CAN A MAJOR NATIONAL FOOD RETAILER IMPROVE THE NUTRITIONAL PROFILE OF US PACKAGED FOOD PURCHASES AND REDUCE DIET-RELATED DISPARITIES?

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ABSTRACT

Lindsey P. Smith: "Can a healthy foods initiative at a major national food retailer improve the nutrient profile of US packaged food purchases and reduce diet-related disparities?"
(Under the direction of Barry M. Popkin)

Since 2011, three of the largest national food retailers in the US have implemented healthier food initiatives (HFIs). Yet, no work has evaluated whether an HFI at a major national food retailer actually improves the nutrient profile of food purchases. The objective of this research is evaluate the impact of the food retailer and food-retailer based HFIs on the nutrient profile of US packaged food purchases (PFPs).

Using a dataset of household PFPs, we employed Walmart as a case study to examine the impact of a single food retailer as a food source in the US and who is most likely to shop there. Secondly, using fixed effects models and inverse probability weighting to account for selectivity, we evaluate whether the nutrient profile of Walmart PFPs improved over time. To test whether improvements in the nutrient profile of Walmart's PFP were attributable to the HFI, we employed counterfactual simulations to compare the observed nutrient profile of post-HFI purchases to the expected trajectory of nutrient profiles based on pre-HFI trends.

We found that not only do the majority of US households buy PFPs at Walmart, the proportion of PFPs purchased from Walmart doubled from 2000 to 2012. Low-income non-Hispanic White and Hispanic households, but not low-income non-Hispanic Black households, were more likely to buy a larger proportion of PFPs at Walmart. From 2000 to 2012, Walmart PFPs showed substantial declines in energy density, sugar density, and sodium density, and these

declines were much larger than declines observed in other chain retailers. Hispanics and non-Hispanic Others showed the largest declines in energy density and sodium density. However, we found that post-HFI shifts in nutrient profile were similar to what would have been expected based on pre-HFI trends, indicating that improvements in the nutrient profile of Walmart PFPs were not attributable to its HFI. Continued evaluation of HFIs at Walmart and other retailers is needed to understand how retailer-driven changes in food purchasing translate into changes in food intake and impacts on health outcomes.

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LIST OF ABBREVIATIONS AND SYMBOLS

AFP Average food price

GBD Grain-based dessert

FPL Federal Poverty Level

HFI Healthy Foods Initiative

HWCF Healthy Weight Commitment Foundation

NFP Nutrition Facts Panel

OCR Other chain retailers

PFPs Packaged food purchases

RTE Ready-to-eat

SSB Sugar-sweetened beverage

SNAP Supplemental Nutrition Assistance Program

UNCFRP University of North Carolina Food Research Program

CHAPTER 1. INTRODUCTION

Background

Since 2011, a number of the largest supermarkets in the US have implemented healthier food initiatives (HFIs) to increase the availability and affordability of healthier foods. These retailer-based strategies have major potential to improve the nutrient profile of what US households purchase and consume, not only because food stores in general provide the majority of daily energy for US children and adults (1, 2), but because national trends towards chain stores and consolidation (3) means that these top retailers account for the majority of US food purchases (4).

However, no work has examined whether an HFI at a major national food retailer can improve the nutritional quality of the US diet in a significant way. First, due to lack of access to retailer data, little work has examined the overall impact of major food retailers on the nutrient profile of the US food supply. Second, while previous studies have shown that supermarket HFIs can improve the healthfulness of purchases, most studies were short-term, limited to a few stores, lacked product-specific nutrient information, and did not examine whether the HFI changed customer purchasing behaviors or simply attracted different customers. In addition, considering recent changes in the economic environment, such as the "Great Recession," and changes in the food retail environment, it is critical to understand whether the HFI truly changed nutritional quality of purchases, or whether changes simply reflect overall trends in purchases from chain

food retailers during this time period. Finally, HFIs at major national food retailers represent a potential strategy to reduce diet-related health disparities for key subpopulations, such as low-income and minorities, who often have nutritionally poorer diets and less access to healthy foods. Yet, to our knowledge, no one has examined whether HFIs successfully improve nutritional quality of purchases in these key groups.

This study uses Walmart, the US' largest supermarket, as a case study to examine the impact of the food retailer and food-retailer based HFIs on the nutrient profile of US household packaged food purchases. The overarching goal of this study is to evaluate whether an HFI at a major national retailer can improve the nutrient profile of food and beverage purchases over time, as measured by reductions in energy, sugar, saturated fat, and sodium densities. We use Nielsen Homescan panel data, a longitudinal dataset of packaged food (PFPs) purchased by US households that has been linked to product-specific nutrition information from 2000 to 2013 for over 2.4 million household quarters. Using this data, we first characterized the role of Walmart as source of PFPs in the US, and who is most likely to shop there. Next, using these characterizations, we developed inverse probability weights to account for the selectivity of shopping at Walmart vs. other chain retailers over time. We examined whether shifts in the nutrient profile of Walmart PFPs were greater than trends at other food retailers, whether these shifts were attributable to Walmart's HFI, and whether these changes were greater among low-income and race/ethnic minority households.

Research Aims

Aim 1: Examine the role of Walmart as a source of PFPs and describe the profile of Walmart shoppers (2000-2013)

1a. We examined the trends in the percent of US households shopping at Walmart as well as changes in the distribution of percentage of PFPs households purchase at Walmart relative to total food store purchases.

1b. We explored the association between socio-demographic characteristics and who was most likely to buy the most at Walmart, and how these associations changed over time.

Aim 2: Test whether the nutritional profile of Walmart PFPs improved from 2000 to 2013, and whether these changes were greater than trends at comparable food retailers:

2a. We developed time-varying inverse probability weights to account for the potential selectivity bias associated with shopping at Walmart or other chain retailers.

2b. We examined changes in the nutrient profile of Walmart and OCR PFPs over time, including energy, sugar, saturated fat, and sodium density.

2c. We examined whether these changes were driven by shifts in purchasing or reformulation by examining changes in percent volume of food groups purchased, as well as changes in the nutrient profile within these food groups from 2000 to 2013.

2d. We examined whether these changes in nutrient profile were greater among SNAP-eligible or race/ethnic minority households.

Aim 3: Test whether shifts in the nutrient profile were attributable to Walmart's HFI:

3a. We conducted counterfactual simulations by comparing the projected pre-HFI trends in

nutrient profile of Walmart PFPs to observed post-HFI trends in nutrient profile, and compared these to concurrent trends in the nutrient profile of PFPs at other chain retailers (OCR).

3b. We tested whether the effect of the HFI varied depending on whether Walmart's stated pre-HFI period (2000-2010) or a data-defined pre-HFI period (2000-2006) was used.

3c. We examined whether the HFI was more impactful in shifting the nutrient profile of PFPs among key subpopulations, including SNAP-eligible households and racial/ethnic minorities.

CHAPTER 2. LITERATURE REVIEW

Food retailers are important allies in the fight against obesity

Public health experts have increasingly recognized food retailers as potential agents for improving nutrition and preventing obesity, (5, 6) because they provide the majority of daily energy for US children and adults (1, 2), and because of their pivotal positioning between food manufacturers and the public (5, 6). In fact, since 2011, several of the US' largest grocers have implemented "healthier foods initiatives" (HFIs) to encourage healthier food purchases (7-10). National trends towards chain stores and consolidation (3) means that these top retailers account for about half of all US food purchases (4) and thus have major potential to influence the nutrient profile of US food and beverage purchases.

Food retailers, food retailer-based HFIs, and nutritional quality

Currently, it is unclear whether supermarket-based HFIs improve nutritional quality of purchases over the long term. Field studies on retailer-based HFIs have been equivocal: while some field studies have found that HFIs demonstrate moderate to high reach (11-13) and improve healthy food availability, sales of targeted foods, and self-reported knowledge, purchasing, and intake of healthier food (11, 14-18), others have found that common HFI components are ineffective at changing long-term purchasing behaviors. For example, while consumers report that nutrition signs and labels improve knowledge (19-21), these strategies are not well-understood or highly used (22-24) and do not significantly impact food purchasing

behavior (25-30). Similarly, studies show that while discounts on healthy foods increase short-term sales, these promotions do not necessarily translate into long-term changes in food intake (31-33).

In addition, most studies examining food retailer HFIs have been in small stores, short-term (~6-18 months of follow-up), with small samples, and limited to a few target foods, providing little understanding of how long-lasting HFIs at a major national supermarkets impact purchases across the population over time. However, HFIs at major supermarkets, including Walmart, are not short-term interventions, but rather represent a long-term shift in how foods are produced, marketed and sold, creating the need to understand how this shift impacts nutritional quality of purchases over the long term. In addition, most previous studies have been unable to accurately quantify nutritional changes, largely because nutrition information rapidly changes due to product introduction, discontinuation and reformulation (34).

To our knowledge, only one study has examined the impact of an HFI on the nutrient profile of purchases at a major chain retailer. The study examined Guiding Stars, a storewide point-of purchase nutrition navigation intervention which used shelf-labeled star icons to indicate healthier options, in a chain of Northwest supermarkets, using two years of purchase data. Investigators found that the HFI showed significant but small (<2%) increases in the percent of purchases with a star logo after the intervention, and that the star logo was associated with a better nutrient profile of purchases (35). However, this work was still limited to only one region of the country and examined only one type of HFI (a labeling initiative), and could not evaluate these shifts at the household level. This latter limitation precludes evaluation of whether some key subgroups were more responsive to the HFI than others.

Finally, one study examining the effects of a insurer-based HFI in South Africa showed that price cuts or rebates can also be an effective HFI strategy. South Africa's Healthy Food project offered enrollees at a major national health insurer a rebate of up to 25% on purchases of healthy foods at a national retail supermarket chain, increased self-reported intake of fruits, vegetables, and whole grains, and decreased intakes of high-salt, high-sugar, and processed foods (36, 37). Purchase data showed that over three years, rebates were associated with a 6-9% increase in healthy food expenditures, suggesting HFIs can impact consumer purchasing over time (38). However, more work is needed to understand whether a multi-component, supermarket-based HFI will similarly impact food store purchases in the U.S.

Secular trends in consumer purchasing and the food retail industry

Due to their short and singular store nature, most HFI evaluations have not been able to address whether HFIs improve nutritional quality beyond secular trends in consumer purchasing, despite major concurrent changes in consumer purchasing, food manufacturing, and food retailing during the first decades of the 21st century**.** For example, surging food prices in 2007 (39-41) and the Great Recession, a period of economic decline in 2007-2009, have increased cost-consciousness and discount seeking, and reduced overall food expenditures (24, 42). In fact, using the Homescan data, the UNC Food Research Program (UNCFRP) has found that consumers decreased purchases of sweets, snacks, grains, soft drinks, and fruits and vegetables after 2003, and this trend accelerated after 2007 (43). Other work has noted overall declines in caloric intake among children(44) and adults(45) in recent years. An additional UNCFRP evaluation found that companies participating in the Healthy Weight Commitment Foundation (HWCF) marketplace pledge reduced daily per capita packaged food caloric purchases by 66

kcal/day among households with children from 2007 to 212, with additional caloric reductions in non-HWCF purchases and in private-label purchases as well (46).

In addition, major food stores have also implemented HFIs in recent years, such as Kroger's "Health Matters" program, Safeway's "SimpleNutrition" program, or Boston supermarkets' recent "Healthier Beverage" initiatives (8, 47, 48). Accounting for these secular trends is important in order to determine whether changes in nutritional quality of purchases are actually attributable to the retailer's HFI and not simply reflections of concurrent trends in food purchasing, manufacturing, or at other chain retailers.

Concerns with selection bias when evaluating HFIs

Shopping choices are driven by a complex set of factors, which not only determine *where* a customer shops, but how much they respond to food retailer HFIs. Sample selection bias may arise because the choice to shop at a certain store is non-random. For example, less educated, lower income, and African American individuals more likely to shop at lower-priced supercenters (49, 50). This choice is also driven by a number of preferences, including quality, variety of products available, store loyalty, proximity, opportunity cost, how much a shopper plans to buy, and price expectations (51-56). For example, those who shop for many items at once prefer "everyday low pricing" stores such as Walmart, which typically set lower, less variable prices across a wide range of products (53, 55, 56). This sample selection bias poses a problem because some households are more likely to shop or buy more at one food retailer than others, and these inherent characteristics also may be associated with the nutritional quality of purchases. Failure to address selectivity can introduce bias in the relationship between that retailer's purchases and nutritional quality, as well as limit the generalizability of study results.

In addition, the selectivity of shopping at a certain retailer could vary over time, complicating evaluations of an HFI. For example, if a retailer's HFI involves cutting prices on fruits and vegetables and offering a wider variety of organic and locally sourced produce, it might attract more health-conscious consumers. If these health-conscious consumers purchase more produce and fewer unhealthy products, the overall nutrient profile of the retailer's purchases would appear to improve. However, attributing these changes to the HFI would be incorrect, since in actuality the improvements would be driven by the introduction of new customers, and would not reflect meaningful improvements in the nutrient profile of other consumers. Thus, a key concern is whether HFIs are successful at improving nutritional quality of PFP purchases, or if they simply attract a different type of customer. However, no studies to date have employed methods to account for this time-varying selection bias.

HFIs and diet-related disparities

HFIs have potential to reduce health disparities by improving availability and affordability of healthy foods for key subpopulations such as race/ethnic minorities and low socio-economic status households, who tend to have less access to healthy foods (57-59) and nutritionally poorer diets (60-62). In fact, the gap in diet quality between high and low socioeconomic status appears to have widened over recent years (63), creating a pressing need to address these disparities. Yet, because of small sample sizes and socio-demographically homogenous populations, previous studies have not determined whether HFIs differentially impact these populations. While some studies show that lower-income customers tend to be more cost-conscious (64) and more likely to take advantage of price promotions(65), other work suggests they may not be more responsive to price cuts than higher income consumers (66-69). Similarly, better educated customers report higher usage of food labels (21, 70), but it is unclear

whether HFIs are more effective at improving nutritional quality of purchases among higher educated customers. In particular, no work has examined whether HFIs differentially impact certain types of low-income households, such as households who are eligible to receive or receive supplemental nutrition assistant program (SNAP) benefits, and could potentially benefit the most from increased affordability and availability of healthy foods (71-73).

Current strategies for evaluating nation-wide industry initiatives to improve nutrition

To our knowledge, there have been no independent evaluations of HFIs at major national food retailers. However, as previously mentioned, UNCFRP has been tasked with evaluating a major initiative by the food industry to cut 1.5 trillion calories from the food supply by 2015. As with Walmart's HFI, the HWCF food companies pledge was nation-wide, which means there is no clear natural experiment or control group to which shifts in calories can be compared. While a simple approach would be to compare pre-initiative trends to post-initiative trends, this approach cannot identify whether observed changes were attributable to the HFI or to concurrent shifts in the economic, socio-demographic, and food retail environments as previously mentioned. To deal with this concern, the UNCFP developed an approach utilizing counterfactual simulations (74-76): what would the nutrient profile of purchases look like if the initiative had not been enacted, if all other factors were held constant (46)? This strategy allows researchers to compare the expected nutrient profile of post-HFI food purchases based on pre-HFI trends to what actually happened during the post-HFI period, while controlling for secular trends.

Walmart as a case study

Because of its size and scope, Walmart represents unique opportunity to examine the impact of a single food retailer as a source of US food purchases, as well as whether national food retailers can successfully improve the nutritional quality of US food purchases. Walmart is

the US' largest food retailer, with grocery sales of $114.7 billion in 2013, compared to the second largest retailer, Kroger, with sales of $76.7 billion(4). In 2011, Walmart, pledged to enact a comprehensive HFI to improve the nutritional quality and affordability of Walmart purchases. Walmart's initiative entails three major components: 1) development of a front-of-package labeling system for Walmart brand store-brand consumer packaged goods (PFPs) that meet specified health criteria; 2) strategic price reductions on healthier items, and 3) product reformulation of Walmart store-brand products, with goals to achieve elimination of *trans* fats, a 25% reduction in sodium, and 10% reduction in added sugar in key PFP categories by 2015 (77, 78). Considering that Walmart accounted for 20% of US food store expenditures in 2012 (79), and is among the largest recipient of SNAP spending (80), successful implementation of this HFI could substantially improve the nutritional quality of the US diet and potentially reduce diet disparities.

Rationale for using a dataset of food and beverage purchases

Traditionally, population-level studies of nutrition use large-scale nutrition surveys, such as the National Health and Nutrition survey. Such surveys are advantageous because they are often repeated over time and are nationally representative, allowing for the monitoring of diet intake and diet-related diseases at the population level. However, because their aim is primarily surveillance of nutrition and health, such surveys do not typically collect information about the food retailer where food is purchased; rather, they simply categorize foods by broad categorizations of source (i.e. home, school, restaurant), precluding the use of such data to evaluate the impact of the food retailer.

A second option is to partner with the food retailers themselves to get data on store purchases. Such an approach is advantageous because it provides a better window into what the

company actually did, when it was implemented, and how; however, such a partnership also comes with limitations. First, companies are not always eager to partner with outside researchers and second, such relationships could influence objectivity. For example, the Guiding Stars HFI evaluation was funded by the food retailer where the HFI was implemented as well as the company who designed the nutrition navigation program. While such studies can still provide useful data, if HFIs were ever to be considered on a bigger scale, policymakers would also need evidence from independent evaluations, where researchers are not encumbered relationships to businesses, which are typically concerned most about their image and their bottom line.

Considering these limitations, this study employs a third approach, capitalizing on the unique features of the Nielsen Homescan panel data, a longitudinal dataset of household purchases which our team has linked to product-specific nutrition information (Nutrition Facts Panels, or NFPs) for over 2.4 million household quarters from 2000-2013 (34). These NFPs are continuously updated and matched to PFP products, providing a more accurate and time-sensitive measure of nutrition, providing a distinct advantage to studies which simply use purchase data and thus cannot study changes in nutrient profile. The Homsecan dataset includes information on all food and beverages with a barcode, including information on price, volume, unit size, and importantly, the retailer where the product was purchased. This data allows us to examine the impact of specific retailers on the nutrient profile of US food purchases. Moreover, the longitudinal nature of this household level data allows us to examine how the nutrient profile of purchases at the HFI store changed over time, whether these changes were above and beyond changes at similar retailers over the same time period, and finally, whether these changes were greater or less in key subpopulations.

CHAPTER 3. THE EMERGING ROLE OF WALMART IN US PACKAGED FOOD PURCASHES: WHO SHOPS THERE, HOW MUCH IS PURCHASED, AND PUBLIC HEALTH IMPLICATIONS

Overview

Despite a growing focus on the food environment, little is known about the impact of specific food retailers as a food source in the US, especially among low-income populations. We examined purchasing trends among the US' largest food retailer, Walmart, and whether low-income and race/ethnic minority households are more likely to shop there. Using nationally representative household purchase data, we analyzed trends in Walmart packaged food purchases (PFPs) from 2000 to 2012. We find that not only do the majority of households buy food at Walmart, the proportion of PFPs purchased from Walmart doubled from 2000 to 2012. Low-income non-Hispanic White and Hispanic households, but not low-income non-Hispanic Black households, were more likely to buy a larger proportion of PFPs at Walmart. We find that a single food retailer—Walmart—is an increasingly dominant source of PFPs, especially among low-income households. As fewer food retailers account for an increasingly large share of PFPs, more work is needed to understand how shifts in the food retail environment affect the nutritional quality of the US diet.

Introduction

Consensus among public health and nutrition scholars has been growing about the importance of the food environment for improving our health (81, 82). Perhaps one of the most important elements of this environment is food stores, which supply the majority of daily caloric energy for children and adults (1, 2, 83). Public health experts have increasingly recognized food retailers as potential agents for improving nutrition and preventing obesity (5, 6), in part because of their major role as a source of food and also because of their pivotal position between food companies and the public.

Despite this growing awareness of the food environment, to our knowledge, no research has explicitly examined the role of specific retailers in the US food supply. Yet, an understanding of the size and scope of food retailers is increasingly important, as the expansion of chains and consolidation (3) has created a food landscape in which fewer retailers are accounting for a larger share of grocery sales: the top eight grocery retailers accounted for nearly 50% of US grocery sales in 2012, compared to only 26% in 1992 (4).

Moreover, identifying the extent to which a single food retailer serves as a source of the US food supply is an important first step in identifying whether and to what degree food retailers can be leveraged to improve diet quality. Many scholars have noted the need to improve labeling (e.g., front-of-the-package food profiling) and reformulate food products as critical components of improving nutrition and combating obesity (84-90). However, few have actually studied these kinds of initiatives implemented by key food retailers (7, 9, 91), yielding an incomplete understanding of their potential impact on the nutritional quality of the US diet.

Understanding the role of the food retailer as a source of PFPs is particularly important among low-income households, who tend to have less food availability and face greater

constraints on cost and time when choosing where to shop for food (92-96). Previous work has established that less educated, lower income, and African-American individuals are more likely to shop at lower-priced food outlets and supercenters (49, 50), yet no work has examined whether low-income households are increasingly likely to buy a larger share of their PFPs from a single retailer. Such trends are important to understand, as a greater propensity to purchase a larger share of PFPs at a given food retailer could make these groups more susceptible to retailers' evolving strategies on the price, product assortment, and product formulation of more- and less-healthful foods.

Perhaps the most influential among these retailers is Walmart**,** a national supercenter chain that grew from 682 supercenters in 1999 to over 3,000 stores in 2014,(97, 98) and is now the US' largest grocery retailer (99), accounting for $113.2 billion in food and non-food grocery sales in 2012 (4). Despite a large body of work examining the impact of Walmart's expansion on wages, jobs, and other food retailers (100-105), to our knowledge, no independent research has examined shifts in packaged food and beverage purchases (PFPs) at Walmart over time. Key questions relate to not only what percent of households shop for food at Walmart, but how much they are buying there: do a small fraction of households purchase a large share of PFPs at Walmart, or do the majority of households shopping at Walmart buy only a small fraction of their total PFPs there? Are low-income households more likely to buy more there, and is this relationship consistent across race/ethnic groups? Understanding the size and scope of Walmart purchasing trends is important for understanding how Walmart impacts the nutritional quality of what households buy and eat, especially in light of recent evidence that the nutritional quality of supercenter purchases may be less healthful than those purchased at more traditional food retailers (106).

The objective of this paper is to quantitatively evaluate the degree to which a single food retailer can serve as a source of PFPs in the US by examining trends in US household PFPs at Walmart from 2000 to 2012. We use a large, nationally representative dataset of household purchases to examine trends in percent of US households shopping at Walmart as well as changes in the distribution of the proportion of PFPs these households purchase there. Secondly, we examine whether low-income households are more likely to purchase a higher proportion of PFPs at Walmart than higher-income households, whether this has changed over time, and whether the association of low-income with Walmart purchasing is constant across race/ethnic groups.

Methods

This study uses Nielsen Homescan, a commercial dataset containing information on PFPs at the household-quarter level.(107) PFPs include all food and beverages with a barcode, including all consumer packaged goods as well as packaged fresh fruit and vegetables (i.e. bag of lettuce, bag of potatoes) but excluding unpackaged meat and produce (i.e. an apple). Participating households use a handheld scanner to record all purchases during each shopping trip. Households are sampled from 76 markets, and weighted to be nationally representative. Households report detailed information on each PFP purchased from outlet channels, including grocery (i.e., Kroger's, Safeway, etc.), drug, supercenters (i.e. Super Target, Walmart), club (i.e. Sam's Club), dollar stores, and convenience stores. Because the types of products available may differ by store type, for this study, we include all PFPs from grocery stores, supermarkets, and supercenters (i.e. "other food stores"), and exclude warehouse, drug, club, dollar, and convenience stores to ensure comparability between Wal-Mart purchases and other food store PFPs. Walmart purchases include all food and beverage PFPs from Walmart Supercenters and

Walmart Neighborhood markets, the latter being smaller in size and assortment while offering a full line of groceries, bakery, and deli items (108). These do not include Sam's Club and Walmart Express, which are Walmart's warehouse and convenience stores, respectively

For this study, purchases were aggregated at the year-household level, for a total of 663,073 household-year observations from 158,382 unique households. For each household in each year from 2000 to 2012, we summed the PFPs from Walmart and from other food stores, measured in terms of grams purchased. We measured purchases in grams instead of calories because our key goal was to understand overall trends in the proportion of PFPs purchased at Walmart relative to other food stores, whereas changes in calories purchased reflect both changes in the proportion of PFPs purchased at Walmart as well as changes in the nutrient of foods over time (7, 109). However, sensitivity analyses conducted using caloric purchases from Walmart and other food stores revealed similar trends to those presented here.

Statistical Analysis

All statistical analyses were performed using STATA, version 13 (Stata Corporation, College Station, Texas).

In initial analyses, data were treated as pooled cross-sectional, and weighted to be nationally representative using Nielsen's projection factors[1]. Logistic regression was used to describe changes in the likelihood of shopping at Walmart (i.e., spent >0$ on any PFP at Walmart) for each year from 2000 to 2012. From these models, we compared the predicted percent of shopping at Walmart in each year to 2000. Secondly, in order to examine changes in the proportion of PFPs purchased at Walmart over time, quantile regression was used to examine

[1]Survey commands (for logistic regression) and probability weights (for quantile regression) were used to adjust estimates to be nationally representative. However, models did not account for the non-independence of repeated measurements on households in the sample over time, because robust covariance estimators are not permitted in STATA in conjunction with these methods. However, we re-ran all models without adjustment to be nationally representative but with robust covariance estimators and found that the results were virtually identical.

the distribution of the proportion of PFPs purchased at Walmart relative to total food store purchases at the 50th, 75th, and 95th percentiles. The predicted percent of PFPs purchased at Walmart in each year was compared to 2000.

Secondly, to examine the association between income, race/ethnicity, and proportion of PFPs purchased at Walmart, households were divided into quartiles of Walmart shopper, based on the distribution of proportion of PFPs purchased at Walmart in 2012. On average, non-shopper households purchased 0% of PFPs from Walmart (range 0.0% to 0.3%), low shopper households purchased 3% (range 3.0% to 7.2%, medium shoppers purchased 18% (range 7.2% to 33.9%), and top shoppers purchased 68% (range 33.9% to 100%) of PFPs from Walmart. Multinomial logistic models included household race (non-Hispanic White, Hispanic, non-Hispanic Black, and non-Hispanic Other) and household income [low <185% Federal Poverty Level (FPL), medium 185-400% FPL, high >400% FPL]. These models controlled for head of household education (≤ high school degree, some college,≥ college degree), household type (single adult, multiple adults with no kids, adult(s) with kid(s)) and household composition (numbers of men or women aged 19-29, 30-39, 40-49, 50-59, ≥60y, and numbers of boys and girls aged 0-1y, 2-5y, 6-12y, 13-18y).

In addition, models controlled for whether there was a Walmart present in a given market in a given year, as defined by>$10,000 annual sales from PFPs per market per year. Additional cut-points for determining presence of a market were also tested (>$0 and $5,000) and generally yielded similar results; however, to be sure that purchases in a market were actually from that market and not a neighboring market where households may have traveled to purchase items, the higher cut-point (>$10,000) was used.

Additional models tested interactions of income and year, and income and race/ethnicity, using Wald "chunk" tests for joint significance of interaction.(110) Robust cluster variance estimators were used to adjust the standard errors to reflect the non-independence of households who remained in the sample across time.(111, 112) For each model, STATA's margins command was used to estimate the predicted percent of households in a shopper category for each income, race/ethnic, or year combination. All analyses were Bonferroni-corrected for multiple comparisons, and statistical significance was set at $p<0.01$ for main effects and $p<0.05$ for interactions.

Results

Household demographic characteristics of the sample are presented in **Table 3.1**. Walmart-shopping households were more likely to have children, be less educated, be non-Hispanic White, and have a low- or middle- income.

The percentage of US households who shopped for PFPs at Walmart increased from 71% in 2000 to 82% in 2012 ($p<0.01$) (**Supplemental Figure 3.1**). Among households who shopped at Walmart, the proportion of PFPs purchased at Walmart also increased substantially from 2000 to 2012 (**Figure 3.1)**. The median Walmart-shopping household nearly doubled the proportion of PFPs purchased from Walmart, from 10% in 2000 to 19% in 2012 ($p<0.01$). Increases in the proportion of PFPs purchased from Walmart were even greater at the upper end of the distribution. In particular, households in the 95th percentile of Walmart shoppers increased the proportion of PFPs purchased at Walmart from 56% in 2000 to 85% in 2012 ($p<0.01$).

Across all time periods, low- and middle-income households were less likely to be Walmart non-shoppers than high-income households, and more likely to be top shoppers than high-income households. All income levels showed a decrease in the percent of Walmart non-

and low-shoppers between 2000 and 2012 (**Figure 3.2**). However, low-income and middle-income households showed a bigger decline than high-income shoppers: the proportion of low shoppers declined by 12%, 10%, and 7% for low, middle, and high-income households, respectively (p <0.05 for interaction). Similarly, while all income levels showed an increase in the proportion of households who were top shoppers, low and middle-income households showed larger increases than higher income households, with increases of 21%, 18%, and 15% of households in the top shopper category from 2000 to 2012 for low, middle, and high-income households, respectively (p <0.05 for interaction).

Across all time periods, there were minimal differences in the likelihood of being a non-, low, middle-, or top- Walmart shopper by race/ethnicity. The only clear difference was that non-Hispanic Blacks were less likely to be non-shoppers than non-Hispanic Whites (24% vs. 28%, respectively [p<0.01]) (not shown). However, as shown in **Figure 3.3**, there was a significant interaction between race/ethnicity and income level. For non-Hispanic Whites, Hispanics, and non-Hispanic Others, high-income households were more likely to be non-shoppers than low-income households, and low-income households were more likely to be top shoppers than high-income households. However, amongst Black households, this trend was reversed: low-income households were 7% more likely to be non-shoppers than high-income households, and high-income households were 4% more likely to be top shoppers than low-income households (p<0.05 for interaction).

Discussion

This study shows that over time, a single food retailer—Walmart-- is becoming an increasingly dominant source of PFPs. Not only are more US households are shopping at Walmart, households are buying a larger proportion of PFPs there over time.

Walmart's growing dominance as a source of PFPs has major implications for the nutritional quality of US food purchases, as well as obesity prevention efforts. First, limited evidence suggests that the food available in supercenters may be less healthful than grocery stores or supermarkets (113), although this work was limited to a small geographic region. More convincingly, using a large commercial dataset from 1998 to 2006, Volpe et al. found that consumers purchased less produce and more processed food at supercenters (including Walmart) relative to supermarkets (106). Secondly, because of its size, changes in Walmart's product assortment, reformulation, and price not only influence the healthfulness of what Walmart customers buy, but what they purchase at other stores as well. For example, Walmart and other supercenters typically offer lower prices (114), which drives down prices at competing stores, including prices of produce, dairy, meat, and packaged goods (50, 115-117).

In fact, some researchers contend that these cost and time savings, particularly for energy-dense, nutritionally-poor processed foods, contribute to excess energy intake and subsequent obesity (118-122). Yet, evidence on the impact of Walmart and supercenters on obesity has been mixed: while one ecological study found that the addition of one Walmart supercenter per 100,000 residents was associated with an increase in the obesity rate of 1 to 2.4 percentage points (123), another ecological study found an inverse association between supercenters per capita and county-level obesity prevalence (124).

Moreover, these studies have not considered the dramatic changes occurring within Walmart stores in recent years, such as increasing sales of locally sourced and organic foods (125, 126). In addition, starting in 2011, Walmart announced a national healthy foods initiative, including introduction of a front-of-package labeling system, price reductions on healthier foods including produce, and product reformulations to reduce saturated fat, added sugar, and sodium

(77). Currently, it is unclear whether these initiatives have resulted in improvements in the nutritional quality of consumer purchases. For example, Walmart recently faced criticism for promoting high- sugar, fat, and sodium foods and beverages in its advertisements targeted at low-income customers (127). Future research should examine whether the nutritional quality of PFPs at Walmart differs from similar food retailers, as well whether these purported shifts in product assortment, formulation, and price have improved the nutritional quality of these purchases. Regardless, the growing dominance of Walmart as a source of US PFPs suggests that it and other major national retailers could be key players in strategies to improve diet and reduce obesity, and should be considered as potentially pivotal agents in efforts to improve the quality of the US food supply.

These nutritional implications are particularly important for low-income households who, as we show, are not only more likely to shop at Walmart, but also more likely to purchase a larger proportion of PFPs there. These results are consistent with previous work showing that low-income consumers prefer supercenters, primarily because they prioritize consistently low prices and a large product assortment (49, 55). In addition, Walmart is the recipient of 18% of SNAP benefits (80). Despite recent cuts to SNAP benefits (128), in its most recent annual meeting, Walmart's CEO reported expectations that its market share will actually grow as a result of SNAP cutbacks, as increasing cost-consciousness will drive low-income consumers to buy even more at Walmart (129). Taken together, these results underscore the importance of understanding how Walmart impacts the nutritional quality of purchases of low income households, who may be especially sensitive to price cuts and promotions on both healthy and unhealthy foods (65, 130).

In this study, we found that among non-Hispanic Whites, Hispanics, and non-Hispanic others, low-income households were more likely to shop at Walmart than their higher-income counterparts; however, this trend was reversed for Blacks. It was unclear why income level had a different effect among Blacks compared to other race/ethnic groups. One possibility is that low-income Blacks are more likely to live in areas with no Walmart, or less likely to have transportation means required to access Walmart. Although we controlled for market as well as whether or not there was a Walmart in the market, some markets cover a wide geographic area and so even if there is a Walmart in that market, low-income Blacks may not be within a reasonable distance to access it. Previous work has suggested that lower-income rural and inner-city populations have lower access to supermarkets and supercenters than higher-income populations or those living in suburbs (131-133). Although these studies did not consider differences in access by race/ethnicity, if low-income Blacks are more likely to live in these areas they may be less likely to have ready access to a Walmart than their higher-income counterparts.

This trend towards increased purchases at Walmart is consistent with an overall transformation in the way US households shop for food in recent decades, moving from traditional, independent grocery stores and supermarkets towards increasing purchases at large chain supermarkets (134-136) and supercenters (24, 134). Other societal shifts, including greater cost consciousness (24) and increased perceptions of time scarcity (137), motivate households to seek out supercenters, which typically maximize both cost and time savings by setting lower, less variable prices (i.e. "everyday low pricing") across a wide assortment of products (53, 55, 56), enabling one-stop shopping (53, 54, 138). However, this shift does not appear to be the result of the Great Recession: although surging food prices in 2007 (39-41) and the Great Recession

increased discount-seeking behavior and reduced overall food expenditures (24, 42), the present results show that that the largest increases in Walmart PFP purchases began well before the 2007 economic downturn. Although we did not test the effects of the recession of the recession explicitly, these increases in Walmart purchasing likely reflect the larger trend towards increased supercenter purchasing that began in the early 2000s and continued during the economic recovery (24, 139).

Limitations

This study has several important limitations. First, because this dataset included only products with a barcode, we did not examine changes in purchasing at Walmart related to unpackaged fresh produce, such as fruits and vegetables. Because shoppers at Walmart tend to purchase a wide assortment of items, most households who purchase unpackaged fresh produce at Walmart likely purchased other PFPs as well, and would have been included in our estimates of Walmart shoppers. Similarly, we are unable to account for non-food-store changes, including changes in restaurants and prepared food outlets and for cooked unpackaged foods sold at retail food outlets, and how these interact with purchasing behavior at Walmart and other food stores. However, given that US consumers consume about 70% of daily energy from food stores, and this has remained fairly stable from 2000 to 2010 (2), it seems unlikely that changes in away-from-home food purchases impacted our results.

Conclusion

This study shows that a single food retailer is a major source of the US diet: US households, and especially low-income households, are increasingly likely to shop for PFPs at Walmart and buy a larger proportion of PFPs there over time. As fewer retailers account for a greater share of US food purchases, these individual retailers will have an important and

growing impact on the nutritional quality of what people buy and eat. In fact, the growing dominance of Walmart and other major national retailers presents a major research and policy opportunity: understanding how these retailers impact the nutrient profile of purchases could provide valuable insight into strategies and potential avenues for improving the healthfulness of US food purchases. In particular, more work is needed to understand the effects of Walmart's rapid expansion and whether Walmart's recent healthy foods initiative substantially improved the nutrient profile of foods purchased there, especially for low-income households, who shop there most.

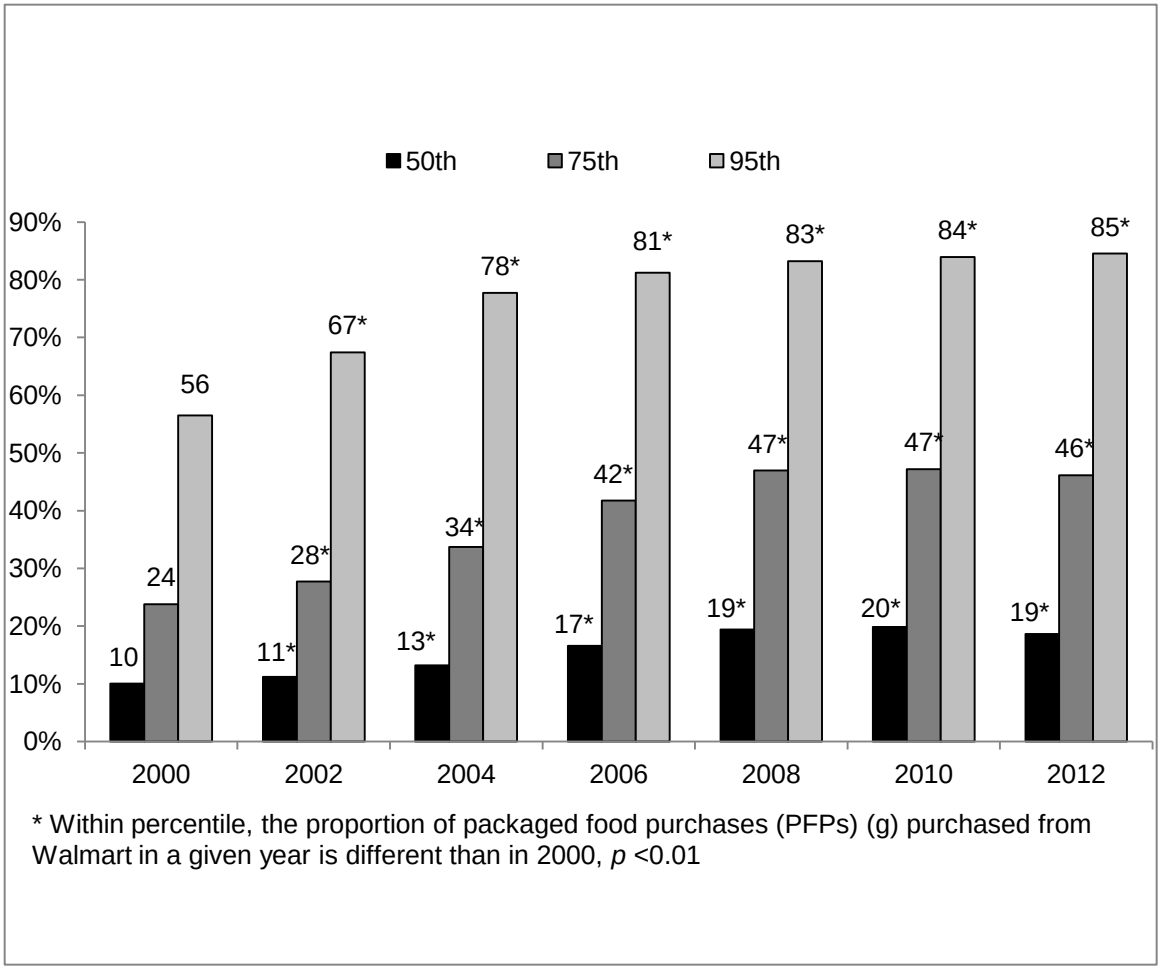
Tables and Figures

Table 3.1. Household characteristics of the Nielsen Homescan sample by whether or not a household shopped at Walmart from 2000 to 2012[a] (n=663,073)

	Walmart non-Shopper %	Walmart Shopper %	p^b
Household composition			
Single adult	37%	23%	<0.001
Multiple adults, no children <18y	38%	39%	0.015
Single adult, with children <18 y	19%	29%	<0.001
Adults, with children <18	6%	8%	<0.001
Race/ethnicity			
Non-Hispanic White	72%	75%	<0.0001
Hispanic	11%	10%	0.049
Non-Hispanic Black	11%	11%	0.012
Non-Hispanic Other	6%	4%	<0.001
Male household head education			
≤High school degree	21%	32%	<0.001
Some college	20%	21%	0.45
≥College degree	30%	18%	<0.001
No male head of household	29%	29%	0.273
Female household head education			
≤High school degree	23%	36%	<0.001
Some college	21%	27%	<0.001
≥College degree	24%	21%	<0.001
No female head of household	32%	16%	<0.001
Income level[c]			
Low	20%	26%	<0.001
Middle	32%	40%	<0.001
High	47%	34%	<0.001

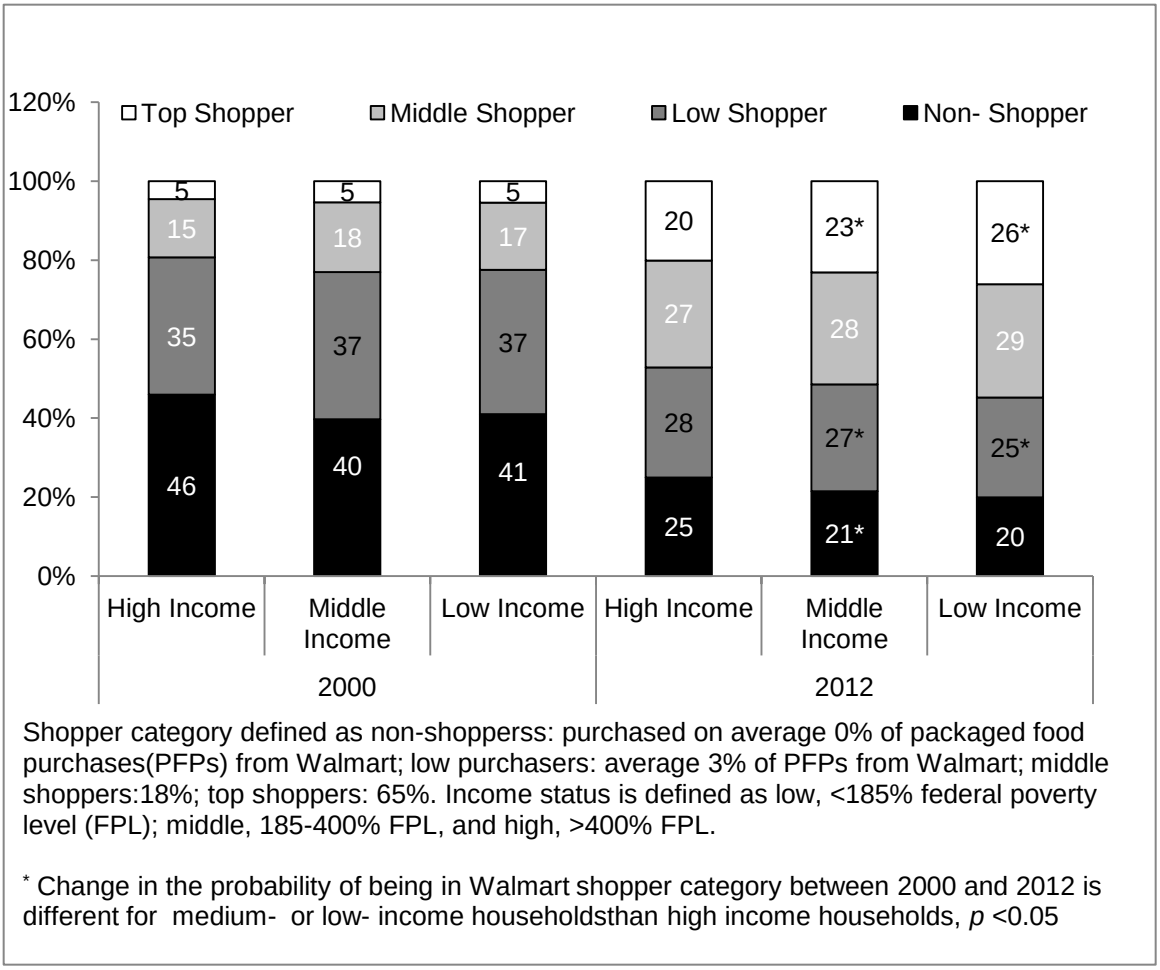
[a] Column percents. Weighted to be nationally representative. A household was defined as "Walmart shopper" if it spent >0$ on any consumer packaged food or beverage in a one-year period.
[b] From proportions testing between Walmart shopping households vs. non-Walmart shopping households. Bonferroni-corrected for multiple comparisons.
[c] Income status is defined as low, <185% federal poverty level (FPL); middle, 185-400% FPL, and high, >400% FPL.

Figure 3.1. Percent of PFP food and beverages purchased from Walmart (g) by percentile among Walmart customers, 2000-2012



* Within percentile, the proportion of packaged food purchases (PFPs) (g) purchased from Walmart in a given year is different than in 2000, p <0.01

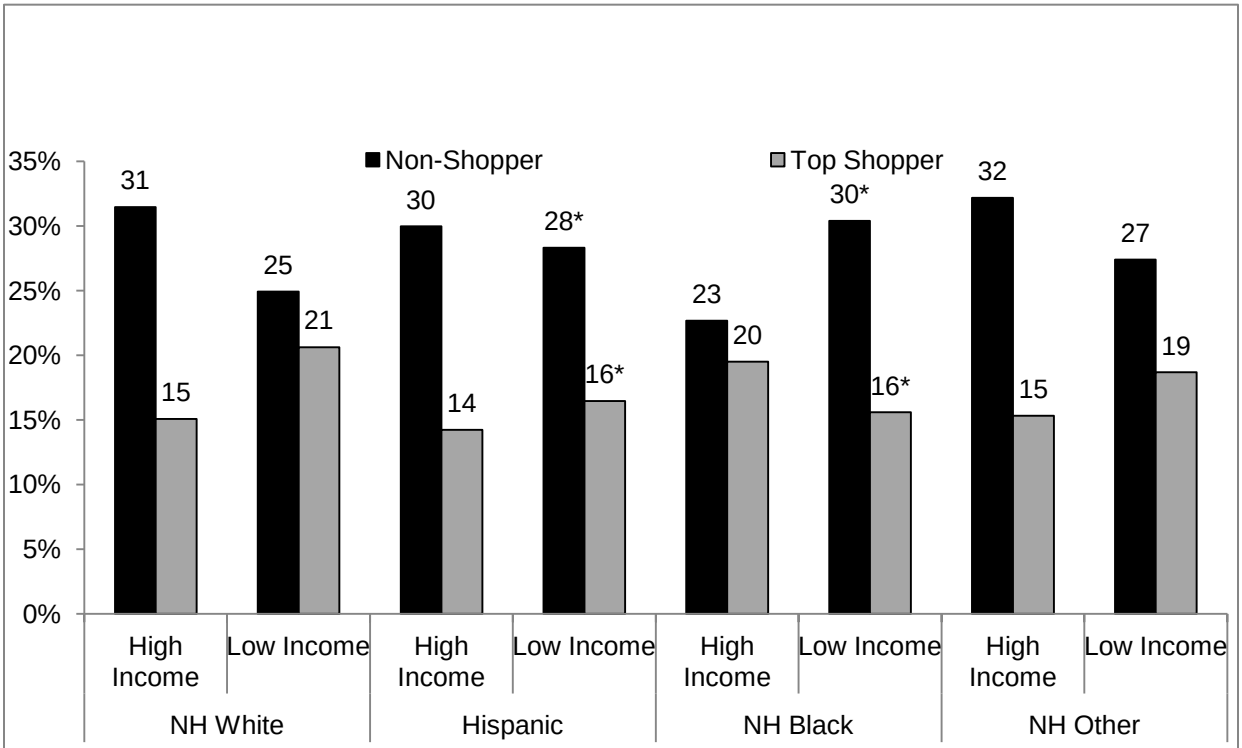
Figure 3.2. Percent of households who were non-,low, middle, and top shoppers of PFPs at Walmart by income status and year, 2000-2012



Shopper category defined as non-shopperss: purchased on average 0% of packaged food purchases(PFPs) from Walmart; low purchasers: average 3% of PFPs from Walmart; middle shoppers:18%; top shoppers: 65%. Income status is defined as low, <185% federal poverty level (FPL); middle, 185-400% FPL, and high, >400% FPL.

* Change in the probability of being in Walmart shopper category between 2000 and 2012 is different for medium- or low- income householdsthan high income households, p <0.05

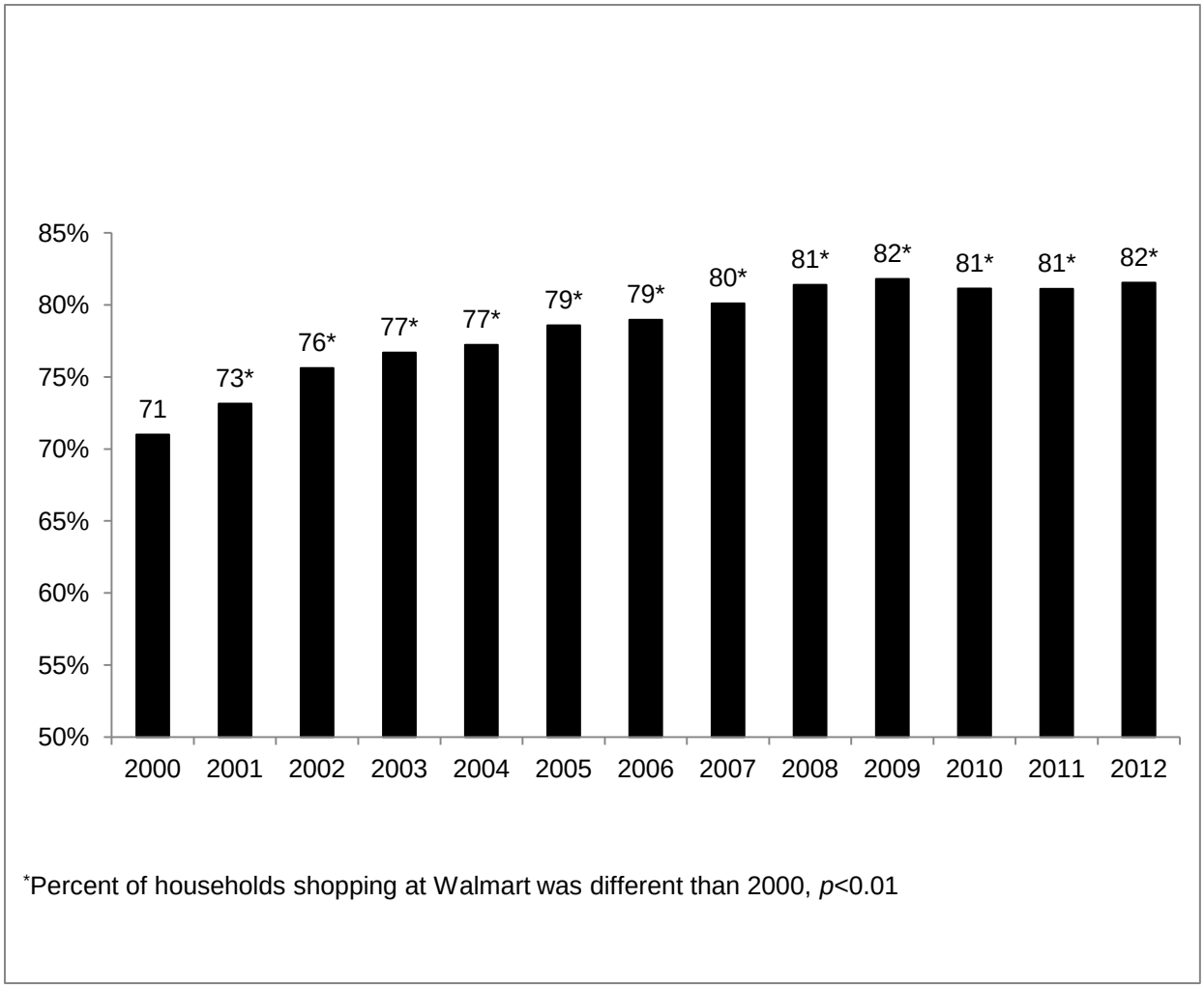
Figure 3.3. Percent of households who were non-shoppers or top-shoppers of PFPs at Walmart by race/ethnicity and income, 2000-2012



Shopper category defined as non-shopper: purchased on average 0% of packaged food purchases (PFPs) (g) from Walmart top shopper: purchased on average 68% of PFPs from Walmart. Income status is defined as low, <185% federal poverty level (FPL); middle, 185-400% FPL, and high, >400% FPL.

* Change in the predicted percent in Walmart shopper category between 2000 and 2012 is different for medium- or low- income households than high income households, p <0.01

Supplemental Figure 3.1. Percent of US households shopping at Walmart, 2000 to 2012



*Percent of households shopping at Walmart was different than 2000, $p<0.01$

CHAPTER 4. THE NUTRIENT PROFILE OF PACKAGED FOOD PURCHASES AT WALMART AND OTHER CHAIN RETAILERS IMPROVED FROM 2000 TO 2013.

Overview

As fewer retailers account for a larger share of US packaged food purchases (PFPs), it is increasingly important to understand the impact of the food retailer on the nutrient profile of PFPs. In particular, little is known about the nutrient profile of PFPs from Walmart, the US's largest food retailer, relative to other chain retailers (OCR). Our objective in this aim was to examine shifts in the nutrient profile of Walmart and OCR PFPs from 2000 to 2013. We used a national dataset of household PFPs from Nielsen Homescan linked to nutrition data (n= 164,315). Using fixed effects models and inverse probability weights to account for the selectivity of shopping at Walmart, we examined changes in energy, total sugar, saturated fat, and sodium density and shifts in percent volume from key food groups at Walmart and OCR over time, and whether these shifts differed by income or race/ethnicity.

There were substantial declines in overall energy density (-74 kcal/100 g), sugar density (-8 g/100g) and sodium density (-33 mg/100g) from PFPs at Walmart. These declines were coupled with decrease in percent volume purchased from sweets (-11%), grain-based desserts (-2%), and savory snacks (-3%), while percent volume from fruits and vegetables increased (3% and 1%, respectively). PFPs from OCR had a more favorable nutrient profile than Walmart PFPs in 2000, and demonstrated similar but smaller shifts in nutrient profile over time. We found only

minor differences in changes in nutrient profile by income, but among Walmart PFPs, we found that disparities in nutrient profile by race/ethnicity shrank over time. The nutrient profile of PFPs from Walmart has improved. While in 2000, Walmart PFPs were higher in energy, sugar, sodium, and saturated fat density relative to OCR, in 2013 the nutrient profile of PFPs purchased at Walmart was comparable to those purchased at OCR.

Introduction

Public health experts have increasingly identified the food retail sector (e.g. supermarkets, supercenters, grocery stores, convenience stores) as unique allies in the fight against obesity (6, 140) because they provide the majority of daily energy for US children and adults (1, 2), and because of their pivotal positioning between food manufacturers and the public (5, 6). As more food retailers account for an increasingly large share of US food purchases (3, 4), even a single retailer can have a major effect on what people buy and eat.

In particular, Walmart has become an increasingly dominant source of packaged food purchases (PFPs) in the US: nearly 80% of US households shopped for PFPs at Walmart in 2012. Among those who shopped at Walmart, the share of PFPs purchased doubled from 10% to 20% from 2000 to 2012 (141). Low income households in particular have become more likely to shop there and buy more PFPs over time. Because of Walmart's increasing importance as a source of US PFPs, it could be a key leader in strategies to improve nutrition and prevent obesity. However, little is known about whether foods and beverages purchased at Walmart are nutritionally comparable to those purchased at other chain retailers, or if the nutrient profile of Walmart-purchased foods has changed over time.

While one ecological study showed an additional Walmart supercenter per 100,000 residents was linked to an 2.4% increase in the obesity prevalence (123), little is known about the actual nutrient profile of Walmart PFPs. First, the lack of food-retailer specific information in most dietary surveys precludes examination of the link between the specific retail outlet and food intake. Secondly, while a few studies have indicated that increased Walmart store or supercenter densities are linked to poorer diet, these studies have significant limitations. For example, Bonnano et al.'s 2012 ecological study found that an increase in Walmart store density

was associated with a decreased percentage of the adults consuming five servings of fruits/vegetables per day (142). However, this study used state-level data on Walmart density and diet intake, and was unable to evaluate the effect of Walmart on the nutritional quality of actual household purchases or food intake. Volpe et al. used data on household PFPs, and found that a 1% increase in local market share of supercenters was associated with a 5-22% decrease in healthful food purchases. However, this study, like the previous study, examined the effect of store density on total purchases, rather than the nutritional profile of actual Walmart purchases compared to comparable stores (106). In addition, while the latter study employed a number of approaches for measuring purchase healthfulness, they were unable to directly link PFPs to nutrition information, precluding examination of the actual nutritional profile of products.

Perhaps most importantly, no study has examined with whether Walmart purchases are healthier or less healthy, or whether Walmart (or any food retailer in question) simply attracts a different type of customer. Shopping choices are driven by a complex set of factors, which not only determine *where* a customer shops, but *what* they buy (51-56). For example, less educated, lower income, and African American individuals are more likely to shop at lower-priced supercenters (49, 50). In addition, those who shop for many items at once prefer "everyday low pricing" stores, which typically set lower, less variable prices across a wide range of products (53, 55, 56). Selection bias arises if these preferences for shopping at a certain retailer type are also associated with some underlying preference for less or more healthy foods. In this case, the perceived link between Walmart and less-healthful purchases may simply be due to differences in the customers it attracts compared to other food retailers, not due to some inherent attribute of PFPs purchased there. One key question is whether, after accounting for this selectivity, low-income and race/ethnic minority households have a worse nutrient profile of Walmart PFP

purchases, since these groups are more likely to shop at Walmart, and also are more likely to nutritionally poorer diets (60-62). Understanding whether Walmart contributes to diet-related disparities is especially salient for administrators of the Supplemental Nutrition Assistance program (SNAP), considering Walmart is among the largest recipient of SNAP dollars spent (80).

This selectivity of shopping at Walmart could also vary over time, as dramatic changes in the Walmart food landscape over recent years could attract a more nutrition-conscious customer, yet previous studies did not consider these changes. Walmart has announced major efforts to increased sales of locally sourced and organic foods (125, 126), and in 2011 announced a national healthy foods initiative (HFI), including the introduction of a front-of-package labeling system, price reductions on healthier foods including produce, and product reformulations to reduce saturated fat, added sugar, and sodium (77). One possibility is that more health-conscious consumers might begin shopping at Walmart as a result of these initiatives. Thus, a second key question is whether the nutrient profile of Walmart PFPs has actually changed over time, or whether changes in nutrient profile simply reflect changes in the type of consumers who shops there.

Finally, it is unknown whether changes in nutrient profile of PFPs stem from shifts in purchasing behaviors by customers, or whether nutrients improved, even within the same purchasing profile. For example: are consumers buying healthier products, or are they simply buying the same products, which are becoming healthier over time? This has important policy implications, since efforts to improve diet have focused on product reformulation (88, 109) as well as changing consumer purchases through strategies such as front-of-package labeling (70, 84, 87). Understanding whether consumer purchasing shifts vs. product formulation are driving

improvements in nutrient profile could help policymakers and interventionists better target their efforts.

The objectives of this study are to examine changes in the nutrient profile of Walmart PFPs over time, including energy density (kcal/100g, total sugar density (g/100g), saturated fat density (g/100g), and sodium density (mg/100g), relative to those purchased at other chain retailers, and whether these changes were greater among SNAP-eligible and race/ethnic minority households after correcting for selectivity. In addition, we will examine whether these changes were driven by shifts in purchasing or reformulation by examining changes in percent volume of food groups purchased, as well as changes in the nutrient profile within these food groups from 2000 to 2013.

Methods

This study uses data from Nielsen Homescan, a commercial dataset of household food and beverage PFPs from 2000 to 2013 (107). PFPs include all food and beverages with a barcode, including all consumer packaged goods and packaged fresh fruit and vegetables (i.e., a bag of potatoes, which has a barcode) but excluding unpackaged meat and produce (i.e., a single potato, which does not). Households are sampled from 76 metropolitan and non-metropolitan markets. Households use handheld scanners to record information on each PFP, including date, number of units, total weight, amount paid, and including location of purchase (143). Walmart purchases included all PFPs from Walmart Supercenters and Neighborhood Markets, which both include a full-line of groceries, although the latter is smaller in size and assortment (108). Because the assortment of products likely differs by store type, to ensure comparability between Walmart PFPs and other food store purchases, we include all PFPs from chain grocery stores and supermarkets (≥10 locations), supercenters, and mass merchandisers, such as Super Target,

Kroger, Safeway, and others (collectively referred to hereafter as "other chain retailers" [OCR]) (362 different retailers), and exclude warehouse, drug, club, dollar, convenience stores, ethnic stores, specialty stores, and independent grocers (<10 locations) (144).

Information on store purchases was linked at the barcode level to nutrition data from the Nutrition Facts Panel (109). Food groups were based on the Nielsen Company, which groups products into 624 modules according to the department in which they are found within the store (for example, tortilla chips and pretzels represent two modules). We then aggregated modules into 56 groups based on how products are consumed (for example, the tortilla chip and pretzel modules are in a group, "Savory Snacks") (**Supplemental Table 4.1**).

Nutrient Outcomes

Nutrient outcomes included energy density (kcal/100 g PFPs from that store type), total sugar (g/100 g PFPs), saturated fat (g/100 g PFPs), and sodium (mg/100 g PFPs). To examine shifts in purchasing, we examined shifts in percent volume purchased (% g) from 13 key food groups from 2000-2013. Key food groups included those which represented top food groups purchased by volume at both food stores (**Supplemental Table 4. 2**) or in some cases, food groups that Walmart has publicly acknowledged to be product categories which have been reformulated (i.e. processed meat, salad dressing).

Market-level Covariates:

Unemployment rate

To provide a proxy for the overall economic environment experienced by each household, we used average quarterly market-level unemployment rates derived from the 2000-2013 Bureau of Labor Statistics Local Area Unemployment Statistics (145).

Walmart store density

A key predictor of whether a household shops at a retailer or not is whether that retailer exists within reasonable proximity to the household. To create an average market-level Walmart density (Walmart supercenters per 100,000 people), we used data on dates of Walmart Supercenter openings and conversions of Walmart discount stores to supercenters, linked by FIPS codes to counties, from 2000-2005 (146, 147). We also used data on Walmart Supercenter and Neighborhood Markets GPS coordinates , again linked by FIPS code, to derive Walmarts per county from 2008-2013 (148). Using these annual county-level estimates of Walmart stores, the number of Walmart food stores per county was interpolated for years 2006 and 2007. These values were then linked by FIPs code to annual mid-year county population estimates from the US Census Bureau to derive county-level Walmart density per 100,000 individuals (149). After linking counties to Homescan markets, we then created an average annual Walmart density score at for each of Homescan's 76 markets in which respondents reside.

Average Food Prices

To control for price differences between Walmart and other food retailers, we included two variables which are the weighted average of prices of products purchased (hereafter refered to as average food price [AFP]) from 1) Walmart or 2) other chain retailers in each market in each quarter.

Sample size

PFPs were aggregated at the quarter-household level. Households were included if they shopped at Walmart or OCR (defined as having purchased >0 g PFPs at a given retailer in a given quarter). Households were excluded from the sample if they purchased zero grams or zero calories from any store types over an entire quarter, since the former represents a lack of food

purchases and the latter represents an implausible purchasing pattern, or for implausible nutrient outcomes, including overall PFP energy density >900 kcal/100 g, sugar density >400 kcal/100g, and saturated or total fat density >900 kcal/gram (n=66,377 observations or 2.5%). Households were then excluded if they had less than 2 quarters of observations (n=2,516 or 0.1%) since repeated observations are required for fixed effects models. The final analytic sample included 2,611,125 household-quarter observations from 164,315 unique households. Households have various compositions, including single adults, adults living together, or adult(s) with children, with 26% having children under age 18 in the house, and an overall mean age of 50 y (± 18).

Inverse probability weight

As previously mentioned, one concern in these models is selectivity, or the idea that those who shop at Walmart may be somehow different than those who do not (141), and that this selectivity could bias the association between purchases and nutritional quality. To address this concern, we used inverse probability weighting (IPW) to account for the likelihood of being a Walmart shopper vs. non-Walmart shopper (no vs. any purchases) in each quarter, conditional upon covariates associated with shopping at Walmart (150-152). Weights were stabilized and truncated at the upper and lower 0.3rd percentile, with a mean of 0.96 ± 0.65 (**Supplemental Table 4.3)**. To test the robustness of estimates to this IPW, we conducted sensitivity analyses without IPW, with the IPW truncated at the upper/lower 0.3rd percentile, and IPW truncated at the upper/lower 1st percentile. Year coefficients remained consistent in terms of both direction and magnitude, regardless of which IPW method was used or if no IPW was used. (**Supplemental Table 4.4**).

Statistical Analysis

All statistical analyses were performed using Stata, version 13 (Stata Corporation, College Station, Texas).

Covariates were included based on a directed acyclic graph approach (153-155), including household race (non-Hispanic White, Hispanic, non-Hispanic Black, and non-Hispanic Other) and whether or not the household was eligible SNAP benefits (household income ≤130% federal poverty level). All models controlled for head of household education (≤ high school degree, some college, ≥ college degree), household type (single adult, multiple adults with no kids, adult(s) with kid(s)) and household composition (numbers of women and men aged 19-49 and ≥50y, and numbers of children aged 0-5y, 6-18y).

We used fixed effects models to separately model all nutrient outcomes at Walmart and OCR, using Stata's areg command for use with time-varying inverse probability weights. Fixed effects models examine average within-household effects, effectively using each household as its own control and thereby removing potential bias from any unobservable time-invariant household characteristics that might influence both exposure and outcome (i.e. unmeasured confounding). Fixed effects models can also be considered a selectivity correction, if the selection is through fixed characteristics of the household or community, since these characteristics are differenced out. For example, the fixed effects models help account for any selectivity associated with each household's decision regarding where to live, (i.e. if some households choose to live in markets with more Walmart stores than others). Stata's margins command was used to predict the mean nutrient density or percent volume from food groups for each year for each retailer. We examined contrasts in means within each retailer type across years, with significance achieved at $p<0.01$, Bonferroni-adjusted for multiple comparisons. To examine whether SNAP-eligible or

race-ethnic households experienced larger changes over time, we used a Wald chunk test to examine the interaction of income or race/ethnicity with year, with significance achieved at p= 0.10.

Results

Demographic characteristics

Demographic characteristics of the sample in 2000 and 2013 are presented in **Table 4.1**. The sample remained predominantly non-Hispanic White, with at least some college education, but more households were SNAP-eligible in 2013 relative to 2000. As expected, the average Walmart density, unemployment rate, Walmart AFP, and OCR AFP all increased over time.

Overall shifts in nutrient profile

Figure 4.1 shows shifts in predicted nutrient density of all food and beverage PFPs from 2000 to 2013. For all nutrient densities, Walmart PFP showed a significant decline between 2000 and 2013, with particularly large declines in densities of energy, sugar, and sodium ($p<0.01$). However, the average nutrient density of PFPs at Walmart was higher than at OCR in 2000; and despite smaller declines in nutrient densities at OCRs during the same time period, remained higher than OCR in 2013.

Shifts in food and beverage groups

Shifts in the percent volume purchased from key food and beverage groups are shown in **Table 4. 2**. Percent volume of grain-based desserts, candy, and savory snacks declined at Walmart from 2000 to 2013, while percent volume from fruits and vegetables increased ($p<0.01$). Smaller shifts were observed in percent volume from food groups at OCR.

There were only small changes in percent volume from key beverage groups at both Walmart and OCR. Among caloric beverages, there were small but significant declines in

percent volume of milk, 100% Juice, and SSBs from OCR. At Walmart, the only significant declines were small decreases in the percent volume of 100% juice and diet beverages.

Nutrient Profile of Food Groups and Beverage Groups

Table 4.3 shows the means and changes in the nutrient density of key food and beverage groups at Walmart and OCR.

Grain-based desserts showed major declines in energy density and sugar density at Walmart, while nutrient density of grain-based desserts at OCRs showed smaller decreases over time. Ready-to-eat breads, ready-to-eat breakfast, and candy all showed declines in energy density at both Walmart and OCR, although declines at Walmart were larger. At OCR but not Walmart, savory snacks and processed meats showed small increases in energy density, while the energy density of fruit increased for both Walmart and OCR. Both 100% juice and SSBs showed similar small declines in energy density at both retailers, while the energy density of diet beverages increased slightly.

Examining changes in sodium density, there appeared to be significant declines in sodium for ready-to-eat bread, ready-to-eat breakfast, processed meat, and salad dressing, although these changes looked larger among OCR PFPs relative to Walmart PFPs. On the other hand, the declines in sodium density for savory snacks and vegetables were larger among Walmart PFPs relative to OCR PFPs.

Socio-economic differences

There were no major differences in changes in nutrient profile of Walmart or OCR PFPs for higher income vs. SNAP-eligible households, with the exception that higher income households showed bigger declines in the sodium density of OCR PFPs than did SNAP-eligible households (-20 mg/100 g vs. -1 mg/100 g respectively, p=0.079) (**Supplemental Table 4.5)**.

There were statistically significant, but small, differences in declines in nutrient density of OCR PFPs by race/ethnicity, with the relative nutrient profile of purchases of each group remaining somewhat stable over time (**Table 4.4)**. However, among Walmart PFPs, disparities in the nutrient profile of purchases by race/ethnicity shrank over time. For example, while Hispanic and Non-Hispanic Others had the highest energy density and sodium density of Walmart PFPs in 2000, but these showed the largest declines in energy density and sodium density over time (p=0.054 and p=0.052 for interaction, respectively). The exception to this was non-Hispanic Blacks, who had virtually identical sodium density as Whites in 2000, but showed smaller declines in sodium density over time. In contrast, non-Hispanic Blacks also showed the largest decline in sodium density of OCR PFPs (p<0.001 for interaction).

Discussion

This study shows that PFPs from Walmart, the US's largest food retailer, showed major declines in energy density, paralleled by a decline in sodium and total sugar density, and to a lesser degree, saturated fat; these trends were accompanied by similar but smaller shifts in PFPs from OCR. While we were unable to examine important distinctions in some of the nutrients (for example, distinguishing added sugar from naturally occurring sugars, or saturated fat from dairy vs. meat), declines in saturated fat and sodium densities represent a shift towards a more healthful nutrient profile in accordance with the 2010 Dietary Guidelines, which suggested limiting saturated fat to 10% of daily calories and cutting sodium intake(156). In addition, since high energy density has been linked to excess energy intake and obesity through poor physiological regulation (84, 86, 87, 90, 157), the observed declines in energy density could potentially be protective against obesity, although further work is needed to link these declines to food intake and health outcomes.

Moreover, while the healthfulness of food groups can be subjective, declines in groups like grain-based desserts and sweets is promising, considering that considering that candy and grain-based desserts are among the largest sources of added sugar in the US, and grain-based desserts are the top source of solid fats (158). While the increases in fruit and vegetable intake were relatively small, this may be due to the fact that we were only able to examined packaged fruits and vegetables, and we would expect increases to be larger among unpackaged, loose produce, which was the key target of Walmart's efforts to cut costs and boost sales of locally sourced and organic foods (125, 126). In fact, if households substituted packaged produce with unpackaged produce as the availability and affordability of the latter increased, we might have expected to see the percent volume from packaged produce go down. Yet, our results show that these increases in packaged produce occurred despite a presumptive increase in unpackaged produce purchased. Regardless, the end result was such that while the overall nutrient profile of PFPs at Walmart was "less healthy" in 2000, it became healthier at a faster rate, and was similar to OCR by 2013.

These shifts in overall nutrient profile indicate two separate but related mechanisms at work: 1) consumers changed the types of products they were purchasing at Walmart, but not at OCR, and 2) the nutrient profile of PFPs from Walmart were changing at a faster rate than OCR PFPs, either due to introduction of new products or through product reformulation. In fact, we would have expected to see declines in energy density of PFPs purchased at both store types, considering the large decline in trillions of calories sold by food manufacturers as part of a pledge to remove calories (109, 159, 160). At the same time, Walmart's HFI included a pledge to reformulate Walmart store-brand products, with goals to achieve elimination of *trans* fats, a 25% reduction in sodium, and 10% reduction in added sugar in key PFP categories. Although the

store announced their initiative in 2011, the store website indicates that these changes may have begun as early as 2008, possibly explaining some of the observed declines (77, 78). Other HFI components, including the development of a front-of-package labeling system and strategic price reductions on healthier items, could explain the observed shifts in purchasing behavior (11, 14-21).

Our work shows that low income households do not buy disproportionately less healthy foods at Walmart, which may provide reassurance to SNAP that spending benefits at Walmart does not equate with poorer nutrient intakes. We also found evidence that disparities in the nutrient profile of Walmart food purchases lessened over time for race/ethnic minorities, especially for Hispanics and non-Hispanic Others, who tended to have a "worse" nutrient profile than non-Hispanic Whites in 2000, but a more comparable profile in 2013. These results beg the question as to whether Walmart's HFI is responsible for the observed improvements in nutrient profile, especially among vulnerable subpopulations. If so, this could indicate that national-scale HFIs at major national retailers can be useful in reducing diet-related disparities in the US population. However, more work is needed to fully understand the real impact of this HFI, especially in light of conflicting evidence about Walmart's marketing strategies. For example, Walmart recently faced criticism for promoting high- sugar, fat, and sodium foods and beverages in its advertisements targeted at low-income customers (127).

Still, it is interesting to note that despite the major changes in nutrient profile and purchasing patterns at Walmart, there were only small changes at OCR during the same time period. This could be because the overall nutrient profile at OCR was comparably "healthier" in earlier years, leaving less room for change: Walmart PFPs have simply shifted to match foods purchased at other food stores. In fact, these results are comparable to those of Volpe et al., who

found that increased supercenter density (i.e., Walmart density) was associated with less healthful PFPs from 2000 to 2006, but this disparity in healthfulness of purchases between supercenter and supermarket had mostly diminished by 2006 (106). On the other hand, we might have expected to see a "compensation effect," where consumers purchased less-healthy food groups or higher energy dense products at OCR in response to purchasing healthier PFPs at Walmart. Instead, we see that on average, the nutrient profile of PFPs from other OCRs remained static, suggesting that changes in PFPs at one retailer may not carry over to other retailers where a household shops.

Limitations

One concern is that these results could simply reflect a shift in how people shop at Walmart: as the years progressed, and people purchased more food at Walmart, they purchased a wider variety of foods, whereas in early years, they may have only purchased non-perishable packaged foods, like candy or snacks. This would result in a decline in energy density of Walmart PFPs, simply because of either a real or perceived shift in Walmart from discount store to full-grocery supercenter, as more supercenters entered the market and offered a wider assortment of products. In addition, we were unable account for unobservable shifts in dietary preference, which could affect how much people buy at Walmart as well as what they buy there, which limits our ability to establish what caused the observed changes in nutrient profile.

Finally, we did not include food purchases at other non-chain food retailers, like specialty stores or ethnic food stores. However, considering that the per capita volume of PFPs purchased from mass merchandisers and grocery chains remained stable from 2000 to 2013 (72% to 70%, respectively) (144), it seems unlikely that observed changes would be due to differential purchasing at other food retailers. Similarly, we were unable to account for changes in food

purchasing at restaurants, fast food, or other prepared-food outlets. However, we would expect any changes in these sectors to affect purchases both at Walmart and at OCR. Considering first that the percent of daily caloric intake from food stores remained stable from 2000 to 2010 (2), and second, the nutrient profile of PFPs from OCR remained fairly stable, it seems that the shifts in nutrient profile of Walmart PFPs are true changes in consumer behavior and the nutrient profile of products, and not simply due to other shifts in away-from-home eating patterns.

However, this study does provide a useful methodology for examining and comparing the impact of food retailers on the healthfulness of the US food supply. Through the use of time-varying inverse probability weights and fixed effects models, we accounted for potential selection bias of individuals who shop at Walmart stores on observed shifts in nutrient profile, ensuring that the observed increases in healthfulness of PFPs was not simply due to Walmart attracting more nutrition-minded consumers. Finally, although we could not statistically compare Walmart PFPs to OCR PFPs, by modeling the predicted nutrient profile of PFPs at each store type, we were able to observe shifts in nutrient profile of purchases at each store type instead of simply examining the effect of store density on healthfulness of overall purchases, like most previous studies. As food retailers are increasingly recognized as potential agents for improving nutrition and reducing obesity, employing such methods will be essential to understanding how various elements of the food environment (retail type, size, location) or strategies (reformulation, price reduction, labeling) influence the nutritional quality of the US food supply, especially among major national retailers (5, 6, 140).

Conclusion

From 2000 to 2013, PFPs from Walmart showed major decreases in energy density, sugar density, and sodium density, and these shifts were larger than those observed at other chain

retailers during this time period. These changes were attributable to both shifts in food purchasing (decreases in the percent volume purchased from sweets, GBDs, and savory snacks, coupled with increases in fruits and vegetables), as well as shifts in nutrient density within food group. More work is needed to understand whether these shifts were attributable to Walmart's Healthy Foods Initiative, and whether these shifts were greater among key subpopulations, who face the highest barriers to achieving a healthful diet.

Tables and Figures

Table 4.1. Household characteristics of the Nielsen Homescan sample in 2000 and 2013[a] (n=2,611,125)

	2000	2013	p^c
Household composition			
Single adult, %[b]	25%	25%	0.070
Multiple adults, no children <18y, %	46%	52%	<0.001
Adults, with children <18,%	28%	22%	<0.001
Race/ethnicity			
Non-Hispanic White,%	85%	81%	<0.001
Hispanic, %	5%	5%	0.243
Non-Hispanic Black, %	8%	9%	<0.001
Non-Hispanic Other, %	2%	4%	<0.001
Maximum Household Education			
High school or less, %	23%	17%	<0.001
Some college,%	31%	29%	<0.001
≥College degree, %	46%	54%	<0.001
Income[d]			
SNAP-eligible, federal poverty level			
≤130%	6%	10%	<0.001
>130%	94%	90%	<0.001
Walmarts/100,000 people, mean (SD)	0.2 (0.3)	1.0 (0.6)	<0.001
Unemployment rate, mean (SD)	3.9 (0.9)	7.8 (1.6)	<0.001
Walmart Food Price Index, mean (SD)	72.2 (12.3)	103.1 (4.4)	<0.001
OCR Price Index, mean (SD)	84.6 (8.4)	117.6 (6.5)	<0.001

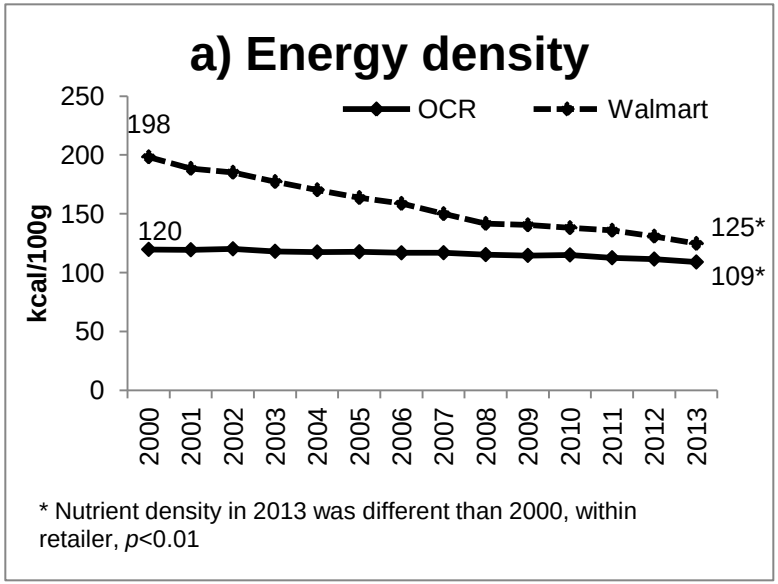
[a] University of North Carolina calculation based in part on data reported by Nielsen through its Homescan Services for all food categories, Including beverages and alcohol for the 2000-2013 periods, for the U.S. market. Copyright © 2014, The Nielsen Company.

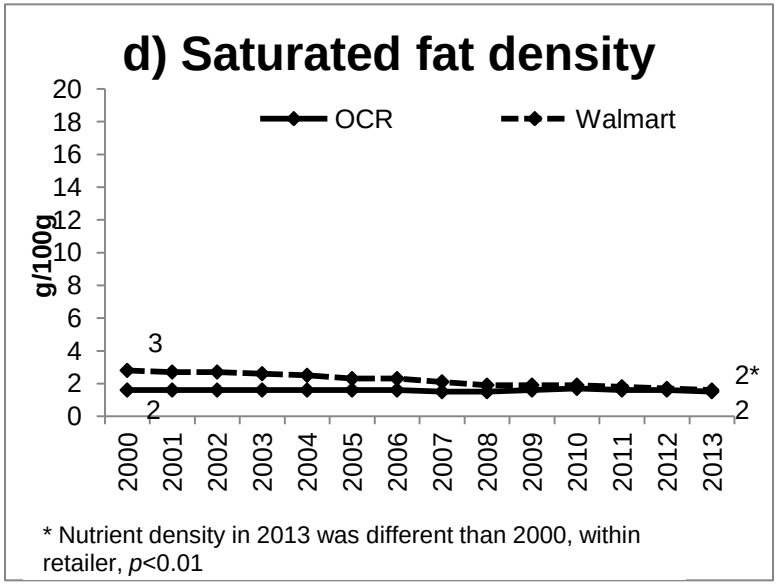
[b] Column percents.

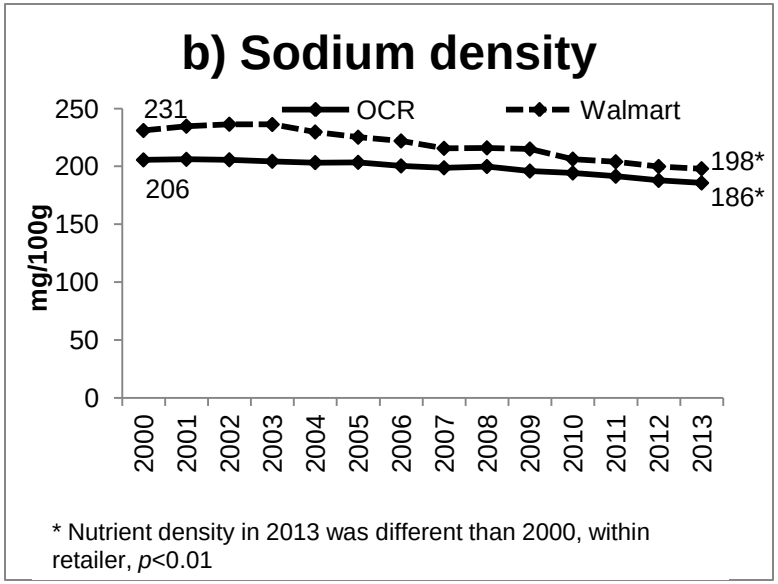
[c] For categorical variables, from proportions testing and for continuous variables, from *t*-tests, comparing households in the sample in 2000 and 2013.

[d] Supplemental Nutrition Assistance Program (SNAP) eligibility based on household income using percent of annual federal poverty level

Figure 4.1: Predicted nutrient density of PFPs purchased from Walmart and other chain retailers (OCR) from 2000 to 2013







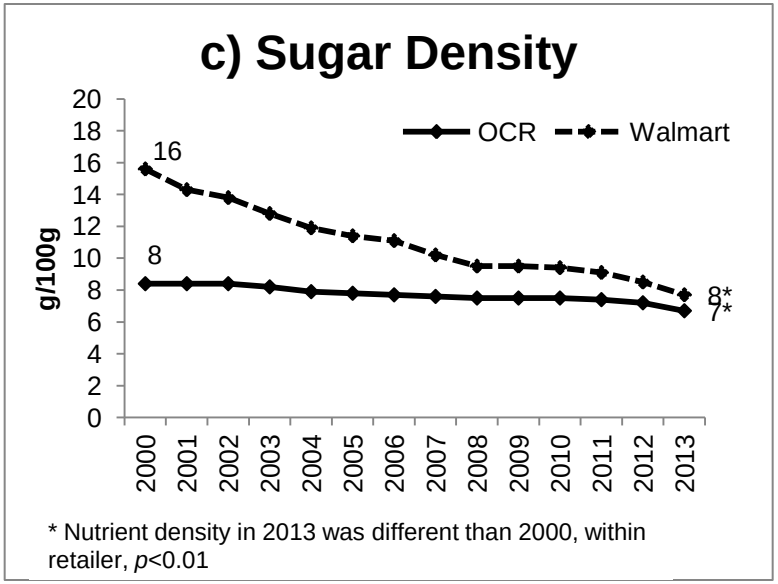


Table 4.2 Percent volume from top food and beverage groups at Walmart and other chain retailers (OCR), 2000 to 2013

	OCR			Walmart		
	2000 Mean % (SE)	2013 Mean % (SE)	Difference*	2000 Mean % (SE)	2013 Mean % (SE)	Difference*
GBD	1.9	2.0	0.1	5.3	3.0	-2.3***
	(0.02)	(0.02)		(0.23)	(0.12)	
Fruit	0.6	2.9	2.3***	-0.3	2.8	3.1***
	(0.02)	(0.02)		(0.09)	(0.06)	
Vegetables	3.7	3.5	-0.2***	2.0	2.8	0.8***
	(0.03)	(0.03)		(0.1)	(0.06)	
Savory Snacks	2.2	2.3	0.1	6.2	3.1	-3.1***
	(0.02)	(0.02)		(0.25)	(0.12)	
RTE Bread	2.4	2.6	0.2	1.9	2.8	0.9***
	(0.02)	(0.02)		(0.13)	(0.08)	
RTE Breakfast	1.7	1.9	0.2***	1.9	3.0	1.1***
	(0.02)	(0.02)		(0.14)	(0.08)	
Sweets	2	0.8	-1.2***	13.1	1.8	-11.3***
	(0.03)	(0.03)		(0.36)	(0.18)	
Processed Meat	1.3	1.9	0.6***	1.1	1.9	0.8***
	(0.01)	(0.01)		(0.08)	(0.05)	
Salad Dressing	0.4	0.6	0.2***	0.2	0.6	0.4***
	(0.01)	(0.01)		(0.05)	(0.03)	
Milk	10.7	9.2	-1.5***	6.4	6.2	-0.2
	(0.05)	(0.05)		(0.19)	(0.11)	
100% Juice	3.3	1.6	-1.7***	1.9	1.2	-0.7***
	(0.03)	(0.02)		(0.1)	(0.06)	
SSB	10.2	9.7	-0.5***	9.3	8.3	-1.0
	(0.06)	(0.06)		(0.28)	(0.16)	
Diet Bev	5.8	6.1	0.3	5.8	4.7	-1.1***
	(0.05)	(0.05)		(0.23)	(0.13)	

* P-value for comparison between predicted percent volume in 2013 compared to 2000, Bonferroni -corrected for multiple comparisons, *** $p<0.001$, ** $p<0.01$, * $p<0.05$

Table 4.3. Nutrient density of food groups at Walmart and other chain retailers (OCR) from 2000 to 2012

	Energy Density (g/100 g)				Sugar Density (g/100g)				Saturated Fat Density (g/100 g)				Sodium Density (mg/100 g)			
	OCR		Walmart		OCR		Walmart		OCR		Walmart		OCR		Walmart	
Grain-based desserts	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
2000	430.7	(1.7)	447.4	(5.9)	30.0	(0.11)	31.9	(0.4)	6.4	(0.05)	6.8	(0.18)	383.4	(1.72)	376.8	(3.63)
2013	417.5	(1.66)	413.5	(1.98)	29.8	(0.09)	29.3	(0.16)	6.4	(0.04)	6.5	(0.06)	372.6	(3.5)	387.3	(2.17)
Difference	**-13.2**		**-33.9**		**-0.2**		**-2.6**		**0.0**		**-0.3**		**-10.8**		**10.5**	
p-value	<0.001		<0.001		1.000		<0.001		1.000		1.000		0.117		0.525	

	Energy Density (g/100 g)				Sugar Density (g/100g)				Saturated Fat Density (g/100 g)				Sodium Density (mg/100 g)			
	OCR		Walmart		OCR		Walmart		OCR		Walmart		OCR		Walmart	
Fruit	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
2000	20.4	(0.4)	20.0	(1.59)	4.9	(0.05)	6.1	(0.23)	-0.1	(0.01)	0.0	(0.04)	1.1	(0.09)	2.3	(0.37)
2013	45.8	(0.44)	44.4	(0.93)	6.4	(0.06)	5.9	(0.13)	0.3	(0.01)	0.2	(0.02)	5.0	(0.09)	4.2	(0.26)
Difference	**25.4**		**24.4**		**1.5**		**-0.2**		**0.4**		**0.2**		**3.9**		**1.9**	
p-value	<0.001		<0.001		<0.001		1.000		<0.001		0.002		0.010		<0.001	

	Energy Density (g/100 g)				Sugar Density (g/100g)				Saturated Fat Density (g/100 g)				Sodium Density (mg/100 g)			
	OCR		Walmart		OCR		Walmart		OCR		Walmart		OCR		Walmart	
Vegetables	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
2000	56.0	(0.15)	48.6	(0.64)	2.7	(0.01)	2.7	(0.04)	0.1	(0)	0.1	(0.01)	40.6	(0.4)	57.4	(1.8)
2013	45.8	(0.15)	44.3	(0.37)	2.2	(0.01)	1.9	(0.02)	0.1	(0)	0.1	(0)	39.5	(0.44)	37.0	(1.08)
Difference	**-10.2**		**-4.3**		**-0.5**		**-0.8**		**0.0**		**0.0**		**-1.1**		**-20.4**	
p-value	<0.001		<0.001		<0.001		<0.001		<0.001		1.000		1.000		<0.001	

	Energy Density (g/100 g)				Sugar Density (g/100g)				Saturated Fat Density (g/100 g)				Sodium Density (mg/100 g)			
	OCR		Walmart		OCR		Walmart		OCR		Walmart		OCR		Walmart	
Savory snacks	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
2000	458.9	(0.45)	462.1	(1.62)	3.6	(0.03)	5.2	(0.15)	5.1	(0.01)	5.3	(0.06)	812.9	(1.54)	858.0	(6.11)
2013	469.9	(0.44)	464.4	(1.01)	4.5	(0.03)	5.6	(0.08)	4.4	(0.01)	4.7	(0.03)	669.6	(1.41)	680.5	(3.51)
Difference	**11.0**		**2.3**		**0.9**		**0.4**		**-0.7**		**-0.6**		**-143.3**		**-177.5**	
p-value	<0.001		1.000		<0.001		0.888		<0.001		<0.001		<0.001		<0.001	

	Energy Density (g/100 g)				Sugar Density (g/100g)				Saturated Fat Density (g/100 g)				Sodium Density (mg/100 g)			
	OCR		Walmart		OCR		Walmart		OCR		Walmart		OCR		Walmart	
Ready-to-eat bread	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
2000	262.9	(0.39)	263.6	(0.93)	5.7	(0.02)	5.7	(0.07)	0.6	(0.01)	1.1	(0.04)	529.0	(0.74)	517.6	(2.16)
2013	264.4	(0.41)	260.7	(0.52)	6.4	(0.02)	6.3	(0.05)	0.3	(0.01)	0.1	(0.02)	477.6	(0.77)	478.7	(1.18)
Difference	**1.5**		**-2.9**		**0.7**		**0.6**		**-0.3**		**-1.0**		**-51.4**		**-38.9**	
p-value	0.553		0.396		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	

	Energy Density (g/100 g)				Sugar Density (g/100g)				Saturated Fat Density (g/100 g)				Sodium Density (mg/100 g)			
	OCR		Walmart		OCR		Walmart		OCR		Walmart		OCR		Walmart	
Ready-to-eat breakfast	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
2000	342.0	(0.35)	346.0	(1.32)	21.4	(0.06)	21.9	(0.25)	1.3	(0.01)	1.4	(0.04)	508.8	(0.98)	502.2	(3.78)
2013	333.9	(0.36)	332.4	(0.8)	19.9	(0.06)	20.5	(0.14)	1.5	(0.01)	1.8	(0.02)	429.3	(0.92)	432.3	(2.08)
Difference	**-8.1**		**-13.6**		**-1.5**		**-1.4**		**0.2**		**0.4**		**-79.5**		**-69.9**	
p-value	<0.001		<0.001		<0.001		<0.002		<0.001		<0.001		<0.001		<0.001	

	Energy Density (g/100 g)				Sugar Density (g/100g)				Saturated Fat Density (g/100 g)				Sodium Density (mg/100 g)			
	OCR		Walmart		OCR		Walmart		OCR		Walmart		OCR		Walmart	
Candy	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
2000	463.7	(9.43)	464.3	(7.75)	63.8	(2.22)	68.8	(1.53)	7.7	(0.06)	6.8	(0.15)	120.7	(1.38)	111.8	(2.58)
2013	423.8	(5.7)	416.1	(4.89)	49.6	(1.28)	47.8	(0.96)	8.4	(0.07)	8.2	(0.1)	105.6	(1.24)	110.7	(1.17)
Difference	**-39.9**		**-48.2**		**-14.2**		**-21.0**		**0.7**		**1.4**		**-15.1**		**-1.1**	
p-value	0.095		0.001		0.001		<0.001		<0.001		<0.001		<0.001			1.000

	Energy Density (g/100 g)				Sugar Density (g/100g)				Saturated Fat Density (g/100 g)				Sodium Density (mg/100 g)			
	OCR		Walmart		OCR		Walmart		OCR		Walmart		OCR		Walmart	
Processed meat	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
2000	229.2	(0.44)	227.7	(1.71)	1.5	(0.01)	1.3	(0.03)	6.8	(0.03)	6.7	(0.08)	906.3	(1.59)	919.4	(6.52)
2013	231.8	(0.42)	229.4	(0.97)	1.6	(0.01)	1.6	(0.02)	6.3	(0.03)	6.1	(0.04)	877.7	(1.51)	908.0	(3.57)
Difference	**2.6**		**1.7**		**0.1**		**0.3**		**-0.5**		**-0.6**		**-28.6**		**-11.4**	
p-value	0.009		1.000		<0.001		<0.001		<0.001		<0.001		<0.001		1.000	

	Energy Density (g/100 g)				Sugar Density (g/100g)				Saturated Fat Density (g/100 g)				Sodium Density (mg/100 g)			
	OCR		Walmart		OCR		Walmart		OCR		Walmart		OCR		Walmart	
Fresh milk	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
2000	50.3	(0.03)	51.9	(0.13)	4.9	(0)	5.0	(0.01)	1.0	(0)	1.1	(0.01)	53.7	(0.05)	54.4	(0.18)
2013	50.7	(0.03)	51.2	(0.07)	5.0	(0)	4.9	(0)	1.0	(0)	1.1	(0.01)	54.9	(0.05)	54.9	(0.12)
Difference	**0.4**		**-0.7**		**0.1**		**-0.1**		**0.0**		**0.0**		**1.2**		**0.5**	
p-value	0.362		1.000		0.489		1.000		<0.001		<0.001		<0.001		0.1	

	Energy Density (g/100 g)				Sugar Density (g/100g)				Saturated Fat Density (g/100 g)				Sodium Density (mg/100 g)			
	OCR		Walmart		OCR		Walmart		OCR		Walmart		OCR		Walmart	
Salad Dressing	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
2000	305.9	(0.92)	297.7	(4.17)	9.9	(0.05)	10.3	(0.23)	3.5	(0.02)	3.3	(0.09)	984.4	(1.97)	964.8	(10.36)
2013	309.6	(0.92)	295.9	(2.37)	10.1	(0.05)	9.8	(0.13)	4.1	(0.02)	3.9	(0.05)	915.6	(2.27)	923.6	(6.65)
Difference	**3.7**		**-1.8**		**0.2**		**-0.5**		**0.6**		**0.6**		**-68.8**		**-41.2**	
p-value	0.362		1.000		0.489		1.000		<0.001		<0.001		<0.001		<0.001	

	Energy Density (g/100 g)				Sugar Density (g/100g)				Saturated Fat Density (g/100 g)				Sodium Density (mg/100 g)			
	OCR		Walmart		OCR		Walmart		OCR		Walmart		OCR		Walmart	
100% Juice	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
2000	48.2	(0.09)	49.2	(0.43)	10.1	(0.02)	10.4	(0.09)	0.0	(0.01)	0.0	(0.03)	3.5	(0.06)	4.7	(0.27)
2013	47.2	(0.12)	46.6	(0.32)	9.2	(0.02)	9.0	(0.06)	0.2	(0.01)	0.2	(0.02)	3.6	(0.07)	3.3	(0.15)
Difference	**-1.0**		**-2.6**		**-0.9**		**-1.4**		**0.2**		**0.2**		**0.1**		**-1.4**	
p-value	<0.001		0.002		<0.001		<0.001		<0.001		0.001		1.000		0.002	

	Energy Density (g/100 g)				Sugar Density (g/100g)				Saturated Fat Density (g/100 g)				Sodium Density (mg/100 g)			
	OCR		Walmart		OCR		Walmart		OCR		Walmart		OCR		Walmart	
Sugar-sweetened beverages	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
2000	48.8	(0.14)	47.9	(0.38)	12.3	(0.04)	12	(0.1)	0.1	(0)	0.1	(0.01)	14.3	(0.1)	14.6	(0.3)
2013	42.3	(0.13)	42.6	(0.25)	10.5	(0.03)	10.8	(0.06)	0.1	(0)	0	(0.01)	15.2	(0.1)	17.2	(0.19)
Difference	**-6.5**		**-5.3**		**-1.8**		**-1.2**		**0.0**		**-0.1**		**0.9**		**2.6**	
p-value	<0.001		<0.001		<0.001		<0.001		<0.001		0.226		<0.001			<0.001

	Energy Density (g/100 g)				Sugar Density (g/100g)				Saturated Fat Density (g/100 g)				Sodium Density (mg/100 g)			
	OCR		Walmart		OCR		Walmart		OCR		Walmart		OCR		Walmart	
Diet beverages	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
2000	0.5	(0.04)	0.6	(0.12)	0.1	(0.01)	0.1	(0.03)	0	(0)	0	(0)	14.5	(0.16)	9.8	(0.34)
2013	2.4	(0.05)	1.7	(0.1)	0.5	(0.01)	0.4	(0.02)	0	(0)	0	(0)	11.3	(0.12)	11.1	(0.2)
Difference	**1.9**		**1.1**		**0.4**		**0.3**		**0.0**		**0.0**		**-3.2**		**1.3**	
p-value	<0.001		<0.001		<0.001		<0.001		<0.001		1.000		<0.001		0.137	

P-value for the difference between 2013 and 2000, Bonferroni-corrected for multiple comparisons

Table 4.4 Nutrient profile of OCR and Walmart PFPs by Race/ethnicity

OCR PFPs

Energy Density (kcal/100 g)

	NH White		Hispanic		NH Black		NH Other		
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	p^a
2000	119	(119,120)	115	(113,118)	128	(126,131)	116	(113,119)	<0.001
2006	116	(116,117)	115	(114,116)	124	(122,125)	118	(116,119)	
2013	108	(107,108)	109	(106,111)	115	(113,117)	116	(114,119)	
Difference[b]	-11		-6		-13		0		

Sugar Density (g/100 g)

	NH White		Hispanic		NH Black		NH Other		
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	*p*
2000	8.3	(8.3,8.4)	8.0	(8,9)	9.4	(9.2,9.6)	8.5	(8.2,8.8)	<0.001
2006	8.0	(7.6,7.6)	8.0	(8,8)	8.0	(8.2,8.4)	8.0	(7.6,7.9)	
2013	7.0	(6.6,6.7)	7.0	(6,7)	8.0	(7.5,7.8)	7.0	(6.7,7.1)	
Difference	-1.3		-1.0		-1.4		-1.5		

Saturated Fat Density (g/100 g)

	NH White		Hispanic		NH Black		NH Other		
	Mean	(95% CI)	(95% CI)	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	*p*
2000	1.6	(1.6,1.6)	1.4	(1.4,1.5)	1.5	(1.5,1.6)	1.5	(1.4,1.5)	0.005
2006	1.6	(1.6,1.6)	1.5	(1.4,1.5)	1.6	(1.5,1.6)	1.5	(1.5,1.6)	
2013	1.5	(1.5,1.6)	1.4	(1.4,1.5)	1.6	(1.5,1.6)	1.6	(1.5,1.7)	
Difference	-0.1		0.0		0.1		0.1		

Sodium Density (mg/100 g)

	NH White		Hispanic		NH Black		NH Other		
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	*p*
2000	204	(202,205)	202	(196,207)	232	(226,237)	203	(195,211)	<0.001
2006	198	(198,199)	199	(196,202)	220	(218,223)	205	(201,209)	
2013	184	(182,185)	184	(179,190)	201	(197,206)	191	(185,197)	
Difference	-20		-18		-31		-12		

Walmart PFPs

Energy Density (kcal/100 g)

	NH White		Hispanic		NH Black		NH Other		
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	*p*
2000	199	(194,203)	210	(191,230)	178	(162,194)	238	(194,281)	<0.054
2006	159	(157,160)	155	(149,161)	153	(148,159)	173	(163,184)	
2013	123	(121,126)	127	(117,137)	135	(128,143)	127	(114,139)	
Difference	-76		-83		-43		-111		

Sugar Density (g/100 g)

	NH White		Hispanic		NH Black		NH Other		
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	*p*
2000	15.6	(15.1,16)	18.0	(14,22)	14.0	(12.3,15.7)	18.1	(13.5,22.7)	0.445
2006	11.0	(10.9,11.2)	11.0	(10,12)	11.0	(10.2,11.3)	11.0	(10.3,12.5)	
2013	8.0	(7.4,7.9)	7.0	(6,8)	9.0	(8.2,9.7)	8.0	(6.8,9.3)	
Difference	-7.6		-11.0		-5.0		-10.1		

Saturated Fat Density (g/100 g)

	NH White		Hispanic		NH Black		NH Other		
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	*p*
2000	2.9	(2.8,3)	2.5	(2,3)	2.5	(2.1,2.9)	4.1	(3.2,5.1)	0.127
2006	2.3	(2.3,2.3)	1.9	(1.8,2.1)	2.0	(1.9,2.1)	2.3	(2.1,2.6)	
2013	1.6	(1.5,1.7)	1.9	(1.6,2.2)	1.6	(1.4,1.8)	1.5	(1.2,1.8)	
Difference	-1.3		-0.6		-0.9		-2.6		

Sodium Density (mg/100 g)

	NH White		Hispanic		NH Black		NH Other		
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	*p*
2000	229	(223,235)	256	(227,286)	230	(207,254)	277	(223,331)	0.052

2006	220	(218,222)	231	(221,241)	234	(225,243)	233	(216,250)
2013	196	(193,200)	189	(174,204)	212	(200,224)	211	(190,231)
Difference	-33		-67		-18		-66	

[a] P-value for Wald chunk test for interaction between race/ethnicity and year
[b] Difference between 2013 and 2000, within race/ethnic group

Supplemental Table 4.1. Food and Beverage Groupings, with Examples

Food Group		**Example of modules**
SSBs		Energy drinks, sports drinks, soda, fruit drinks
Fresh plain milk		Refrigerated milk
Coffee (grounds, beans, RTD)		Ground and whole bean coffee
Diet beverage		Carbonated soft drinks, <20 cal/100g
Tea (bags, loose, RTD)		Herbal tea, tea bags
Water and ice		Bottled water, bagged ice
Candy		Hard candy, chocolate, marshmallows
Savory Snacks		Chips, pretzels, frozen hors d'oevres
GBD		Frozen cookie dough, ready-to-eat cookies,
RTE breads		Fresh bagels, fresh bread, frozen bread
RTE Breakfast		Ready-to-eat cereal, granola
Vegetables, fresh or frozen		Fresh carrots, frozen broccoli
Dairy-based dessert		Ice cream, sherbert, frozen novelties
Shelf-stable soups & stews		Ramen noodles, canned soup, soup mixes
Condiments & sauces		Ketchup, barbecue sauce, cocktail sauce
Alcohol		Wine, liquor, beer, malt beverage
Frozen entrees		Frozen dinners
Processed Meat		Canned corned beef, lunch meat, bacon
100% Juice		Drinks containing 100% juice
Fats and oils		Butter, olive oil, margarines and spreads
Cheese		American Cheddar cheese, cream cheese, mozzarella
Fruit, fresh & frozen		Refrigerated fruit salad, fresh apples, frozen fruits
Sweeteners		Granulated sugar, molasses
Vegetables, canned or dried		Canned tomatoes, canned artichokes
Yogurt		Refrigerated yogurt
Eggs		Fresh eggs
Pasta & Rice		Boxed spaghetti, instant rice, pasta macaroni
Desserts, prepare-at-home		Brownie mix, cake mix, muffin mix
RTE, prepared dishes		Refrigerated entrees, refrigerated chili
Potatoes and corn		Dehydrated mashed potatoes, canned corn, canned yams
Beef/pork		Frozen ground beef, frozen veal
Shelf-stable creamers, evaporated or condensed milks		Powdered creamer, liquid creamer
Beans and legumes		Garbanzo beans, lima beans, pinto beans
Refrigerated sweetened dairy drinks		Refrigerated shakes, eggnog
Nut and fruit spreads		Peanut butter, honey, jams, jelly
Canned mixed dishes		Canned lasagna, canned chow mein
Nuts and seeds		Nuts, unshelled
Flours		All-purpose flour, white wheat flour
Frozen/refrigerated dairy-based toppings/condiments		Sour cream, whipping cream
Salad dressing		Refrigerated salad dressing, dressing mixes
Fruit, canned		Canned peaches
Frozen pizza		Frozen pizza
Seafood		Frozen breaded shrimp, frozen un-breaded fish
Cereals (requires cooking)		Wheat germ, hominy grits
Other fruit (dried, etc)		Dried cranberries, raisins
Sweets, misc		Chocolate syrup
Shelf-stable milks, milk substitutes and milk-based powders		Powdered milk

Supplemental Table 4.2 Percent volume of PFP groups purchased at other chain retailers (OCR) and Walmart for top 30 food groups, pooled from 2000-2013

		OCR		Walmart
Rank	% volume	Food Group	% Volume	Food Group
1	10.1	Sugar-sweetened beverages	9.4	Sugar-sweetened beverages
2	9.7	Fresh plain milk	6.9	Fresh plain milk
3	7.2	Coffee (grounds, beans, RTD)	6.7	Coffee (grounds, beans, RTD)
4	6.5	Diet soda and other diet beverages	5.4	Diet soda and other diet beverages
5	5.1	Tea (bags, loose, RTD)	5.2	Tea (bags, loose, RTD)
6	4.3	Water and ice	4.7	Water and ice
7	3.4	Vegetables, fresh or frozen	4.5	Candy & gum
8	3.3	Dairy-based dessert	3.3	Savory Snacks
9	2.6	Alcohol	3.2	GBD
10	2.5	RTE breads	3.0	Beverage powder and concentrates
11	2.5	Shelf-stable soups & stews	2.5	RTE breads
12	2.2	Savory Snacks	2.5	RTE Breakfast
13	2.2	100% Juice	2.4	Vegetables, fresh or frozen
14	2.2	Condiments & sauces	2.3	Dairy-based dessert
15	2.0	Beverage powder and concentrates	2.3	Shelf-stable soups & stews
16	1.9	GBD	2.1	Condiments & sauces
17	1.8	RTE Breakfast	2.0	Alcohol
18	1.7	Frozen entrees	1.9	Frozen entrees
19	1.6	Fruit, fresh & frozen	1.7	Processed Meat
20	1.6	Processed Meat	1.5	100% Juice
21	1.5	Candy & gum	1.4	Cheese
22	1.4	Cheese	1.4	Fats and oils
23	1.3	Vegetables, canned or dried	1.3	Fruit, fresh & frozen
24	1.2	Fats and oils	1.3	Sweeteners
25	1.1	Yogurt	1.1	Yogurt
26	1.1	Pasta & Rice	1.1	Vegetables, canned or dried
27	1.1	Sweeteners	1.0	Eggs
28	1.1	Eggs	0.9	Pasta & Rice
29	0.9	Potatoes and corn	0.8	Desserts, prepare-at-home
30	0.9	RTE, prepared dishes	0.8	RTE, prepared dishes

Supplemental Table 4.3. Creation of inverse probability weight

To deal with selectivity, every model includes a time-varying inverse probability weight for being a Walmart customer (i.e., being in the sample) in a given quarter. We use logistic regression to predict the probability of being a Walmart customer in a given quarter, using market-level and household-level covariates which our previous work has shown to be associated with shopping at Walmart(141).

$$P(\text{Walmart customer})_{hq} = \text{Household size}_h + \text{Household type}_h + \text{Race/ethnicity}_h + FPL_{hq} + \text{Walmart AFP}_{mq} + \text{Foodstore AFP}_{mq+} + \text{Walmart Density}_{my} + \text{Unemployment Rate}_{mq}$$

Where *h* is household, *q* is quarter, and *m* is market.

FPL=Indicator variables for federal poverty level decile

Household size= indicator variables for number of individuals in household

Household type= indicator variable for household composition: single adult, multiple adult(s), adult(s) with child(ren)

AFP= weighted average price of foods and beverages purchased

Walmart density= average annual Walmarts per 100,000 individuals

The weights are then stabilized (150, 151) by including in the numerator the overall probability of being a Walmart customer in a given quarter:

$$\frac{P(\text{Walmart customer}_q)}{P(\text{Walmart customer})_{hq} = \text{Household size}_h + \text{Household type}_h + \text{Race}_h + FPL_{hq} + \text{Walmart AFP}_{mq} + \text{Foodstore AFP}_{mq+} + \text{Walmart Density}_{my} + \text{Unemployment Rate}_{mq}}$$

These stabilized were then truncated at the upper and lower 0.3rd percentile to reduce the influence of large weights. Large weights occur when individuals who had very high likelihoods of being a Walmart customer, were not; or when households who had very low likelihoods of being a Walmart customer, were(152). In this sample, these large weights occurred primarily because the Walmart density variable was a very strong predictor of whether someone shopped at Walmart or not, especially for markets with no Walmart. Individuals who shopped at Walmart despite the presence of no Walmart in their market (or vice versa) tended to have more extreme weights. Progressively truncating these weights at increases precision by eliminating the influence of large weight (151). Results appeared robust to the use of various types of inverse probability weights (Supplemental Tables 3 and 4).

Supplement Table 4.3. Descriptive statistics on inverse probability weights

		Mean	SD	Minimum	Maximum
Walmart					
	IPW	4.86	13.50	1.02	744.36
	Stabilized IPW	1.00	0.89	0.24	224.72
	Stabilized IPW, truncated at 0.3rd and 99.7th percentiles	0.99	0.65	0.36	6.11
OCR					
	IPW	1.48	0.04	1.00	1.48
	Stabilized IPW	1.00	0.2	0.08	140.6
	Stabilized IPW, truncated at 0.3rd and 99.7th percentiles	0.99	0.11	0.28	1.96

Supplemental Table 4.4 Year coefficients using different inverse probability weight approaches

	Energy Density (kcal/100g)					
	Other Chain Retailers			Walmart		
	No IPW β (SE)	Stabilized IPW β (SE)	Truncated IPW[a] β (SE)	No IPW β (SE)	Stabilized IPW β (SE)	Truncated IPW[a] β (SE)
2000	ref	ref	ref	ref	ref	ref
2001	-0.29	-0.29	-0.29	-8.66***	-9.62***	-9.79***
	(0.21)	(0.21)	(0.21)	(0.83)	(1.60)	(1.52)
2002	0.52*	0.51*	0.51*	-10.38***	-14.40***	-13.05***
	(0.23)	(0.23)	(0.23)	(0.82)	(1.64)	(1.50)
2003	-1.57***	-1.58***	-1.58***	-17.88***	-20.58***	-20.91***
	(0.24)	(0.24)	(0.24)	(0.85)	(1.63)	(1.54)
2004	-2.14***	-2.15***	-2.15***	-25.40***	-27.08***	-27.93***
	(0.25)	(0.24)	(0.24)	(0.89)	(1.75)	(1.62)
2005	-1.97***	-1.98***	-1.98***	-30.75***	-34.26***	-34.56***
	(0.26)	(0.25)	(0.25)	(0.95)	(1.84)	(1.72)
2006	-2.84***	-2.85***	-2.85***	-35.49***	-39.90***	-39.60***
	(0.26)	(0.26)	(0.26)	(0.98)	(1.91)	(1.77)
2007	-2.78***	-2.78***	-2.78***	-43.76***	-48.11***	-48.20***
	(0.30)	(0.30)	(0.30)	(1.14)	(2.23)	(2.02)
2008	-4.38***	-4.39***	-4.39***	-51.29***	-56.29***	-56.57***
	(0.35)	(0.35)	(0.35)	(1.29)	(2.52)	(2.26)
2009	-5.04***	-5.05***	-5.05***	-51.31***	-57.20***	-57.71***
	(0.44)	(0.44)	(0.44)	(1.47)	(2.76)	(2.46)
2010	-4.66***	-4.68***	-4.68***	-53.84***	-59.63***	-60.15***
	(0.45)	(0.45)	(0.45)	(1.50)	(2.81)	(2.50)
2011	-7.06***	-7.09***	-7.09***	-55.55***	-61.70***	-62.33***
	(0.46)	(0.46)	(0.46)	(1.56)	(2.96)	(2.62)
2012	-8.09***	-8.13***	-8.13***	-60.49***	-66.53***	-67.30***
	(0.48)	(0.48)	(0.48)	(1.68)	(3.26)	(2.85)
2013	-10.67***	-10.71***	-10.71***	-66.18***	-72.62***	-73.55***
	(0.51)	(0.51)	(0.51)	(1.77)	(3.42)	(2.98)

	Sugar (g/100 g)					
	Other Chain Retailers			Walmart		
	No IPW β (SE)	Stabilized IPW β (SE)	Truncated IPW β (SE)	No IPW β (SE)	Stabilized IPW β (SE)	Truncated IPW β (SE)
2000	ref	ref	ref	ref	ref	ref
2001	-0.07***	-0.07***	-0.07***	-1.08***	-1.27***	-1.27***
	(0.02)	(0.02)	(0.02)	(0.09)	(0.18)	(0.17)
2002	0.00	0.00	0.00	-1.45***	-1.90***	-1.79***
	(0.02)	(0.02)	(0.02)	(0.08)	(0.18)	(0.17)
2003	-0.27***	-0.27***	-0.27***	-2.31***	-2.71***	-2.79***
	(0.02)	(0.02)	(0.02)	(0.09)	(0.19)	(0.17)
2004	-0.51***	-0.51***	-0.51***	-3.23***	-3.59***	-3.65***
	(0.02)	(0.02)	(0.02)	(0.09)	(0.20)	(0.18)
2005	-0.66***	-0.66***	-0.66***	-3.64***	-4.16***	-4.19***
	(0.02)	(0.02)	(0.02)	(0.10)	(0.20)	(0.19)
2006	-0.77***	-0.77***	-0.77***	-3.95***	-4.55***	-4.54***
	(0.02)	(0.02)	(0.02)	(0.10)	(0.21)	(0.20)
2007	-0.82***	-0.82***	-0.82***	-4.66***	-5.36***	-5.37***
	(0.03)	(0.03)	(0.03)	(0.12)	(0.25)	(0.23)
2008	-0.95***	-0.95***	-0.95***	-5.39***	-6.12***	-6.15***
	(0.03)	(0.03)	(0.03)	(0.13)	(0.28)	(0.25)
2009	-0.90***	-0.90***	-0.90***	-5.29***	-6.09***	-6.14***
	(0.04)	(0.04)	(0.04)	(0.15)	(0.30)	(0.27)
2010	-0.90***	-0.90***	-0.90***	-5.33***	-6.14***	-6.18***
	(0.04)	(0.04)	(0.04)	(0.15)	(0.31)	(0.28)
2011	-1.08***	-1.08***	-1.08***	-5.56***	-6.45***	-6.50***
	(0.04)	(0.04)	(0.04)	(0.16)	(0.33)	(0.29)
2012	-1.28***	-1.28***	-1.28***	-6.11***	-7.01***	-7.08***
	(0.04)	(0.05)	(0.05)	(0.17)	(0.36)	(0.32)
2013	-1.71***	-1.71***	-1.71***	-6.81***	-7.78***	-7.86***
	(0.05)	(0.05)	(0.05)	(0.18)	(0.38)	(0.33)

	Saturated Fat (g/100g)					
	Other Chain Retailers			Walmart		
	No IPW	Stabilized IPW	Truncated IPW	No IPW	Stabilized IPW	Truncated IPW
	β (SE)	β (SE)	β (SE)	β (SE)	β (SE)	β (SE)
2000	ref	ref	ref	ref	ref	ref
2001	0.01	0.01*	0.01*	-0.12***	-0.14***	-0.14***
	(0.01)	(0.00)	(0.00)	(0.02)	(0.04)	(0.03)
2002	0.06***	0.05***	0.05***	-0.13***	-0.19***	-0.16***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.04)	(0.03)
2003	0.05***	0.05***	0.05***	-0.22***	-0.25***	-0.24***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.04)	(0.03)
2004	0.04***	0.04***	0.04***	-0.30***	-0.34***	-0.33***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.04)	(0.04)
2005	0.02**	0.02***	0.02***	-0.45***	-0.49***	-0.49***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.04)	(0.04)
2006	0.02	0.02*	0.02*	-0.52***	-0.59***	-0.57***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.04)	(0.04)
2007	-0.02	-0.02*	-0.02*	-0.69***	-0.74***	-0.73***
	(0.01)	(0.01)	(0.01)	(0.03)	(0.05)	(0.05)
2008	-0.05***	-0.05***	-0.05***	-0.88***	-0.95***	-0.93***
	(0.01)	(0.01)	(0.01)	(0.03)	(0.06)	(0.05)
2009	0.03*	0.03*	0.03*	-0.82***	-0.91***	-0.90***
	(0.01)	(0.01)	(0.01)	(0.04)	(0.07)	(0.06)
2010	0.09***	0.09***	0.09***	-0.87***	-0.96***	-0.95***
	(0.01)	(0.01)	(0.01)	(0.04)	(0.07)	(0.06)
2011	0.07***	0.07***	0.07***	-0.91***	-1.01***	-1.00***
	(0.01)	(0.01)	(0.01)	(0.04)	(0.07)	(0.06)
2012	0.06***	0.06***	0.06***	-1.02***	-1.12***	-1.11***
	(0.02)	(0.01)	(0.01)	(0.04)	(0.08)	(0.07)
2013	-0.03	-0.03	-0.03	-1.14***	-1.25***	-1.23***
	(0.02)	(0.01)	(0.01)	(0.04)	(0.08)	(0.07)

Sodium (mg/100g)

	Other Chain Retailers			Walmart		
	No IPW β (SE)	Stabilized IPW β (SE)	Truncated IPW β (SE)	No IPW β (SE)	Stabilized IPW β (SE)	Truncated IPW β (SE)
2000	ref	ref	ref	ref	ref	ref
2001	0.46	0.47	0.47	1.98	3.60	3.65
	(0.48)	(0.47)	(0.47)	(1.41)	(2.16)	(2.10)
2002	0.09	0.09	0.09	4.63***	4.43*	5.32*
	(0.51)	(0.51)	(0.51)	(1.40)	(2.26)	(2.08)
2003	-1.20*	-1.21*	-1.21*	2.18	5.61*	5.20*
	(0.54)	(0.55)	(0.55)	(1.45)	(2.28)	(2.14)
2004	-2.32***	-2.32***	-2.32***	-3.83*	-0.40	-1.38
	(0.55)	(0.55)	(0.55)	(1.52)	(2.44)	(2.26)
2005	-2.12***	-2.14***	-2.14***	-8.78***	-4.87	-5.89*
	(0.57)	(0.58)	(0.58)	(1.62)	(2.56)	(2.40)
2006	-5.21***	-5.25***	-5.25***	-12.73***	-7.92**	-9.05***
	(0.59)	(0.59)	(0.59)	(1.66)	(2.66)	(2.46)
2007	-6.73***	-6.76***	-6.76***	-20.04***	-13.60***	-15.45***
	(0.68)	(0.69)	(0.69)	(1.93)	(3.12)	(2.84)
2008	-5.76***	-5.76***	-5.76***	-18.95***	-12.74***	-15.06***
	(0.79)	(0.81)	(0.81)	(2.20)	(3.57)	(3.19)
2009	-9.64***	-9.64***	-9.64***	-20.17***	-13.32***	-16.07***
	(0.98)	(1.00)	(1.00)	(2.49)	(3.98)	(3.52)
2010	-11.27***	-11.29***	-11.29***	-29.14***	-21.92***	-24.77***
	(1.00)	(1.03)	(1.03)	(2.55)	(4.06)	(3.59)
2011	-14.08***	-14.11***	-14.11***	-31.27***	-23.90***	-27.07***
	(1.02)	(1.04)	(1.04)	(2.65)	(4.28)	(3.75)
2012	-17.68***	-17.69***	-17.69***	-36.09***	-27.35***	-31.16***
	(1.08)	(1.11)	(1.11)	(2.87)	(4.70)	(4.08)
2013	-19.89***	-19.88***	-19.88***	-37.90***	-28.80***	-33.00***
	(1.14)	(1.17)	(1.17)	(3.02)	(4.94)	(4.28)

[a] IPWs truncated at the upper and lower 0.3rd percentile

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Supplement Table 4.5 Predicted nutrient Profile of OCR and Walmart PFPs by Household Income[a]

OCR PFPs

	Energy Density (kcal/100 g)					Sugar Density (g/100 g)				
	Higher Income		SNAP-eligible			Higher Income		SNAP-eligible		
	Mean	(95% CI)	Mean	(95% CI)	*p*[b]	Mean	(95% CI)	Mean	(95% CI)	*p*
2000	119	(119,120)	125	122	0.091	8.4	(8.3,8.4)	9.0	(8.7,9.3)	0.022
2006	116	(116,117)	122	121		7.6	(7.6,7.6)	8.2	(8.1,8.4)	
2013	108	(108,109)	114	111		6.7	(6.6,6.7)	7.0	(6.8,7.2)	
Difference[c]	-11		-11			-1.7		-2.0		
	Saturated Fat Density (g/100 g)					Sodium Density (mg/100 g)				
	Higher Income		SNAP-eligible			Higher Income		SNAP-eligible		
	Mean	(95% CI)	Mean	(95% CI)	*p*	Mean	(95% CI)	Mean	(95% CI)	*p*
2000	1.6	(1.5,1.6)	1.7	(1.6,1.8)	0.065	205	(204,206)	209	(202,215)	0.079
2006	1.6	(1.6,1.6)	1.7	(1.7,1.7)		200	(199,207)	211	(205,217)	
2013	1.5	(1.5,1.6)	1.6	(1.5,1.7)		185	(183,206)	208	(203,213)	
Difference	-0.1		-0.1			-20		-1		

Walmart PFPs

	Energy Density (kcal/100 g)					Sugar Density (g/100 g)				
	Higher Income		SNAP-eligible			Higher Income		SNAP-eligible		
	Mean	(95% CI)	Mean	(95% CI)	*p*	Mean	(95% CI)	Mean	(95% CI)	*p*
2000	200	(195,204)	190	(175,205)	0.245	15.7	(15.2,16.2)	14.6	(12.5,16.6)	0.620
2006	159	(158,161)	154	(149,159)		11.1	(10.9,11.2)	11.0	(10.5,11.5)	
2013	124	(122,126)	127	(120,134)		7.7	(7.4,7.9)	8.4	(7.7,9.2)	
Difference	-76		-63			-8.0		-6.2		
	Saturated Fat Density (g/100 g)					Sodium Density (mg/100 g)				
	Higher Income		SNAP-eligible			Higher Income		SNAP-eligible		
	Mean	(95% CI)	Mean	(95% CI)	*p*	Mean	(95% CI)	Mean	(95% CI)	*p*
2000	2.8	(2.7,2.9)	2.8	(2.5,3.2)	0.284	231	(225,238)	231	(210,252)	0.049
2006	2.3	(2.2,2.3)	2.2	(2.1,2.3)		222	(220,241)	236	(218,253)	

2013	1.6	(1.5,1.6)	1.6	(1.5,1.8)	198	(194,201)	200	(190,210)
Difference	-1.2		-1.2		-33		-31	

[a] Household income categorized as higher income (income >130% the federal poverty level [FPL]) or Supplemental Nutrition Assistance Program eligible (income ≤ 130% FPL)
[b] P-value for Wald chunk test for interaction
[c] Difference between 2013 and 2000, within race/ethnic group

CHAPTER 5. CAN A HEALTHY FOODS INITIATIVE BY A MAJOR NATIONAL FOOD RETAILER IMPROVE THE NUTRIENT PROFILE OF US FOOD PURCHASES?

Overview

The goal of this study is evaluate whether a healthy foods initiative (HFI) to improve the affordability and availability of health foods at a major national US food retailer (Walmart) improved the nutrient profile of packaged food and beverage purchases (PFPs), especially among households eligible for the Supplemental Nutrition Assistance Program (SNAP) and race/ethnic minorities. We used a longitudinal dataset of US household PFPs from Walmart and other chain retailers (OCR) to compare trends in the nutrient density (energy, total sugar, saturated fat, and sodium) of PFPs and percent volume of key food group in the pre-HFI period (2000-2010) and post-HFI period (2011-2013), controlling for concurrent changes in the social, economic, and food retail environment. We used time-varying inverse probability weights and fixed effects models to account for potential selectivity of customers into Walmart and OCR stores over time, and also tested whether the HFI was more impactful among low-income and race/ethnic minority households.

While Walmart PFPs showed major declines in energy, sodium, and sugar density from 2000 to 2013 as well as declines in the percent volume of sugary beverages, grain-based desserts, snacks, and candy, these declines were steepest in the 2000 to 2007 period. For most nutrient

densities and food groups, post-HFI declines were similar to what would be expected based on pre-HFI trends, indicating that the HFI did not have a major impact. The effect of the HFI

appeared consistent for SNAP-eligible households compared to higher income households, and for race/ethnic minorities compared to non-Hispanic Whites. PFPs from OCR showed only minor declines across the time period, and post-HFI trends at OCR were similar to those expected based on pre-HFI trends. While the nutrient profile of Walmart PFPs improved over time, these trends were already well underway by the time the HFI was initiated. The HFI was not more effective in any socio-economic group, suggesting a more targeted approach may be needed to reduce diet disparities.

Introduction

Food retailers represent unique and critical allies in the fight against obesity (6, 140). In fact, since 2011, three of the US' largest grocers have implemented "healthier foods initiatives" (HFI) to encourage healthier food purchases[2]. These initiatives typically consist of an effort to help consumers identify healthier options through shelf or front-of-package labels, and sometimes additional measures, such as price cuts on produce, product reformulation, or additional educational or marketing initiatives. Such retailer-based strategies have major potential to improve the nutrient profile of what US households purchase and consume, not only because food stores in general provide the majority of daily energy for US children and adults (1, 2), but because national trends towards chain stores and consolidation (3) means that these top retailers account for the majority of US food purchases (4).

Yet, no independent work has evaluated whether an HFI at a major national retailer actually improves the nutritional quality of food purchases. To date, field studies on HFIs have been equivocal: while some have found that HFIs demonstrate moderate to high reach (11-13) and improve healthy food availability, sales of targeted foods, self-reported knowledge, and intake of healthier food (11, 14-18), other studies have found that common HFI components are ineffective at changing long-term purchasing behaviors, including nutrition signs and labels (25-30) and discounts on healthy foods (31-33). However, most studies examining food-retailer-based HFIs have been short-term (<2 years) and small scale, typically representing only one store or perhaps a handful of stores in a single region, or limited to a few target foods, providing little understanding of how an HFI at a major national supermarkets impacts purchases across the population over time.

[2]"Healthier food purchases" means different things at different retailers, but usually refers to fruits and vegetables, whole grains, and/or products which have less *trans* fat, saturated fat, sodium and added sugars.

Evaluating the effects of a national-scale retailer based HFI is further complicated by data limitations: retailers are not always willing to share their data with independent evaluators, and currently, national health and nutrition surveys do not indicate from which retailers foods were purchased, making it difficult to attribute any changes to a specific retailer or initiative. In fact, the only study to our knowledge to examine the effects of a chain-retailer based HFI had access to the chain's sales data, and was funded by the company who created the shelf-labeling system. The study, which examined a storewide supermarket point-of purchase nutrition navigation intervention using shelf-labeled star icons in a chain of Northwest supermarkets, found that the HFI showed significant but small (<2%) increases in the percent of purchases with a star logo after the intervention (35).

These evaluation efforts are further complicated by concerns about selectivity issues: as the retailer implements its HFI, it may attract more customers seeking out these new healthier food options. Thus, a key question is whether a retailer truly improved the nutrient profile of packaged food purchases (PFPs), or whether it simply attracted a more health-conscious consumer base as opposed to changing the behaviors of current customers.

The lack of an appropriate control group also poses a major barrier to evaluations of national-scale HFIs, since there are no stores which remain "unexposed" to the intervention. A basic approach would be to simply look at the nutrient profile of foods before and after the HFI was initiated. However, such an approach cannot distinguish whether changes are attributable to the HFI, or other concurrent secular trends that impacted food purchasing, including the "Great Recession," the skyrocketing of global food prices, shifts in the US socio-demographic composition, or shifts in the food retail environment (24, 39-42, 134, 161). Ideally, we would want to observe the counterfactual (74-76): what would the nutrient profile of purchases look

like if the HFI had not been enacted, if all other factors were held constant? This approach was recently used by Ng et al. to examine whether food manufacturers' pledge to cut calories was associated with a decline in the calories purchased (46), but has not yet been applied to examine HFIs by food retailers.

To address these concerns, we use Walmart as a case study to examine whether an HFI at a national food retailer can improve the nutrient profile of packaged food purchases (PFPs) of its customers in the US. Walmart is the US' largest food retailer (4), with over 80% of households shopping there in 2012 (141). In 2011, Walmart announced an HFI to improve the nutritional quality and affordability of their products. Walmart's initiative entails three major components: 1) development of a front-of-package labeling system for Walmart brand store-brand PFPs that meet specified health criteria; 2) strategic price reductions on healthier items, and 3) product reformulation of Walmart store-brand products, with goals to achieve elimination of *trans* fats, a 25% reduction in sodium, and 10% reduction in added sugar in key PFP categories by 2015 (77, 78). However, one key question is what is the appropriate baseline period against which to measure these changes: although Walmart formally announced the HFI in January of 2011, much of their online marketing suggests an earlier start date (i.e. "between 2008 and 2011 we removed 1.5 million pounds of salt across the commercial bread category)(77).

Finally, it is unclear whether major HFIs to date differentially impact key subpopulations, such as low-income and race/ethnic minority households, who typically have less access to healthy foods (57-59) and nutritionally poorer diets (60-62), and thus could benefit the most from increased availability and affordability of healthier food. Considering Walmart is among the largest recipient of Supplemental Nutrition Assistance Program (SNAP) spending(80),

evaluation of Walmart's HFI among SNAP-eligible households in particular is important for understanding if such strategies could be useful for reducing diet disparities among the poor.

The objective of this study is to examine whether Walmart's HFI improved the nutrient profile of PFPs from pre-HFI (2000-2010) to post-HFI (2011-2013). We conduct counterfactual simulations by comparing the projected pre-HFI trends in nutrient profile of Walmart PFPs to observed post-HFI trends in nutrient profile, and also compare these to concurrent trends in PFPs at other chain retailers (OCR). To deal with selectivity, we employ fixed effects models and inverse probability weights, to ensure that the sample remains balanced overtime. We also examine whether results varied by whether Walmart's stated pre-HFI period vs. a data-driven pre-HFI period were used. Finally, we examine whether the HFI differentially impacted key subpopulations, including SNAP-eligible households and race/ethnic minorities.

Methods

Dataset

This study uses data on household food and beverage PFPs from 2000 to 2013 from the Nielsen Homescan longitudinal commercial purchase dataset. Details of the sampling frame and methodology have been published elsewhere (107, 143, 162). In brief, households are sampled from 76 metropolitan and non-metropolitan US markets, and use a handheld scanner to record information on all PFPs purchased during each shopping trip. PFPs include all food and beverages with a universal bar code, including all consumer packaged goods and packaged fresh fruit and vegetables (i.e., bag of lemons), but excluding unpackaged meat and produce (i.e., a lemon). Walmart PFPs included all PFPs from Walmart Supercenters and Neighborhood Markets, which both include a full-line of groceries, although the latter is smaller in size and assortment (108).

In order to understand whether shifts in the nutrient profile of Walmart PFPs were above and beyond industry trends, we also examined shifts in PFPs from other chain retailers (OCRs), who are the most comparable group of stores given their scope, size, and product assortment. OCR purchases include all PFPs from chain grocery stores and supermarkets (≥10 locations), supercenters, and mass merchandisers, but excluding warehouse, drug, club, dollar, convenience stores, ethnic stores, specialty stores, and independent grocers (<10 locations) (362 different retailers) (144). Information on PFPs was linked at the barcode level to nutrition data from the Nutrition Facts Panel (109). PFPs were aggregated at the household-quarter level. Household-quarter observations were included if they shopped for PFPs at Walmart (n= 1,212,803) or OCR (n= 2,521,128) for at least two quarters.

Nutrition Outcomes

Nutrient outcomes were evaluated separately for Walmart and OCR PFPs, and included energy density (kcal/100 g), total sugar (g/100 g), saturated fat (g/100 g), and sodium (mg/100 g). To examine shifts in purchasing, we examined shifts in percent volume purchased (% g) from key food groups, including sugar-sweetened beverages (SSBs), grain-based desserts (GBDs), savory snacks, candy, fresh/frozen fruit, and fresh/frozen vegetables. We used percent volume rather than percent calories to evaluate changes in food groups, since shifts in calories could reflect changes in either purchasing or changes in product reformulation.

Addressing selectivity

As previously mentioned, one concern in these models is selectivity, or the idea that as a retailer implements an HFI, it may attract more health-conscious consumers, and that this shift in consumer base may be responsible for any shifts in nutrient profile of purchases (141). To address this concern, we created two sets of quarterly inverse probability weights (IPW) to

account for: a) the likelihood of being a Walmart shopper, and b) the likelihood of being an OCR shopper (these are separate and non-mutually exclusive because a household could shop in both Walmart and OCR in any given quarter). Each of these are IPWs are created conditional upon covariates associated with shopping at a certain food retailer, including socio-demographics (household composition, race/ethnicity, maximum household education, and household income), average retailer food prices, and density of Walmart supercenters in the market (150-152). Both Walmart and OCR IPWs were stabilized and truncated at the upper and lower 0.3rd percentile, with means of 0.99and 1.00 respectively. Sensitivity analyses revealed that results were robust to the use of Walmart and OCR IPWs, and year coefficients remained consistent in direction and magnitude.

In addition, we use fixed effects models examine average within-household effects over time. Fixed effects models can correct for selectivity if the likelihood of shopping at a certain retailer is associated with fixed characteristics of the household (i.e. income, race/ethnicity), since in the model each household essentially serves as its own control.

Counterfactual simulation:

We first identified potential dates when the HFI occurred by using switching regression (163) for both energy and sodium density of Walmart PFPs, since food industry initiatives to reduce sodium in processed foods began prior to Walmart's HFI (164). This technique uses linear regression to test for an interaction of the time trend with each potential HFI starting date, along with shifts from year to year in the directionality of this interaction, to identify time points when shifts in the nutrient density of PFPs occurred (and thus presumably when the HFI began), and also evaluates whether one starting point better fits the data than other starting points. Changes in the direction of the time trend*HFI start date interaction indicated shifts at 2011 as

well as a shift at 2007 and 2013 **(Supplemental Table 5.1)**. However, the summary statistics were virtually identical across models, suggesting that no one model better fit the data, or there was no clear "switch". Sodium density also had no clear switch point; rather, there were switches in different directions at 2- and 3-year increments across the time period, and again summary statistics were similar across models. Thus, we chose to use 2011 as the beginning of the post-HFI period for all main models for all nutrient densities, since this was Walmart's stated HFI initiation date, while examining 2007 as the beginning of the post-HFI period as a sensitivity analysis.

Using these HFI start dates, we then tested the shape of the trend. For energy models (energy, sugar, and saturated fat), we found that using the 2011 HFI start date, a quadratic trend provided the best fit (based on model R^2 and visual inspection), whereas using the 2007 HFI start date, a linear trend provided the best fit. For sodium, a linear trend provided the best fit for the 2011 HFI start date, while a quadratic term provided the best fit for the 2007 start date. Models with the appropriate terms were then used for the remainder of analyses.

Statistical Analysis

We used fixed effects models to separately model all nutrient outcomes at Walmart and OCR, using Stata's areg command for use with time-varying inverse probability weights. In order to control for secular trends that occurred alongside Walmart's HFI, all models included covariates representing the economic, food retail, and price environments, including average quarterly market-level unemployment rates (145), the weighted average of prices purchased from each retailer type, and average market-level Walmart density variable (Walmart supercenters per 100,000 people) (146-149). Household-level covariates included household race (non-Hispanic White, Hispanic, non-Hispanic Black, and non-Hispanic Other) and SNAP eligibility (≤130%

federal poverty level). All models controlled for head of household education (≤ high school degree, some college, ≥ college degree), household type (single adult, multiple adults with no kids, adult(s) with kid(s)) and household composition (numbers of adults aged 19-49 and ≥50y, and numbers of children aged 0-5y, 6-18y).

To examine the observed nutrient profile of purchases pre-and post-HFI, Stata's margins command was used to predict the mean nutrient density or percent volume from food groups for each year for each retailer. For models examining the counterfactual post-HFI nutrient profile, the pre-HFI time trend (2011 or 2007; linear or quadratic) for each nutrient outcome was estimated, then Stata's predict command was used to predict mean nutrient outcomes during the post-HFI period. The observed mean nutrient profile was considered statistically significantly different from the counterfactual mean nutrient profile if 99% confidence intervals did not overlap (p<0.01) or for race/ethnic comparisons, the 95% confidence intervals (p<0.05). To test whether the effect of the HFI varied by key socio-demographic groups, we first examined the interaction between time and subgroup (SNAP-eligible or race/ethnicity) using Wald chunk tests, indicating that the nutrient profile of Walmart PFPs in this group differentially changed over time. If the test for interaction was significant, we then employed counterfactual simulations in stratified models to examine the effect of the HFI in each group. All statistical analyses were performed using STATA, version 13 (Stata Corporation, College Station, Texas).

Results

Graphs comparing the nutrient density of Walmart PFPs prior to the HFI with the best-fit counterfactual based on pre-HFI trend are shown in **Figure 5.1**. Walmart PFPs showed a 74 kcal/100g decline in energy density from 2000 to 2013, although this decline leveled off around the late 2000's. In fact, after the 2011 HFI, Walmart PFPs declined less in energy density than

what would be expected based on the pre-HFI trend (p<0.01 in 2013). While the rate of decline for total sugar density of Walmart PFPs also slowed around 2007, the sugar density of PFPs during the post-HFI period was very similar to what we would expect based on pre-HFI trends, and in 2013, the sugar density of Walmart PFPs was less than what we would expect based on pre-HFI trends (p <0.01). The saturated fat density of Walmart PFPs showed small declines from 2000 to 2013, but again, the saturated fat density of PFPs during the post-HFI period was slightly but significantly higher than expected based on the pre-HFI trend (p <0.01). Sodium density decreased by 33 mg/100g from 2000 to 2013, but post-HFI sodium density was virtually identical to the sodium density we would have expected based on pre-HFI trends.

During the 2000 to 2013 time period, OCR also showed declines across all nutrient densities, but generally these were substantially smaller than those observed at Walmart (**Figure 5.2)**. The energy density of OCR PFPs declined by 11 kcal/100g from 2000 to 2013 during the post-HFI period (p<0.01), and this decline were bigger than expected based on pre-HFI trends (p<0.01). Similarly, while total sugar density and sodium density showed minor declines over time, (<2 g/100g and 20mg/100g, respectively), during the post-HFI period, these declines were bigger than expected based on pre-HFI trends (p<0.01 in 2013 for each nutrient density). Saturated fat density of OCR PFPs remained stable over time.

Figures 5.3 and **5.4** show the percent volume purchased of key food groups at Walmart and OCR, respectively. Overall, the percent volume of SSBs from Walmart declined only slightly, although this decline was less than expected based on pre-HFI trend (p <0.01). Percent volume of fruits and vegetables increased only slightly, and increases during the post-HFI period were the same as expected. Percent volume of grain-based desserts, savory snacks, and candy from Walmart also declined, although the post-HFI declines were no different than expected

from pre-HFI trends. At OCR, percent volume from food groups showed similar but smaller shifts over time. In the post-HFI period, these changes represented negligible deviations from what would have been expected based on pre-HFI trends, except for SSBs, which declined slightly less than expected (p <0.01).

Using 2007 as the HFI cut-point tended to amplify the results for Walmart PFPs, and in some cases reversed them, with the general effect being that observed post-2007 HFI nutrient densities were even higher than what would be expected based on the pre-2007 trend. For example, the disparity between the observed decline in energy density of Walmart PFPs and what we would have expected based on pre-HFI trends widened (**Supplemental Figure 5.1)**. Using the 2007 HFI start date reversed the result for sugar density, with post-HFI sugar density substantially higher than what would be expected based on pre-2007 trends (p <0.01). For OCR, there were no substantive differences in results if the 2007-start date was used **(Supplemental Figure 5.2).**

Similar results were found when we examined shifts in percent volume of food groups from Walmart, with a reversal or widening of the gap so that post-HFI nutrient densities declined less than expected. For example, using the 2007 start-date, we find that there was no difference between the percent volume of SSBs purchased fromWalmart post-HFI and what would have been expected based on pre-HFI trends (**Supplemental Figure 5.3)**. For savory snacks, candy, and fruit, changes in the percent volume purchased post-HFI were less than expected based on pre-HFI trends. For OCR, using 2007 as a cut-point did not seem to have an effect on percent volume of food groups purchased **(Supplemental Figures 5.4**).

Wald chunk tests indicated that there was no significant differences in changes in nutrient profiles of Walmart PFPs for SNAP-eligible vs. non-SNAP eligible households over time. There

were significant differences in shifts energy density and sodium density by race/ethnicity (p <0.05). However, these differences were in place prior to the HFI. For all race/ethnicities, post-HFI energy density and sodium density declined either similar to or less than expected relative to pre-HFI trends (**Supplemental Figures 5.5 and 5.6**), suggesting no differential effect of the HFI on income or race/ethnic subpopulations.

Discussion

From 2000 to 2013, food and beverage purchases from Walmart showed substantial declines in calorie, sugar, and sodium density, and these changes were greater than what was observed in PFPs purchased from other chain food retailers. On the whole, however, using 2011 as the date for which the HFI was enacted, we find that post-HFI shifts in nutrient density and percent volume of key food groups (SSBs, grain-based desserts, savory snacks, fruits, and vegetables) were similar to or less than what we would expect had pre-HFI trends simply continued. These results are contrary to what we would expect if the HFI truly marked a turning point in how Walmart formulates, prices, and markets its foods: if anything, we would expect nutrient densities of Walmart PFPs to have declined more quickly after the HFI was enacted.

Instead, we see that the declines in nutrient density and shifts in percent volume from key food groups were steepest in the early 2000's, and leveled off around 2007/2008. These declines are consistent with other work showing that caloric intake and purchases have been declining since the early 2000's, independent of changing economic conditions (45, 143, 165). In fact, these results mirror a recent evaluation of the "Healthy Weight Commitment Foundation" (HWCF) pledge by food manufacturers to cut 1.5 trillion calories by 2015: Ng et al. found that annual US calories sold by HWCF companies was declining by roughly a trillion calories a year prior to the pledge, but that post-pledge declines in caloric purchases were smaller than expected

based on the pre-pledge trend (46). In the current example, the declines in the earlier 2000's followed by a leveling off around 2007 could simply reflect Walmart's continued expansion of its grocery lines within Supercenters, as well as increased consumer perception of Walmart as a place to shop for groceries, not just for household items and the occasional sweet or soda. In fact, by the end of the observation period, purchases at Walmart simply resemble those at other chain retailers. It will be interesting in the future to see whether the nutrient profile of Walmart purchases continues its decline, or remains similar to other retailers.

One notable exception is the percent volume of SSBs purchased from Walmart. Although the total decline in SSBs was only 1% from 2000 to 2013, the percent of SSBs purchased at Walmart was less than we would have expected given pre-HFI SSB purchasing trends, which indicated that SSB purchases were actually increasing prior to the 2011 HFI. Given that Walmart has not publically indicated whether their HFI has targeted SSB purchases, it is unclear whether this shift in SSB purchases was truly the result of the HFI. An alternate possibility is that these changes simply reflect a shift in the public attitudes towards SSBs as a result of public health campaigns and emerging policies about the potential health consequences of SSBs--- although, in all likelihood, such a shift in awareness would have also resulted in a downwards shift in SSB purchases at OCR as well, which we did not see. In general, both Walmart and OCR SSB results are contradictory to recent findings showing that caloric purchases from SSBs have decreased over recent years (165, 166). However, since our results focused on only on volume purchased, the lack of decline in SSB volume purchased could indicate that consumers are not decreasing the total volume of SSBs purchased, but simply shifting to less energy dense purchases as more beverages with lower-calorie sweeteners are introduced(167).

This lack of post-HFI changes raises the major question of whether Walmart, aware of the declines in calories, sugar, saturated fat, and sodium over the past decade, was simply marketing an HFI that simply reflected pre-existing trends. As Mozzafarian points out, such a strategy could be beneficial to food manufacturers or retailers, with the HFI providing a promising opportunity to improve its public image and get ahead of mounting pressure from public health advocates to improve the nutritional quality of US foods and beverages (168). On the other hand, it is not uncommon for organizations to initiate changes in products prior to the formal beginning of a program or policy: for example, schools started more-healthful school feeding programs prior to the initiation of national policies (169, 170) and some New York City chain restaurants voluntarily posted calorie information prior to mandatory labeling laws (171). Walmart itself has acknowledged it likely started earlier than its official announcement, since they use 2008 as a baseline in their materials documenting the effectiveness of their HFI—although the use of 2008 as a baseline could be viewed as conservative, given that we show the majority of changes occurred prior to 2008.

Regardless, these results show that identifying the appropriate starting point for evaluating food industry efforts can be complicated, and that this choice matters in determining whether initiatives are responsible for the observed changes. In the current example, when we use a 2007 start-date for the HFI, we find that declines in the energy, sugar, sodium, and saturated fat density of Walmart PFPs are markedly less than we would have expected. This likely occurred because for the energy-containing nutrients, the majority of declines occurred prior to 2007, and then leveled off. Thus, when 2011 is used as the start-date, the quadratic trend fits best and creates a post-HFI trajectory that is very similar to what was actually observed for energy, sugar, and saturated fat densities. However, a 2007 start dates yields us a linear post-HFI

trajectory, and since these declines were occurring at a relatively steeper rate prior to 2007, when we look to see what happened after 2007, the post-HFI nutrient densities declined less than we would have expected had the pre-HFI trend continued.

It was also surprising to note that although the energy density, sugar, and sodium density of OCR PFPs declined more rapidly than expected during the post-HFI period, these overall declines were minimal. Even though the time trend was based on Walmart's HFI, we would have expected to see larger declines, especially after 2007 and 2011, in part because of Walmart's influence. Because of its size, Walmart's price cuts on produce or negotiations with suppliers to reformulate products could have likely led to lower prices on produce or the introduction of healthier options (i.e. items with lower added sugar, sodium, etc) at other chain retailers as well (115-117). Additionally, we would have expected to see steeper declines in later years due to the implementation of HFIs by other major retailers, including Safeway's shelf-tag labeling system for healthier items (8) and other shelf- and product- nutrition labeling initiatives by Kroger (9, 47), DelHaize subsidiaries (10), and others, although the geographic scope of these HFIs is currently unclear. One possibility is that PFPs purchased from OCR were already "healthier" even in the early 2000's, so there was less potential for HFI-related shifts in nutrient profile. An alternate possibility is that these HFIs, which were comprised primarily of shelf- and front-of-package nutrition labeling to identify "healthier" options, were not powerful enough to create observable shifts in nutrient profiles. More work is needed to explicitly examine the effects of HFIs at these other retailers.

Finally, the Walmart HFI did not appear to have a differential effect on SNAP-eligible households or race/ethnicities. Previous work has been equivocal regarding whether socio-demographic subgroups respond differentially to various HFI components. For example, while

some studies show that lower-income customers tend to be more cost-conscious (64) and more likely to take advantage of price promotions(65), other work suggests they may not be more responsive to price cuts than higher income consumers (66-69). Lower-SES groups may also be less likely to utilize other elements of Walmart's HFI, like its front-of-packaging food labeling system (21, 70). While our work shows that the HFI was similarly effective across groups, a more targeted approach may be needed to further improve the nutrient profile of these key demographic groups and reduce diet disparities.

Strengths & Limitations

This study has several limitations which might have precluded our ability to detect all potential HFI-related changes in Walmart PFPs. For example, Walmart pledged to reduce sodium, added sugar, and trans fat in "key categories" of products (i.e. food groups). Since we did not examine changes in nutrient profile of specific food groups, it is possible that post-HFI changes were greater in some of these key categories than for overall purchases; however, it is impossible to know without access to Walmart data what all of these key categories are or what foods they comprise. Similarly, we could not distinguish added sugar from total sugar, or trans fat from other saturated fats; however, we would expect if these changes were large enough to be meaningful, they would have been detected in the overall nutrient profile of PFPs.

A second major limitation is that the Homescan dataset captures only foods that are purchased and also have a barcode. First, food purchases do not necessarily equate to food consumed, and further work is needed to understand how HFIs are related to changes in dietary behaviors and intake. Secondly, while our dataset included fresh produce with a barcode (for example, bagged lettuce) it misses unpackaged products like a single apple or bunch of bananas. Given that much of Walmart's initiative has focused on increasing the availability and

affordability of produce, including increasing sales of locally sourced and organic foods (125, 126), our observed declines in energy density and increases in fruit and vegetable purchases are likely an underestimate . In fact, we might have expected to see declines in packaged fruits and vegetables as consumers shifted to fresh produce (which we could not capture). More work is needed to understand the degree to which the HFI impacted fresh fruits and vegetable purchases, and how this shift may link to shifts in PFP purchasing patterns.

We were unable to explicitly examine shifts in the nutrient profile of Walmart private-label products vs. OCR private-label products, although private-label products of each retailer type are included in the totals. Since Walmart's purported efforts on product reformulation and front-of-package labeling focused on their private-label products, and considering that private-label products account for an increasing proportion of foods purchased (139), we may have observed more substantial post-HFI declines if we had been able to distinguish private-label PFPs from non-private-label.

In addition, we were unable to explicitly examine each distinct component (reformulation vs. labeling vs. price cuts) of the HFI to identify which pieces were most effective. In using these results to craft future policies, it would be useful to understand whether declines were attributable to shifts in consumer behavior (purchasing), or whether product reformulations were the major driver. In addition, we did not look at how HFI-related changes in purchasing may have impacted other foods that were purchased, at Walmart or other retailers. For example, it is unclear whether decreases in SSB purchases were substituted with other beverages, replaced by more SSB purchases from away-from-home food outlets, or whether consumers just purchased fewer beverages.

While our estimates likely represent a conservative estimate of shifts in nutrient profile related to Walmart's HFI, this analysis still represents the first independent evaluation of an HFI at a major national retailer. Further work should delve more deeply into specific HFI components, to understand which strategies are the most effective and the most feasible for implementation by other food retailers.

Conclusion

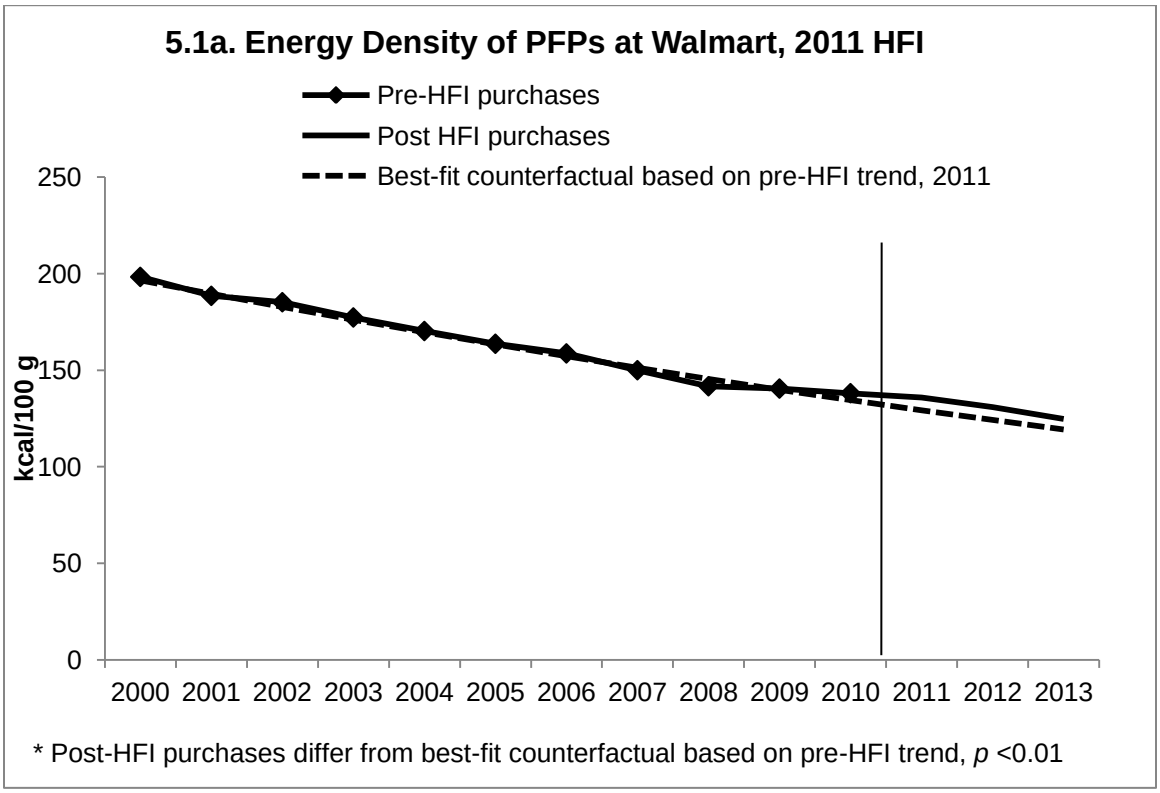
From 2000 to 2013, the largest food retailer in the US, Walmart, showed major declines in energy, sugar, and sodium density of PFPs, above and beyond concurrent trends in comparable food retailers. However, the majority of these changes occurred prior to the implementation of its HFI. Furthermore, we illuminate the importance of identifying the appropriate initiative start date when evaluating efforts by food retailers or food manufacturers, in order to establish whether ostensible HFI-related shifts in nutrient profiles are related to actual changes in the food supply, or simply reflective of pre-existing purchasing trends. Regardless, these declines suggest that while Walmart's HFI might not be the sole factor in improving the nutrient profile of purchases, food retailers are a key player in strategies to improve nutrition and reduce obesity, and should be included in the national conversation developing policies to improve the health of the US population.

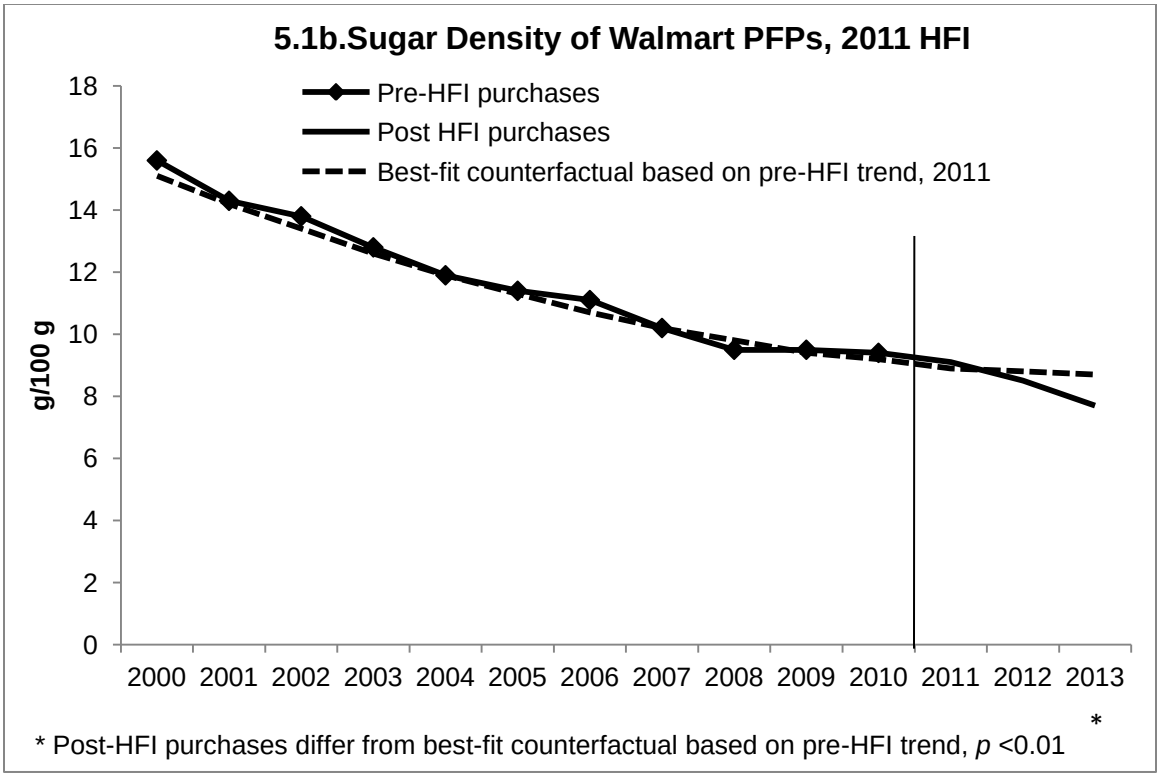
Table 5.1 Household characteristics of the Nielsen Homescan sample in 2000 and 2013[a]

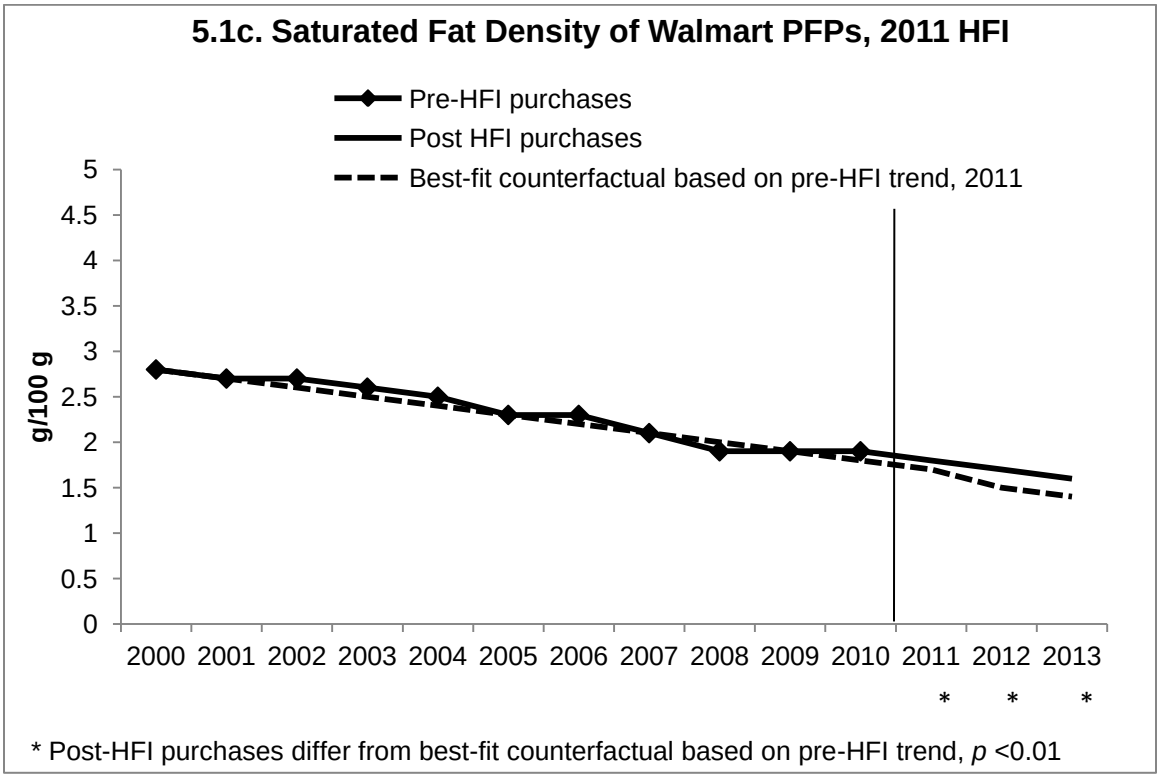
	Other Chain Retailers			Walmart		
	2000	2013	p^c	2000	2013	p^c
Households who shopped at retailer, %	99	95	<0.001	31	70	<0.001
Total grams purchased, %	94	81	<0.001	28	42	<0.001
Household composition						
Single adult, %[b]	25	25	67%	19	22	<0.001
Multiple adults, no children <18y, %	46	52	<0.001	51	55	<0.001
Adults, with children <18,%	28	22	<0.001	30	23	<0.001
Race/ethnicity						
Non-Hispanic White,%	84	81	<0.001	86%	82	<0.001
Hispanic, %	5	5	0.128	5%	5	0.778
Non-Hispanic Black, %	8	10	<0.001	8%	10	<0.001
Non-Hispanic Other, %	2	5	<0.001	1%	4	<0.001
Maximum Household Education						
High school or less, %	23	17	<0.001	27	20	<0.001
Some college,%	31	29	<0.001	32	31	<0.001
≥College degree, %	46	54	<0.001	40	49	<0.001
Income[d]						
SNAP-eligible, federal poverty level ≤130%	6	10	<0.001	7	12	<0.001
Federal poverty level, >130%	94	90	<0.001	93	88	<0.001
Walmarts/100,000 people, mean (SD)	0.2 (0.3)	1.0 (0.6)	<0.001	0.4 (0.3)	1.2 (0.5)	<0.001
Unemployment rate, mean (SD)	3.9 (0.9)	7.8 (1.6)	<0.001	3.8 (0.8)	7.7 (1.6)	<0.001
Walmart Food Price Index, mean (SD)	72 (12)	103 (4)	<0.001	68 (8)	102 (4)	<0.001
OCR Price Index, mean (SD)	84 (8)	118 (6)	<0.001	81 (6)	116 (6)	<0.001

[a] University of North Carolina calculation based in part on data reported by Nielsen through its Homescan Services for all food categories, Including beverages and alcohol for the 2000-2013 periods, for the U.S. market. All estimates are an average of values of four quarterly periods in the relevant year for households who shopped at OCR or Walmart.
[b] Column percents.
[c] For categorical variables, from proportions testing and for continuous variables, from t-tests, comparing households in the sample in 2000 and 2013.
[d] Supplemental Nutrition Assistance Program (SNAP) eligibility based on household income using percent of annual federal poverty level

Figure 5.1 Nutrient densities of PFPs at Walmart before and after the 2011 HFI






5.1c. Saturated Fat Density of Walmart PFPs, 2011 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2011
g/100 g
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* * *
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01

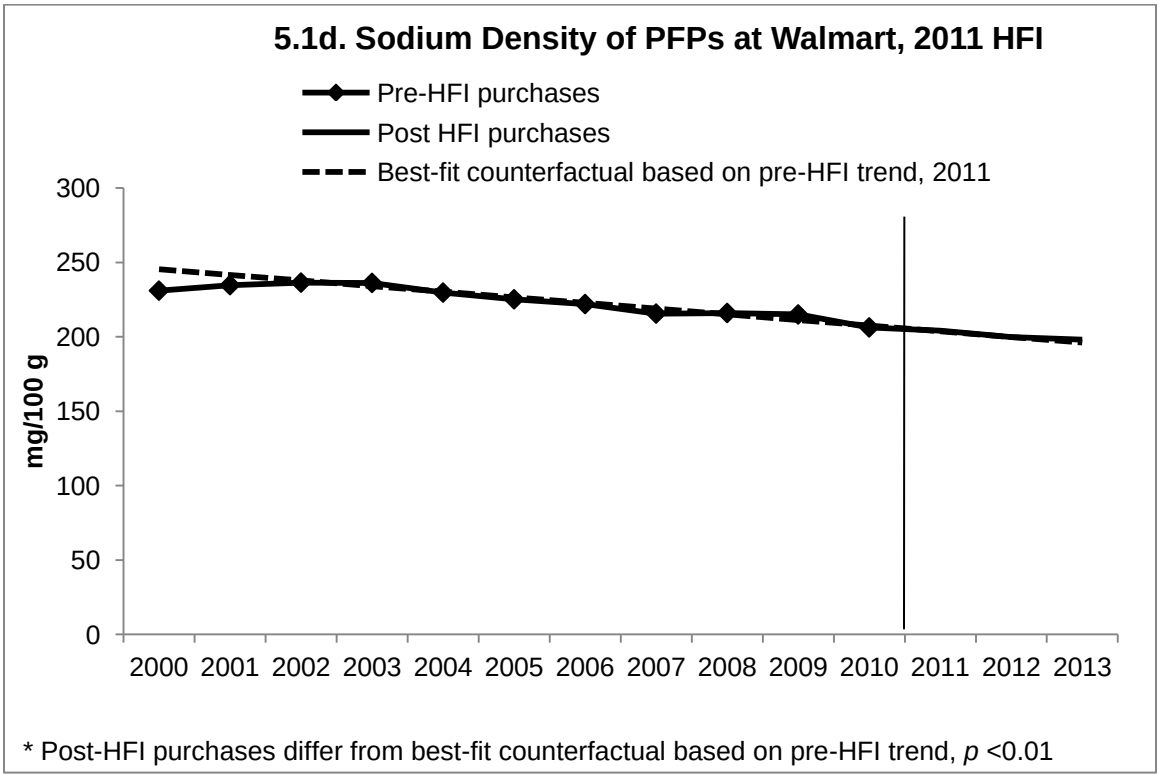
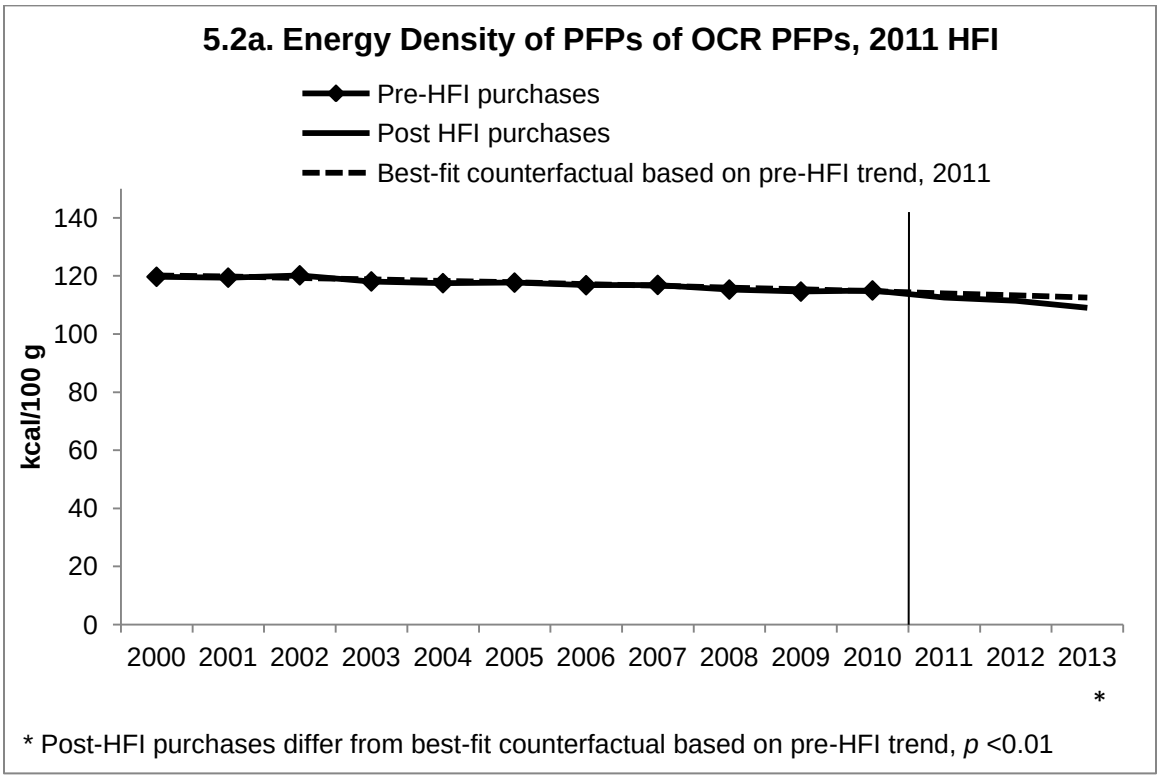
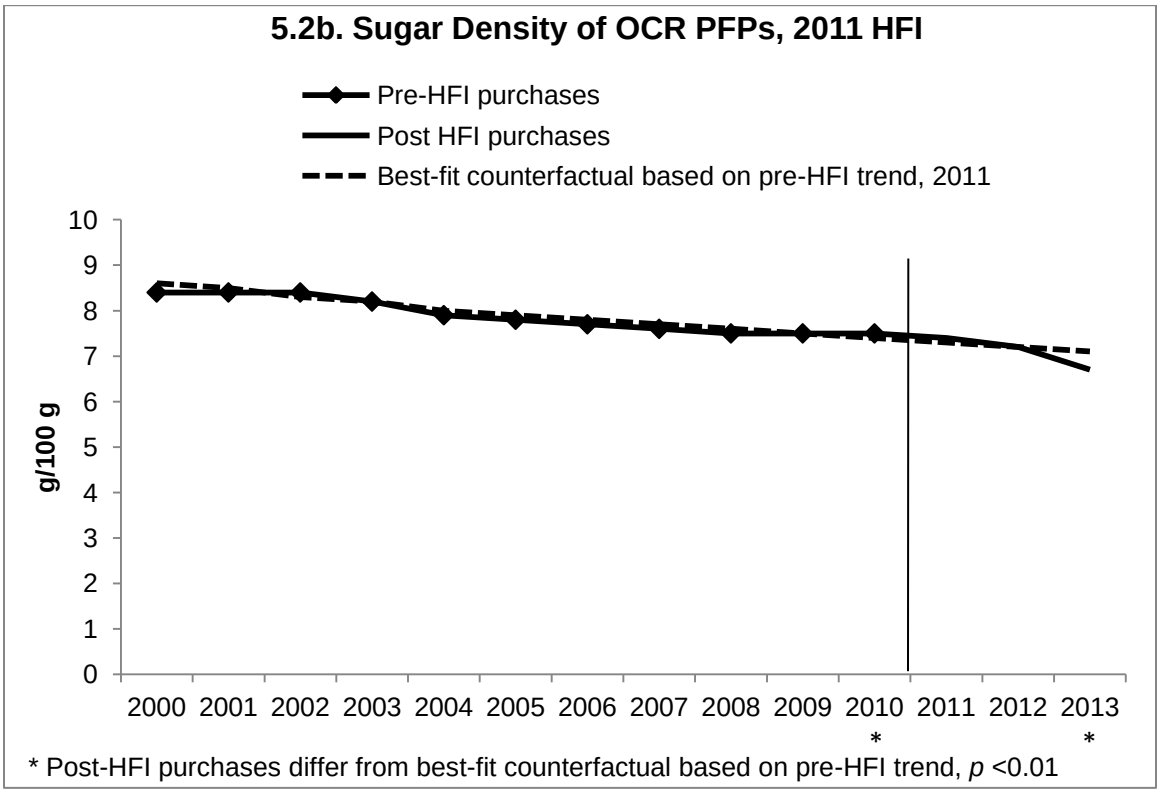
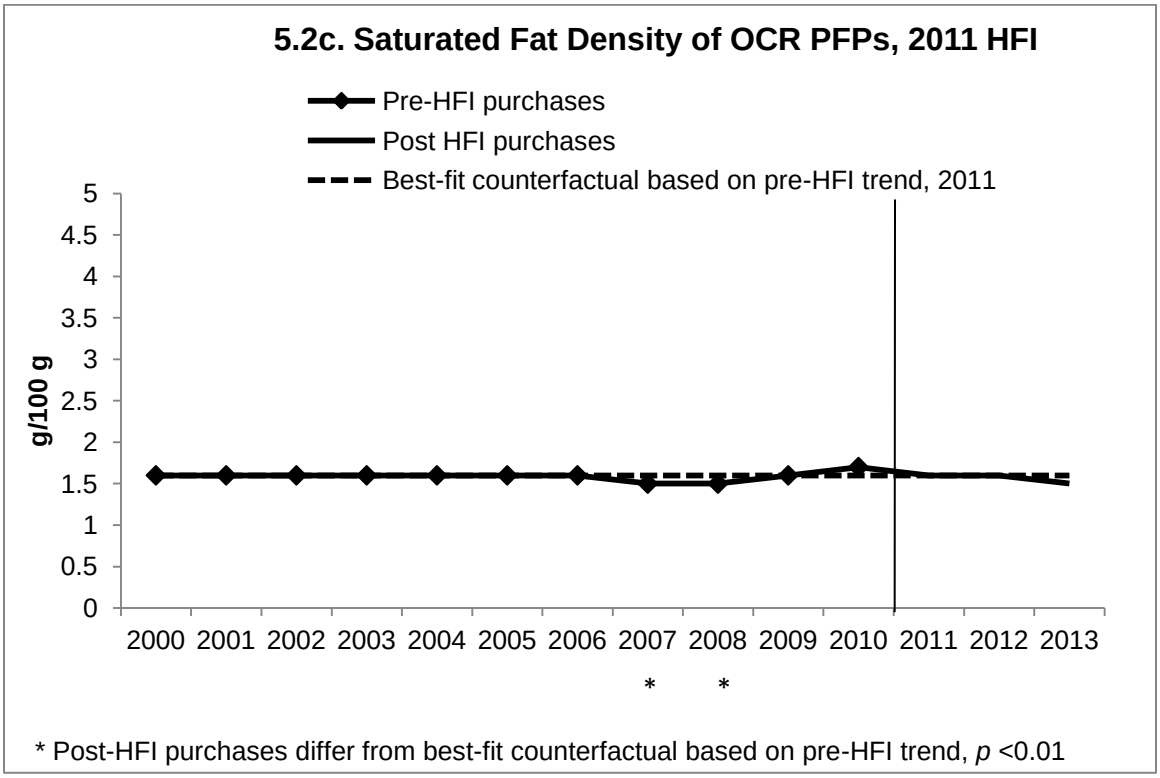

5.1d. Sodium Density of PFPs at Walmart, 2011 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2011
mg/100 g
300
250
200
150
100
50
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01

Figure 5.2 Nutrient densities of PFPs at OCR before and after the 2011 HFI






5.2c. Saturated Fat Density of OCR PFPs, 2011 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2011
g/100 g
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* *
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01

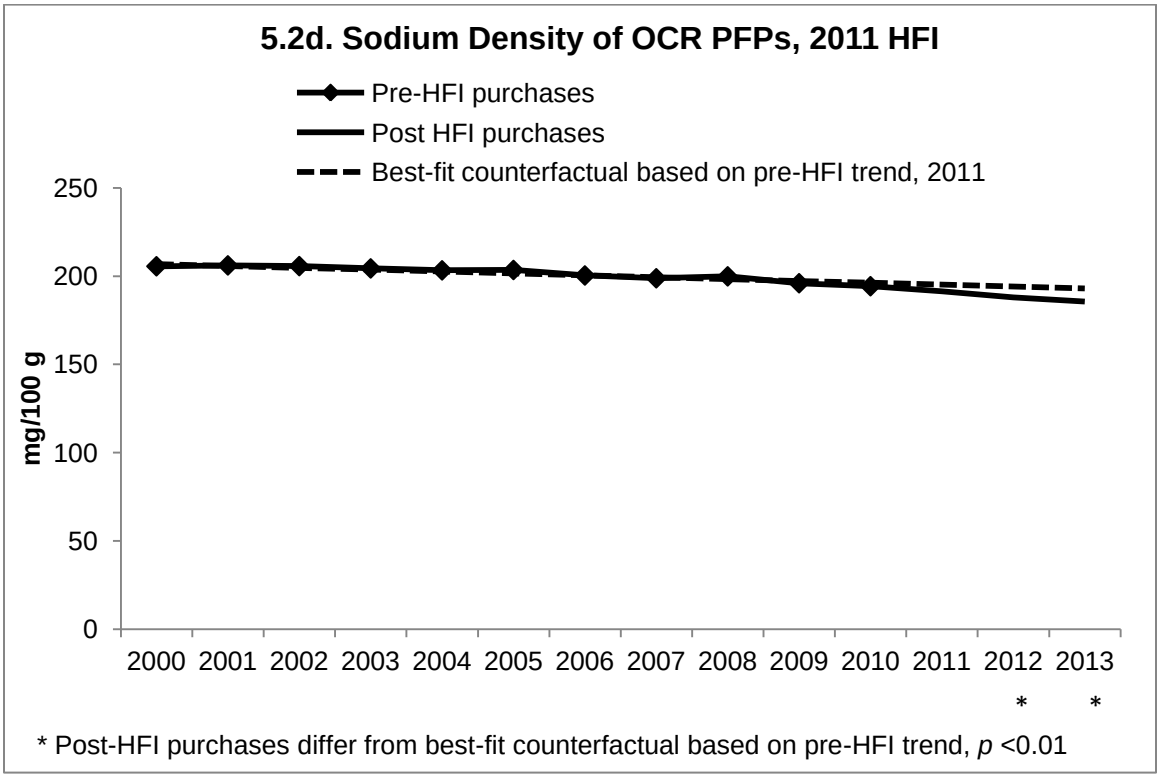
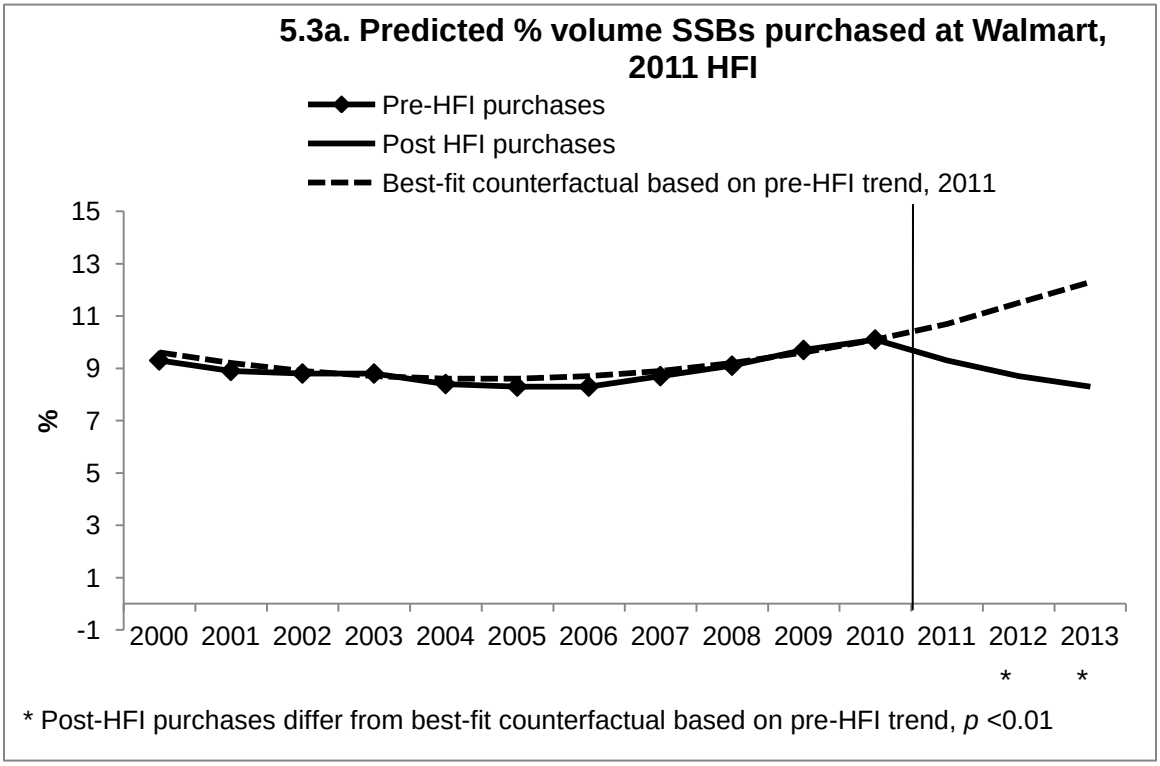
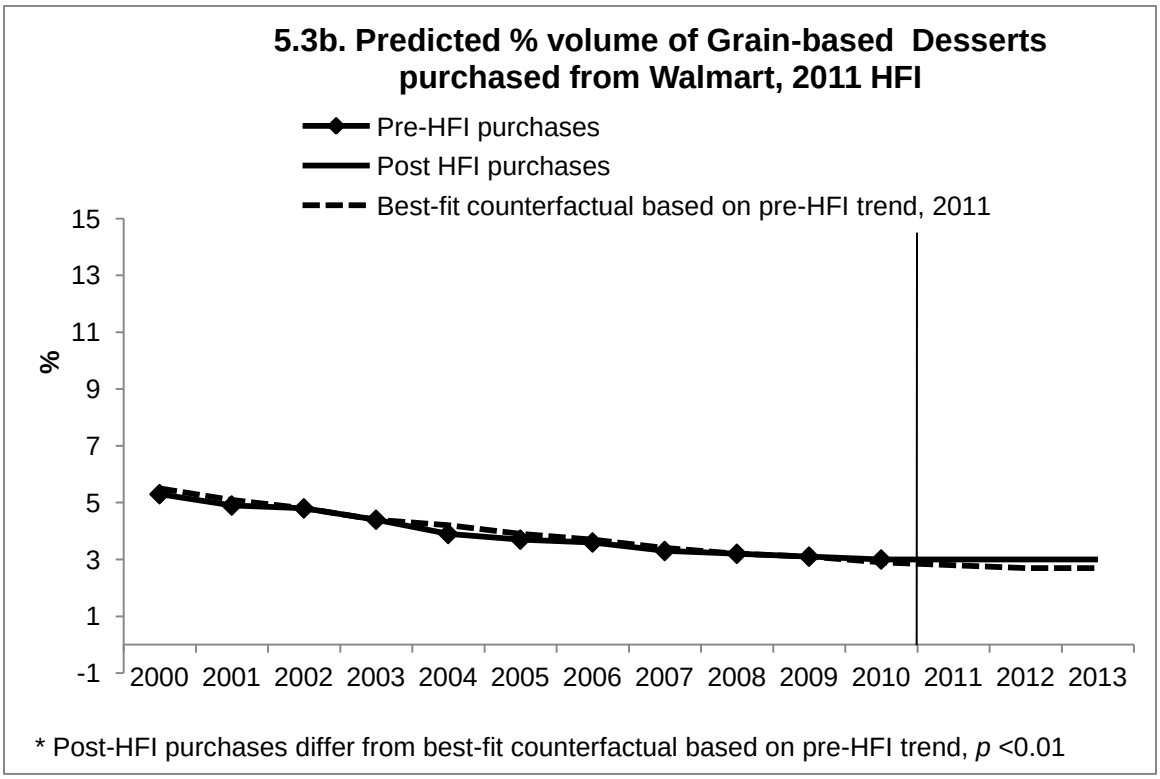
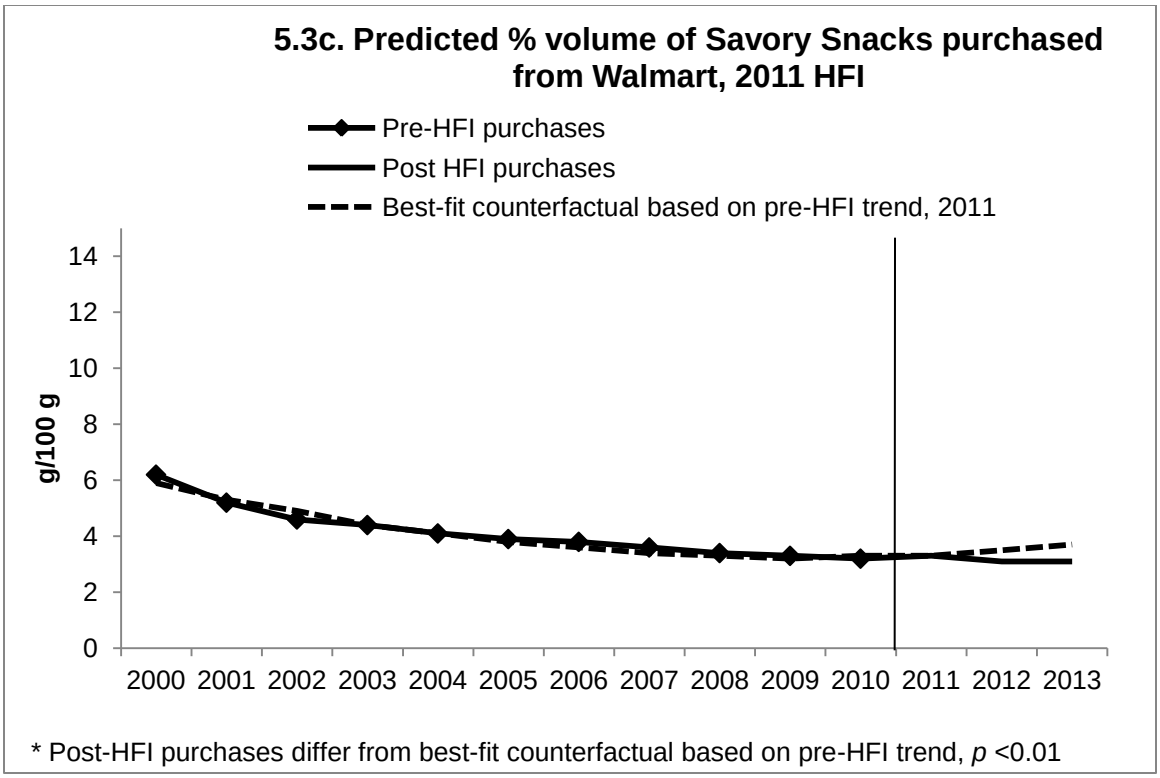
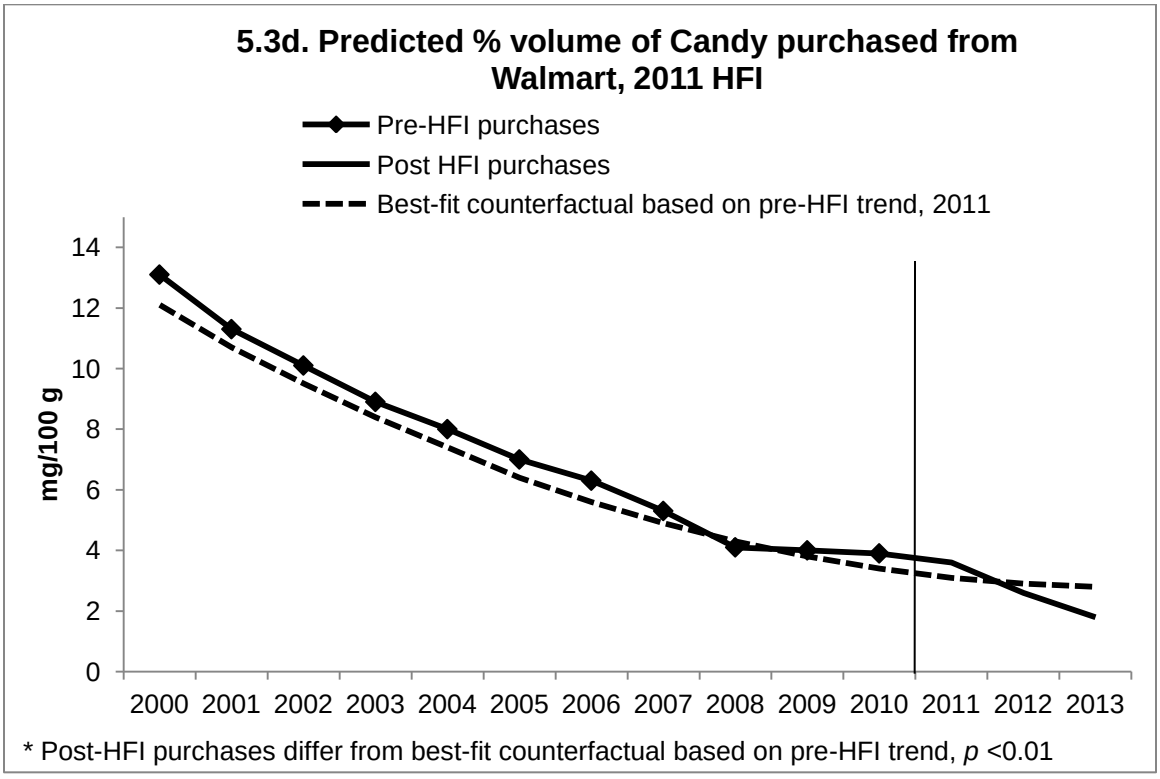

5.2d. Sodium Density of OCR PFPs, 2011 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2011
mg/100 g
250
200
150
100
50
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* *
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01

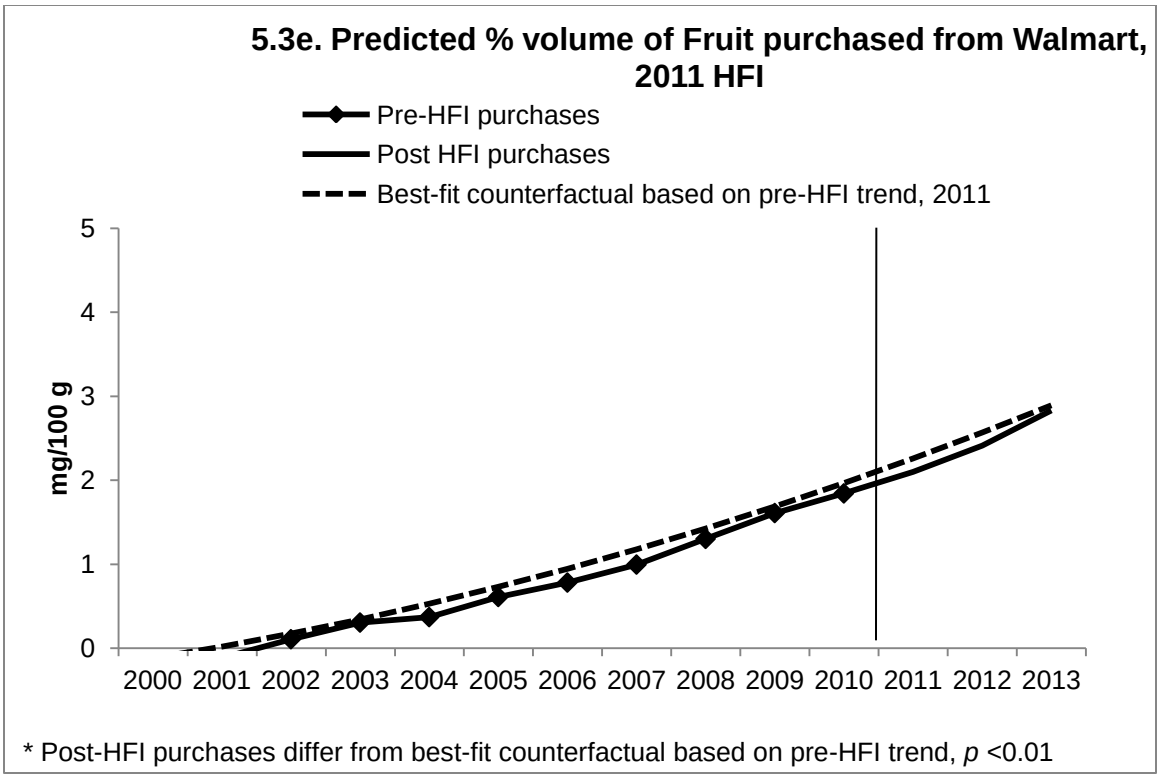
Figure 5.3 Percent volume of key food groups at Walmart before and after the 2011 HFI






5.3c. Predicted % volume of Savory Snacks purchased from Walmart, 2011 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2011
g/100 g
0
2
4
6
8
10
12
14
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01


5.3d. Predicted % volume of Candy purchased from Walmart, 2011 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2011
mg/100 g
0
2
4
6
8
10
12
14
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01


5.3e. Predicted % volume of Fruit purchased from Walmart, 2011 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2011
mg/100 g
0
1
2
3
4
5
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01

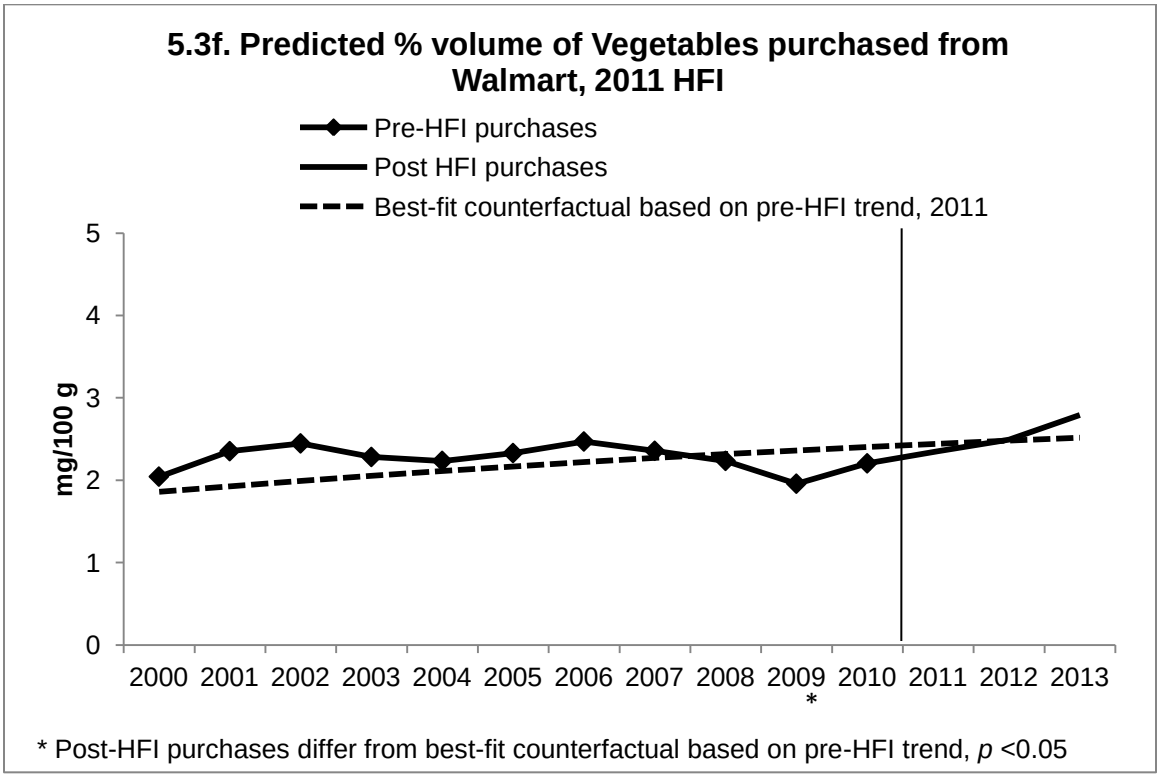
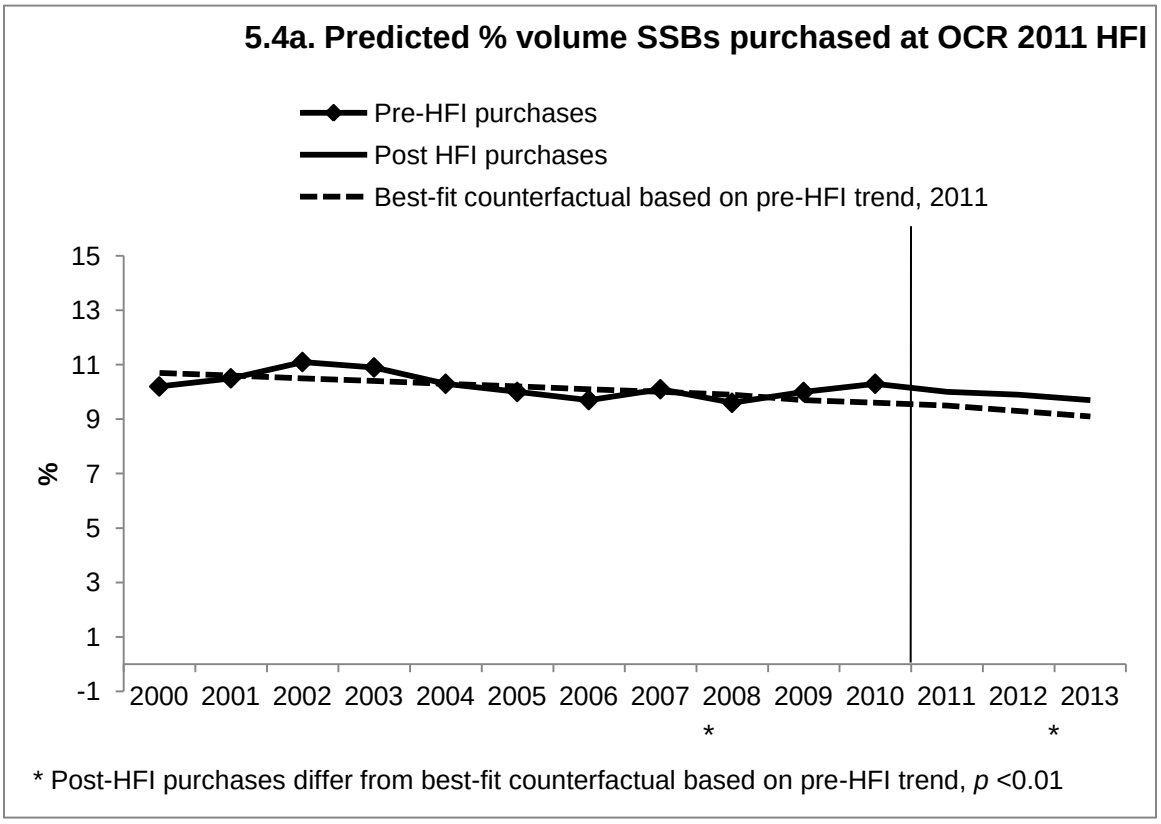
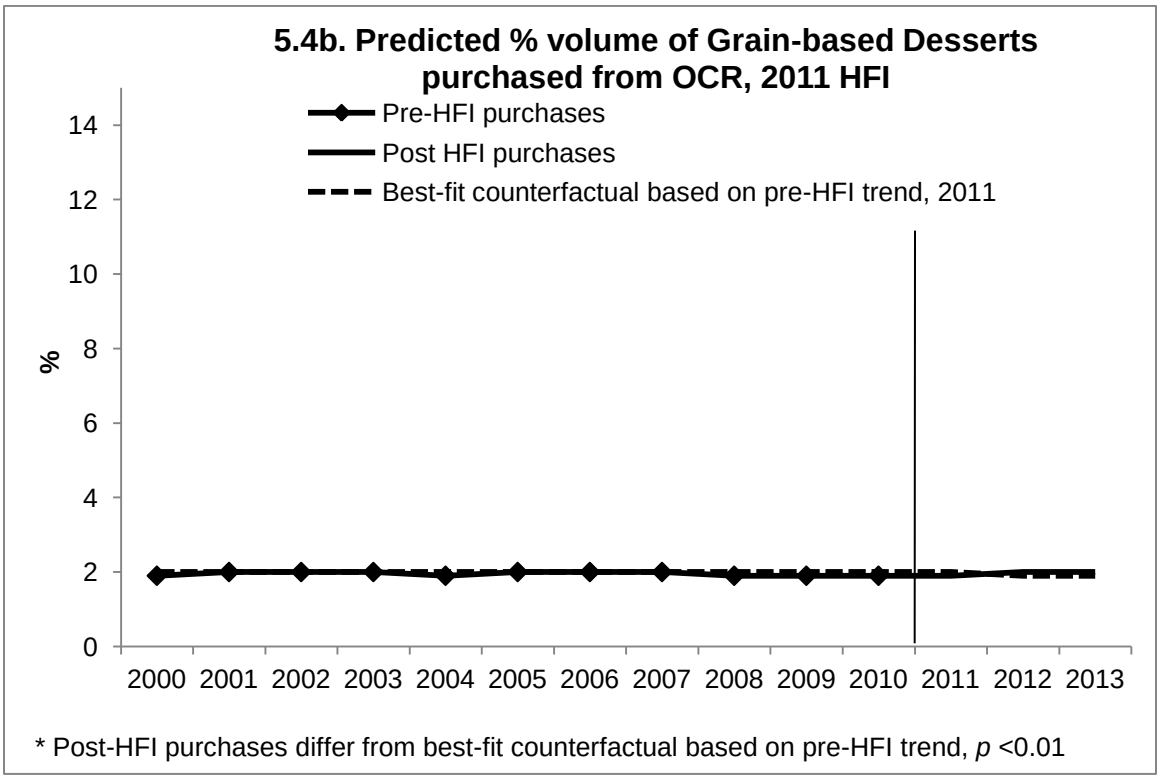
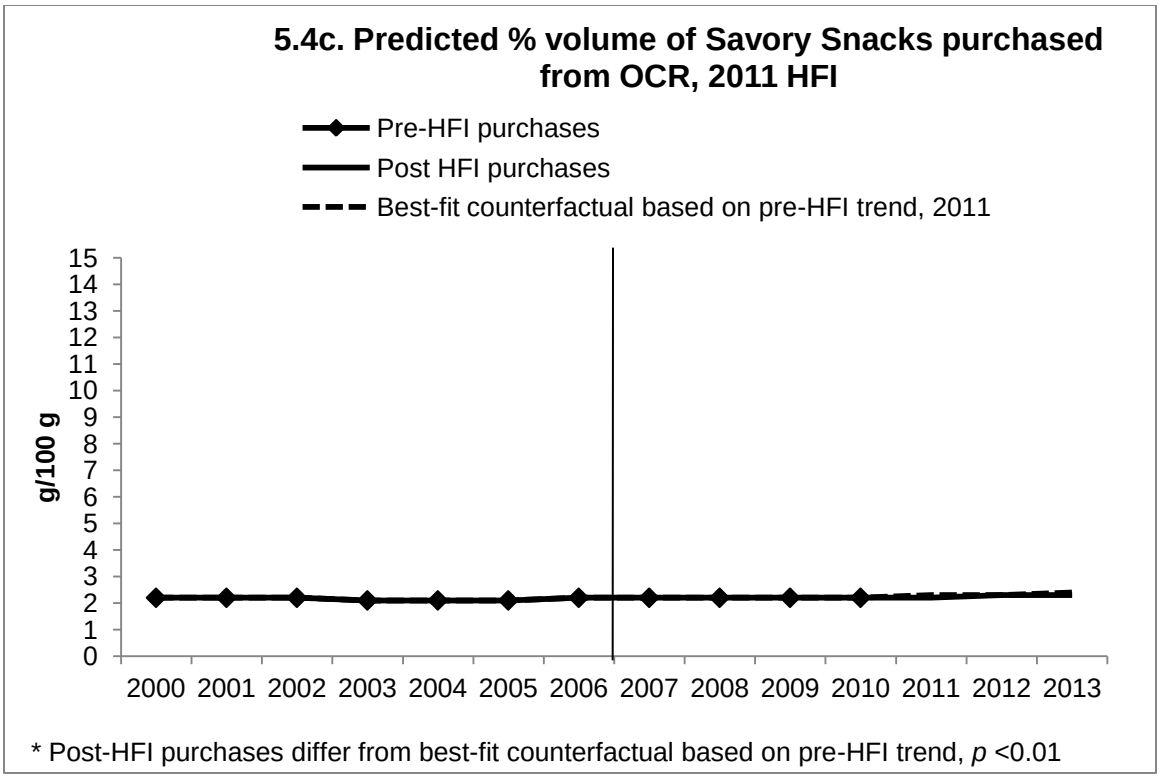
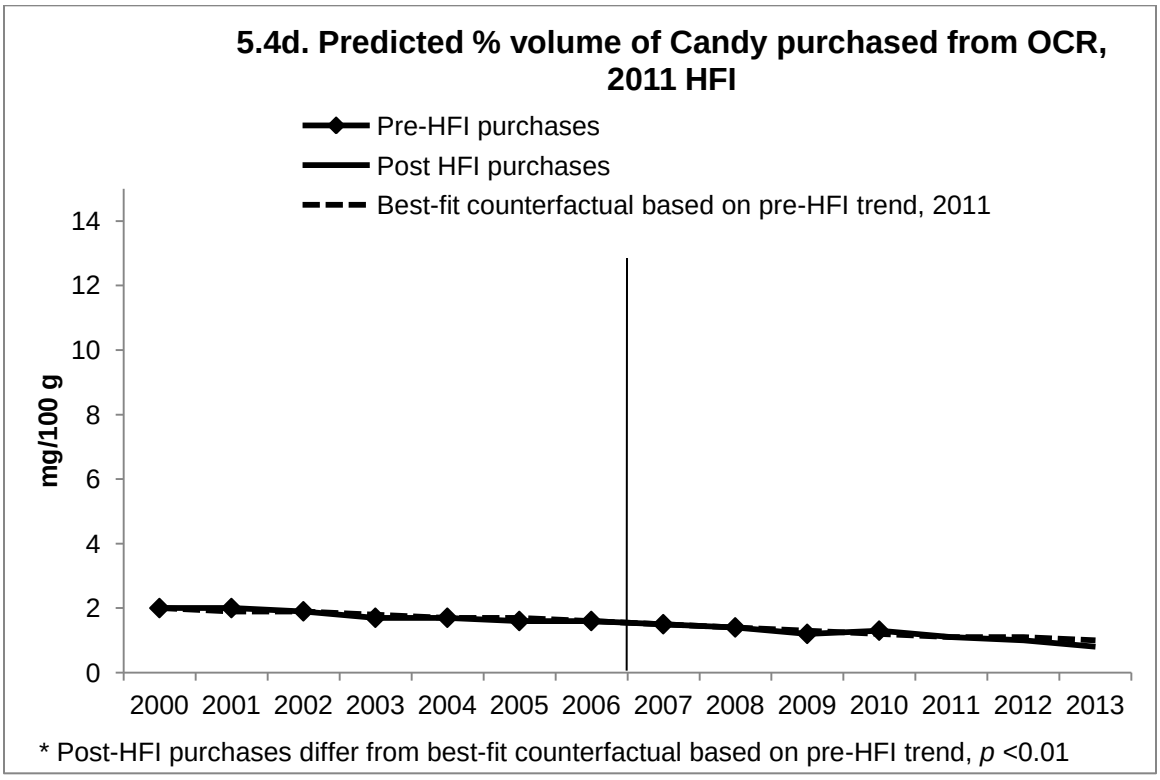

5.3f. Predicted % volume of Vegetables purchased from Walmart, 2011 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2011
mg/100 g
0
1
2
3
4
5
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
*
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.05

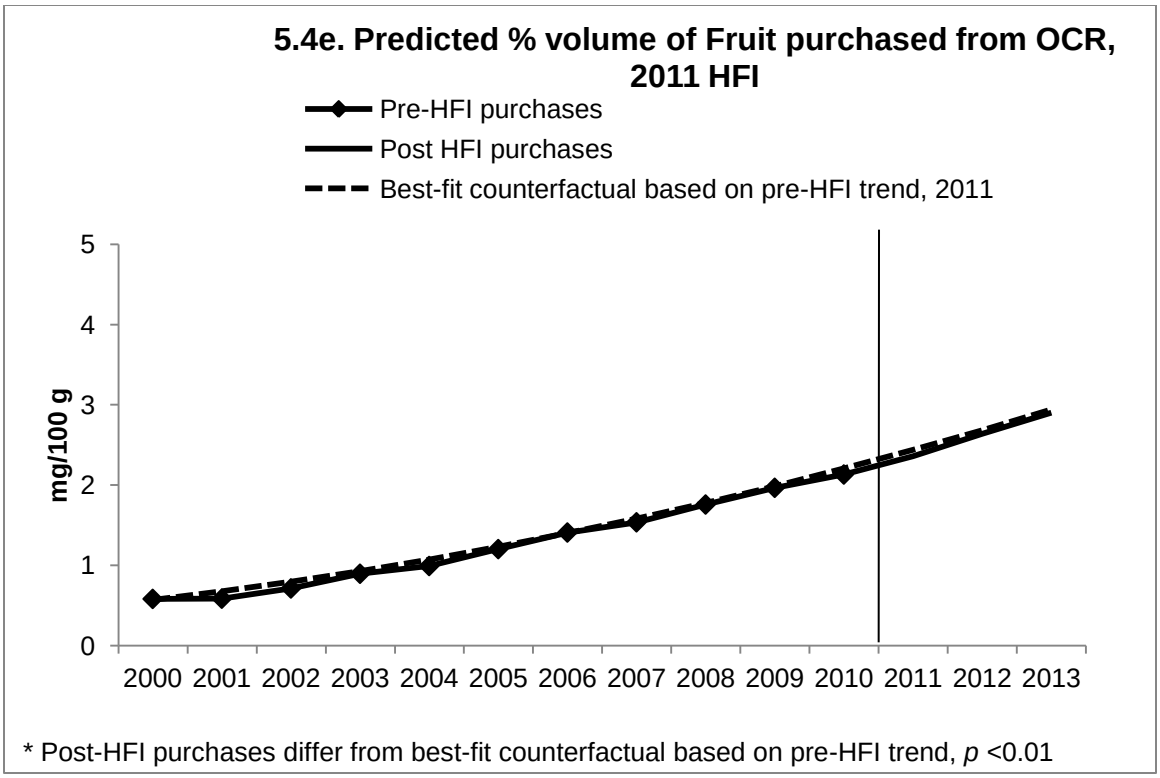
Figure 5.4 Percent volume of key food groups at OCR before and after the 2011 HFI

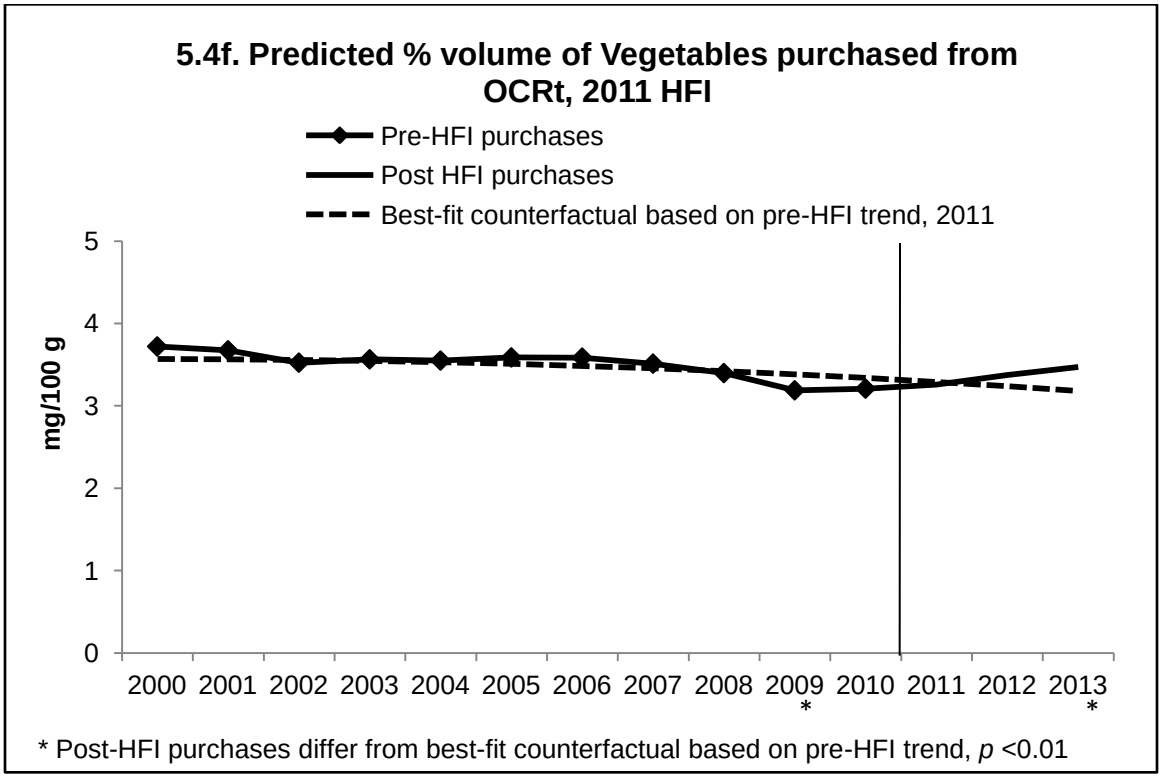





5.4c. Predicted % volume of Savory Snacks purchased from OCR, 2011 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2011
g/100 g
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01


5.4d. Predicted % volume of Candy purchased from OCR, 2011 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2011
mg/100 g
0 2 4 6 8 10 12 14
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01


5.4e. Predicted % volume of Fruit purchased from OCR, 2011 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2011
mg/100 g
0
1
2
3
4
5
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01


5.4f. Predicted % volume of Vegetables purchased from OCRt, 2011 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2011
mg/100 g
0
1
2
3
4
5
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* *
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01

Supplemental Table 5.1 Coefficients for switching regression models of energy density and sodium density of Walmart PFPs, 2000 to 2013

Supplement Table 1. Coefficients for switching regression models of energy density and sodium density of Walmart PFPs, 2000 to 2013

Energy Density[a]	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	β	β	β	β	β	β	β	β	β	β	β	β	β
Year	-7.3	-7.1 ***	-7.2 ***	-7.0 ***	-7.0 ***	-7.1 ***	-6.9 ***	-6.9 ***	-7.1 ***	-6.9 ***	-7.1 ***	-6.9 ***	-7.5 ***
Year squared	0.4 ***	0.3 ***	0.4 ***	0.3 ***	0.3 ***	0.3 ***	0.3 ***	0.3 ***	0.3 ***	0.3 ***	0.3 ***	0.3 ***	0.4 ***
Year*Switch year	-3.0 **	0.1	0.2	0.3	0.0	0.2 **	**-0.2 ** **	-.1 **	0.0	-0.2 ***	**0.2 *** **	0.2 ***	**-0.4 *** **
Adjusted R-squared	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
MSE	93.14	93.13	93.13	93.13	93.13	93.13	93.13	93.12	93.13	93.13	93.13	93.13	93.13

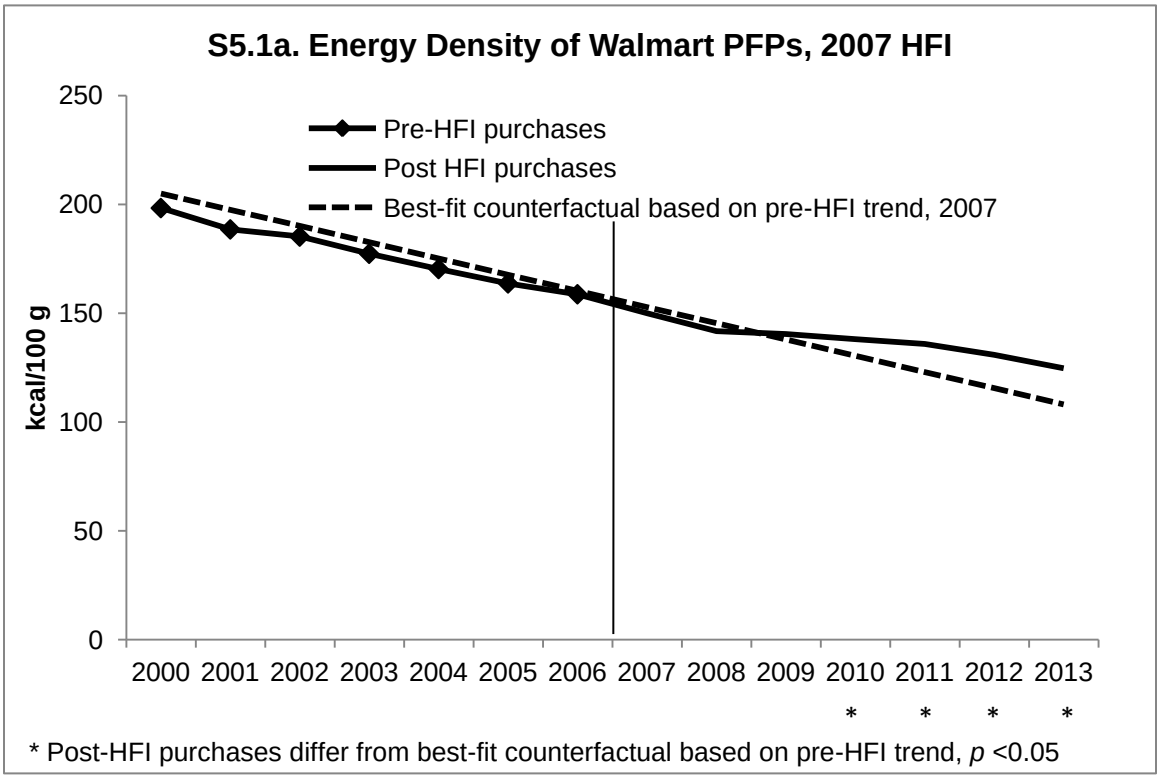
Sodium Density	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	β	β	β	β	β	β	β	β	β	β	β	β	β
Year	-1.1	-1.1 ***	-1.0 ***	-1.1 ***	-1.1 ***	-1.2 ***	-1.2 ***	-1.1 ***	-1.1 ***	-1.1 ***	-1.1 ***	-1.0 ***	-1.1 ***
Year*Switch year	-1.1	**1.4 ***	2.1 ***	0.4	-0.2	**-0.3 ***	-0.8 ***	**0.3 *** ***	0.7 ***	**-0.2 *** ***	0.0	**-0.1 ***	0.0
Adjusted R-squared	0.19	0.19	0.19	0.27	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
MSE	152.82	152.82	152.82	152.82	152.82	152.82	152.82	152.82	152.82	152.82	152.82	152.82	152.82

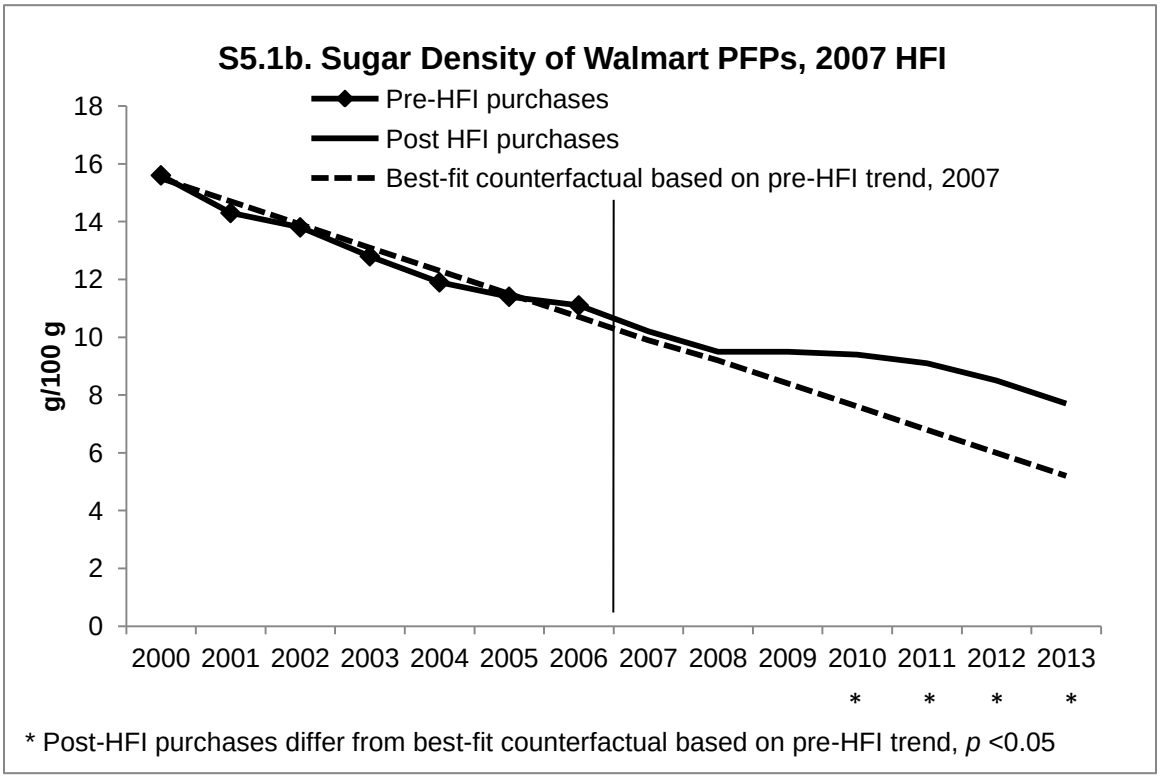
*** $p<0.001$, ** $p<0.01$, * $p<0.05$

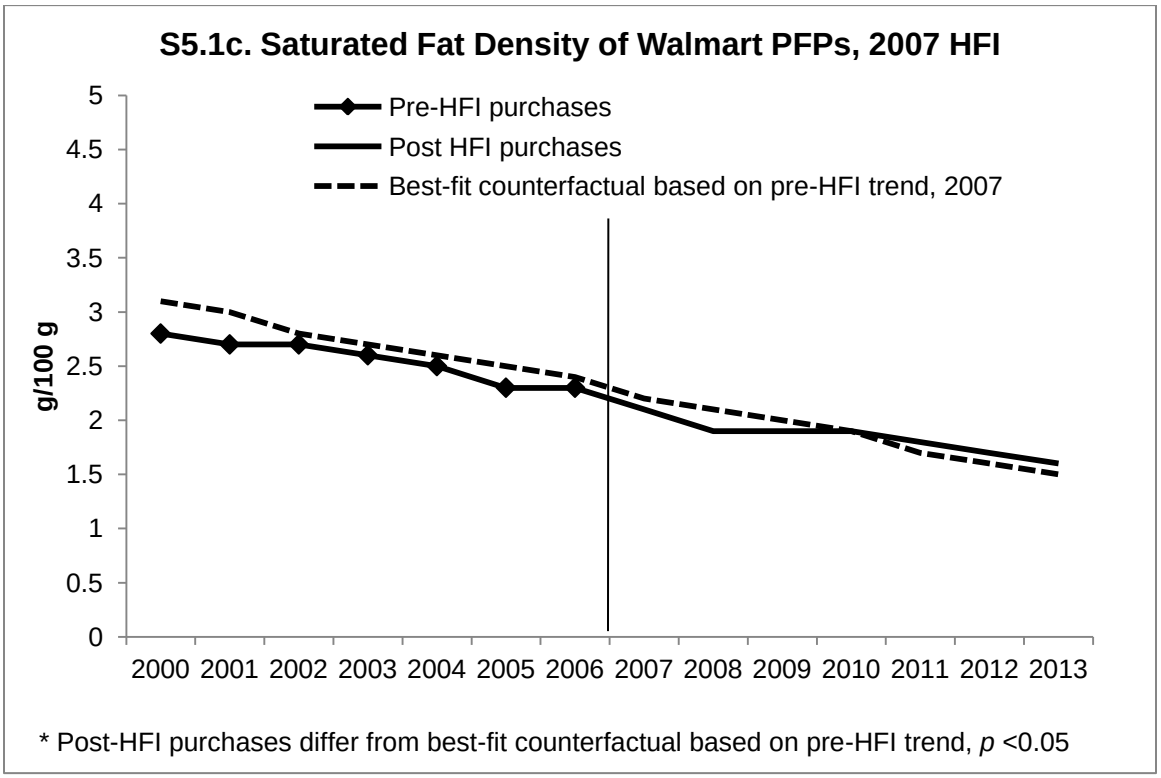
BOLD represents a switching point as indicated by a change in both sign of coefficient and statistical significance in the coefficient for year trend*HFI year

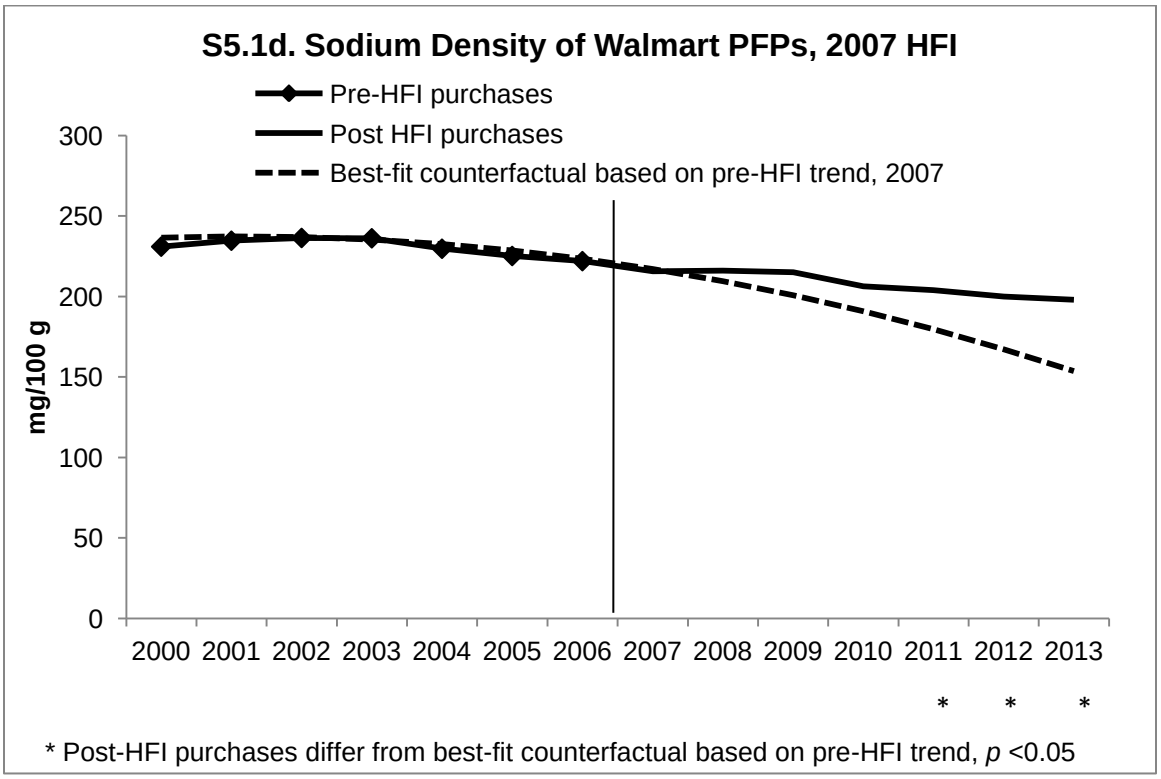
[a]Model for energy density contains a quadratic time term for best fitting model. The interaction between the time trend squared and HFI year drops out of the model due to collinearity. The model for sodium density contains only a linear term for best fit.

Supplemental Figure 5.1 Nutrient densities of Walmart PFPs, using a 2007 initiation date

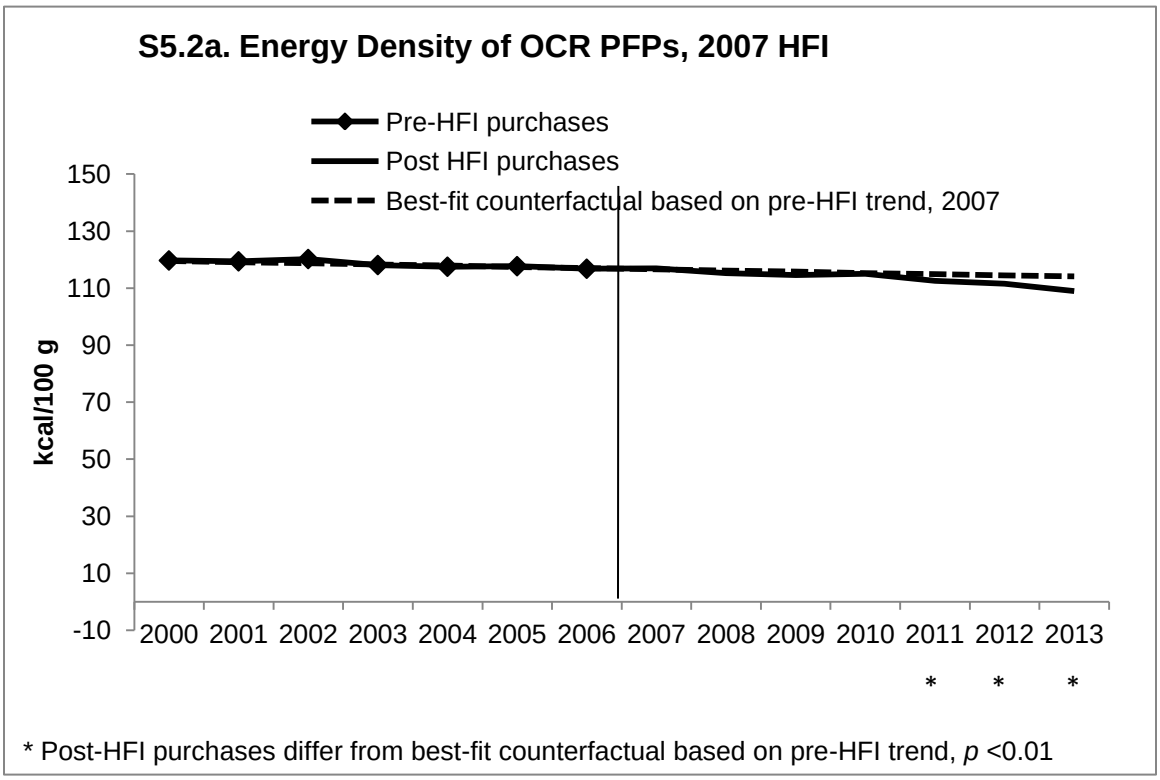


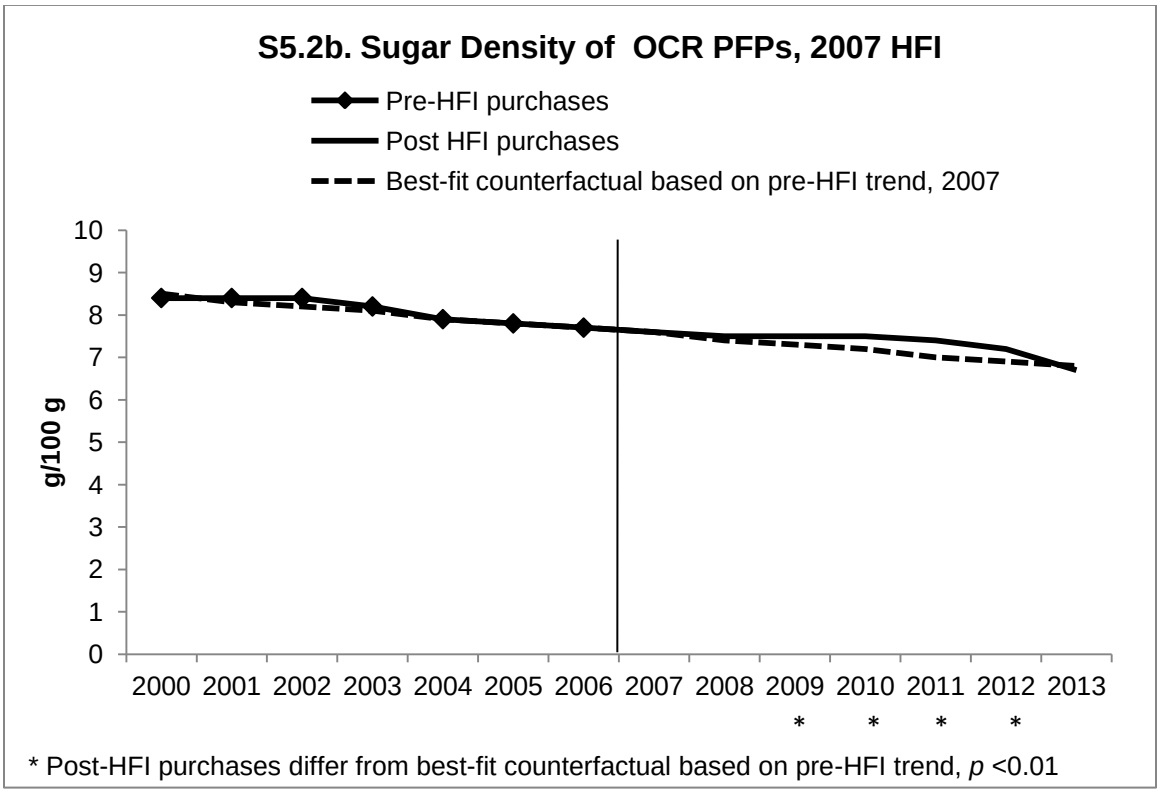



S5.1c. Saturated Fat Density of Walmart PFPs, 2007 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2007
g/100 g
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.05

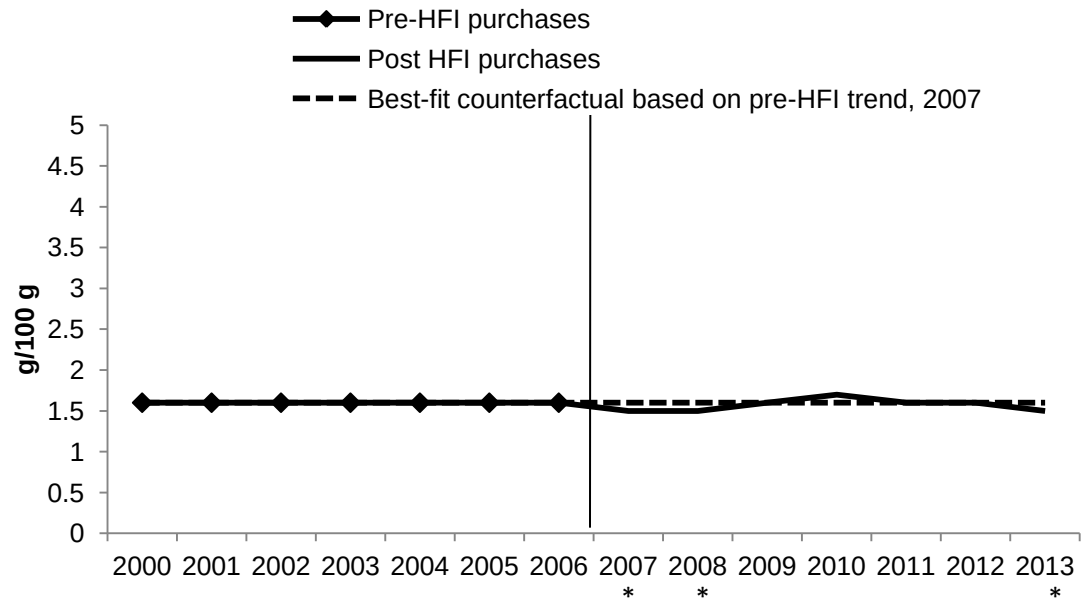

S5.1d. Sodium Density of Walmart PFPs, 2007 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2007
mg/100 g
300
250
200
150
100
50
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* * *
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.05

Supplemental Figure 5.2 Nutrient densities of OCR PFPs, using a 2007 initiation date



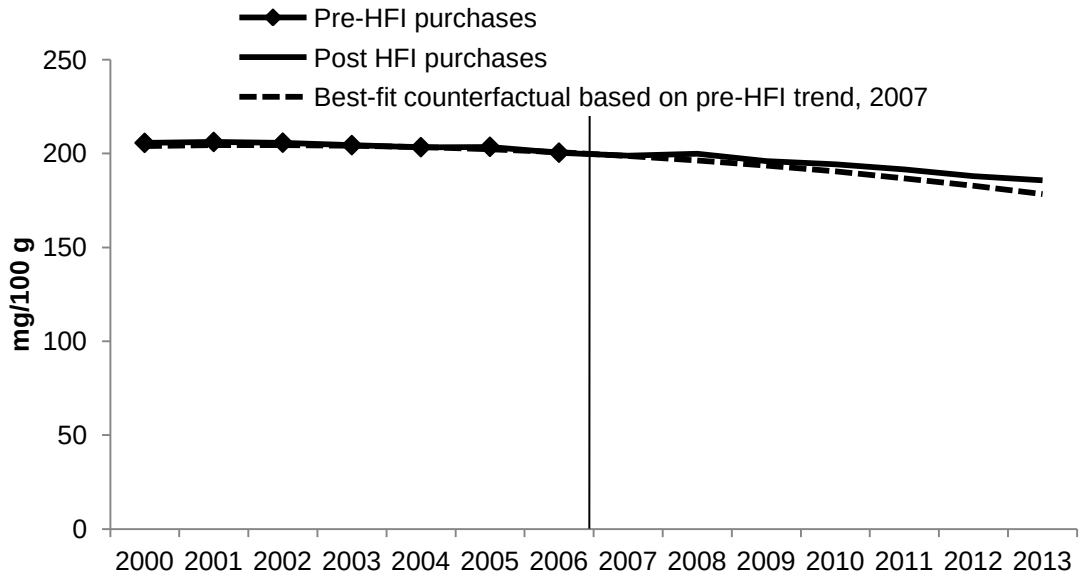


S5.2c. Saturated Fat Density of OCR PFPs, 2007 HFI



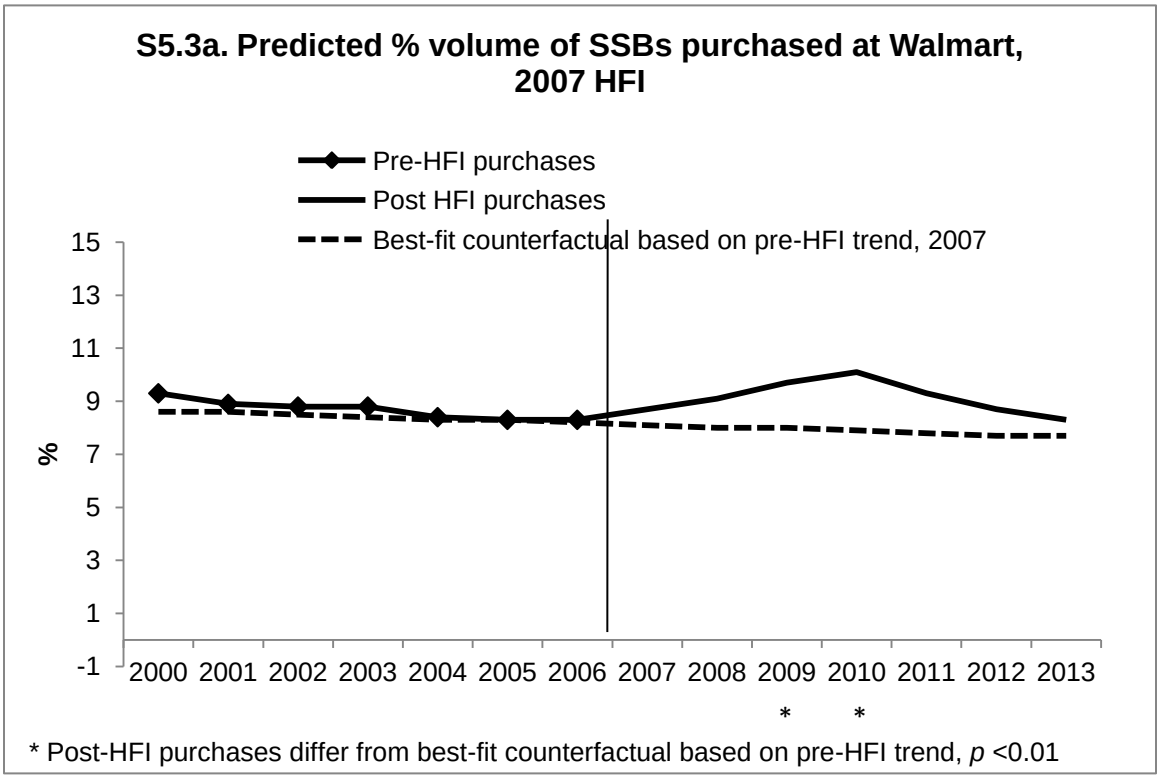
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01

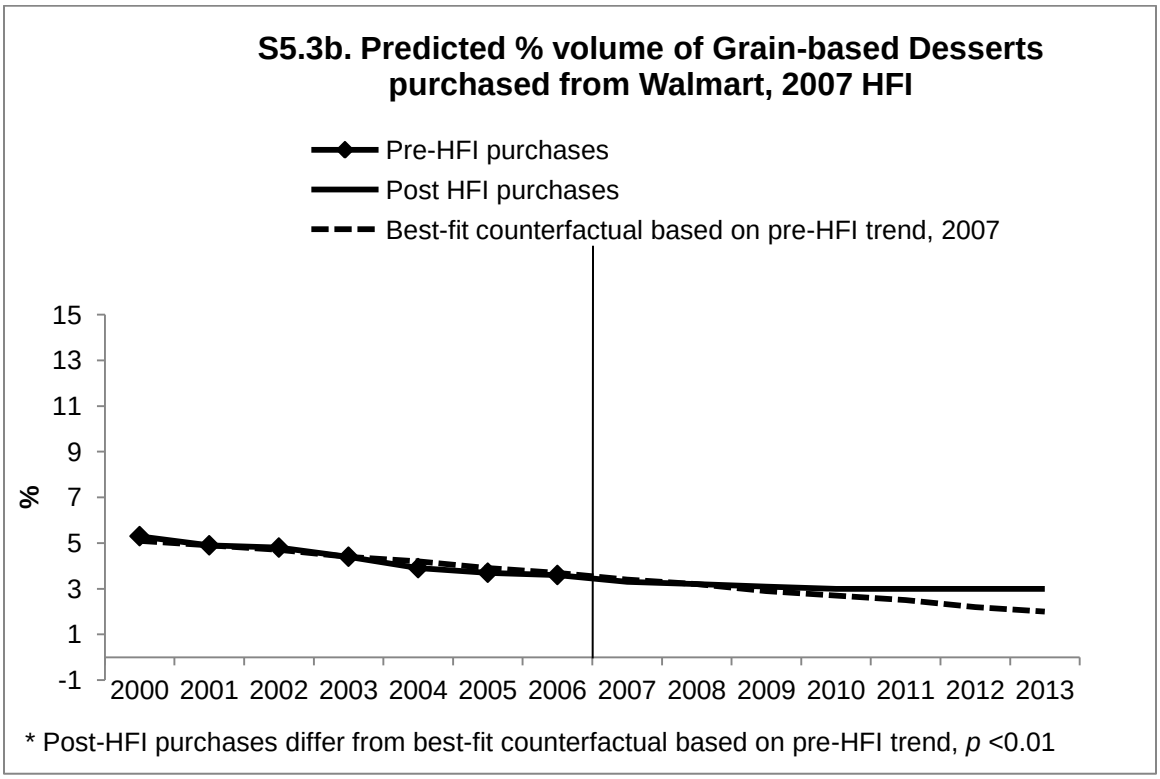
S5.2d. Sodium Density of OCR PFPs, 2007 HFI



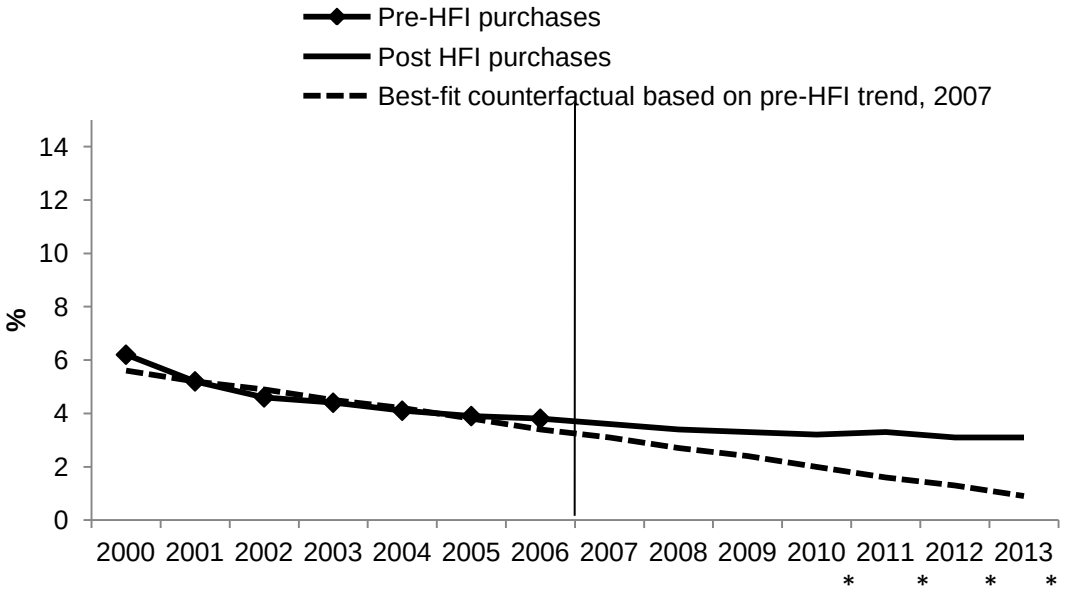
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01

Supplemental Figure 5.3 Percent volume of key food groups at Walmart, using a 2007 HFI initiation date



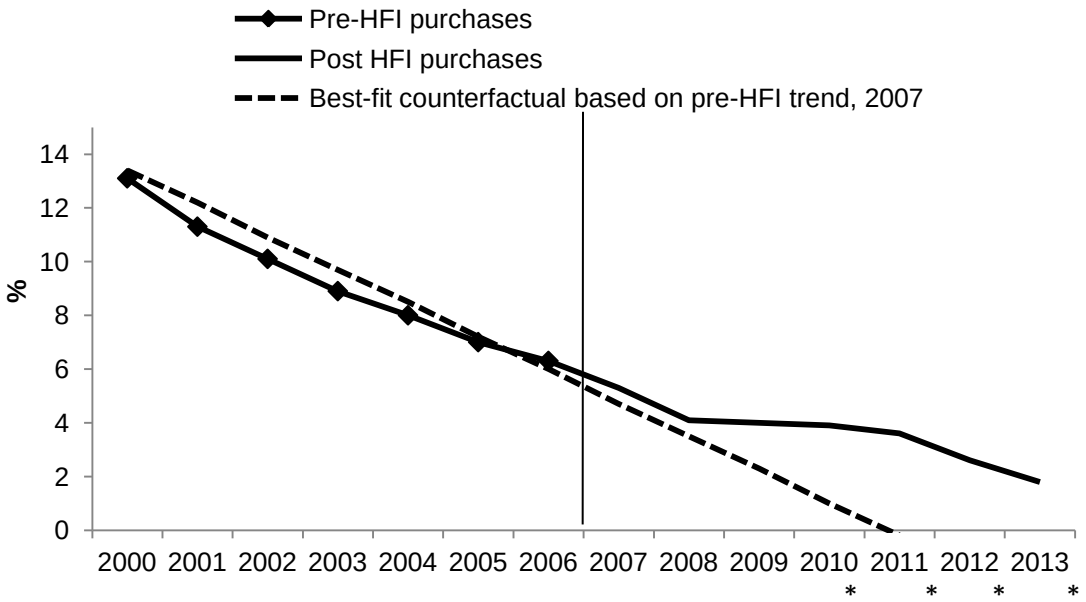


S5.3c. Predicted % volume of Savory Snacks purchased from Walmart, 2007 HFI

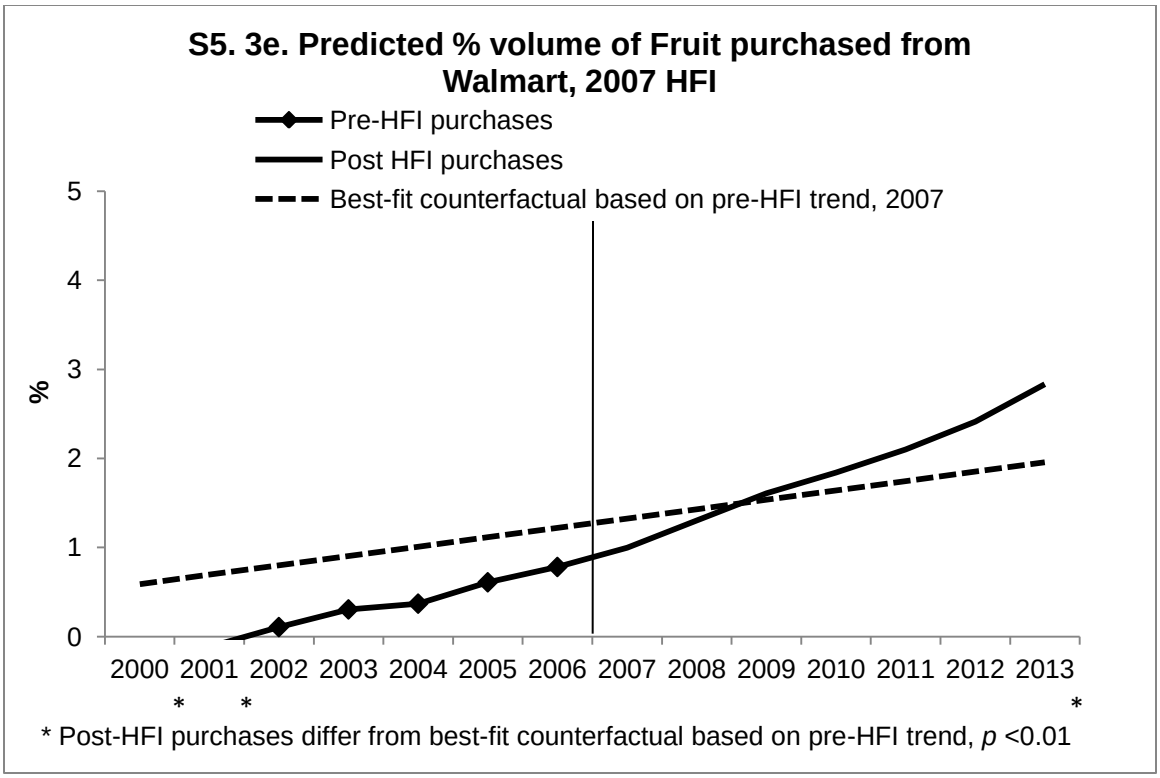


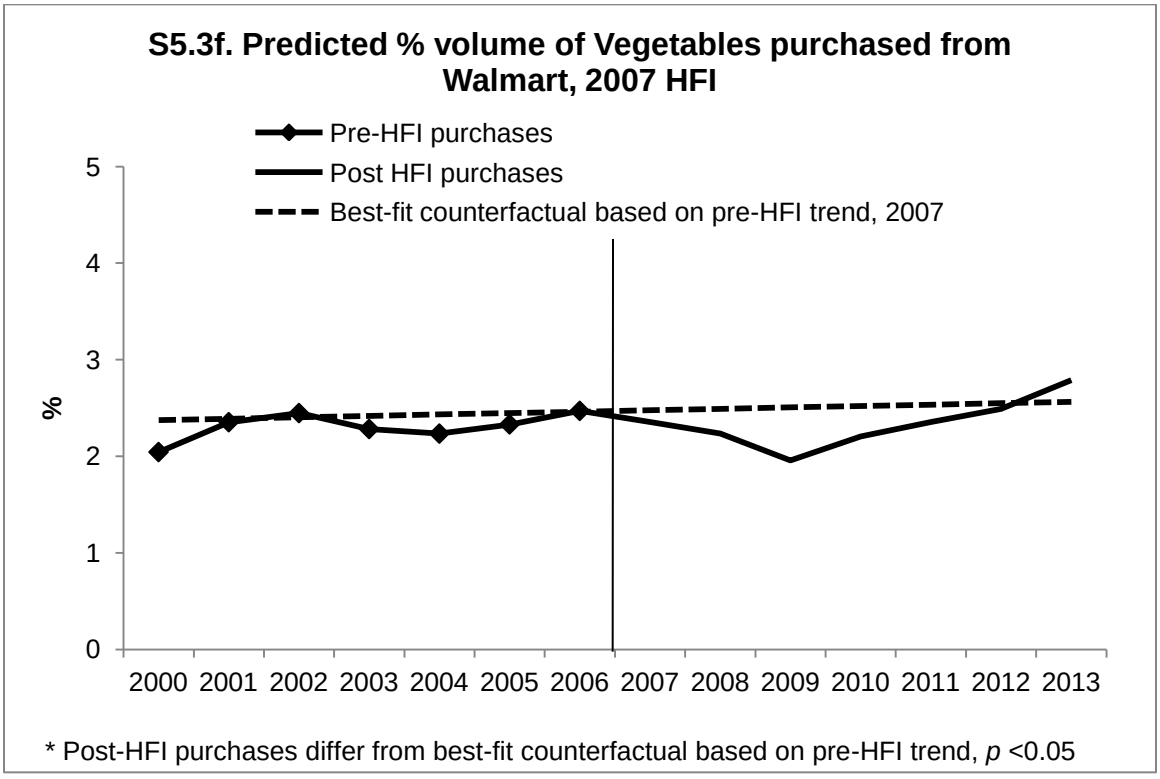
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01

S5. 3d. Predicted % volume of Candy purchased from Walmart, 2007 HFI

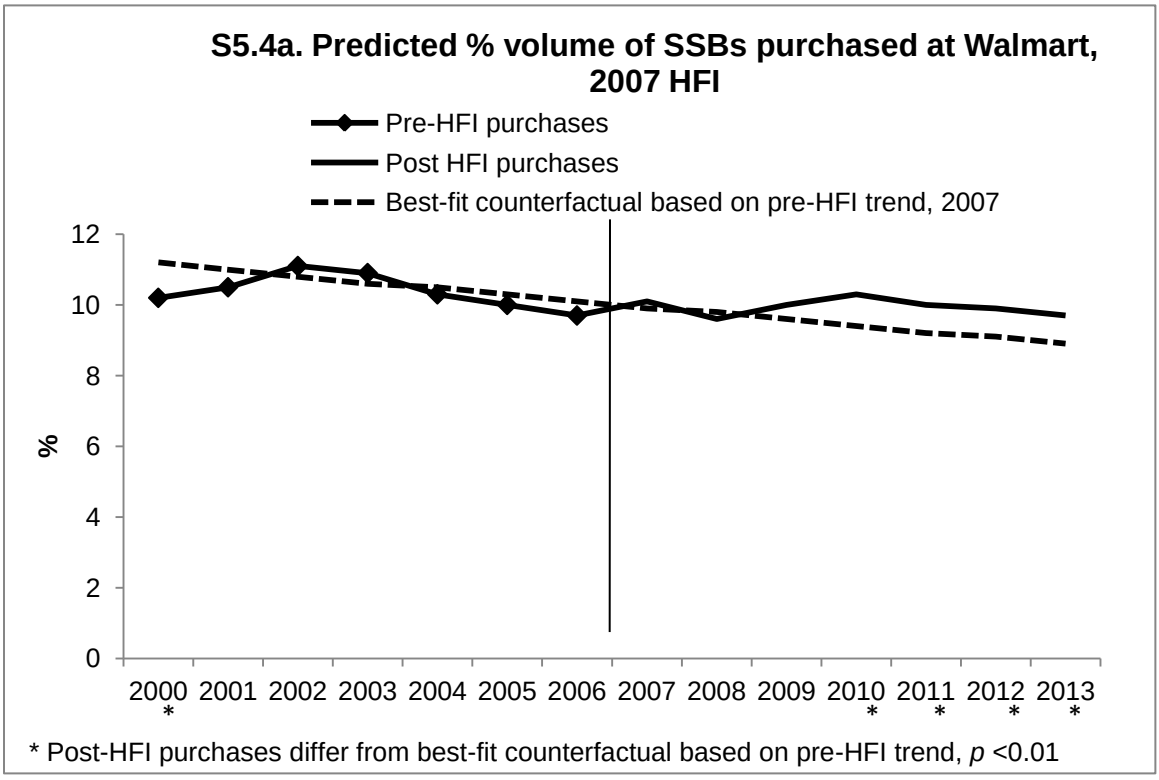


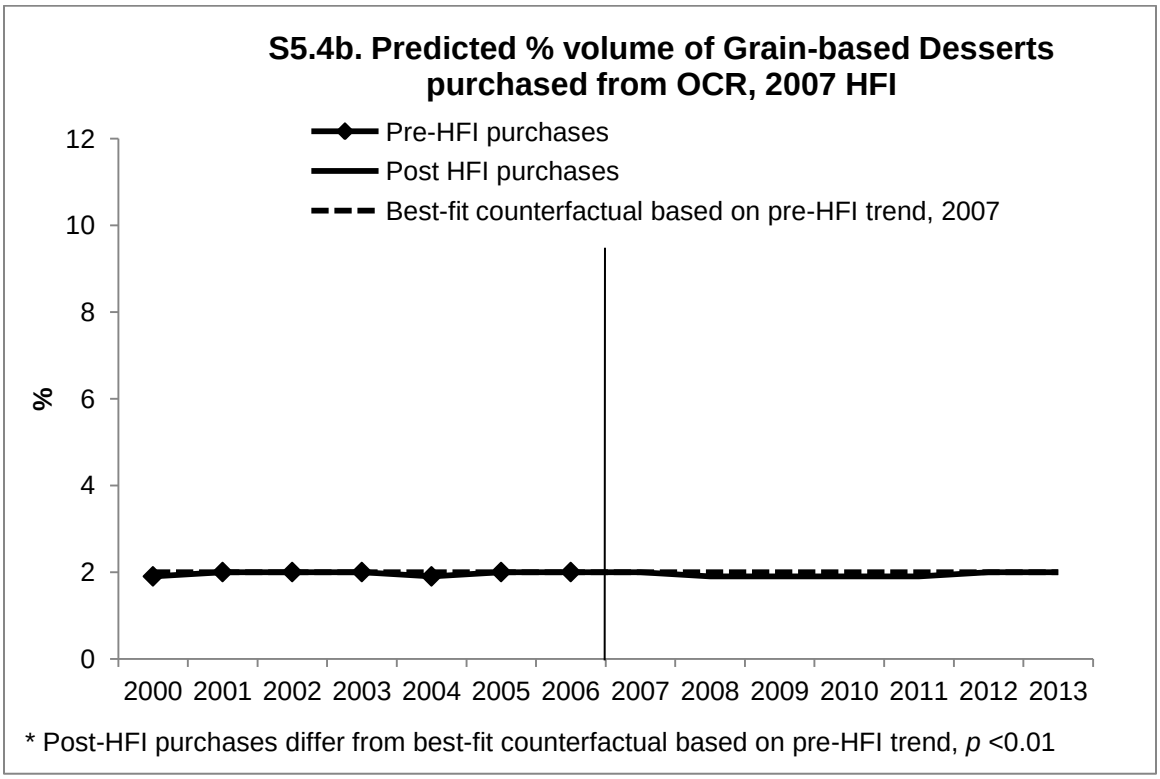
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01


S5. 3e. Predicted % volume of Fruit purchased from Walmart, 2007 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2007
%
0
1
2
3
4
5
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* * *
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01

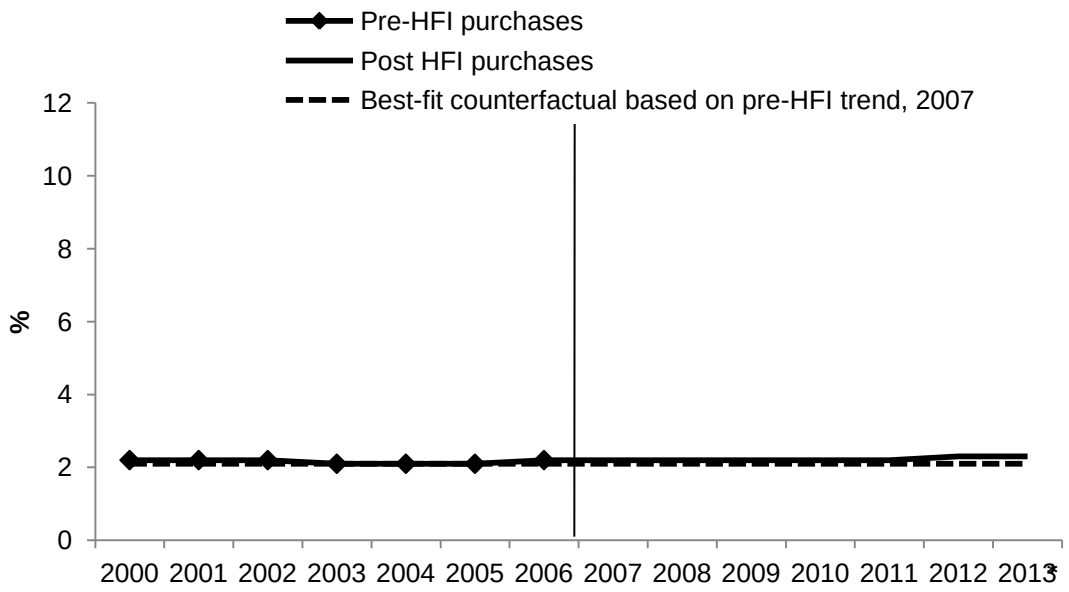

S5.3f. Predicted % volume of Vegetables purchased from Walmart, 2007 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2007
%
0
1
2
3
4
5
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.05

Supplemental Figure 5.4 Percent volume of key food groups at Walmart, using a2007 HFI initiation date



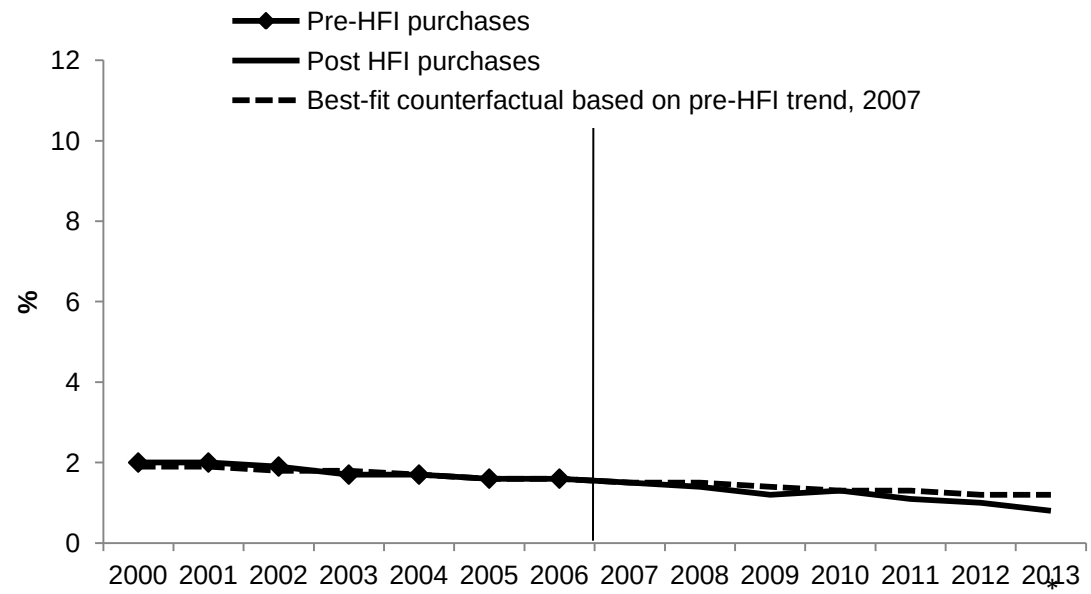


S5.4c. Predicted % volume of Savory Snacks purchased from OCR, 2007 HFI

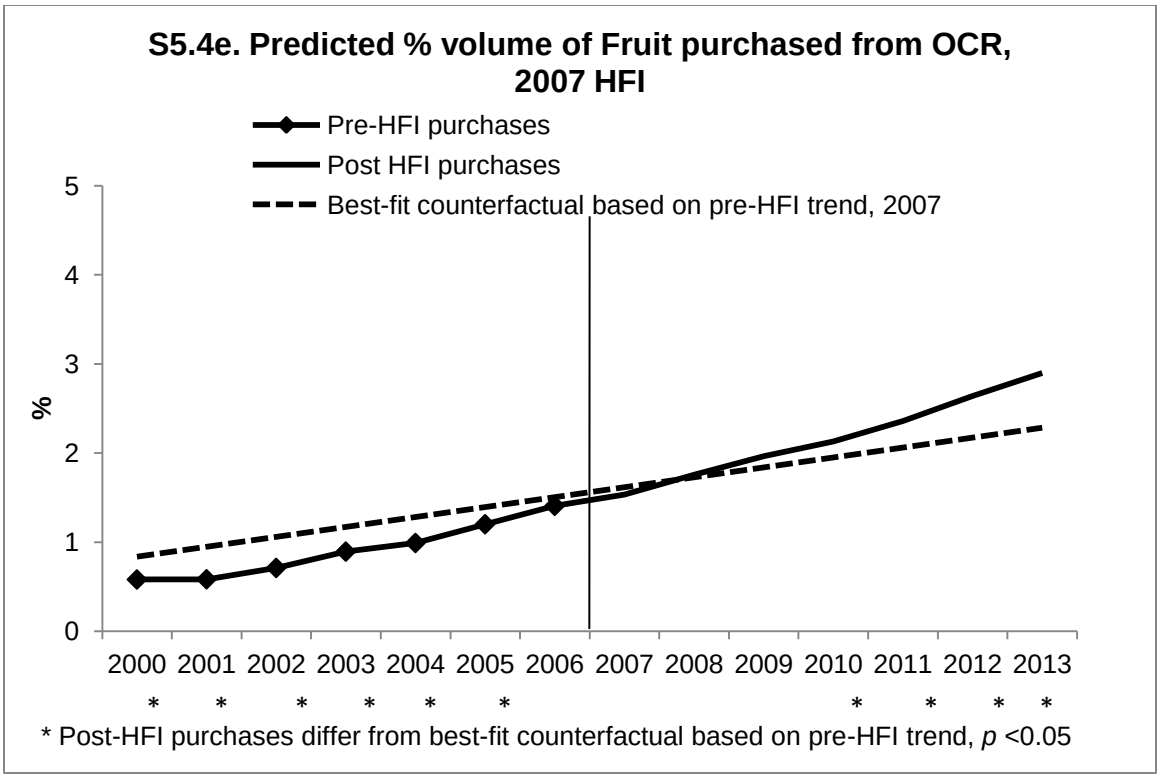


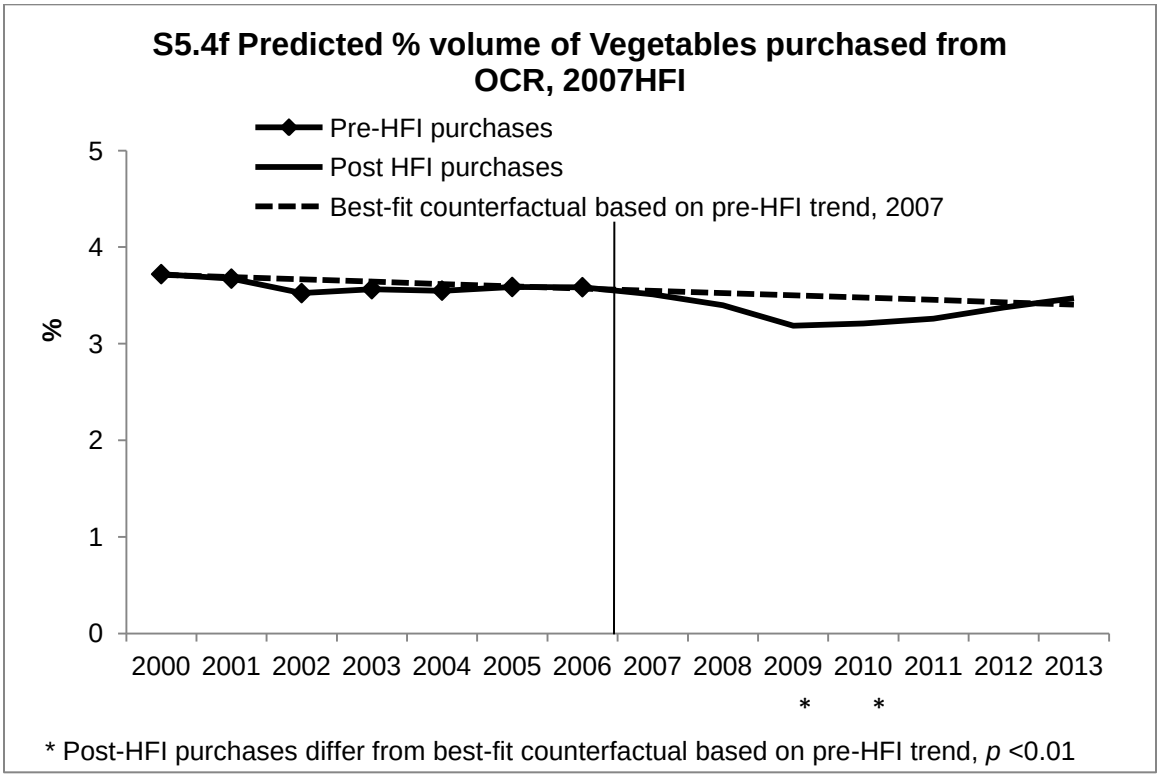
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01

S5.4d. Predicted % volume of Candy purchased from OCR, 2007 HFI

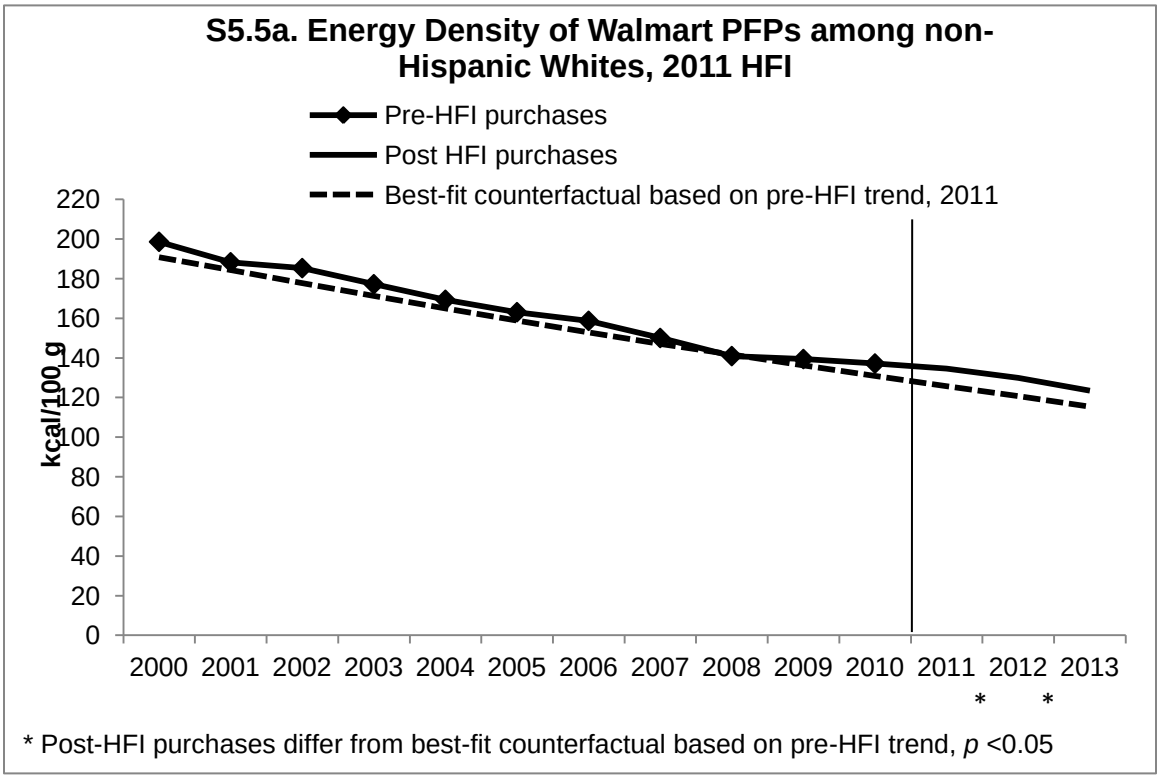


* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01

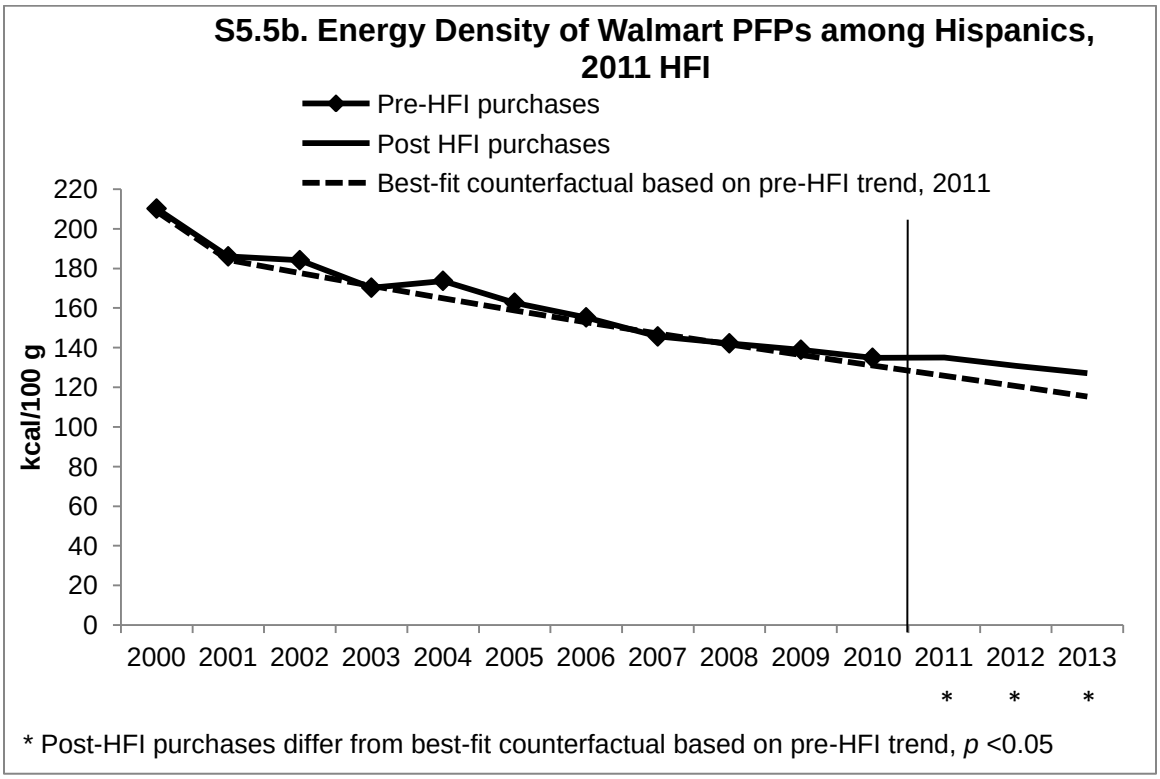

S5.4e. Predicted % volume of Fruit purchased from OCR, 2007 HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2007
%
0
1
2
3
4
5
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* * * * * * * * * *
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.05


S5.4f Predicted % volume of Vegetables purchased from OCR, 2007HFI
Pre-HFI purchases
Post HFI purchases
Best-fit counterfactual based on pre-HFI trend, 2007
%
0
1
2
3
4
5
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
* *
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.01

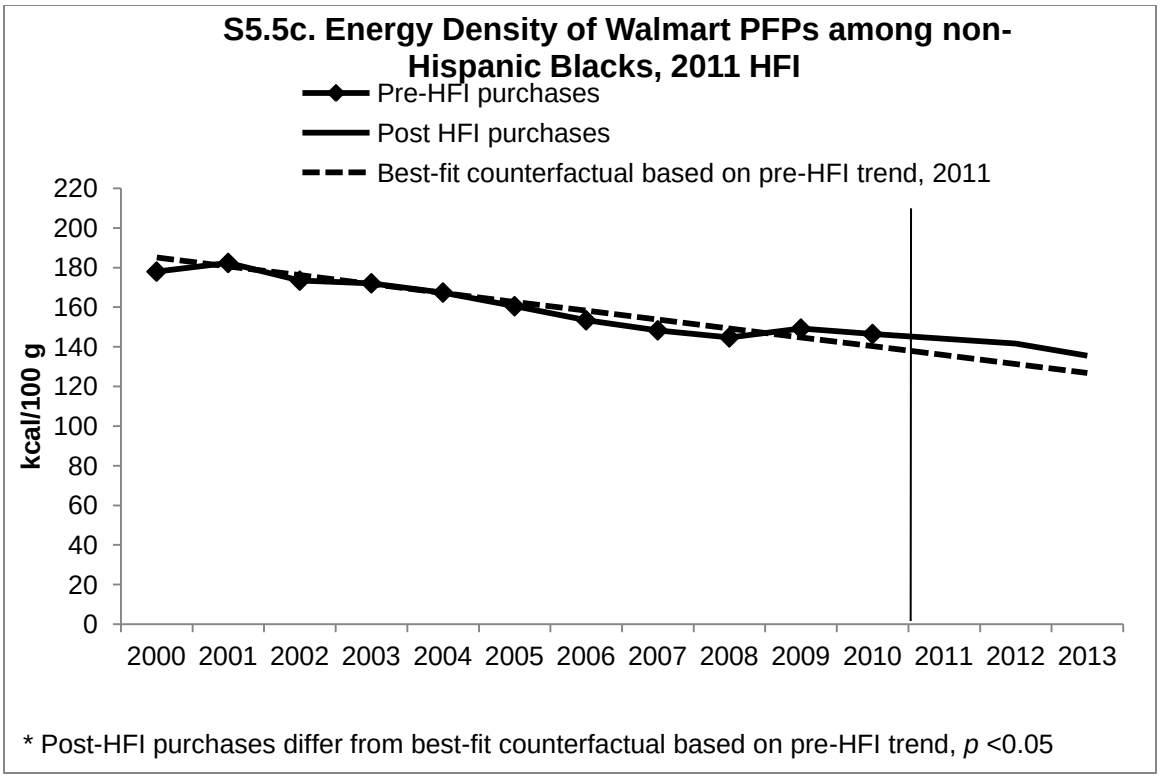
Supplemental Figure 5.5 Energy density of PFPs at Walmart, before and after the 2011 HFI, by race/ethnicity



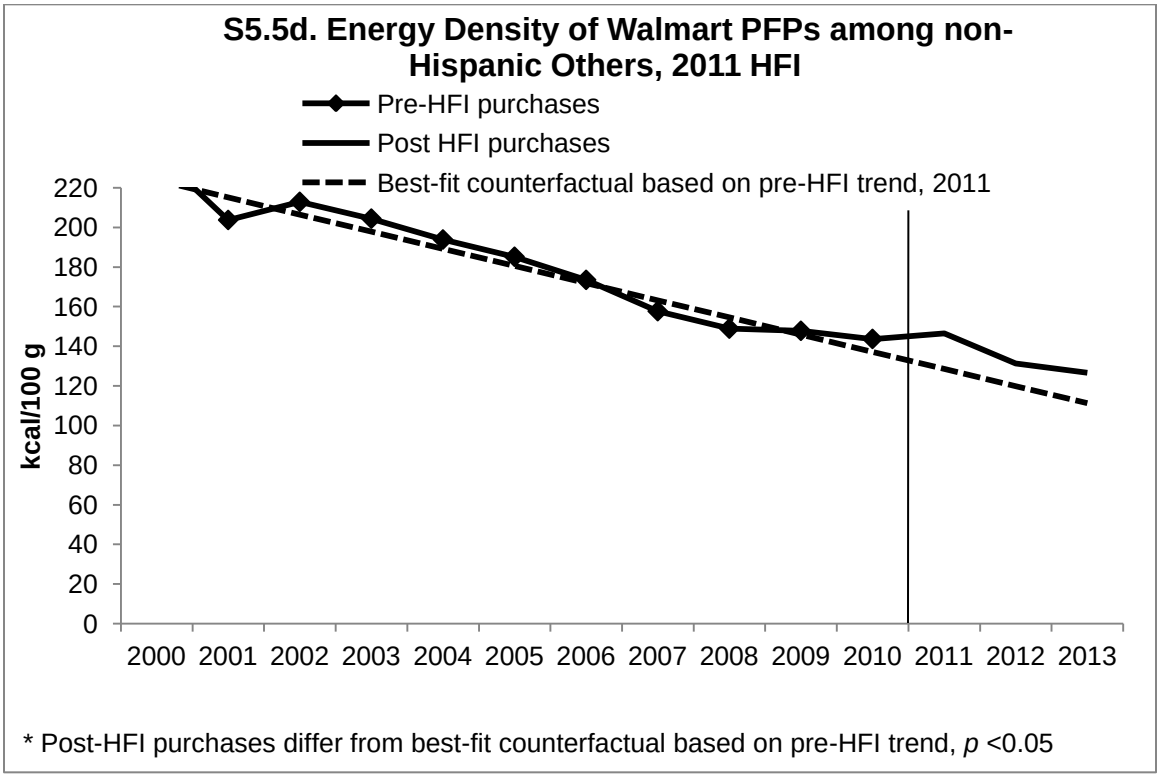
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.05



* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.05

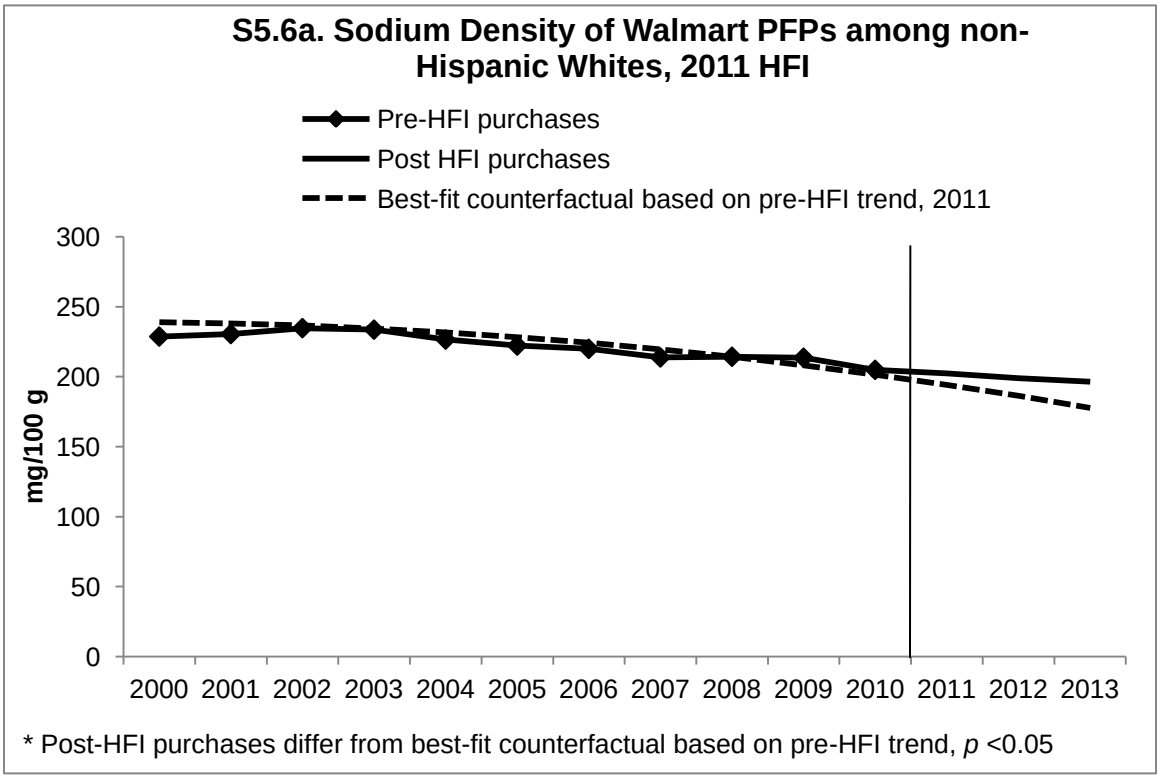


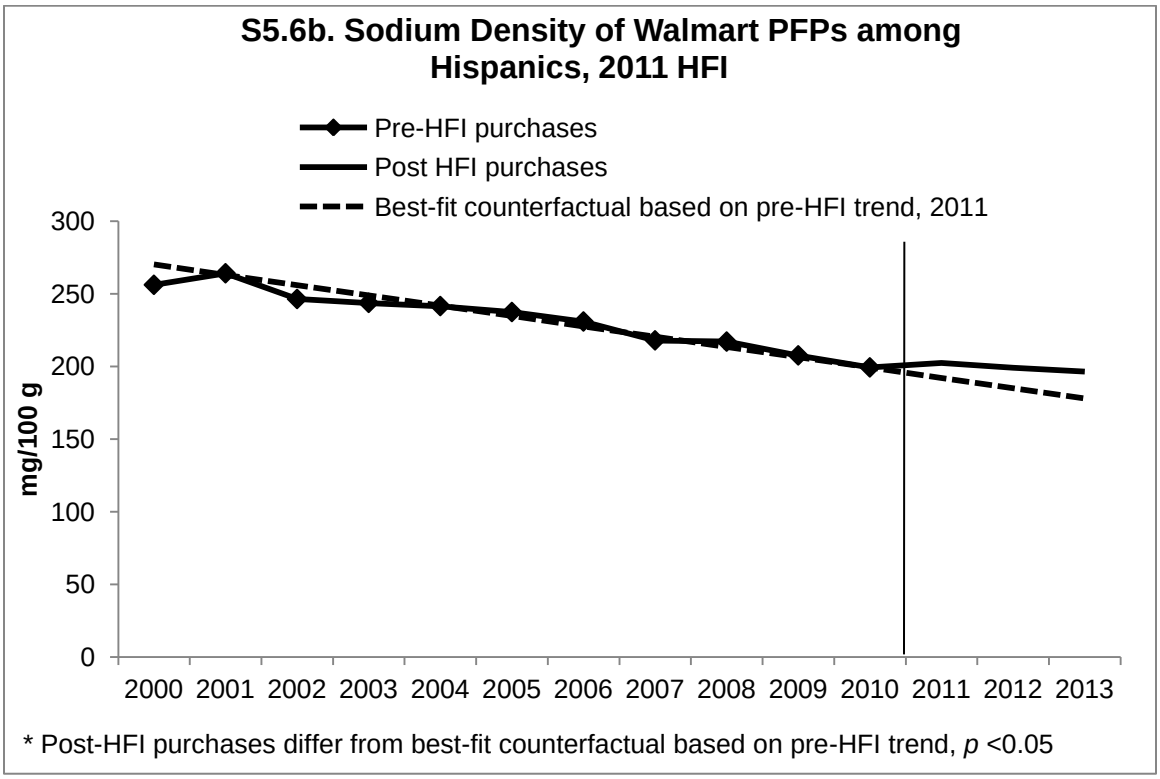
* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.05

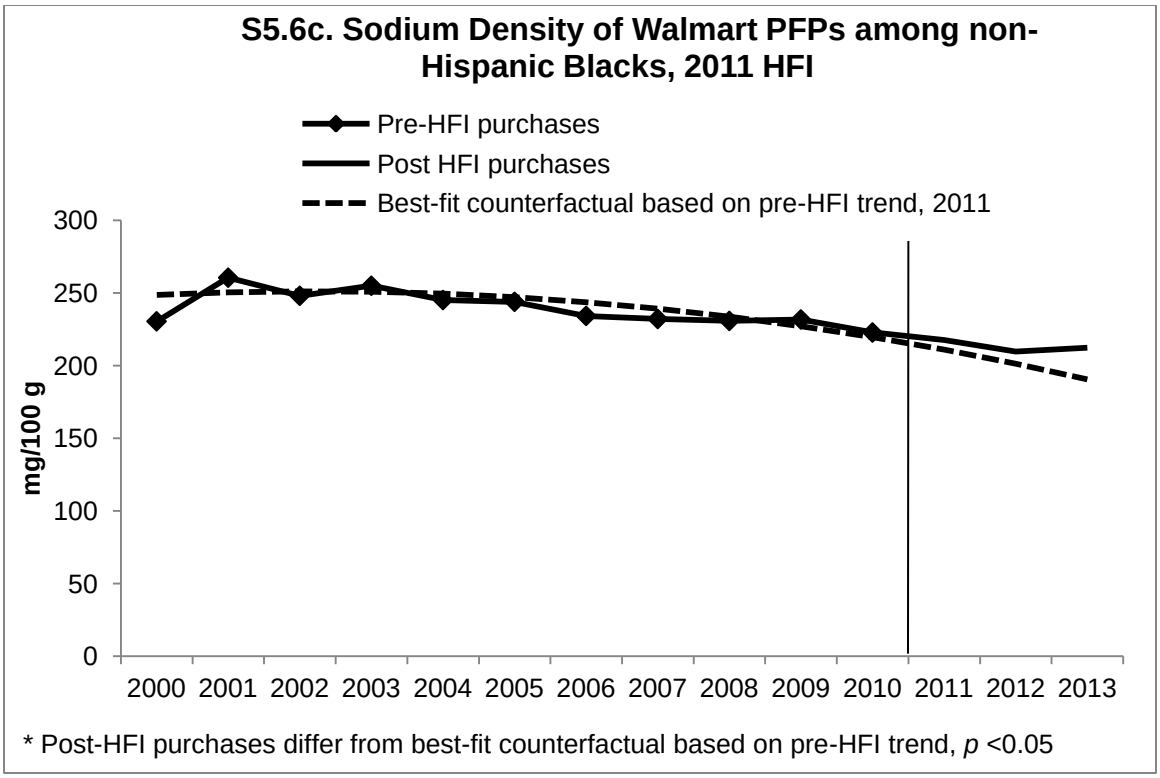


* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.05

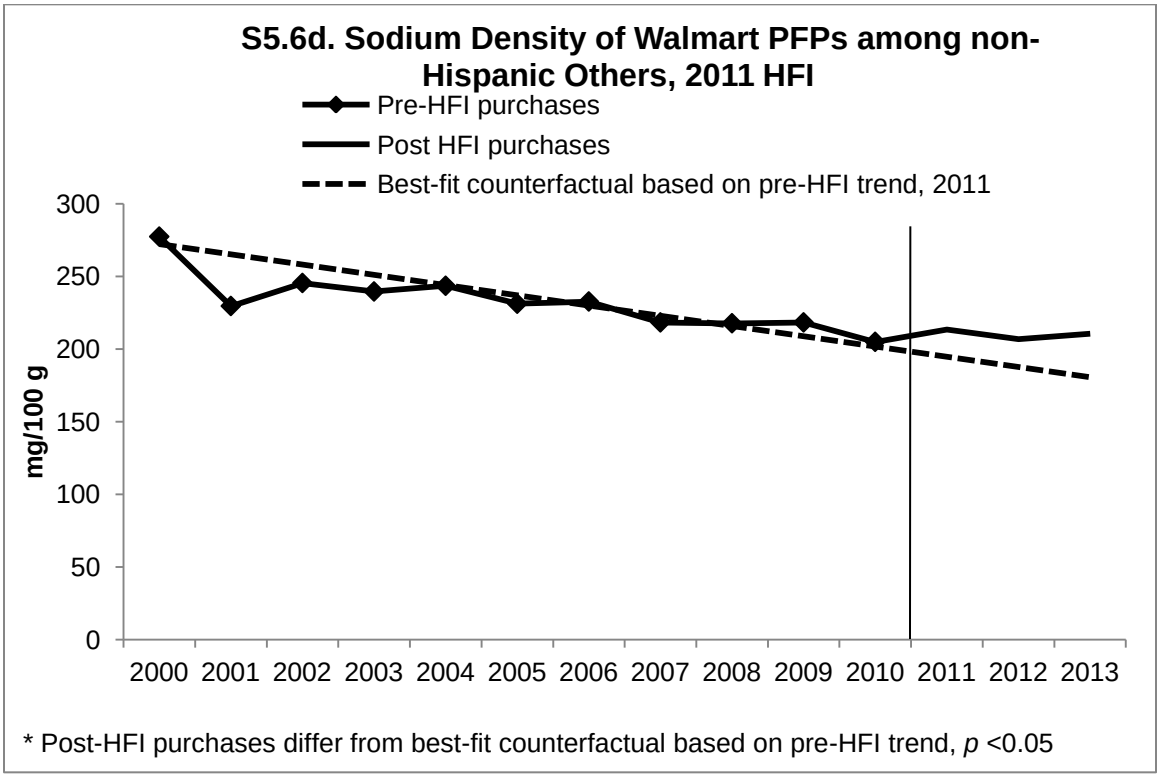
Supplemental Figure 5.6 Sodium density of PFPs at Walmart, before and after the 2011 HFI, by race/ethnicity







* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.05



* Post-HFI purchases differ from best-fit counterfactual based on pre-HFI trend, p <0.05

CHAPTER 6. SYNTHESIS

Overview of findings

In a climate of increasing food retailer consolidation and chain stores, this research investigated the impact of a single food retailer, and a retailer-based healthy foods initiative, on the nutrient profile of US packaged food purchases (PFPs). Using Walmart as a case study of a major national retailer, in Aim 1, we quantified how many households shopped there, how much they purchased there, and which socio-demographic characteristics were associated with buying more foods and beverages. In Aim 2, we examined shifts in the nutrient profile of PFPs from Walmart, compared these to trends at other chain retailers, and evaluated whether shifts were greater among low-income and race/ethnic minority households. In Aim 3, we employed counterfactual simulations to test whether Walmart's HFI was responsible for changes in nutrient profile by comparing the observed nutrient profile of purchases during the post-HFI period (2011-2013) to the expected trajectory of nutrient profile of purchases based on the pre-HFI period (2000-2010), controlling for concurrent changes in the socio-demographic, economic, and food retail environments. Again, we examined whether these changes were different for key subpopulations.

To conduct this research, we used a longitudinal commercial dataset of household PPFs from Nielsen Homescan from 2000 to 2012 (Aim 1) or 2013 (Aim 2 and Aim 3). This unique dataset captures information on all PFPs purchased during each shopping trip, including price,

unit, and importantly, location of purchases, and also contains socio-demographic information, including household composition, race/ethnicity, income, and market of residence. For this study, we included all PFPs from Walmart and from other chain retailers (chain grocery stores and supermarkets [≥10 locations], supercenters, and mass merchandisers), who were the most comparable to Walmart given their scope, size, and product assortment. Information on PFPs was linked at the barcode level to nutrition data from the Nutrition Facts Panel. We also used datasets on Walmart store openings and store location, along with national datasets on population and unemployment rates, to capture and control for key changes in the economic and food retail environments.

1. *Walmart is an increasingly dominant source of US PFPs, and low-income households are more likely to shop there.*

Despite growing awareness of the food environment, to our knowledge, no research has explicitly examined the impact of a specific retailer as a source of US food and beverage purchases. Yet, the expansion of chains and consolidation of retailers has created a food landscape in which fewer retailers are accounting for a larger share of grocery sales, suggesting that a single retailer could have a major impact on purchases and subsequent diet. To address this gap, we used the Homescan dataset to examine purchasing trends among the US' largest food retailer, Walmart, and whether low-income and race/ethnic minority households were more likely to shop there. We found that not only do the majority of households buy food at Walmart, the proportion of PFPs purchased from Walmart doubled from 2000 to 2012. Low-income non-Hispanic White and Hispanic households, but not low-income non-Hispanic Black households, were more likely to buy a larger proportion of PFPs

at Walmart. In summary, we found that a single food retailer, Walmart, is an increasingly dominant source of PFPs, especially among low income households.

2. The nutrient profile of PFPs at Walmart improved from 2000 to 2013

Little is known about the nutrient profile of PFPs from Walmart compared to other chain retailers (OCR), and how these have changed over time. In addition, most previous work has not accounted for whether any changes in nutrient profile at a given retailer are simply the result of attracting more health-conscious customers (i.e. selectivity). Using fixed effects models and inverse probability weighting to account for selectivity, we evaluated whether the nutrient profile of Walmart and OCR PFPs improved over time, and whether these changes were greater among households eligible for the Supplemental Nutrition Assistance Program (SNAP) and race-ethnic minorities. We also examined whether observed shifts were driven by shifts in consumer purchasing (i.e. buying more or less of certain food groups), or driven by product reformulation or introduction of lower-calorie options (i.e., shifts in nutrient profiles within food groups).

From 2000 to 2013, Walmart PFPs showed substantial declines in energy density, total sugar density, and sodium density, and these declines were much larger than declines observed among OCR PFPs in the same time period. Although there were no major differences by income status, Hispanics showed the largest declines in energy density and sodium density. Overall shifts were driven in part by changes in food purchasing, including declines in "less healthy" food groups, like grain-based desserts, candy, and snack foods, as well as by changes in product formulation, as demonstrated by major declines in nutrient densities within food groups. In summary, while in 2000 Walmart PFPs were higher in energy, sugar, sodium, and saturated fat density relative to OCR, by 2013, relatively larger

declines in nutrient densities at Walmart compared to OCR resulted in similar nutrient profiles between the two retailers.

3. Shifts in nutrient profile of PFPs do not appear to be attributable to Walmart's HFI

Since 2011, three of the largest national food retailers in the US have implemented healthier food initiatives (HFIs). However, no independent work has evaluated whether an HFI at a major national food retailer actually improves the nutrient profile of food purchases. To test whether improvements in the nutrient profile of Walmart's PFP were attributable to the HFI, we employed counterfactual simulations to compare the observed nutrient profile of post-HFI (2011-2013) purchases to the expected trajectory of nutrient profiles based on the pre-HFI (2000-2010) trend, controlling for concurrent changes in the social, economic, and food retail environment. We tested whether choice of a baseline period (2000-2010 vs. a 2000-2007) changed the results, and whether the HFI was more impactful among SNAP-eligible and race/ethnic minority households.

While Walmart PFPs showed major declines in energy, sodium, and sugar density from 2000 to 2013, as well as declines in the percent volume of sugary beverages, grain-based desserts, snacks, and candy, these declines were steepest in the 2000 to 2007 period. For most nutrient densities and food groups, post-HFI declines were similar to what would be expected based on pre-HFI trends, indicating that the HFI did not have a major impact on the nutrient profile of purchases. The effect (or lack thereof) of the HFI appeared consistent for SNAP-eligible households compared to higher income households, and for race/ethnic minorities compared to non-Hispanic Whites. PFPs from OCR showed only minor declines across the time period, and post-HFI trends were similar to those expected based on pre-HFI trends. In summary, **w**hile the nutrient profile of Walmart PFPs improved over time, these

trends were already well underway by the time the HFI was initiated, and were not more effective among key socio-demographic populations.

Strengths and Limitations

A key strength of this work was the use of a commercial dataset of household packaged food purchases, which captures information on not only what was purchased, how much was purchased, and the cost, but also records where the food was purchased. This ability to identify food retailer was essential to evaluating the role of a food retailer's HFI on the nutrient profile of foods, yet is an element that is typically missing from national health and nutrition surveys. Another option to obtain retailer-specific data would be to partner with the retailer in question; however, many retailers are not keen on engaging with academic researchers, and moreover, such data would not provide information on other similar retailers to serve as a comparison group. By using a dataset of household purchases, we were able to objectively evaluate shifts in the nutrient profile of Walmart purchases, as well as compare them to trends at comparable retailers. In addition, because our dataset was comprised of all purchases at Walmart and other chain retailers, we were also able to develop an inverse probability weight to identify and account for the probability that some households were more likely to shop at Walmart or OCR than other households. Utilization of methods like inverse probability weighting is critical if the likelihood of shopping at a given retailer is linked to inherent dietary preferences (for example, if those who tend to shop at Walmart also prefer higher energy dense foods). Dealing with selectivity is also essential for ensuring that observed changes are not attributable to a retailer simply attracting a more health-conscious consumer, especially after HFI implementation, but actually due to effects of the HFI itself.

Another key advantage of this study is that this purchase dataset was linked to information from the nutrition facts panel, which allowed us to examine the actual nutrient profile of purchases at specific retailers. This ability to examine both food groups and nutrients was a key advantage over other studies also using the Homescan dataset, which typically apply an ecological approach linking the densities of a food retailer or retailer type (i.e. supercenters) to some approximation of healthfulness of purchases (by assigning scores to certain foods groups, or by examining fruits and vegetables only) (106, 172). Here, we were actually able to monitor shifts in nutrient densities of purchases from Walmart and other chain retailers over time at the household level, as well as examine shifts in food groups. Another advantage of using the commercial purchases data is that it provides accurate information on household packaged food purchasing: while some studies have found that Homescan may suffer from sample selection and participation biases (173), others have found these biases can be adjusted for by controlling for household demographics (162). Moreover, comparison of the Homescan data from grocery retailers sales data (174, 175) and household expenditures diary surveys (162) confirm the validity of the Homescan data for packaged food purchases.

Finally, by using commercial purchase data on items purchased, price, and socio-demographic data, coupled with data on Walmart store openings, US population shifts, and the unemployment rate, we were able to control for concurrent changes in the socio-demographic, economic, and food retail environment. This was critical to our effort, as major events like the "Great Recession," or secular trends, such as the proliferation of Walmart supercenters, could have potentially biased our results. In addition, the longitudinal nature of our data, as well as the inclusion of households sampled from across the country, allowed us to explore the long-term

effects of the HFI on a larger sample of the US population, as opposed to previous HFI evaluations, which were typically short-term and geographically localized.

However, the use of commercial purchase data to examine the effects of a retailer-based HFI also had several significant limitations, which likely attenuated the observed effects of the HFI. Perhaps the most important of these is that the Homescan data includes only foods that are purchased (as opposed to consumed) and those with a barcode. First, food purchases do not necessarily equate to food consumed, due to wastage and spoilage, and further work is needed to understand how HFIs are related to changes in dietary behaviors and intake. Secondly, limiting the dataset to foods with a barcode misses foods like loose fruits or vegetables, which typically do not have a barcode. Failure to capture these products could impose a major restriction on our ability to evaluate Walmart's HFI, since one of its major goals was increasing the availability and affordability of produce, including increasing sales of locally sourced and organic foods (125, 126). If we were able to include these items, we would likely see a bigger impact of the HFI on the nutrient profile of foods and beverages, as well as higher increases in fruits and vegetables. On the other hand, using data on PFP expenditures from 2007-2011, we found that on average, only 5% of total food expenditures was spent on unpackaged food purchases at Walmart, and only 2% of total food expenditures was on unpackaged produce, whereas packaged food purchases accounted for 93% of expenditures. Thus, even though we could not measure changes in unpackaged fruits and vegetables, these foods represent only a minor fraction of overall Walmart food purchases.

We were able to examine key elements of Walmart's HFI which affected packaged food purchases, including as product formulation (reformulating products, removing products, or introducing new products) and front-of-package labeling, focused on packaged foods and

beverages. Our methodology was appropriate for examining these changes, as well as HFIs at other major retailers, which have also focused primarily on shelf- and package-labeling initiatives that are targeted towards packaged foods. In addition, food manufacturers and suppliers are increasingly packaging fresh produce in mesh or plastic bags, and multi-packs, to encourage increased purchasing (e.g., a bag of three avocados) or in one-serving, snack-sized containers, to appeal to evolving consumer preferences and an increased market for convenience foods (176). This suggests that datasets of packaged food purchases may be better able to capture fresh produce over time, and in the meantime, can still capture the impact of key HFI elements like product reformulation and labeling.

Similarly, with the available data, we could only evaluate changes in overall purchasing, and could not distinguish effects from individual HFI components to determine which component was most effective. We were also limited in the degree to which we could explore shifts in nutrient profile. Most importantly, we could not explicitly examine decreases in added sugar or *trans* fats, which were two targets of Walmart's HFI. In addition, we were partially limited in our examination of food-group specific changes because we do not have data on which products Walmart purportedly targeted for its reformulation efforts. However, we were able to examine whether shifts in overall nutrient profile were driven by changes in consumer purchasing (i.e. shifts in food groups purchased) or by changes in product formulation (i.e. shifts in nutrient profile within food groups purchased). In the future, we would like to build on this work by more carefully examining certain food and beverage groups, and linking shifts more directly to individual HFI components (i.e. price cuts vs. labeling vs. reformulation), in order to determine which elements are most useful.

Another key limitation is that our analysis includes only three years of post-HFI data, which may not provide a long enough period to fully capture HFI-related shifts in purchasing, given that Walmart's pledge was to complete all changes by 2015. Evaluating the HFI prior to this 2015 deadline means that we may not be able to capture the effects of all product reformulations, and it also may not allow for enough time for consumers to respond to the HFI. However, by 2013, Walmart had announced that they had already achieved a 9% decline in sodium and a 50% reduction in industrial produced trans fats, due to product reformulation, as well as a 10% decline in added sugars, attributable to reformulation, which they attribute to the entrance of new low-sugar products, and consumers making healthier choices (77). Although our findings did not confirm the magnitude of these shifts, nor did our findings indicate that the shifts we did observe were attributable to the HFI, the fact that Walmart was willing to make these announcements suggests that changes were well underway. Thus our evaluation still provides useful evidence as to whether the HFI has begun to shift the nutrient profile of Walmart purchases.

A further limitation also contributed to our likely underestimation of the impact of Walmart's HFI. We were unable to explicitly examine changes in Walmart private-label products vs. non-private-label products, in part due to confidentiality agreements with the vendors, and in part because linkages of packaged food purchases to nutrition information were less accurate for private-label products than non-private-label products. In many cases, a private-label product without a direct linkage to that product's nutrition facts panel would be assigned the average nutrient profile of all private-label products. For example, a "Great Value" brand soft drink without the corresponding nutrition facts panel information would be linked to an average nutrient profile of all private-label soft drinks. Since Walmart's purported efforts on product

reformulation and front-of-package labeling focused on their private-label products, and considering that private-label products account for an increasing proportion of foods purchased (139), we may have observed more substantial post-HFI declines if we had been able to distinguish private-label PFPs from non-private-label. However, in addition to reformulating its own products, Walmart also asked manufacturers of branded PFPs to reformulate their products, and our dataset was more likely to capture shifts in the reformulations of these products. Still, in order to better understand whether private-label products did show greater changes in nutrient profile than branded products, we plan to conduct a sensitivity analysis examining only products that were the most accurately linked to nutrition data. Although such an analysis might still miss a number of private label products, it would provide a sense of whether changes in private label products were greater than branded products during this time period.

An additional concern is that these results could simply reflect a shift in how people shop at Walmart: as the years progressed, and people purchased more food at Walmart, they purchased a wider variety of foods, whereas in early years, they may have only purchased non-perishable packaged foods, like candy or snacks. This would result in a decline in energy density of Walmart PFPs, simply because of either a real or perceived shift in Walmart from discount store to full-grocery supercenter, as more supercenters entered the market and offered a wider assortment of products. In addition, we were unable to measure household dietary preference, which could affect how much people buy at Walmart as well as what they buy there, which limits our ability to establish what caused the observed changes in nutrient profile.

A final limitation relates to the generalizability of our results. While we employed multiple strategies for addressing selectivity within our sample, the Homescan sample overall tends to be more highly educated, more non-Hispanic White, and higher income than the general

US population. Moreover, participation in Homescan requires using a handheld scanner to scan all purchases a household makes, without direct financial compensation (participants are enrolled in various lotteries to win prizes or given points they can redeem for gifts). Households with limited time resources, or those for whom gift rewards hold little value, may not be interested in participating.

We also restricted our sample to Walmart and OCR customers, in order to examine comparable groups, and because major retailers like Walmart and OCR account for the highest proportion of grocery sales, and are thus the most poised to affect the food system. Households that shopped at either OCR or at Walmart accounted for 98% of total households participating in Homescan, with only 2% of households shopping at only ethnic stores, club stores, convenience stores, individual grocery stores, specialty stores, or other small stores. However, households that shop at only farmer's markets, local stores, or convenience stores/drug stores may have a different response to similar measures enacted in the places where they shop than the households included in this study. Thus, more work in varying samples is needed to truly understand how HFIs impact different segments of the population. For example, Sheetz, a chain of convenience stores, recently implemented a healthier foods initiative, and it would be useful to understand how this type of initiative impacts households who buy groceries there.

Because of these concerns, the results of this study should not be interpreted as "HFIs do not work." While a key strength of our work was our ability to harness the unique characteristics of a dataset of household purchases, this dataset also contained a number of limitations which reduced our ability to detect the effect of the HFI. To get a comprehensive understanding of whether HFIs impact the nutrient profile of purchases, ideally we would triangulate our results with those from field studies, which could test individual HFI components, and data from

retailers, which could provide information on key elements like unpackaged produce and private-label products. Data from a number of sources, from HFIs in various store settings (for example, a chain retailer vs. regional grocery store), and from various populations would provide a stronger evidence base to establish the effectiveness of HFIs for improving nutrition.

Significance and public health impact

This study provides a novel methodology for evaluating how a single food retailer, and a retailer-based HFI, impacts the nutritional profile of US food purchases. First, lack of data on retailers in national nutrition surveys, and difficulty in partnering with food retailers to access store-level data, necessitate use of commercial purchase data. However, our study shows that a dataset of household purchases can be used to examine the impact of a single food retailer as a food source in the US food supply. Our study provided further evidence that as food retailers consolidate and chains grow, a single retailer can have a major impact on what US households buy and eat. In addition, by using household food purchases, we were able to examine shifts in the nutrient profile of Walmart purchases, and examine whether these shifts were above and beyond those observed at other chain retailers, as opposed to relying on ecological data to link store densities, or proximity to stores, with nutritional quality. Moreover, by using the price and socio-demographic data provided by Homescan, coupled with data on Walmart store locations, we were able to control for concurrent trends that may have otherwise impacted the observed shifts in nutrient profile. These characteristics are necessary in order to understand whether changes in nutrient profile and purchasing were attributable to the HFI and not simply the reflection of secular trends.

Secondly, this work provides a useful methodology for evaluating national-scale food initiatives, such as soda bans or menu labeling, which often do not have an appropriate control

group for comparison. First, conducting counterfactual simulations by comparing post-initiative results to expected results based on pre-initiative trends, while controlling for concurrent trends, allows researchers to determine whether changes are attributable to the initiative in question. We were also able to use inverse probability weighting to account for selectivity, or the potential for shifts in the consumer base over time. This approach could also be useful in the evaluation of major national food policies, or for smaller-scale HFIs, if there is some suspected relationship between the likelihood of being "exposed" to the policy or HFI, and shifts in nutrient profile. For example, to examine the effects of Berkeley's recent soda tax, investigators would want to compare soda purchases in Berkeley to those in a comparable city that did not implement the tax. However, since the populations living in the two cities would still have some different characteristics, inverse probability weighting could be used to deal with the possibility that those who live in Berkeley may different underlying nutritional preferences (perhaps they drink less soda) and thus may be more or less responsive to such a ban than those in Toledo.

On a related note, we also found that evaluation of an HFI or similar effort requires identifying an appropriate baseline period. Since manufacturers, retailers, or even government entities may begin making shifts prior to the official start date of the initiative, examining the data to determine when the shift actually occurred can provide a more appropriate reference point for evaluating post-HFI changes. Similarly, understanding pre-baseline trends is a necessity for understanding whether the party in question truly made a change, or simply claimed responsibility for what was actually a preexisting trend. This consideration could be critical in evaluating other food and nutrition policies. For example, in evaluating the effect of mandatory calorie labeling on menus stemming from the Affordable Care Act, it would be important first to understand whether away-from-home calories were already declining prior to implementation, as

well as when restaurants actually made these changes. As our results show, the choice of a baseline period is not always obvious, and can make a difference in how impactful an initiative appears, and thus requires careful consideration.

In the current study, we found that although the nutrient profile of packaged food purchases from Walmart improved above and beyond trends at other chain retailers, the vast majority of these improvements occurred prior to the HFI. However, given that we were unable to examine individual HFI components or evaluate shifts in unpackaged produce, it is likely that our estimates of HFI-related changes are conservative. Moreover, we show that Walmart is a major source of packaged food purchases in the US—especially among low-income households. These results suggest that Walmart and other major food retailers can be key leaders in efforts to improve nutrition and prevent obesity, and should be included in conversations and collaborations on industry food initiatives to achieve these goals. One example is the Partnership for a Healthy America, which has already partnered with Walmart, food manufacturers, convenience stores, and other companies to improve the healthfulness of food choices and reduce obesity (177).

This study also has implications for understanding how retailers could contribute to, or reduce, diet-related disparities. We found that while Hispanics and non-Hispanic Others had worse nutrient profile of purchases in 2000 relative to non-Hispanic Whites, they showed the largest declines in energy density and sodium density over time. In addition, both SNAP-eligible households showed shifts towards a more favorable nutrient profile. However, for all groups, the HFI did not seem particularly impactful at creating shifts above and beyond what was already expected given pre-HFI trajectories. On one hand, this trend towards more favorable nutrient profiles over time is promising, given that Walmart is the largest recipient of SNAP benefits, but

on the other, more work needs done to understand whether more targeted efforts can be more impactful at reducing diet disparities in these vulnerable subpopulations.

In summary, Walmart is a major source of PFPs in the US, particularly among low-income households. While the nutrient profile of PFPs improved over time, and these improvements were greatest among Hispanic and non-Hispanic Other households, Walmart's HFI did not have a clear impact in pushing these improvements beyond what was expected given their pre-existing trajectories. Regardless, this work demonstrates that food retailers can have a major impact on the nutrient profile of US food and beverage purchases, and can be important contributors in strategies to improve nutrition. Public health advocates, nutrition scientists, and policymakers should engage and work collaboratively with food retailers to further improve the diet of the US population.

Future Directions

While this research examined whether an HFI at a major national retailer impacted the nutrient profile of packaged food purchases, more work is needed to understand how HFIs affect non-packaged produce, diet intake, and health outcomes, as well as also their impact at other retailers. Ultimately we would want to know whether these initiatives are actually successful at improving diet, and diet-related disease like obesity, diabetes, and cardiovascular disease.

For example, future research should explore how HFIs impact the purchases of unpackaged fruits and vegetables, as well as whether these purchases translate into increased intake, or changes in weight status. To address the unpackaged produce element, one option would be to use Homescan's expenditures data, which includes the amount spent on packaged products as well as unpackaged fresh produce (although further detail is not included, such as the volume or units purchased). As long as price cuts on produce were controlled for, such analysis

would allow us to see how people's total expenditures changed over time, whether they purchased relatively more unpackaged produce after the HFI, and potentially whether substitutions were made (i.e. unpackaged produce for packaged produce). Currently, we only have access to limited years of this expenditures data (2007-2011). However, we do plan to conduct a sensitivity analysis using this data to understand what proportion of total produce expenditures is accounted for by unpackaged produce, and whether this differs between Walmart and other chain retailers.

Additional analyses could also focus on understanding how shopping patterns and initiatives across retailers work together to produce changes in *total* food purchases across all stores where households shop. This is especially important considering that many households shop at multiple retailers or only buy certain products at certain retailers, and because other major retailers have also introduced initiatives to help consumers make healthier choices. If households buy more produce at the HFI retailer, but compensate by buying less produce at another retailer where they shop, the HFI may not be a useful strategy for promoting increased produce purchases. In the current study, we only examined concurrent trends in purchasing at the HFI retailer and comparable retailers; however, in the future, we will also examine whether households made substitutions or additions of produce or other products as a result of the HFI.

Along these lines, it would also be useful to understand whether retailer-based HFIs produce changes in people's purchasing *patterns*. Our analysis only looked at changes in nutrients and key food groups. However, people do not consume nutrients or foods in isolation, but rather as part of an overall diet, which may be more predictive of disease risk (178). Thus, one key question to address in the future is whether HFIs promote healthier purchasing patterns:

for example, after an HFI is implemented, are households more likely to have a purchasing pattern that reflects the Mediterranean dietary pattern (179-181)?

Future work should also seek to understand what could be done to boost the impact of these retailer-based HFIs. One potential reason for the lack of effect is that while the HFI focused on improving the availability and affordability of healthy foods, it did not work to decrease the availability of unhealthy foods through price increases, product placement, or package labeling—perhaps over concerns regarding profit loss. However, previous work has shown that increased shelf-space devoted to more energy-dense snack foods is associated with an increase in BMI (182), suggesting that interventions to reduce the availability of unhealthy foods might be needed alongside interventions to boost the availability of healthy foods. Thus, one question for future exploration is whether a combined approach of boosting healthy foods coupled with reducing the availability of unhealthful foods is financially sustainable, and whether it can yield a more powerful impact on nutrient profile. Other policy options, such as a tax on SSBs or on junk food, as recently implemented in Mexico, could also achieve the goal of reducing the affordability of healthful foods, and don't depend on the retailer to make choices that might impact its bottom line.

Finally, more research is needed to understand how food retailers can be leveraged to reduce diet-related disparities in low-income and race/ethnic minority households. One option could be to target small, non-chain food stores, which are more common in neighborhoods with high proportions of low-income and race/ethnic minority households (183-185), and have been suggested as a potential target for improving diets among these key groups (186). In fact, a 2012 systematic review found that small-store HFIs consistently improve the availability, purchase, and consumption of healthier foods (32). In this study, we did not examine these small stores

because they tend to offer a smaller assortment of products than Walmart and other chain retailers, and thus may not be an appropriate comparison group. However, future work should examine whether HFIs are more impactful at different types of retailer (for example, drug stores, club stores, convenience stores, mass merchandisers), or whether across-the-board changes are needed to see an impact. Such work also provides a critical opportunity to integrate data from national-scale studies like ours, which can show how such initiatives work at the population level, with smaller, isolated field studies, which can tease out which HFI components might be most effective, and in which geographic regions or socio-demographic subpopulations.

REFERENCES

1. Poti JM, Popkin BM. Trends in energy intake among US children by eating location and food source, 1977-2006. J Am Diet Assoc 2011;111(8):1156-64.

2. Smith LP, Ng SW, Popkin BM. Trends in US home food preparation and consumption: analysis of national nutrition surveys and time use studies from 1965–1966 to 2007–2008. Nutr J 2013;12(1):45.

3. Wood S. Revisiting the US food retail consolidation wave: regulation, market power and spatial outcomes. Econ Geog 2013:lbs047.

4. United States Department of Agriculture Economic Research Service. Retail Trends. 2014.

5. Hawkes C. Dietary implications of supermarket development: a global perspective. Dev Policy Rev 2008;26(6):657-92.

6. Glanz K, Bader MD, Iyer S. Retail grocery store marketing strategies and obesity: an integrative review. Am J Prev Med 2012;42(5):503-12.

7. Wal-mart Stores Inc. Walmart Launches Major Initiative to Make Food Healthier and Healthier Food More Affordable. Washington, D.C., 2011.

8. BusinessWire. Internet: http://www.businesswire.com/news/home/20110215007790/en/Safeway-Announces-%E2%80%98SimpleNutrition%E2%80%99-In-Store-Shelf-Tag-System#.VD57YvldWSo 2014).

9. Kroger. Internet: https://www.kroger.com/topic/health-matters-3 (accessed May 2014).

10. Food Lion. Internet: http://www.foodlion.com/NutritionWellBeing/Nutrition/GuidingStars (accessed October 2014).

11. Gittelsohn J, Song H-J, Suratkar S, Kumar MB, Henry EG, Sharma S, Mattingly M, Anliker JA. An urban food store intervention positively affects food-related psychosocial variables and food behaviors. Health Educ Behav 2010;37(3):390-402.

12. Gittelsohn J, Suratkar S, Song H-J, Sacher S, Rajan R, Rasooly IR, Bednarek E, Sharma S, Anliker JA. Process evaluation of Baltimore Healthy Stores: a pilot health intervention program with supermarkets and corner stores in Baltimore City. Health Promot Pract 2010;11(5):723-32.

13. Curran S, Gittelsohn J, Anliker J, Ethelbah B, Blake K, Sharma S, Caballero B. Process evaluation of a store-based environmental obesity intervention on two American Indian Reservations. Health Educ Res 2005;20(6):719-29.

14. Song H-J, Gittelsohn J, Kim M, Suratkar S, Sharma S, Anliker J. A corner store intervention in a low-income urban community is associated with increased availability and sales of some healthy foods. Public Health Nutr 2009;12(11):2060.

15. Gittelsohn J, Dyckman W, Tan ML, Boggs MK, Frick KD, Alfred J, Winch PJ, Haberle H, Palafox NA. Development and implementation of a food store–based intervention to improve diet in the Republic of the Marshall Islands. Health Promot Pract 2006;7(4):396-405.

16. Gittelsohn J, Dyckman W, Frick KD, Boggs MK, Haberle H, Alfred J, Vastine A, Palafox N. A pilot food store intervention in the Republic of the Marshall Islands. Pac Health Dialog 2007;14(2):43-53.

17. Gittelsohn J, Vijayadeva V, Davison N, Ramirez V, Cheung LW, Murphy S, Novotny R. A food store intervention trial improves caregiver psychosocial factors and children's dietary intake in Hawaii. Obesity 2010;18(S1):S84-S90.

18. Levy AS, Mathews O, Stephenson M, Tenney JE, Schucker RE. The impact of a nutrition information program on food purchases. J Public Policy Mark 1985:1-13.

19. Food Marketing Institute. Trends in the United Stats- Consumer Attitudes and the Supermarket, 2000. Washington, DC, 2000.

20. Vyth EL, Steenhuis IH, Mallant SF, Mol ZL, Brug J, Temminghoff M, Feunekes GI, Jansen L, Verhagen H, Seidell JC. A front-of-pack nutrition logo: a quantitative and qualitative process evaluation in the Netherlands. J Health Commun 2009;14(7):631-45.

21. Williams P. Consumer understanding and use of health claims for foods. Nutr Rev 2005;63(7):256-64.

22. Mhurchu CN, Gorton D. Nutrition labels and claims in New Zealand and Australia: a review of use and understanding. Aust N Z J Public Health 2007;31(2):105-12.

23. Rayner M, Boaz A, Higginson C. Consumer use of health-related endorsements on food labels in the United Kingdom and Australia. J Nutr Educ 2001;33(1):24-30.

24. Food Marketing Institute. US Grocery Shopper Trends 2012 Executive Summary. 2012.

25. Jeffery RW, Pirie PL, Rosenthal BS, Gerber WM, Murray DM. Nutrition education in supermarkets: an unsuccessful attempt to influence knowledge and product sales. J Behav Med 1982;5(2):189-200.

26. Ernst ND, Wu M, Frommer P, Katz E, Matthews O, Moskowitz J, Pinsky JL, Pohl S, Schreiber GB, Sondik E. Nutrition education at the point of purchase: the foods for health project evaluated. Prev Med 1986;15(1):60-73.

27. Mayer JA, Dubbert PM, Elder JP. Promoting nutrition at the point of choice: a review. Health Educ Behav 1989;16(1):31-43.

28. Steenhuis I, van Assema P, van Breukelen G, Glanz K. The effectiveness of nutrition education and labeling in Dutch supermarkets. Am J Health Promot 2004;18(3):221-4.

29. Olson CM, Bisogni CA, Thonney PF. Evaluation of a supermarket nutrition education program. J Nutr Educ 1982;14(4):141-5.

30. Kristal AR, Goldenhar L, Muldoon J, Morton RF. Evaluation of a supermarket intervention to increase consumption of fruits and vegetables. Am J Health Promot 1997;11(6):422-5.

31. Hawkes C. Sales promotions and food consumption. Nutr Rev 2009;67(6):333-42.

32. Gittelsohn J, Rowan M, Gadhoke P. Interventions in small food stores to change the food environment, improve diet, and reduce risk of chronic disease. Prev Chronic Dis 2012;9.

33. Geliebter A, Ang IY, Bernales-Korins M, Hernandez D, Ochner CN, Ungredda T, Miller R, Kolbe L. Supermarket discounts of low-energy density foods: Effects on purchasing, food intake, and body weight. Obesity 2013;17(10):20484.

34. Ng SW, Popkin BM. Monitoring foods and nutrients sold and consumed in the United States: dynamics and challenges. J Acad Nutr Diet 2012;112(1):41.

35. Sutherland LA, Kaley LA, Fischer L. Guiding stars: the effect of a nutrition navigation program on consumer purchases at the supermarket. Am J Clin Nutr 2010;91(4):1090S-4S.

36. An R, Patel D, Segal D, Sturm R. Eating better for less: a national discount program for healthy food purchases in South Africa. Am J Health Behav 2013;37(1):56.

37. Lambert EV, Kolbe-Alexander TL. Innovative Strategies Targeting Obesity and Non-communicable Diseases in South Africa: What Can We Learn from the Private Health Care Sector? Obesity Rev 2013.

38. Sturm R, An R, Segal D, Patel D. A Cash-Back Rebate Program for Healthy Food Purchases in South Africa: Results from Scanner Data. Am J Prev Med 2013;44(6):567-72.

39. Brinkman H-J, de Pee S, Sanogo I, Subran L, Bloem MW. High food prices and the global financial crisis have reduced access to nutritious food and worsened nutritional status and health. J Nutr 2010;140(1):153S-61S.

40. Bernstein AM, Bloom DE, Rosner BA, Franz M, Willett WC. Relation of food cost to healthfulness of diet among US women. Am J Clin Nutr 2010;92(5):1197-203.

41. Monsivais P, Drewnowski A. The rising cost of low-energy-density foods. J Am Diet Assoc 2007;107(12):2071-6.

42. Beatty TK, Senauer B. The New Normal? U.S. Food Expenditure Patterns and the Changing Structure of Food Retailing. Am J Agric Econ 2012.

43. Ng SW, Annis I, Guilkey D, Popkin BM. The Great Recession and purchase of consumer packaged foods and beverages among US households. Working paper. Chapel Hill, NC: UNC Food Research Program.

44. Slining MM, Mathias KC, Popkin BM. Trends in Food and Beverage Sources among US Children and Adolescents: 1989-2010. J Acad Nutr Diet 2013;2(13):00679-5.

45. Ford ES, Dietz WH. Trends in energy intake among adults in the United States: findings from NHANES. Am J Clin Nutr 2013;97:848-53.

46. Ng SW, Popkin BM. The Healthy Weight Commitment Foundation Marketplace Commitment and Consumer Packaged Goods purchased by US households with children. Am J Prev Med 2014;47(4):520-30.

47. Kentucky.Com. Internet: http://www.kentucky.com/2010/03/03/1165084/kroger-stores-begin-testing-nutritional.html (accessed November 2013).

48. City of Boston. Press Release: Mayor Menino and Boston's biggest supermarkets launch partnership to promote healthy beverages. 2013.

49. Carpenter JM, Moore M. Consumer demographics, store attributes, and retail format choice in the US grocery market. IJRRBP 2006;34(6):434-52.

50. Hausman J, Leibtag E. Consumer benefits from increased competition in shopping outlets: Measuring the effect of Wal-Mart. Journal of Applied Econometrics 2007;22(7):1157-77.

51. Marmorstein H, Grewal D, Fishe RP. The value of time spent in price-comparison shopping: survey and experimental evidence. J Consum Res 1992:52-61.

52. Kim B-D, Park K. Studying patterns of consumer's grocery shopping trip. J Retailing 1998;73(4):501-17.

53. Tang CS, Bell DR, Ho T-H. Store choice and shopping behavior: how price format works. Calif Manage Rev 2001;43(2):56-74.

54. Bell DR, Ho T-H, Tang CS. Determining where to shop: fixed and variable costs of shopping. J Marketing Res 1998:352-69.

55. Fox EJ, Montgomery AL, Lodish LM. Consumer Shopping and Spending Across Retail Formats. J Bus 2004;77(S2):S25-S60.

56. Bell DR, Lattin JM. Shopping behavior and consumer preference for store price format: Why "large basket" shoppers prefer EDLP. Market Sci 1998;17(1):66-88.

57. Gustafson A, Hankins S, Jilcott S. Measures of the Consumer Food Store Environment: A Systematic Review of the Evidence 2000-2011. J Community Health 2012;37(4):897-911. doi: 10.1007/s10900-011-9524-x.

58. Larson NI, Story MT, Nelson MC. Neighborhood environments: disparities in access to healthy foods in the US. Am J Prev Med 2009;36(1):74-81. e10.

59. Baker EA, Schootman M, Barnidge E, Kelly C. Peer reviewed: The role of race and poverty in access to foods that enable individuals to adhere to dietary guidelines. Prev Chronic Dis 2006;3(3).

60. Wang Y, Chen X. How much of racial/ethnic disparities in dietary intakes, exercise, and weight status can be explained by nutrition-and health-related psychosocial factors and socioeconomic status among US adults? J Am Diet Assoc 2011;111(12):1904-11.

61. Dubowitz T, Heron M, Bird CE, Lurie N, Finch BK, Basurto-Dávila R, Hale L, Escarce JJ. Neighborhood socioeconomic status and fruit and vegetable intake among whites, blacks, and Mexican Americans in the United States. Am J Clin Nutr 2008;87(6):1883-91.

62. Hiza HA, Casavale KO, Guenther PM, Davis CA. Diet quality of Americans differs by age, sex, race/ethnicity, income, and education level. J Acad Nutr Diet 2013;113(2):297-306.

63. Wang DD, Leung CW, Li Y, Ding EL, Chiuve SE, Hu FB, Willett WC. Trends in dietary quality among adults in the United States, 1999 through 2010. JAMA Intern Med 2014;174(10):1587-95.

64. Steenhuis IH, Waterlander WE, de Mul A. Consumer food choices: the role of price and pricing strategies. Public Health Nutr 2011;14(12):2220-6.

65. Walters R, Jamil M. Measuring cross-category specials purchasing: theory, empirical results, and implications. JMFM 2002;5(1):25-42.

66. Bartlett RW. Fluid Milk Sales as Related to Demand Elasticities. J Dairy Sci 1964;47(12):1314-21.

67. Huang KS, Lin B-H. Estimation of food demand and nutrient elasticities from household survey data: US Department of Agriculture, Economic Research Service, 2000.

68. Park JL, Holcomb RB, Raper KC, Capps O. A demand systems analysis of food commodities by US households segmented by income. Am J Agric Econ 1996;78(2):290-300.

69. Gould BW, Cox TL, Perali F. The demand for fluid milk products in the US: a demand systems approach. Western J Agr Econ 1990:1-12.

70. Vyth EL, Steenhuis IH, Vlot JA, Wulp A, Hogenes MG, Looije DH, Brug J, Seidell JC. Actual use of a front-of-pack nutrition logo in the supermarket: consumers' motives in food choice. Public Health Nutr 2010;13(11):1882.

71. Nguyen BT, Shuval K, Njike VY, Katz DL. The Supplemental Nutrition Assistance Program and Dietary Quality Among US Adults: Findings From a Nationally Representative Survey. Mayo Clin Proc 2014;89(9):1211-9.

72. Bleich SN, Vine S, Wolfson JA. American adults eligible for the Supplemental Nutritional Assistance Program consume more sugary beverages than ineligible adults. Prev Med 2013;57(6):894-9.

73. Leung CW, Ding EL, Catalano PJ, Villamor E, Rimm EB, Willett WC. Dietary intake and dietary quality of low-income adults in the Supplemental Nutrition Assistance Program. Am J Clin Nutr 2012;96(5):977-88.

74. Hofler M. Causal inference basedon counterfactuals. BMC Med Res Methodol 2005;5(1):28.

75. Robins J. Causal inference from complex longitudinal data. Edtion ed. In: Berkane M, ed. Latent Variable Modeling and Applications to Causality: Lecture Notes in Statistics 120. New York: Springer-Verlag, 1997:69-117.

76. Robins JM, Hernán MÁ, Brumback B. Marginal structural models and causal inference in epidemiology. Epidemiology 2000;11(5):550-60.

77. Wal-Mart Stores Inc. Internet: http://corporate.walmart.com/global-responsibility/hunger-nutrition/our-commitments (accessed October 2013).

78. Wal-mart Stores Inc. Internet: http://corporate.walmart.com/global-responsibility/hunger-nutrition/great-for-you (accessed October 2013).

79. Wal-mart Stores Inc. Walmart 2013 Annual Report. 2013.

80. Banjo S, Gasparro A. Retailers Brace for Reduction in Food Stamps. Wall Street Journal 2013. Internet: http://online.wsj.com/news/articles/SB10001424052702303843104579168011245171266 accessed Date Accessed)|.

81. Morland K, Wing S, Roux AD. The contextual effect of the local food environment on residents' diets: the atherosclerosis risk in communities study. Am J Public Health 2002;92(11):1761-8.

82. Story M, Kaphingst KM, Robinson-O'Brien R, Glanz K. Creating healthy food and eating environments: policy and environmental approaches. Annu Rev Public Health 2008;29:253-72.

83. Poti JM, Slining MM, Popkin BM. Where Are Kids Getting Their Empty Calories? Stores, Schools, and Fast-Food Restaurants Each Played an Important Role in Empty Calorie Intake among US Children During 2009-2010. J Acad Nutr Diet 2013;4(13):01336-1.

84. Roodenburg A, Popkin B, Seidell J. Development of international criteria for a front of package nutrient profiling system: international Choices Programme. Eur J Clin Nutr 2011;65(11):1190-200.

85. Sacks G, Rayner M, Swinburn B. Impact of front-of-pack 'traffic-light' nutrition labelling on consumer food purchases in the UK. Health Promot Int 2009;24(4):344-52.

86. Rayner M, Scarborough P, Kaur A. Nutrient profiling and the regulation of marketing to children. Possibilities and pitfalls. Appetite 2013;62(0):232-5. doi: http://dx.doi.org/10.1016/j.appet.2012.06.021.

87. IOM C. Examination of Front-of-Package Nutrition Rating Systems and Symbols: Phase I Report. In: Wartella A, Lichtenstein A, Boon C, eds.: Institute of Medicine, 2010.

88. Vyth EL, Steenhuis IH, Roodenburg AJ, Brug J, Seidell JC. Front-of-pack nutrition label stimulates healthier product development: a quantitative analysis. Int J Behav Nutr Phys Act 2010;7:65.

89. Vyth EL, Steenhuis IH, Vlot JA, Wulp A, Hogenes MG, Looije DH, Brug J, Seidell JC. Actual use of a front-of-pack nutrition logo in the supermarket: consumers' motives in food choice. Public health nutrition 2010;13(11):1882-9.

90. Wartella EA, Lichtenstein AH, Boon CS, Editors, eds. Examination of Front-of-Package Nutrition Rating Systems and Symbols: Phase 1 Report. Washington DC: National Academy Press, 2010.

91. Cawley J, Sweeney MJ, Sobal J, Just DR, Kaiser HM, Schulze WD, Wethington E, Wansink B. The impact of a supermarket nutrition rating system on purchases of nutritious and less nutritious foods. Public Health Nutr 2014;FirstView:1-7.

92. Institute of Medicine, National Research Council. The public health effects of food deserts: workshop summary. Washington, DC, 2009.

93. Bitler M, Haider SJ. An Economic View of Food Deserts in the United States. J Policy Anal Manage;In press.

94. Cummins S, Macintyre S. Food deserts---evidence and assumption in health policy making Br Med J 2002;325:436-38.

95. Walker RE, Keane CR, Burke JG. Disparities and access to healthy food in the United States: A review of food deserts literature. Health Place 2010;16(5):876-84. doi: http://dx.doi.org/10.1016/j.healthplace.2010.04.013.

96. Gordon C, Purciel-Hill M, Ghai NR, Kaufman L, Graham R, Van Wye G. Measuring food deserts in New York City's low-income neighborhoods. Health Place 2011;17(2):696-700. doi: http://dx.doi.org/10.1016/j.healthplace.2010.12.012.

97. Holmes TJ. The diffusion of Wal-mart and economies of density. Econometrica 2011;79(1):253-302.

98. Walmart Inc. Internet: http://corporate.walmart.com/our-story/our-business/locations/.

99. Euromonitor International. Grocery Retailers in the US. 2013.

100. Artz GM, Stone KE. Analyzing the impact of Wal-Mart supercenters on local food store sales. Am J Agr Econ 2006;88(5):1296-303.

101. Basker E. Job creation or destruction? Labor market effects of Wal-Mart expansion. Rev Econ Stat 2005;87(1):174-83.

102. Goetz SJ, Rupasingha A. Wal-Mart and social capital. Am J Agric Econ 2006;88(5):1304-10.

103. Neumark D, Zhang J, Ciccarella S. The effects of Wal-Mart on local labor markets. Journal of Urban Economics 2008;63(2):405-30.

104. Basker E. The causes and consequences of Wal-Mart's growth. J Econ Perspect 2007;21(3):177-98.

105. Drewianka S, Johnson D. Wal-Mart and Local Labor Markets, 1990-2004. University of Wisconsin-Milwaukee Working Paper, 2006.

106. Volpe R, Okrent A, Leibtag E. The effect of supercenter-format stores on the healthfulness of consumers' grocery purchases. Am J Agric Econ 2013;95(3):568-89.

107. Nielsen Company. Internet: http://www.nielsen.com/us/en/nielsen-solutions/nielsen-measurement/nielsen-retail-measurement.html (accessed April 2014).

108. Wal-Mart Stores Inc. Internet: corporate.walmart.com/our-story/our-business/walmart-us May 2014).

109. Slining MM, Ng SW, Popkin BM. Food companies' calorie-reduction pledges to improve U.S. diet. Am J Prev Med 2013;44(2):174-84.

110. Kleinbaum DG, Klein M. Modeling strategy for assessing interaction and confounding. Edtion ed. Logistic Regression: Springer, 2010:203-39.

111. Williams RL. A note on robust variance estimation for cluster-correlated data. Biometrics 2000;56:645-6.

112. Rogers WH. Regression standard errors in clustered samples. Stata Technical Bulletin 1993;13:19-23.

113. Bustillos B, Sharkey JR, Anding J, McIntosh A. Availability of more healthful food alternatives in traditional, convenience, and nontraditional types of food stores in two rural Texas counties. J Am Diet Assoc 2009;109(5):883-9.

114. Kaufman PR, MacDonald JM, Lutz SM, Smallwood DM. Do the Poor Pay More for Food? Item Selection and Price Differences Affect Low-Income Household Food Costs. Food and Rural Economics Division, Economic Research Service, US Department of Agriculture, 1997.

115. Basker E, Noel M. The Evolving Food Chain: Competitive Effects of Wal-Mart's Entry into the Supermarket Industry. J Econ Manag Strategy 2009;18(4):977-1009.

116. Volpe RJ, Lavoie N. The effect of Wal-Mart supercenters on grocery prices in New England. Appl Econ Perspect Pol 2008;30(1):4-26.

117. Leibtag ES, Barker C, Dutko P. How much lower are prices at discount stores? An examination of retail food prices. United States Department of Agriculture, Economic Research Service, 2010.

118. Chou S-Y, Grossman M, Saffer H. An economic analysis of adult obesity: results from the Behavioral Risk Factor Surveillance System. J Health Econ 2004;23(3):565-87.

119. Lakdawalla D, Philipson T. The growth of obesity and technological change: a theoretical and empirical examination. National Bureau of Economic Research, 2002.

120. Drewnowski A. Obesity and the food environment: dietary energy density and diet costs. Am J Prev Med 2004;27(3 Suppl):154.

121. Ludwig DS. Technology, diet, and the burden of chronic disease. JAMA 2011;305(13):1352-3. doi: 10.1001/jama.2011.380.

122. Monteiro CA, Levy RB, Claro RM, de Castro IR, Cannon G. Increasing consumption of ultra-processed foods and likely impact on human health: evidence from Brazil. Public Health Nutr 2011;14(1):5-13. doi: 10.1017/S1368980010003241.

123. Courtemanche C, Carden A. Supersizing supercenters? The impact of Walmart Supercenters on body mass index and obesity. J Urban Econ 2011;69(2):165-81.

124. Jilcott SB, Keyserling T, Crawford T, McGuirt JT, Ammerman AS. Examining associations among obesity and per capita farmers' markets, grocery stores/supermarkets, and supercenters in US counties. J Am Diet Assoc 2011;111(4):567-72.

125. Martinez S, Hand M, Da Pra M, Pollack S, Ralston K, Smith T, Vogel S, Clark S, Lohr L, Low S, et al. Local Food Systems: Concepts, Impacts, and Issues. US Department of Agriculture, Economic Research Service, 2010.

126. Walmart Inc. Internet: http://corporate.walmart.com/global-responsibility/environment-sustainability/sustainable-agriculture April 2014).

127. Harkinson J. Internet: http://www.motherjones.com/mojo/2013/11/walmart-targets-low-income-consumers-junk-food May 2014).

128. United States Congress. Federal Agriculture Reform and Risk Management Act of 2013, One Hundred Thirteenth Congress, Second Session, January 27, 2014. In: House of Representatives Committee on Agriculture, ed. Washington: Government Printing Office, 2014.

129. Walmart. The 20th Annual Meeting for the Investment Community. 2013.

130. Hoch SJ, Kim B-D, Montgomery AL, Rossi PE. Determinants of store-level price elasticity. Journal of Marketing Research 1995:17-29.

131. Sharkey JR, Horel S, Han D, Huber JC, Jr. Association between neighborhood need and spatial access to food stores and fast food restaurants in neighborhoods of colonias. Int J Health Geogr 2009;8(9):8-9.

132. Dean WR, Sharkey JR. Rural and urban differences in the associations between characteristics of the community food environment and fruit and vegetable intake. J Nutr Educ Behav 2011;43(6):426-33.

133. Kaufman PR. Measuring Access to Nutritious, Affordable Food: A National Assessment. JFDR 2010;41(1).

134. Stiegert KW, Sharkey T. Food pricing, competition, and the emerging supercenter format. Agribusiness 2007;23(3):295-312.

135. Balto DA. Supermarket merger enforcement. J Public Policy Mark 2001;20(1):38-50.

136. Davis DE. Prices, promotions, and supermarket mergers. JAFIO 2010;8(1).

137. Jabs J, Devine CM. Time scarcity and food choices: an overview. Appetite 2006;47(2):196-204. doi: 10.1016/j.appet.2006.02.014.

138. Seiders K, Simonides C, Tigert DJ. The impact of supercenters on traditional food retailers in four markets. IJRRBP 2000;28(4/5):181-93.

139. Tropp D, Ragland E, Barham J. The Dynamics of Change in the US Food Marketing Environment. Washington, DC: U.S. Department of Agriculture, 2008.

140. Cummins S, Petticrew M, Higgins C, Findlay A, Sparks L. Large scale food retailing as an intervention for diet and health: quasi-experimental evaluation of a natural experiment. J Epidemiol Community Health 2005;59(12):1035-40.

141. Smith LP, Ng SW, Popkin BM. The emerging role of Walmart in US packaged food purchases: who shops there, how much is purchased, and public health implications. Under review 2014.

142. Bonanno A, Goetz SJ. Food Store Density, Nutriton Education, Eating Habits and Obesity. International Food and Agribusiness Management Review 2012;15(4):1-26.

143. Ng SW, Slining MM, Popkin BM. Turning point for US diets? Recessionary effects or behavioral shifts in foods purchased and consumed. Am J Clin Nutr 2014;99(3):609-16.

144. Stern D, Ng SW, Popkin BM. Where do we shop? Understanding the nutrient profile of US households packaged food purchases by type of store. In preparation 2014.

145. Bureau of Labor Statistics. Internet: http://www.bls.gov/lau/ June 2014).

146. Holmes TJ. The Diffusion of Wal-Mart and Economies of Density. Econometrica 2011;79(1):253-302.

147. Holmes TJ. Internet: http://www.econ.umn.edu/~holmes/data/WalMart/store_openings.html June 2014).

148. AggData. Internet: http://www.aggdata.com/aggdata/complete-list-walmart-locations June 2014).

149. United States Census Bureau. Internet: http://www.census.gov/popest/data/ June 2014).

150. Hogan JW, Lancaster T. Instrumental variables and inverse probability weighting for causal inference from longitudinal observational studies. Stat Methods Med Res 2004;13(1):17-48.

151. Cole SR, Hernán MA. Constructing inverse probability weights for marginal structural models. Am J Epidemiol 2008;168(6):656-64.

152. Seaman SR, White IR. Review of inverse probability weighting for dealing with missing data. Stat Methods Med Res 2013;22(3):278-95.

153. Greenland S. Modeling and variable selection in epidemiologic analysis. Am J Public Health 1989;79(3):340-9.

154. Weng H-Y, Hsueh Y-H, Messam LLM, Hertz-Picciotto I. Methods of covariate selection: directed acyclic graphs and the change-in-estimate procedure. Am J Epidemiol 2009;169(10):1182-90.

155. Greenland S, Pearl J, Robins JM. Causal diagrams for epidemiologic research. Epidemiology 1999;10(1):37-48.

156. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2010. 7th ed. Washington, D.C., 2010:1-91.

157. Prentice AM, Jebb SA. Fast foods, energy density and obesity: a possible mechanistic link. Obesity Rev 2003;4(4):187-94.

158. Agriculture USDo, Services USDoHaH. Dietary Guidelines for Americans, 2010. 7th ed. Washington, DC, 2010.

159. Ng SW, Slining MM, Popkin BM. The Healthy Weight Commitment Foundation Marketplace Commitment and Consumer Packaged Goods purchased by US households with children Am J Prev Med 2014;47(4):520-30.

160. Ng SW, Slining MM, Popkin BM. The healthy weight commitment foundation pledge: calories sold from U.S. Consumer packaged goods, 2007-2012. Am J Prev Med 2014;47(4):508-19.

161. Bower KM, Thorpe Jr RJ, Rohde C, Gaskin DJ. The intersection of neighborhood racial segregation, poverty, and urbanicity and its impact on food store availability in the United States. Prev Med 2014;58:33-9.

162. Zhen C, Taylor JL, Muth MK, Leibtag E. Understanding differences in self-reported expenditures between household scanner data and diary survey data: a comparison of

Homescan and consumer expenditure survey. Appl Econ Perspect Pol 2009;31(3):470-92.

163. Akin JS, Guilkey DK, Popkin BM. The school lunch program and nutrient intake: A switching regression analysis. Am J Agric Econ 1983;65(3):477-85.

164. Dötsch M, Busch J, Batenburg M, Liem G, Tareilus E, Mueller R, Meijer G. Strategies to reduce sodium consumption: a food industry perspective. Crc Cr Rev Food Sci 2009;49(10):841-51.

165. Ford CN, Ng SW, Popkin BM. Are food and beverage purchases in households with preschoolers changing?: a longitudinal analysis from 2000 to 2011. Am J Prev Med 2014;47(3):275-82.

166. Kit BK, Fakhouri TH, Park S, Nielsen SJ, Ogden CL. Trends in sugar-sweetened beverage consumption among youth and adults in the United States: 1999-2010. Am J Clin Nutr 2013;98(1):180-8.

167. Piernas C, Ng S, Popkin B. Trends in purchases and intake of foods and beverages containing caloric and low-calorie sweeteners over the last decade in the United States. Pediatr Obes 2013.

168. Mozaffarian D. The Healthy Weight Commitment Foundation Trillion Calorie Pledge: Lessons from a Marketing Ploy? Am J Prev Med 2014;47(4):e9-e10.

169. Marcason W. What are the new national school lunch and breakfast program nutrition standards? J Acad Nutr Diet 2012;112(7):017.

170. Ohri-Vachaspati P, Turner L, Chaloupka FJ. Fresh Fruit and Vegetable Program participation in elementary schools in the United States and availability of fruits and vegetables in school lunch meals. J Acad Nutr Diet 2012;112(6):921-6.

171. Bassett MT, Dumanovsky T, Huang C, Silver LD, Young C, Nonas C, Matte TD, Chideya S, Frieden TR. Purchasing behavior and calorie information at fast-food chains in New York City, 2007. Am J Public Health 2008;98(8):1457-9.

172. Bonanno A, Goetz SJ. Adult Obesity and Food Stores' Density–Evidence from State-Level Panel Data. Agricultural and Applied Economics Association, Denver, CO 2010.

173. Lusk JL, Brooks K. Who Participates in Household Scanning Panels? Am J Agric Econ 2011;93(1):226-40.

174. Einav L, Leibtag E, Nevo A. Not-so-classical measurement errors: a validation study of Homescan. National Bureau of Economic Research, 2008.

175. Einav L, Leibtag E, Nevo A. Recording discrepancies in Nielsen Homescan data: Are they present and do they matter? QME 2010;8(2):207-39.

176. Spinner J. Internet: http://www.foodproductiondaily.com/Markets/Food-packaging-reflects-trends-in-fresh-products October 2014).

177. Partnership for a Healthier America. Internet: http://ahealthieramerica.org/our-partners/ November 2014).

178. Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. Curr Opin Lipidol 2002;13(1):3-9.

179. Calton EK, James AP, Pannu PK, Soares MJ. Certain dietary patterns are beneficial for the metabolic syndrome: reviewing the evidence. Nutr Res 2014;34(7):559-68.

180. Steffen LM, Van Horn L, Daviglus ML, Zhou X, Reis JP, Loria CM, Jacobs DR, Duffey KJ. A modified Mediterranean diet score is associated with a lower risk of incident metabolic syndrome over 25 years among young adults: the CARDIA (Coronary Artery Risk Development in Young Adults) study. Br J Nutr 2014;19:1-8.

181. Jacobs S, Harmon BE, Boushey CJ, Morimoto Y, Wilkens LR, Le Marchand L, Kroger J, Schulze MB, Kolonel LN, Maskarinec G. A priori-defined diet quality indexes and risk of type 2 diabetes: the Multiethnic Cohort. Diabetologia 2014;16:16.

182. Rose D, Hutchinson PL, Bodor JN, Swalm CM, Farley TA, Cohen DA, Rice JC. Neighborhood food environments and Body Mass Index: the importance of in-store contents. Am J Prev Med 2009;37(3):214-9.

183. Morland K, Wing S, Diez Roux A, Poole C. Neighborhood characteristics associated with the location of food stores and food service places. Am J Prev Med 2002;22(1):23-9.

184. Galvez MP, Morland K, Raines C, Kobil J, Siskind J, Godbold J, Brenner B. Race and food store availability in an inner-city neighbourhood. Public Health Nutr 2008;11(6):624-31.

185. Powell LM, Slater S, Mirtcheva D, Bao Y, Chaloupka FJ. Food store availability and neighborhood characteristics in the United States. Prev Med 2007;44(3):189-95.

186. Bodor JN, Rice JC, Farley TA, Swalm CM, Rose D. The association between obesity and urban food environments. J Urban Health 2010;87(5):771-81.