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DISSERTATION

Eating Better for Less

Effectiveness of Financial Incentives in Modifying Dietary and Grocery Shopping Behavior

Ruopeng An

This document was submitted as a dissertation in April 2013 in partial fulfillment of the requirements of the doctoral degree in public policy analysis at the Pardee RAND Graduate School. The faculty committee that supervised and approved the dissertation consisted of Roland Sturm (Chair), Emmett Keeler, and Chloe Bird.

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Dissertation Abstract

Improving diet quality is a key health promotion strategy. Despite substantial interest in the role of prices and financial incentives to encourage healthy eating, there is little data on population-level price interventions. My dissertation examines the effectiveness of subsidies in modifying dietary and grocery shopping behavior by evaluating a nationwide price rebate program for healthy food purchases in South Africa.

Chapter I systematically reviews evidence from field experiments on the impact of subsidies in promoting healthy diet. Among the 20 interventions included in the review, all but one study found subsidies to significantly increase the purchase and consumption of promoted products. Types of interventions include randomized controlled trial, cohort study, or pre-post study. Almost all studies were implemented in very restrictive settings, such as in one or a few supermarkets, cafeterias, vending machines, farmers' markets, or restaurants, and usually had short intervention duration of a few weeks.

Subsequent chapters evaluate the HealthyFood program funded by the South Africa's largest private health insurance company Discovery Health. The HealthyFood program aims to promote healthy diet among privately-insured health plan members by providing price rebate for healthy food purchases. Till March 2012, about 330,000

Discovery Health health plan members had voluntarily participated in the HealthyFood program and received cash back by purchasing about 6,000 eligible food items in over 400 designated supermarkets across all nine provinces in South Africa. To my knowledge, it is the only price intervention to promote healthy diet that is fully funded by a private firm on an ongoing basis rather than as a short-term research project.

Chapter II provides an overview of the HealthyFood program and basic descriptive statistics of the survey sample. Because program participation is voluntary, a direct comparison between program participants and nonparticipants is likely to overestimate the price effects as those who have already adopted a healthier diet are also more likely to enroll.

Chapter III addresses the issue of self-selection bias using the instrumental variable method. Survey respondents' residential addresses and supermarkets are geocoded and differential distances from home to the nearest competing supermarket minus the distance to the nearest designated supermarket calculated. Differential distances to supermarkets affect program participation but are unlikely to directly influence diet. The instrument tries to approximately randomize individuals to different likelihoods of receiving rebate, so that the estimated effects are uncontaminated by selection bias. The instrumental variable method correcting for selection bias predicts a 25% price rebate for healthy food purchases to be associated with an increase in self-reported daily fruit and vegetable consumption by 21%, an increase in the probability of having three or

more servings of wholegrain foods per day by 40%, and a decrease in the probability of regularly having foods high in sugar by 26%, foods high in salt by 22%, fried foods by 23%, processed meat by 15%, and fast-food by 15%.

Chapter IV examines the impact of a 25% price rebate for healthy food purchases in modifying grocery shopping behavior. The analysis is restricted to purchases made with a Discovery credit card as this is the only identifying information for purchases not receiving a rebate. A case-control difference-in-differences method and panel data models are conducted on purchase data. Program participation predicts an increase in the ratio of expenditure on healthy foods and fruits and vegetables, a subcategory of healthier foods, to total food expenditure, and a decrease in the ratio of less desirable to total food expenditure. This result confirms the beneficial rebate effects on diet as seen in self-reported consumption data in Chapter III.

Increasing attention has been paid to the use of financial incentives to encourage healthy eating. A substantial subsidy for healthy foods is a promising strategy to improve diet quality among a large population.

Table of Contents

Dissertation Abstract.....ii
Acknowledgments.....ix
Introduction.....1
Chapter I Effectiveness of Subsidies in Promoting Healthy Food Purchases and Consumption: A Review of Field Experiments.....6
1.1 Introduction.....6
1.2 Methods.....9
1.2.1 Study Selection Criteria.....10
1.2.2 Search Strategy.....10
1.2.3 Data Extraction and Synthesis.....13
1.2.4 Study Quality Assessment.....13
1.3 Results.....14
1.3.1 Study Selection.....14
1.3.2 Intervention Effectiveness.....23
1.3.3 Study Quality.....26
1.4 Discussion.....27
1.5 Conclusion.....32
Chapter II HealthyFood – a National Rebate Program for Healthy Food Purchases in South Africa.....34
2.1 Introduction.....34
2.2 Setting and Data.....36
2.2.1 Discovery Health.....36
2.2.2 HealthyFood Program.....36
2.2.3 Health Risk Assessment Survey.....42
2.3 Methods.....44
2.3.1 Variable Construction.....44
2.3.2 Statistical Analysis.....46
2.4 Results.....46
2.5 Discussion.....48
Chapter III Evaluation of a National Rebate Program for Healthy Food Purchases: Instrumental Variable Analysis.....51
3.1 Introduction.....51
3.2 Methods.....52
3.2.1 Instrument Construction.....52
3.2.2 Instrumental Variable Analysis.....54
3.2.2.1 Linear Instrumental Variable Model.....55
3.2.2.2 Bivariate Probit Model.....57
3.2.3 Alternative Model Specifications and Sensitivity Analysis.....59
3.3 Results.....60
3.4 Discussion.....70

Chapter IV Effect of a National Rebate Program for Healthy Food Purchases in Modifying Grocery Shopping Behavior.....77
4.1 Introduction.....77
4.2 Data and Methods.....77
4.2.1 Supermarket Purchase Data.....77
4.2.2 Variable Construction.....79
4.2.3 Grocery Shopping Analysis.....80
4.2.4 Sensitivity Analyses.....82
4.3 Results.....84
4.4 Discussion.....92
References.....96

List of Figures

Figure 1.1 *Study Selection Flowchart……16*
Figure 2.1 *Flowchart of Discovery Health's HealthyFood Program……..38*
Figure 2.2 *Food Items Eligible for the HealthyFood Benefit Highlighted in Pick n Pay Supermarket……40*
Figure 2.3 *Food Items Eligible for the HealthyFood Benefit Marked on Pick n Pay Cash Register Receipt……41*
Figure 4.1 *Sample Selection Flowchart for Grocery Shopping Analysis……...79*
Figure 4.2 *Monthly Household Grocery Shopping Pattern among HealthyFood Participants and Nonparticipants Before and After Receiving a 25% Price Rebate for Healthy Food Purchases……87*

List of Tables

Table 1.1 *Search Strategy for MEDLINE Database……..12*
Table 1.2 *Summary of Studies Included in a Review of Field Experiments on the Effectiveness of Subsidies in Promoting Healthy Food Purchases and Consumption……..…18*
Table 1.3 *Quality Assessment of Studies Included in a Review of Field Experiments on the Effectiveness of Subsidies in Promoting Healthy Food Purchases and Consumption…….27*
Table 2.1 *Descriptive Statistics of the Health Risk Assessment Survey Respondents……..…48*
Table 3.1 *Descriptive Statistics of the Health Risk Assessment Survey Respondents by Rebate Reception Status for Healthy Food Purchases…….……61*
Table 3.2 *Descriptive Statistics of the Health Risk Assessment Survey Respondents by Differential Distances to Supermarkets…….……..63*
Table 3.3 *Estimated Effects on Receiving a 25% Price Rebate for Healthy Food Purchases of Differential Distance to Supermarkets…….……..……..64*
Table 3.4 *Estimated Associations between Differential Distance to Supermarkets and Individual Demographics…….……..……65*
Table 3.5 *Estimated Effects on Diet and Body Weight of a 25% Price Rebate for Healthy Food Purchases Using Ordinary Least Squares, Linear Instrumental Variable, Bivariate Probit, and Individual Fixed-effect Models…….…….68*
Table 3.6 *Comparison of Estimated Effects Using Individual Fixed-effect Models on Dietary Intake and Body Weight of a 25% Rebate for Healthy Food Purchases between Subsamples with Non-missing and Missing Values of Differential Distances to Supermarkets.....70*
Table 4.1 *Baseline Household Food Purchases at Designated Supermarkets (Prior to Eligibility for Rebate), by Eventual Rebate Status…….....85*
Table 4.2 *Estimated Effects on Monthly Household Grocery Shopping Pattern of a 25% Price Rebate for Healthy Food Purchases in Household Fixed-effect Models……..……...91*

Acknowledgments

I would like to show my earnest gratitude to my Dissertation Committee Chair Dr. Roland Sturm, Senior Economist at RAND Corporation and Professor at RAND Graduate School. He is an admirable advisor who helps me grow in every aspect in the academic field from proposal writing to data analysis and from manuscript drafting to editorial services. I could never thank him enough for his sincerity, thoroughness, and trust.

I thank my Dissertation Committee Members Dr. Emmett Keeler and Dr. Chloe Bird for their inspirational instructions and decisive support on my academic pursuit. I also thank Dr. Derek Yach for his insightful comments on my dissertation as an outside reader.

I thank my collaborators in Discovery Vitality Dr. Deepak Patel, Mr. Darren Segal, Mr. Josiase Maroba, and Ms. Lauren Wyper for sharing institutional knowledge and hard work in data preparation.

I cannot imagine myself accomplishing anything without the everlasting support from my wife Jing Liu. Throughout all these years of hard work, joy or sorrow, she and her

encouragement are always with me. And now we have our son Louwyn Mingze An, a heritage from the Lord, a fountain of happiness, and a source of willpower to move forward and embrace a new phase in our life.

Introduction

Improving diet quality is a key health promotion strategy. Since 1980, a major theme of U.S. Federal dietary guidelines has been to increase consumption of nutrient-rich foods and reduce consumption of energy-dense foods (USDA & HHS, 2010). Based on National Health and Nutrition Examination Survey 2001-2004 data, a large majority of the U.S. population fails to meet those guidelines, with insufficient consumption of nutrient-rich foods and excessive discretionary calorie intake (Smith et al., 2010). Despite substantial interest in the role of prices and financial incentives to encourage healthy diet, data are limited and none come from interventions in a large population.

The idea of price interventions to promote healthy diet has drawn much attention from policy makers worldwide. The World Health Organization (WHO) recommended fiscal policies (i.e., subsidy, taxation, and direct pricing) to influence food prices "in ways that encourage healthy eating" (WHO, 2004, 2008). In September 2011, Hungary imposed a ten forint (approximately $0.04) tax on packaged foods high in fat, sugar or salt (Cheney, 2011). One month later, Denmark implemented a tax of 16 Danish Kroner (approximately $2.80) per kg of saturated fat on domestic and imported foods with a

saturated fat content exceeding 2.3% (USDA, 2011); however, the tax was repealed within a year of implementation (Strom, 2012). The Food, Conservation, and Energy Act of 2008 (HR 2419, 2008) required a U.S. Department of Agriculture pilot project to examine the effectiveness of a 30% price discount for fruits, vegetables, and other healthy foods in changing dietary behavior among a low-income population enrolled in the Supplemental Nutrition Assistance Program (USDA, 2012). Study subjects are limited to residents in one Massachusetts county, and preliminary results may be available in 2013.

My dissertation evaluates a large subsidy program that has been operating nationwide since 2009 in South Africa. The program is known as the "HealthyFood" benefit and is available to members of Discovery Health, South Africa's largest private health insurance company. Program participants receive a 25% price rebate for purchases of eligible food items in designated supermarkets. To my knowledge, Discovery Health's HealthyFood program is the only price intervention to promote healthy diet that is fully funded by a private firm on an ongoing basis, rather than as a short-term research project. The program may also be unique worldwide due to its size (approximately 330,000 enrollees) and geographic scope (over 400 participating supermarkets across the nation). I examine the effect of receiving the rebate on diet and grocery shopping

behavior by analyzing repeated surveys on program participants and nonparticipants and monthly household supermarket food purchase data.

Little is known about whether reducing prices for nutrient-rich, low-energy-dense foods can meaningfully change dietary behavior at the population level. Chapter I systematically reviews evidence from field interventions on the effectiveness of monetary subsidies in promoting healthy food purchases and consumption. The 20 interventions included in the review were conducted in seven countries, enrolled various population subgroups such as school/university students, metropolitan transit workers, and low-income women, with subsidies in the form of price discounts or vouchers applied to different foods such as fruits, vegetables, and low-fat snacks.

Numerous studies have estimated the own price elasticity of demand for fruits and vegetables. A recent systematic review of 20 U.S. based studies documents a 1% decrease in price to be associated with 0.70 (95% CI: 0.41-0.98) and 0.58 (95% CI: 0.44-0.71) percentage increase in purchased quantity of fruits and vegetables, respectively (Andreyeva et al., 2010). Little research has been done in estimating price effects on substitutions from less desirable to healthy foods. Economic theory suggests when the price of healthy diets drops, individuals will substitute healthy foods for less desirable

ones, but as their real income increases due to price reduction, they may spend more on food and nonfood overall, including less desirable foods. Chapter II and III assesses the impact of a 25% price rebate for healthy foods on consumption of both healthy and less desirable foods by analyzing repeated health risk assessment surveys of HealthyFood program participants and nonparticipants.

In the diet analysis using survey data, a direct comparison between HealthyFood program participants and nonparticipants is likely to overestimate the rebate effects, as those who have already adopted a healthier diet are also more likely to enroll. Chapter III uses instrumental variable method to address the selection bias. Differential distances from home to the nearest competing supermarket minus the distance to the nearest designated supermarket are likely to affect program participation but unlikely to directly influence diet, while the latter cannot be directly tested empirically. If differential distances constitute a valid instrument, they approximately randomize individuals to different likelihoods of receiving rebate, so that the estimated effects are uncontaminated by selection bias.

Chapter IV examines the impact of the 25% price rebate for healthy foods in modifying grocery shopping patterns. I link purchases to individuals before and after rebate

eligibility to assess the effect of a 25% price change. The analysis is restricted to purchases made with a Visa credit card issued by Discovery as this is the only identifying information for purchases not receiving a rebate. A difference-in-difference approach and household fixed-effect models are conducted on monthly household food purchase scanner data at designated supermarkets, and the dependent variables are the ratio of healthy food, fruit and vegetable, which is a subcategory of healthy foods, and less desirable food to total food expenditure.

Chapter I

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

1.1 Introduction

Poor diet quality and physical inactivity are among the most pressing behavior-related health challenges in the U.S. and worldwide, and are associated with major causes of morbidity and mortality, including cardiovascular disease, hypertension, type 2 diabetes, and some types of cancer (USDA & HHS, 2010). According to a systematic analysis on the global disease burden, dietary risk factors accounted for 7.2% of global disability-adjusted life years in 2010, with the most salient dietary risks being diets low in fruits and those high in salt (Lim et al., 2012). 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 (HHS National Prevention Council, 2011).

High prices remain a formidable barrier for many people, especially those of low socioeconomic status, to adopting a healthier diet (Darmon & Drewnowski, 2008). A 2004-2006 survey of major supermarket chains in Seattle found that 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

(Monsivais & Drewnowski, 2007). The large price differential between nutrient-rich, low-energy-dense foods such as fruits and vegetables and nutrient-poor, energy-dense foods may contribute to poor diet quality and various sociodemographic health disparities (Drewnowski & Specter, 2004; Drewnowski & Darmon, 2005; Monsivais & Drewnowski, 2007; Drewnowski, 2010).

The use of financial incentives in the promotion of health-related behavior change, including healthy diet, has received increasing attention. Preventive Medicine published a supplemental issue on the relationship between financial incentives and public health (Higgins et al., 2012), with extensive applications on diet, substance use, physical activity, medication adherence, etc. The World Health Organization recommended fiscal policies (i.e., taxation, subsidies, or direct pricing) to influence food prices "in ways that encourage healthy eating" (WHO, 2004, 2008). In September 2011, Hungary imposed a ten forint (approximately $0.04) tax on packaged foods high in fat, sugar or salt (Cheney, 2011). One month later, Denmark implemented a tax of 16 Danish Kroner (approximately $2.80) per kg of saturated fat on domestic and imported foods with a saturated fat content exceeding 2.3% (USDA Foreign Agricultural Service, 2011). However, the tax was appealed within a year of implementation (Strom, 2012). The Food, Conservation, and Energy Act of 2008 (Public Law H.R.6124, also known as the Farm Bill) (US Senate and House of Representatives, 2008) required a U.S. Department of Agriculture pilot project to examine the effectiveness of a 30% price rebate on fruits, vegetables, and other healthier foods in changing dietary behavior among low-income residents enrolled in the

Supplemental Nutrition Assistance Program (USDA, 2012). Preliminary results may be available in 2013.

In this study, I 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? Is the impact maintained after the withdrawal of the incentive? Admittedly, it is unrealistic to address all these issues in a single review as answers to those issues remain tentative, incomplete, and at times contradictory. Nevertheless, findings from existing literature serve as a starting point in the direction to synthesize relevant findings.

The current study is built upon the following four previous literature reviews. 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. Wall et al. (2006) reviewed randomized controlled trials (RCTs) that used monetary rewards to incentivize healthy eating and weight control. 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. Jensen et al. (2011) reviewed the effectiveness of economic incentives in modifying dietary behavior among school children.

The current study contributes to the literature by systematically reviewing the most recent scientific evidence on the effectiveness of monetary subsidies in promoting healthier food purchases and consumption. I exclusively focus on: (1) prospective field interventions with a clear study design; (2) monetary subsidies in the form of price rebate or voucher for healthier foods; and (3) food purchases and intake among adolescent and adult population.

1.2 Methods

1.2.1 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 rebates 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, I 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 rebate 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).

1.2.2 Search Strategy

I searched five electronic bibliographic databases – Cochrane Library, EconLit, MEDLINE, PsycINFO, and Web of Science, using various combinations of keywords such as "subsidy", "rebate", "voucher", "food", and "diet". A complete search algorithm for MEDLINE is reported in Table 1.1. 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.

I 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. I repeated reference searches on all newly-identified articles until no additional relevant article was found.

Table 1.1 Search Strategy for MEDLINE Database

	Search History
1	Economic
2	Financial
3	Monetary
4	Pecuniary
5	Fiscal
6	Incentive
7	Motivation
8	Rebate
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 January 1st 1990 and May 1st 2012

1.2.3 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 20 interventions included in this review, few adopted the same identification 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.

1.2.4 Study Quality Assessment

Following Wu et al. (2011), 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 five weeks; (4) the follow-up period was at least three 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 zero to ten 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.

1.3 Results

1.3.1 Study Selection

A total of 8,036 articles were identified in the keyword and reference search, among which 7,963 were excluded as off topic based on title/abstract screening. The remaining 73 articles were further evaluated in full text against the study selection criteria. Figure 1.1 shows the study selection process. Among them, 13 were controlled laboratory experiments (Epstein et al., 2006a, 2006b, 2007, 2010; Giesen et al., 2012), computer simulations (Waterlander et al., 2012a, 2012b), or modeling exercises (Cash et al., 2005; Jensen & Smed, 2007; Smed et al., 2007; Yaniv et al., 2009; Lin et al., 2010; Nordström & Thunström, 2011) rather than field interventions; six

exclusively enrolled children participants 11 years and younger (Lowe et al., 2004; Ponza et al., 2004; Siega-Riz et al., 2004; Nelson et al., 2006; Gentile et al., 2009; Horne et al., 2009); 10 were cross-sectional observational studies without clear study designs (Taren et al., 1990; Anliker et al., 1992; Balsam et al., 1994; Perez-Escamilla et al., 2000; Swensen et al., 2001; Kunkel et al., 2003; Ard et al., 2007; Kropf et al., 2007; Racine et al., 2010; Freedman et al., 2011); seven provided fruits and vegetables in school or other settings for free rather than using price rebate or voucher (Johnson et al., 2004; Bere et al., 2005, 2006, 2007; Jamelske et al., 2008; Cullen et al., 2009; Lachat et al., 2009), seven used economic incentives unrelated to healthier foods, i.e., financial rewards for weight loss (Jeffery et al., 1993, 1998; Jeffery & Wing, 1995; Jeffery & French, 1997, 1999) or subsidies on staple or other basic food necessities (Galal, 2002; Jensen & Miller, 2011); four used weight loss rather than food purchases or consumption as the outcome measure (Wing et al., 1996; Finkelstein et al., 2007; Volpp et al., 2008; John et al., 2011); and two were published before 1990 (Cinciripini, 1984; Mayer et al., 1987). Excluding the above articles yielded a final pool of 24 articles (Jeffery et al., 1994; Paine-Andrews et al., 1996; French et al., 1997a, 1997b, 2001, 2010a, 2010b; Kristal et al., 1997; Anderson et al., 2001; Bamberg, 2002; Hannan et al., 2002; Horgen & Brownell, 2002; Herman et al., 2006, 2008; Burr et al., 2007; Michels et al., 2008; Brown & Tammineni, 2009; Bihan et al., 2010, 2012; Lowe et al., 2010; Ni Mhurchu et al., 2010; Blakely et al., 2011; Kocken et al., 2012; An et al., 2013) with reported outcomes from 20 distinct field interventions.

Figure 1.1 Study Selection Flowchart

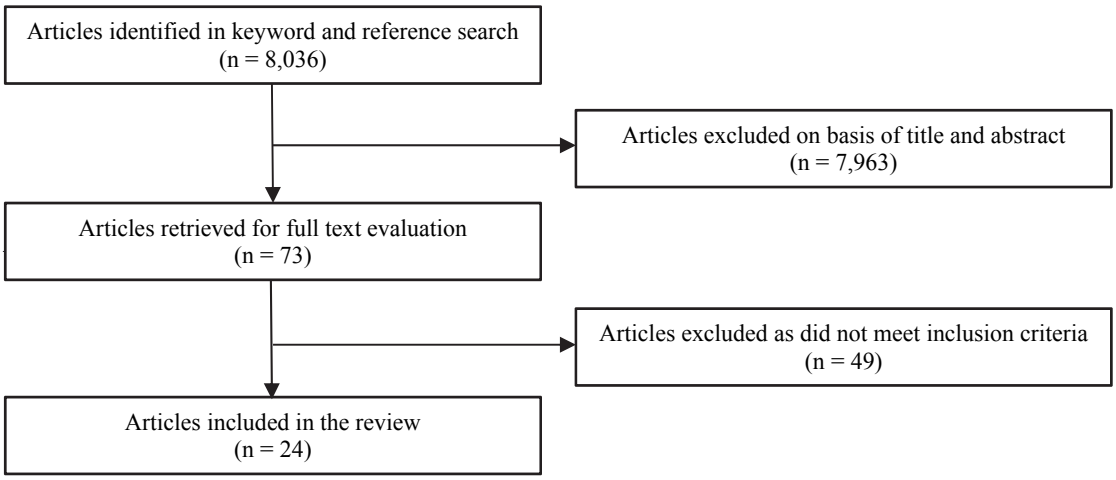


Table 1.2 (including three subsections i.e. 1.2a, 1.2b, and 1.2c) summarizes the studies included in the review. The 20 interventions were conducted in seven countries: a majority of them in the U.S., and the remaining six in Canada, France, Germany, Netherlands, South Africa, and United Kingdom. Fourteen interventions provided price rebates for healthier food items, and the other six used vouchers worth a certain amount of money exchangeable for healthier foods. Subsidies (i.e., price rebates 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.

Table 1.2a Summary of Studies Included in a Review of Field Experiments on the Effectiveness of Subsidies in Promoting Healthy Food Purchases and Consumption

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 rebate	Fruits, salad	University cafeteria
2	Paine-Andrews A, 1996	United States	9.5 hours	0	Pre-post	Price rebate	Low-fat milk, low-fat salad dressings, low-fat frozen desserts	Supermarket
3	French SA, 1997a	United States	4	3	Pre-post	Price rebate	Low-fat snacks	University
4	French SA, 1997b	United States	3	3	Pre-post	Price rebate	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 rebate	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 rebate	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 rebate	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 rebate	Healthier foods	University cafeteria
14	Brown DM, 2009	United States	40	0	Pre-post	Price rebate	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 rebate	Healthier foods and drinks	Worksite
17	Lowe MR, 2010	United States	12	36	RCT	Price rebate	Low-calorie foods	Hospital cafeteria
18	Ni Mhurchu C, 2010; Blakely T, 2011	New Zealand	24	24	RCT	Price rebate	Healthier foods	Supermarket
19	Kocken PL, 2012	Netherlands	18	0	RCT	Price rebate	Low-calorie foods and drinks	High school
20	An R, 2013	South Africa	132	0	Cohort	Price rebate	Healthier foods and drinks in 7 categories: vegetables, fruits, carbohydrate-rich foods, protein-rich foods, dairy and dairy alternatives, lentils and legumes, and oils, nuts, seeds and spreads	Supermarket

Table 1.2b 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 rebate 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-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% rebate) 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 rebates for a low-fat grilled chicken sandwich, a low-fat salad with grilled chicken, and a low-fat vegetable soup; health messages; price rebates plus health messages
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

Table 1.2b 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
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 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 rebate 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 rebate on healthier foods; tailored nutrition education; rebate 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	Supermarket grocery purchase and food intake	351,319 HealthyFood participants	HealthyFood program participants received 10–25% price rebates for healthier food purchases in supermarkets; non-price features of the intervention include labeling, point-of-sale marketing, and nutrition education; nonparticipants received no rebate

Table 1.2c 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 rebates 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 rebate 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 rebates 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 rebate 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 rebate 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 rebates of 10%, 25%, and 50% on low-fat snacks were associated with increases in the 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	Price rebate effective in fruit and carrot consumption; promotional signage marginally effective
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 rebate alone, rather than a combination of price rebate and health messages, was associated with increased purchases of healthier food items relative to control items	Price rebates but not health messages effective in healthier food consumption

Table 1.2c Summary of Studies Included in a Review of Field Experiments on the Effectiveness of Subsidies in Promoting Healthy Food Purchases and Consumption

Study ID	First Author, Year	Outcome Measure	Study Result	Intervention Effectiveness
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 substantially in the voucher group · Education had no effect on fruit consumption	Vouchers but not education effective in fruit juice 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 rebates 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 rebates, 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 rebates (approximately 31%) were associated with 10-42% higher sales of healthier items	Combination of price rebates 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 groups, and the change remained significant after intervention	Both price rebates and labeling effective in low-calorie food consumption
18	Ni Mhurchu C, 2010; Blakely T, 2011	Objectively measured nutrients purchased; objectively measured healthier food purchases	· Price rebates 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 rebates nor tailored nutrition education had a significant effect on nutrients purchased	Price rebates but not education effective in healthier food consumption
19	Kocken PL, 2012	Objectively measured vending machine sales	· Availability, labeling, and price rebates 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 rebate, increased availability, and labeling effective in healthier food consumption
20	An R, 2013	Objectively measured household supermarket food purchase; self-report dietary behavior	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 rebates effective in healthier food consumption

1.3.2 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. 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 rebates 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). The lower bounds (i.e., 10% price rebate 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 rebate interventions that the demands for fruits sold in cafeteria and low-fat snacks sold in vending machines 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. French et al. (1997b) reported the fruit sales in high school cafeterias increased fourfold following a 50% price reduction. Lowe et al. (2010) reported an increase of fruit intake by about 30% in hospital cafeterias when price was lowered by 15-25%. 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. French et al. (2010a) reported a fourfold increase in sales of low-fat snacks sold in worksite vending machines when prices decreased by 50%. 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 while French et al. (1997b) reported none.

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 rebate 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. An et al. (2013) reported a 10% and 25% rebate on healthier food purchases to be associated with an increase in daily fruit/vegetable intake by 0.38 and 0.64 servings, respectively.

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 rebate on food purchases across ethnic and socioeconomic groups. No variation in intervention effect was identified by household income or education, and the evidence for differential effects of price rebates 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) and Bihan et al. (2010, 2012) 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), Ni Mhurchu et al. (2010), and Blakely et al. (2011) found no impact of nutrition education on fruit or

other healthier food purchases. No effects on healthier food sales were found for health message (Horgen & Brownell, 2002), and some but limited effects were reported for product labeling (Lowe et al., 2010; Kocken et al., 2012), promotional signage (French et al., 2001), and stimulation message (Bamberg, 2002).

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 six-month follow-up reported in Herman et al. (2006, 2008), increased by about twofold in the five-week follow-up in Michels et al. (2008), and decreased by half in the six-month follow-up in Ni Mhurchu et al. (2010). Conversely, the other four interventions (Jeffery et al., 1994; French et al., 1997a, 1997b; Lowe et al., 2010) found no extended effect in the follow-up period.

1.3.3 Study Quality

Table 1.3 reports the results of study quality assessment. On average, studies included in the review met six 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.

Table 1.3 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.

1.4 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, I 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 less desirable ones, but as their real income increases due to price reduction, they may spend more on food overall, including less desirable 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. In practice, the long-term security of funding sources for subsidies could be of concern. 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. None of the reviewed studies explicitly measured cost-effectiveness of the interventions or evaluated the potential impact on the food industry. Moreover, 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, study 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 rebates 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), Kim and Kawachi (2006), and Brownell et al. (2009).

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. All four RCTs reviewed in Wall et al. (2006) documented a positive effect of monetary incentives on food purchases, food consumption, or weight loss. 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. Jensen et al. (2011) reviewed evidence from thirty articles and found price incentives to be effective for altering children's food and beverage intake at school.

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 (Cheney, 2011; USDA Foreign Agricultural Service, 2011), and the tax in Denmark has recently been withdrawn. 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 (Kim & Kawachi, 2006). Although a majority of U.S. states have a sales tax on sugar-sweetened drinks at a higher rate than the tax on other types of food (Brownell et al., 2009), the tax rate is still believed to be too small to induce a meaningful change in beverage consumption (Sturm et al., 2010), and no tax revenue is earmarked for subsidizing healthier food purchases or physical activity programs (Jacobson & Brownell, 2000). Besides the opposition against targeted subsidies and taxation of foods from the food industry (Caraher & Cowburn, 2005), concerns on the unintended consequences of these policies may also contribute to the slow and reluctant adoption of economic incentives in improving diet quality (Kim & Kawachi, 2006). 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 study 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.

1.5 Conclusion

Subsidizing healthier foods tends to be effective in modifying dietary behavior. 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.

Chapter II

HealthyFood – a National Rebate Program for Healthy Food Purchases in South Africa

2.1 Introduction

Improving diet quality is a key health promotion strategy. Released in June 2011, the National Prevention Strategy: America's Plan for Better Health and Wellness, considers healthy eating a priority area and calls for increased access to affordable healthy foods in communities (HHS National Prevention Council, 2011). A hotly debated topic is the role of food prices: Nutrient-rich foods including fruits and vegetables have become more expensive relative to calorie-dense nutrient-poor foods, and some researchers believe that the increasing price differential contributes to obesity and sociodemographic health disparities (Drewnowski & Specter, 2004; Drewnowski & Darmon, 2005; Monsivais & Drewnowski, 2007; Drewnowski, 2010).

It is not known whether a price rebate on fruits, vegetables, or other healthy foods can meaningfully change dietary behaviors in the population, let alone reduce the prevalence of obesity. The Food, Conservation, and Energy Act of 2008 (Public Law 6124, also known as the Farm Bill) requires the U.S. Department of Agriculture (USDA) to field a pilot project - the Healthy Incentives Pilot (HR 2419, 2008). The pilot project is expected to enroll individuals eligible for the Supplemental Food Assistance Program in one Massachusetts county, and offer them a 30% cash back on healthy food purchases during 2012 (USDA, 2012). This project is not expected to have preliminary results until 2013.

However, a much larger rebate program has been operating nationwide since 2009 – but in South Africa. The program, known as the "HealthyFood" benefit, is available to members of Discovery Health, South Africa's largest private health insurance company. Under the HealthyFood benefit, members receive cash back on healthy food purchases. To my knowledge, Discovery Health's HealthyFood program is the only price intervention to promote healthy diet that is fully funded by a private firm on an ongoing basis, rather than as a short-term study project. The program may also be unique worldwide due to its size (about 330,000 households are enrolled) and geographic scope (nationwide across South Africa with over 400 participating supermarkets). This chapter

provides an overview of the HealthyFood program and some descriptive statistics using the repeated surveys on members of Discovery Health. The impact of HealthyFood program participation on dietary behavior and body weight will be examined in the subsequent chapter.

2.2 Setting and Data

2.2.1 Discovery Health

Discovery Health is South Africa's largest private health insurance provider with over two million members, accounting for about 40% of the total industry market share. It offers a variety of plan options to address different medical demands – from Executive Plan which offers extensive care and broad access to healthcare professionals to KeyCare which provides essential healthcare needs.

2.2.2 HealthyFood Program

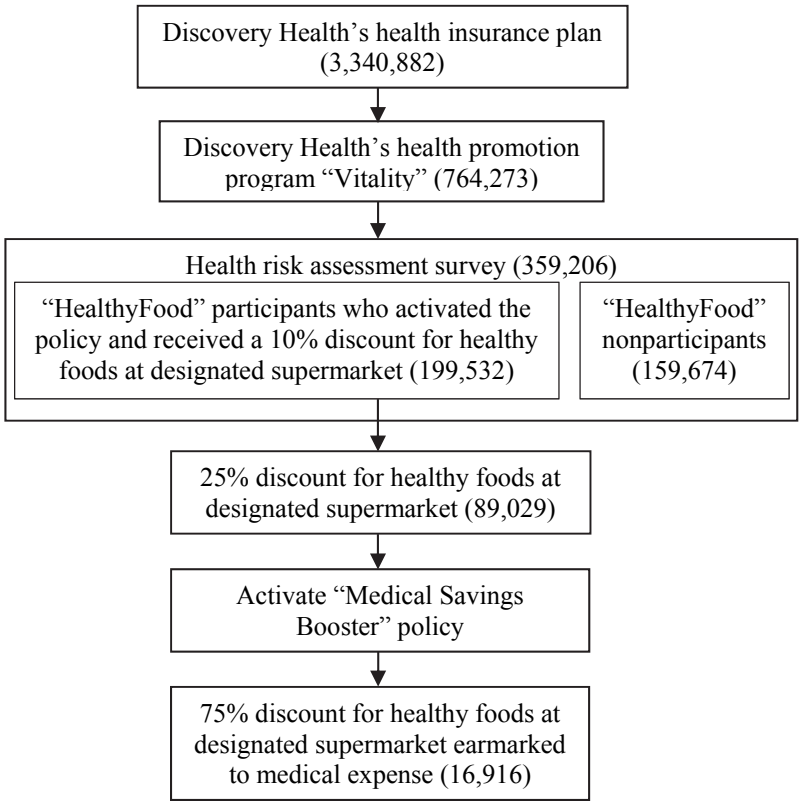
The HealthyFood program aims to promote healthy diet among privately-insured health plan members. The program was launched in February 2009 by the South African health insurance company Discovery Health, as part of Discovery Health's health promotion program Vitality. Vitality is a supplemental program to augment Discovery Health's health insurance plan. Vitality membership is a prerequisite for the HealthyFood benefit. Everyone enrolled in Vitality is eligible for the benefit at no cost, but one needs to activate membership either online or with a phone call. Upon activation of the benefit, Vitality members immediately begin to receive a 10% rebate for healthy foods and become eligible for a 25% rebate as soon as the policy holder and spouse, if applicable, have both completed an online health risk assessment questionnaire.

The rebate is capped at a maximum monthly purchase amount of 4,000 rands (approximately $480) per household and a limit related to participation in health promotion activities. The main goal of this nonlinear pricing scheme is to prevent fraud and the constraints are intended not to be binding for a typical household engaged in Vitality.

A temporary option called "Medical Savings Booster" once provided a 75% rebate for healthy foods to HealthyFood enrollees but the cash back had to be used for out-of-pocket medical expenses. This option was ended in 2011.

Currently over 330,000 individuals from all nine provinces in South Africa are enrolled in the HealthyFood program. Participants can claim rebate at 432 full-size Pick n Pay supermarkets. Eligible items are marked on cash register receipts. Figure 2.1 shows a flowchart of the HealthyFood program.

Figure 2.1 Flowchart of Discovery Health's HealthyFood Program



Note: Number of enrollees during February 2009 and November 2011 is in parenthesis.

A panel consisting of nutritionists, physicians and behavioral scientists has systematically reviewed food items in seven categories – vegetables, fruits, carbohydrate-rich foods, protein-rich foods, dairy and dairy alternatives, lentils and legumes, and oils, nuts, seeds and spreads – to determine which are eligible for the HealthyFood benefit. Selection is based on South African, U.S., and other international dietary guidelines on healthy nutrition (Vorster et al., 2001; HHS & USDA, 2005), and is continuously updated. A complete list of eligible items (about 6,000) can be found on Discovery Health's website (https://www.discovery.co.za/portal/individual/vitality-nutrition), and is also distributed as brochures to program participants.

As Figure 2.2 shows, food items eligible for the HealthyFood benefit are highlighted inside Pick n Pay supermarkets. Moreover, as Figure 2.3 shows, eligible items are marked on cash register receipts together with the message "Discovery Vitality members save up to 25% on HealthyFood™. Visit www.discovery.co.za. Now more than ever it pays to be healthy!"

Figure 2.2 Food Items Eligible for the HealthyFood Benefit Highlighted in Pick n Pay Supermarket

Figure 2.3 Food Items Eligible for the HealthyFood Benefit Marked on Pick n Pay Cash Register Receipt

Pick n Pay
Inspired by you

PLEASE RETAIN AS YOUR GUARANTEE
CUSTOMER CARE LINE: 0800 11 22 88

MINERAL WATER STILL	000			12.99
WHITE GRAPES BOX	000	#	VIT	24.99
F/F STRAWBERRY YOG	000		VIT	14.99
CHICKEN STIRFRY	000			10.09
LOW FAT CHEESE VP	000			25.99
BABY MARROWS	000	#	VIT	11.99
PRETZELS SESAME RING	000			18.39
CHIPS CARIB/ONION&B/	000			7.29

ITEMS	8	T O T A L	126.72
BANK CARDS			126.70
CARD-NO		**********	3013
Rounding			0.02

TAX EXEMPT INDICATOR *
NON-TAXABLE INDICATOR #
DISCOVERY VITALITY VIT

TAX INVOICE
VAT REG NO. 4390107474

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*7576 2621/012/032 10.01.09 11:58 AC-00

Discovery Vitality members save up to
25% on HealthyFood™.
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Now more than ever it pays to be healthy!

Besides healthy foods, less desirable food items are also identified by the panel. A less desirable item is defined as a food or drink that is high in saturated fat, trans fat, sugar, salt, or refined starch. These items are typically low in vitamins, minerals, or fiber, and usually have a high energy-density. The less desirable food category consists of sugary foods and drinks, biscuits, crisps, high fat baked and fried items, sweets, chocolates, and ice-cream.

2.2.3 Health Risk Assessment Survey

A health risk assessment (HRA) is a standardized questionnaire to elicit information about a respondent's health status and health-related habits and risks (Perez et al., 2009). Discovery Health regularly fields HRA on its Vitality members. Participation is voluntary, and there is no penalty associated with nonparticipation, but in order to receive (or keep) a 25% rebate for healthy foods, at least one survey needs to be completed on a rolling 12-month basis. During the study period from February 2009 to November 2011, a total of 359,206 (47%) Vitality members took the survey. On average, each individual took the survey twice. About 42% of the survey respondents activated

the HealthyFood benefit and 25% received a 25% rebate rate, among which 19% ever activated the "Medical Savings Booster" policy.

In my dissertation, I exclusively focus on the impact of a 25% rebate on diet and grocery shopping behavior because: all and only 25% rebate recipients are required to take the HRA survey, and a 75% rebate under the provisional "Medical Savings Booster" policy is fundamentally different from its 25% counterpart in earmarking cash back to medical expenditure. The total study sample consists of 480,299 surveys completed by 274,406 Vitality members.

Unlike more complete diet assessments such as a food-frequency questionnaire or 24-hour dietary recall, questions on diet in the HRA survey are limited. The specific items include:

"How many servings of vegetables and fruits do you eat on average in a day?";

"How often do you eat wholegrain products (such as whole grain bread, cereal, oats, barley, millet, whole corn, whole grain crackers, brown rice or whole wheat pasta)? – never, less than three servings a day, or three or more servings a day";

"How salty do you like your food? – not salted, lightly salted, or very salty";

And "How often do you eat any of the following? (a) cakes, cookies, pastries, muffins, chocolate, regular ice cream or sweets – never, sometimes, often; (b) fried foods like chips, fried chicken or fritters – never or occasionally, weekly, or daily; (c) processed meats like viennas and other deli meats – never or occasionally, weekly, or daily; and (d) fast-food – never or occasionally, weekly, or daily."

The survey also includes questions on body weight and height:

"How much do you weigh?";

And "How tall are you?"

2.3 Methods

2.3.1 Variable Construction

Using the HRA survey data, I construct 10 variables related to dietary behavior and/or body weight status:

A count variable for daily servings of fruits and vegetables;

A dichotomous variable for eating three or more servings of wholegrain foods per day;

A dichotomous variable for often consuming foods high in sugar (zero denoting "never" or "sometimes");

A dichotomous variable for consumption of foods high in salt (zero denoting "not salted" or "lightly salted");

Three dichotomous variables for "daily" or "weekly" consumption of fried foods, processed meat, and fast-food (zero denoting "never or occasionally");

A continuous variable for body mass index (BMI, i.e., ratio of weight in kilograms to height in square meters) calculated from self-reported weight and height;

And two dichotomous variables for being overweight (BMI ≥ 25) and obese (BMI ≥ 30).

The treatment variable which denotes participation in the HealthyFood program is a dichotomous variable for receiving a 25% rebate for healthy foods at the time of survey. Individuals who had not activated the benefit and thus had not received any rebate prior to the survey date have a zero value on the treatment variable.

Other demographic variables include:

A dichotomous variable for male;

Age in years at the time of survey;

And the interaction between gender and age.

2.3.2 Statistical Analysis

As part of the descriptive statistics, I compare demographic characteristics, dietary behavior, and body weight status between HealthyFood program participants and nonparticipants using two-sample t-test with unequal variance. Statistical analyses are conducted in STATA 12.0 (StataCorp, College Station, TX).

2.4 Results

Table 2.1 Column 3 shows the descriptive statistics of the HRA survey respondents. On average, they consume 3.4 servings of fruits and vegetables daily. Twenty-four percent of them have three or more servings of wholegrain foods per day, and 12%, 6%, 30%, 22%, and 29% have foods high in sugar, foods high in salt, fried foods, processed meats, and fast-food on a regular basis, respectively. Prevalence of overweight and obesity are

55% and 20%, respectively, which are substantially lower than South Africa's population average in 2008 with overweight rate of 65% and obesity rate of 31% (WHO, 2011).

Table 2.1 Columns 4-6 compare the outcome measures on diet and body weight between HealthyFood program participants and nonparticipants using two-sample t-test with unequal variance. Compared to nonparticipants who received no rebate for healthy food purchases, program participants receiving a 25% price rebate consume 0.7 more servings of fruits and vegetables daily, are 8% more likely to have three or more servings of wholegrain foods per day, and were 4%, 2%, 9%, 7%, and 8% less likely to have foods high in sugar, foods high in salt, fried foods, processed meats, and fast-food on a regular basis, respectively. The two subgroups by rebate reception status are similar in body weight measures, although the overweight and obesity prevalence among the 25% rebate recipients are slightly lower. Gender composition differs between HealthyFood program participants and nonparticipants. Forty-four percent of the 25% rebate recipients are male, compared to 50% among nonparticipants.

Table 2.1 Descriptive Statistics of the Health Risk Assessment Survey Respondents by Rebate Reception Status for Healthy Food Purchases

Variable	Attribute	All Mean (SD)	No Rebate Mean (SD)	25% Rebate Mean (SD)	Mean Difference
Dietary intake					
Daily servings of fruits and vegetables	Count	3.588 (1.868)	3.170 (1.755)	3.872 (1.882)	0.702***
Having ≧ 3 servings of wholegrain foods daily	Dichotomous	0.260 (0.408)	0.215 (0.400)	0.292 (0.427)	0.077***
Often having foods high in sugar	Dichotomous	0.109 (0.292)	0.135 (0.334)	0.093 (0.271)	-0.042***
Having foods high in salt regularly	Dichotomous	0.057 (0.221)	0.071 (0.253)	0.048 (0.205)	-0.023***
Having fried foods regularly	Dichotomous	0.273 (0.422)	0.326 (0.459)	0.233 (0.402)	-0.093***
Having processed meats regularly	Dichotomous	0.203 (0.381)	0.243 (0.421)	0.177 (0.362)	-0.066***
Having fast-food regularly	Dichotomous	0.270 (0.422)	0.313 (0.455)	0.235 (0.405)	-0.078***
Weight status					
Body mass index (BMI)	Continuous	26.258 (5.024)	26.290 (5.109)	26.230 (5.030)	-0.060**
Overweight (BMI ≥ 25)	Dichotomous	0.542 (0.483)	0.546 (0.493)	0.536 (0.484)	-0.010***
Obesity (BMI ≥ 30)	Dichotomous	0.191 (0.381)	0.194 (0.392)	0.190 (0.381)	-0.004**
Gender					
Male	Dichotomous	0.483 (0.500)	0.497 (0.500)	0.443 (0.497)	-0.054***
Age					
Age in years	Continuous	36.492 (10.267)	36.316 (10.354)	36.907 (10.325)	0.591***

Notes: Two-sample t-test with unequal variance is used to examine the difference in means of outcome variables between HealthyFood program participants and nonparticipants. * P < 0.05, ** P < 0.01, *** P < 0.001

2.5 Discussion

This chapter provides an overview of the HealthyFood program and basic descriptive statistics of the survey sample. The HealthyFood program started in February 2009 and has since enrolled about 330,000 households who are eligible for a 25% price rebate on healthy food choices in over 400 full-size supermarkets in South Africa. Analytic data were collected through repeated online health risk assessments. Program participants are found to consume more fruit/vegetables and wholegrain foods but less high sugar/salt foods, fried foods, processed meats, and fast-food.

The study sample has noticeably lower overweight and obesity rate compared to the national average in South Africa. This is not surprising as those who joined the Vitality health promotion program (and Discovery Health) are likely to be a selective subgroup that is wealthier and healthier than the general population. The sample is thus less representative of the population in South Africa which may limit the generalization of study findings.

Arguably, the biggest limitation of this descriptive piece stems from potential selection biases into the HealthyFood benefit. While all Vitality members were eligible to participate, 74% of families did not activate the benefit, and among the participants, 55%

did not complete the HRA to become eligible for the full 25% rebate. If the enrollees were those who could potentially gain the most from the program in healthier diet and weight loss, simply taking the difference in group means would overstate the true effects in the population and thus should be interpreted as an upper bound of what can be achieved with a price intervention. In Chapter III, I employ instrumental variable method to address the issue of self-selection bias.

Chapter III

Evaluation of a National Rebate Program for Healthy Food Purchases: Instrumental Variable Analysis

3.1 Introduction

Chapter II provides an overview of the HealthyFood program and basic descriptive statistics of the healthy risk assessment survey sample. The HealthyFood program aims to promote healthy diet among privately-insured health plan members by providing price rebates for healthy food purchases. Till March 2012, about 330,000 Discovery Health health plan members had voluntarily participated in the program and received cash back by purchasing about 6,000 eligible food items in over 400 designated supermarkets across all nine provinces in South Africa.

A direct comparison between program participants and nonparticipants is likely to overestimate the rebate effects because participation in the program is also a function of taste and lifestyle preferences. In particular, people who prefer healthier diets (and may

have already adopted them) should be more likely to select into the program because they have more to gain from it economically. To address the potential selection bias, I use an instrumental variable (IV) method. The IV is the differential distance from home to the closest supermarket providing the rebate versus the distance from home to the closest competing supermarket not providing the rebate. A valid IV approximately randomizes individuals to different likelihoods of receiving rebate, so that the estimated effects are uncontaminated by selection bias. The approach of using distance to a treatment site has been used in the medical literature to study hospital specialization and quality of care (e.g. McClellan et al., 1994).

3.2 Methods

3.2.1 Instrument Construction

Competitors of Pick n Pay supermarkets are determined based on their market share, geographic location, targeted customer, and historical relation. Shoprite Holdings, Pick n Pay Group, and Woolworths Holdings are the three largest national supermarket retail chains operating in all nine provinces in South Africa with a total market share of about

78% in 2009 (USDA, 2011). Shoprite Holdings mainly consists of two supermarket brands – Shoprite and Checkers. Both Shoprite and Pick n Pay are primarily sited in large cities but also have a presence in townships, and have long been competing for market leadership. Checkers and Woolworths mainly target consumers in large cities. Pick n Pay Group, Shoprite Holdings, and Woolworths Holdings currently operate 432, 482, and 354 full-size supermarkets across South Africa, respectively.

Differential distances from an individual's home to the nearest competing supermarket minus the distance to the nearest designated supermarket are used to instrument HealthyFood program participation in the IV analysis. For example, if one lives two kilometers away from the nearest Pick n Pay supermarket and three kilometers away from the nearest competing Shoprite-Checkers or Woolworths store, the value of the instrument for that person equals one kilometer. If the Pick n Pay is farther away than the Shoprite store, the differential distance will be negative.

To construct the instrument, survey respondents' residential addresses and supermarkets are geocoded and point-to-point distances from home to the nearest Pick n Pay supermarket and to the nearest competing supermarket calculated. Supermarket addresses are obtained from the companies' official websites (i.e., Pick n Pay

supermarket/hypermarket locator webpage: http://www.picknpay.co.za/picknpay/content/en/store-search; Shoprite supermarket locator webpage: http://www.shoprite.co.za/pages/127416071/Store-Locator.asp; Checkers supermarket/hypermarket locator webpage: http://www.checkers.co.za/pages/storelocator.aspx; and Woolworths supermarket locator webpage: http://www.woolworths.co.za/company/storeFinderHelp.jsp). About 29% of the HRA respondents' home addresses were not recorded, and 40% of the recorded addresses could not be geocoded using Google Maps API. This results in 43% of the total study sample to be included in the IV analysis. If addresses are not missing at random, it may limit the generalization of the IV estimates to the whole study sample. A sensitivity analysis is conducted to assess the impact of missing addresses on modeling outcomes.

3.2.2 Instrumental Variable Analysis

I use the IV method to address selection bias. The instrument is differential distance to supermarkets, which should predict participation in the Healthy Food program, but be independent from other individual characteristics that affect food purchases. Individuals living closer to Pick n Pay relative to a competing store are more likely to join the

HealthyFood program because the program has a higher value to them than otherwise identical individuals who live closer to a competing store. If the only difference between these two populations is the likelihood of receiving rebate, any difference in outcome measures, namely diet and body weight, can be attributed to the rebate effect.

Following Angrist (2001), Altonji et al. (2005), and Chiburis et al. (2012), I use two types of causal models to identify the price effect on diet – linear IV model and bivariate probit model (only for dichotomous dependent variables, namely having three or more servings of wholegrain foods daily, often having foods high in sugar or salt, having fried foods, processed meat, or fast-food regularly, and being overweight or obese). If the instrument is valid, a linear IV model yields unbiased estimates even when the normality assumption is violated. Additional estimation efficiency may be gained using a bivariate probit model, but its unbiasedness relies on the stronger assumption of joint normality compared to its linear counterpart.

3.2.2.1 Linear Instrumental Variable Model

The linear IV model has the following setup. We intend to obtain an unbiased estimate of the discount effect θ in Eq.1, known as the "structural equation":

$$Y = \theta D + \beta X + \varepsilon \quad \text{(Eq.1)}$$

where Y is the outcome variable such as fruit/vegetable intake, D a dichotomous variable for discount reception, X a vector of observed individual characteristics i.e. gender, age, and their interaction, and ε the error term. The error term ε is likely to be positively correlated with both outcome Y and treatment status D due to its inclusion of unobserved individual characteristics, such as personal preference for healthy food consumption, so that the estimated θ based on Eq.1 is likely to be upward biased.

Instead of estimating Eq.1 directly, I first estimate Eq.2, known as the "first stage", and substitutes treatment status D in Eq.1 with its predicted value $\widehat{D}$ based on Eq.2:

$$D = \pi Z + \beta X + \gamma \quad \text{(Eq.2)}$$

where Z is the instrument namely differential distance to supermarkets. If Z satisfies two conditions – having a significant impact on discount reception ($\pi \neq 0$) and being uncorrelated with unobserved differences in individual characteristics (i.e., covariance between Z and ε equals zero), the predicted value $\widehat{D}$ based on Eq.2 will be uncorrelated with the error term ε in Eq.1 and substitution of D by $\widehat{D}$ in estimating Eq.1 will yield unbiased estimate of the discount effect θ.

The two critical assumptions for IV estimations to hold are that the instrument significantly influences treatment status and is uncorrelated with unobserved differences in individual characteristics. We test the first assumption by estimating π in Eq.2. The second assumption cannot be directly proven, but to at least partially assess the exogeneity of the instrument, I regress differential distances to supermarkets on observed individual characteristics i.e. gender, age, and their interaction.

Two-stage least squares is used to estimate linear IV models. Relevant Stata 12.0 command is "ivregress 2sls". The Eicker-Huber-White sandwich estimator is used to calculate standard errors clustered at individual level.

3.2.2.2 Bivariate Probit Model

The bivariate probit model is a joint model for two dichotomous dependent variables that generalizes the index function model from one latent variable to two latent variables that may be correlated (Cameron & Trivedi, 2005).

The bivariate probit model has the following setup.

$$D^* = \pi Z + \beta X + \gamma$$

$$D = 1\{D^* > 0\}$$

$$Y^* = \theta D + \beta X + \varepsilon$$

$$Y = 1\{Y^* > 0\} \quad \text{(Eq.3)}$$

where $D^*$and $Y^*$are the two latent variables for treatment status D and dichotomous outcome Y, respectively. The two error terms γ and ε are jointly distributed as standard bivariate normal with correlation ρ and independent of the instrumental variable Z.

Simulation results show that deviation from joint normality often leads to highly biased bivariate probit estimates, and tests based those estimates substantially overreject a true null hypothesis when the model is misspecified (Chiburis et al., 2012). I use the Rao score test developed by Murphy (2007) to assess the goodness-of-fit of the bivariate probit model. This test embeds the bivariate normal distribution within a larger family of distributions by including more parameters to the model and evaluates whether the additional parameters are all zeros using the score for those parameters at the bivariate probit estimate (Murphy, 2007; Chiburis, 2010; Chiburis et al., 2012).

Maximum likelihood is used to estimate bivariate probit models. Relevant Stata 12.0 command is "biprobit". To ease the interpretation of estimated coefficients and facilitate comparison with linear IV models, average marginal effect on the treated is calculated using the Stata command "biprobittreat" developed by Chiburis et al. (2012). Standard error of the marginal effect is calculated by bootstrapping. Murphy's (2007) score test is

conducted using the Stata command "scoregof" developed by Chiburis et al. (2012). Both "biprobittreat" and "scoregof" programs are available at https://webspace.utexas.edu/rcc485/www/code.html.

3.2.3 Alternative Model Specifications and Sensitivity Analysis

Besides the analyses using instrumental variable, two alternative models specifications – ordinary least squares (OLS) and individual fixed-effect models are conducted on the HRA survey data. Fixed-effect models use within-individual variations in program enrollment status and diet/body weight to identify the rebate effects, and thus eliminate the omitted variable bias from unobserved time-invariant individual characteristics. Fixed-effect estimations are based on a subgroup of people in the sample who filled the HRA survey at least twice. The Eicker-Huber-White sandwich estimator is used to calculate standard errors clustered at individual level.

To assess the impact of missing/incomplete address data, individual fixed-effect models are conducted separately among the two subsamples with non-missing and missing values for the instrument.

All models including linear IV models, bivariate probit models, OLS, and fixed-effect models control for gender (except for fixed-effect models), age, and their interaction. All statistical analyses are conducted in STATA 12.0 (StataCorp, College Station, TX).

3.3 Results

Table 3.1 shows the descriptive statistics of the study sample by rebate reception status. Compared to nonparticipants who receive no rebate for healthy foods, program participants receiving a 25% rebate consume more fruits/vegetables, are more likely to have three or more servings of wholegrain foods per day, and are less likely to have foods high in sugar or salt, fried foods, processed meat, and fast-food on a regular basis. Rebate recipients live substantially closer (about 0.4 kilometer) to the nearest Pick n Pay supermarket relative to the nearest competing Shoprite-Checkers or Woolworths store. Conversely, the two subsamples by rebate reception status are similar in BMI and overweight/obesity prevalence.

Table 3.1 Descriptive Statistics of the Health Risk Assessment Survey Respondents by Rebate Reception Status for Healthy Food Purchases

Variable	Attribute	No Rebate Mean (SD)	25% Rebate Mean (SD)
Dietary intake			
Daily servings of fruits and vegetables	Count	3.170 (1.755)	3.872 (1.882)
Having ≧ 3 servings of wholegrain foods daily	Dichotomous	0.215 (0.400)	0.292 (0.427)
Often having foods high in sugar	Dichotomous	0.135 (0.334)	0.093 (0.271)
Having foods high in salt regularly	Dichotomous	0.071 (0.253)	0.048 (0.205)
Having fried foods regularly	Dichotomous	0.326 (0.459)	0.233 (0.402)
Having processed meats regularly	Dichotomous	0.243 (0.421)	0.177 (0.362)
Having fast-food regularly	Dichotomous	0.313 (0.455)	0.235 (0.405)
Weight status			
Body mass index (BMI)	Continuous	26.290 (5.109)	26.230 (5.030)
Overweight (BMI ≥ 25)	Dichotomous	0.546 (0.493)	0.536 (0.484)
Obesity (BMI ≥ 30)	Dichotomous	0.194 (0.392)	0.190 (0.381)
Gender			
Male	Dichotomous	0.497 (0.500)	0.443 (0.497)
Age			
Age in years	Continuous	36.316 (10.354)	36.907 (10.325)
Proximity to grocery store			
Distance (km) from home to nearest Shoprite/Woolworths store	Continuous	2.075 (3.813)	2.452 (4.433)
Distance (km) from home to nearest Pick n Pay store	Continuous	2.306 (3.695)	2.311 (4.189)
Differential distance (km)	Continuous	-0.231 (1.273)	0.141 (1.529)
Sample size (number of individuals)			
Total sample		159,674	89,029
Sample with non-missing values of residential address		99,908	43,605

Notes: Differential distance is defined as the distance in kilometer from an individual's home to the nearest competing Shoprite or Woolworths store minus the distance to the nearest Pick n Pay store.

Table 3.2 shows the descriptive statistics of the study sample by differential distances to supermarkets. Compared to those who live at least one kilometer further away from the nearest Pick n Pay relative to the nearest competing store, individuals living at least one kilometer closer to the nearest Pick n Pay have more daily fruit/vegetable consumption, more regularly have three or more servings of wholegrain foods per day, and less regularly have foods high in sugar or salt, fried foods, processed meat, and fast-food. Conversely, the two subsamples by differential distances to supermarkets appear similar in individual demographics including gender and age.

Table 3.2 Descriptive Statistics of the Health Risk Assessment Survey Respondents by Differential Distances to Supermarkets

Variable	Attribute	Differential Distance < -1 km Mean (SD)	Differential Distance > 1 km Mean (SD)
Gender			
Male	Dichotomous	0.576 (0.494)	0.564 (0.496)
Age			
Age in years	Continuous	37.489 (10.543)	37.218 (10.416)
Dietary intake			
Daily servings of fruits and vegetables	Count	3.275 (1.795)	3.489 (1.822)
Having ≥ 3 servings of wholegrain foods daily	Dichotomous	0.232 (0.401)	0.257 (0.412)
Often having foods high in sugar	Dichotomous	0.122 (0.313)	0.111 (0.297)
Having foods high in salt regularly	Dichotomous	0.062 (0.233)	0.056 (0.221)
Having fried foods regularly	Dichotomous	0.320 (0.448)	0.294 (0.435)
Having processed meat regularly	Dichotomous	0.236 (0.408)	0.222 (0.398)
Having fast-food regularly	Dichotomous	0.299 (0.441)	0.282 (0.432)
Body weight			
Body mass index (BMI)	Continuous	26.702 (5.114)	26.560 (5.015)
Overweight (BMI ≥ 25)	Dichotomous	0.586 (0.480)	0.574 (0.480)
Obesity (BMI ≥ 30)	Dichotomous	0.212 (0.398)	0.206 (0.394)
Price rebate for healthy foods			
Receiving a 25% rebate at time of survey	Dichotomous	0.208 (0.355)	0.430 (0.429)

Notes: Differential distance is defined as the distance in kilometer from an individual's home to the nearest competing Shoprite or Woolworths store minus the distance to the nearest Pick n Pay store.

Table 3.3 reports the estimated first stage, namely the impact on rebate reception of differential distance to supermarkets. Regardless of controlling for individual demographics, those living one kilometer closer to the nearest Pick n Pay supermarket relative to the nearest competing store are about 6% more likely to receive a 25% rebate for healthy foods. The differential distance to supermarkets predicts HealthyFood program participation and is used to as the instrumental variable.

Table 3.3 Estimated Effects on Receiving a 25% Price Rebate for Healthy Food Purchases of Differential Distance to Supermarkets

Independent Variable	**Dichotomous Variable for Receiving a 25% Price Rebate for Healthy Food Purchases**	
Differential distances to supermarkets	0.0555*** (0.0010)	0.0552*** (0.0010)
Dichotomous variable for male		-0.0539*** (0.0101)
Age in years		0.0022*** (0.0002)
Interaction between male and age		-0.0014*** (0.0003)

Notes: Differential distance is defined as the distance in kilometer from an individual's home to the nearest competing Shoprite or Woolworths store minus the distance to the nearest Pick n Pay store. Coefficient and standard error (in parenthesis) of ordinary least squares are reported. Eicker-Huber-White sandwich estimator is used to calculate standard error clustered at individual level. *** $P < 0.001$

Table 3.4 reports the estimated associations between differential distance to supermarkets and individual demographics. The coefficients of gender, age, and their interaction are all very small and statistically insignificant at $P < 0.05$, suggesting the absence of correlation between the instrumental variable and observed differences in individual characteristics.

Table 3.4 Estimated Associations between Differential Distance to Supermarkets and Individual Demographics

Independent Variable	**Differential Distance to Supermarkets**
Dichotomous variable for male	0.0331 (0.0331)
Age in years	-0.0008 (0.0007)
Interaction between male and age	-0.0015 (0.0009)

Notes: Differential distance is defined as the distance in kilometer from an individual's home to the nearest competing Shoprite or Woolworths store minus the distance to the nearest Pick n Pay store. Coefficient and standard error (in parenthesis) of ordinary least squares are reported. Eicker-Huber-White sandwich estimator is used to calculate standard error clustered at individual level. * $P < 0.05$

Table 3.5 reports the estimated effects on diet and body weight of a 25% rebate for healthy food purchases using OLS, linear IV, bivariate probit, and individual fixed-effect models. The OLS estimations of the rebate effects on diet are always larger than their IV

counterparts. The linear IV and bivariate probit models produce very similar estimates. Rebate effects on diet are comparable between instrumental variable and fixed-effect estimations, although those on consumption of fruits and vegetables, wholegrain foods, and fried foods are somewhat smaller based on fixed-effect models.

There is some but largely inconsistent evidence across model specifications that HealthyFood program participation reduces body weight. The linear IV model finds a 0.7 unit reduction in BMI associated with the price rebate. The estimated reductions in overweight and obesity rate are 3.8% and 3.3% respectively but not statistically significant at $P < 0.05$. The bivariate probit models suggest impacts on overweight and obesity of similar magnitude with statistical significance. However, Murphy's (2007) score test strongly rejects the null hypothesis on the joint normality of error distribution for all bivariate probit models with chi-square statistics (nine degrees of freedom) ranging from 572 to 2004. This throws doubt on both the point estimates and standard errors of the bivariate probit model, as Chiburis et al. (2012) finds tests based bivariate probit model estimates to greatly overreject a true null hypothesis when the model is misspecified. A slight decrease in obesity rate by 0.4% is found based on fixed-effect estimations but no impact from price rebate is identified on BMI or overweight rate.

Based on the linear IV estimations of the rebate effects, I calculate the percentage change in diet (in the marginal person whose HealthyFood program participation is changed by the differential distance to supermarkets) by dividing the coefficients (fourth column in Table 3.5) by their corresponding baseline values (third column in Table 3.1). A 25% rebate for healthy foods is associated with an increase in daily fruit and vegetable consumption by 21%, an increase in the probability of having three or more servings of wholegrain foods per day by 40%, and a decrease in the probability of regularly having foods high in sugar by 26%, foods high in salt by 22%, fried foods by 23%, processed meat by 15%, and fast-food by 15%.

Table 3.5 Estimated Effects on Diet and Body Weight of a 25% Price Rebate for Healthy Food Purchases Using Ordinary Least Squares, Linear Instrumental Variable, Bivariate Probit, and Individual Fixed-effect Models

Dependent Variable	**Attribute**	**Model**			
		OLS	Linear IV	Bivariate probit	FE
Dietary behavior					
Daily servings of fruits and vegetables	Count	0.7484*** (0.0086)	0.6590*** (0.0769)		0.3495*** (0.0094)
Having ≥ 3 servings of wholegrain foods daily	Dichotomous	0.0884*** (0.0019)	0.0860*** (0.0164)	0.0894*** (0.0106)	0.0363*** (0.0026)
Often having foods high in sugar	Dichotomous	-0.0446*** (0.0012)	-0.0351*** (0.0101)	-0.0345*** (0.0089)	-0.0359*** (0.0019)
Having foods high in salt regularly	Dichotomous	-0.0245*** (0.0009)	-0.0159* (0.0078)	-0.0152* (0.0075)	-0.0162*** (0.0013)
Having fried foods regularly	Dichotomous	-0.0862*** (0.0018)	-0.0757*** (0.0158)	-0.0737*** (0.0127)	-0.0560*** (0.0025)
Having processed meat regularly	Dichotomous	-0.0611*** (0.0016)	-0.0364** (0.0144)	-0.0339** (0.0117)	-0.0395*** (0.0023)
Having fast-food regularly	Dichotomous	-0.0699*** (0.0018)	-0.0467** (0.0158)	-0.0435*** (0.0106)	-0.0513*** (0.0024)
Body weight					
Body mass index (BMI)	Continuous	0.0224 (0.0204)	-0.6653** (0.2292)		0.0141 (0.0124)
Overweight (BMI ≥ 25)	Dichotomous	0.0005 (0.0019)	-0.0379 (0.0212)	-0.0371** (0.0140)	0.0022 (0.0017)
Obesity (BMI ≥ 30)	Dichotomous	-0.0038* (0.0016)	-0.0334 (0.0176)	-0.0323* (0.0137)	-0.0035** (0.0013)
Sample size		159,674	99,908	99,908	111,494

Notes: Reported parameters (standard error in parenthesis) are estimated using ordinary least squares (OLS), linear instrumental variable (IV), bivariate probit, and linear individual fixed-effect (FE) models. All models control for gender (except for FE models), age, and their interaction. Eicker-Huber-White sandwich estimator is used to calculate standard error clustered at individual level for OLS, linear IV, and individual FE models. Standard error in bivariate probit model is calculated by bootstrapping. In the linear IV and bivariate probit models, rebate reception is instrumented by differential distances from home to the nearest competing supermarket (Shoprite or Woolworths store) minus the distance to the nearest designated supermarket (Pick n Pay store). * P < 0.05, ** P < 0.01, *** P < 0.001

To assess the impact of missing values on IV estimations, I conduct individual fixed-effect models based on the two subsamples with non-missing and missing values for differential distances to supermarkets. As Table 3.6 shows, the estimated rebate effects are similar between these subsamples.

Table 3.6 Comparison of Estimated Effects Using Individual Fixed-effect Models on Dietary Intake and Body Weight of a 25% Rebate for Healthy Food Purchases between Subsamples with Non-missing and Missing Values of Differential Distances to Supermarkets

Dependent Variable	**Missing Differential Distances to Supermarkets**	
	No	Yes
Dietary behavior		
Daily servings of fruits and vegetables	0.3599*** (0.0133)	0.3371*** (0.0134)
Having ≥ 3 servings of wholegrain foods daily	0.0345*** (0.0037)	0.0382*** (0.0038)
Often having foods high in sugar	-0.0380*** (0.0028)	-0.0337*** (0.0027)
Having foods high in salt regularly	-0.0155*** (0.0018)	-0.0169*** (0.0019)
Having fried foods regularly	-0.0562*** (0.0036)	-0.0557*** (0.0035)
Having processed meats regularly	-0.0396*** (0.0032)	-0.0396*** (0.0032)
Having fast-food regularly	-0.0512*** (0.0035)	-0.0513*** (0.0034)
Body weight		
Body mass index (BMI)	0.0232 (0.0180)	0.0049 (0.0169)
Overweight (BMI ≥ 25)	0.0044 (0.0023)	-0.00004 (0.0024)
Obesity (BMI ≥ 30)	-0.0037 (0.0019)	-0.0034 (0.0018)
Sample size	99,908	59,766

Notes: Coefficients are estimated using linear individual fixed-effect regressions. Eicker-Huber-White sandwich estimator is used to calculate standard error clustered at individual level. * P < 0.05, ** P < 0.01, *** P < 0.001

3.4 Discussion

In this study, I evaluate the effectiveness of a nationwide rebate program for healthy food purchases in modifying dietary behavior. Direct comparisons between program participants and nonparticipants tend to overestimate the rebate effects due to self-selection bias. Differential distances to supermarkets are strong independent predictor of program participation, and are unlikely to be correlated with unobserved determinants of diet. The IV method instruments program participation by differential distances to supermarkets finds program participation to increase consumption of fruits/vegetables and wholegrain foods and decrease consumption of foods high in sugar or salt, fried foods, processed meat, and fast-food.

In the diet analysis, individual fixed-effect models are applied as an alternative identification strategy to address selection bias. Estimations based on the IV and fixed-effect models are fairly comparable but not identical. At least two factors may be held responsible for the differences. First, the two types of models are based on different assumptions. While the validity of the IV method relies on the exogeneity of the instrument, the unbiasedness of fixed-effect estimations are dependent upon the absence of unobserved time-variant confounder between treatment status and outcome measures. Moreover, the IV and fixed-effect estimations are likely to be based on

different subsamples. Unlike randomized trials with perfect compliance, differential distances to supermarkets merely change the probability of rebate reception, so that the IV estimations only pertain to those whose program participation decision was altered by the instrument. Conversely, the fixed-effect estimations are based on those who took the HRA survey multiple times. Heterogeneities between these two subsamples may lead to differences in the estimated rebate effects between the IV and fixed-effect models.

Effectiveness of Healthyfood program participation on weight loss is largely inconclusive. The linear IV model estimates a 0.7 unit reduction in BMI to be associated with a 25% rebate rate for healthy food purchases, but the effect is not replicated by individual fixed-effect model. Moreover, given merely a modest impact on diet, the HealthyFood program is unlikely to substantially influence body weight status. Therefore, a large estimated effect on BMI (or overweight and obesity prevalence) may not be trustworthy.

Measurement limitations pertain to the outcome measures in the diet analysis. The HRA survey does not comprehensively capture diet, but only has some general questions on eating behaviors. Items are not specific in relation to type of food, unit of measurement,

and frequency of intake, and respondents are provided with limited instructions on how to frame their responses. Both diets and height/weight were self-reported and subject to measurement errors.

For an online survey, the response rate of the HRA (47%) is very good, and actually not very different from telephone household surveys in the U.S., including the California Health Interview Surveys (CHIS) and the Behavioral Risk Factor Surveillance System (BRFSS) whose response rates have been falling (CHIS, 2009; BRFSS, 2010). Nevertheless, the results are based on a minority of individuals eligible for the HealthyFood benefit.

While the HealthyFood program addresses a hot policy question worldwide, its generalizability to other populations remains uncertain. Employers or health insurers in other countries may not be as committed to improving diets and reducing obesity through food subsidies. In the U.S., food subsidy programs funded by the federal government are considered an entitlement program that often carries negative political implications, but the U.S. is the only place where a similar rebate program is being piloted.

Despite various limitations, this study serves as a preliminary analysis of an ongoing effort to quantify the role of prices on dietary behavior. The IV method correcting for selection bias estimates the own price elasticity of demand for fruits and vegetables to be 0.83 that falls into the range of the systematic review by Andreyeva et al. (2010). Moreover, there is evidence that a 25% price rebate for healthy food purchases not only increases healthy food consumption and but also meaningfully decreases less desirable food consumption.

Drawing from the limitations of the current study, I expect to move beyond the dissertation and carry out this strand of research into the future. The current study exclusively looks at residential neighborhood grocery shopping environment, but the grocery shopping environment near workplace could also play a role. We have gained access to a large volume (about half of the size of the residential address data) of Vitality members' work address data. As for an immediate next step, I plan to geocode those data and experiment with different ways of instrumental variable construction. For example, one such instrument taking into account both residential and workplace neighborhood grocery shopping environment could be the differential distance from either home or workplace (whatever is closer) to the nearest competing supermarket minus the distance to the nearest program-designated supermarket; an alternative

specification of the instrumental variable could be the differential distance from the nearest competing supermarket to the aerial path between home and workplace minus the distance from the nearest designated supermarket to the same path.

Recent research on the relationship between neighborhood food environment and diet has moved from aerial distance to travel distance that takes into account street network connection (e.g., Drewnowski et al., 2012). However, to date it is still often infeasible to measure ground travel path due to poor street network data for most developing countries. Nevertheless, the landscape of technology and geographical data quality are advancing rapidly, and it is possible that within a few years, street network data for South Africa may allow us to calculate actual travel distance from home or workplace to supermarkets. This is expected to reduce measurement error introduced by aerial distance.

Accessibility and affordability are two critical factors that influence people's dietary behavior. Almost all studies to date investigate one or the other, but few look at both simultaneously and their potential interactions. The Seattle Obesity Study is one exception that examines whether physical proximity to supermarkets or supermarket price is more strongly related to obesity (Drewnowski et al., 2012), but the study is

limited to residents in one county in Washington and only considers home neighborhood food environment. Contrastingly, the Vitality program covers all nine provinces in South Africa and both residential and workplace neighborhood food environment can be measured. Moreover, the price effects on both dietary behavior and household supermarket grocery shopping behavior can be examined. The unique features of the Vitality program and its rich data could potentially contribute to the field of environment and diet which demands more innovation and evaluation.

Chapter IV

Effect of a National Rebate Program for Healthy Food Purchases in Modifying Grocery Shopping Behavior

4.1 Introduction

Chapter III examines the effect of a 25% price rebate for healthy food purchases in modifying self-reported dietary behavior by evaluating the health risk assessment survey data among HealthyFood program participants and nonparticipants. In this chapter, I use differences-in-differences method and household fixed-effect models on monthly household supermarket food purchase scanner data to identify the rebate effect in modifying grocery shopping behavior.

4.2 Data and Methods

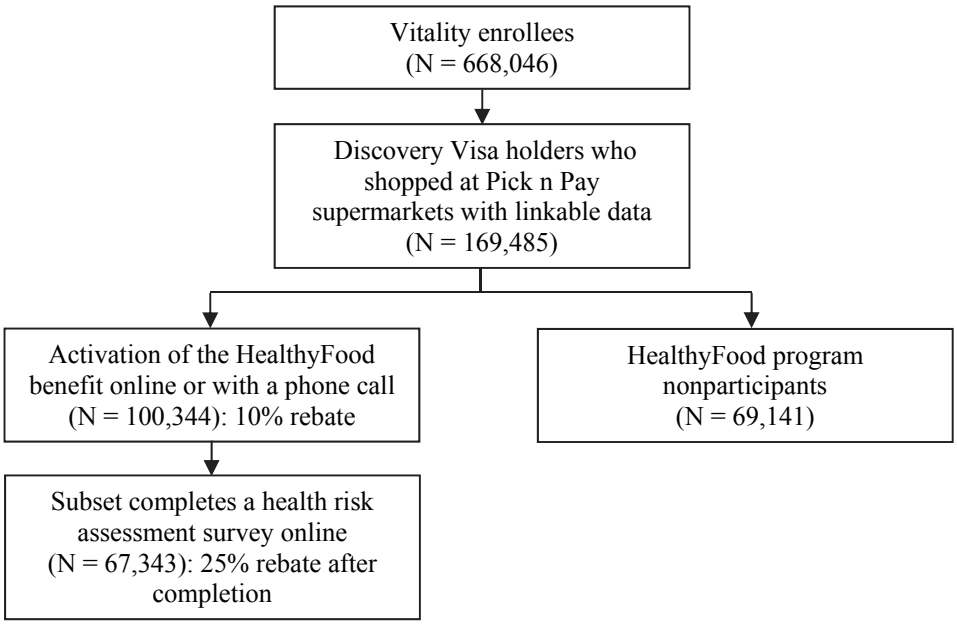
4.2.1 Supermarket Purchase Data

I assess the effect of a 25% price change by analyzing household purchase data before and after rebate eligibility. The unique challenge is to attribute purchases prior to HealthyFood program participation, and it is accomplished by linking household purchases through credit cards. This restricts the analysis to purchases made with a Visa credit card issued by Discovery as it is the only identifying information for purchases not receiving a rebate. About one third of all households enrolled in Discovery Vitality use such a credit card.

Figure 4.1 shows a flowchart for sample selection. During the study period from November 2009 to March 2012, a total of 668,046 Discovery Health health plan members had been enrolled in the Vitality Program. Among them, 169,485 used Discovery Visa credit card when shopping at Pick n Pay supermarkets and thus had linkable purchase data. About 40% of them (67,343) activated the HealthyFood benefit and also completed the health risk assessment survey so that they became eligible for the 25% rebate rate for healthy food purchases at Pick n Pay. About 41% (69,141) did not activate the HealthyFood benefit during the study period and received no rebate. This brings about a total sample of 136,484 individuals included in the grocery shopping analysis. Their purchases are collapsed into monthly observations, resulting in a total of 1,389,502

observations (household months). Household food purchases are categorized into healthy foods (21% of total food spending), fruits and vegetables (a subcategory of healthy foods, 10% of total food spending), less desirable foods (19% of total food spending), and neutral foods (60% of total food spending).

Figure 4.1 Sample Selection Flowchart for Grocery Shopping Analysis



Note: Number of enrollees during November 2009 to March 2012 is in parenthesis.

4.2.2 Variable Construction

The three dependent variables are the ratios of healthy food, fruit and vegetables, and less desirable food to total food expenditure in a household. The dependent variables are ratios because absolute purchase amounts at Pick n Pay were expected to increase (supermarkets participate to have a competitive advantage). By definition, there are no data for months where individuals had no (linkable) food purchases at Pick n Pay (the ratio is undefined).

The main explanatory variable is the dichotomous variable for receiving a 25% rebate on healthy food purchases in a month. The reference group is households that were not eligible for any rebate.

To analyze whether duration in the program is associated with changes in purchasing patterns (e.g. positive habit formation or a loss of novelty), I construct an interaction between the number of months in the 25% rebate policy and the corresponding dichotomous variable for receiving that rebate rate.

4.2.3 Grocery Shopping Analysis

Participation in the program is self-selected and households in the 0% and 25% are likely to differ systematically. Two methods are used to address this problem: a case-control difference-in-differences method and household fixed effects models.

The case-control difference-in-differences method calculates the effect of the rebate effect by subtracting the change in ratios (of healthy food, fruit/vegetable, or less desirable food to total food expenditure in a household) among people before and after becoming eligible for the rebate from the change in ratios over the same time period among nonparticipants. For participants, the before/after period is demarcated by the date they became eligible for the rebate. Each of those households is matched to a randomly-selected household that enrolled into Discovery Vitality at the same month, but never became eligible for the healthy foods rebate. Although this approach appears somewhat similar to a traditional difference-in-differences analysis, it is a weaker design because the timing of the intervention (eligibility for the rebate) is not exogenously fixed. In other words, other changes such as a population dietary trend might impact the results (e.g., there is some evidence that Vitality members purchased more fruit and vegetable in summer).

The household fixed-effects method uses within-household variations in program enrollment status to identify the rebate effects. This approach deals with any selection biases due to a household-specific component (observable or unobservable) that is constant over time. The approach cannot address differences between eligible and non-eligible households that vary over time. Time trends and seasonality in grocery shopping pattern are controlled with a set of dichotomous variables for each specific month in a year. For each regression, one main-effect model and one interaction model are estimated. Eicker-Huber-White sandwich estimator is used to calculate standard errors clustered at household level. All statistical analyses are conducted in STATA 12 (StataCorp, College Station, TX).

4.2.4 Sensitivity Analyses

The data exclude purchases from competing supermarkets or other grocery stores and non-linkable cash purchases at Pick n Pay. An implied assumption of our ratio analysis is that the linkable shopping carts at Pick n Pay are representative of total purchases. If shoppers only switched from competing stores for those foods that receive a rebate, but not for other foods, I could overestimate the effect of program participation on grocery shopping. The selective purchasing bias should be more severe for individuals near

alternative supermarkets (where additional time and travel costs for a second shopping trip are small), but the selective purchasing bias should be smaller for individuals close to a Pick n Pay, but far away from a competing store (where additional time and travel costs are large). As a sensitivity analysis, I re-estimate the models based on those who lived at least two kilometers closer to the nearest Pick n Pay than the nearest competing supermarket. Shrinking coefficients on rebates would indicate that selective purchasing exists and that our estimates are biased upward. This sensitivity analysis surely has its own limitations. People may chose stores closer to workplace or school rather than home, and traffic patterns may also play a role in store selection. As discussed in Chapter III, I plan to advance my study by looking at both residential and workplace grocery shopping environment in the short run, and eventually conduct network analysis taking into account road connectivity, transportation mode, and traffic condition as street network data in South Africa permits.

Households with very few linkable data may simply not shop at Pick n Pay very often or may rely more on cash transactions. If linkable data are not representative of purchases and payment mechanisms were related to the type of foods bought (e.g. use the credit card when buying eligible food items and cash for soft drinks), results would be biased. The bias would be small if few purchases are unlinkable – even with a strong

relationship between transaction type and ratio of healthy foods – but increases with the share of unlinkable purchases. Data are missing mainly due to two reasons – a household did not shop at Pick n Pay in a particular month, or did shop at Pick n Pay but made their payment by cash or other card rather than Discovery credit card. However, it is not known which exact reason that leads to missing data. As a sensitivity analysis, I re-estimate all models using only "loyal" Pick n Pay shoppers defined as having no missing data for at least 20 months during the study period.

4.3 Results

Table 4.1 provides descriptive statistics on grocery shopping patterns at Pick n Pay supermarkets by rebate status. Households spend about twice as much at Pick n Pay with a 25% rebate than without one. Participation is related to store location as rebate recipients live closer to a Pick n Pay supermarket than to a competing supermarket, with the reverse being true for people not in the program. Rebate recipients spend a larger proportion of food expenditure on healthy foods and a smaller proportion on less desirable foods.

Table 4.1 Baseline Household Food Purchases at Designated Supermarkets (Prior to Eligibility for Rebate), by Eventual Rebate Status

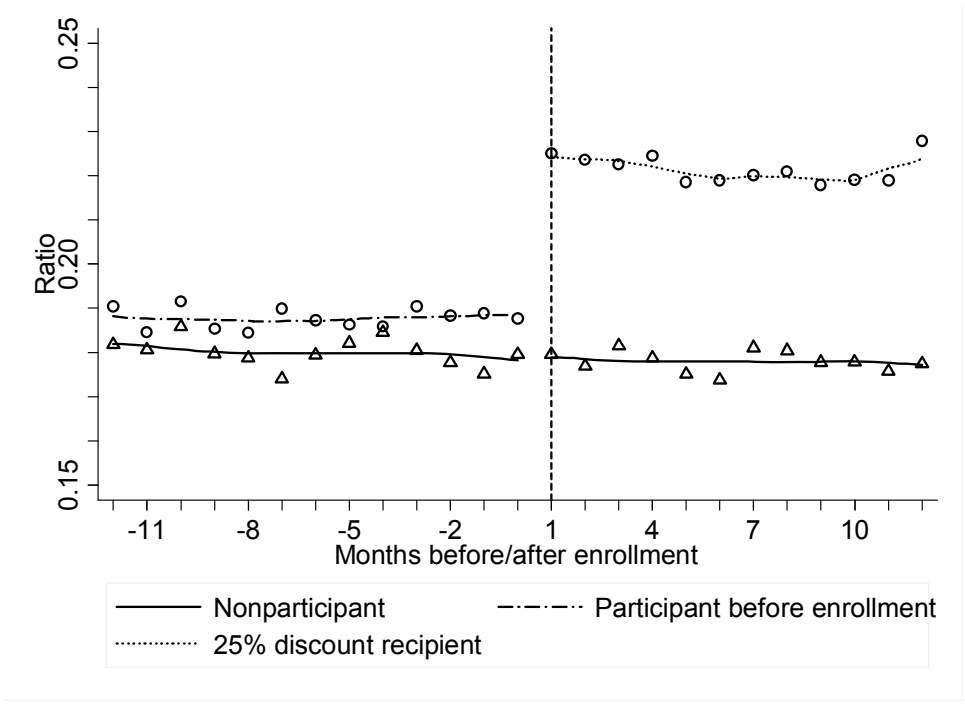
Variable	Attribute	No Rebate Mean (SD)	25% Rebate Mean (SD)
Total food expenditure in South African rand	Continuous	558.086 (743.530)	1073.411 (1116.917)
Ratio of healthy to total food expenditure	Continuous	0.168 (0.130)	0.214 (0.120)
Ratio of fruit and vegetable to total food expenditure	Continuous	0.085 (0.095)	0.104 (0.084)
Ratio of less desirable to total food expenditure	Continuous	0.224 (0.170)	0.186 (0.119)
Distance (km) from home to nearest Shoprite or Woolworths store	Continuous	1.893 (3.372)	2.515 (4.638)
Distance (km) from home to nearest Pick n Pay store	Continuous	2.281 (3.241)	2.364 (4.91)
Differential distance (km)	Continuous	-0.388 (1.175)	0.151 (1.719)

Figure 4.2 displays the case-control difference-in-differences analysis graphically. Among program participants, the ratio of healthy food (Subfigure 1) and fruit/vegetable (Subfigure 2) to total food expenditure increased and the ratio of less desirable food to total food expenditure (Subfigure 3) decreased immediately upon eligibility for a rebate. No similar pattern exists among the matched ineligible households. The percentage change in ratios associated with the price change is calculated by dividing the differences-in-differences estimates by their corresponding baseline values (third column in Table 4.1). A 25% rebate for healthy foods is associated with an increase in the ratio of healthy to total food expenditure by 12.1%, an increase in the ratio of fruit and

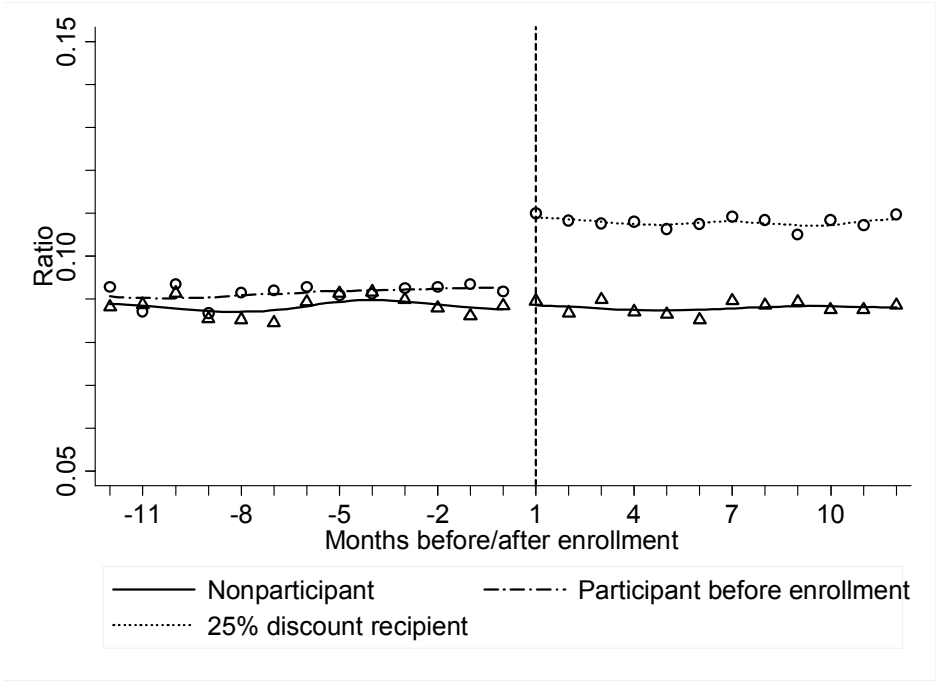
vegetables to total food expenditure by 9.6%, and a decrease in the ratio of less desirable to total food expenditure by 6.3%.

Figure 4.2 Monthly Household Grocery Shopping Pattern among HealthyFood Participants and Nonparticipants Before and After Receiving a 25% Price Rebate for Healthy Food Purchases

Subfigure 1 Ratio of Healthy to Total Food Expenditure



Subfigure 2 Ratio of Fruit/Vegetable to Total Food Expenditure



Subfigure 3 Ratio of Less desirable to Total Food Expenditure

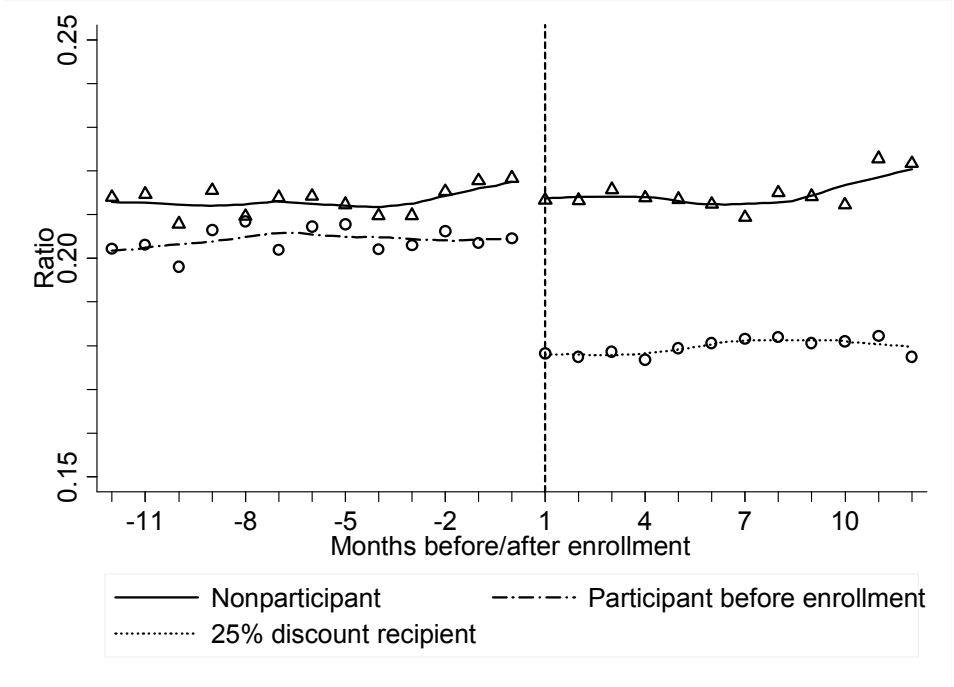


Table 4.2 reports the results from household fixed-effect regression models. The percentage change in the ratios of healthy food, fruit/vegetable, and less desirable food to total food expenditure (divide coefficients in Table 4.2 by baseline values in Table 4.1) are similar to the difference-in-differences analysis: a 25% rebate for healthy foods is associated with an increase in the ratio of healthy to total food expenditure by 12.1%, an increase in the ratio of fruit and vegetables to total food expenditure by 10.9%, and a decrease in the ratio of less desirable to total food expenditure by 6.7%.

The third column in Table 4.2 shows the sensitivity analysis which restricts the sample to people who lived at least two kilometers closer to the nearest Pick n Pay supermarket than to the nearest competing store. This is a small group, only about 3% of the total, but it should be the group least likely to shop only for discounted healthy foods at Pick n Pay. If such a bias were to exist among shoppers generally, this sensitivity analysis should show smaller effect sizes, but if anything, the estimates are larger than for the full sample (except for fruit/vegetable purchase which is slightly smaller).

The last column in Table 4.2 shows the sensitivity analysis which restricts the sample to "loyal" shoppers who shopped at Pick n Pay supermarkets for at least 20 months out of the 29 months study period. The estimated price effects are essentially unchanged.

Table 4.2 Estimated Effects on Monthly Household Grocery Shopping Pattern of a 25% Price Rebate for Healthy Food Purchases in Household Fixed-effect Models

Dependent Variable	All Shoppers	Nearby Shoppers	Regular Shoppers
Ratio of healthy to total food expenditure	0.0214*** (0.0012)	0.0304*** (0.0059)	0.0202*** (0.0017)
Ratio of fruit/vegetable to total food expenditure	0.0093*** (0.0008)	0.0075* (0.0038)	0.0100*** (0.0012)
Ratio of less desirable to total food expenditure	-0.0151*** (0.0012)	-0.0190** (0.0058)	-0.0130*** (0.0016)
Sample size	136,484	4,586	23,886

Notes: Reported parameters (standard error in parenthesis) are estimated using linear household fixed-effect models, controlling for month/year fixed effects. Nearby shoppers are defined as those who lived at least two kilometers closer to the nearest Pick n Pay supermarket relative to the nearest Shoprite or Woolworths supermarket. Regular shoppers are defined as those who shopped at Pick n Pay supermarkets for at least 20 months out of the 29-month study period. Eicker-Huber-White sandwich estimator is used to calculate standard error clustered at household level. * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

An alternative specification of the fixed-effects models allows for an interaction between duration in the program and rebate. Time in the program does not appear to play a major role and the estimated coefficients are small (not shown in tables). It suggests the price effects on food purchase remain stable over time, so people respond immediately and permanently to the price effect.

4.4 Discussion

In this chapter, I examine the relationship between a price reduction for healthy food items and supermarket shopping in a nationwide program. Rebates predict a higher ratio of healthy to total food expenditure and lower ratio of less desirable to total food expenditure. The price effects remain stable over time.

I conduct sensitivity analyses to identify biases that could be a consequence of data collection (only purchases paid by credit card) or strategic consumer behavior (more shopping at Pick n Pay, but only for foods eligible for rebates). My approach selects subsamples where biases would be reduced, but estimated magnitudes are robust and do not change in a substantial way, suggesting biases due to payment type or strategic shopping are negligible.

Rebate eligibility is not randomly assigned, but households have to opt into the program even though the program is free to them. Program participation results from the interaction between program rules, geographic location, and taste and lifestyle preferences. A direct comparison of purchasing patterns between households eligible for

the rebate and those not eligible would confound price effects with determinants of participation selection. Such confounding cannot be satisfactorily addressed in cross-sectional data where adjustment is based on observed variables. With panel data, however, confounding factors (even if unobservable) can be controlled as long as they are constant, e.g. if a participating household would always buy x% more healthy foods than a nonparticipating household at the same set of prices during the study period. It is not a complete solution for any possible selection effects as the model cannot control for unobserved time-varying differences between participating and non-participating households. Plausible hypotheses for non-constant differences (e.g. different price elasticities) could be developed, but cannot be tested with existing data.

Studying a large real-life program entails compromises and I have to work around constraints resulting from the day-to-day operations of supermarkets and health plans. At times, it allows unexpected ways to strengthen an analysis (in this case, creating panel data of credit card holders). At other times, even seemingly simple analyses become infeasible: the design could have been strengthened with data prior to 2009 (preceding the program) and although I had an agreement to obtain earlier data, the supermarket had deleted all data prior to 2009 during a software transition in 2011.

While an experiment designed for research follows a fixed protocol, the actual program develops over time with rules to prevent fraud, increase attractiveness, multiple rebate levels, etc. While all those details add up to a complex nonlinear price schedule, they are intended not to constrain the typical participant. However, the detailed rules may be constraining for nonparticipants and possibly explain why they do not participate: even though the program is available to them at no costs, it would also have little value due to other constraints.

Besides the price incentive, the HealthyFood program also consists of non-price elements such as food labeling, point-of-sale marketing, and education initiative. They could play an important role in healthy diet promotion, but the data to date do not allow me to disentangle their independent contributions net of the price effects. Therefore, the estimated rebate effect should be interpreted as the combined impact of both price and non-price features of the HealthyFood program.

It is noted that the total food expenditure doubled among the 25% rebate recipients, but because I can only track purchases from Pick n Pay stores, I am unable to tell how much of the increase denotes a real increase and how much comes from pure switching effect resulted from lower opportunity cost of shopping all types of foods (i.e., healthy, less desirable, and neutral foods) all in one store. Nevertheless, there is a probability that the

rebate program has some unintended effects on increasing the total food consumed and thus mediating the program's effectiveness in healthy diet promotion.

While the HealthyFood program addresses a hot policy question worldwide, its generalizability to other populations remains uncertain. The program may be unique worldwide due to its size and geographic scope and is the only large price intervention led by the private sector on an ongoing basis. This makes the study novel and interesting, but also contributes to its limitations by weakening the study design. Nevertheless, this study serves as an important data point in the ongoing effort to quantify the role of prices on dietary behaviors.

The results from this rebate program suggest that reducing the costs of healthy food purchases is likely to change purchasing patterns in a meaningful way. However, it is not a cheap way to achieve major changes in population diets. Changes in purchases are commensurate with price changes, however our findings suggest that even a large price change for healthy foods, like 25%, can at best address a small part of the discrepancy of population dietary patterns and dietary guidelines.

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