsidies on total diet/energy intake.

In addition to weaknesses of the individual studies, the review itself also suffers from various limitations. Studies included in the review differed substantially by study population, intervention setting, experimental design, and outcome measure, which precluded meta-analysis. Only a small proportion of the reviewed studies examined each predefined research questions, resulting in a wide range of uncertainties. The literature search was restricted to peer-reviewed journal articles in English published between 1990 and 2012. Although this restriction may potentially increase the likelihood of obtaining concurrent studies with reasonably high quality, publication bias can be a concern. This review exclusively focused on one specific type of economic incentive, namely subsidies in the form of price discounts and vouchers for healthier food purchases, while other forms of economic incentives, such as taxes on less-healthy foods, food stamps for basic necessities, or rewards for weight loss, were not examined. Readers interested in the role of taxation in modifying dietary behavior may refer to the review articles by Caraher and Cowburn (2005)[93], Kim and Kawachi (2006)[94], and Brownell et al. (2009)[12].

This study confirms findings on the effectiveness of economic incentives in modifying health behaviors from previous review articles. Kane et al.'s (2004) meta-analysis of 47 RCTs estimated that the economic incentives, on average, worked 73% of the time to improve consumers' preventive health behaviors[15]. All 4 RCTs reviewed in Wall et al. (2006) documented a positive effect of monetary incentives on food purchases, food consumption, or weight loss[16]. Thow et al. (2010) reviewed 24 relevant studies and concluded that a substantial subsidy or tax on food was likely to influence consumption and improve health[17]. Jensen et al. (2011) reviewed evidence from 30 articles and found price incentives to be effective for altering children's food and beverage intake at school[18].

Despite the accumulated evidence on the effectiveness of economic incentives in modifying dietary behavior, policy adoptions remain scarce. Hungary and Denmark are the only countries so far that have imposed a fat tax[10,11]. In the U.S., since the snack food tax in Maine and the District of Columbia was repealed in 2000 and 2001, respectively, no states currently levy taxes on snacks[94]. Although a majority of U.S. states have adopted a soft drink tax[12], the tax rate is believed to be too small to induce a meaningful change in beverage consumption[95], and no tax revenue is earmarked for subsidizing healthier food purchases or physical activity programs[96]. Besides the opposition against targeted subsidies and taxation of foods from the food industry[93], concerns on the unintended consequences of these policies may also contribute to the slow and reluctant adoption of economic incentives in improving diet quality[94]. For example, a fat tax could be regressive for low-income populations who spend a higher proportion of income on food and consume more energy-dense foods. Although subsidies on low-fat foods are generally observed to increase sales and consumption of those products, improved health outcomes might not be achieved if higher consumption of low-fat foods leads to an increase in total energy intake.

Further research is warranted to advance knowledge about the role of subsidies and other economic incentives in modifying dietary behavior. Based on the limitations of existing literature, future studies should aim to improve several aspects. A sufficiently large and representative sample should be used to obtain more precise estimates at the population level and facilitate subgroup comparison. More rigorous experimental designs, such as RCT, should be adopted to clearly demonstrate causal effects and prevent contamination of potential confounders. Overall food purchases and total diet/energy intake, in addition to that of the subsidized foods, need to be carefully documented to detect any unintended

consequences. Finally, the experiment and follow-up period need to be sufficiently long to assess the evolution and long-term effectiveness and cost-effectiveness of intervention.

Conclusions

Subsidizing healthier foods tends to be effective in modifying dietary behavior. Even so, existing evidence is compromised due to various study limitations – small and convenience sample of interventions obscures the generalizability of study results, absence of overall diet assessment questions the effectiveness in reducing total caloric intake, short intervention and follow-up duration does not allow assessment of long-term impact, and lack of cost-effectiveness analysis precludes comparison across competing policy scenarios. Future studies are warranted to address those limitations and examine the long-term effectiveness and cost-effectiveness of economic incentives at the population level.

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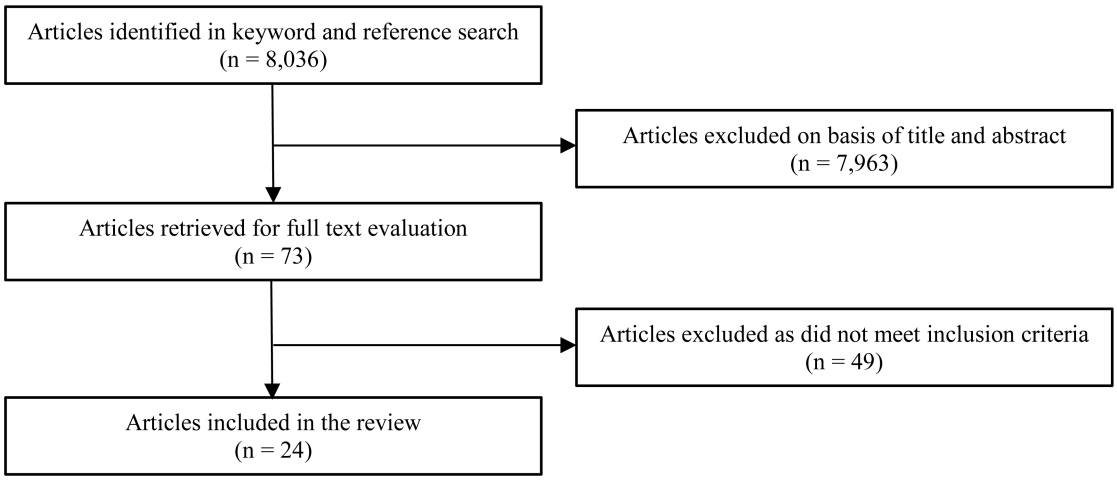

Figure 1.
Study Selection Flowchart

Table 1

Search Strategy for MEDLINE Database

	Search History
1	Economic
2	Financial
3	Monetary
4	Pecuniary
5	Fiscal
6	Incentive
7	Motivation
8	Discount
9	Rebate
10	Refund
11	Subsidy
12	Cash
13	Voucher
14	Bonus
15	Reward
16	Award
17	Coupon
18	Token
19	Reimbursement
20	Repayment
21	Ticket
22	Gift
23	Raffle
24	Lottery
25	Prize
26	Money
27	Price
28	Food
29	Diet
30	Nutrition
31	Eating
32	1 or 2 or 3 or 4 or 5
33	6 or 7
34	32 and 33
35	8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27
36	34 or 35
37	28 or 29 or 30 or 31
38	36 and 37
	Limited to title/abstract, human, English, and between

Search History
January 1st 1990 and May 1st 2012

Table 2a

Summary of Studies Included in a Review of Field Experiments on the Effectiveness of Subsidies in Promoting Healthy Food Purchases and Consumption, Continued

Study ID	First Author, Year	Intervention Country	Intervention Duration (Week)	Follow-up Duration (Week)	Study Design	Economic Incentive	Eligible Item	Intervention Environment
1	Jeffery RW, 1994	United States	3	3	Pre-post	Price discount	Fruits, salad	University cafeteria
2	Paine-Andrews A, 1996	United States	9.5 hours	0	Pre-post	Price discount	Low-fat milk, low-fat salad dressings, low-fat frozen desserts	Supermarket
3	French SA, 1997a	United States	4	3	Pre-post	Price discount	Low-fat snacks	University
4	French SA, 1997b	United States	3	3	Pre-post	Price discount	Fruits, carrot, salad	High school cafeteria
5	Kristal AR, 1997	United States	32	0	RCT	Voucher	Fruits/vegetables	Supermarket
6	Anderson JV, 2001	United States	8	0	Cohort	Voucher	Fruits/vegetables	Farmers' market
7	French SA, 2001	United States	48	0	RCT	Price discount	Low-fat snacks	Secondary school, worksite
8	Bamberg S, 2002	Germany	1	0	RCT	Voucher	Organic fruits/vegetables	Organic food store
9	Hannan P, 2002	United States	31	0	Pre-post	Price discount	Fresh fruits, low-fat cookies, low-fat cereal bars, low-fat chips	High school cafeteria
10	Horgen KB, 2002	United States	16	0	Pre-post	Price discount	Low-fat chicken sandwich, low-fat salad, vegetable soup	Restaurant
11	Herman DR, 2006; Herman DR, 2008	Unite States	24	24	Cohort	Voucher	Fresh fruits/vegetables	Supermarket, farmers' market
12	Burr ML, 2007	United Kingdom	32	0	RCT	Voucher	100% orange juice	Home
13	Michels KB, 2008	United States	5	5	Pre-post	Price discount	Healthier foods	University cafeteria
14	Brown DM, 2009	United States	40	0	Pre-post	Price discount	Healthier beverages	Middle/high school
15	Bihan H, 2010; Bihan H, 2012	France	48	0	RCT	Voucher	Fresh fruits/vegetables	Supermarket
16	French SA, 2010a; French SA, 2010b	United States	72	0	RCT	Price discount	Healthier foods and drinks	Worksite
17	Lowe MR, 2010	United States	12	36	RCT	Price discount	Low-calorie foods	Hospital cafeteria
18	Ni Mhurchu C, 2010; Blakely T, 2011	New Zealand	24	24	RCT	Price discount	Healthier foods	Supermarket
19	Kocken PL, 2012	Netherlands	18	0	RCT	Price discount	Low-calorie foods and drinks	High school
20	An R, 2013	South Africa	132	0	Cohort	Price discount	Healthier foods	Supermarket

Table 2b

Summary of Studies Included in a Review of Field Experiments on the Effectiveness of Subsidies in Promoting Healthy Food Purchases and Consumption, Continued

Study ID	First Author, Year	Targeted Population	Targeted Behavior	Sample Size/Unit	Intervention Strategy
1	Jeffery RW, 1994	University employees	Cafeteria food purchase	321 employees	The cafeteria intervention consisted of doubling the number of fruit choices, increasing salad ingredient selections by 3, and reducing the prices of fruits and salad by 50%
2	Paine-Andrews A, 1996	Supermarket shoppers	Supermarket food purchase	N/A	The supermarket intervention consisted of prompting, product sampling, and a 20–25% price discount for low-fat milk, salad dressings, and frozen desserts using an interrupted time series design with switching replications
3	French SA, 1997a	University students and employees	Vending machine purchase	9 vending machines	Prices of low-fat snacks in vending machines were reduced by 50% during the intervention and returned to normal after the intervention
4	French SA, 1997b	High school students and employees	Cafeteria food purchase	2 cafeterias	Prices of fruits, carrot, and salad were lowered by about 50% during intervention, and attractive signs promoting the target items at half price were placed; prices returned to normal after the intervention
5	Kristal AR, 1997	Supermarket shoppers	Supermarket grocery purchase	960 shoppers	Eight supermarkets were randomized to 2 groups: the intervention consisted of 3 components (i.e., provision of supermarket flyers identifying fruits/vegetables on sale, recipes and menu ideas for using sale foods, and a voucher of $0.5 for fruit/vegetable purchases; store signage to identify fruits/vegetables featured on flyer; consciousness-

Study ID	First Author, Year	Targeted Population	Targeted Behavior	Sample Size/Unit	Intervention Strategy
					raising activities e.g. food demonstrations and nutrition related signage); the control supermarkets remained the same
6	Anderson JV, 2001	Low-income women	Farmers' market produce purchase	564 women	Participants were assigned to 4 groups: education about the use, storage and nutritional value of fruits/ vegetables; distribution of farmers' market vouchers ($20); education plus vouchers; no intervention
7	French SA, 2001	Secondary school students, employees	Vending machine purchase	55 vending machines	Four pricing levels of low-fat snacks (0%, 10%, 25%, 50% discount) and 3 promotional conditions (none, low-fat label, and low-fat label plus promotional sign) were crossed in a Latin square design
8	Bamberg S, 2002	University students	Organic food purchase	320 students	Participants were randomized to 4 groups: a $7.5 voucher for organic food purchase; a stimulation message to form a specific plan when to act; voucher plus stimulation message; and no intervention
9	Hannan P, 2002	High school students and employees	Cafeteria food purchase	1 cafeteria	Prices on 3 high-fat food items popular with students (i.e., French fries, cookies, and cheese sauce) were raised by about 10%, and prices on 4 lower fat items (i.e., fresh fruits, low-fat cookies, low-fat cereal bars, and low-fat chips) were lowered approximately 25%
10	Horgen KB, 2002	Restaurant patrons	Restaurant food purchase	1 restaurant	The restaurant had 3 consecutive interventions: 20–30% price discounts for a low-fat grilled chicken sandwich, a low-fat salad with grilled chicken, and a low-fat vegetable soup; health messages; price discounts plus health messages

Study ID	First Author, Year	Targeted Population	Targeted Behavior	Sample Size/Unit	Intervention Strategy
11	Herman DR, 2006; Herman DR, 2008	Low-income postpartum women	Fruit/vegetable intake	602 postpartum women	Participants were assigned to 3 groups: vouchers ($40 /month) exchangeable for fresh fruits/vegetables in farmers' market; vouchers ($40 /month) exchangeable for fresh fruits/vegetables in supermarket; control condition with a minimal nonfood incentive
12	Burr ML, 2007	Low-income pregnant women	Fruit intake	190 pregnant women	Participants were randomized to 3 groups: a control group who received usual care; an advice group given advice and leaflets promoting fruit and fruit juice consumption; a voucher group given vouchers exchangeable for daily fruit juice delivered for free
13	Michels KB, 2008	University students and employees	Cafeteria food purchase	1 restaurant	Prices of healthier foods/dishes in cafeteria were reduced by 20%, and educational materials on current knowledge about the relationship between diet and health were distributed during intervention; prices returned to normal after intervention
14	Brown DM, 2009	Middle/high school students	Vending machine purchase	15 schools	Prices of healthier beverages in school vending machines were reduced by 10−25%, healthier beverages were advertised on vending machine fronts and in school stores, and the types and proportions of healthier beverages were increased
15	Bihan H, 2010; Bihan H, 2012	Low-income adults	Fruit/vegetable intake	302 adults	Participants were randomized into 2 groups: dietary advice alone; dietary advice plus vouchers (€10–40 / month) exchangeable for fresh fruit/ vegetables
16	French SA, 2010a; French SA, 2010b	Metropolitan transit workers	Vending machine purchase	33 vending machines	The number of healthier items was increased to 50% and

Study ID	First Author, Year	Targeted Population	Targeted Behavior	Sample Size/Unit	Intervention Strategy
					prices were lowered by 10% or more in the vending machines in 2 metropolitan bus garages; 2 control garages offered vending choices at usual availability and prices
17	Lowe MR, 2010	Hospital and university employees	Cafeteria food purchase; food intake	96 employees	Participants were randomly assigned to 2 groups: environmental change only (i.e., introduction of new low-calorie foods and provision of labels for all foods sold); environmental change plus 15–25% price discount for low-calorie foods purchase and education about low-calorie eating
18	Ni Mhurchu C, 2010; Blakely T, 2011	Supermarket shoppers	Supermarket grocery purchase	1,104 supermarket shoppers	Participants were randomly assigned to 4 groups: 12.5% price discount on healthier foods; tailored nutrition education; discount plus education; no intervention
19	Kocken PL, 2012	High school students and employees	Vending machine purchase	28 schools	Schools were randomly assigned to 2 groups: 3 consecutive interventions – increasing the availability of lower-calorie products in vending machines, labeling products, and reducing price of lower-calorie products, with phase 3 incorporating all 3 strategies, were introduced to the intervention schools; the control schools remained the same
20	An R, 2013	Health insurance plan members	Food intake	351,319 HealthyFood participants	HealthyFood program participants received 10–25% price discounts for healthier food purchases in supermarkets; nonparticipants received no discount

Table 2c

Summary of Studies Included in a Review of Field Experiments on the Effectiveness of Subsidies in Promoting Healthy Food Purchases and Consumption, Continued

Study ID	First Author, Year	Outcome Measure	Study Results	Intervention Effectiveness
1	Jeffery RW, 1994	Objectively measured cafeteria sales; self-report food purchases	• Fruit and salad purchases increased threefold during intervention and largely returned to normal after intervention • Women and those trying to control weight were most responsive to the intervention	Combination of price discounts and increased availability effective in fruit and salad consumption
2	Paine-Andrews A, 1996	Objectively measured supermarket sales	The combination of prompting, product sampling, and price discount was associated with low to moderate increases in the purchases of low-fat milk, salad dressings, and frozen desserts	Combination of prompting, product sampling, and price discounts effective in low-fat food consumption
3	French SA, 1997a	Objectively measured vending machine sales	The ratio of low-fat snacks to total purchases increased from 25.7% to 45.8% during intervention and decreased to 22.8% after intervention	Price discount effective in low-fat snacks consumption
4	French SA, 1997b	Objectively measured cafeteria sales	• Fruit and carrot sales increased approximately fourfold and twofold during intervention, respectively • No significant effects on salad sales	Price discount effective in fruit and carrot consumption
5	Kristal AR, 1997	Self-report fruit/vegetable intake	No evidence was found that the intervention increased shoppers' consumption of fruits and vegetables	Larger financial incentive needed to induce shoppers to purchase more fruits/vegetables
6	Anderson JV, 2001	Self-report fruit/vegetable intake; objectively measured voucher redemption	• Both vouchers and education were associated with significant increase in fruit/vegetable intake • The maximum impact of the intervention was achieved through a combination of vouchers and education	Both vouchers and education effective in fruit/vegetable consumption; combination most effective
7	French SA, 2001	Objectively measured vending machine sales	• Price discounts of 10%, 25%, and 50% on low-fat snacks were associated with increases in the	Price discount effective in fruit and carrot consumption; promotional signage marginally effective

Study ID	First Author, Year	Outcome Measure	Study Results	Intervention Effectiveness
			percentages of low-fat snack sales by 9%, 39%, and 93%, respectively • Promotional signage was independently but weakly associated with increases in low-fat snack sales • Average profits per machine were not affected by intervention	
8	Bamberg S, 2002	Objectively measured voucher redemption	• Vouchers, stimulation message, and a combination of both were all associated with higher probability of organic produce purchases compared to no intervention • The difference in effectiveness of the 3 interventions was not statistically significant	Both vouchers and stimulation message effective in organic produce consumption
9	Hannan P, 2002	Objectively measured cafeteria sales	• Fresh fruit sales increased throughout the intervention • Sales of low-fat cookies/chips increased but later declined • Sales of low-fat cereal bars remained stable • Four high-fat foods each showed a slow decline in sales	Revenue-neutral pricing (i.e., using revenue from taxing less-healthy food to subsidize healthier food purchase) effective in improving diet quality
10	Horgen KB, 2002	Objectively measured restaurant sales	Price discount alone, rather than a combination of price discount and health messages, was associated with increased purchases of healthier food items relative to control items	Price discounts but not health messages effective in healthier food consumption
11	Herman DR, 2006; Herman DR, 2008	Self-report fruit/vegetable intake	Fruit and vegetable consumption increased significantly among both the farmers' market participants (0.33 servings /1000 kJ) and the voucher group (0.19 servings /1000 kJ)	Vouchers effective in fruit/vegetable consumption
12	Burr ML, 2007	self-report fruit/juice intake; clinically measured β-carotene concentration	• Consumption of fruit juice and serum β-carotene concentration increased	Vouchers but not education effective in fruit juice consumption

Study ID	First Author, Year	Outcome Measure	Study Results	Intervention Effectiveness
			substantially in the voucher group • Education had no effect on fruit consumption	
13	Michels KB, 2008	Objectively measured restaurant sales	• Healthier food sales increased by 6% and less-healthy food sales decreased by 2% during intervention • After intervention, healthier food sales increased further to 17%, and a 2% decline in less-healthy food sales persisted	Price discounts effective in healthier food consumption with effect maintained beyond promotion period
14	Brown DM, 2009	Objectively measured vending machine sales	• Sales of soft drinks decreased and sales of healthier beverages increased during intervention • Total profits increased for a majority of schools during intervention	Combination of price discounts, passive marketing, and increased availability effective in healthier beverage consumption
15	Bihan H, 2010; Bihan H, 2012	Self-report fruit/vegetable consumption; clinically measured vitamin intake	• Fruit/vegetable consumption increased significantly in both the advice (0.62 times/day) and the voucher group (0.74 times/day) • Subjects in the voucher group had significantly decreased risk of low fruit/vegetable consumption relative to the advice group • No change in vitamin C and β-carotene concentration	Both vouchers and dietary advice effective in fruit/vegetable consumption
16	French SA, 2010a; French SA, 2010b	Objectively measured vending machine sales	Increases in availability (50%) and price discounts (approximately 31%) were associated with 10−42% higher sales of healthier items	Combination of price discounts and increased availability effective in healthier food consumption
17	Lowe MR, 2010	Objectively measured cafeteria sales; self-report food intake	• No difference between groups in total energy intake • Percent of energy from fat decreased and percent of energy from carbohydrate increased for both	Both price discounts and labeling effective in low-calorie food consumption

Study ID	First Author, Year	Outcome Measure	Study Results	Intervention Effectiveness
			groups, and the change remained significant after intervention	
18	Ni Mhurchu C, 2010; Blakely T, 2011	Objectively measured nutrients purchased; objectively measured healthier food purchases	• Price discounts were associated with increase in healthier food purchases by 11% during intervention and 5% after intervention • Education had no effect on food purchases • Neither price discounts nor tailored nutrition education had a significant effect on nutrients purchased	Price discounts but not education effective in healthier food consumption
19	Kocken PL, 2012	Objectively measured vending machine sales	• Availability, labeling, and price discounts raised the proportional sales of low-calorie drinks and reduced those of high-calorie foods • Labeling alone had no effect on food and drink purchases	Combination of price discount, increased availability, and labeling effective in healthier food consumption
20	An R, 2013	Self-report fruit/vegetable consumption	Participants consumed more fruit/vegetables and wholegrain foods, and less high sugar/salt foods, fried foods, processed meats, and fast-food relative to nonparticipants	Price discounts effective in healthier food consumption

Table 3

Quality Assessment of Studies Included in a Review of Field Experiments on the Effectiveness of Subsidies in Promoting Healthy Food Purchases and Consumption

Item	Criterion of Study Quality	Mean (SD)
1	A control group was included	0.60 (0.50)
2	Baseline characteristics between control and intervention groups were similar	0.25 (0.44)
3	The intervention period was at least 5 weeks	0.75 (0.44)
4	The follow-up period was at least 3 weeks	0.35 (0.49)
5	An objective measure of food purchases or intake was used	0.90 (0.31)
6	The measurement tool was shown to be reliable and valid in previously published studies	0.95 (0.23)
7	Participants were randomly recruited with a response rate of 60% or higher	0.05 (0.22)
8	Attrition was analyzed and determined not to significantly differ by respondents' baseline characteristics between control and intervention groups	0.35 (0.49)
9	Potential confounders were properly controlled in the analysis	0.50 (0.51)
10	Intervention procedures were documented in detail in the article	0.90 (0.31)
11	Total study quality score by Summing up Item 1 through 10	5.60 (1.90)

Note: Item 1 through 10 are all dichotomous variables.