UNDERSTANDING THE ROLES THAT FOOD MANUFACTURERS, GOVERNMENT, AND CONSUMERS PLAY IN EFFORTS TO REDUCE PURCHASES OF GRAIN-BASED DESSERTS

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ABSTRACT

Kevin Clark Mathias: Understanding the Roles that Food Manufacturers, Government, and Consumers Play in Efforts to Reduce Purchases of Grain-Based Desserts
(Under the direction of Barry Popkin)

The obesity epidemic has resulted in an interest among food manufacturers and government officials to develop strategies to reduce excess caloric intake and improve dietary quality in the United States (US). Grain-Based Desserts (GBD) (e.g., cakes, cookies and pies) were the main focus of this dissertation because they are one of the largest sources of calories in the US diet. This analysis examined food/beverage purchases from households in the Nielsen Homescan longitudinal dataset 2000-2012 (n=159,184). The aims of this research were to evaluate strategies involving food manufacturers and governmental legislation to reduce excess caloric intake and improve dietary quality in the US.

Aim 1 examined changes in the energy, saturated fat, and sugar density of GBD manufactured in the US between 2005 and 2012. An increase in the saturated fat density of manufactured GBD was shown. Aim 2 determined if households purchased fewer GBD across time or purchased GBD with lower energy, saturated fat, or sugar densities. Households purchased GBD with lower energy and sugar densities, and GBD with higher saturated fat density. Overall purchases of GBD decreased between 2005 and 2012. Aim 3 examined simulations increasing the price of only GBD by 10% on household purchases versus increasing the price of multiple snack/dessert foods by 10%. Evidence that a 10% increase in the price of GBD could result in consumers shifting to other snack/dessert foods was shown. In addition, a 10% increase in the price of multiple snack/dessert foods was more effective at decreasing purchases of calories, saturated fat and sugar. The results also suggest that legislation to

increase prices of snack/dessert foods by 10% would not place economic burden on households with low, medium, or high economic status. In summary, the results from this dissertation inform both food manufacturers and government officials on potential opportunities to reduce excess caloric intake and improve dietary quality in the US.

TABLE OF CONTENTS

List of Tables vii

List of Figures ix

List of Abbreviations x

Chapter 1: Introduction 1

Background 1

Research Aims 2

Chapter 2: Literature Review 3

Why Grain-Based Desserts? 3

Why Examine Purchases? 3

Grain-Based Desserts in the Literature 4

Less Healthy Components in Grain-Based Desserts 5

Household Characteristics Associated with Lower Dietary Quality 6

Tax Simulations 6

Chapter 3: Monitoring Changes in the Nutritional Content of Ready-To-Eat Grain-Based Dessert Products Manufactured and Purchased Between 2005 and 2012 8

Abstract 8

Introduction 9

Methods 11

Results 14

Discussion 15

Chapter 4: Associations of Higher Prices with Lower Purchases of Ready-To-Eat Grain-Based Desserts and Alternative Snacks/Desserts 26

Abstract 26

Introduction 27

Methods 29

Results 33

Discussion 35

Chapter 5: Estimating the Potential Impacts of a Snack and Dessert Tax on Households Differing in Economic Status 46

Abstract 46

Introduction 47

Methods 49

Results 52

Discussion 53

Chapter 6: Synthesis 63

Overview of the Findings 63

Public Health Impact and Significance 65

Limitations and Strengths 67

Directions for Future Research 68

References 70

LIST OF TABLES

Table 3.1 Characteristics of the Nielsen Homescan household sample in 2005 and 2012 20

Table 3.2 Ready-to-eat Grain-Based Dessert (GBD) products with available Nutrition Facts Panel (NFP) information for the product and purchase level analyses in 2005-2012 21

Table 3.3 Distributions of the ready-to-eat Grain-Based Dessert (GBD) products available to consumers by energy, saturated fat, and sugar density in 2005-2012 22

Table 3.4 The average energy, saturated fat, and sugar density of ready-to-eat Grain-Based Dessert (GBD) products purchased by households in 2005-2012 23

Table 3.5 Nationally representative average per capita daily ready-to-eat Grain-Based Dessert (GBD) purchases, and the percent change in ready-to-eat GBD purchases from 2005-2012 using a log-linear random effects model 24

Table 3.6 The percent decrease in grams of ready-to-eat Grain-Based Dessert (GBD) products purchased from 2005-2012 between households with and without children using a log-linear random effects model 25

Table 4.1 Characteristics of the Nielsen Homescan household sample in 2000, 2006, and 2012 39

Table 4.2 Descriptive statistics for price, energy density, saturated fat density, sugar density, and per capita grams purchased per day for selected food groups in 2000, 2006 and 2012 40

Table 4.3 Price elasticity of GBD products between 2000 and 2012 from two part marginal effects models 41

Appendix Table 4.1 Types of products categorized as snacks & desserts 44

Appendix Table 4.2 Beta coefficients for the interaction of logged price with time with respect to logged purchases of GBD for the probit and conditional regression model 45

Table 5.1 Characteristics of the Nielsen Homescan sample in 2012 by Federal Poverty Guidelines (FPG) 58

Table 5.2 Descriptive statistics for price, energy, dollars, and percent of total purchases of foods and beverages for selected food groups by household economic status 59

Appendix Table 5.1 Types of products categorized as snacks & desserts 62

LIST OF FIGURES

Figure 4.1 Predicted changes in store-bought nutrients from Alternative Snacks/Desserts and Total Snacks/Desserts associated with a 10% increase in the price of RTE GBD and a 10% increase in the price of Total Snacks/Desserts 42

Figure 4.2 Predicted decreases in total calorie purchases from stores (A) and the predicted weight loss (B) associated with a 10% increase in the price of RTE GBD and a 10% increase in the price of Total Snacks/Desserts 43

Figure 5.1 Predicted changes in store-bought nutrients and expenditures from snacks & desserts associated with a 10% increase in the price of snacks & desserts 60

Figure 5.2 Predicted changes in store-bought nutrients and expenditure from all foods and beverages associated with a 10% increase in the price of snacks & desserts 61

LIST OF ABBREVIATIONS

GBD	Grain-Based Desserts
FOP	Front of Package
FPG	Federal Poverty Guidelines
FSRG	Food Surveys Research Group
NFP	Nutrition Facts Panel
NHANES	National Health and Nutrition Examination Survey
RTE	Ready-To-Eat
SoFAS	Solid Fats and Added Sugars
SSB	Sugar-Sweetened Beverages
UPC	Universal Product Code
US	United States

Chapter 1. Introduction

Background

The 2010 Dietary Guidelines for Americans states that consuming fewer foods high in solid fats and added sugars (SoFAS) is a strategy to control caloric intake, manage body weight, and limit intake of food components that increase the risk of many chronic diseases. Grain-based desserts (GBD) (e.g., cakes, cookies and pies) are the largest source of solid fats and the second largest source of added sugars in American's diets. In addition, GBD were the top contributor of calories in 2005-06 among children (2-18 years old) and adults (≥19 years old). Currently, the few studies that have focused on GBD consumption have been cross-sectional and have ignored determinants of purchasing behaviors. Given that over 70% of GBD are purchased at the store, identifying factors that affect household purchases of GBD from stores is essential for developing strategies to decrease intake of GBD, less healthy nutrients from GBD, and total calories in the US. This study will use longitudinal data from households that participated in the Nielsen Homescan panel between 2000 and 2012, which provides information on household composition, demographics, socioeconomic status, as well as, household purchases of consumer packaged foods/beverages. Both the amount purchased and the content of GBD products contribute to SoFAS intake; linking the Nutrition Facts Panel information to the products purchased by the Homescan panel allows a unique opportunity to evaluate the concentration of less healthy components in GBD products; identify household characteristics that are associated with purchasing GBD with higher concentrations of less healthy components; and finally, evaluate potential policy strategies to decrease purchases of GBD.

Research Aims

Aim 1: Examine how the concentration of less healthy components (e.g., energy, saturated fat and total sugars) in GBD products has changed between 2005 and 2012.

Aim 2: Examine how consumer purchases of GBD with higher concentrations of less healthy components has changed between 2005 and 2012.

- **2a**. Examine changes in the amount of GBD household purchase over time (2005-2012)
- **2b**. Examine interactions between household characteristics and change in purchases of GBD over time.
- **2c**. Examine interactions between household characteristics and change in the average densities of energy, saturated fat, and sugar of GBD products purchased over time.

Aim 3: Determine the association of higher prices of GBD on purchases of alternative snacks/desserts. Compare simulations increasing the price of GBD products versus increasing the prices of total snacks/desserts with purchases of total snack/desserts and total calories purchased from stores.

- **3a**. Examine dietary changes and economic burden associated with a 10% increase in the prices of snacks and desserts between households differing in economic status.

Chapter 2. Literature Review

Why Grain-Based Desserts?

In the United States (US), roughly one-third of children and two-thirds of adults are overweight or obese.[1,2] Limiting consumption of foods high in Solid Fats and Added Sugars (SoFAS) has been recommended as a strategy to control caloric intake and manage body weight by the 2010 Dietary Guidelines for Americans.[3] SoFAS are sources of energy that contain little nutritional value[4] and therefore are considered discretionary calories (the calories that are allowable only after recommended nutrient intakes have been met).[5] All age-gender groups in the US exceed their recommended discretionary calorie intake and Grain-Based Desserts (GBD) (e.g., cakes, cookies and pies) are the largest source of solid fats and the second largest source of added sugars in American's diets.[3] In addition, GBD were the top contributor of calories in 2005-06 among both children (2-18 years old) and adults (≥19 years old); contributing seven and six percent of their total energy intake, respectively.[3]

Why Examine Purchases?

Currently, the few studies that have examined GBD consumption on a national level have been cross-sectional and have ignored determinants of purchasing behaviors.[4,6] After analyzing the most recent 2009-2010 What We Eat In America, National Health and Nutrition Examination Survey (NHANES), it was determined that 76% of GBD consumed (kcal) were purchased from stores. Analysis of the NHANES 2003-04, 2005-06, and 2007-08 all showed that stores have been consistently the primary (>70%) provider of GBD to children and adolescents ages 2-18 years old. Given these findings, by utilizing the Homescan data of store purchases by households, we will be able to examine factors that affect over 70% of GBD consumption. Identifying factors that affect household purchases of GBD is essential for

developing strategies to decrease intake of GBD in the US. The proposed study will use data from households that participated in the Nielsen Homescan panel between 2000 and 2012, which provides information on household composition (i.e., the number, age and gender of children and adults living in a household), demographics, and socioeconomic status of the household. The Nielsen Homescan panel is a nationally representative longitudinal panel report on household purchases of consumer packaged foods/beverages, the quantity purchased, and the amount paid for each item from supermarkets, grocery stores, convenience stores, and other food retail outlets. The advantage of examining household purchases is that we can begin to understand factors that govern the home food environment. Availability of less healthy foods (e.g., sweet snacks at home is positively associated with sweet snack consumptions among adolescent girls).[7] In addition, the Nielsen Homescan panel provides a unique opportunity to investigate how price affects GBD purchases which allows for tax simulations to be conducted.

Grain-Based Desserts in the Literature

One concern when investigating the largest sources of energy or a nutrient of interest is how large and broad of an umbrella does the definition of a food category cover. For instance an extremely diverse food category that covers many different types of products might be a large source of calories solely because of the number of different products that fall into that category. The definition of GBD used by the National Cancer Institute[6] and as defined by the Food Surveys Research Group FSRG for all What We Eat In America NHANES includes the following food categories: cakes, cookies, pies, pastries, doughnuts, breakfast bars, breakfast pastries granola bars, and graham crackers.[8] With such a diverse product category, it is difficult to determine if the size of the category or the products themselves result in GBD being a top source of calories and less healthy food components. Currently, the few studies that have focused on the GBD category have only examined intake, and investigations into the nutritional quality of the products themselves are limited.[9-11] This will be the first study in the US to comprehensively examine the concentration of less healthy components of GBD products sold

in the market. In order to understand why GBD are among the top sources of calories in the US, the first step is to examine the nutritional attributes of the GBD products themselves**.** Understanding if it is the content of the GBD products, the amount that people consume of those products, or both, is important to develop targeted strategies to decrease intake of less healthful food components. In addition, monitoring changes in the composition of the GBD products provides insight into whether or not the food industry has made any attempt to decrease the concentration of components that are known to have adverse health effects in GBD products sold in the market.

Less Healthy Components in Grain-Based Desserts

Saturated Fat

Grain-Based Desserts are the third largest source of saturated fat in the diets of the US population[3], and saturated fats have been shown to be associated with cardiovascular disease. Feeding studies replacing saturated fat with mono-unsaturated fatty acids and poly unsaturated fatty acids resulted in decreased total cholesterol and LDL cholesterol,[12-14] both of which are markers for increased risk of cardiovascular disease. A meta-analysis of 11 cohort studies examining the effects of exchanging mono-unsaturated, poly- unsaturated or carbohydrates for saturated fatty acids found an inverse association of coronary death hazard ratio 0.74, 95% CI, 0.61-0.89 for a 5% substitution of saturated fatty acids with polyunsaturated fatty acids.[15]

Total/Added Sugars

A recent meta-analysis of 30 randomized controlled trials and 38 cohort studies of adults with ad libitum diets showed that reduced intake of sugars was associated with weight loss, and increased sugar intake was associated with weight gain.[16] Substitution of other carbohydrates for sugars did not result in changes in body weight indicating that the weight change is mediated by changes in energy intake. Sugar intake, relative to other carbohydrate sources, is also associated with increased levels of triglycerides; a risk factor for coronary heart disease.[17] Consumption of sweet foods has been associated with increased risk of breast cancer (OR:

1.27, 95% CI: 1.00-1.61) comparing the highest to lowest quartile. The OR was higher when only dessert foods were considered (OR = 1.55), and even stronger when the dessert consumption of only pre-menopausal women was analyzed (OR = 2.00).[18]

Energy Density

In 2003, the World Health Organization issued a statement that consumption of energy-dense foods in excessive amounts can lead to weight gain.[19] Both, children and adults have been shown to consume fewer calories when eating low-energy-dense foods as compared to high-energy-dense foods.[20-25]

Household Characteristics Associated with Lower Dietary Quality

Previous research has examined differences in adherence to the 2005 Dietary Guidelines[26] and specifically with intake of added sugars[27] by race/ethnicity and socioeconomic status. Currently, studies examining household characteristics that are associated with GBD purchases have focused on volume and expenditure, but have not examined caloric content or the concentrations of less healthy components in the GBD products purchased.[28,29]

Tax Simulations

Tax simulations have been conducted by utilizing observational data that contains variation in the price paid for a product across different populations and/or across time. Simulations using the effects of price on purchases have been utilized to predict the effects of placing a saturated fat tax on consumers' intake of saturated fat.[30-33] While increases in price resulted in lower purchases of saturated fat they also resulted in unintended dietary outcomes. For instance, simulations of taxing saturated fat have also shown increases in less healthy dietary components from foods and beverages such as salt,[31,33] and sugar.[34] Other taxation models have examined taxing individual food groups such as sugar-sweetened beverages (SSB),[35-41] pizza,[36] and potato chips/salty snacks.[42] One concern with taxing single food groups is the impact on foods associated with the taxed food group, and if taxation results in higher purchases of other less healthy food/beverage groups. One study examining the effects of a

SSB tax on purchases of non-beverage items found that purchases of cookies and candy were not affected, but that salty snacks and ice-cream also decreased when the price of SSB increased.[40] Given these findings, understanding how taxation of GBD affects purchases of other less healthy foods is important to understand how future taxations will affect the overall diet.

Chapter 3. Monitoring Changes in the Nutritional Content of Ready-To-Eat Grain-Based Dessert Products Manufactured and Purchased Between 2005 and 2012

Abstract

Background: Monitoring changes in the nutritional content of food/beverage products and shifts in consumer purchasing behaviors is needed to measure the effectiveness of efforts by both food manufacturers and policy makers to improve dietary quality in the United States.

Objective: Examine changes in the nutritional content (e.g., energy, saturated fat, and sugar density) of Ready-To-Eat (RTE) Grain-Based Dessert (GBD) products manufactured and purchased between 2005 and 2012.

Design: Nutrition facts panel information from commercial databases was linked to RTE GBD products purchased by households (n=134,128) in the Nielsen Homescan longitudinal dataset 2005-2012.

Statistical Analysis: Linear regression models were utilized to examine changes in the energy, saturated fat, and sugar density of RTE GBD products manufactured in each year between 2005 and 2012. Random effects models controlling for demographics, household composition/size, and geographic location were utilized to examine changes in household purchases of RTE GBD products (grams) and the average energy, saturated fat, and sugar density of RTE GBD products purchased.

Results: The saturated fat density (g/100 g) of RTE GBD products increased significantly from 6.5 ± 0.2 in 2005 to 7.3 ± 0.2 and 7.9 ± 0.2 for pre-existing and newly introduced products in 2012, respectively. Between 2005 and 2012, the energy density (kcal/100 g) of RTE GBD products purchased decreased significantly from 433 ± 0.2 to 422 ± 0.2, the saturated fat density (g/100 g) of products purchased increased significantly from 6.3 ± 0.01 to 6.6 ± 0.01, the

sugar density (g/100 g) of products purchased decreased significantly from 32.4 ± 0.03 to 31.3 ± 0.02, and household purchases of RTE GBD products (grams) decreased by 24.1 ± 0.4%. **Conclusions:** These results highlight an opportunity for both food manufacturers and public health officials to develop new strategies to shift consumer purchases towards products with lower energy, saturated fat, and sugar densities in addition to decreasing overall purchases of RTE GBDs.

Introduction

The obesity epidemic[43,44] has resulted in an interest among food retailers[45] and food manufacturers[46,47] to develop strategies to reduce excess caloric intake and improve dietary quality in the United States (US). In 2005, The Institute of Medicine released a report on food marketing to children recommending shifts towards new and reformulated youth-oriented products with less energy, fat, salt and added sugar.[48] Recent large scale initiatives by Walmart[3] and the Healthy Weight Commitment Foundation,[47] whose members include 16 of the nation's leading food manufacturers, demonstrate intent within the food industry to improve dietary quality in the US; however, current methods to monitor changes to manufactured food products and consumers' responses to these changes are limited.

Grain-Based Dessert (GBD) products (e.g., cakes, cookies and pies) were chosen for this case-study because they constitute 7.2% of calories in the US diet and are the largest or one of the largest contributors of calories to children, adolescents, and adults.[49-52] GBDs are also the largest source of solid fats (10.8%), and the 2nd largest source of added sugar (12.9%);[53] both of which are targeted by the 2010 Dietary Guidelines for Americans as components of foods to limit as a strategy to control caloric intake, manage body weight, and prevent increased risk of many chronic diseases. A complexity with researching the entire GBD category is that dry cake/brownie mixes, frozen/refrigerated sweet-rolls, and Ready-To-Eat (RTE) products such as cookies are all categorized as GBDs. This analysis focused on RTE

GBD products because they represent the majority of the purchases of GBD products and the nutrition information available is in the form of what is consumed.

Reformulation of existing products or new product development by food manufacturers can provide products with lower concentrations of saturated fat, sugar, salt and energy to consumers. Additional tactics to modify purchases include public health campaigns, taxation/subsidies, and shifts in marketing strategies to promote healthier products. With the introduction of front-of-package labeling systems rating the healthfulness of products[54-56] and initiatives to decrease marketing of less healthy products to children,[46] monitoring changes in consumer purchases is essential to determine the effectiveness of these initiatives. Currently, researchers utilize the National Health and Nutrition Examination Surveys (NHANES) to examine changes in intake of food/beverage groups or nutrients across time. A difficulty with measuring changes in the nutritional content of foods/beverages manufactured and purchased using NHANES is that with the exception of RTE cereals,[57] and a few other items, the nutrition information for the products reported consumed is not at the brand-level.[58] An alternative approach taken by this analysis was to use the Nutrition Facts Panel (NFP) information from consumer packaged foods/beverages purchased by consumers in the US. Utilizing the NFP information from products purchased allows for a more detailed examination of changes to the nutritional content of products manufactured and monitoring if consumers are shifting purchases within categories towards products with lower concentrations of energy, saturated fat, and sugar. For this study, two levels of analysis using NFP information were conducted. The product level analysis reported distributions of energy, saturated fat, and sugar density of RTE GBD products manufactured in 2005 through 2012. The purchase level analysis determined if households purchased fewer RTE GBD products across time or purchased RTE GBD products with lower energy, saturated fat, or sugar densities.

Methods

Household Sample

The sample of households (n=134,128) was obtained from the Nielsen Homescan panel (2005-2012), a longitudinal dataset on household purchases of foods/beverages from supermarkets, grocery stores, convenience stores, and other food retail outlets.[47,59-62] A convenience sample of households is continually recruited by Nielsen using direct mailing and Internet advertising. On average, households in the panel between 2005 and 2012 provided 14 quarters (quarter is equivalent to 3 months) of purchase data. Households selected to participate were geographically dispersed with a total of 76 markets included in the analysis. Each participating household was provided with a scanner to record the Universal Product Code (UPC) of each purchase and quantity of each item. Purchases from each household were aggregated for each quarter. Reports from single person households with food/beverage purchases less than $45 per quarter and households with 2 or more individuals with food/beverage purchases less than $135 per quarter were deemed unreliable and excluded from the analysis. Based on this criteria, 2.8% of the quarterly reports by households were excluded. The characteristics of the final household sample in 2005 and 2012 are provided in (**Table 3.1**).

Ready-To-Eat Grain-Based Dessert Definition

Ready-to-eat products such as cakes, cookies, pies, pastries, sweet strudels, doughnuts, granola/yogurt bars, and graham crackers were classified as RTE GBDs. Products that are specifically grouped with breakfast products such as toaster pastries and breakfast bars were excluded. Dry mixes and frozen/refrigerated products were excluded because information on the final product consumed was not available. Products from service outlets (e.g., restaurants and bakeries) and products baked on location at food retail stores were not included in this analysis.

Nutrition Facts Panel Information

Each year, commercial data sources[47] collected up-to-date NFP information on a new sample of products from the RTE GBD product population. The UPC for a product purchased by a household in Homescan was linked with NFP information obtained from the commercial databases with the exact UPC. If NFP information was not available for a product in the year it was purchased then NFP information from the subsequent year or the next closest previous year was assigned. For RTE GBD products without an exact UPC match, NFP information was obtained by a series of steps: 1) match NFP information from a product of the same brand and product description, but different size package; 2) match NFP information by brand, product type, and similar attributes in the product description; 3) match NFP information based on similar product type and product description. Products with infeasible NFP information (e.g., ≥100% sugar) were removed from all analyses utilizing NFP information (1.4% of products with NFP information across all years had infeasible NFP information).

For the product level analysis only exact UPC matches with NFP information updated in the same year the product was purchased were utilized. While these restrictions minimized the sample of products with available NFP, using only up-to-date NFP information combined with repeated sampling of RTE GBD products in each year between 2005 and 2012 increased the likelihood of detecting changes in the distribution of RTE GBD products across time. In order to examine new product development, the products with updated 2012 NFP information were divided into two categories: 1) pre-existing products prior to 2012; 2) new products that only existed in 2012. New products in 2012 were identified as UPCs that were not purchased by any household in any year between 2000 and 2011.

For the purchase level analyses, all NFP information available was assigned to the products to maximize the amount of products purchased with NFP information. The number of RTE GBD products with NFP information in the product level and purchase level analyses; the percent of total purchases those products represent; and the total number of RTE GBD products

available to consumers in each year are presented in (**Table 3.2**). It should be noted that the total number of RTE GBD products with UPCs available to consumers each year might be underestimated if a particular product was not purchased or scanned by any household in the sample in a given year.

Statistical Analysis

All analyses were conducted using Stata (version 12.0, 2011, StataCorp, College Station, TX) with a significance criteria of ($P<0.05$). This secondary data analysis was deemed exempt by the University of North Carolina at Chapel Hill Institutional Review Board.

Product Level Analysis

Each year, the percentage of products with available up-to-date NFP information from commercial data sources differed between types of RTE GBD products (e.g., in 2005, 5% of cookie products had NFP information versus 9% of granola bars). Inverse probability weights for having NFP information were applied to each type of RTE GBD in each year so that the distribution of products with NFP information reflected the distribution of all RTE GBD products manufactured. The distribution of RTE GBD products manufactured in 2005 through 2012 was separately analyzed for energy density (kcal / 100 g), saturated fat density (g / 100 g), and sugar density (g / 100 g). In order to calculate percentiles that represent the distribution of RTE GBD products manufactured, replicates of products within each type of RTE GBD corresponding to the inverse probability weight were generated. In a separate analysis, linear regression models applying the inverse probability weights were used to determine if the mean energy, saturated fat, or sugar density of RTE GBD products changed over time.

Purchase Level Analysis

For each household, the quarterly reports were averaged within each year. Random effects models, clustering at the household level, were used to examine changes over time (2005-2012) of RTE GBD purchases (grams) and the average energy, saturated fat, and sugar density of RTE GBD products purchased by households. Due to the positive skewness in the

distribution of RTE GBDs purchased (grams), log-linear models (logged outcome) were utilized resulting in interpreting coefficients as percent change rather than absolute change. Across all years, the average percentage of non-consumers was 2.2%, with a range of 1.93-2.44%. Given the similarity in percentage of non-consumers across years, non-consumers (zeros) were excluded from the log-linear models. Covariates listed in (**Table 3.1**) were included in all models along with dummy variables for year and the 76 markets. Household composition and household size was controlled for by including sex specific variables for the number of individuals in the household belonging to particular age groups. A second set of models including interactions between year (dummy variable) and the covariates in (**Table 3.1**) were analyzed to determine if changes across time were different between household characteristics. Due to the large sample size, both statistical and meaningful differences needed to be considered; therefore, interactions were only reported if a difference in change over time between household characteristics was greater than 5% and statistically significant. To provide context for the magnitude of change in the log-linear models, survey commands applying sampling weights were used to generate estimates of nationally representative average per capita daily purchases for each year.

Results

Product Level Results

Significant differences in the average energy and sugar density of RTE GBD products available to consumers in 2005 and 2012 were not observed (**Table 3.3**). The average saturated fat density (g / 100 g) of RTE GBD products increased significantly from 6.5 ± 0.2 in 2005 to 7.3 ± 0.2 and 7.9 ± 0.2 for pre-existing RTE GBD products and new RTE GBD products in 2012, respectively. The average saturated fat density was significantly higher in all years following 2005 except in 2007.

Purchase Level Results

The average energy density (kcal / 100 g) of RTE GBD products purchased decreased significantly from 433 ± 0.2 in 2005 to 422 ± 0.2 in 2012 (**Table 3.4**). The average saturated fat density (g / 100 g) of RTE GBD products purchased increased significantly from 6.3 ± 0.01 in 2005 to 6.6 ± 0.01 in 2012. The average sugar density (g / 100 g) of RTE GBD products purchased decreased significantly from 32.4 ± 0.04 in 2005 to 31.3 ± 0.02 in 2012. Households significantly decreased their purchases of RTE GBD products by 24.1 ± 0.4% from 2005 to 2012 (**Table 3.5**). A significant interaction ($p<0.05$) between household composition and year with respect to percent change in RTE GBD purchases was shown. Significant differences in changes over time between singleton males, singleton females, and multiple adults without children were not observed (data not shown); therefore, those three groups were aggregated to form a reference group of all households without children. Households without children decreased their purchases of RTE GBD products from 2005 to 2012 by 21 ± 1%, whereas, households with only 2-11 year olds and households with only 12-18 year olds decreased by 28 ± 2%, and 36 ± 1%, respectively (**Table 3.6**).

Discussion

The average energy and sugar density of RTE GBD products manufactured did not change between 2005 and 2012, whereas, an increase in the average saturated fat density of RTE GBD products was shown. Consumers purchased RTE GBD products with lower energy and sugar densities, and RTE GBD products with higher saturated fat density. Overall purchases of RTE GBD products decreased between 2005 and 2012.

Previous studies have examined changes in the nutritional content of items sold at fast-food and restaurant chains over time.[63,64] This study demonstrates a new approach to estimate changes in the distribution of RTE GBD products manufactured in the US based on energy, saturated fat, and sugar densities with the intention of providing measures on the healthfulness of these products to public health officials, food manufacturers, and food retailers. The Grocery

Manufacturers Association reported that reformulations to food/beverage products reducing energy, saturated fat, and/or sugar occurred between 2002 and 2009.[65] The results from this study did not detect shifts in the distribution of RTE GBDs towards products with lower energy, saturated fat, or sugar density; indicating that larger wide-scale efforts are needed among all manufacturers of RTE GBDs. While an increase in the density of saturated fat in RTE GBD products was shown, this increase coincides with the mandatory labeling of trans fats on the NFP label effective in 2006.[66] Product reformulations lowering trans fats have been shown to increase the saturated fat content of products.[67] A limitation of this analysis is that listing of the trans fats content on NFP labels is limited prior to 2006; therefore, it is not possible using this dataset to determine if the increase in saturated fat density was a result of reformulations to remove or decrease trans fats in RTE GBD products. Introduction of new products is another strategy to improve the healthfulness of products available to consumers. The results from this analysis show that the new RTE GBD products released in 2012 did not have lower energy, saturated fat, or sugar densities than the products already existing on the market. Future reformulations and development of new products should focus on the product categories that are the largest sources of energy, saturated fat, and sugars.

The purchase level analyses indicated that between 2005 and 2012, consumers made shifts towards less energy and sugar dense RTE GBD products and purchased products with higher saturated fat densities. While the decreases in energy and sugar density of RTE GBD products purchased is encouraging, the magnitude of the decreases (<4%) indicates that efforts to promote consumption of RTE GBD products with lower energy, saturated fat, and sugar density have had limited effectiveness. Front-of-package labeling systems[54-56] are currently in use or being developed to assist consumers with identifying healthier foods and have been shown to promote development of healthier products by food manufacturers.[68] Introduction of shelf-tag nutrition labeling systems such as the Guiding Stars Program increased demand for RTE cereals that were considered more nutritious.[69] In order to determine the effectiveness of

front-of-package labeling systems and other initiatives to improve dietary quality in the US it is important to measure changes both between product categories (e.g., shifts from RTE GBD to fruits) and within product categories (e.g., shifts from energy dense RTE GBDs to lower energy dense RTE GBDs). The new approach presented in this paper addresses a limitation of current dietary surveys by using NFP information from store purchases to identify if consumers are shifting within product categories to products with lower energy, saturated fat, or sugar densities. The results from this study identify an opportunity to develop new strategies to shift purchases towards RTE GBD products with lower energy, saturated fat, and sugar density in addition to decreasing overall purchases of RTE GBDs. A potential concern of shifting purchases of RTE GBD towards products with lower energy, saturated fat or sugar densities is that consumers could potentially purchase more RTE GBD products if they are perceived to be healthier. Stealth reformulations by which changes in the product composition are conducted unbeknownst to consumers is one option to circumvent this issue.[70] Alternatively, the lack of evidence that reformulations to RTE GBD products occurred might be due to consumer preferences for products with higher energy, saturated fat, or sugar densities. Future studies are need to understand how consumers respond to product reformulations or changes in marketing strategies; these potential issues highlight the importance of monitoring both the changes in the nutritional content of purchases as well as the overall purchases of RTE GBD products.

All household compositions decreased purchases of RTE GBD products between 2005 and 2012, with households with 12-18 year olds having the largest decreases. This decrease in purchases was also reflected by decreases in GBD intake among 2-18 year olds in NHANES between 2005 and 2010.[7] Decreases in marketing of baked goods to children, adolescents, and all consumers were reported between 2006 and 2009.[71] A difficulty with attributing changes in marketing to decreases in purchases is that both occurred during the recession (2007- 2009) and households in the Homescan panel have been consistently decreasing purchases of foods and beverages since 2003.[72] Continual monitoring of both the nutritional content of products

manufactured and purchased by consumers is needed to determine the effectiveness of future efforts to shift consumer purchases towards healthier products.[73,74]

A limitation of this study is that changes in the package size of products and shelf-space given to products cannot be monitored using information from Nielsen or NFP labels. Future research on changes in package size and shelf-space in stores is needed to further examine the efforts of food manufacturers to improve dietary quality and reduce excess caloric intake in the US. Another limitation is the low percentage of up-to-date NFP information for RTE GBD products each year; however, the similarities in the distributions from the eight different samples between 2005 and 2012 further support the findings that only small changes have been made to RTE GBD products with respect to energy, saturated fat, and sugar density. It is important to note that reformulations and/or release of new healthier products may have been conducted by individual companies; however, the results of this analysis focused on the RTE GBD market as a collective to best capture the food environment that consumers experience. For the household level analysis, it has been previously reported that the Homescan sample does not perfectly match the US population based on demographics, and that males and individuals with low education are underrepresented.[75] Ideally, the sample should represent the population of US food/beverage shoppers rather than the overall US population. Without knowledge of the true US food/beverage shopper population, generalizing the results from this sample of shoppers should be made with caution. Finally, given that households volunteered to participate, there is always the possibility of participation bias;[75] therefore, when possible, it is important to compare the results of Homescan with other dietary surveys (e.g., NHANES).

In conclusion, this study demonstrates a new approach to monitor changes in the nutritional content of food products as well as monitor the effectiveness of FOP labeling systems, taxation/subsidies, or other public health initiatives to shift consumer purchases towards products with lower energy, saturated fat and sugar densities. The results from both the product and purchase level analyses highlight an opportunity for both food manufactures and

public health officials to work together to develop strategies to shift consumer purchases towards products with lower energy, saturated fat, and sugar densities in addition to decreasing overall purchases of RTE GBDs.

Tables and Figures

Table 3.1. Characteristics of the Nielsen Homescan household sample in 2005 and 2012

	2005		2012	
Household Characteristics	N	Weighted Percent of Sample	n	Weighted Percent of Sample
Race/Ethnicity				
Non-Hispanic White	40,102	74	47,259	71
Non-Hispanic Black	4,390	11	5,548	11
Non-Hispanic Other Races	1,906	4	2,894	6
All Hispanics	2,968	10	3,095	12
Household Income as % Poverty Level				
0% - 185%	10,536	26	12,709	30
186% - 300%	12,022	20	14,706	24
>300%	26,808	54	31,381	46
Male Head of Household Education				
< High school	2,422	6	2,072	5
= High school	9,615	25	10,442	23
< High school	24,077	40	31,036	42
No male head of household	13,252	29	15,246	30
Female Head of Household Education				
< High school	1,638	4	1,272	3
= High school	12,746	31	12,753	27
< High school	30,068	46	39,132	49
No female head of household	4,914	18	5,639	20
Household Composition				
Singleton (male)	3,837	12	4,168	12
Singleton (female)	9,199	14	10,299	13
Multiple adults no children	23,588	37	30,801	40
Adult(s) with children-(only 2-11 year olds)	4,759	17	5,268	16
Adult(s) with children-(only 12-18 year olds)	5,200	13	5,531	12
Adult(s) with children-(2-18 year olds)[a]	2,783	8	2,729	7

Values are the number of households and percent of the sample after sampling weights were applied to create a nationally representative sample of households in the United States.
[a]Excludes households with only 2-11 year olds and households with only 12-18 year olds.

Table 3.2. Ready-to-eat Grain-Based Dessert (GBD) products with available Nutrition Facts Panel (NFP) information for the product and purchase level analyses in 2005-2012

Product Level					Population/Household Level			
Year	Products with NFP	% of Total Products	% of Total Purchases (grams)[a]	Total Products	Year	Products with NFP	% of Total Products	% of Total Purchases (grams)[a]
2005	1,038	3.8%	17%	27,587	2005	15,942	58%	87%
2006	1,537	5.4%	23%	28,347	2006	16,537	58%	87%
2007	1,391	4.9%	19%	28,181	2007	16,608	59%	88%
2008	872	3.1%	9%	27,994	2008	17,105	61%	89%
2009	1,208	4.5%	16%	26,832	2009	16,892	63%	91%
2010	1,610	5.9%	30%	27,276	2010	17,147	63%	91%
2011	1,131	4.4%	20%	25,551	2011	16,133	63%	89%
2012[b]	920	4.5%	25%	20,627	2012	17,428	64%	88%
2012[c]	583	8.6%	32%	6,805	-	-	-	-

Values are the number of products and the percentages of total products or total purchases (grams) those products represent. GBD, grain-based dessert; NFP, nutrition facts panel.

[a]Percent of total purchases (grams) was calculated as follows: grams of GBD products purchased with NFP information divided by the total grams of GBD products purchased

[b]GBD products available for purchase in 2012 and prior to 2012

[c]GBD products newly introduced to consumers in 2012

Table 3.3. Distributions of the ready-to-eat Grain-Based Dessert (GBD) products available to consumers by energy, saturated fat, and sugar density in 2005-2012

Energy Density (kcal / 100 g) of GBD Products								
	Percentiles							
Year	5th	10th	25th	50th	75th	90th	95th	Mean[a]
2005	246	314	378	424	469	500	529	411 ± 4
2006	252	307	368	423	465	508	537	411 ± 3
2007	246	293	358	413	462	512	535	404 ± 4
2008	251	300	362	423	467	506	533	408 ± 3
2009	256	320	370	423	462	500	529	410 ± 3
2010	250	300	363	417	466	504	527	408 ± 3
2011	235	299	362	415	463	500	522	405 ± 4
2012[b]	226	292	363	417	471	514	536	412 ± 7
2012[c]	235	306	370	424	470	510	529	413 ± 5
Saturated Fat Density (g / 100 g) of GBD Products								
Year	5th	10th	25th	50th	75th	90th	95th	Mean[a]
2005	0.1	1.8	3.5	5.5	8.8	12.8	15.0	6.5 ± 0.2
2006	0.0	1.6	3.8	6.3	9.7	14.1	16.7	7.2 ± 0.1*
2007	0.0	1.5	3.5	6.0	9.0	14.1	16.7	6.9 ± 0.2
2008	0.0	1.5	3.7	6.4	9.6	14.1	16.6	7.2 ± 0.2*
2009	0.0	1.8	4.0	6.6	10.0	13.4	16.5	7.3 ± 0.2*
2010	0.0	1.6	4.1	7.0	10.1	14.1	16.6	7.5 ± 0.1*
2011	0.0	1.8	3.9	7.0	10.1	13.0	15.0	7.2 ± 0.2*
2012[b]	0.0	1.3	3.5	6.4	10.1	14.8	17.5	7.3 ± 0.2*
2012[c]	0.0	2.1	4.4	7.1	10.6	14.5	17.6	7.9 ± 0.2*
Sugar Density (g / 100 g) of GBD Products								
Year	5th	10th	25th	50th	75th	90th	95th	Mean[a]
2005	2.7	13.8	24.1	32.1	39.7	44.7	47.2	30.9 ± 0.5
2006	0.0	11.0	23.0	31.3	38.8	44.1	47.0	29.6 ± 0.4*
2007	2.6	13.6	22.6	30.1	37.0	43.5	47.0	29.3 ± 0.5*
2008	8.7	17.6	24.0	30.1	37.7	43.8	45.9	30.1 ± 0.5
2009	7.1	15.9	24.7	31.3	38.2	44.3	47.6	30.6 ± 0.4
2010	6.7	15.0	22.5	30.4	38.5	44.3	48.8	30.0 ± 0.4
2011	10.5	17.6	24.4	31.0	38.8	44.2	47.0	30.7 ± 0.5
2012[b]	10.2	19.3	25.4	31.4	38.8	44.6	48.5	31.2 ± 0.6
2012[c]	6.6	16.1	24.7	32.4	40.0	45.7	48.6	31.5 ± 0.7

[a]Means were generated from linear regression model coefficients using the STATA post-estimation –margins- command.
[b]products available for purchase in 2012 and prior to 2012.
[c]products newly introduced to consumers in 2012.
*Indicates a significant difference (P<0.05) from 2005.

Table 3.4. The average energy, saturated fat, and sugar density of ready-to-eat Grain-Based Dessert (GBD) products purchased by households in 2005-2012

Year	Energy Density (kcal / 100 g of GBD) ± SE	Saturated Fat Density (g / 100 g of GBD) ± SE	Sugar Density (g / 100 g of GBD) ± SE
2005	433 ± 0.2	6.3 ± 0.01	32.4 ± 0.03
2006	429 ± 0.2*	6.4 ± 0.01*	32.3 ± 0.02*
2007	423 ± 0.2*	6.3 ± 0.01*	31.8 ± 0.02*
2008	423 ± 0.2*	6.2 ± 0.01*	31.5 ± 0.02*
2009	421 ± 0.2*	6.4 ± 0.01*	31.1 ± 0.02*
2010	423 ± 0.2*	6.5 ± 0.01*	31.2 ± 0.02*
2011	422 ± 0.2*	6.5 ± 0.01*	30.9 ± 0.02*
2012	422 ± 0.2*	6.6 ± 0.01*	31.3 ± 0.02*

Means ± SE were generated using the STATA post-estimation –margins- command from the coefficients generated by the random effects models. All models were adjusted by the following household characteristics: race/ethnicity, federal poverty status, education, household composition/size, and geographical location.
*Indicates a significant difference ($P<0.05$) from 2005.

Table 3.5. Nationally representative average per capita daily ready-to-eat Grain-Based Dessert (GBD) purchases, and the percent change in ready-to-eat GBD purchases from 2005-2012 using a log-linear random effects model

Year	GBD Purchases[a] (grams/person/day)	% Change[b] ± SE
2005	18.6	Reference
2006	18.5	-3.2 ± 0.4*
2007	18.0	-8.3 ± 0.4*
2008	17.5	-13.2 ± 0.4*
2009	16.9	-16.7 ± 0.4*
2010	16.8	-19.1 ± 0.4*
2011	15.7	-26.1 ± 0.4*
2012	15.9	-24.1 ± 0.4*

[a]Per capita GBD purchases (grams/person/day) using household sampling weights were calculated as follows: household average quarterly purchases/household size/91 days.
[b]The coefficients of the log-linear model are interpreted as the percent change in purchases using 2005 as the reference year and were adjusted by covariates for race/ethnicity, federal poverty status, education, household composition/size and geographical location.
*Indicates a significant difference ($P<0.05$) in the percent change in GBD purchases from 2005

Table 3.6. The percent decrease in grams of ready-to-eat Grain-Based Dessert (GBD) products purchased from 2005-2012 between households with and without children using a log-linear random effects model

	2005	2006	2007	2008	2009	2010	2011	2012
	% decrease from 2005 ± SE							
Households without children	Ref	-3 ± 1	-8 ± 1	-12 ± 1	-15 ± 1	-18 ± 1	-24 ± 1	-21 ± 1
Adult(s) with children-(only 2-11 year olds)	Ref	-3 ± 1	-8 ± 1	-17 ± 1*	-22 ± 1*	-23 ± 2*	-30 ± 2*	-28 ± 2*
Adult(s) with children-(only 12-18 year olds)	Ref	-4 ± 1	-12 ± 1*	-17 ± 1*	-20 ± 1*	-24 ± 1*	-35 ± 1*	-36 ± 1*
Adult(s) with children-(2-18 year olds)[a]	Ref	-5 ± 1	-13 ± 1*	-18 ± 1*	-24 ± 2*	-25 ± 2*	-36 ± 2*	-35 ± 2*

[a]Excludes household with only 2-11 year olds and households with only 12-18 year olds.

A significant interaction between household composition and year was observed using a random effects log-linear model with covariates for race/ethnicity, federal poverty status, education, and geographical location of the households. The percent change ± SE were generated using the STATA post-estimation –margins- command to estimate the marginal effect of year on the change from 2005 within each household composition.

*Indicates a significant difference (P<0.05) between the percent decrease in purchases of GBD (grams) from 2005 for a particular household composition as compared to households without children. Statistical significance was determined from the interaction term coefficients in the random effects log-linear model.

Chapter 4. Associations of Higher Prices with Lower Purchases of Ready-To-Eat Grain-Based Desserts and Alternative Snacks/Desserts

Abstract

Background: Grain-Based Dessert (GBD) products (e.g., cakes, cookies and pies) are one of the largest sources of calories in the United States. Limited research has focused on the potential for increasing the prices of snack and dessert foods as a strategy to limit excess caloric intake in the United States.

Objectives: Determine the association of higher prices of Ready-To- Eat (RTE) GBD on purchases of alternative snacks/desserts (candy, ice cream, salty snacks, and frozen GBD). Compare simulations increasing the price of GBD products versus increasing the prices of total snacks/desserts with purchases of calories, saturated fat, and sugar from total snack/desserts and total calories purchased from stores.

Design: Nutrition facts panel information from commercial databases was linked to products purchased by households (n=159,184) in the Nielsen Homescan longitudinal dataset 2000-2012. Two part marginal effects models were used to estimate the association between price of RTE GBDs and purchases of RTE GBDs. Linear regression models were utilized to simulate the associations between a 10% increase in price of RTE GBDs and a 10% increase in the prices of total snacks/desserts (including RTE GBD) on purchases of calories, saturated fat and sugar from snacks/desserts and total calories purchased from stores.

Results: A 10% increase in the price of RTE GBDs was associated with increased purchases (1.4 ± 0.5 grams/person/day) of alternative snacks/desserts. A 10% increase in the price of RTE GBDs was associated with lower calories purchased (-4.6 ± 2.3 kcals/person/day) from total snacks/desserts. Comparatively, a 10% increase in the prices of snacks/desserts was

associated with lower purchases of total snack/desserts of (-30.2 ± 4 kcals/person/day), (-0.5 ± 0.1 grams of saturated fat/person/day), and (-2.0 ± 0.3 grams of sugar/person/day). Decreases of (-18 ± 8 kcals/person/day) and (-86 ± 13 kcals/person/day) of total calories from store purchases were associated with a 10% increase in the price of RTE GBDs versus a 10% increase in the prices of total snacks/desserts, respectively.

Conclusions: These results suggest that taxation policies increasing the price of a single snack/dessert group could be circumvented by consumers switching to untaxed snacks/desserts. These results highlight the magnitude to which taxing multiple snack/dessert groups simultaneously can decrease purchases of calories, saturated fat and sugar as compared to only taxing a single snack/dessert group.

Introduction

The current obesity epidemic[43,44] has resulted in the need to identify new strategies to reduce excess calorie intake. Taxation of sugar-sweetened beverages (SSB)[76] and energy-dense products[77] are two policies that have been proposed as potential strategies to reduce excess caloric intake and improve dietary quality in the United States. Rationale for taxing less healthful food/beverage products is based on economic theory which predicts that increases in the price of a product will result in a corresponding decrease in purchases. Currently, a considerable amount of attention has been given to the effects of sugar-sweetened beverages (SSB) on weight gain[78,79] and the potential health benefits that taxing sugar-sweetened beverages could have in the United States (US).[80-88] Less research has focused on determining the potential impacts of taxing the Grain-Based Dessert (GBD) (e.g., cookies, cakes and pies) category; one of the largest contributors of calories to children, adolescents, and adults in the US.[49-52] GBDs are also the largest source of solid fats (10.8%), and the second largest source of added sugars (12.9%); both of which are targeted by the 2010 Dietary Guidelines for Americans as components of foods to limit as a strategy to control caloric intake, manage body weight, and prevent increased risk of many chronic diseases.[53] From an economic standpoint, an additional

concern regarding GBD products is that compared to other food and beverage categories, Ready-To-Eat (RTE) GBD products such as cookies provide consumers the most energy per dollar spent. [88] The relatively low cost per calorie and high consumption of RTE GBD products provides rationale for examining the potential of taxing RTE GBD products as a strategy to lower excess caloric intake.

Simulations of taxes on foods/beverages are commonly used by researchers to examine the potential impacts of increasing the price of food/beverage products on purchases or consumption of foods.[31,33,82-89] It should be noted that these studies examined observational data comparing prices and purchases across markets and time and used the expected change in purchases for a change in price to simulate a tax. The expected change in purchases is generally measured as price elasticities (% change in purchases for a % change in price). Given that observational data is examined, the results should be interpreted as associations rather than the effect of price on purchases. These studies also assume that a real-life tax would be transmitted one-for-one onto the price consumers pay for the taxed good.

When considering the impact of price on purchases it is also important to investigate the potential for unintentional consequences of increasing the price of a given food on purchases of other foods groups. For instance, simulations taxing the amount of saturated fat in products provides evidence that consumers might increase consumption of less healthful dietary components from foods and beverages such as salt[31,33] and sugar[90] as a result of a tax on saturated fat content. Increases in the price of soda have also been associated with higher purchases of salt and fat resulting from product substitutions; [87] however, the price of soda has been associated with lower purchases of salty snacks, and ice cream, [88] and higher purchases of pizza.[82] Given the potential for consumers to change purchases of untaxed food/beverage groups, researchers have also examined tax simulations increasing the price of multiple food/beverage items.[82,91] Recent legislation imposing a tax on high calorie foods has been implemented in Mexico;[92] however, the potential effects of such a tax have only been examined

in Australia using price elasticities from the United Kingdom. [91] The first objective of this paper was to determine the price elasticity of RTE GBD. The second objective was to simulate a 10% increase in the price of RTE GBD on purchases of other snacks/desserts to determine the potential for consumers to shift to non-taxed products when RTE GBD are taxed. The third objective of this paper was to compare simulations increasing the price of only RTE GBD products by 10% versus a 10% increase in the prices of total snacks/desserts on purchases of calories, saturated fat, and sugar from total snack/desserts and total calories purchased from stores.

Methods

Household Purchase Data

The sample of households (n=159,184) was obtained from the Nielsen Homescan panel (2000-2012), a longitudinal dataset on household purchases of food/beverages from supermarkets, grocery stores, convenience stores, and other food retail outlets.[47,59-61,93] Households are continually recruited by Nielsen using direct mailing and Internet advertising. On average, households in the panel between 2000 and 2012 provided 14 quarters (1 quarter= 3 months) of purchase data. Households selected to participate were geographically dispersed with a total of 76 markets (metropolitan and non-metropolitan areas) included in the analysis. Each participating household was provided with a scanner to record the Universal Product Code (UPC) of each purchase and quantity of each item. Purchases from each household were aggregated for each quarter. Reports from single person households with food/beverage purchases less than $45 per quarter and households with 2 or more individuals with food/beverage purchases less than $135 per quarter were deemed unreliable and excluded from the analysis. Based on this criteria, 2.8% of the quarterly reports by households were excluded. The characteristics of the final household sample in 2000, 2006 and 2012 are provided in (**Table 4.1**).

Nutrition Facts Panel Information

The UPC for a product purchased by a household in Homescan was linked with NFP information obtained from the commercial databases with the exact UPC.[47] If NFP information was not available for a product in the year it was purchased then NFP information from the subsequent year or the next closest previous year was assigned. For products without an exact UPC match, NFP information was obtained by a series of steps: 1) match NFP information from a product of the same brand and product description, but different size package; 2) match NFP information by brand, product type, and similar attributes in the product description; 3) match NFP information based on similar product type and product description; 4) remaining unmatched products received the average NFP information from the food/beverage category in which they were categorized.

Defining Classes of Snacks/Desserts

A complexity with researching the GBD category is that products such as dry cake mixes, frozen/refrigerated sweet-rolls, and Ready-To-Eat (RTE) products such as cookies can all be considered GBDs. Each sub-category of GBDs was included in the analysis; however, the analysis focused on RTE GBD products because they represent the majority of the purchases of GBD products and the nutrition information available is in the form of what is consumed.

Ready-To-Eat Grain-Based Desserts

Ready-to-eat (RTE) products such as cakes, cookies, pies, pastries, sweet strudels, doughnuts, granola/yogurt bars, and graham crackers were classified as RTE GBDs. Dry GBD mixes and frozen/refrigerated GBD products were classified as separate groups.

Alternative Snacks/Desserts

Salty snacks, ice cream, candy, and frozen/refrigerated GBDs were considered Alternative Snacks/Desserts for RTE GBD products. While dry GBD mixes and pudding mixes could also be considered Alternative Snacks/Desserts, these products were not included

because they require additions (e.g., milk, eggs, oil, or frosting) rendering it difficult to use NFP information to estimate nutrients consumed from these types of products.

Total Snacks/Desserts

For this manuscript, the combination of RTE GBDs and Alternative Snacks/Desserts was labeled as Total Snacks/Desserts to simplify the nomenclature. The selection of foods to include as Total Snack/Desserts was also chosen by identifying which snack foods have higher state sales tax rates in the United States: chips, pretzels, chewing gum, candy, popsicles, milkshakes, ice cream, and baked goods.[94] A detailed list of the products that were included in each category of total snacks & desserts is provided in (**Appendix Table 4.1)**.

Prices

Prices ($/100 g) for food/beverage groups were generated at the market level in each quarter by dividing the total dollars spent by the total grams purchased by households within a given market. Given the ecological study design of comparing prices and purchases across markets, in order to isolate the effect of market-level price it is necessary to control for additional market-level variables that effect purchases of snacks & desserts or total foods/beverages. The overall cost of foods/beverages for each market in a quarter was generated as the price of food/beverages (57 groups) in a market weighted by the proportion of expenditure for each food/beverage group in that market. Overall food/beverage price represents the cost of a standardized basket of food in a given market for a given quarter.

Statistical Analysis

All analyses were conducted using Stata (version 12.0, 2011, StataCorp, College Station, TX) with a significance criteria of ($P<0.05$). Elasticities (% change in purchases over % change in price) generated by models using natural logged exposures and natural logged outcomes were used to measure the association of price with purchases of RTE GBD products. To account for non-consumers of RTE GBDs, two part marginal effect models[95] were used where the first model estimated the association of logged RTE GBD price on the probability of

purchasing RTE GBD products in a given quarter using a probit model and the second model estimated the association of logged RTE GBD price on logged RTE GBD purchases (grams) using linear regression models conditional on a household purchasing RTE GBD products in a given quarter. Both models included the same set of household level covariates: quarter (to account for seasonality effects), head of household race/ethnicity, male head of household education, female head of household education, household income, household type, and variables for the number of household members of each gender by age group. The models also controlled for the following market level covariates measured quarterly: FPI, percent unemployment, and logged prices of foods that were hypothesized to affect a consumer's choice to purchase RTE GBDs or influence the amount purchased (candy, ice cream, salty snacks, frozen GBD, GBD baking mixes, pudding, and bread). The standard errors were adjusted by clustering on household to account for the multiple observations on the same household across and within years. A significant interaction between the association of RTE GBD price and purchases over time was detected in both the probit and conditional regression models using Wald-tests. The sample was then stratified by year, probit and conditional regression models were conducted on each stratified sample, and the estimates were combined to generate the price elasticities for RTE GBD in each year. Bootstrapped standard errors for price elasticities were calculated using 1000 replications with resampling at the household level. Given that the price elasticity of RTE GBD in 2012 was similar to the elasticity prior to the recession (**Table 4.3**), the remainder of the analysis focused on 2012, the most recent year of data available.

Ordinary least squares regression models were used to simulate a 10% increase in the price of RTE GBD on purchases of Alternative Snacks/Desserts and Total Snacks/Desserts only using data from 2012. These models were also used to simulate a 10% increase in the prices of Total Snacks/Desserts on purchases of Total Snack/Desserts. The percent of households not consuming Alternative Snacks/desserts or Total Snacks/Desserts in any quarter was less than

5%; therefore, it was not necessary to use two-part models for this portion of the analysis. Grams, calories, saturated fat, and sugar from the Alternative Snacks/Desserts and Total Snacks/Desserts as well as total calories from store purchases were used as outcome variables. The outcome variables for these models were not logged, but were divided by 91 days and household size (only including household members above 2 years of age) to arrive at per capita average daily purchases. All models controlled for the same set of covariates previously described including natural logged values for prices of each group of Total Snacks/Desserts to use in the simulations and control variables for the price of foods hypothesize to influence the purchases of Total Snacks/Desserts (GBD baking mixes, pudding, and bread). The standard errors were adjusted by clustering on household to account for the multiple observations on the same household across the quarters in 2012. For the simulations increasing prices by 10% the use of a linear-log model (untransformed purchases and natural log transformed prices) provides the ability to interpret changes in the beta coefficients as the change in purchases associated with percent increases in price. The expected change in an outcome variable associated with a 10% increase in price is calculated as $\beta*\ln(100+10/100)$. Simulations increasing prices of Total Snacks/Desserts were calculated as the linear combination of increasing each coefficient of price for RTE GBDs, candy, salty snacks, ice cream, and frozen GBDs by 10%.

Results

Increases in the prices of RTE GBDs and candy were shown between 2000 and 2012, whereas, the price of salty snacks and ice cream remained stable, and the price of frozen GBDs decreased (**Table 4.2**). The price of ice cream ($0.23/100 g) was the lowest of the Alternative Snacks/Desserts and the price of candy was the highest ($0.68/100 g). Salty snacks contained the most energy per 100 g, and candy had the highest saturated fat and sugar density. Consumers purchased more ice cream than any other dessert/snack category; however, ice

cream also had relatively lower densities of calories, saturated fat and sugar. Between 2000 and 2012, decreases in purchases of all snack/dessert except salty snacks were observed.

A significant interaction between year and logged price of RTE GBDs was shown with respect to purchases of RTE GBDs in both the probit and conditional regression model (**Appendix Table 4.2**). The results of the two part marginal effects model showed that the price elasticity of RTE GBDs was the highest between 2007 and 2009 and then decreased to -0.94 ± 0.23 in 2012 (**Table 4.3**).

A 10% increase in the price of RTE GBDs was associated with higher grams purchased (+1.4 ± 0.5 grams/person/day) from Alternative Snacks/Desserts, and higher purchases of sugar (+0.42 ± 0.2 grams/person/day) from Alternative Snacks/Desserts (**Figure 4.1**). Taking into account purchases of RTE GBDs, a 10% increase in price of RTE GBDs was associated with lower calories purchased -4.6 ± 2.27 kcals/person/day from Total Snacks/Desserts. Comparatively, a 10% increase in the prices of Total Snacks/Desserts was associated with lower purchases of (-5.9 ± 1.2 grams/person/day), (-30.2 ± 4 kcals/person/day), (-0.5 ± 0.1 grams of saturated fat/person/day), and (-2.0 ± 0.3 grams of sugar/person/day) from Total Snacks/Desserts.

With respect to total calories purchased, increasing the price of RTE GBDs was associated with a significant decrease of -18 ± 8 kcals/person/day in total calories purchased, whereas increasing the prices of Total Snacks/Desserts by 10% was associated with a significant decrease of -86 ± 13 kcals/person/day (**Figure 4.2**). An equation generated from weight loss trials was used to estimate average changes in body weight in the adult US population for a given decrease in daily calories.[96] This equation uses a dynamic model that takes into account the decreases in energy required to maintain a lower weight body; in other words, as a person loses weight they require less calories to maintain their new weight. The estimated decreases in calories purchased from stores was predicted to result in a significant decrease of -1.8 ± 0.8 lbs for a 10% increase in price of RTE GBD and -8.6 ±1.3 lbs for a 10%

increase in the prices of Total Snacks/Desserts. These estimates are based on an estimate of 10 kcal per day per pound of weight change[96] and represent the average weight loss in the adult US population if the estimated decreases in daily calories were maintained.

Discussion

The elasticities (% change in purchases for a % change in price) for RTE GBDs were shown to be higher during the economic recession (2007-2009) indicating the consumers were more sensitive to price of RTE GBDs during this time period. The price elasticity of RTE GBD in 2012 was similar to the elasticity prior to the recession; therefore, the remainder of the analysis focused on 2012, the most recent year of data available. In 2012, a 10 percent increase in the price of RTE GBDs was associated with higher purchases of grams and sugar from Alternative Snacks/Desserts. Taking into account the decrease in purchases of RTE GBDs, a 10 percent increase in the price of RTE GBDs was associated with lower purchases of calories from Total Snacks/Desserts. Comparatively, a 10 percent increase in the price of RTE GBDs, candy, salty snacks, ice cream, and frozen GBDs was associated with lower purchases of calories, saturated fat, and sugar from Total Snacks/Desserts as well as lower total calories purchased from stores.

Previous research has provided evidence for both foods and beverages that taxation strategies could result in higher purchases of untaxed or lower taxed products which can impact the overall purchases of calories, fat and sugar. Increases in the price of soda were associated with lower purchases of calories, but higher purchases of salt and fat resulting from product substitutions;[87] however, the price of soda has been associated with lower purchases of salty snacks, and ice cream,[88] and higher purchases of pizza.[82] The results from this analysis provide evidence that a tax only on RTE GBDs could result in consumers shifting purchases to untaxed snacks and desserts; however, when considering the decrease in RTE GBDs, a 10% increase in price of RTE GBD was still associated with lower purchases of Total Snacks/Desserts. Furthermore, the results from this analysis provide evidence that a tax on each category of Total

Snacks/Desserts would be considerably more effective at reducing purchases of calories, saturated fat, and sugar from Total Snacks/Desserts as compared to only taxing RTE GBD.

The emphasis of previous studies examining the associations of price and purchases of food and beverage products in the US has focused on increasing the price of a single food or beverage category. The results from this analysis showed that a 10% increase in the prices of Total Snacks/Desserts was associated with a -86 kcal/person/day decrease in total calories purchased from stores. This decrease in daily calories purchased was estimated to result in a -8.6 lbs decrease in the average body weight of adults in the US.[96] While previous research has shown that ice cream and salty snacks are economic complements of sugar-sweetened beverages,[88] an additional decrease in non-snack/dessert foods of -56 kcals/person/day associated with a 10% increase in the prices of Total Snacks/Desserts was unexpected. Future research is needed to confirm these findings and a conservative estimation of the potential weight loss can be calculated using the decrease in calories purchased from Total Snacks/Desserts. One study using elasticities from the United Kingdom and food intake from Australia showed that a 10% 'junk food' tax was estimated to result in average weight loss of 3.5 lbs; the majority of the weight loss being due to decreases in cereal-based products.[91] Given that consumers in different countries will likely have different responses to increases in price, using price elasticities from one country to predicted changes in purchases in another country should be avoided. Estimations of weight loss have also been conducted for SSB tax simulations. Decreases in the average body weight of the adult US population ranging from 4.0-5.3 lbs have been estimated from simulations of a 20% SSB tax.[82,84] Small decreases in daily caloric intake have been argued to be an effective strategy to preventing weight gain,[97] and while expectations for food/beverage taxes to solve the current obesity epidemic are not realistic, identifying strategies to prevent future weight gain are equally important.

Implementing taxes on multiple food/beverage items becomes complicated when deciding which foods/beverages should be taxed.[77] An excellent example of this dilemma has

been previously proposed by asking the question of whether or not an untaxed breakfast bar is healthier than a taxed candy bar.[98] Recently, a “junk” food tax on SSB and high calorie foods was implemented in Mexico. The “junk” food tax covers all products analyzed in this paper and includes puddings/flans, nut spreads, RTE cereals and selected products with energy densities greater than 275 kcal/100 grams. For this study, Total Snacks/Desserts included food groups that were reported to have higher rates of state sales taxes applied in the US.[94] It is beyond the scope of this paper to recommend which foods/beverages should be considered for taxation; rather, these results provide evidence for policy-makers that taxation of single snack/dessert group could be considerably less effective than taxing multiple snack/dessert groups simultaneously.

The ecological study design with respect to the price of snacks and desserts across different markets limits interpreting the findings to associations between price and purchases. While these models are informative, it is possible that all market level and household level variables associated with purchases of snack and dessert foods were not included in the model and therefore the results are subject to omitted variable bias. A difficulty with determining effects rather than associations of price with purchases is that a tax would need to be implemented and purchases compared between taxed and untaxed markets or within markets prior to and after the tax. Another limitation of the study design is that an interaction between all prices of snacks and desserts was not conducted; therefore, the results of the joint increase in the prices of Total Snacks/Desserts could be underestimated if taxing multiple groups simultaneously prevents cross-substitutions between the snack/dessert categories. Finally, it is important to note that only the price and purchases of foods with UPC or barcodes were included in this analysis. These models cannot address the possibility that consumers in markets with higher prices of RTE GBDs or Total Snacks/Desserts purchased higher amounts of non-barcode products from stores, bakeries, fast food, or restaurants. Therefore, the possibility that the weight loss

predicted from these models could be offset by purchases of foods and beverages without barcodes is a limitation of the store purchase data.

In conclusion, evidence of the potential for consumers to purchase more Alternative Snacks/Desserts when RTE GBD are taxed indicates that unintended consequences of taxing a single group of snacks/desserts can occur. The findings from this study provide evidence that a tax on all snacks/desserts could have a larger impact on daily purchases of calories, saturated fat, and sugar from store bought snacks/desserts as compare to only taxing RTE GBD. Finally, these results suggest that a 10% tax on all snacks/desserts has potential to be used as an effective strategy to limit future weight gain in the US.

Tables and Figures

Table 4.1. Characteristics of the Nielsen Homescan household sample in 2000, 2006, and 2012

	2000		2006		2012	
	n	Weighted %	n	Weighted %	n	Weighted %
Household Characteristics						
Race/Ethnicity						
Non-Hispanic White	29,088	79	50,697	74	48,364	71
Non-Hispanic Black	2,835	11	5,218	11	5,660	11
Non-Hispanic Other Races	852	2	2,469	5	2,990	6
All Hispanics	1,861	9	3,314	10	3,153	12
Household Income as % Poverty Level						
0% - 185%	4,680	23	11,641	25	12,982	30
186% - 400%	15,341	42	25,921	36	24,810	37
>400%	14,615	34	24,136	39	22,375	33
Male Head of Household Education						
< High school	1,934	7	2,659	5	2,095	5
= High school	6,909	22	11,876	25	10,574	23
< High school	16,931	43	31,653	40	31,795	42
No male head of household	8,862	28	15,510	29	15,703	30
Female Head of Household Education						
< High school	1,360	5	1,758	4	1,291	3
= High school	9,133	31	15,180	30	12,926	27
< High school	20,746	46	38,783	46	39,868	48
No female head of household	3,397	18	5,977	20	6,082	21
Household Composition						
Singleton (male)	2,727	13	4,680	13	4,562	13
Singleton (female)	6,141	13	10,585	13	10,692	13
Multiple adults no children	16,028	39	29,582	38	31,310	40
Adult(s) with children-(only 2-11 year olds)	3,931	16	6,651	16	5,302	15
Adult(s) with children-(only 12-18 year olds)	3,728	12	6,592	12	5,561	12
Adult(s) with children-(2-18 year olds)[a]	2,081	7	3,608	8	2,740	7

Values are the number of households and percent of the sample after sampling weights were applied to create a nationally representative sample of households in the United States.
[a]Excludes households with only 2-11 year olds and households with only 12-18 year olds.

Table 4.2. Descriptive statistics for price, energy density, saturated fat density, sugar density, and per capita grams purchased per day for selected food groups in 2000, 2006 and 2012.

	$/100 g[a] (Range)	Kcal/100 g[b] (SD)	Saturated Fat/100g[b] (SD)	Sugar/100 g[b] (SD)	Grams/person/day[c] (SD)
Year 2000					
RTE GBD	0.51 (0.41 – 0.58)	443 (59)	6.8 (4.9)	33 (7)	20 (24)
Ice Cream	0.23 (0.17 – 0.31)	134 (46)	3.8 (2.1)	14 (5)	37 (50)
Candy	0.64 (0.50 – 0.88)	448 (59)	8.8 (6.0)	56 (10)	16 (26)
Salty Snacks	0.59 (0.48 – 0.68)	479 (107)	6.1 (4.1)	4 (6)	18 (18)
Frozen GBD	0.51 (0.38 – 0.67)	352 (74)	5.8 (3.2)	26 (8)	3 (7)
Year 2006					
RTE GBD	0.53 (0.47 – 0.59)	431 (58)	6.4 (3.0)	32 (7)	19 (23)
Ice Cream	0.23 (0.18 – 0.30)	134 (52)	3.8 (3.4)	13 (6)	35 (49)
Candy	0.65 (0.56 – 0.73)	452 (71)	10.1 (7.2)	54 (12)	15 (22)
Salty Snacks	0.59 (0.53 – 0.68)	470 (80)	5.2 (2.7)	4 (5)	18 (18)
Frozen GBD	0.48 (0.32 – 0.57)	351 (78)	5.7 (2.9)	26 (8)	3 (8)
Year 2012					
RTE GBD	0.55 (0.46 – 0.62)	424 (56)	6.6 (2.9)	31 (7)	17 (21)
Ice Cream	0.22 (0.17 – 0.28)	139 (58)	3.8 (2.6)	14 (6)	29 (46)
Candy	0.68 (0.60 – 0.78)	440 (71)	9.9 (6.4)	54 (12)	14 (24)
Salty Snacks	0.61 (0.53 – 0.69)	475 (78)	4.6 (2.8)	4 (4)	18 (19)
Frozen GBD	0.44 (0.34 – 0.54)	346 (73)	6.3 (3.1)	26 (8)	3 (7)

[a]Prices ($/100 g) were calculated for each market by dividing the total dollars spent by the total grams purchased and multiplying that ratio by 100. These prices were then divided by the Food Price Index of each market to account for inflation across time

[b]Energy, saturated fat, and sugar densities for each product category were calculated by dividing the total nutrient purchased by the total grams purchased.

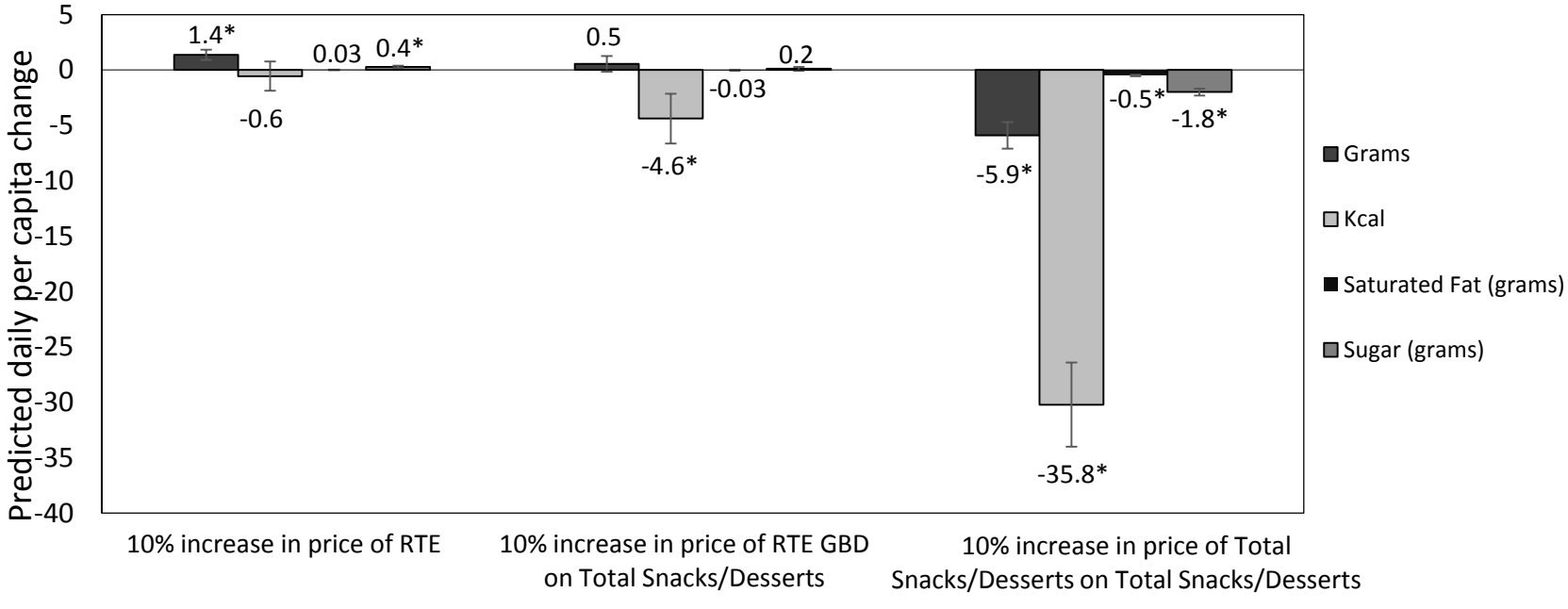
[c]Grams/person/day were generated by averaging the quarterly purchases of each household divided by the household size and divided by 91 (91 days in a quarter)

Table 4.3. Price elasticity of GBD products between 2000 and 2012 from two part marginal effects models

Year	RTE GBD Price Elasticity[a] ± SE
2000	-0.53 ± 0.24
2001	-1.12 ± 0.24
2002	-1.00 ± 0.23
2003	-1.41 ± 0.23
2004	-0.84 ± 0.23
2005	-0.93 ± 0.22
2006	-1.5 ± 0.21
2007	-2.0 ± 0.21
2008	-2.2 ± 0.24
2009	-2.7 ± 0.24
2010	-1.9 ± 0.25
2011	-1.6 ± 0.23
2012	-0.94 ± 0.23

[a]Price elasticity is defined as the percent change in purchases divided by a 1% increase in price of RTE GBD. Elasticities were generated from two part marginal effects models where the first model estimated the association of logged price on the probability of purchasing RTE GBD products in a given quarter using a probit model and the second model estimated the association of logged price on logged consumption conditional on a household purchasing RTE GBD products in a given quarter. The results from the two models were combined and bootstrapped standard errors were calculated using 1000 replications with resampling of households

Figure 4.1. Predicted changes in store-bought nutrients from Alternative Snacks/Desserts and Total Snacks/Desserts associated with a 10% increase in the price of RTE GBD and a 10% increase in the price of Total Snacks/Desserts.



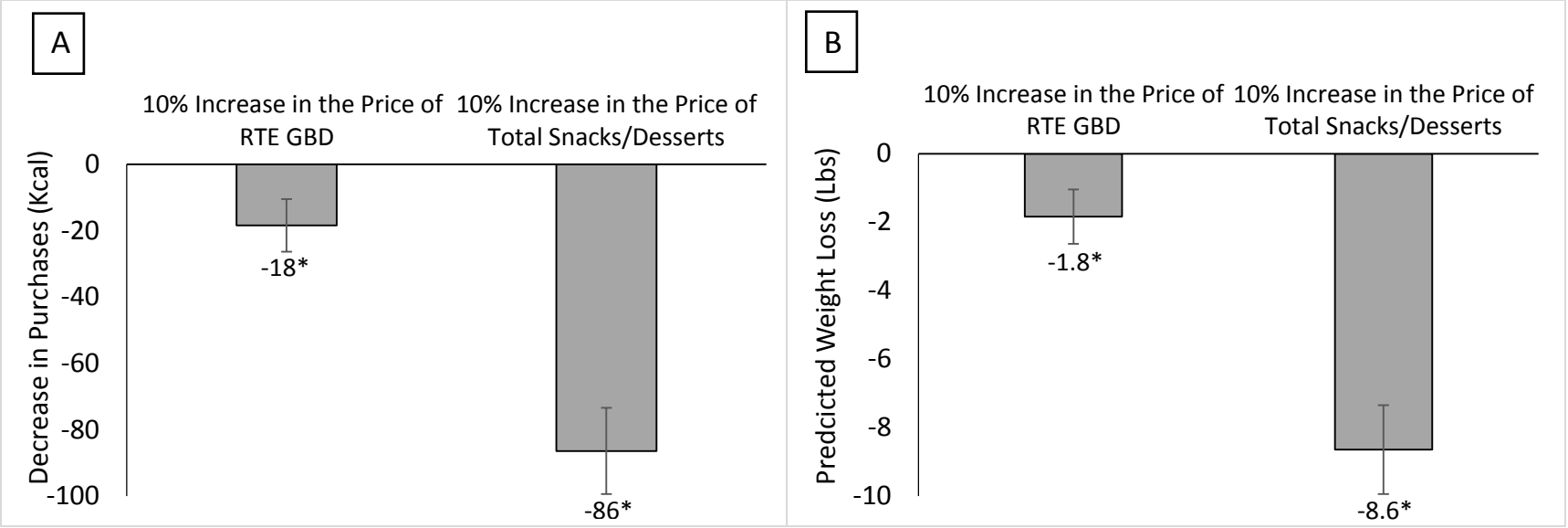
Daily per capita purchases were calculated by dividing household purchases by household size and 91 days (91 days in a quarter). Estimates were derived from linear regression models including the logged prices of RTE GBD and each alternative snack as wells as dry GBD mixes, pudding, and bread. Additional covariates included in the models were quarter (to account for seasonality effects) head of household race/ethnicity, male head of household education, female head of household education, household income , household type, and a series of sex specific variables for the number of individuals in the household belonging to particular age groups. The models also controlled for the following market level covariates measured quarterly: FPI, percent unemployment. The standard errors were adjusted by clustering on household to account for the multiple observations across the four quarters.

[a]Alternative Snacks/Desserts include: salty snacks, ice cream, candy, frozen GBD

[b]Total Snacks/Desserts include: salty snacks, icecream, candy, frozen GBD, and RTE GBD

*Indicates that the estimate was significantly different from zero (P<0.05)

Figure 4.2. Predicted decreases in total calorie purchases from stores (A) and the predicted weight loss (B) associated with a 10% increase in the price of RTE GBD and a 10% increase in the price of Total Snacks/Desserts.



Daily per capita purchases were calculated by dividing household purchases by household size and 91 days (91 days in a quarter). Estimates for decreases in purchases were derived from linear regression models including the logged prices of RTE GBD and each alternative snack as wells as dry GBD mixes and pudding. Additional covariates included in the models were quarter (to account for seasonality effects) head of household race/ethnicity, male head of household education, female head of household education, household income , household type, and a series of sex specific variables for the number of individuals in the household belonging to particular age groups. The models also controlled for the following market level covariates measured quarterly: FPI, percent unemployment. The standard errors were adjusted by clustering on household to account for the multiple observations across the four quarters. The weight loss is estimated for the US population using equations from a dynamic model from Hall et al. The model predicts the average weight change resulting from a change in daily total calories and equates to 10 kcal per day per pound of weight change. The standard errors for predicted weight changes were based on the standard errors for the decrease in purchases form the regression models.

[a]Total Snacks/Desserts include: salty snacks, icecream, candy, frozen GBD, and RTE GBD

*Indicates that the estimate was significantly different from zero (P<0.05)

Appendix Table 4.1. Types of products categorized as total snacks & desserts

Snack & Dessert Category	Types of Products
RTE GBD	Cakes, cookies, pies, pastries, sweet strudels, doughnuts, granola/yogurt bars, and graham crackers
Ice Cream	Ice cream, frozen novelties, sherbet, frozen yogurt, refrigerated pudding, and ice pops
Candy	Chocolate, chocolate bars/pieces, non-chocolate sweets, confectionary products, lollipops
Salty Snacks	Popcorn, puffed cheese, pretzels, potato chips, tortilla chips
Frozen GBD	Cakes, cookies, brownies, cobblers, sweet strudels, doughnuts, pies, éclairs, and cheesecakes

Appendix Table 4.2. Beta coefficients for the interaction of logged price with time with respect to logged purchases of GBD for the probit and conditional regression model

Year	Probit Model: Interaction Coefficient (Year*lnPrice)	Conditional Regression Model: Interaction Coefficient: (Year*lnPrice)
2000	Ref	Ref
2001	-0.28 ± 0.22	-0.06 ± 0.12
2002	-0.08 ± 0.23	-0.21 ± 0.14
2003	-0.20 ± 0.23	-0.40 ± 0.14*
2004	-0.03 ± 0.24	0.05 ± 0.15
2005	-0.07 ± 0.23	0.03 ± 0.14
2006	-0.33 ± 0.23	-0.33 ± 0.15*
2007	-0.49 ± 0.23*	-0.44 ± 0.15*
2008	-0.59 ± 0.23*	-0.42 ± 0.15*
2009	-0.81 ± 0.23*	-0.70 ± 0.15*
2010	-0.33 ± 0.23	-0.36 ± 0.15*
2011	-0.16 ± 0.23	-0.30 ± 0.15
2012	-0.07 ± 0.23	0.02 ± 0.15

Note: Both models included the same set covariates: quarter (seasonality effects), head of household race/ethnicity, male head of household education, female head of household education, household income, household type, and a series of sex specific variables for the number of individuals in the household belonging to particular age groups. The models also controlled for the following market level covariates: Food Price Index, percent unemployment, and logged prices of foods that were hypothesized to affect a consumer's choice to purchase RTE GBD or influence the amount purchased (in other words foods that are complements or substitutes for RTE GBD products. The standard errors were adjusted by clustering on household to account for the multiple observations across and within years. To test for an interaction between the effects of price on purchases over time, the covariate year was fully interacted with all other covariates in both the probit and conditional regression model. Wald Chunk tests were conducted in both models to test if the overall interaction of price and year was significant. A significant interaction of year and price was observed in both models.
*Signifies a significant difference from the reference year 2000

Chapter 5. Estimating the Potential Impacts of a Snack and Dessert Tax on Households Differing in Economic Status

Abstract

Background: Higher rates of diet-related diseases and lower dietary quality are found among households with lower economic status. While taxation of energy-dense foods has been proposed as a strategy to address this issue, the potential economic burden that this type of tax could place on households with low economic status has not been investigated in the United States (US).

Objectives: The objectives of this study were to examine dietary changes and economic burden associated with a 10% increase in the prices of snacks and desserts between households differing in economic status.

Design: Nutrition facts panel information from commercial databases was linked to products purchased at stores by households (n=60,167) in the 2012 Nielsen Homescan dataset. The sample of households was divided into three groups based on the Federal Poverty Guidelines (0-185%, 186-400% and >400%). Linear regression models were utilized to simulate a 10% increase in the prices of snacks and desserts on household purchases of calories, saturated fat, sugar, and expenditure ($) on foods/beverages from stores.

Results: For all three household economic levels, a 10% increase in the prices of snacks and desserts was associated with significant decreases in calories, saturated fat (grams) and sugar (grams) from snacks and desserts and total foods/beverages purchased from stores. Associations of a 10% increase in the price of snacks and desserts with purchases of calories, saturated fat, sugar, and expenditure ($) on snacks and desserts or total foods/beverages purchased from stores were not significantly different between the levels of household economic

status. Changes in household expenditure on snacks & desserts or total foods/beverages purchased at stores were not statistically different from zero for any level of household economic status for a 10% increase in the price of snacks and desserts.

Conclusions: These results suggest that a 10% increase in the price of snacks and desserts could decrease purchases of calories, saturated fat and sugar from stores without placing economic burden on households with low economic status.

Introduction

Taxation of foods and beverages has been proposed as a potential strategy to reduce excess caloric intake in the United States (US).[99] The focus of proposed food and beverage taxes have been on high-sugar[76] or energy-dense[77] products because these types of products provide dietary energy at the lowest cost to consumers,[100,101] and comprise some of the largest sources of calories in the US.[49-52] An argument often raised against taxation of foods is that foods are a necessity; therefore, there is potential for these types of taxes to be regressive and place a higher burden on low-income households. Others argue that low-income households have the greatest to gain given that they are disproportionally affected by diet-related diseases[76] and more likely to consume lost cost, low quality diets.[102] Given that low-income households spend a larger percentage of their disposable income on food,[103] this analysis examined both the potential for health benefits and economic burden that a tax on snack and dessert products purchased at stores could place on households differing in economic status.

A misconception regarding taxation of foods and beverages is that taxes are innately regressive. The economic impact of taxation on households can both be detrimental and favorable depending on how households respond to the taxation. For instance, a tax that has no effect on purchases transmits a 100% of the increase in price on to the consumer, whereas, a small tax that is highly effective at reducing purchases can result in less money spent by households. Currently, a limited number of studies have been conducted in the US to examine the potential for food/beverage taxes to be regressive and all have focused on Sugar-

Sweetened Beverages (SSB).[83-85] It should be noted that these studies examined observational data comparing prices and purchases across markets and time and used the expected change in purchases for a change in price to simulate a tax. Given that observational data was examined, the results should be interpreted as associations rather than the effect of price on purchases. One study simulating a 40% tax on SSB concluded that the tax was not regressive due to higher-income households paying a larger share of the revenues generated by the tax.[83] The economic burden that a tax on SSB would place on households was not estimated for different levels of household income. Another study simulating a 20% tax on SSB estimated that the tax could result in low-income households annually paying $19.97 after the tax as compared to $18.84 for high-income households.[84] By expressing the increase in dollars spent as a percentage of food and beverage spending the authors concluded that the tax was regressive and placed a higher burden on low-income households (1% of food spending) as compared to (0.6% of food spending) for high-income households. Lastly, simulation of a half-cent per ounce tax on SSB showed that low-income households would be estimated to pay about $1 to $2 more annually after the tax as compared to high-income households.[85] The authors concluded that the tax burden was regressive in that it represented 0.1% of annual income for low-income households as compared to 0.03% for high-income households.

Currently, studies evaluating the potential of alternative taxation strategies (e.g., taxes on energy-dense foods) to be regressive have not been conducted in the US. With the recent implementation of an 8% tax on non-essential "junk" foods in Mexico,[92] examining the potential effects of a similar tax in the US would inform legislators on the efficacy for this type of strategy to reduce excess caloric intake and improve dietary quality in the US. An unpublished study from our research team provides evidence that increasing the price of multiple snack/dessert groups would be more effective at reducing calories purchased from stores as compared to increasing the price of a single snack/dessert food. A concern with increasing the price of multiple food groups is that this could potentially increase the economic burden placed on low-

income households. The objectives of this study were to examine dietary changes and economic burden associated with a 10% increase in the prices of snacks and desserts between households differing in economic status.

Methods

Household Purchase Data

The sample of households (n=60,167) was obtained from the 2012 Nielsen Homescan panel, a longitudinal dataset on household purchases of food/beverages from supermarkets, grocery stores, convenience stores, and other food retail outlets.[47,59-61,93] Households are continually recruited by Nielsen using direct mailing and Internet advertising. Households selected to participate were geographically dispersed with a total of 76 markets (metropolitan and non-metropolitan areas) included in the analysis. Each participating household was provided with a scanner to record the Universal Product Code (UPC) of each purchase and quantity of each item. Purchases from each household were aggregated for each quarter. Reports from single person households with food/beverage purchases less than $45 per quarter and households with 2 or more individuals with food/beverage purchases less than $135 per quarter were deemed unreliable and excluded from the analysis. Based on this criteria, 2.8% of the quarterly reports by households were excluded. The characteristics of the final household sample in 2012 for three levels of household economic status are provided in (**Table 5.1**). The three levels were based on the Federal Poverty Guidelines (0-185%, 186-400%, and >400%). In the literature, 130% and 185% of the Federal Poverty Guidelines are used as thresholds to separate households into high and low poverty status and correspond to eligibility requirements to qualify for the Supplemental Nutrition Assistance Program[104] and Women Infants and Children.[105] To enable comparisons between previous research,[84,85] this study used 185% as the lower threshold, but divided high economic status into two categories based on the wide range of household economic status in the Nielsen Homescan panel

Nutrition Facts Panel Information

The UPC for a product purchased by a household in Homescan was linked with NFP information obtained from the commercial databases with the exact UPC.[47] If NFP information was not available for a product purchased then NFP information from the next closest previous year was assigned. For products without an exact UPC match, NFP information was obtained by a series of steps: 1) match NFP information from a product of the same brand and product description, but different size package; 2) match NFP information by brand, product type, and similar attributes in the product description; 3) match NFP information based on similar product type and product description; 4) remaining unmatched products received the average NFP information from the food/beverage category in which they were categorized.

Definition of Snacks & Desserts

Salty snacks, ice cream, candy, frozen/refrigerated and ready-to-eat grain-based desserts (GBD) were classified as snacks & desserts. The selection of snacks & desserts to model the taxation simulations was chosen by identifying foods that provide dietary energy at the lowest cost to consumers,[88] foods that are among the largest sources of calories in the US,[49-52] and foods where additional state sales tax rates have been applied in the US.[94] A detailed list of the products that were included in each category of snacks & desserts is provide in (**Appendix Table 5.1**).

Prices

Prices ($/100 g) for food/beverage groups were generated at the market level in each quarter by dividing the total dollars spent by the total grams purchased by households within a given market. Given the ecological study design of comparing prices and purchases across markets, in order to isolate the effect of market-level price it is necessary to control for additional market-level variables that effect purchases of snacks & desserts or total foods/beverages. The overall cost of foods/beverages for each market in a quarter was generated as the price of food/beverages (57 groups) weighted by the proportion of expenditure for each food/beverage

group. Overall food/beverage price represents the cost of a standardized basket of food in a given market for a given quarter.

Statistical Analysis

All analyses were conducted using Stata (version 12.0, 2011, StataCorp, College Station, TX) with a significance criteria of ($p<0.05$). For each household, quarterly reports of food/beverage purchases were analyzed. Ordinary least squares regression models were used to estimate the association of increasing the prices of snacks & desserts by 10% on purchases of snacks & desserts as well as total food/beverage purchases from stores. Outcomes from household purchases examined were calories, saturated fat, sugar, and expenditures ($). Per capita daily purchases of energy, saturated fat, and sugar were calculated by dividing household purchases by household size (excluding children <2 years of age) and 91 days (3 months). Expenditures ($) on snacks & desserts and total foods/beverages were analyzed as quarterly reports at the household level. The main objective of this manuscript was to report the change in purchases associated with a 10% increase in the price of snacks & desserts by level of household economic status (0-185% FPL, 186-400 FPL, and >400% FPL); therefore, the final estimates reported were generated from stratified models for each level of household economic status. To test for statistical differences between the estimates from the stratified models, all covariates were interacted with household economic status using the full sample and then Wald-tests were conducted using only the interaction terms for prices of snacks & desserts with household economic status. If the overall interaction was statistically significant then linear combinations of the interaction terms for each category of snacks & desserts with economic status were tested to determine statistical differences between different levels of household economic status. All models included the same set of household level covariates: quarter (to account for seasonality effects), head of household race/ethnicity, male head of household education, female head of household education, household type, and a series of sex specific variables for the number of individuals in the household belonging to particular age groups.

Natural log transformed prices for each snack & dessert group were included in the models. Natural log transformed price variables provides the ability to interpret beta coefficients as the change in purchases associated with percent increases in price. Given the ecological study design of comparing prices and purchases across markets, in order to isolate the effect of market-level price it is necessary to control for additional market-level variables that effect purchases of snacks & desserts or total foods/beverages. The following market-level variables measured quarterly were included in the models: Overall food/beverage price, percent unemployment, and logged prices of foods that were hypothesized to affect purchases of snacks & desserts (GBD baking mixes, pudding, and bread). The standard errors were adjusted by clustering on household to account for the multiple observations across the quarters in 2012. As mentioned previously, for the simulations of increasing prices of snacks & desserts by 10% the use of a linear-log model (untransformed purchases and natural log transformed prices) provides the ability to interpret beta coefficients as the change in purchases associated with percent increases in price. The expected change in purchases associated with a 10% increase in price is calculated as $\beta*\ln(100+10/100)$. Simulations increasing prices of snacks & desserts were calculated as the linear combination of simultaneously increasing each coefficient of price for RTE GBD, candy, salty snacks, ice cream, and frozen GBD by 10% in the stratified models.

Results

Households with lower economic status spent less (dollars ($)/ 100 grams) for each category of snacks & desserts (**Table 5.2**). Minimal differences were shown between the three levels of economic status for calories purchased from snacks & desserts (kcal/person/day), and total expenditure on snacks & desserts per household ($/household/day). Across all three household economic levels, approximately 20 percent of the calories purchased from stores were from snacks & desserts and 15 percent of expenditure at stores on foods and beverages were from snacks & desserts.

For all three household economic levels, a 10% increase in the price of snacks & desserts was associated with significant decreases in calories, saturated fat (grams) and sugar (grams) from snacks & desserts purchases from stores (**Figure 5.1**). Changes in household expenditures on snacks & desserts purchased at stores were not statistically different from zero for any of the three household economic levels when a 10% increase in the price of snacks & desserts was simulated. Associations of a 10% increase in the price of snacks & desserts with purchases of calories, saturated fat, sugar and expenditures on snacks & desserts were not significantly different between the levels of household economic status.

For all three household economic levels, a 10% increase in the price of snacks & desserts was associated with significant decreases in calories, saturated fat (grams) and sugar (grams) from total food and beverage purchases from stores (**Figure 5.2**). Changes in household expenditures on total foods & beverages purchased at stores were not statistically different from zero for any of the three household economic levels when a 10% increase in the price of snacks & desserts was simulated. Associations of a 10% increase in the price of snacks & desserts with purchases of calories, saturated fat, sugar, and expenditures on total foods and beverages from stores were not significantly different between the levels of household economic status.

Discussion

Purchases of calories and expenditures on total snacks & desserts were similar across the different levels of household economic status. A 10% increase in the price of snacks & desserts was associated with significant decreases in purchases of calories, saturated fat, and sugar from both snacks & desserts as wells as total food/beverage purchases from stores across all levels of household economic status. A 10% increase in price of snacks & desserts was not shown to be regressive and the results suggest that this taxation strategy would not place economic burden on households with low, medium, or high economic status.

While households with lower economic status are more likely to consume lower cost, lower quality diets,[102] the results from this study show that the calories and expenditures on snack & desserts were similar across the three household economic levels. Previous studies have shown similarities in the intake of sweet products (e.g., candy, pastries, cakes) between levels of household economic status.[106] The results from this study also show that a 10% increase in the price of snacks & desserts would be equally effective across each level of household economic status at decreasing calories, saturated fat, and sugar from both snacks & desserts as wells as other foods and beverages purchased from stores. It may be expected that households with higher economic status would be less responsive to a tax than lower income households;[89] however, results from simulations of a 20% tax on SSB in the US have also shown similar decreases in calories from all beverages between households with high and low economic status.[84,85] From a dietary quality standpoint it is also important to encourage households with lower economic status to purchases more healthful foods and beverages. A difficulty achieving this within the current food environment is that healthful products are more expensive than less healthful options.[107] Future research combining taxation of less healthful foods with subsidies on more healthful foods can provide insights to address lower dietary quality among households with lower economic status.

Given the concern over the potential for taxes to place economic burden on low income households, this study examined the associations of a 10% increase in price of snacks & desserts on purchases of foods/beverages across different levels of household economic status. Previous studies examining simulations of SSB taxes have shown the potential for a SSB tax to be regressive.[84,85] By expressing the increase in dollars spent as a percentage of food and beverage spending, one study concluded that a 20% tax on SSB was regressive and placed a higher burden on low-income households (1% of food spending) as compared to (0.6% of food spending) for high-income households.[84] A second study simulating a half-cent per ounce tax on SSB concluded that the tax burden was regressive in that it represented 0.1% of

annual income for low-income households as compared to 0.03% for high-income households.[85] The results from this study suggest that a 10% increase in the price of snacks & desserts would not place economic burden on households of low, medium, or high economic status. Future work regarding the economic burden that food/beverage taxes place on households is needed; however, the current body of literature, although limited, suggests that the economic burden from a SSB tax or snack & dessert tax would be minimal.

An important caveat that has not been discussed in the literature regarding taxation of foods/beverages is that low income households purchasing foods/beverages with Supplemental Nutrition Assistance Program (SNAP) dollars are not required to pay sales taxes.[108] Given that 75% of individuals that are qualified receive SNAP,[62] this is an important issue to discuss regarding different types of taxation policies. There are multiple types of taxation strategies that can be imposed at various stages of production, distribution, and sales of foods/beverages. An excise tax is imposed at the production/distribution stages and is reflected in the shelf prices, whereas, a sales tax is imposed at the point of purchase and the burden is placed on to the customer.[109] Higher sales tax rates have been placed on a variety of snack & dessert foods in the US.[94] Given that sales taxes are not applied to purchases of foods/beverages with SNAP benefits, a sales tax would be less likely to place economic burden or decrease purchases in households participating in SNAP. The results from this study suggest that an excise tax increasing the shelf price of snack & dessert foods would potentially have a larger impact on purchases among low-income households without imposing economic burden. A limitation of our dataset is that knowledge of whether or not a household was receiving SNAP benefits was not obtained from Nielsen. In the interest of not placing economic burden on any household, future research is needed to determine if low-income households participating in SNAP are affected differently by food/beverage taxes than eligible households that do not receive benefits.

Recently, an excise tax on SSB and a “junk” food sales tax on high calorie foods was implemented in Mexico.[92] The “junk” food tax covers all products analyzed in this paper and

includes puddings/flans, nut spreads, RTE cereals and selected products with energy densities greater than 275 kcal/100 grams. While previous research using information on the effects of prices on purchases from one country to predict changes in another have been conducted [91], this practice should be avoided given that consumers in different countries will likely have different responses to increases in price. Evaluation of the "junk" food tax should be conducted using a sample of households in Mexico to determine if the new taxation policy is improving dietary purchases or imposing economic burden.

The ecological study design with respect to the prices of snacks and desserts across different markets limits interpreting the findings to associations between price and purchases. With observation data, this analysis compared prices and purchases across markets to determine if households in markets with higher prices of snacks & desserts purchased smaller quantities of snacks & desserts. While the average economic burden was not significantly different from zero for any level of household economic status, it was not possible to estimate the economic burden that a real-life tax could potentially place on low-income households living in parts of the country where the price of foods/beverages is higher than average. Finally, it is important to note that only the price and purchases of foods with UPC or barcodes were included in this analysis. These models cannot address the possibility that consumers in markets with higher prices of snacks & desserts purchased higher amounts of non-barcode products from bakeries, fast food, or restaurants.

In conclusion, these results suggest that a 10% increase in the price of snacks & desserts would be equally effective for each level of household economic status at decreasing calories, saturated fat, and sugar from both snacks & desserts as wells as total foods and beverages purchased from stores. A 10% increase in the price of snacks & desserts was not shown to be regressive or place an economic burden on low-income households. These findings provide evidence to inform legislators on a new strategy to reduce excess calorie intake

and improve dietary quality in the US without placing an economic burden on households with low economic status.

Tables and Figures

Table 5.1. Characteristics of the Nielsen Homescan sample in 2012 by Federal Poverty Guidelines (FPG)

	0-185% FPG		186-400% FPG		>400% FPG	
Household Characteristics	n	%	n	%	n	%
Race/Ethnicity						
Non-Hispanic White	10,501	81	20,169	81	17,694	79
Non-Hispanic Black	1,240	10	2,196	9	2,224	10
Non-Hispanic Other Races	555	4	1,119	5	1,141	5
All Hispanics	686	5	1,326	5	1,316	6
Male Head of Household Education						
< High school	930	7	866	3	299	1
= High school	2,820	22	4,931	20	2,823	13
< High school	4,470	34	12,492	50	14,833	66
No male head of household	4,762	37	6,521	26	4,420	20
Female Head of Household Education						
< High school	656	5	478	2	157	1
= High school	4,033	31	5,975	24	2,918	13
< High school	6,993	54	16,104	65	16,771	75
No female head of household	1,300	10	2,253	9	2,529	11
Household Type						
Singleton (male)	946	7	1,721	7	1,895	8
Singleton (female)	2,782	21	4,618	19	3,292	15
Multiple adults no children	5,511	42	11,722	47	14,077	63
Adult(s) with children-(only 2-11 year olds)	1,331	10	2,619	11	1,352	6
Adult(s) with children-(only 12-18 year olds)	1,452	11	2,569	10	1,540	7
Adult(s) with children-(2-18 year olds)[a]	960	7	1,561	6	219	1

Values are the number of households and percent of the Nielsen Homescan sample in 2012
[a]Excludes households with only 2-11 year olds and households with only 12-18 year olds.
Average household size for each level of household poverty (0-185%, 186-400%, and >400%) were 2.6, 2.5 and 2.1, respectively

Table 5.2. Descriptive statistics for price, energy, dollars, and percent of total purchases of foods and beverages for selected food groups by household economic status

	Unit Price ($/100 g)[a] (SD)	Kcal/Person/ Day (SD)	Expenditure ($)/ Household/ Day(SD)	%Total Calories[b] (SD)	%Total Dollars[c] (SD)
0-185% FPG[d]					
RTE GBD	0.57 (0.86)	77 (96)	0.26 (0.33)	5 (5)	4 (4)
Ice Cream	0.27 (0.25)	39 (64)	0.18 (0.25)	3 (4)	3 (3)
Candy	0.82 (0.74)	62 (143)	0.25 (0.35)	4 (6)	4 (5)
Salty Snacks	0.63 (0.29)	82 (90)	0.30 (0.31)	6 (5)	4 (4)
Frozen GBD	0.46 (0.21)	9 (23)	0.03 (0.08)	1 (2)	0.5 (1)
Total Snacks/Desserts	-	268 (258)	1.03 (0.88)	19 (11)	15 (9)
186-400% FPG[d]					
RTE GBD	0.61 (0.32)	73 (92)	0.27 (0.31)	5 (5)	4 (4)
Ice Cream	0.29 (0.26)	38 (57)	0.19 (0.26)	3 (4)	3 (3)
Candy	0.84 (0.80)	63 (119)	0.27 (0.36)	4 (6)	4 (5)
Salty Snacks	0.65 (0.48)	84 (87)	0.32 (0.31)	6 (5)	4 (4)
Frozen GBD	0.47 (0.22)	9 (25)	0.03 (0.08)	1 (2)	0.5 (1)
Total Snacks/Desserts	-	267 (238)	1.08 (0.86)	19 (11)	15 (8)
>400 FPG[d]					
RTE GBD	0.68 (1.24)	67 (87)	0.25 (0.30)	5 (5)	3 (3)
Ice Cream	0.32 (0.26)	36 (55)	0.18 (0.26)	3 (4)	3 (3)
Candy	0.90 (1.25)	67 (132)	0.26 (0.36)	5 (6)	4 (5)
Salty Snacks	0.68 (0.45)	85 (89)	0.31 (0.30)	6 (5)	4 (4)
Frozen GBD	0.48 (0.23)	8 (24)	0.03 (0.07)	1 (2)	0.4 (1)
Total Snacks/Desserts	-	264 (240)	1.03 (0.83)	20 (11)	14 (9)

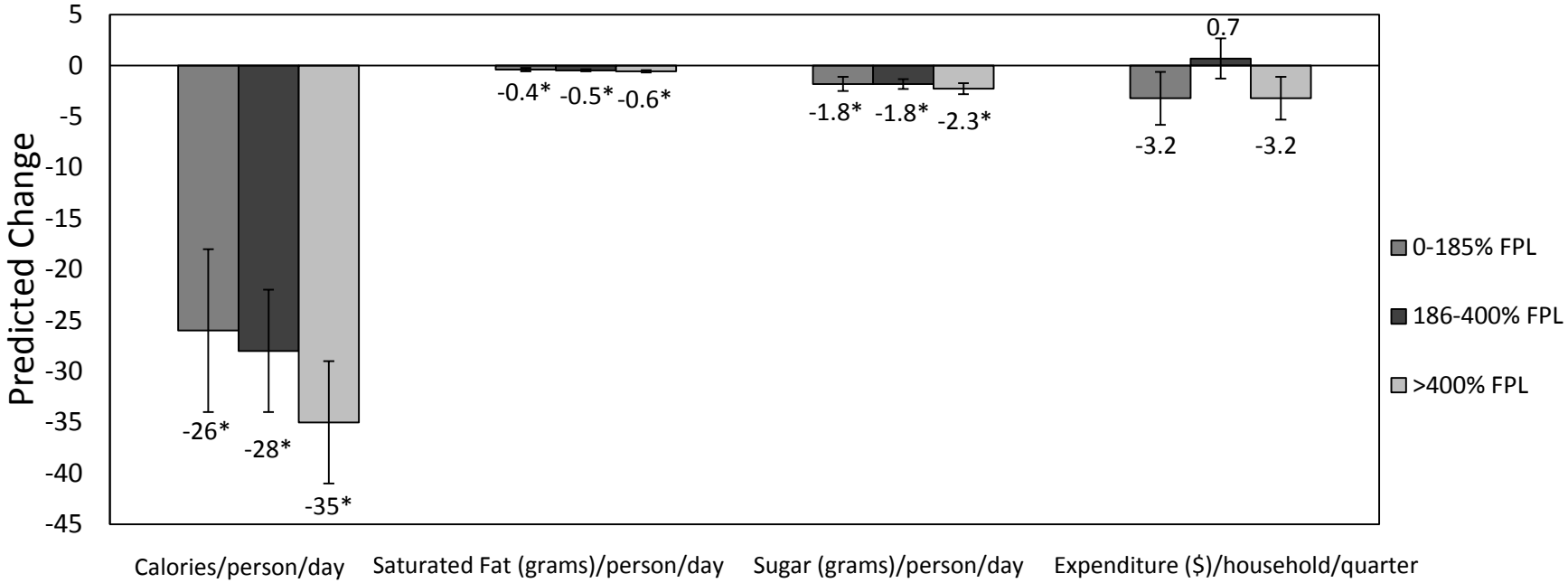
[a]Unit price ($/100 g) for foods groups were calculated for each household as the dollars ($) spent divided by the total grams purchased and then multiplied by 100. These unit prices were then divided by the overall food/beverage price of each market to calculate the price of a food group relative to the overall cost of food/beverages in that market

[b]Percent total calories was calculated as the calories from a food group divided by the total calories of foods/beverages purchased by a household

[c]Percent total dollars was calculated as the dollars spent on a food group divided by the total dollars of foods/beverages purchased by a household

[d]Federal Poverty Guidelines

Figure 5.1. Predicted changes in store-bought nutrients and expenditures from snacks & desserts associated with a 10% increase in the price of snacks & desserts

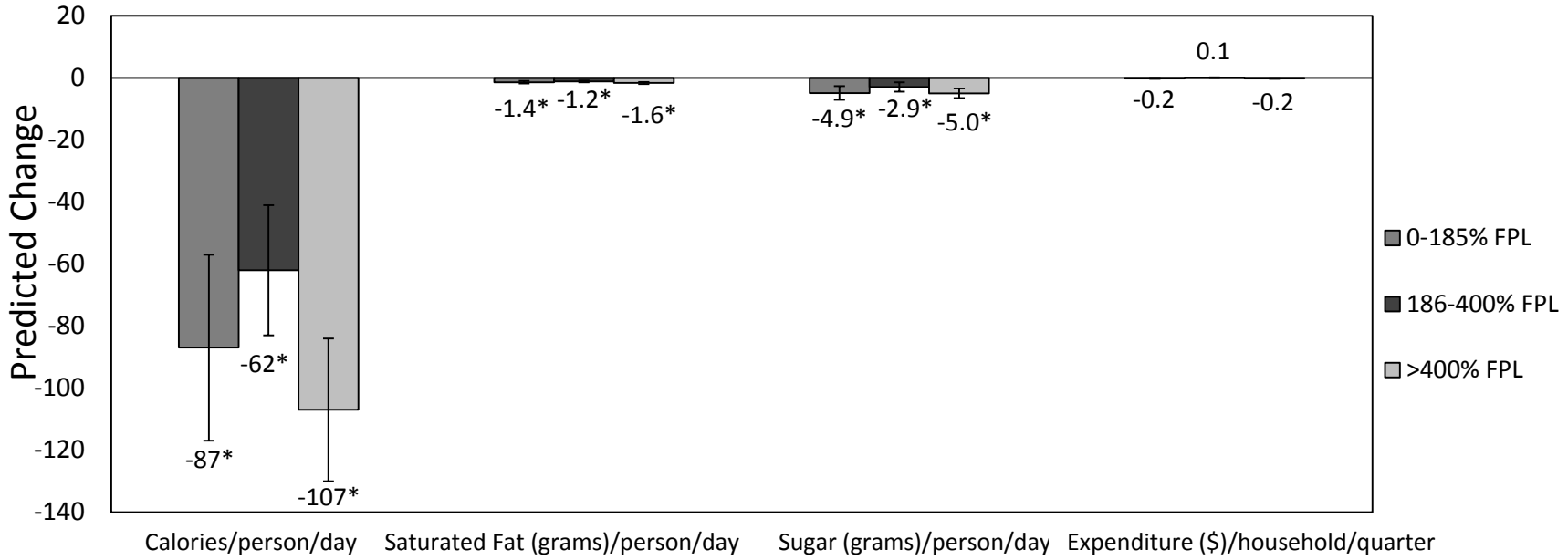


Daily per capita purchases (energy, saturated fat (grams), sugar (grams)) were calculated by dividing household purchases by household size and 91 days (91 days in a quarter). Expenditures were calculated at the household level and divided by 91 days. Estimates were derived from linear regression models including the logged prices of each snack and dessert (RTE GBD, candy, salty snacks, ice cream, and frozen GBD) as wells as dry GBD mixes, pudding, and bread. Predicted changes were calculated as the linear combination of simultaneously increasing the price of each snack and dessert by 10%. Additional covariates included in the models were quarter (to account for seasonality effects) head of household race/ethnicity, male head of household education, female head of household education, household income , household type, and a series of sex specific variables for the number of individuals in the household belonging to particular age groups. The models also controlled for the following market level covariates measured quarterly: overall price of foods/beverages, percent unemployment. The standard errors were adjusted by clustering on household to account for the multiple observations across the four quarters.

*Indicates a significant difference (P<0.05) of a predicted change from zero.

Significant differences (P<0.05) were not detected between levels of household economic status for any of the purchase outcomes.

Figure 5.2. Predicted changes in store-bought nutrients and expenditure from all foods and beverages associated with a 10% increase in the price of snacks & desserts.



Daily per capita purchases (energy, saturated fat (grams), sugar (grams)) were calculated by dividing household purchases by household size and 91 days (91 days in a quarter). Expenditures were calculated at the household level and divided by 91 days. Estimates were derived from linear regression models including the logged prices of each snack and dessert (RTE GBD, candy, salty snacks, ice cream, and frozen GBD) as wells as dry GBD mixes, pudding, and bread. Predicted changes were calculated as the linear combination of simultaneously increasing the price of each snack and dessert by 10%. Additional covariates included in the models were quarter (to account for seasonality effects) head of household race/ethnicity, male head of household education, female head of household education, household income , household type, and a series of sex specific variables for the number of individuals in the household belonging to particular age groups. The models also controlled for the following market level covariates measured quarterly: overall price of foods/beverages, percent unemployment. The standard errors were adjusted by clustering on household to account for the multiple observations across the four quarters.

*Indicates a significant difference (P<0.05) of a predicted change from zero.

Significant differences (P<0.05) were not detected between levels of household economic status for any of the purchase outcomes.

Appendix Table 5.1. Types of products categorized as snacks & desserts

Snack & Dessert Category	Types of Products
RTE GBD	Cakes, cookies, pies, pastries, sweet strudels, doughnuts, granola/yogurt bars, and graham crackers
Ice Cream	Ice cream, frozen novelties, sherbet, frozen yogurt, refrigerated pudding, and ice pops
Candy	Chocolate, chocolate bars/pieces, non-chocolate sweets, confectionary products, lollipops
Salty Snacks	Popcorn, puffed cheese, pretzels, potato chips, tortilla chips
Frozen GBD	Cakes, cookies, brownies, cobblers, sweet strudels, doughnuts, pies, éclairs, and cheesecakes

Chapter 6. Synthesis

Overview of the Findings

This research identifies new opportunities to develop strategies to reduce purchases of GBD that involve both foods manufactures and government officials. In Aim 1, new methodology was developed to determine if food manufacturers made product reformulations or introduced products onto the market with lower densities of energy, saturated fat, and/or sugar between 2005 and 2012. The analysis used RTE GBD as a case study because GBD are one of the largest sources of calories in the US and the nutrition information available for RTE GBD was in the form of "as consumed." The results from Aim 1 showed that the average energy and sugar density of RTE GBD products manufactured did not change between 2005 and 2012, whereas, an increase in the average saturated fat density of RTE GBD products was shown. These results identify a new opportunity for food manufacturers to improve dietary quality in the US by reformulating or developing new RTE GBD products with lower energy, saturated fat and/or sugar densities. Developing new methodology to monitor changes to products manufactured also provides the ability to determine if reformulations and new product development have had an impact on consumer purchases of unhealthy dietary components. Therefore, in addition to measuring changes in the nutrient composition of food and beverage products it is also important to examine changes in the nutrient density of products consumers are purchasing.

The results from Aim 2 showed that purchases of RTE GBD products with lower energy and sugar densities increased, and purchases of RTE GBD products with higher saturated fat densities increased between 2005 and 2012. Increases in the saturated fat density of RTE GBD products manufactured were also detected suggesting that changes in manufactured products can have an impact on consumer purchases of saturated fat. While the decreases in energy and

sugar density of RTE GBD products purchased is encouraging, the magnitude of the decreases (<4%) indicates that efforts by food manufacturers or public health officials to promote consumption of RTE GBD products with lower energy, saturated fat, and sugar densities have had limited effectiveness. Changes in the grams of RTE GBD purchased were also examined. Consumers decreased purchases of RTE GBD and households with 12-18 year olds had the largest percent decreases as compared to households without children. It is difficult to ascertain why consumers decreased purchases of RTE GBD between 2005 and 2012 and while decreases in purchases are promising, this research identifies an opportunity to educated consumers on making more healthful choices when purchasing RTE GBD products.

In the interest of promoting decreases in RTE GBD purchases, taxation simulations were conducted to determine the potential for increases in the price of RTE GBD to decrease purchases of RTE GBD. The results suggest that purchases of RTE GBD could decrease if prices are increased; however, there is evidence to suggest that increasing the price of RTE GBD could also result in consumers shifting to alternative snacks/desserts. The analysis then compared the association of increasing the price of only RTE GBD on purchases versus increasing the price of multiple snacks & desserts. The results showed that increasing the prices of multiple snacks & desserts was more effective at decreasing purchases of calories, saturated fat, and sugar from snack & desserts as compared to only increasing the price of RTE GBD. These findings inform governmental officials, interested in proposing tax legislation, on the potential impact on dietary quality and caloric intake that increasing the prices of multiple snacks & desserts could have in the US. A concern with increasing the prices of multiple snacks/desserts is that this type of policy may result in placing economic burden on households with lower economic status. The findings from Aim 3 provide evidence to inform legislators on a new strategy to reduce excess calorie intake and improve dietary quality in the US without placing an economic burden on households with low economic status. In summary, the results

from this dissertation inform both food manufacturers and government officials on potential opportunities to reduce excess caloric intake and improve dietary quality in the US.

Public Health Impact and Significance

The main concept of this dissertation is that total consumption of a given nutrient is affected by two factors: 1) density of a nutrient in food products and 2) the amount of food products consumed. The first two aims focused on identifying opportunities to reduce the density of energy, saturated fat, and sugar in RTE GBD purchases and the third aim was focused on identifying strategies to decrease consumer purchases of RTE GBD as well as other snack and dessert foods. Aim 1 identified an opportunity for food manufacturers to decrease the energy, saturated fat, and sugar densities in RTE GBD products as a method to decrease consumption of less healthful food components. New methodology was developed using databases with Nutrition Facts Panel information to determine if food manufacturers had made efforts to decrease the energy, saturated fat or sugar density of RTE GBD products in the US. Monitoring of changes to the nutritional composition of foods sold at fast food, restaurant chains[63,64] and RTE breakfast cereals[57] have been previously conducted. This is the first study to monitor changes in the nutrient composition of consumer packaged goods other than RTE breakfast cereals in the US. Monitoring changes in the nutrient composition of food products available to consumers provides the ability to monitor efforts by food manufactures to increase the healthfulness of food products, but also allows monitoring if consumers respond to these changes or other public health initiatives. In order to determine the effectiveness of front-of-package labeling systems and other initiatives to improve dietary quality in the US it is important to measure changes both between product categories (e.g., shifts from RTE GBD to fruits) and within product categories (e.g., shifts from energy dense RTE GBDs to lower energy dense RTE GBDs). The new approach presented in Aim 2 addresses a limitation of current dietary surveys by using NFP information from store purchases to identify if consumers are shifting within product categories to products with lower energy, saturated fat, or sugar densities.

The final aim of this dissertation was the first study in the US to examining taxation strategies to reduce consumer purchases of low-cost energy dense food products from stores. With the recent implementation of an 8% tax on non-essential "junk" foods in Mexico,[92] examining the potential effects of a similar tax in the US would inform legislators on the efficacy for this type of strategy to reduce excess caloric intake and improve dietary quality in the US. The results demonstrate that the potential for consumers to switch to non-taxed foods can limit the effectiveness of taxation policies on a single group of foods products. Increasing the price of multiple snacks & dessert was shown to be an effective strategy to reduce purchases of calories, saturate fat, and sugar from snacks & desserts. A common concern raised in the literature is that taxation of foods/beverage will be regressive and place an economic burden on low income households. Others argue that low-income households have the greatest to gain given that they are disproportionally affected by diet-related diseases[76] and more likely to consume lost cost, low quality diets.[102] Only three studies addressing the concern over economic burden have been conducted in the US and all three examined taxation simulations of SSB.[83-85] The results of our last study address both points and provide evidence that a 10% increase in the price of multiple snacks/desserts is equally effective at decreasing store purchases of calories, saturated fat and sugar across all levels of household economic status and would not place economic burden on low income households. An important caveat that has not been discussed in the literature regarding taxation of foods/beverages, but was raised by this research, is that low income households purchasing foods/beverages with Supplemental Nutrition Assistance Program (SNAP) dollars are not required to pay sales taxes.[108] Given that sales taxes are not applied to purchases of foods/beverages with SNAP benefits, a sales tax would be less likely to place economic burden or decrease purchases in households participating in SNAP. The results from this study provide important insights to legislators on the use of a sales or excise taxes to decrease purchases of less healthful foods and beverages. Our results suggest that an excise tax increasing the shelf price of snack & dessert foods would

potentially have a larger impact on purchases among low-income households without imposing economic burden. This dissertation provides valuable insights into monitoring the effectiveness of strategies to improve dietary quality in the US, as well as, presenting new opportunities for both food manufacturers and government officials to shift consumer purchases towards products with lower energy, saturated fat, and sugar densities.

Limitations and Strengths

A limitation of this work, and all dietary studies for that matter, is the accuracy of the nutrition information for the foods and beverages reported consumed. Table 3.2 shows that 4-6% of the RTE GBD products in each year had up-to-date NFP information, which represented 9-30% of the grams purchased by consumers. As mentioned in the methods section of chapter 3, if NFP information was not available for a product in the year it was purchased then NFP information from the subsequent year or the next closest previous year was assigned. Large scale reformations to products could potentially not be captured using the current amount of products provided with updated NFP information each year. A strength of this analysis is that Aim 1 examined evidence to indicate whether reformulations of RTE GBD products occurred over time. The analysis showed that changes in the energy or sugar densities were not detected, and the analysis detected the increase in saturated fat in 2006, presumably from reformulations to reduce trans fats. These findings provide evidence to show that the NFP information available across years represents the NFP information of products purchased.

A second broad limitation of using the Homescan dataset is that it is not possible to assume that purchases equate to intake due to food waste/spoilage. There is also concerns for under-reporting of purchases, in that participants in Homescan might not scan every item purchased. Particular products of concern are purchases from convenience stores where consumers might consume the product prior to being scanned. A strength of this dissertation is that the analyses were structured to avoid most of these issues. First, the analysis focused on changes in the nutrient densities of products manufactured and purchased which would not be

affected by food spoilage and unlikely to be affected by under-reporting. Second, the analysis avoided reporting absolute estimates in the main analyses, rather, changes over time were reported with the assumption that changes in food spoilage or under-reporting did not change over time. The author acknowledges the possibility that the Great Recession led to reduced waste among low income households. Lastly, for the taxation models it is unlikely that food spoilage or under-reporting is associated with prices of snacks & desserts; therefore, estimating change in purchases for a change in price should not be affected by food spoilage or under-reporting.

Directions for Future Research

This research presents a new approach to monitor changes in the nutrient composition of foods and beverages manufactured and purchased by consumers. Ready-to-eat GBD were used as a case-study in this dissertation and future research on other product categories (e.g., salty snacks) that are the largest sources of less healthy food components is needed. This dissertation also points out areas in the collection of NFP information where improvements can be made to allow for better detection of changes to the products available to consumers. Collection of NFP information from a larger sample of products is needed each year to prevent nutrient information lagging behind changes made to the food supply. This research also highlights the importance of measuring changes both between product categories (e.g., shifts from RTE GBD to fruits) and within product categories (e.g., shifts from energy dense RTE GBDs to lower energy dense RTE GBDs). With discussions on development of a new FOP labeling system, future studies can utilized the approach presented in Aim2 to determine if the new FOP labeling system has an impact on consumers choices to purchase more healthful products within a product category. Finally, the taxation simulations examined in this dissertation focused only on decreasing purchases of energy-dense, low cost snacks & desserts. Taxation policies to encourage consumers to shift within product categories to more healthful products have not been investigated. Future research examining higher taxation of

less healthful foods in a product category could potentially be more effective at reducing consumer purchases of energy, saturated fat and sugar from stores.

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