Three Essays on Obesity

Food Environment, Attitudes toward Food, and Cash Transfers

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Introduction

This dissertation analyzes determinants of obesity and a public policy to alleviate poverty and its effects on obesity. Obesity is a global phenomenon and one of the leading causes of diabetes, ischaemic heart disease, high blood pressure, fatty liver disease, and breast, colon, endometrial, and kidney cancer. In 2015, more than 1.9 billion adults were overweight and more than 600 million were obese (WHO, 2015). In this dissertation, I used data from the United States and Mexico to highlight evidence from the two countries with the highest prevalence of overweight and obesity; while they are neighbors, these countries are very different in their respective socioeconomic makeups. In the United States, 31.8% of children from 2-19 years old and 68.5% of adults over 20 years old are overweight or obese (Ogden et al., 2012). In Mexico, the problem is present in 34.9% of adolescents between 12 and 19 years and in 71.2% of adults over 20 years (Gutierrez et al., 2012).

The food environment, a factor potentially influencing diet, has received considerable attention from the media and policymakers in recent years. In particular, it is taken for granted that the food environments of a particular neighborhood, such as “food deserts” (where healthy food options are difficult to access), determine obesity, and thus, the food environment needs to be regulated. However, this idea does not assess the role of distance between the food environment and work, school, and home. Although some investigations have shown a significant association between these factors, others have not corroborated it. Therefore, my objective in the first chapter of this study was to examine the association between the number and type of food outlets in residential neighborhoods and dietary intake and body mass index (BMI) among adults in Los Angeles County. I also assessed whether this association depends on the geographic size of the food environment.

To accomplish this research goal, I used data from the 2011 Los Angeles County Health Survey. I established buffer zones (from 0.25 to 3.0 miles in radius) centered in respondents' homes and counted the number of food outlets by type within each buffer zone. The dependent variables were weekly intake of fruits and vegetables, sugar-sweetened beverages, and fast food; BMI; and being overweight ($\text{BMI} \geq 25.0 \text{ kg/m}^2$) or obese ($\text{BMI} \geq 30.0 \text{ kg/m}^2$). The explanatory variables were the number of outlets classified in five categories: fast-food outlets, convenience stores, small food stores, grocery stores, and supermarkets. I used

negative binomial models to assess the association between the food environment and the counts of food intake, ordinary least squares for BMI, and logistic models for the probability of being overweight or obese. In total, 150 effects from estimating models for all explanatory variable and buffer size combinations were tested.

After performing these tests on the data, I found little evidence of associations between residential neighborhood food environment in small geographic sizes and dietary intake or BMI among adults in Los Angeles County. Only 2 of 150 effects were statistically significant after being adjusted for multiple comparisons. The number of fast-food restaurants in non-walkable areas (within a 3.0-mile radius) was positively associated with fast-food consumption, and the number of convenience stores in a walkable distance (within a 0.25-mile radius) was negatively associated with obesity. Possible explanations for the null finding are that purchasing patterns in Los Angeles are unrelated to short distances because it is a highly-motorized area and that food supply in LA County offers easy access to all types of food. In addition to physical access to food outlets, other dimensions that affect diet behavior are affordability, availability and food quality in those outlets, preferences, perceived attributes of food, and budget constraints. The last two dimensions were analyzed in the following chapters.

In the second chapter, I investigated pathways linking consumer attitudes toward food and BMI of adults in the United States through physical activity and diet quality. The uniquely modern phenomenon that combines higher caloric intake with lower energy expenditure has led to important energy imbalances that foster obesity worldwide. Although food has become cheaper and more accessible for a large part of the global population, price may not be the only factor guiding people's food choices. There is an ongoing debate about how people make choices, whether they select food weighting their perception of several attributes (classic economics) or only a few attributes (heuristics) of the food they consume. Therefore, I focused on analyzing the associations between consumer attitudes toward food by socioeconomic status and food intake, physical activity and body mass index in this chapter. I used data from the National Health and Nutrition Examination Survey (NHANES) 2007-2008 and 2009-2010. These versions contain a special module named "Consumer Behavior Phone Follow-up" that provides information on various dietary and related consumer behavior topics. I used pathway analysis with maximum likelihood estimators hypothesizing that consumer attitudes are associated with diet quality, physical activity, and BMI and, at the same time, BMI is associated

with diet quality and physical activity. Therefore, consumer attitudes were expected to be directly and indirectly associated with BMI.

Four consumer attitudes toward food were used as explanatory variables: importance of nutrition, taste, freshness, and preparation time relative to price of food, and a composite index of consumer attitudes regarding those four variables. Diet quality was assessed with the Healthy Eating Index constructed from data from the 24-hour dietary recall included in the survey. Physical activity is the number of metabolic equivalent (MET) minutes that an individual spent doing moderated or vigorous physical activity during the last week.

In analyzing the data, I found that the importance of nutrition relative to price is the only consumer attitude significantly associated with BMI and diet quality. No consumer attitudes were significantly associated with the level of physical activity. Socioeconomic status influenced BMI, diet quality, and physical activity both directly and indirectly. There were two main policy implications from these findings. First, the problem of excess weight and obesity could be addressed by implementing policies that change the perception of the nutrition of healthy and unhealthy food among the overall population. Second, improving socioeconomic status may result in higher diet quality, higher physical activity, and lower obesity levels.

Given the role of income constraints and socioeconomic status in the food intake and BMI of people found in the previous two chapters, in the third and last chapter I analyze the effects of a cash transfer program on the obesity and diet of a highly-vulnerable group in a middle income country: persons aged 70 and older in Mexico. I used data from a cash transfer experiment designed by RAND in the state of Yucatan in Mexico that targeted this specific population. Two cities in the state of Yucatan, Valladolid (treatment) and Motul (control), were selected for the cash transfer experiment. Elderly Valladolid residents were provided the equivalent of an additional \$87 per month, a 44% increase in average household income. As part of the experiment, a survey was given to residents of both cities before and six months after the cash transfer intervention started regarding their frequency of food consumption and other aspects of overall well-being. Both baseline and follow-up surveys collected self-reported data on food demand, health, and biomarkers. Trained personnel collected anthropometric measurements for every age-eligible respondent including height and weight. I assessed the effect of the program with difference-in-differences models.

My results do not provide strong evidence about the short-run influence of the program on the body mass index and obesity-related outcomes for the older population, neither by poverty nor by income level. There was, however, a significant change in the food demand associated with additional income. Relative to the control site, there was a statistically significant decrease in the weekly demand of tortillas -a food with high caloric content-, and a slight decrease in the prevalence of anemia in the treatment site. Although an increase in income may not have a short-run impact on BMI, it has an impact on health (as indicated by a decrease in anemia) and the quality of food intake (as indicated by a decrease in “tortilla” consumption). Both of these may likely have a beneficial impact on reducing obesity in the longer-run if they are sustained. BMI effects on older populations may take much longer to materialize than six months, as opposed to effects on anemia or other health outcomes, which could be more immediate. Food insecurity, measured by the proportion of elderly people reporting that they had been hungry, that they or another member in their households did not eat all day because they did not have enough money to buy food, or that they ran out of food in the last three months, also decreased among the treatment site in comparison to the control. Furthermore, residents did not report any significant loss of weight without dieting. In sum, this study finds evidence that cash transfers to the elderly reduce their demand for food rich in calories but do not significantly affect their obesity in the short run. These results suggest that cash transfer programs may be implemented among similarly vulnerable populations without fostering unhealthy eating.

In sum, this dissertation addressed three dimensions of obesity: food environment, consumer attitudes, and budgetary constraints. Findings suggest that effective policies to address the problem need to focus more on elements influencing food demand at the purchasing point, such as food price, perception of nutrition, and income expansion, and less in macro elements such as food environment.

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Abstract

This dissertation analyzes determinants of obesity and a cash transfer policy to alleviate poverty and its effects on obesity. I used data from the United States and Mexico to highlight evidence from two countries that are neighbors but very different in their socio-economic makeup.

In the first chapter, I examined the relationship between the number and type of food outlets in a neighborhood and dietary intake and body mass index (BMI) among adults in Los Angeles County. I also assessed whether this relationship depends on the geographic size of the food environment. I found little evidence for associations between proximity of respondents' homes to food outlets and dietary intake or BMI among adults in Los Angeles County. A possible explanation for the null finding is that shopping patterns are weakly related to neighborhoods in Los Angeles County because of motorized transportation.

In the second chapter, I investigated pathways linking consumer attitudes toward food (nutrition, taste, freshness, and preparation time) and BMI through physical activity and diet quality among adults in the United States. I found that the importance of nutrition relative to price is the only consumer attitude significantly associated with BMI and diet quality. No consumer attitudes were significantly associated with the level of physical activity. Socioeconomic status influenced BMI, diet quality, and physical activity both directly and indirectly. These results suggest that the problems of excess weight and obesity could be reduced by implementing policies that change the perception of the nutrition of healthy and unhealthy food.

In the third chapter, I analyzed the effects of a cash transfer program on the obesity and diet of a highly-vulnerable group in a middle income country: persons aged 70 and older in Mexico. Two cities in the state of Yucatan, Valladolid (treatment) and Motul (control), were selected for the cash transfer experiment. Elderly residents of Valladolid were provided the equivalent of an additional \$87 per month, a 44% increase in average household income. Relative to the control site, there was a significant decrease in the prevalence of anemia in the treatment site, but no effect on obesity in the short run. I also found that the program reduced the demand of tortillas --a food with high caloric content--, and decreased food insecurity. These findings

suggest that cash transfer programs may be implemented among similar vulnerable populations without fostering unhealthy eating.

Chapter 1

Neighborhood Food Environment, Diet, and Obesity among Los Angeles County Adults

1.1 Introduction

Food environments have become an important topic in policy debates to address the obesity epidemic (USDA, 2010; USDHHS, 2014; WHTFCO, 2014). Food environment is defined as “the distribution of food sources, that is, the number, type, location, and accessibility of food outlets, with stores and restaurants being the most common” (Glanz et al. 2005 cited in Sallis and Glanz 2009). Overweight and obesity clusters in certain areas indicate a role of shared environments, including the possibility that there are “obesogenic” environments (Lake and Townshend, 2006). The obesogenicity of an environment is “the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations” (Swinburn et al. 2002 cited in Lake et al., 2006:262). A recurring theme is the role of the food environment, in particular the notion of “food deserts”, defined as a lack of access to healthy, affordable foods which are more common in disadvantaged neighborhoods, particularly in populated urban areas (Ver Ploeg M, 2009; Cummins and Macintyre, 2002; Walker, Keane and Burke, 2010); as well as “food swamps”, defined as “areas with a heavy concentration of fast food restaurants and convenience stores offering nutrient poor food” (Huff Post, 2014).

However, these definitions do not capture the distance between the food outlets and home, work, or school. They directly imply that diet of people is conditioned by their food environment regardless of its size. Indeed, distance to food swamps and food deserts may be a determinant of general food intake, particularly for low-income groups whose mobility constraints (lack, cost, or time of transportation) make it more difficult to travel farther for healthy food. Consequently, to effectively fight obesity it is necessary to fully understand the role of different sizes of food environment in diet and BMI.

The evidence on the way in which neighborhood food environments affect an individual's diet and body mass index (BMI) continues to develop, but it remains tentative, to a much greater degree than is often presented in the media and policy arguments (Saguy and Almeling, 2008; Bliss, 2015). Prominent hypotheses include the belief that fast-food restaurants and convenience stores encourage overconsumption of unhealthy foods and consequently higher BMI, while the presence of supermarkets generally lead to increased intake of fruits and vegetables and thus lower BMI.

Although associations between some types of food outlets and obesity have been reported, there have also been many null findings. For instance, Raja et al. (2010) found that the proximity of women's homes to a supermarket relative to a convenience store is associated with lower BMI in New York. Similarly, Morland et al. (2006) indicated that the prevalence of supermarkets is correlated to lower BMI of residents, while a higher presence of convenience stores is associated with higher obesity in Mississippi, North Carolina, Maryland, and Minnesota. In contrast to both of these findings, Jeffery et al. (2006) did not find evidence of an association between BMI and the proximity of fast-food restaurants to work or home in Minnesota. Therefore, the existing literature would not seem to support a single, iron-clad conclusion.

Even when there is a positive association between food outlets and BMI, this association does not necessarily seem to be replicated in associations between distance to food outlets and diet (Giskes et al., 2011). Among the authors that found positive associations in both BMI and diet, there is Laska et al. (2010), whose results suggested that adolescents' sugar-sweetened beverage intake is associated with residential proximity to restaurants, fast food outlets, convenience stores, and grocery stores, while their BMI is associated to the presence of a convenience store within a 1600m radius. In contrast, Jeffery et al. (2006) did not find any significant association between fast-food intake and proximity between fast-food outlets and work or residential homes in Minnesota. An and Sturm (2012) analyzed data of children and adolescents in California and found no robust association between food environment and diet. Similarly, Richardson et al. (2011) analyzed the environment at national level and their results indicate that food availability was not correlated to consumption of fast-food in both low and high-density urban areas.

Despite the widespread use of the term “neighborhood food environment”, there has been no consensus on what this term means in relation to geographic area. Geographic definitions used in the research literature can be as large as a state (Maddock, 2004). In practice, the unit most commonly used is a census tract (Morland, Roux and Wing, 2006; Walker, Keane and Burke, 2010; Shier, An and Sturm, 2012) or a zip code (Powell, Chaloupka and Bao, 2007; Cummins and Macintyre, 2002) because they are more feasible for monitoring purposes, measures reflecting the actual distance to food outlets such as Euclidean distance or road network may identify disparities between communities more reliably; as a rule, they more effectively show the real distance and opportunity cost that people must travel to access food. Research using actual distance is growing (Jeffery et al., 2006; Laska et al., 2010; Richardson et al., 2011; Hattori, 2013; An and Sturm, 2012). Moreover, some researchers have gone beyond these definitions and explored some more accurate to real life considerations, such as travel time, which is the distance that an individual walks or drives within a given unit of time around her residence or place of interest (Raja et al., 2010). This definition has the advantage of accounting for the opportunity cost of travel time to a specific outlet.

The White House Task Force on Childhood Obesity Report (2010) references a single study, which was based on densities in postal and zip codes, in its recommendation to increase the number of supermarkets to reduce childhood obesity (Powell et al., 2007). However, a similar analysis using census tracts showed no such association (Shier, An and Sturm, 2012). Most studies were limited by grouping respondents into large geographic areas because there was no information on actual locations of respondents, so the sensitivity of results to distances between respondents and food outlets were not tested. However, there are a couple of exceptions for studies of adults. One study using data from California found that food outlets within walking distance (≤ 1.0 mile) were not strongly associated with dietary intake or BMI, although there were some significant associations beyond walking distance (Hattori, 2013). Another study conducted longitudinally of young adults found no strong associations between supermarkets and diet quality and fruits and vegetables intake, but it found that fast-food consumption among low-income men was related to fast-food availability in areas beyond immediate walking distance (Boone-Heinonen et al., 2011).

The US Department of Agriculture created an interactive web-mapping tool to identify food deserts (Food Access Research Atlas, 2013). In that tool, the Food Access Research Atlas, the

criterion for a food desert is based on distance from residential address to a supermarket; a census tract is considered to have low access to food if a significant number or share of individuals in the tract is far from a supermarket. The original distance was 1 mile, but a second criterion was added using 0.5 miles to show how sensitive the food desert map is to the distance demarcation. The definition of physical access to food retailers is also evident in a publication by the Centers for Disease Control and Prevention that recommends that communities “improve geographic availability of supermarkets” and proposes the number of supermarkets in census tracts as a measure to assess a food environment (Khan et al., 2009).

The hypothesis this analysis tested is whether associations between food environment and food intake and BMI are related to the geographic size of the food environment. I analyzed adults in Los Angeles County and used both an administrative definition of food environment, census tract, and one of real distance, with radii of varying sizes centered in individuals’ homes. My contribution is twofold. First, I contribute to the debate on the role of food environment of different types and sizes on the food intake and BMI of adults. Second, I use data from Los Angeles County (a very particular food environment) that is not publicly available and has not been used to broaden the current discussion and analysis on the topic.

1.2 Conceptual Framework

Based on the economic conceptual framework proposed by Rose et al. (2010) that accounts for the idea that food environment influences food purchases, I modified it to include food intake and BMI, the final health and diet outcomes influenced by the food environment. In this framework I included other variables affecting dietary intake and BMI as well, such as physical activity.

Figure 1. 1 Conceptual Framework Integrating Neighborhood Food Environment into a Model of Consumer Choice

Source: Author's framework based on Rose et al. (2010).

This economic framework stipulates that food purchases result from individuals maximizing their utility function taking into account income, food cost, and their tastes and preferences. Income is influenced to some extent by socio-demographic characteristics such as age, race-ethnicity, and educational achievement. Tastes and preferences are influenced mainly by social acceptability of the characteristics of the food in the stores, the promotional effect of products within stores, and the socio-demographic characteristics of individuals. Rose et al. (2010) emphasized the use of food cost instead of food price because the first accounts for the real opportunity cost of food incurred by people, which includes food price and the resources spent in travelling the distance to the outlet and buying food that people implicitly include in the maximization of their utility. Distance travelled depends on vehicle ownership or transportation means, and on some dimensions of the food environment indicated by the number and type of food outlets (or their in-store characteristics) and their location relative to places such as home, school, or work. Finally, BMI is a function of food intake, physical activity, and other factors outside of the scope of this study, such as genetics or health status.

Boxes highlighted in blue are the associations tested in this chapter using available data. As mentioned above, the aim of this study is to address the association between the food environment measured by type and size of food outlets and their distance to home on the

dietary intake and BMI controlled by socio-demographic characteristics. Detailed data and methods are presented in the next section.

1.3 Methods

Data from the 2011 Los Angeles County Health Survey (LACHS), a random-digit-dial telephone survey of the adult county population (aged 18 years or older, $N = 8,036$) were used in this research (LACHS, 2011). The LACHS is a health survey conducted periodically by the Los Angeles County Department of Public Health. The survey collects self-reported information on demographics, health behaviors, insurance status and access to health care, and health conditions. Data are weighted to be representative of the adult population of Los Angeles County. It accounts for the main ethnic and racial groups at the county level, and 19.5% of interviews were conducted in non-English languages: Spanish, Chinese, Korean, and Vietnamese. Participants were excluded from the analysis who were missing geographic data to determine distances to food outlets, who were missing data on height and weight to determine BMI, and who were missing data on food consumption indicators, and 72 pregnant women, resulting in an unweighted sample size of $n = 5,185$.

Measures related to food consumption were the self-reported number of sugar-sweetened beverages, the number of servings of fruits and vegetables consumed per day, and the frequency of fast-food consumption. Questions related to food consumption were, “How many total servings of fruits and vegetables did you eat yesterday?”, “On an average day, about how many sodas or sweetened drinks such as Gatorade, Red Bull, or Sunny Delight do you drink? Do not include diet sodas or sugar-free drinks. Please count a 12-ounce can, bottle, or glass as one drink.”, and “How often do you eat any food, including meals and snacks, from a fast-food restaurant like McDonald's, Taco Bell, Kentucky Fried Chicken, or another similar type of place?” (LACHS 2011). Each of these measures was standardized as weekly intake. Weight and height responses were used to calculate BMI (kg/m^2). According to the definition of the World Health Organization (WHO), overweight was categorized as a BMI of 25 or more and obese as a BMI of 30 or more (WHO, 2014).

Five circular buffers of varying radii (0.25, 0.5, 1.0, 1.5, and 3.0 miles) were drawn and centered in each respondent's residential address (or nearest cross street) and the number of food outlets by type was counted in each buffer (Hattori, 2013; Boone-Heinonen et al., 2011; Jeffery

et al., 2006). Straight line (Euclidean) distances were set using ArcMap 10.1 (ESRI, Redlands, California) rather than actual travel distances using a road network. One-quarter mile or 400 meters is often considered a standard for walkability (e.g., for transport planning), so the definition of the smallest area would include locations that were further away using road networks. Food outlets, LACHS sample points, and buffers were overlaid to count the number of outlets by type lying inside those radii. The same analyses were also conducted using the census tract of the respondent's residential address, instead of using circular buffers.

Food outlet data from the 2009 release of InfoUSA were used and classified into 5 types: fast-food restaurants, convenience stores, small food stores, midsize grocery stores, and large supermarkets, using the North American Industry Classification System (NAICS). Because no formal definition of fast food exists, this category included food outlets that offered pizza, burgers, tacos, and club sandwiches. The codes used for each category were a subsample of NAICS codes: 72221105–6 for fast-food outlets; 44512001 for convenience stores; and 44511001–3 for small food stores (annual sales of less than \$1 million), grocery stores (annual sales of \$1–\$5 million), and supermarkets (annual sales of more than \$5 million) (Hattori, 2013).

Three types of regression models were used — negative binomial, ordinary least squares, and logistic — each to address a different type of association. The relationship between neighborhood food environment and dietary intake was analyzed through negative binomial models. Dietary intake measures (weekly consumption of fruits and vegetables, sugar-sweetened beverages, and fast food) were the dependent variables, and the numbers of food outlets by type (convenience stores, small food stores, mid-size food stores, large supermarkets, and fast-food restaurants) in each radius were the explanatory variables. Different regressions were conducted for each dependent variable and for each buffer size. Average marginal effects (AMEs) and Bonferroni's adjustment for multiple tests were also calculated. Models controlled for potential confounders with sociodemographic variables including sex, age, age squared, race/ethnicity (white, black, Hispanic, Asian/Pacific Islander, Native American, and other race or multi-race), household size, educational level (not a high school graduate, high school graduate, some college, and college graduate or more), marital status (married or living together, single, and separated, divorced, or widowed), poverty level (income $\leq 100\%$ of the federal poverty level [FPL]), and physical activity level (sedentary, some

activity, and regular activity). Census 2010 data were used to control at the tract level for median annual household income, population density, and the ratio of white to nonwhite Latino population (US Census Bureau, 2010). All explanatory and control variables were divided by their standard deviation to homogenize units and their magnitudes.

The relationship between BMI and food environment was analyzed using ordinary least squares, where the dependent variable was BMI and food environment characteristics were the covariates. The same set of control variables at the individual and census tract levels previously described were used. Finally, the relationship between binary outcomes (overweight and obesity) and the food environment was analyzed using logistic regression models with the same set of controls previously described. In all analyses, separate regressions were conducted for each buffer size. This analysis resulted in 15 regressions and a total of 75 effects for each outcome: (5 buffer sizes) x (5 types of outlets) x (3 types of food or 3 measures of BMI).

The density of food outlets per census tract was also analyzed by utilizing the same models previously described, but instead of using number of outlets by buffer size, I used number of outlets in a census tract per 1,000 inhabitants and in a census tract per square mile. Additionally, a sensitivity analysis was conducted including an additional measure of poverty level (income $\leq 200\%$ of the FPL). This sensitivity analysis replicated all the models described but only for the survey respondents who were above and then below 200% of the FPL. The statistical software used for all analyses was Stata version 12.1 IC (StataCorp LP, College Station, Texas). Models included sampling weights provided by LACHS. *P* values were estimated based on heteroskedasticity-robust standard errors from the Eicker-Huber-White sandwich estimator. Significance was set at the 0.05 level.

1.4 Results

Of the approximately 10 million residents of Los Angeles County, 18% reside below than the poverty threshold. Forty-eight percent of the population is Hispanic/Latino, 29% non-Hispanic White, 10% African American, and 11% Asian. The median household income is \$56,000. The median census tract in Los Angeles County has an area of 0.45 square miles and 4,500 residents (US Census Bureau, 2010).

Adults in Los Angeles County consume on average 5.4 sugar-sweetened beverages each week, at a rate nearly one per day (Table 1.1). Survey respondents eat fast food on average once per week and eat 19.6 portions of fruit and vegetables. Average BMI was 27.5; 62.3% of survey respondents were overweight and 24.6% were obese.

Table 1.1 Characteristics of Respondents and Census Tracts, Los Angeles County Health Survey, 2011^a

Characteristic	Value	Characteristic	Value
Dietary intake, mean no. of servings (IQR)		Education, no. (%)	
Sugar-sweetened beverages	5.4 (0–7)	Not a high school graduate	1,271 (24.5)
Fast food	1.0 (0–2)	High school graduate	1,205 (23.2)
Fruits and vegetables	19.6 (14–28)	Some college	1,454 (28.0)
Body mass index category (kg/m²), no. (%)^b		College graduate or higher	1,254 (24.2)
Mean (SD)	27.5 (7.2)	Marital Status, no. (%)	
Overweight (≥25.0)	3,057 (62.3)	Married or living together	2,875 (55.9)
Obese (≥30.0)	1,206 (24.6)	Divorced/separated/widowed	859 (16.7)
Male, no. (%)	2,572 (49.6)	Single	1,413 (27.4)
Mean age, y (SD)	42.3 (16.8)	Physical activity level, no. (%)	
Race/ethnicity, no. (%)		Sedentary	565 (10.9)
White, non-Hispanic	2,190 (42.2)	Some activity	1,264 (24.4)
African American, non-Hispanic	472 (9.1)	Regular activity	3,261 (62.9)
Asian or Pacific Islander, non-Hispanic	684 (13.2)	LACHS participants interviewed in 2011, no. (%)	5,185 (49.3)
Native American, non-Hispanic	148 (2.9)	Census tracts^b	
Other race or multirace, non-Hispanic	156 (3.0)	Population per square mile, mean (IQR), no.	13,525.4
Hispanic	1,535 (29.6)	Median annual household income, \$ (SD)	57,965.6 (27,155.7)
Mean no. of household members (IQR)	3.6 (2–5)	Mean % non-Hispanic white (SD)	50.3 (19.2)
FPL ≤100%, no. (%)	1,397 (26.9)		

Abbreviations: FPL, federal poverty level; LACHS, Los Angeles County Health Survey; IQR, interquartile range; SD, standard deviation.

^a Percentages and means are weighted using LACHS sampling weights. Data are unweighted. Percentages may not sum to 100 because of rounding.

^b Data source: Census Bureau, 2010.

Number of outlets by type and radius size (Table 1.2) were non-overlapping or mutually exclusive in radii of different size centered in the same residence. The largest number of food outlets in any buffer size was small food stores: 0.8 in a 0.25-mile radius, 57.8 in a 3.0-mile radius, and 3.9 in a census tract. The lowest number of food outlets in all buffers was midsize grocery stores: 0.04 in a 0.25-mile radius, 3.0 in a 3.0-mile radius, and 0.2 in a census tract. On average, in a radius of 0.5 miles of the respondent's residence, there were 1.8 fast-food outlets, 0.5 convenience stores, 2.2 small food stores, 0.1 midsize grocery stores, and 0.7 supermarkets. There were more outlets of all types in areas of residents with lower income.

Table 1.2 Number of Food Outlets by Type, Buffer Size^a, and Federal Poverty Line (FPL), Los Angeles County Health Survey, 2011

Buffer size	No. of Outlets			Mean No. of Outlets	
	Mean	95% IC		FPL<=100%	FPL>100%
0.25-Mile radius					
Fast-food restaurant	0.684	0.650	0.719	0.731	0.672
Convenience Store	0.222	0.208	0.235	0.293	0.204
Small food store	0.839	0.798	0.880	1.421	0.690
Mid-size grocery store	0.045	0.039	0.051	0.082	0.035
Large supermarket	0.289	0.273	0.306	0.356	0.272
0.5-Mile radius					
Fast-food restaurant	1.780	1.725	1.836	2.007	1.723
Convenience Store	0.532	0.509	0.555	0.647	0.503
Small food store	2.192	2.102	2.283	3.664	1.816
Mid-size grocery store	0.114	0.104	0.124	0.167	0.101
Large supermarket	0.706	0.678	0.733	0.849	0.669
1.0-Mile radius					
Fast-food restaurant	6.615	6.486	6.745	7.416	6.411
Convenience Store	1.963	1.913	2.012	2.417	1.847
Small food store	7.976	7.695	8.257	12.760	6.753
Mid-size grocery store	0.421	0.400	0.443	0.633	0.367
Large supermarket	2.553	2.489	2.617	3.048	2.426
1.5-Mile radius					
Fast-food restaurant	10.134	9.956	10.311	11.735	9.724
Convenience Store	2.974	2.905	3.042	3.681	2.793
Small food store	12.308	11.889	12.727	19.021	10.591
Mid-size grocery store	0.651	0.623	0.679	0.927	0.580
Large supermarket	3.827	3.741	3.912	4.603	3.628
3.0-Mile radius					
Fast-food restaurant	47.937	47.281	48.592	55.278	46.059
Convenience Store	13.938	13.694	14.182	17.075	13.136
Small food store	57.816	56.005	59.627	86.655	50.440
Mid-size grocery store	2.976	2.888	3.064	4.071	2.696
Large supermarket	17.817	17.517	18.117	20.694	17.081

a. Means and standard deviations are weighted using LACHS sampling weights. Buffer size was determined by measuring the distance from the respondent's residence.

Only 8% of the effects of the food outlets on the dietary intake in all buffers (6 of 75) were significant at 0.05 level. After applying Bonferroni's adjustment, only 1.3% (1 of 75) was

significant (Table 1.3). That effect corresponds to the number of fast-food restaurants in large, non-walkable areas (3.0 miles) on the consumption of fast food. Most effects of the number of food outlets in all buffers (88%, or 66 of 75) on BMI were not significant (Table 1.4). After applying Bonferroni's adjustment, only 1.3% (1 of 75) of the associations was significant; convenience stores in walkable distances (0.25 miles) was negatively associated to the probability of being obese. When analyzing the density of food outlets in census tract per square mile (data not shown), there was no significant effect after applying Bonferroni's adjustment. Also, no significant effect was found between the density of food outlets in a census tract per 1,000 population and the outcomes of interest.

In the sensitivity analysis (data not shown), there were only significant associations between the number of midsize grocery stores within 0.25 miles and the frequency of fast-food intake among respondents with an income above 200% of the FPL. No significant effect was found on food intake in respondents with income below 200% of the FPL. Significant effects of convenience stores in a 0.25-mile radius on the probability of being obese were found for respondents at an income below 200% of the FPL. These effects were similar to those of the models with the entire pool of respondents. There was no effect of the explanatory variables on BMI of respondents with an income above 200% of the FPL. All results held after conducting every model previously described without income, a variable potentially correlated with education.

Table 1.3. Estimated Change in Intake^a of Food Item, By Food Outlet Type^b and Food Environment^c, Los Angeles County Health Survey, 2011

Food Item, by Food Outlet Type	0.25 miles		0.5 miles		1.0 mile		1.5 miles		3.0 miles	
	AME ^d	<i>P</i> Value ^e	AME ^d	<i>P</i> Value ^e	AME ^d	<i>P</i> Value ^e	AME ^d	<i>P</i> Value ^e	AME ^d	<i>P</i> Value ^e
Fast-food restaurant										
F&V	-0.070	0.801	-0.795	0.018	-0.252	0.434	-0.223	0.495	-0.860	0.119
SSB	0.684	0.153	0.969	0.096	-0.815	0.171	0.809	0.313	0.050	0.963
Fast-food	-0.049	0.067	0.036	0.177	0.034	0.237	0.037	0.242	0.149 ^f	0.002
Convenience store										
F&V	0.135	0.597	0.469	0.101	0.233	0.547	0.191	0.583	1.096	0.048
SSB	-0.575	0.273	0.029	0.956	0.835	0.215	0.112	0.890	1.748	0.115
Fast-food	-0.029	0.263	0.008	0.752	-0.006	0.838	0.060	0.065	-0.074	0.161
Small food store										
F&V	-0.149	0.613	-0.312	0.369	-0.216	0.600	-0.198	0.640	-0.773	0.221
SSB	-0.200	0.685	0.432	0.533	0.993	0.270	-0.310	0.715	-1.204	0.291
Fast-food	0.035	0.244	0.016	0.628	0.025	0.519	-0.007	0.866	0.023	0.678
Mid-size grocery store										
F&V	0.000	0.999	0.495	0.072	0.020	0.952	-0.192	0.539	0.928	0.106
SSB	0.044	0.943	-0.742	0.190	-0.663	0.321	-0.743	0.336	1.168	0.254
Fast-food	0.004	0.852	0.008	0.775	0.005	0.869	-0.014	0.656	0.007	0.883
Large supermarket										
F&V	0.056	0.842	-0.112	0.729	0.214	0.524	0.270	0.520	-0.166	0.746
SSB	-0.513	0.377	-0.831	0.167	-0.867	0.208	-0.044	0.957	-2.437	0.043
Fast-food	-0.006	0.826	-0.013	0.640	-0.062	0.054	-0.093	0.017	-0.129	0.007

Abbreviation: AME, average marginal effect; F&V, fruits and vegetables; SSB, sugar-sweetened beverages.

^a Number of times the item was consumed per week.

^b Food outlet types are fast-food outlets, convenience stores, small food store, midsize food store, and large supermarkets.

^c Food environment was defined by counting the number of food outlet types in each buffer of a certain radius (e.g., 1.0 mile) centered on a respondent's residence.

^d AME measures an estimated change in the per-week frequency of consumption of each food item associated with 1 unit change in the regressor of interest. All regressors were divided by their standard deviations. Statistics were adjusted by using Los Angeles County Health Survey sampling weights.

^e *P* values were calculated by using the *z* statistic obtained through negative binomial regression and based on standard errors estimated using the Eicker-Huber-White sandwich estimator.

^f AME is significantly different from zero (at the 0.05 level) after applying Bonferroni's adjustment for multiple comparisons. All five food outlet types were included in the regression models, and individual- and census tract-level characteristics were controlled for (but are not presented here).

Table 1.4. Estimated Change in BMI (kg/m²) and the Probability of Overweight or Obesity, by Food Outlet Type^a and Food Environment^b, Los Angeles County Health Survey, 2011

Food Outlet Type/BMI	0.25 miles		0.5 miles		1.0 mile		1.5 miles		3.0 miles	
	AME ^c	PValue ^d	AME ^c	PValue ^d	AME ^c	PValue ^e	AME ^c	PValue ^d	AME ^c	PValue ^d
Fast-food restaurant										
BMI	-0.035	0.758	0.011	0.873	0.049	0.120	0.041	0.147	0.019	0.099
BMI ≥25.0	-0.007	0.488	0.013	0.208	0.015	0.189	0.024	0.036	0.034	0.078
BMI ≥30.0	-0.003	0.756	0.000	0.994	0.023	0.015	0.014	0.177	0.019	0.255
Convenience store										
BMI	-0.516	0.082	0.079	0.638	-0.032	0.744	-0.027	0.732	-0.057	0.115
BMI ≥25.0	-0.022	0.025	0.001	0.917	-0.009	0.425	-0.002	0.878	-0.020	0.298
BMI ≥30.0	-0.031 ^c	<0.001	-0.001	0.875	-0.021	0.036	0.011	0.355	-0.039	0.040
Small food store										
BMI	-0.133	0.225	0.046	0.428	-0.004	0.838	-0.011	0.437	-0.008	0.114
BMI ≥25.0	-0.007	0.514	-0.001	0.939	-0.026	0.086	-0.030	0.072	-0.044	0.052
BMI ≥30.0	-0.015	0.129	0.003	0.820	0.011	0.396	-0.005	0.698	0.007	0.705
Mid-size grocery store										
BMI	0.353	0.629	-0.162	0.667	0.510	0.019	-0.156	0.351	0.110	0.245
BMI ≥25.0	-0.004	0.675	-0.009	0.375	0.022	0.073	-0.012	0.321	0.018	0.342
BMI ≥30.0	0.006	0.475	-0.003	0.775	0.016	0.143	-0.012	0.242	0.001	0.940
Large supermarket										
BMI	0.293	0.394	-0.007	0.960	-0.176	0.012	-0.043	0.490	-0.005	0.833
BMI ≥25.0	-0.003	0.729	-0.007	0.529	-0.017	0.164	-0.022	0.106	-0.029	0.122
BMI ≥30.0	-0.006	0.482	-0.001	0.905	-0.024	0.024	-0.012	0.351	0.001	0.936

Abbreviation: AME, average marginal effect; BMI, body mass index.

^a Food outlet types are fast-food outlets, convenience stores, small food store, mid-size food store, and large supermarkets.

^b Food environment was defined by counting the number of food outlet types in each buffer of a certain radius (e.g., 1.0 mile) centered on a respondent's residence.

^c AME measures an estimated change in the per-week frequency of consumption of each food item associated with 1 unit change in the regressor of interest. All regressors were divided by their standard deviations. Statistics were adjusted by using Los Angeles County Health Survey sampling weights.

^d *P* values for BMI were calculated by using the *t* statistic obtained through ordinary least squares regressions. *P* values for overweight (BMI ≥25.0) and obesity (BMI ≥30.0) were calculated by using *z* statistic obtained through logistic regressions and based on standard errors estimated using the Eicker-White sandwich estimator.

^e AME is significantly different from zero (at the 0.05 level) after applying Bonferroni's adjustment for multiple comparisons. All five food outlet types were included in the regression models, and individual- and census tract-level characteristics were controlled for (but are not presented here).

1.5 Conclusion

Overall, no strong evidence emerged that local food environments affect diet or BMI of adults in Los Angeles County. There were a few significant effects of two types of food outlets: fast-food outlets and convenience stores, but they represent only 1.3% (2 of 150) of all effects analyzed. Fast-food outlets in non-walkable distances (3.0 miles) were positively associated with fast-food intake. The density of convenience stores in walkable distances (0.25 miles) was negatively associated with the probability of being obese, but it was not related to any other health or dietary outcome. There was no association between the intake of fruits and vegetables or sugar-sweetened beverages and any type of food outlet in all buffers analyzed. Similarly, there was no association between fast-food outlets, small food stores, midsize grocery stores, and supermarkets with BMI.

This study does not provide evidence to support the hypothesis that the food environment within walkable distances affects the BMI and diet of adults, as other studies do (Jeffery et al., 2006; Powell, Chaloupka and Bao, 2007; Walker, Keane and Burke, 2010). This analysis included the number of full-service grocery stores and supermarkets, which is suggested as a community measure to prevent obesity (Khan et al., 2009), but it does not predict dietary and obesity outcomes.

A large majority of non-significant effects in all neighborhood sizes analyzed suggests that the food environment within walkable distances in Los Angeles County is not a factor related to overweight or obesity, fruit and vegetable consumption, sugar-sweetened beverage consumption, or fast-food intake, which parallels the findings from other data sets (Hattori, 2013; Richardson et al., 2011; An and Sturm, 2012). To the extent that there are significant associations, they seem to occur at distances beyond walking distance.

1.6 Discussion

This study contributes to the debate on whether the geographic definition of a neighborhood food environment and the density of certain types of food outlets are associated with dietary and BMI related outcomes. It used a dataset from Los Angeles County that has not been used before to explore this topic. It created neighborhoods centered in each respondent's home, a

geospatial tool for analysis that is a better measure of the real distance than predefined administrative units such as zip codes or census tracts.

There are, however, several limitations to this study. First, the data were cross-sectional, therefore no causation can be inferred. Second, because the data were self-reported, recall and social desirability may bias BMI (Stommel and Schoenborn, 2009), fast-food, sugar-sweetened beverage, and fruits and vegetables consumption. Food intake measures came from single questions for specific foods, not from a detailed food diary or a full 24-hour food recall. This single-item approach is standard for most surveys such as the Behavioral Risk Factor Surveillance System, California Health Interview Survey, and Early Childhood Longitudinal Survey, but it does not allow for comparison of food quality measures. Third, complete geographic and indicator data were available for approximately 65% of the respondents. It is unclear whether respondents with missing information differed in any way from those included in the analysis. Fourth, the response rate of the 2011 LACHS was 66%. Fifth, the food outlet data and survey dates were not identical; I used InfoUSA 2009 and 2011 LACHS. Business data listings are never complete or up-to-date. In previous work, we compared listing and on-the-ground verification in the City of Santa Monica and found excellent agreement for outlets belonging to chains, whether restaurants or retail, but not for small individually-owned businesses. Field studies (Bader et al., 2010; Liese et al., 2010) found reasonably good predictive values but discrepancies at small scales. Furthermore, categorizing food outlets by type is insufficient to reflect outlet heterogeneity, and more detailed measures, such as ratings of food quality, size availability, and affordability could be more predictive for health outcomes. Additionally, business data normally does not include mobile food outlets such as food trucks, which are important food vendors in Los Angeles County. Finally, the buffer analysis used Euclidean distance rather than road networks, so even a small buffer (0.25 miles or 400 meters) may include outlets that residents consider to be outside walking distance.

This analysis focused on the concept of access to particular types of stores. Access is a key element in the policy debate, as exemplified by the United States Department of Agriculture's Food Access Research Atlas, policy recommendations for supermarkets, or regulations such as the Los Angeles Fast-Food Ban, a zoning ordinance that prohibits opening a stand-alone fast-food restaurant in certain neighborhoods (Sturm and Hattori, 2015; LA Office of the City

Clerk, 2010). However, store distance seems to consistently show little association with diet even when associations with BMI are reported (Giskes et al., 2011; Caspi et al., 2012).

The concept of neighborhood food environments has been the focus of the news media and policy makers, yet the evidence is not clear on whether promoting or discouraging a particular type of food outlet is an effective approach to promoting healthful dietary behaviors and a healthy weight. Initial findings in a new area of research — such as food environments — may be qualified over time, and both exact replication and conceptual replication of previous findings using alternative data sources and methods is a central theme for advancing scientific knowledge and informing policies. However, in Los Angeles County, the relationship between neighborhood food outlets and dietary intake or BMI is subtler than the relationship presented in the news media for other settings (Saguy and Almeling, 2008; Bliss, 2015). The relationship appears to exist in larger geographic areas rather than in walking distances or in a typical urban census tract.

There are several reasons why the original idea that neighborhood outlets determine diet should be modified. One of them is that the importance of proximity has diminished in a highly motorized society, which may be more true in an area such as Los Angeles County than, for example, in New York City. Along with this idea, food delivery systems (e.g., fast-food or supermarket delivery services) allow people to access food that may not be within their neighborhood, and many of them are available at no additional charge. Perhaps, the relevant neighborhood influencing obesity and diet quality is not the residential area, but those around workplace and academic settings, or anywhere people spend most of their time. Furthermore, Los Angeles County may have reached a level of density of food outlets that implies easy access to all type of food across most of its territory, instead of limited access, that make it more difficult to understand the role that a particular type of food venders plays on the obesity of its population. In addition to physical access to a certain type of food outlets, other important dimensions that affect diet behavior are affordability, availability and food quality in those outlets, preferences, income constraints, and consumer attitudes toward food. These last two ideas are explored in the next two chapters.

Further comprehensive research on food environment is needed. It would be useful to include and compare all types of food environments that a person is exposed to, as well as other

characteristics of the food consumed, such as size, quality, and price; and other physical and societal characteristics of the neighborhood, such as vehicle access, crime rates, area of green spaces, and walkability indexes. Additional measures of neighborhood food environment also need further exploration and development such as walking and driving travel time, which is a more accurate measure of the opportunity cost of traveling for food.

Chapter 2

Association between Consumer Attitudes toward Food, Body Mass Index, Healthy Eating Index, and Physical Activity among Adults in the United States

2.1 Introduction

Poor dietary quality is a major factor contributing to the pandemic of obesity. Although there is no consensus on the proportion of Americans that do not meet Federal Dietary Recommendations, most studies indicate that it is a large and important share. Krebs-Smith et al. (2010) reported that over 75% of Americans of all ages do not meet the recommended intake of fruits and vegetables, but over 50% meet the consumption of total grains, meat, and beans, and over 90% exceed recommended intakes of sugar fats, added sugars, and alcoholic beverages. Guenther et al. (2006) indicated that the proportion of Americans adhering to the guidelines on fruits and vegetables ranges between 0.8% to 40% depending on the age group analyzed. According to the Office of Disease Prevention and Health Promotion (ODPHP), 75% of Americans have a diet low in vegetables, fruit, dairy, and oils; more than 50% exceed the total grain and protein foods, and most of the population exceeds the added sugars, saturated fats, and sodium recommended by the dietary guidelines (ODPHP, 2015).

Since the 1960s there has been a shift in the global pattern of food intake and body mass index (BMI) levels that has moved the burden of obesity and overweight toward the poor in both high and low income countries (Popkin, 2006; Ng et al., 2014). A decrease in the international prices of meat, sugar, and edible oils (Popkin, 2011) has resulted in a change in diet toward higher intakes of animal and processed food rich in fat and calories and lower intakes of fiber and vegetables (Popkin, 2006; Bray, Nielsen and Popkin, 2004). In the United States, sugar-sweetened beverages such as sodas and fruit juice account for over 50% of the increase in the caloric intake between 1962 and 2000 (Popkin and Nielsen, 2003).

Along with the change in diet, physical activity patterns are also changing toward lower energy expenditure in the world (Popkin, 2006; Ng et al., 2014; Waxman, 2005). According to Ng and Popkin (2012), in the United States energy expenditure in physical activities measured by the metabolic equivalents of task (MET) in 1965 was 235, while in 2009 it has dropped to 160 and is projected to further decrease to 126 MET hours per week by 2030 (Ng and Popkin, 2012). The Physical Activity Advisory Committee also reported that only 21% of American adults currently meet the 2008 Physical Activity Guidelines which recommend at least 2 hours and 30 minutes of moderate physical activity or 75 minutes of intense aerobic activity per week (Physical Activity Guidelines Advisory Committee, 2008). Tucker, Welk, and Beyler (2011) provided a more conservative number. Using different measurements of physical activity, they found that between 59.6% and 62.0% of American adults meet those guidelines, depending on the measure used. Furthermore, disparities in physical activity are associated with inequalities in the socioeconomic status. Diverse studies provide evidence that lower physical activity for the overall American population and among some ethnic groups is related to lower socioeconomic status measured by education, income, and occupation (Harper and Lynch, 2007; Marshall et al., 2007; Cerin and Leslie, 2008).

Taken together, a trend emerges in modern society of higher caloric intake alongside lower energy expenditure; this has led to important energy imbalances that foster obesity worldwide (Downs, Loewenstein and Wisdom, 2009; Popkin, 2006). In this study, I focus on analyzing the association of consumer attitudes toward food by socioeconomic status with food intake and body mass index of adults in the United States.

Classical economics models household consumption of goods and nutrients by assuming that people are rational and maximize household utility by making optimal choices in the short and long term (Behrman and Deolalikar, 1987; Cohen and Babey, 2012). These theories assume that there are a few key variables that interact to guide the food choice of the average household: price of food and other commodities, physical activity, income (from labor and other sources), and leisure (Becker, 1965; Posner and Philipson, 2003). However, these models fail to take into account other behavioral aspects.

Based on the historical global trends in commodity prices and following the classical economic theory, price is one of the main attributes of food. In the United States, the energy density of

foods is inversely related to its costs; therefore, consuming high-energy density food costs less and results in savings for the household, regardless of whether it is nutrient poor (Drewnowski and Darmon, 2005b). Energy-dense grains, fats, and sweets represent the lowest-cost per gram of protein options to consumers in the United States (Drewnowski and Darmon, 2005a). As a consequence, there is evidence that the highest rates of obesity occur among people with low socioeconomic status at all ages (Drewnowski and Specter, 2004; Wang and Beydoun, 2007; Singh et al., 2011).

Although food has become cheaper and more accessible, price may not be the only factor leading people's food choice. There is an ongoing debate about the way in which people make these choices. Classical economics stipulates that people weight different criteria and make a choice that maximizes their utility (Edwards, 1954). However, behavioral economics suggests that when people make rapid choices, only one or a couple of salient attributes or criteria, such as appearance of objects and size, determine the outcome. Furthermore, on average, results of choices made using heuristics are not significantly different than those made by people using more criteria (Cohen and Babey, 2012).

Food choice may be complex because it could be affected by many factors besides price, such as sensory appeal, familiarity and habit, social interactions, cost, availability, time constraints, personal ideology, media and advertising, and health (Pollard, Kirk and Cade, 2002). In this context of multiple attributes, there is some evidence that applying heuristics to food choice results in choosing foods with high content of sugar, fat, and calories (Shiv and Fedorikhin, 1999; Friese, Hofmann and Wänke, 2008). If the main attributes or characteristics of food leading people's food choice are understood, it will be possible to provide evidence that helps to design better policies encouraging people to eat healthier. For instance, suggested policies have included regulating the size of commercial meals (Cohen and Babey, 2012) or tagging their nutritional content.

In this study, I focus on the individuals' attitudes and beliefs that may be related to food choice. I used the National Health and Nutrition Examination Survey (NHANES), a rich dataset that is nationally representative of the United States population. I explored pathways assessing the relationship between consumer attitudes toward food and BMI through quality of food intake and physical activity among adults in the United States. This study therefore

provides evidence regarding how specific consumer attitudes toward food (nutrition, taste, freshness, preparation time, and price) are associated with diet quality, physical activity, and BMI by income level and other socio-demographic characteristics.

The chapter is structured as follows: Section 2 provides a revision of previous related literature; Section 3 presents the conceptual framework; Section 4 describes the data and methodology employed in this study; Section 5 presents the results; and Section 6 concludes and provides some preliminary discussion.

2.2 Literature

There are several attitudes toward food that may affect or influence consumers' food choices (Kearney and McElhone, 1999; EUFIC, 2004; Moser et al., 2005; Beydoun and Wang, 2008a; Bogdanovich, 2013). Some attitudes are related to the characteristics of the individual and others to the characteristics of food. The literature includes these as the most common self-reported attitudes or beliefs toward food influencing food choice: price, taste and flavor, lengthy preparation, freshness, perishability, unappealing foods, strange or unusual foods, storage facilities/limited cooking facilities, irregular work hours, busy lifestyle, willpower, unwillingness to change eating habits, cooking skills, giving up foods the individual likes, feeling conspicuous amongst others, taste preferences of families and friends, not knowing enough about healthy eating, healthy options not available in shop or canteen or home, and having not enough food to satisfy hunger (Kearney and McElhone, 1999; Pollard, Kirk and Cade, 2002; EUFIC, 2004; Guillaumie, Godin and Vézina-Im, 2010).

The literature of attitudes toward food can be categorized in two types of studies, those analyzing their relationship with the intake of fruits and vegetables and those analyzing the association with overall eating. In the first category of literature there is a study among older population in the Netherlands (Dijkstra et al., 2015) that found that the main obstacles to adhere to fruit, vegetable, and fish guidelines were the high price of fruit and fish and the dislike of vegetables. Furthermore, low-income individuals perceived more obstacles overall. Bogdanovich (2013) analyzed the mediator role of attitudes toward food for fruit and vegetable intake among adults in Ontario, Canada and reported that knowledge about different vegetables and the lack of cooking skills and time of preparation were significant.

A study using cross-sectional data representative of Afro-American men aged 35 and above in the United States created a scale of attitudes and indicated that for fruit intake, no particular attitude was significant, but the perception of having other interests was significantly associated with vegetables intake (Moser et al., 2005). Shaikh et al. (2008) conducted a systematic review of studies addressing the relationship between psychosocial predictors and consumption of fruits and vegetables. It included 35 studies, and nine of them analyzed attitudes toward food. The authors found that attitudes were significant in six of them and non-significant in three. Knowledge, preference for meat, preference for fruits and vegetables, and beliefs about the benefits of food were the significant attitudes in the six studies with significant results.

Another more recent systematic review (Guillaumie, Godin and Vézina-Im, 2010) analyzing the association between consumer attitudes toward food and fruit and vegetable intake included 23 articles, with 15 studying the determinants of consumption of fruit and vegetables, seven studying the determinants of consumption and intention, and one analyzing only the determinants of intention. Results suggest that attitudes or beliefs predicting fruit and vegetable intake more consistently across the literature were habits (e.g., cooking habits), motivation and goals (intention), beliefs about capabilities (e.g., perceived behavioral control, barriers, and self-efficacy), knowledge about the recommended dietary guidelines, and taste (like/dislike).

The category of studies analyzing the association between consumer attitudes toward food and overall healthy eating is smaller than the category analyzing only fruit and vegetable intake. Some of the main studies are as follows. Sun (2008) tested the mediator role of attitudes toward food between health concerns and healthy eating among undergraduate students in Taiwan and found that price, health concerns, and natural content and ethical concern were attitudes significantly associated with healthy eating; however, attitudes and beliefs about convenience, sensory appeal, and familiarity were not significant. In Australia, a study among women showed that the most common perceived obstacles to physical activity and healthy eating by young women were related to lack of motivation and time and cost. Moreover, these attitudes did not differ by socioeconomic status (Andajani-Sutjahjo et al., 2004). A regional cross-sectional study conducted among European adults ages 15 and older tested for 15 consumer attitudes toward healthy eating and indicated that lack of time, giving up a favorite food, willpower, and price were the main ones reported (Lappalainen et al., 1997; Kearney and

McElhone, 1999). Chambers et al. (2008) conducted focus groups among people in the United Kingdom, and participants reported that food preparation and knowledge, prices, and time prevent them from consuming a healthy diet.

Similarly, House et al. (2006) conducted focus groups with students and found that taste, money, lack of time, lack of choice within the campus, and media advertising influence their food choice. Silliman et al. (2004) surveyed college students in the United States about their diet, exercise habits, and attitudes toward food for a healthy lifestyle. Factors that they found to be significant were the lack of time, lack of money, taste, lack of motivation, and convenience. Perez-Cueto et al. (2009) analyzed attitudes toward food obstructing healthy eating among students in Belgium, and, similar to the studies above, the main attitudes were lack of information, price, peer pressure, lack of willpower, and the perception of healthy food as boring. Biloukha and Utermohlen (2001) surveyed students in college in Ukraine. Price, giving up foods I like, and a busy lifestyle are the main consumer attitudes reported as an obstacle to healthy eating.

Other studies have analyzed low-income people in the United States. For instance, Eikenberry and Smith (2004) studied attitudes toward food in Minnesota. The authors found that the attitudes toward food obstructing healthy eating were time, cost, money situation, being lazy, taste, lack of discipline, being picky, live alone, food preparation, transportation, availability, how I was raised, unable to choose my food, other expenses, and knowledge.

Most previous studies analyze the attitudes toward food of a specific group of individuals or for limited types of food, and their results may lack external validity for the overall population or for a healthy diet in general. There is only one study that analyzed data at the national level: Beydoun and Wang (2008a). These authors used data from the Continuing Survey of Food Intake by Individuals (CSFII) 1994-1996, and using structural models, found that the socioeconomic status mediated by attitudes toward food relative toward food price had a positive and significant effect on dietary quality intake. The same authors (Beydoun and Wang, 2008b), in another study using the same dataset but a different quantitative model and substituting attitudes toward food by depression and food insecurity as the mediating factors, found that socioeconomic status is the main driver of diet quality, but beliefs about food could also be an important determinant.

The contribution of this study is threefold. First, it proposes and tests a new framework of pathways using attitudes toward food as the variable linking socioeconomic status and physical activity, diet quality, and BMI that can bring evidence to bear on the complex associations or mechanisms involved. Most existing literature separately assesses, attitudes toward food with BMI, physical activity, or diet quality, but there is no study exploring a comprehensive pathway involving all three outcomes. Second, it uses the most recent nationally representative data, NHANES, exploiting rich information on BMI, food intake, physical activity, and attitudes and beliefs toward food. Previous research addressed the role of attitudes or food beliefs for a specific population group around the globe, and the only study exploring the topic with nationally representative data employed a dataset (CSFII) from 1994-1996. Furthermore, most of those studies do not have objective information on diet and BMI as this study does. Third, it contributes to the better understanding of how people make food choices.

2.3 Conceptual Framework

Figure 2.1 presents the potential pathways involving attitudes toward food that would link socioeconomic status to diet quality, physical activity, and BMI. The idea behind this model is that individuals' beliefs about a specific characteristic of food, such as how nutritious a food item is, may be associated with poorer or healthier diets. Similarly, attitudes toward food can be related to physical activity; for instance, it may be the case that individuals exercise to stay healthier or control their weight according to their beliefs about their diet. Therefore, attitudes toward food can be associated with both physical activity and diet quality. For example, an individual who believes that the taste of food is very important relative to its price may have a low quality diet, but do vigorous physical activity to balance what she perceives as an obstacle to healthy eating and adequate BMI. These relationships may predict BMI and obesity levels.

In the path model, demographic characteristics such as age, gender, ethnicity, and marital status are exogenous variables that can predict the socioeconomic status of individuals and may be directly and indirectly associated with all other variables (attitudes toward food, diet quality, physical activity, and BMI). Although the focus of this analysis is on attitudes toward food, in the literature the main independent variable is socioeconomic status. This is due to the fact that socioeconomic status is influenced by exogenous variables but at the same time is associated with attitudes toward food, diet quality, physical activity, and BMI. Socioeconomic

status was measured by education and income. Given the previous research described above, attitudes toward food are expected to be directly and indirectly (through diet and physical activity) associated with BMI. Diet quality and physical activity are assumed to be directly associated with BMI; one measures energy intake and the other its expenditure.

Figure 2.1. Conceptual Framework of Associations between Attitudes toward Food, Weight, Socioeconomic Status, Physical Activities and Diet

Abbreviations: SES, socioeconomic status; HEI, healthy eating index; and BMI, body mass index.

This diagram indicates the pathways that I explored in this study. Specifically, I examined the following: 1) the association between attitudes toward food and BMI; 2) the role of physical activity and diet quality linking attitudes and BMI; and 3) the differences in these pathways by gender, ethnicity, and income level.

2.4. Methodology

2.4.1. Data

I used data from the National Health and Nutrition Examination Survey (NHANES) 2007-2008 and 2009-2010. This is a cross-sectional survey with a stratified multistage probability

sample collecting information about the health and nutrition status of the population in the United States. This survey combines interviews and physical examinations, and it is representative of the United States population of all ages. Its editions of 2007-2008 and 2009-2010 contain a special module named “Consumer Behavior Phone Follow-up” that provides information on various dietary and related consumer behavior topics for individuals 16 years or older (NHANES, 2007 and 2009). In this study, I focused on understanding the association between attitudes toward food and physical activity, diet quality and BMI among adults 18 years and older.

2.4.2 Dependent variables

Outcome variables are level of BMI and prevalence of underweight, normal weight, overweight, and obesity. NHANES records weight and height which are both self-reported and objectively measured by health professionals with the adequate equipment. I employed the objective weight and height records to calculate BMI (kg/m^2). Following the definition of the World Health Organization (WHO), I categorized underweight as a BMI below 18.5, normal weight as a BMI between 18.5 and 25.0, overweight as a BMI of 25 or more, and obese as a BMI of 30 or more (WHO, 2015).

Variables expected to directly influence BMI are diet quality and physical activity. Diet quality is measured by the Healthy Eating Index (HEI). The Healthy Eating Index (HEI) is an index of diet quality with twelve components addressing conformance to the Dietary Guidelines for Americans created by the Centre for Nutrition Policy and Promotion (CNPP) within the United States Department of Agriculture (USDA). I used the HEI 2010, which measures diet quality according to the Dietary Guidelines for Americans updated to 2010. (For more information on the development and validation of this Index, please see "Update of the Healthy Eating Index: HEI-2010." by Guenther, et al., 2013).

The HEI uses data from the 24-hour dietary recalls in national surveys, such as the National Cancer Institute’s Automated Self-Administered 24-hour Recall (ASA24) or the dietary recall from the NHANES. The CNPP publishes the datasets, methodology, and programming codes to estimate the different versions of HEI. In this paper, I applied the HEI methodology to the first day of the dietary recall in NHANES (there are two days of dietary recalls). This index has twelve components: total fruit, whole fruit, total vegetables, greens and beans, whole grains,

dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, and empty calories. HEI score ranges from 0 to 100, where 100 represents the highest possible quality diet (Guenther et al., 2013).

Data measuring levels of physical activity come from NHANES' questions reporting the number of minutes that an individual spent doing moderated or vigorous physical activity in work and leisure time during the last week. Based on previous literature (Lagerros and Lagiou, 2007; Beydoun and Wang, 2010) I transformed the minutes of physical activity into metabolic equivalent of tasks (MET) hours per week using the suggested scores provided by the NHANES to convert time spent in the activities recorded in the survey into MET. I obtained a continuous variable that I classified into four categories: sedentary if MET equals zero, some activity between a few MET minutes and below MET 500 minutes, regular activity if the individual met the Physical Activity Guidelines 2008 (Physical Activity Guidelines Advisory Committee 2008) by spending between 500 -1000 MET minutes a week doing physical activity, and vigorous if the person spent more than 1000 MET minutes.

2.4.3. Attitudes toward Food

Attitudes toward food are the main variables of this study. NHANES contains information about the perception of five attributes of food when purchasing in different outlets: price, nutrition, taste, how well the food keeps after bought (freshness), and food preparation easiness (preparation). This is the exact question describing the consumer attitude in grocery stores and supermarkets: When you buy food from a grocery store or a supermarket, how important is "X"? Would you say very important, somewhat important, not too important, or not at all important? Answers are recorded in a 4-point Likert scale, from very important to not at all important. Given that price is the main driver of food demand and following previous literature (Beydoun and Wang, 2008a), I normalized all other attitudes by the perceived importance of food price. This allows me to use a measure of the relative importance of other characteristics of food to the perceived price. Following Beydoun and Wang (2008a), the score of each attitude relative to the price is calculated by dividing the score of X attitudes by the score of perceived price and multiplying it by 100. Then, "the variables are regrouped into an ordinal one centered at 100 (0=equally important) and ranging between - 5 (x=25) and +5 (x=400) where

$$x = \frac{Score_{Attitude}}{Score_{Price}} \times 100$$

As a last step, I multiplied the resulting score by -1 to make it easier to interpret: the higher the score the more important the food attribute is relative to its perceived food price. If the score is zero, both the price and the attribute are equally valuable. This procedure resulted in four scores of attitudes toward food that are referred in the text from this point on as nutrition, taste, freshness, and preparation.

In addition, I used principal component analysis of the four scores of attitudes toward food to generate a single index of attitudes on a standardized z-score scale. This index has two purposes. The first is to provide a measure that condenses the four beliefs about the importance of different attributes of food and account for their possible correlations. The second is to contribute to testing whether people in this study make food choices based on multiple perceived attributes or whether they do so heuristically.

As described above, there is evidence that socioeconomic status is an important determinant of BMI and related outcomes, and it may also affect the perception of food attributes relative to price. Socio economic status was included in three ways: employing a measure of education (less than high school, high school graduate, some college, and college and more), a measure of income as percentage of the federal poverty line (below 130%, between 130% and 180%, and above 180% of the FPL); and as a compound index that condenses education and income. The latter was generated through the principal component analysis technique.

2.4.4 Covariates

Based on previous research (Beydoun and Wang, 2010; Beydoun and Wang, 2008b; Beydoun and Wang, 2008a), I used sociodemographic variables that are exogenous to the model in order to account for potential confounders: age, gender, marital status (single, married/living together, separated/divorced/widowed), and race or ethnicity (white, Hispanic, black, other).

All independent variables (attitudes toward food, HEI score, socioeconomic status, and physical activity) and covariates were standardized on a z-score scale to facilitate the interpretation of results.

2.4.5 Methods

In order to build a pathways model with the variables described above, I first tested each path from the conceptual framework separately using the Sobel-Goodman Test. Then, I also tested each path through OLS methods to show the descriptive linear relationship between 1) socioeconomic status and attitudes toward food and 2) between socioeconomic status and attitudes toward food and the final and intermediate outcomes BMI, Healthy Eating Index, and physical activity;

$$1) \text{Attitude}_i = \beta_0 + \beta_1 \text{SES}_i + \sum_{j=1}^k \beta_{z_{j2}} Z_{ji} + e_i$$

$$2) Y_i = \beta_0 + \beta_1 \text{Attitude}_i + \beta_2 \text{SES}_i + \sum_{j=1}^k \beta_{z_{j3}} Z_{ji} + e_i$$

where Y_i are BMI, Healthy Eating Index, and Physical Activity, Attitude is each of the five analyzed attitudes toward food (nutrition, taste, freshness, preparation, and the index of attitudes), SES are variables related to socioeconomic status (education and income levels), Z are covariates, and e_i is an error term.

Continuing to build and test the pathway, I used logistic regression models to understand the nonlinear relationship between socioeconomic characteristics and attitudes toward food and the probability of being obese, overweight, underweight, or normal weight. I used four models, each of which represents a specific segment of the pathway or conceptual framework and therefore is adjusted by different sets of variables:

Model 1. Adjusted for socioeconomic status and covariates or demographic factors (age, gender, ethnicity, marital status, education, and poverty income ratio)

$$\text{logit}(P(Y_i = 1 | \text{Attitude}_i, \text{SES}_i, Z_i)) = \beta_0 + \beta_1 \text{Attitude}_i + \beta_2 \text{SES}_i + \sum_{j=1}^k \beta_{z_{j3}} Z_{ji}$$

Model 2. Adjusted for HEI, socioeconomic status, and covariates

$$\begin{aligned} \text{logit}(P(Y_i = 1 | \text{Attitude}_i, \text{SES}_i, \text{HEI}_i, Z_i)) \\ = \beta_0 + \beta_1 \text{Attitude}_i + \beta_2 \text{SES}_i + \beta_3 \text{HEI}_i + \sum_{j=1}^k \beta_{z_j} Z_{ji} \end{aligned}$$

Model 3. Adjusted for physical activity, socioeconomic status, and covariates

$$\begin{aligned} \text{logit}(P(Y_i = 1 | \text{Attitude}_i, \text{SES}_i, \text{PA}_i, Z_i)) \\ = \beta_0 + \beta_1 \text{Attitude}_i + \beta_2 \text{SES}_i + \beta_3 \text{PA}_i + \sum_{j=1}^k \beta_{z_j} Z_{ji} \end{aligned}$$

Model 4. Adjusted for HEI, physical activity, socioeconomic status, and covariates

$$\begin{aligned} \text{logit}(P(Y_i = 1 | \text{Attitude}_i, \text{SES}_i, \text{HEI}_i, \text{PA}_i, Z_i)) \\ = \beta_0 + \beta_1 \text{Attitude}_i + \beta_2 \text{SES}_i + \beta_3 \text{HEI}_i + \beta_4 \text{PA}_i + \sum_{j=1}^k \beta_{z_j} Z_{ji} \end{aligned}$$

where Y_i is an indicator of being obese, overweight, underweight, or normal weight, Attitude is each of the five analyzed attitudes toward food (nutrition, freshness, taste, preparation, and the index of attitudes), SES are variables related to socioeconomic status (education and income levels), HEI is the Healthy Eating Index, PA is physical activity in MET hours a week, and Z are covariates.

Based on the correlated relationships found in the models conducted above (shown in the section of results), I defined the pathway and tested the direct and indirect associations between attitudes toward food and socioeconomic status and the dependent variable BMI, through the variables diet quality and physical activity.

The equations of the path analysis are:

$$SES = \sum_{j=1}^k \beta_{z_{j1}} Z_j + e_1$$

$$Attitudes = \beta_{12} SES + \sum_{j=1}^k \beta_{z_{j2}} Z_j + e_2$$

$$HEI = \beta_{13} SES + \beta_{23} Attitudes + \sum_{j=1}^k \beta_{z_{j3}} Z_j + e_3$$

$$PA = \beta_{14} SES + \beta_{24} Attitudes + \sum_{j=1}^k \beta_{z_{j4}} Z_j + e_4$$

$$BMI = \beta_{15} SES + \beta_{25} Attitudes + \beta_{35} HEI + \beta_{45} PA + \sum_{j=1}^k \beta_{z_{j5}} Z_j + e_5$$

$$Corr(e_i, e_m) = 0$$

$$i = 1, 2, 3, 4, 5$$

$$m = 1, 2, 3, 4, 5$$

$$i \neq m$$

Where BMI is the body mass index, e_i and e_m are error terms, and all other variables are the same as described above in the previous models. Figure 2.2 is the graphic representation of this proposed path analysis.

Figure 2.2 Path Analysis for the Association of Socioeconomic Status and Attitudes toward Food with Diet Quality, Physical Activity, and BMI

Abbreviation: BMI, body mass index.

Note: Model is adjusted by socio-demographic characteristics.

Although the basic pathway was explained in the conceptual framework, here I expand it by describing the meaning of each of its arrows.

Socioeconomic status - attitudes toward food. Previous research has shown that income level and education are related to people's perception of attributes of food or their attitudes toward food (Beydoun and Wang, 2008a; Beydoun and Wang, 2008b). It is expected that higher socioeconomic status is associated with a positive perception of attributes such as nutrition and freshness and with lower importance of price or cost (Kearney et al., 2000; Beydoun and Wang, 2008a).

Socioeconomic status - physical activity. Socioeconomic factors are related to the neighborhoods where people reside, study, or work, with their occupation, with their perception about physical activity, and with their leisure time and activities, among others. These factors influence an individual's level of physical activity. Although most literature associates lower socioeconomic status with lower physical activity (Harper and Lynch, 2007; Marshall et al., 2007; Cerin and Leslie, 2008), in this study the expected direction of the

association is not clear. This is due to the fact that the measure employed here (MET) includes both physical activity done in leisure activities, such as working out, and in working time, such as lifting heavy weight as part of job duties, and they are associated to different economic status.

Socioeconomic status - diet quality. Healthy food such as vegetables and fruits in the United States are more expensive than food rich in carbohydrates, fats, and sugar (Drewnowski and Darmon, 2005a). There is a direct link between socioeconomic status or what people have in their pockets to afford food and the final diet. Low-income groups spend less money on healthy foods than higher-income groups with some of the reasons beside having a lower budget being costs, transportation, variety, food environment, and societal norms (Haynes-Maslow, 2013).

Socioeconomic status - BMI. Despite the previous paragraphs describing the main ways in which socioeconomic status may influence BMI through attitudes, physical activity, and diet quality, there are other influences that those variables in the model do not capture. Some of those uncaptured elements associated with socioeconomic status that may influence BMI are food insecurity and depression (Beydoun and Wang, 2010), social and physical characteristics of the neighborhood environment such as walkability, green areas, food environment (Dubowitz et al., 2012), social attitudes toward obesity and thinness (Sobal and Stunkard, 1989), and smoking (Hiscock et al., 2012; Harper and Lynch, 2007), among others.

Attitudes toward food - physical activity. This association is not straightforward, but it relies on the idea that consumer attitudes toward food could influence the level of physical activity in order to counterbalance or reinforce the feeling produced by the perception of their diet. For instance, if a person considers that a healthy diet is very expensive and cannot access it, he could exercise more to compensate for the poor quality diet that he thinks he is consuming. In another example, an individual could exercise more because he feels good and lighter by perceiving good attributes in the diet he is consuming (O'Dea, 2003).

Attitudes toward food - diet quality. As described in the Literature section there is a vast research relating consumer preferences and attitudes to the intake of specific foods among certain population groups around the world (Kearney and McElhone, 1999; EUFIC, 2004; Moser et al., 2005; Beydoun and Wang, 2008a; Bogdanovich, 2013). In general, the higher

perception of attributes of food such as taste or cooking time are associated with lower quality diets, while others such as nutrition and low cost are associated with better quality diets.

Diet quality - BMI. The association between diet quality and BMI is expected to be positive, but not to capture the full association between these variables because HEI measures the compliance with the dietary guidelines which are designed to be healthy, but not strictly to be non-obese. These guidelines include the twelve most important groups of food; each of them is assigned a value that does not necessarily align with their effect on the BMI. For example, total vegetable consumption has a maximum HEI score of 5, which is the same score than the intake of total protein foods (Guenther et al., 2013) regardless of the fact that these groups affect BMI very differently. In other words, a certain HEI score could be associated with very different levels of BMI, but the general association is expected to be positive.

Physical activity - BMI. Physical activity, energy expenditure, is clearly a factor related to BMI (Ferro-Luzzi and Martino, 1996). MET, the measure used in this study includes both vigorous and moderate physical activity self-reported.

Attitudes toward food - BMI. Most of the association between attitudes toward food and BMI are mediated by diet quality and MET, however, both variables are not perfect measures, and there is room for a potential direct association between attitudes and BMI. As described above, HEI captures part of the effect of the diet on BMI, but it is not a perfect measure and the same happens with MET. Therefore, all other ways in which attitudes toward food are associated with BMI are captured by this link, such as the quality of diet directly related to BMI, not through recommended guidelines. One potential example is the consumption of large amounts of calories and fats when individuals do not consider nutrition an important characteristic of food.

The path analysis was estimated through maximum likelihood regressions, and they included survey sampling weights provided by NHANES. The statistical software employed for all analyses was Stata version 13.1 IC (StataCorp LP). Model fit was assessed using chi-squared, the comparative fit index (CFI), and the root mean square error of approximation (RMSEA). I used the conventional thresholds of good fit: CFI $\geq$ 0.90, p-value of Chi-squared $>$ 0.10 and RMSEA $\leq$ 0.05.

Finally, I conducted the same path analysis by sub-population groups. This analysis by sub-sample provided a deeper understanding of the heterogeneity of the relationships between consumer attitudes toward food and BMI, diet quality, and physical activity. I carried out the same path analysis indicated above by these population groups: gender, ethnicity (white, Hispanic, black, and other), and income level (<130% FPL, 130%-180% FPL, and >180% FPL). These analyses were conducted by restricting the sample to each of the indicated populations.

2.5. Results

2.5.1. Descriptive Characteristics

Table 2.1 shows the descriptive characteristics of the sample. I removed observations with missing information on the variables of interest (32.0% of total sample), and the resulting final sample size was N=8,432. Less than half of the population is male (46.8%); the average age is 47.1 years old; 71.9% of the population in the sample is white; 12.0% is Hispanic, 10.9% is black and 5.2% is of other race or ethnicity; 65.4% is married or cohabites with a partner, 16.8% is single, and 17.8% is divorced or separated. Seventeen point one percent reported to have attained an educational degree lower than high school; 23.5% attained a high school education; 30.3% reported having some college, and 29.0% of the population have college or more. Twenty three point one percent of the population has a household income below 130% of the federal line of poverty; 12.5% have a household income between 130% and 180% the poverty threshold, and 63.6% lives in households with an income larger than three times the poverty line. Twenty two point two percent of the sample is sedentary, 12.8% reported to be somewhat active, 11.2% meet the guidelines of physical activity, and 53.8% of the sample does physical activities longer than the recommended guidelines. The mean weekly MET hours of physical activity of the sample is 59.4. The average BMI is 28.9; 28.5% of people have normal weight, 69.9% overweight, and 36.1% are obese. Regarding the scores of attitudes toward food, the average importance of taste relative to price is the largest (1.2), followed by nutrition (0.7), freshness (0.2), and preparation (-0.5).

Table 2.1. Characteristics of Adults with Complete Information on Attitudes toward Food by Gender, NHANES 2007-2008 and 2009-2010^a

Characteristics	All sample (N=8,432)			Men (N=3,965)			Women (N=4,467)		
	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
Male	3,965	46.826	49.902						
Age (years)		47.111	16.194		46.280	15.837		47.842	16.469
Race/ethnicity									
White	4,263	71.940	44.932	2,051	72.062	44.875	2,212	71.833	44.986
Hispanic	2,233	12.001	32.499	1,004	12.647	33.243	1,229	11.432	31.823
Black	1,626	10.905	31.172	761	9.898	29.867	865	11.791	32.254
Other	310	5.154	22.111	149	5.392	22.590	161	4.944	21.681
Marital Status									
Single	1,384	16.761	37.354	667	18.123	38.525	717	15.561	36.253
Married or living together	5,135	65.380	47.578	2,669	69.339	46.115	2,466	61.895	48.570
Divorced/separated/widowed	1,908	17.793	38.248	626	12.500	33.076	1,282	22.454	41.733
Education									
<High School	2,201	17.068	37.625	1,045	17.191	37.735	1,156	16.960	37.533
High School graduate	2,002	23.490	42.396	961	23.833	42.611	1,041	23.188	42.208
Some college	2,408	30.348	45.979	1,050	28.735	45.258	1,358	31.768	46.563
≥ College	1,814	28.983	45.371	906	30.066	45.860	908	28.030	44.919
Income as proportion of FPL									
0-130% of FPL	2,852	23.075	42.134	1,214	20.534	40.400	1,638	25.313	43.485
130%-180% of FPL	1,223	12.534	33.113	559	11.657	32.095	664	13.307	33.969
>180% of FPL	4,280	63.637	48.107	2,149	66.742	47.120	2,131	60.904	48.802
Physical activity									
Sedentary (0 MET minutes)	1,870	22.179	41.548	666	16.787	37.380	750	26.868	44.332
Somewhat active (1-499 MET minutes)	1,075	12.750	33.355	373	9.405	29.194	420	15.649	36.336
Guidelines (500-1000 MET minutes)	947	11.237	31.584	371	9.352	29.120	418	12.905	33.529
Highly active (>1000 MET minutes)	4,539	53.834	49.856	2,556	64.456	47.871	2,879	44.578	49.711
MET hours/week		59.444	96.650		81.4707	115.16		40.1517	71.433
Diet Quality									
HEI Score		48.619	14.737		47.381	14.339		49.709	14.996
Weight Status									
Underweight (BMI <18.5)	126	1.615	12.606	40	0.866	9.266	86	2.275	14.911
Normal Weight (18.5 ≤ BMI <25)	2,159	28.516	45.152	946	24.157	42.809	1,213	32.355	46.788
Overweight (BMI ≥ 25)	6,147	69.869	45.886	2,979	74.977	43.320	3,168	65.370	47.584
Obese (BMI ≥ 30)	3,289	36.143	48.044	1,446	35.704	47.919	1,843	36.529	48.156
BMI (kg/m ²)		28.858	6.754		28.881	5.995		28.838	7.358
Attitudes toward food									
Nutrition		0.686	2.137		0.629	2.153		0.735	2.123
Taste		1.242	2.009		1.332	2.031		1.162	1.987
Freshness		0.237	2.868		0.219	2.202		0.252	3.347
Preparation		-0.517	2.406		-0.475	2.674		-0.554	2.143
Index of attitudes		-0.002	0.993		0.008	0.983		-0.012	1.002
Survey year									
2007-2008	4,067	48.726		1,922	48.726		2,145	48.726	
2008-2009	4,365	51.274		2,043	51.274		2,322	51.274	

Abbreviations: BMI, body mass index; HEI, Healthy Eating Index; NHANES, National Health and Nutrition Examination Survey; MET, Metabolic equivalents; and SD, Standard Deviation.

^aPercentages and means are weighted using NHANES sampling weights. Data are unweighted. Percentages may not sum to 100 because of rounding.

2.5.2. Association between socio-demographic characteristics and attitudes toward food

Table 2.2 presents the correlates between socio-demographic and economic characteristics and the scores of attitudes toward food relative to price. Gender only was significantly correlated with nutrition and taste. Age is an important element influencing attitudes toward food, and it is significantly correlated with all of them, with the exception of taste. Perception of food attributes varies across lifecycle, and it is expected that some characteristics of food such as nutrition become more important with ageing. Being Hispanic is associated with all attitudes; while being black or from other ethnicity is associated with taste and to the overall index of attitudes. Being married is negatively associated with freshness, preparation, and the index of attitudes. A possible explanation for this result is that married persons, particularly if both are employed and have children, may have less available time than a single person for preparing or cooking food and may prefer processed foods that, although less fresh, require less cooking time. Different levels of poverty and education, the socioeconomic factors, were significantly associated with some attitudes toward food. The direction of those relationships support the idea that lower socioeconomic status is associated with assigning lower importance to food attributes relative to its price, particularly with nutrition, freshness, and taste.

Table 2.2. Association between Attitudes toward Food and Socio-demographic Characteristics, Multivariate OLS Regressions, NHANES 2007-2010

Characteristic	Nutrition		Taste		Freshness		Preparation		Index of Attitudes	
Male	-0.030	(0.014)**	0.034	(0.012)***	0.014	(0.010)	-0.001	(0.012)	0.006	(0.012)
Age (years)	0.113	(0.020)***	0.024	(0.020)	0.037	(0.015)**	0.133	(0.018)***	0.099	(0.021)***
Race/ethnicity (reference white)										
Hispanic	0.084	(0.013)***	-0.037	(0.012)***	0.088	(0.012)***	0.067	(0.012)***	0.064	(0.013)***
Black	-0.013	(0.015)	-0.069	(0.010)***	0.003	(0.011)	0.014	(0.020)	-0.025	(0.013)*
Other	-0.005	(0.019)	-0.056	(0.017)***	-0.003	(0.017)	0.004	(0.014)	-0.022	(0.016)
Marital Status (reference single)										
Married	-0.027	(0.021)	-0.004	(0.020)	-0.060	(0.016)***	-0.050	(0.014)***	-0.044	(0.018)**
Divorced	-0.034	(0.022)	0.001	(0.021)	-0.012	(0.017)	-0.012	(0.014)	-0.019	(0.020)
Education (reference < High School)										
High School	-0.012	(0.016)	0.028	(0.016)*	-0.027	(0.011)**	-0.016	(0.017)	-0.008	(0.015)
Some college	0.055	(0.015)***	0.058	(0.015)***	-0.029	(0.008)***	-0.037	(0.012)***	0.021	(0.013)
> College	0.152	(0.017)***	0.073	(0.014)***	0.003	(0.014)	-0.072	(0.015)***	0.061	(0.016)***
Income (reference 0-130% of FPL)										
130%-180% of FPL	-0.016	(0.019)	0.001	(0.018)	0.000	(0.014)	-0.003	(0.011)	-0.007	(0.018)
>180% of FPL	0.075	(0.017)***	0.159	(0.012)***	0.078	(0.017)***	0.038	(0.014)**	0.121	(0.016)***

Abbreviations: FPL, Federal Poverty Line; NHANES, National Health and Nutrition Examination Survey.

Note: Standard error in parenthesis.

*p<0.10 **p<0.05 ***p<0.01

2.5.3. Association between socio-demographic characteristics and attitudes toward food and BMI, Healthy Eating Index, and physical activity

After adjusting for potential confounders (age, gender, ethnicity, and marital status), the score of consumer attitudes toward nutrition was significantly and negatively associated with BMI, positively associated with the Healthy Eating index, and had no significant relationship with physical activity (Table 2.3). This means that an increase in the perceived importance of nutrition relative to price is associated with a decrease in BMI and an increase in the quality of diet. The negative association with BMI and the positive relationship with HEI can be explained with the idea that people preferring nutrition over price may select healthier food leading to lower BMI levels.

Similarly, the index of attitudes toward food is significantly ($p < 0.01$) and negatively associated with BMI and positively with the HEI score. Although both nutrition and the index of attitudes are associated with BMI, nutrition holds a larger correlation. Due to all scores of attitudes being standardized in z-scores, coefficients can be interpreted homogeneously, and in this case, an increase of a standard deviation in the importance of nutrition relative to price is associated with a decrease of 0.449 BMI units while an increase in a standard deviation in the index of attitudes is associated with a reduction of 0.290 units of BMI. The score of taste is only slightly significantly ($p < 0.10$) associated with BMI, freshness with HEI, and preparation with physical activity.

Some of the socioeconomic indicators, such as having attained college or more are significantly associated with BMI, HEI, and physical activity. Socioeconomic status is negatively associated with the level of BMI and physical activity, and positively associated with the diet quality (HEI). Income above 180% of the poverty threshold is significantly and positively associated with the diet quality across all scores of food attitudes. This means, on average, that an increase in income is related to an increase in the diet quality.

Table 2.3 Association of Attitudes toward Food with BMI, Healthy Eating Index Score, and Physical Activity, Multivariate OLS Regressions, NHANES 2007-2010

Models by Attitudes toward Food and Socioeconomic Variables		Body Mass Index		Healthy Eating Index		Physical Activity	
		β	SE	β	SE	β	SE
1)	Nutrition	-0.449	(0.108)***	0.156	(0.014)***	0.013	(0.013)
	Education (reference < high school)						
	High school graduate	-0.020	(0.121)	0.030	(0.018)*	-0.004	(0.020)
	Some college	0.084	(0.099)	0.105	(0.017)***	-0.034	(0.023)
	College graduate or higher	-0.641	(0.119)***	0.230	(0.019)***	-0.119	(0.025)***
	Income (reference 0-130% of FPL)						
	130%-180% of FPL	-0.063	(0.121)	-0.013	(0.013)	0.037	(0.016)**
	>180% of FPL	-0.066	(0.124)	0.028	(0.014)**	0.005	(0.016)
2)	Taste	-0.166	(0.092)*	-0.006	(0.015)	0.000	(0.009)
	Education (reference < high school)						
	High school graduate	-0.010	(0.122)	0.029	(0.018)	-0.004	(0.020)
	Some college	0.069	(0.096)	0.114	(0.017)***	-0.032	(0.023)
	College graduate or higher	-0.697	(0.120)***	0.254	(0.019)***	-0.116	(0.025)***
	Income (reference 0-130% of FPL)						
	130%-180% of FPL	-0.056	(0.121)	-0.016	(0.012)	0.037	(0.016)**
	>180% of FPL	-0.073	(0.122)	0.041	(0.013)***	0.006	(0.017)
3)	Freshness	-0.043	(0.090)	0.018	(0.010)*	0.015	(0.009)
	Education (reference < high school)						
	High school graduate	-0.016	(0.122)	0.029	(0.018)	-0.004	(0.020)
	Some college	0.057	(0.095)	0.115	(0.017)***	-0.032	(0.023)
	College graduate or higher	-0.712	(0.121)***	0.255	(0.020)***	-0.115	(0.025)***
	Income (reference 0-130% of FPL)						
	130%-180% of FPL	-0.056	(0.121)	-0.016	(0.012)	0.036	(0.016)**
	>180% of FPL	-0.098	(0.124)	0.039	(0.013)***	0.006	(0.016)
4)	Preparation	-0.191	(0.113)	-0.002	(0.014)	-0.020	(0.011)*
	Education (reference < high school)						
	High school graduate	-0.020	(0.123)	0.029	(0.018)	-0.005	(0.019)
	Some college	0.054	(0.095)	0.114	(0.017)***	-0.033	(0.023)
	College graduate or higher	-0.709	(0.122)***	0.254	(0.019)***	-0.117	(0.025)***
	Income (reference 0-130% of FPL)						
	130%-180% of FPL	-0.056	(0.120)	-0.016	(0.012)	0.036	(0.016)**
	>180% of FPL	-0.084	(0.122)	0.040	(0.013)***	0.008	(0.016)
5)	Index of attitudes	-0.290	(0.105)***	0.059	(0.014)***	0.002	(0.009)
	Education (reference < high school)						
	High school graduate	-0.017	(0.123)	0.029	(0.018)	-0.005	(0.020)
	Some college	0.065	(0.097)	0.113	(0.017)***	-0.033	(0.023)
	College graduate or higher	-0.691	(0.121)***	0.250	(0.019)***	-0.118	(0.025)***
	Income (reference 0-130% of FPL)						
	130%-180% of FPL	-0.058	(0.121)	-0.015	(0.012)	0.036	(0.017)**
	>180% of FPL	-0.064	(0.124)	0.033	(0.013)**	0.006	(0.016)

Abbreviations: BMI, body mass index; SE, standard error; FPL, Federal Poverty Line; NHANES, National Health and Nutrition Examination Survey.

Note: Multivariate linear regression adjusted for survey design complexity, using PSU, stratum and weight variables. All models were adjusted for age, gender, ethnicity, marital status and survey year.

*p<0.10 **p<0.05 ***p<0.01

2.5.4 Association of Attitudes toward Food with the Probability of Being Underweight, Normal Weight, Overweight, and Obese

Table 2.4 shows results for multivariate logistic regressions for the relationship between attitudes toward food and binary weight outcomes: underweight, normal weight, overweight, and obese. The score of nutrition was significantly associated with the probability of normal weight, overweight, and obesity. It holds a positive relation with normal weight and a negative relation with overweight and obesity. This means that an increase in the importance of nutrition relative to the food price is related to a decrease in the probability of being overweight or obese, and to an increase in the probability of being normal weight. Taste, freshness, and preparation scores were only significantly and negatively associated with the probability of being obese. In other words, a decrease in the importance assigned to the food attributes relative to its price is associated with an increase in the probability of being obese. The composite index of attitudes was associated with the probability of being overweight or obese.

Table 2.4. Estimated Change in the Probability of Underweight, Normal Weight, Overweight, and Obesity by Score of Attitudes toward Food, NHANES 2007-2010

Models by Attitudes toward Food	Underweight (BMI <18.5)		Normal Weight (18.5 ≤ BMI <25)		Overweight (BMI ≥ 25)		Obese (BMI ≥ 30)	
	AME	SE	AME	SE	AME	SE	AME	SE
Nutrition								
Model 1	0.003	(0.002)	0.022	(0.007)***	-0.024	(0.008)***	-0.028	(0.006)***
Model 2	0.002	(0.002)	0.018	(0.007)**	-0.020	(0.008)***	-0.023	(0.006)***
Model 3	0.003	(0.002)*	0.021	(0.007)***	-0.024	(0.008)***	-0.028	(0.006)***
Model 4	0.002	(0.002)	0.017	(0.007)**	-0.019	(0.008)**	-0.023	(0.006)***
Taste								
Model 1	0.001	(0.002)	0.005	(0.005)	-0.006	(0.006)	-0.014	(0.005)***
Model 2	0.001	(0.002)	0.005	(0.005)	-0.006	(0.006)	-0.015	(0.005)***
Model 3	0.001	(0.002)	0.004	(0.006)	-0.005	(0.006)	-0.013	(0.005)***
Model 4	0.001	(0.002)	0.004	(0.005)	-0.005	(0.006)	-0.014	(0.005)***
Freshness								
Model 1	0.002	(0.002)	0.005	(0.007)	-0.007	(0.008)	-0.012	(0.006)*
Model 2	0.002	(0.002)	0.005	(0.007)	-0.006	(0.008)	-0.011	(0.006)*
Model 3	0.002	(0.002)	0.003	(0.006)	-0.005	(0.007)	-0.011	(0.007)*
Model 4	0.002	(0.002)	0.003	(0.006)	-0.005	(0.007)	-0.011	(0.007)
Preparation								
Model 1	0.002	(0.002)	0.003	(0.006)	-0.005	(0.008)	-0.016	(0.009)*
Model 2	0.002	(0.002)	0.003	(0.007)	-0.005	(0.008)	-0.016	(0.009)*
Model 3	0.002	(0.002)	0.002	(0.007)	-0.004	(0.008)	-0.017	(0.009)*
Model 4	0.002	(0.002)	0.002	(0.007)	-0.004	(0.008)	-0.017	(0.009)*
Index of Attitudes								
Model 1	0.002	(0.001)	0.012	(0.006)*	-0.014	(0.007)**	-0.023	(0.006)***
Model 2	0.002	(0.001)	0.010	(0.006)*	-0.012	(0.007)*	-0.021	(0.006)***
Model 3	0.003	(0.002)*	0.010	(0.006)	-0.013	(0.007)*	-0.023	(0.006)***
Model 4	0.002	(0.001)	0.009	(0.006)	-0.011	(0.007)	-0.021	(0.006)***

Abbreviations: BMI, body mass index; AME, average marginal effects; SE, standard error; NHANES, National Health and Nutrition Examination Survey.

Note: Model 1 adjusted for socio-demographic variables (age, gender, ethnicity, marital status, education, and poverty income ratio); Model 2 adjusted for socio-demographics and Healthy Eating Index (HEI); Model 3 adjusted for socio-demographics and physical activity; and Model 4 adjusted for socio-demographics, HEI and physical activity.

*p<0.10 **p<0.05 ***p<0.01

2.5.5 Possible Pathways in which Attitudes toward Food are Associated with Diet, Physical Activity, and BMI

Based on results from the above models testing the association between variables on each path of the theoretical model, I built the comprehensive pathway and tested its parsimony through global goodness of fit indices (Chi squared, CFI, and RMSEA) as indicated in the methods section. When exploring alternative models using different measures for certain variables, I kept those models that were significant at a type I error of 0.10. The final model included these variables: composite index of income and education (socioeconomic status), scores of attitudes toward food, HEI score (diet quality), MET hours per week (physical activity), and BMI level. Sociodemographic variables (age, gender, marital status, and ethnicity) are given exogenously, and their associations with the independent and dependent variables were tested in the path analysis as well. After the goodness of fit tests, only age was retained.

Table 2.5 evaluates the theoretical model of the relationship between socioeconomic status, HEI, physical activity, and BMI levels by each type of attitude analyzed. The path analysis provides results for direct and indirect associations between variables. Direct associations are those in which the independent variable is directly related to the outcome, while indirect associations are those whose path toward the final outcome occurs through one or more variables. For instance, in the case of attitudes toward food, they are independent variables directly associated with BMI (dependent variable), but they are also indirectly associated through physical activity and HEI score (see Figures 2.2 and 2.3 for direct and indirect associations). Total association is the sum of direct and indirect associations.

Results in Table 2.5 indicate that associations of the perceived nutrition of food relative to price are significantly associated with BMI and HEI, but not with physical activity. As expected, the relation with BMI is negative, while the correlation with the HEI score is positive. This supports the idea that an increase in the importance of nutrition relative to price could improve diet quality and reduce BMI. The non-significant and close to zero association between nutrition and physical activity is consistent with results from the models above, but it is not straightforward because the measure employed here (MET) includes both physical activity performed in leisure activities, such as working out, and in working time, such as lifting heavy weight as part of job duties. People perceiving food as nutritious may opt to do less

exercise, particularly during their leisure time, while people involved in jobs requiring high amounts of physical activity, such as construction work, may assign more importance to price and to other characteristics of food not included in this study than to nutrition. Therefore, the expected direction of the total effect is unclear.

Consistent with findings in the models tested above, the compound index of attitudes toward food showed significant associations with the outcomes of interest and move in the same direction as those of nutrition. The perception of freshness of food and preparation were marginally ($p < 0.10$) and negatively associated with BMI. Taste holds a significant ($p < 0.05$) and negative relationship with BMI. An increase in the perception of the importance of food preparation time, freshness, or taste relative to price is related to a reduction in BMI.

Socioeconomic status is significantly associated with all variables: BMI, HEI, physical activity, and attitudes toward food. Across all attitudes, higher socioeconomic status is related to lower BMI levels and physical activity, and positively associated with diet quality. These findings are consistent with the idea that people with lower socioeconomic status have a lower quality diet. Socioeconomic status is positively related to the perceived importance of nutrition, taste, and preparation as well as the compound index of attitudes.

Table 2.5. Direct, Indirect^a, and Total Associations between Socioeconomic Status, Attitudes toward Food, HEI, Physical Activity and BMI by Score of Attitude to Food, NHANES 2007-2010

Attitudes toward Food	Association with Attitudes toward Food			Association with SES			
	Body Mass Index	Healthy Eating Index	Physical Activity	Body Mass Index	Healthy Eating Index	Physical Activity	Attitudes toward Food
Nutrition							
Direct	-0.395***	0.183***	-0.005	-0.465***	0.147***	-0.055***	0.142***
Indirect	-0.121***			-0.153***	0.026***	-0.001***	
Total	-0.516***	0.183***	-0.005	-0.619***	0.173***	-0.055***	0.142***
Taste							
Direct	-0.199**	-0.008	0.007	-0.466***	0.174***	-0.056***	0.209***
Indirect	0.003			-0.151***	-0.002***	0.002***	
Total	-0.196**	-0.008	0.007	-0.617***	0.172***	-0.055***	0.209***
Freshness							
Direct	-0.002	0.014	0.015	-0.505***	0.173***	-0.055***	-0.030
Indirect	-0.016*			-0.11***	0***	0***	
Total	-0.018	0.014	0.015	-0.615***	0.173***	-0.055***	-0.030
Preparation							
Direct	-0.149*	0.006	-0.015	-0.503***	0.172***	-0.054***	0.044***
Indirect	0.001			-0.116***	0***	-0.001***	
Total	-0.148*	0.006	-0.015	-0.62***	0.172***	-0.055***	0.044***
Index of Attitudes							
Direct	-0.265***	0.069***	0.000	-0.472***	0.163***	-0.056***	0.133***
Indirect	-0.05***			-0.141***	0.009***	0***	
Total	-0.315***	0.069***	0.000	-0.614***	0.172***	-0.056***	0.133***

Abbreviations: BMI, body mass index; HEI, Healthy Eating index; SES, socioeconomic status; NAHNES, National Health and Nutrition Examination Survey.

^aIndirect relationship between attitudes toward food and BMI via Healthy Eating Index and physical activity. Indirect relationship between socioeconomic status and BMI via attitudes toward food, Healthy Eating Index, and physical activity.

Note: Models were adjusted for age.

*p<0.10 **p<0.05 ***p<0.01

Below is the graphic representation of results when the analyzed attitude to food is nutrition, the attitude that was significantly associated with most outcomes of interest. Results for all other attitudes are in Table 2.5.

Figure 2.3 Results of Path Analysis for the Association of Socioeconomic Status and Perceived Nutrition Relative to Price with Diet Quality, Physical Activity and BMI

Abbreviation: BMI, body mass index; MET, metabolic equivalents; HEI, Healthy Eating Index.
 Goodness of fit. Chi square =2.487; degrees of freedom =1; $p > \chi^2 = 0.115$; RMSEA=0.013; CFI=0.999, TLI=0.987.
 Note: Model adjusted by age.

2.5.6 Heterogeneous associations by gender, ethnicity, and poverty level

In addition to addressing the different associations from the theoretical paths between socioeconomic status, attitudes toward food, and body mass index for the overall population, I also explored those correlations by subpopulation groups: gender, ethnicity, and income (see Tables 2.6a, 2.6.b and 2.7). This analysis by subgroup provides a deeper understanding of the mechanisms linking the attitudes toward food to the final outcome BMI. For instance, it is expected that women assign weights related to food characteristics differently than men because of social and biological factors. Furthermore, given that most of the extant literature analyzes attitudes toward food for a specific population group, it is important to explore whether the findings here differ by group and whether they are consistent with previous similar research. In particular, the analysis by income level is interesting because the literature emphasizes its role in influencing all three outcomes: physical activity, diet, and BMI.

I found that overall results from the previous section hold in Table 2.6.a and 2.6.b. The perception of nutrition is significantly and directly associated with the BMI of men, women, white, and black (Table 2.6.a). The index of attitudes toward food is negatively related to the BMI of men, white, and black. Furthermore, BMI of women is only associated with their perception of nutrition and the index of attitudes, but not to other attitudes; while BMI of men is associated with their perception of nutrition and taste, and the index of attitudes. The BMI of population by all income levels is significantly related to the perception of nutrition and the magnitude of the association increases along the income. The index of attitudes is only significant among people with income >180% of FPL. Freshness, taste, and preparation are not associated with BMI.

Perception of nutrition is positively associated with diet quality among all subgroups (Table. 2.6.b). Taste is only slightly significant among black population, freshness is significant among Hispanic and black people, and preparation among Hispanics and people from other ethnicity. HEI score of population by income level is only related to the perception of nutrition and to the index of attitudes.

Physical activity is only associated with the perception of nutrition among black people. It is important to note that the other attitudes toward food do not have any relationship with physical activity of any specific subgroup. These null associations are consistent with the overall results.

The index of socioeconomic status is indirectly and negatively associated to BMI across all subpopulations through all analyzed attitudes toward food, except for persons whose income is between 130% and 180% of the FPL (see Table 2.7). Socioeconomic status showed a significant, negative, and direct correlation with BMI of women, white and Hispanic people, and people with income above 180% of the poverty line or below 130%. This means that an increase in socioeconomic status (regardless of a particular attitude to food) is associated with a decrease in BMI of women, white, Hispanic, poor, and non-poor people.

The path analysis also showed that socioeconomic status is significantly and positively associated with the attitudes toward food among most subgroups. The perception of nutrition and taste are related to socioeconomic status among the largest number of subgroups, while the perception of freshness is not significantly related to socioeconomic status among any

ethnic group and women. Among the poorest, socioeconomic status is only slightly related to the perception of nutrition, freshness and preparation. Among people with income above 180% of the FPL all attitudes toward food were significantly associated with socioeconomic status. In most cases analyzed, the perception of nutrition relative to food price is the most significant attitude.

When analyzing the association between socioeconomic status and HEI, I found a positive, direct, and significant association among all population groups across all attitudes toward food. There are also significant indirect associations with almost all population groups through nutrition, taste and preparation. In other words, an increase in socioeconomic status is associated directly and indirectly with better diet quality among all sub-groups.

Socioeconomic status had a significant direct association with the physical activity of men, white, Hispanic, and people with income >180% of FPL. In the case of women, this direct association was not significant. Socioeconomic status holds an indirect relation with physical activity of men, women, white, and Hispanic people through nutrition, taste, and the index of attitudes. Indeed, socioeconomic status had no significant indirect association with the physical activity of any ethnic group and women when the analyzed attitude toward food is freshness. Socioeconomic status is related to physical activity both directly and indirectly through all attitudes among people with income above 180% of the FPL. However, most of these indirect associations are very small and go in opposite direction in many relationships presented.

Table 2. 6.a Direct, Indirect^a and Total Associations between Attitudes toward Food and BMI by Attitude and Sub-groups of Population, NHANES 2007-2010

Attitudes toward Food	Body Mass Index								
	Gender		Ethnicity				Income		
	Men	Women	White	Hispanic	Black	Other	0-130% of FPL	130%-180% of FPL	>180% of FPL
Nutrition									
Direct	-0.284**	-0.468***	-0.388***	-0.188	-0.582**	-0.462	-0.253	-0.477*	-0.44***
Indirect	-0.099***	-0.134***	-0.147***	-0.042***	0.008	-0.087***	-0.078***	-0.003	-0.137***
Total	-0.383***	-0.602***	-0.535***	-0.23	-0.574**	-0.549	-0.332**	-0.48*	-0.577***
Taste									
Direct	-0.226**	-0.153	-0.14	-0.092	-0.464**	-0.005	-0.277*	-0.24	-0.182
Indirect	0.012	-0.007	-0.002	0.013	0.033**	-0.017	0.007	-0.013	0.006
Total	-0.214**	-0.16	-0.142	-0.078	-0.431**	-0.022	-0.27*	-0.253	-0.176
Freshness									
Direct	-0.164	0.093	0.042	-0.145	-0.106*	0.112	0.094	-0.176	-0.029
Indirect	-0.022	-0.011	-0.013	-0.014	-0.008***	0.007	-0.008	-0.033*	-0.02*
Total	-0.185	0.082	0.028	-0.159	-0.115**	0.119	0.086	-0.209	-0.049
Preparation									
Direct	-0.142	-0.131	-0.193	-0.068	-0.179	-0.495	-0.279*	-0.226	-0.08
Indirect	0.002	0.001	0.026	-0.015***	0.014	-0.052*	-0.004	-0.004	0.012
Total	-0.139	-0.13	-0.167	-0.083	-0.166	-0.547	-0.283*	-0.229	-0.068
Index of attitudes									
Direct	-0.284**	-0.217	-0.245**	-0.145	-0.474***	-0.263	-0.284*	-0.361	-0.26**
Indirect	-0.037**	-0.058***	-0.06***	-0.019	0.01***	-0.061**	-0.028	-0.016	-0.055***
Total	-0.321**	-0.274**	-0.304**	-0.164	-0.464***	-0.325	-0.312*	-0.377	-0.315***

Abbreviations: BMI, body mass index; FPL, Federal Poverty Line; NHANES, National Health and Nutrition Examination Survey.

^aIndirect relationship between attitudes toward food and BMI via Healthy Eating Index and physical activity.

Note: Model adjusted by age.

*p<0.10 **p<0.05 ***p<0.01

(Table continues)

(Table 2.6 continued)

Table 2.6.b Associations between Attitudes toward Food and HEI and Physical Activity by Score of Attitudes toward Food and Sub-groups of Population, NHANES 2007-2010

Attitudes toward Food	Healthy Eating Index								
	Gender		Ethnicity				Income		
	Men	Women	White	Hispanic	Black	Other	0-130% of FPL	130%-180% of FPL	>180% of FPL
Nutrition	0.176***	0.184***	0.203***	0.082***	0.064***	0.212***	0.139***	0.189***	0.183***
Taste	-0.017	0.006	-0.006	-0.018	-0.046*	0.032	-0.018	0.006	-0.007
Freshness	0.028	0.007	0.001	0.043*	0.02***	-0.019	-0.002	0.045	0.024*
Preparation	0.002	0.012	-0.024	0.033***	-0.017	0.115*	0.032	0.037	-0.012
Index of attitudes	0.064***	0.073***	0.071***	0.045**	0.013	0.12**	0.054**	0.087***	0.069***
Physical Activity									
Nutrition	-0.007	0.003	0.001	-0.009	-0.058**	0.056	-0.02	-0.026	0.013
Taste	-0.007	0.004	0.017	-0.018	-0.045	0.007	0.008	0.032	-0.001
Freshness	0.019	0.01	0.029	-0.041	0.006	0.033	0.014	0.067	0.001
Preparation	-0.016	-0.022	-0.016	-0.012	-0.022	0.006	-0.027	-0.005	-0.011
Index of attitudes	-0.01	0.001	0.008	-0.026	-0.033	0.032	-0.014	0.013	0.001

Abbreviations: HEI, Healthy Eating Index; FPL, Federal Poverty Line; NHANES, National Health and Nutrition Examination Survey.

Note: Model adjusted by age.

*p<0.10 **p<0.05 ***p<0.01

Table 2. 7. Direct, Indirect^a, and Total Associations between Socioeconomic Status and BMI, HEI, Physical Activity, and Attitudes toward Food by Score of Attitudes and Sub-groups of Population, NHANES 2007-2010

Attitudes toward Food	Body Mass Index									Attitudes to Food								
	Gender		Ethnicity				Income			Gender		Ethnicity				Income		
	Men	Women	White	Hispanic	Black	Other	0-130% of FPL	130%-180% of FPL	>180% of FPL	Men	Women	White	Hispanic	Black	Other	0-130% of FPL	130%-180% of FPL	>180% of FPL
Nutrition																		
Direct	0.054	-0.895***	-0.363***	-0.25*	0.27	-0.582	-0.788**	-0.514	-1.328***	0.114***	0.169***	0.204***	0.119***	0.051**	0.082	0.115**	-0.025	0.374***
Indirect	-0.086***	-0.219***	-0.218***	-0.036***	-0.064***	-0.096**	-0.197***	0.002	-0.478***	0.114***	0.169***	0.204***	0.119***	0.051**	0.082	0.115**	-0.025	0.374***
Total	-0.033	-1.114***	-0.581***	-0.287*	0.206	-0.678*	-0.985**	-0.512	-1.807***	0.114***	0.169***	0.204***	0.119***	0.051**	0.082	0.115**	-0.025	0.374***
Taste																		
Direct	0.078	-0.924***	-0.392***	-0.256*	0.294	-0.586*	-0.786**	-0.449	-1.403***	0.195***	0.218***	0.221***	0.202***	0.101***	0.076	0.067	0.084	0.18***
Indirect	-0.105***	-0.19***	-0.188***	-0.033**	-0.088***	-0.073**	-0.201***	-0.064**	-0.39***	0.195***	0.218***	0.221***	0.202***	0.101***	0.076	0.067	0.084	0.18***
Total	-0.028	-1.113***	-0.58***	-0.289*	0.206	-0.658*	-0.987**	-0.513	-1.793***	0.195***	0.218***	0.221***	0.202***	0.101***	0.076	0.067	0.084	0.18***
Freshness																		
Direct	0.029	-0.956***	-0.426***	-0.261*	0.24	-0.576	-0.782**	-0.493	-1.452***	-0.049***	-0.015	-0.009	0.022	-0.071	0.05	-0.153***	-0.15***	-0.216***
Indirect	-0.053***	-0.158***	-0.158***	-0.015	-0.03**	-0.073**	-0.193***	-0.017	-0.351***	-0.049***	-0.015	-0.009	0.022	-0.071	0.05	-0.153***	-0.15***	-0.216***
Total	-0.024	-1.114***	-0.584***	-0.277*	0.21	-0.649**	-0.974**	-0.509	-1.803***	-0.049***	-0.015	-0.009	0.022	-0.071	0.05	-0.153***	-0.15***	-0.216***
Preparation																		
Direct	-0.142	-0.951***	-0.41***	-0.276*	0.265	-0.574	-0.859**	-0.512	-1.437***	0.11	0.068***	0.097***	-0.01	0.023	0.039	-0.164***	-0.187***	0.084*
Indirect	-0.063***	-0.165***	-0.177***	-0.014***	-0.043***	-0.084*	-0.131**	-0.001	-0.363***	0.11	0.068***	0.097***	-0.01	0.023	0.039	-0.164***	-0.187***	0.084*
Total	-0.205	-1.116***	-0.586***	-0.29**	0.222	-0.658*	-0.989**	-0.514	-1.801***	0.11	0.068***	0.097***	-0.01	0.023	0.039	-0.164***	-0.187***	0.084*
Index of attitudes																		
Direct	0.063	-0.925***	-0.384***	-0.244	0.282	-0.574	-0.806**	-0.514	-1.418***	0.101***	0.159***	0.182***	0.117***	0.044	0.085	-0.033	-0.089	0.164***
Indirect	-0.037***	-0.187***	-0.198***	-0.03**	-0.057***	-0.095***	-0.161***	<0.001	-0.39***	0.101***	0.159***	0.182***	0.117***	0.044	0.085	-0.033	-0.089	0.164***
Total	0.027	-1.111***	-0.582***	-0.273*	0.225	-0.669*	-0.967**	-0.515	-1.808***	0.101***	0.159***	0.182***	0.117***	0.044	0.085	-0.033	-0.089	0.164***

Abbreviations: BMI, body mass index; HEI, Healthy Eating Index; FPL, Federal Poverty Line; NHANES, National Health and Nutrition Examination Survey.

^aIndirect relationship between socioeconomic status and BMI via attitudes toward food, Healthy Eating Index, and physical activity.

Note: Model adjusted by age.

*p<0.10 **p<0.05 ***p<0.01

(Table continues)

(Table 2.7 continued)

Attitudes toward Food	Healthy Eating Index									Physical Activity								
	Gender		Ethnicity				Income			Gender		Ethnicity				Income		
	Men	Women	White	Hispanic	Black	Other	0-130% of FPL	130%-180% of FPL	>180% of FPL	Men	Women	White	Hispanic	Black	Other	0-130% of FPL	130%-180% of FPL	>180% of FPL
Nutrition																		
Direct	0.126***	0.173***	0.189***	0.043**	0.115***	0.129**	0.335***	0.362***	0.458***	-0.129***	-0.015	-0.068***	-0.066***	0.013	-0.047	-0.093	-0.038	-0.353***
Indirect	0.02***	0.031***	0.041***	0.01***	0.003**	0.017	0.016**	-0.005	0.069***	-0.001***	<0.001***	<0.001***	-0.001***	-0.003**	0.005	-0.002***	0.001	0.005***
Total	0.146***	0.204***	0.23***	0.053***	0.119***	0.147**	0.351***	0.358***	0.527***	-0.13***	-0.015	-0.068***	-0.067***	0.01	-0.043	-0.095*	-0.037	-0.348***
Taste																		
Direct	0.148***	0.203***	0.231***	0.056***	0.123***	0.146**	0.351***	0.359***	0.531***	-0.128***	-0.015	-0.071***	-0.064**	0.014	-0.041	-0.094*	-0.039	-0.346***
Indirect	-0.003***	0.001***	-0.001***	-0.004***	-0.005***	0.002***	-0.001	<0.001	-0.001***	-0.001***	0.001***	0.004***	-0.004***	-0.005***	0.001	0.001	0.003	<0.001***
Total	0.145***	0.204***	0.23***	0.052**	0.118***	0.148**	0.349***	0.359***	0.53***	-0.13***	-0.014	-0.067***	-0.067**	0.009	-0.04	-0.093	-0.037	-0.346***
Freshness																		
Direct	0.147***	0.204***	0.231***	0.049**	0.121***	0.158***	0.35***	0.365***	0.537***	-0.128***	-0.014	-0.066***	-0.067***	0.01	-0.042	-0.093	-0.027	-0.347***
Indirect	-0.001***	<0.001***	<0.001	0.001	-0.001	-0.001	<0.001***	-0.007***	-0.005***	-0.001***	<0.001	<0.001	-0.001	<0.001	0.002	-0.002***	-0.01***	<0.001***
Total	0.146***	0.204***	0.231***	0.05**	0.12***	0.157***	0.35***	0.358***	0.531***	-0.129***	-0.014	-0.067***	-0.068***	0.009	-0.041	-0.095*	-0.038	-0.347***
Preparation																		
Direct	0.146***	0.202***	0.232***	0.053***	0.118***	0.143**	0.353***	0.366***	0.531***	-0.128***	-0.014	-0.066***	-0.067***	0.01	-0.04	-0.1*	-0.038	-0.346***
Indirect	<0.001	0.001***	-0.002***	<0.001***	<0.001	0.005***	-0.005***	-0.007***	-0.001*	<0.001	-0.001***	-0.002***	<0.001***	-0.001	<0.001	0.004***	0.001***	-0.001*
Total	0.146***	0.203***	0.23***	0.053***	0.118***	0.148**	0.348***	0.359***	0.53***	-0.128***	-0.015	-0.067***	-0.067***	0.009	-0.04	-0.096*	-0.037	-0.347***
Index of attitudes																		
Direct	0.139***	0.191***	0.217***	0.045**	0.116***	0.146**	0.348***	0.369***	0.518***	-0.129***	-0.015	-0.069***	-0.065**	0.01	-0.046	-0.097*	-0.037	-0.349***
Indirect	0.006***	0.012***	0.013***	0.005***	0.001	0.01	-0.002	-0.008	0.011***	-0.001***	<0.001***	0.002***	-0.003***	-0.001	0.003	<0.001	-0.001	<0.001***
Total	0.146***	0.203***	0.23***	0.05**	0.117***	0.156**	0.347***	0.361***	0.529***	-0.13***	-0.015	-0.067***	-0.068***	0.008	-0.043	-0.097*	-0.038	-0.349***

Abbreviations: HEI is healthy eating index, BMI is body mass index, and FPL is Federal Poverty Line.

^aIndirect relationship between socioeconomic status and BMI via attitudes toward food, Healthy Eating Index, and physical activity.

Note: Model adjusted by age.

*p<0.10 **p<0.05 ***p<0.01

2.6. Conclusions

This study presented evidence on the comprehensive and complex association between attitudes toward food, socioeconomic status, diet quality, and BMI. However there was no strong association between attitudes toward food and physical activity. Results also suggest that there is a significant association between socioeconomic status and the composite index of attitudes toward food and the key outcome variables: BMI, HEI, and physical activity.

The perceived importance of nutrition of food relative to price was the attitude most strongly associated with diet quality and BMI levels, as well as with the probability of being normal weight, overweight, or obese. Higher perceived importance of nutrition relative to price was associated with higher quality diet, lower BMI, obesity, and overweight. The other attitudes toward food -taste, freshness, and preparation-, did not strongly predict BMI, diet quality, and physical activity; but they were significant variables linking socioeconomic status and the outcome variables. This weak association of the perception of taste, freshness, and preparation with the outcomes of interest could indicate that contrary to common beliefs, they are not important characteristics of food contributing to the problem of unhealthy eating and obesity. Furthermore, since only the perception of nutrition relative to price holds a significant relation with the outcomes of interest, healthy food policy may focus on these two elements.

When analyzing the heterogeneity of the associations by specific population groups, I found similar results to those for the overall sample. Among the few differences found, preparation time was significantly associated with HEI score of Hispanics and freshness with HEI score of black people. Nutrition predicted the amount of physical activity among black people. In contrast, women's BMI was strongly and directly associated with their socioeconomic status across all food attitudes, but men's was not. BMI of people with an income below 130% or above 180% of the FPL is predicted by nutrition, but this is not replicated among people with income between 130%-180% of the PFL.

Overall results of the associations tested using nutrition as the mediating attitude to food were similar in significance and direction to results using the index of attitudes. This finding may contribute to supporting the idea that people make food choices heuristically (based on one or two attributes) and that on average, choices involving many criteria produce results similar than heuristic choices.

2.7. Discussion

Although findings of this analysis are not necessarily conclusive, they need to be taken carefully and could be important for policymakers because they center the discussion of food choice at the point of purchase with a focus on three elements: perceived nutrition, price, and socioeconomic status (or what people can afford). This approach suggests three policy implications. First, the problem of excess weight and obesity could be addressed by implementing policies that change the perception of the nutrition of healthy and unhealthy food among the population. For instance, a campaign of nutrition literacy that helps people understand the nutrition benefits of food from an early age and the consequences on their body might help them to make healthier choices. There are many other options to improve the perception of nutrition of healthy food, such as advertising campaigns, providing more salient nutritional information in menus and packages of food, and relocating healthy items to more visible places within a market, among others. Second, price is the main element determining food choice. Therefore, assuring low or reduced prices for healthy food could encourage healthier diets and lower BMI, especially among the lowest income people. Third, improving socioeconomic status may result in higher quality diet, higher physical activity, and lower obesity levels. This policy implication is very intuitive and straightforward but is sometimes overlooked by policymakers. Examples of policies that can help to keep prices low and at the same time improve the socioeconomic status of people are programs such as food subsidies including the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and the Supplemental Nutrition Assistance Program (SNAP).

Taste, preparation time, and freshness were three characteristics of food whose weak or null association with BMI can be attributed to different factors. One of them is that survey questions refer to a supermarket or a grocery store, while preparation and freshness can be attributes that determine food choice in other settings, such as at home or at a restaurant. In other words their importance in food choice may be higher in settings other than a supermarket.

Admittedly, this study has some limitations. First, the datasets used herein are cross-sectional and do not allow causality to be established. Second, NAHNES is a secondary dataset whose information was collected by calling and visiting individuals at home; it does not collect behavioral information in the moment that people make their purchasing decisions in the market. Attitudes toward food were reported in a Likert scale and may not correspond to the real choices in the setting. Moreover, these

data on attitudes toward food are general, and although they are for a supermarket or a grocery store, they do not refer to a specific group of food (e.g., fruits, sodas, processed food); therefore, results may not apply to all types of foods. Third, related to the previous point, dietary intake and physical activity are self-reported and may be subject to bias. Fourth, the conceptual model considers the main variables related to obesity indicated by previous literature, but other pathways including other type of behavioral factors such as motivation and peer effects are worthy of exploration. Fifth, even when the survey is representative at a national level, N=8,372 individuals are a small sample size (68% of adults in NHANES 2007-2009) to find significant associations to be generalized for an entire population. Sixth, path analysis is a good way to explore comprehensive associations between several variables, but even this model does not allow causality to be established. Although this research contributes to a better understanding of the links between consumer attitudes toward food and BMI, further research with larger and more accurate datasets exploring new paths remains necessary.

Chapter 3

A Cash Transfer Program for Older Persons in Yucatan, Mexico: Effects on Obesity

3.1 Introduction

In recent years, there has been a growing trend in developed countries in which the poor are more likely to be overweight or obese. As the gross national product has increased in developing countries, the incidence of obesity has steadily moved from high-income groups to lower-income groups (Monteiro et al., 2004). One hypothesis is that developing country industrialization and modernization has left individuals with less time for cooking and increased the availability of cheap, processed food with high caloric content (Popkin, 2001). The poor have severe budgetary constraints that prevent them from consuming more expensive healthy food (e.g., fish, vegetables, fruit, etc.). In other words, the poor eat what they can afford, not what is healthy. Cash transfers to the poor expand income constraints but have an ambiguous effect on their intake of healthy foods and, therefore, on obesity. As cash transfers are one of the main anti-poverty policies used internationally, identifying their effect on different populations is crucial to avoid increasing the prevalence of overweight and obesity among the poor.

Mexico is a middle-income country with high inequality that is undergoing a relatively new phenomenon among countries experiencing the nutrition transition: the combination of undernourished children and overweight adults. Furthermore, both nutrition of these problems (undernourishment and overweight) have spread across all age groups in recent years. This unhealthy situation is more prevalent among low-income people who consume foods that are low-cost and calorie-dense, but low in micronutrients (Torres Ornelas et al., 2011).

Mexico is a pioneer in implementing conditional or unconditional cash transfer programs targeting different populations. *Oportunidades*, -now named *Prospera*-, the most popular of these policies, targets households with school-aged children. It has proven to reduce the prevalence of anemia among

children but has had ambiguous effects on the nutrition of young adults. This program has been imitated by many other developing countries so its impact has been widespread.

The elderly, as a particularly vulnerable group, are a priority target of cash transfers programs around the world (Willmore, 2007). It is also the group with the highest per capita health care costs due to the prevalence of chronic diseases such as heart disease and diabetes, as well as age-dependent disorders that increase substantially with longevity (Alemayehu and Warner, 2004). Despite the importance of the health of the ageing population for fiscal costs and sustainability of the healthcare and social security systems, there is little evidence about the effects of cash transfer programs on their dietary and obesity-related outcomes in both developing and developed countries.

In Mexico, only 20.4% of people aged 70 and above have a contributory pension (ENESS, 2013) . For this reason, non-contributory pensions are a policy that different levels of governments have implemented since 2002. Additionally, 70.2% of people aged 60 and above are overweight or obese (ENSANUT, 2012), and 46.2% are below the poverty line (ENIGH, 2014) . Understanding the effect of these cash transfers programs on the obesity of older people is fundamental for designing and implementing effective anti-poverty and public health policies.

Through this study I aim to answer two research questions. First, I aim to address the effect of non-conditional cash transfers on the obesity levels of elderly people. Second, I aim to address whether cash transfers are a policy instrument that may help to reduce the epidemic of obesity among the elderly.

To answer these questions, I analyze the short-run effects of the non-contributory pension program, *Reconocer*, on anemia, waist circumference, body mass index (BMI), overweight, and obesity in the elderly population of Yucatan, Mexico. As a secondary analysis, I assess the effect of the program on other related outcomes, such as the frequency of food consumption, food insecurity, and household food demand. My empirical strategy consists of addressing the effect on all outcomes of interest through difference-in-differences models and, as robustness checks, conducting another set of difference-in-differences models adjusted with covariates and using logistic models for the probability of being overweight or obese, also adjusted for covariates. Following the economic theory developed by Posner and Philipson (2003) which establishes that the effect of income on obesity is inverted U-shaped, I expect to find a significant increase of the consumption of unhealthy

food and a small increase in the prevalence of obesity among the poor and the opposite effect among wealthier individuals.

This study contributes to the research literature and the policy debate in two ways. First, it explores whether extra income has an effect on BMI, waist circumference, and anemia in the elderly using rich panel data from a field experiment in Mexico. Second, it contributes to the discussion regarding whether these types of programs improve or worsen the health of one of the most vulnerable groups in a developing country context. This is especially relevant for countries like Mexico, where there is a national program that provides unconditional cash transfers to the elderly that, in many cases, lack of any other source of income. This research builds upon the economic model of Posner and Philipson (2003) stating that people choose a combination of quantity and quality of food that balances the joy of eating against the forgone consumption of alternative goods.

3.2 Background

3.2.1 Obesity in the elderly

Some studies associate obesity in elderly populations with lower health risks (Elia, 2001; Adams et al., 2006) while others indicate that losing weight at this age is associated with potential harmful effects on muscle and bone mass (Villareal et al., 2005). Although these results suggest that obesity in older ages may not be necessarily bad for health, other studies indicate the opposite, emphasizing evidence that obesity at all ages contributes to other chronic diseases, such as diabetes, hypertension, and metabolic syndrome (Osher and Stern, 2009). Furthermore, studies discouraging weight loss are primarily cross sectional whose results could be confounded by body changes related to ageing and by survival bias, as obese people have higher mortality rates at younger ages (Osher and Stern, 2009; Villareal et al., 2005).

The literature analyzing cross sectional data of large populations in developed countries indicates that average BMI gradually increases in both men and women reaching its peak in the decade 50-59 years and decreasing thereafter (Villareal et al., 2005; Hedley et al., 2004; Elia, 2001): this suggests that body mass above 50 follows a natural lifecycle and weight control may not be necessary. In

contrast, longitudinal studies show that BMI is very stable or slightly decreases in people over 60 years old (Villareal et al., 2005).

Aging is associated with changes in body composition and redistribution of body fat. From age 30 on, fat-free mass decreases and fat mass increases to reach its maximum during the decade 60–70 years of age. After 70 years of age the body composition changes due to a decrease in the fat and bone mass and muscle (Villareal et al., 2005) that could worsen by losing weight. However, both BMI and abdominal fat at all ages are associated with diabetes, metabolic syndrome, and hypertension and their related mortality (Osher and Stern, 2009). Thus, some studies encourage individuals to lose weight regardless of natural body ageing and weight redistribution (Gregg et al., 2003).

The literature also indicates in both longitudinal and cross-sectional studies that obesity in older people is associated with lower survival and lost years of life that range between 6 to 13 years, depending on the sex, age, and ethnicity of the group analyzed (Villareal et al., 2005; Osher and Stern, 2009). “From a clinical standpoint, the health complications associated with obesity increase linearly with increasing BMI until the age of 75 years” (Villareal, et al., 2005, p. 925).

Most studies do not distinguish between the effect of weight loss for obese and lean individuals, whether it was intentional or unintentional, and most do not use experimental data, preferring to study middle-aged adults rather than older adults. Involuntary weight loss in the elderly is associated with increased mortality rates because it may be related to other serious diseases that confound the result, such as Alzheimer or Parkinson (Villareal et al., 2005; Osher and Stern, 2009). However, when weight loss is intentional, it is associated with reduced mortality rate in older people with diabetes and other health conditions, such as morbid obesity (Villareal et al., 2005; Zamboni et al., 2005).

Aside from the redistribution of body fat, ageing is also associated with height loss. In this context, BMI may not be the most accurate measure of overweight and obesity among older individuals. Some researchers (Loria et al., 2015; Kuwabara, Ogawa-Shimokawa and Tanaka, 2011) alternatively suggest using the ratio of weight to knee height instead of BMI because as people age, knee height is more stable than total height. This alternative measure named BMIS, is calculated by substituting the squared meters of height in the formula of BMI by the squared centimeters of knee height and multiplying the result by 1,000.

Another factor to consider in the analysis of obesity and health among older people is that smokers tend to be thinner than non-smokers. Smoking cessation increases weight (Chou, Grossman and Saffer, 2004). Studies analyzing only non-smokers suggest that obesity is associated with higher mortality in the elderly (Zamboni et al., 2005).

Finally, there is wide evidence supporting the association of obesity with reduced skills and Alzheimer, low mobility and physical dependence, frailty, osteoarthritis, incontinence, and renal disease in older subjects (Osher and Stern, 2009).

In sum, there is evidence suggesting that obesity in the elderly is associated with chronic health conditions that increase mortality and that intentional weight loss may reduce health risks.

3.2.1.1 Mexican Case

In 2012, Mexico ranked as the second highest in terms of prevalence of obesity around the world, just below the United States (OECD, 2014). The latest National Survey of Health and Nutrition (ENSANUT) 2012 revealed that the high prevalence of obesity is spread across all age groups (See Table 3.1).

Table 3. 1. Prevalence of Body Mass Index in Adults Aged 20 and Above by Age Group (%), Mexico, ENSANUT 2012

Age	Normal	Overweight	Obesity Class I	Obesity Class II	Obesity Class III	Abdominal Obesity
20-29	43.0	32.3	15.2	4.8	2.1	53.3
30-39	24.1	40.6	23.3	7.8	3.3	75.4
40-49	18.0	41.2	28.2	8.5	3.8	82.9
50-59	18.2	42.6	24.4	10	4.3	84.8
60+	28.3	40.2	21.7	6.6	1.7	82.3
Total	27.5	38.8	22.1	7.3	3.0	74.0

Obesity thresholds: Normal BMI 18.5-24.9 kg/m²; Overweight 25.0-29.9 kg/m²; Obesity class I 30.0-34.9 kg/m²; Obesity class II 35.0-39.9 kg/m²; Obesity class III >40.0 kg/m².

Source: INSP (2012) based on data from ENSANUT 2012.

In addition, 35.4% of all deaths in 2013 in Mexico were due to diseases associated with obesity: 14.3% due to diabetes, 12.6% due to heart diseases, 5.2% due to cerebrovascular diseases, and 3.2% due to hypertensive diseases (SINAIS 2014).

In 2016, there are 12.5 million older persons (aged 60 years and over) in Mexico, representing 10.2% of the country population and only 28.3% of them have normal weight (CONAPO 2010 and ENSANUT 2012). Of people aged 60 years and over, 33.9% work, 43.2% is in poverty, and 10.0% is in extreme poverty (ENIGH 2014).

The obesity problem in Yucatan is particularly worrisome because this state has a higher prevalence of overweight and obesity than the rest of the country, even compared to other populations with similar proportions of indigenous persons. According to Arroyo et al. (2007), 81.6% of females and 74.5% of males 50-75 years old in rural Yucatan were obese or overweight. At the national level, 81.2% females and 71.4% males aged 50-69 were overweight or obese, and 44.4% females and 18.8% males in Mixteco communities in Oaxaca -another state with a high proportion of indigenous persons.

A possible explanation for the higher prevalence of overweight and obesity in the residents of Yucatan may be their diet and cooking techniques, which often rely on frying with lard. Arroyo et al. (2010) explored the cooking techniques of two rural communities and found that on an average day, out of 763 main ingredients used, 374 were fried (49%) and 389 boiled/grilled (51%). Within the fried ingredients, 205 out of 374 were fried in lard (55%), and 169 were fried in vegetable oil (45%).

These authors indicate that lard frying increases palatability and leads to better taste, texture, and aroma of most dishes, but it also increases the calorie and fat content and reduces the water, increasing the absolute energetic density of the food and the risk of diabetes, obesity, and cardiovascular disease. Furthermore, the community with a larger proportion of Mayan speakers that is located farther from the capital than the other community, consumed more fried dishes (65% versus 45%) and cooked more with lard (65% versus 46% of dishes) on average. These differences in cooking techniques could be related to cultural preferences and different access to other oils and cooking techniques.

Another element to consider when analyzing Yucatan is its large proportion of indigenous population and high levels of poverty. Yucatan is the Mexican state with the largest proportion of indigenous; in 2012, 51.4% of its population was Mayan (CONEVAL, 2014). The indigenous population is very vulnerable in Mexico, and it faces higher poverty prevalence than the non-indigenous population. In 2012, 76.6% (5.1 million) of indigenous people were in poverty vis a vis only 42.9% (44.9 million) of non-indigenous people (CONEVAL, 2014). This difference is larger when observing the extreme poor: 33.2% (2.2 million) of indigenous are in extreme poverty, while only 7.2% (7.6million) of non-indigenous are in the same conditions. These numbers reveal how vulnerable the population in Yucatan truly is.

3.2.1.2 Cash transfers

One cause of obesity is the affordability of healthy food. The poor in high and middle-income countries have limited access to healthy food and prefer to consume cheap food with high palatability and caloric content. Economic theory predicts that an increase in income expands their budgetary constraint and that their elasticity of food demand depends on the type of good that food represents (normal, luxury, necessary, or inferior). As income and the quantity demanded of a good increase, that commodity moves from being a luxury good to a necessary one. In other words, a normal good can be a luxury for poor people and a necessity for rich people (Aitchison and Brown, 1954).

Monetary transfers or supplemental income are a policy tool used around the world to ameliorate the poverty of different social groups. This additional income affects the health and weight of beneficiaries by allowing them to demand more quantity and quality of good and services, among

them food. It is important to address and understand the effect of these types of programs on the diet, weight, and health of intended beneficiaries.

3.3 Literature

Effects of Cash Transfers on the Nutrition and BMI of Different Population Groups

There is widespread evidence of the effects of cash transfers on the nutrition and health status of program recipients. Those effects vary by population group. Although many cash transfers to households in developing countries have been proven to be positively associated with the health of children, research is still developing. In Nicaragua, Maluccio and Flores (2005) found that the cash transfer program *Red de Proteccion Social* improved the nutritional status of children under age 5, measured by their height, weight, and hemoglobin levels. In rural Ecuador, Schady and Paxson (2007) discovered that the program *Bono de Desarrollo Humano* had a positive relationship with hemoglobin levels, height for age, and fine motor control of children 3 to 7 years old. In South Africa, the cash transfers program *Child Support Grant* boosted child nutrition early in life (Aguero, Carter and Woolard, 2006). In Mexico, Berhman and Hodinnott (2005) did not find any positive effect of a cash transfer program *Oportunidades* on the nutritious status of children caused by the expansion in income. Akee et al. (2013) analyzed a lump-sum cash transfer program among native Americans and established that extra income for the poorest households is associated with an increase in the body mass index of recipient teenagers. Most of these effects were larger for the extreme poor.

Cash transfers may represent an overall positive for children's health, but not necessarily for adults. Fernald et al. (2008) indicated that *Oportunidades* in rural Mexico is associated with higher BMI, diastolic blood pressure, and incidents of diabetes among adults. Skoufias's (2005) and Hoddinot and Skoufias (2004) also found that *Oportunidades* is associated with an increase in the caloric intake of recipients, while it did not necessarily improve their health. In the United States, participation in the Supplemental Nutritional Assistance Program (SNAP) was linked to an increase of obesity in adult women (Gibson, 2003). In contrast, the Women, Infants, and Children (WIC) vouchers for healthy food baskets had a small positive effect on healthy food intake among low-income Latinas and Afro-American mothers (Odoms-Young et al., 2014).

Overall, food consumption increases among families receiving cash transfers. In Colombia, Attanasio and Mesnard (2006) evaluated the impact of the program *Familias en Accion* and found a significant growth in the expenditure on food consumption concentrated in proteins (milk, meat, and eggs). Similarly, Skoufias et al. (2008) and Skoufias (2005) found that *Oportunidades* in rural increased the total food consumption of recipients and that such expansion was driven by an increase in the expenditure on fruit, vegetables, meats, and other animal products. Later, Gertler et al. (2012) found that the increase in consumption that resulted from *Oportunidades* is steady over the long term.

While most studies have focused on children and young and middle-aged adults, they have paid little attention to the effect of cash transfers on the obesity of the elderly. Older adults are the group with the highest per capita health costs in countries undergoing demographic transition (Alemayehu and Warner, 2004). This is due to the growing prevalence of chronic and degenerative diseases such as obesity and related cardiovascular illnesses in the older population. The elderly are vulnerable because of their age, health, and reduced income potential, especially if they lack a pension. Non-contributory pensions are one of the main poverty-reduction policy tools targeting this population.

Effect of Cash Transfers Programs on BMI of Older Persons

There are two types of cash transfer programs that may have an impact on the elderly: 1) cash transfers targeting households and 2) non-contributory pensions targeting older people. The first is widely used, but its effect on the elderly is indirect because in aiming to alleviate the poverty of all household members, the intra-household allocation of the extra income among each member may vary widely. In the second type of cash transfers, the effect is expected to be more direct on the older persons because it targets them specially and may give them more power on to decide how to use the extra income. In the paragraphs below, I present the available evidence of both types of programs.

Among the first type of cash transfer programs, there is *Oportunidades*. In Mexico, it has proven to significantly improve different health outcomes of the elderly population. Barham and Rowberry (2013) analyzed its effect on the mortality rate of people aged 65 and older and found that it significantly decreased by 4% in the treatment group relative to the control group. Behrman and Parker (2011) found that women experienced a significant reduction in days reported ill and days in which they were unable to carry out their normal activities. The proportion of women reporting high

blood pressure was reduced and the proportion of those reporting an ability to carry out vigorous activities such as running or carrying heavy objects, increased. No effects on health outcomes were found in men. Salinas-Rodriguez and Manrique-Espinoza (2013) indicated that *Oportunidades* increased the percent of elderly populations with a complete schedule of vaccination by 5.5%; 6.9% for the influenza vaccine, 7.2% for the pneumococcal, and 6.6% for tetanus. Gertler and Boyce (2001) discovered at the earlier stages of the implementation of *Oportunidades* a small significant effect on the health of adults aged 50 and older measured by the days of difficulty with daily activities, days incapacitated, and days in bed due to illness.

Similar cash transfer programs in other countries did not show significant effects. In Jamaica, the Programme of Advancement Through Health and Education (PATH) did not show any impact on the health of people aged 65 and older (Levy and Ohls, 2007). In the United States, the Food Stamp Program and Elderly Nutrition Program (ENP) did not have a significant impact on the nutrient intake of elderly participants in comparison to non-participants (Lee and Frongillo, 2001).

Evidence on cash transfer programs targeting the elderly is more limited. Case and Deaton (1998) studied the large cash transfer program of pensions to the elderly in South Africa and revealed a positive effect on food expenditure and on the likelihood of spending on food. Aguila et al. (2015) used data from the same experiment in which I based this study, the non-contributory pension to the elderly in Yucatan Mexico named *Reconocer*, and found significant positive impacts on the availability of food, income, number of doctor visits, buying medications, anemia, memory, and satisfaction with their family.

Téllez-Rojo et al. (2013) analyzed the program *70 y mas* for adults aged 70 and older and discovered that there was a significant effect on increasing the intake of proteins and carbohydrates. The impact on energy and macronutrient intake and the percentage of adequate intake were significantly higher among women, the indigenous population, and the elderly in the lowest socioeconomic segments of the population. No effect was found on body mass index. Galiani et al. (2014) studied the same program and indicated that 71% of the pension is used on consumption, representing an increase of 23% in the total household consumption. Finally, Manrique-Espinoza et al. (2014) found that after 14 months of follow-up, the association between obesity and disability of beneficiaries was marginally significant.

In sum, there is evidence supporting positive effects of cash transfers on child nutrition, but contradictory evidence about its effects on adults. The evidence regarding the effects on the elderly is less conclusive still. Thus, this study contributes to the field by filling the gap in the literature about the effect of cash transfers on the diet and obesity of the elderly. It uses unique data from a quasi-experiment providing a monthly cash transfer to the elderly in two towns in the south of Mexico with high levels of poverty and large indigenous populations. Furthermore, this study tests the economic model of Posner and Philipson (2003) who postulated an inverted U-shape relationship exists between weight and income.

3.4 Theoretical Framework

I used the economic model developed by Posner and Philipson (2003) to explain how food demand and weight of people are affected by an expansion in their income. This approach theorizes that the relationship between the utility derived from weight and the income is inverted U-shaped, as well as the relation between obesity and income. In other words, that at very low levels of income, an increase will be translated into a higher demand of calories that starts to decrease at the inflexion point after which the disutility derived from higher weight does not compensate for the joy of eating even if the food were free (due to very high incomes or very low food prices). At higher incomes, an expansion in income reduces the demand for food with high caloric content and increases the demand for food with higher nutritious quality. Below is the detailed model.

First, consider the case in which the physical activity S is constant or external. This model assumes that the weight of an individual $W(F, S)$ is a function of intake of calories. Where F is the food or intake of calories and S is the physical activity or calories expenditure. Then,

- W_F is positive because weight rises with the food consumption and
- W_S is negative because weight decreases with the expenditure of calories.

The cross-derivative W_{FS} is assumed to be positive because the intake and expenditure of calories are complementary: “the more calories are expended, the more valued is calorie intake” (Posner and Philipson, 2003; p. S92).

An individual maximizes his utility

$$U(W(F, S), F, S, C)$$

which depends on his weight, food consumption, physical activity, and consumption of other goods and services C . This function has an inverted U-shape with respect to W because this model assumes that there is an ideal weight W_0 , that the individual would choose if achieving it were costless. This ideal weight is subjective and independent of the weight that maximizes health. The model also assumes that there is diminishing marginal utility of consumption of food and other goods:

$$-U_{FF} \text{ and } U_{CC} < 0$$

Another assumption is that the inverted U-shape function over weight is concave:

$$U_{WW} < 0$$

meaning that gaining weight is valued the more underweight and less valued the more overweight a person is.

Assuming that S is fixed, this is the utility problem to maximize:

$$\text{Max } U(W(F), F, C)$$

$$\text{s.t. } C + pF = I$$

where p is the price of food and I is income. After some algebra, this is the solution:

$$U_W W_F = U_F - pU_C$$

This implies that the rational choice of how many calories one consumes balances the weight effect $[U_W W_F]$ and joy of eating $[U_F]$ vis-à-vis the forgone consumption of alternative goods $[pU_C]$.

This result has three implications:

- 1) Weight is not the only concern when maximizing utility; otherwise, no one would chose a weight different from their subjective ideal weight. “Because calorie intake is costly, weight

gains above the subjective ideal weight must be valued positively at the optimal level of food intake. “ (Posner and Philipson, 2003; S93)

- 2) Calorie intake is complementary to calorie expenditure S . If S rises, the marginal benefit of eating (calorie intake) also rises.
- 3) There is a limit to how far reductions in price or gains in income can raise weight. If utility is separable in weight, food, and non-food consumption, the price of calories affect weight negatively and income affects weight positively:

$$\frac{dW}{dp} \leq 0 \text{ and } \frac{dW}{dI} \geq 0$$

That means that weight becomes inelastic at high I or very low p . The marginal utility will decline and turn negative at the caloric intake level F_M , which is the level that would maximize the utility from eating if it were costless. Then,

$$W_M = W(F_M)$$

is the limit on weight above which there is a net loss from consuming more calories even if they are free. The utility loss of gaining weight eclipses the joy of eating. Then, as prices get close to zero or income rises indefinitely, the weight W approaches the upper bound W_M .

“The inverted U-shaped effect of weight on utility implies that income may have an inverted U-shaped as well.” (Posner and Philipson, 2003; s90) If income and weight are complementary, then the effect of consumption on the marginal disutility of weight gains is relatively higher for higher incomes. In other words, the health price of greater food consumption rises with income.

As a next step, the authors added S as an internal variable and derived results and conclusions. I did not include that extension of the model because the intuition behind the results and the implications remain the same. For further details, please, see Posner and Philipson (2003).

The authors additionally explained with their model how an expansion in income due to an income transfer affects weight and utility. Consider the case in which the average weight reaches its peak as a function of income at $W^*(income \text{ at which is } I^*)$ as in

$$W(I) = W^* - m(I - I^*)^2$$

Where $m > 0$ measures the steepness at which weight falls around the peak. This formula implies that at the left of the peak, quantity is preferred over quality and at the right side of the pick quality domains quantity. Now, consider a program that transfers income $T(I)$ to income class I with a balanced-budget constraint paid with taxes; in other words, that in the aggregate the average transfers are zero, $E[T(I)] = 0$. The average weight with and without transfers are W_T and W_N , they satisfy

$$W_N = E[W(I)] = W^* - E[m(I - I^*)^2]$$

$$W_T = E[W(I + T(I))] = W^* - E[m(I + T(I) - I^*)^2]$$

After some algebra,

$$W_N - W_T = m\{2Cov[I, T] + Var[T]\}$$

If transfers were linear in income,

$$T(I) = a + bI$$

The transfer program will be progressive at $b < 0$, neutral at $b = 0$, and regressive at $b > 0$. The weight effect of the transfer would be then

$$W_N - W_T = mVar[I]b(2 + b)$$

This shows that the more progressive a program is, the more it raises weight W_T above the level that would prevail in the absence of transfer payment, W_N .

In the case of cash transfers that are not funded with taxes and are neutral to the income, it is expected that weight increases in the poor population and diminishes in the richer. The first will get closer to the peak weight W^* as their income gets closer to I^* , while the later will be farther from W^* , increasing the quality of the food and moving toward the point at which weight is inelastic to income (see Figure 3.1).

Figure 3.1. Effect of a Cash Transfer Program (Neutral on Income) on Weight

Source: Author's based on Posner and Philipson (2003).

Given this theoretical framework, an increase of income may change the diet of individuals and consequently their weight and related outcomes measured by waist circumference, BMI, overweight, obesity, and hemoglobin levels.

BMI and waist circumference are two measures of obesity that are closely related. The literature suggests that waist circumference is a better predictor of cardiovascular diseases associated with obesity such as hypertension, type-2 diabetes, dyslipidemia, metabolic syndrome, and general cardiovascular outcomes, than BMI of adults of different nationalities (Janssen, Katzmarzyk and Ross, 2004; Ashwell, Gunn and Gibson, 2012; Janssen, Heymsfield and Ross, 2002).

The association between BMI levels and anemia is weak. Ausk and Ioannou (2008) found that in the US, after controlling for confounding variables, people with higher BMI categories did not have a significant change in hemoglobin concentration compared to normal-weight persons. In Mexico, Samper-Ternent et al. (2012) described the results of a national survey and found that 10.3% of people aged 60 and above are anemic, 25.0% are obese, and 2.6% are both anemic and obese. A systematic review including studies from different countries (Cheng et al., 2012) indicated that most analyzed papers reported a positive association between obesity and higher mean hemoglobin concentration, but the results are not conclusive.

3.5 Methodology

3.5.1 Data

Reconocer is a program of the state government of Yucatan, Mexico, that provides a cash payment of MXN \$550 per month (about US\$87 at 2014 purchasing power parity [PPP]) to people aged 70 and older. This transfer represents a 44% increase in average household income. *Reconocer* started in 2007 and was gradually introduced in several localities with populations of 2,500 to 6,500 in the state of Yucatan, and then it was progressively expanded to cities within the state (see Aguila et al., 2014).

A screener was conducted in the cities of Valladolid and Motul between June and July of 2008 which aimed to design and test the program. The response rate in the screener was 80.1% and 68.6% in Valladolid and Motul, respectively. Those localities were chosen by the state government because of their easy access from Merida, the state capital. The levels of poverty in those localities were high and medium. The treatment locality was Valladolid, and the control was Motul. The pension payments started in December 2008. Pensions were distributed monthly in cash and are lifelong.

Development of the baseline survey instrument began in the fall of 2007. It included survey measures that had been validated and tested in other surveys in both English and Spanish. The survey instrument was based on the Mexican Health and Aging Study (MHAS) (*Estudio Nacional sobre Salud y Envejecimiento en México* or ENASEM), which is equivalent to the United States' Health and Retirement Study (HRS). The result is the Survey of Socioeconomic and Household Characteristics in the State of Yucatan (*Encuesta de Características Socioeconómicas del Hogar en el Estado de Yucatán*, or ENCAHEY).

The ENCAHEY collected detailed household- and individual-level data such as household expenditure in food and demographic characteristics of the elderly. Baseline data were collected between August and November 2008, before the pension program was announced or implemented and had a response rate of 91.4% in Valladolid and 95.2% in Motul. The treatment group at the baseline included 1,146 people, all the people in Valladolid aged 70 and older; while the control group was compound by 835 elderly in the locality of Motul. One follow-up survey was administered in both cities in June and July of 2009, approximately six months after Valladolid received the intervention (the first non-contributory pension payment). The response rate in the follow up was 87.9% in Valladolid and 81.9% in Motul. The surveys were developed in English and

later translated into Spanish and Maya, the local indigenous language. The survey was programmed to be administered by computer through Computer-Assisted Personal Interviewing (CAPI), developed by RAND. The use of CAPI dramatically reduces interviewer errors and increases the ability to detect and correct coding errors quickly.

Anthropometric and biomarker measurements were collected both at baseline and in the follow-up interview by trained interviewers. Using direct assessments of health parameters offers a significant advantage in tracking changes in the health in a population. In addition to these biomarkers, hemoglobin levels were measured using a portable hemoglobin analyzer used worldwide.

During the data collection in the follow up, the federal government implemented a similar program at national level called *70 y mas*. This program gives a monthly cash transfer amounting to MXN \$500 (~76.2 USD at 2014 purchasing power parity [PPP]) to each person aged 65 and older regardless of their income level or social security status in localities with less than 30,000 inhabitants. These rules allowed people in Motul, the control city with around 21,436 people, to be included in the program *70 y mas* while Valladolid was excluded (44,906 inhabitants). The first payment of this program started during the last stage of the follow-up data collection in July of 2009. The results was that 331 (out of 835) older persons in the control group received the cash transfer from *70 y mas* by the time that their information was collected. I conducted a t-test to assess whether older people that received *70 y mas* were different from those that did not receive it during the follow-up survey and did not find any significant difference (see Table 3.A.1 in Additional Tables). Although the interruption of *70 y mas* in Motul may not have any impact in the outcomes analyzed, I decided to exclude from the analysis the households who received those benefits in order to conduct a more strict analysis. Therefore, the number of individuals included in the analysis fell from 835 to 504 in Motul while there was no change in Valladolid (1,146 individuals). Additionally, I conducted a sensitivity analysis of the outcomes including and excluding this subgroup of recipients of *70 y mas*, and I did not find any demonstrable differences (see Table 3.A.2 in Additional Tables).

I used twelve variables to assess the effect of the program on the weight-related outcomes: hemoglobin level and prevalence of anemia, weight, BMI level, prevalence of overweight and obesity (total and by grades), weight-to-knee height ratio (known as BMIS), BMIS/BMI ratio, and waist circumference. Table 3.2 describes the outcome variables used in this analysis.

Table 3. 2. Description of Outcome Variables, ENCAHEY 2008

Outcome	Questions	Units
Hemoglobin level	Grams per deciliter g/dl	g/dl
Anemic	Low hemoglobin <13.5g/dl men, <12 women	0 Normal / 1 Low
Weight	Weight in kilograms	Kg
BMI	Height and weight, kg/m2	kg/m2
Overweight	BMI > 25.0 kg/m2	0 Non-overweight / 1 overweight
Obese	BMI > 30.0 kg/m2	0 Non-obese / 1 obese
Obese class I	BMI 30.0-34.9 kg/m2	0 Non-obese I/ 1 obese I
Obese class II	BMI 35.0-39.9 kg/m2	0 Non-obese II/ 1 obese II
Obese class III	BMI >40.0 kg/m2	0 Non-obese III/ 1 obese III
BMIS	Knee height and weight, [kg/kh cm2]*1000	[kg/kh cm2]*1000
Ratio BMIS/BMI	BMIS/BMI	BMIS/BMI
Waist circumference	Waist circumference	Centimeters

3.5.2 Empirical Methods

This study included three types of models:

- 1) Difference in Differences (Diff-in-Diff). Due to the program design is experimental, I tested for the difference in the means of each outcome between the follow-up and the baseline of the treatment group and that of the control group, and then between those differences in means:

$$DID = \{E[Y_{2t}|T_i = 1] - E[Y_{1t}|T_i = 1]\} - \{E[Y_{2t}|T_i = 0] - E[Y_{1t}|T_i = 0]\}$$

- 2) Ordinary least squares (OLS). Although the experiment ensured at the baseline that the control and the treatment groups were equivalent in most socio-demographic variables, I included multivariate OLS regressions adjusted by covariates that increase the accuracy and robustness of the estimated effect by controlling for possible heterogeneity between the control and the treatment groups. These covariates refer to individual characteristics and include age, sex, years of education, speaks Mayan, reads and writes in Spanish, lives alone, exercises, household size, the number of chronic diseases, being diabetic, and dummy

variables for marital status (coupled, divorced or separated, or widowed) (see Table 2.3). In addition, these OLS regressions will be controlled for wave and the treatment site, so they are equivalent to Diff-in-Diff models adjusted by covariates.

$$Y_{it} = \beta_0 + \beta_1 T_i + \beta_2 Post_t + \beta_3 (T_i * Post_t) + \beta_x Controls_{it} + \varepsilon_{it}$$

- 3) Logistic models were used to estimate the probability of being anemic, overweight or obese. The latter was categorized by each of its three levels: obese class I 30.0-34.9 kg/m²; obese class II 35.0-39.9 kg/m²; and obese class III >40.0 kg/m². This model includes the same control variables as the OLS regressions, and it serves as a second robustness check.

$$\begin{aligned} \text{logit}(P(Y_{it} = 1 | T_i, Post_t, T_i * Post_t, Controls_{it})) \\ = \beta_0 + \beta_1 T_i + \beta_2 Post_t + \beta_3 (T_i * Post_t) + \beta_x Controls_{it} \end{aligned}$$

I also performed a sensitivity analysis running the same models constraining the data by gender, type of household (live alone or not), language (Maya or Spanish), poverty (minimum poverty line and poverty line), quintile of income, overweight, obesity, and anemic status at baseline.

Table 3. 3. Description of Covariates, ENCAHEY (2008)

Variable	Description	Units
Age	Age	Years
Male	Male	0 no / 1 yes
Years of education	Years of education	Years
Speaks Mayan	Speaks Mayan	0 no / 1 yes
Reads and Writes in Spanish	Reads and writes in Spanish	0 no / 1 yes
Lives alone	Lives alone	0 no / 1 yes
Exercises	Whether exercised or did hard physical work during last month	0 no / 1 yes
Household size	Number of members	Number (1-15)
Number of chronic diseases	Number of self-reported chronic diseases (hypertension, diabetes, cancer, respiratory illness, heart attack, stroke, arthritis, liver or kidney infection, tuberculosis, pneumonia)	Number (0-10)
Diabetes	Self-reported being diabetic	0 no / 1 yes
Single	Single	0 no / 1 yes
Coupled	Coupled	0 no / 1 yes
Divorced or separated	Divorced or separated	0 no / 1 yes
Widowed	Widowed	0 no / 1 yes

3.6 Results

3.6.1 Descriptive Characteristics

Using data from the baseline assessment, I conducted a T-test on the treatment and the control cities to ensure that the premises of a randomized control trial (RCT) held. Table 3.4 indicates that the proportion of anemic, overweight, and obese people, ratio BMIS/BMI, age, gender, marital status, years of education, living alone, average household size, proportion of people that exercises, income, and people being below the poverty line are comparable in both localities. However, the treatment group has a significantly larger proportion of older people that speaks Maya, does not read a message in Spanish, has lower average hemoglobin level, BMI, BMIS, waist circumference, and number of chronic diseases, but higher proportion of people below the line of extreme poverty.

Due to one city having a larger proportion of indigenous population than the other, some of the observed differences in few variables are not surprising. As mentioned in the background section, indigenous persons are generally more vulnerable than non-indigenous; they have higher poverty rates and lower literacy rates. However, the robustness checks (shown in the next paragraphs) accounted for the main socio-demographic characteristics and showed that baseline differences did not bias the results.

Table 3. 4. T-test of Baseline Characteristics (People ≥70 years), ENCAHEY 2008

Characteristic	Control (Motul)		Treatment (Valladolid)		P-value
Outcome Variables					
Hemoglobin (g/dl, SD)	12.139	(1.729)	11.960	(1.883)	0.086
Anemic (% , SD)	54.036	(49.893)	56.169	(49.645)	0.458
Weight (mean kg, SD)	59.746	(11.899)	58.712	(12.4670)	0.143
BMI (mean kg/m², SD)	27.174	(4.528)	26.703	(4.788)	0.092
Overweight (% , SD)	50.595	(50.046)	50.611	(50.018)	0.995
Obese (% , SD)	23.896	(42.7)	21.444	(41.065)	0.338
Obese Class I (% , SD)	18.961	(39.25)	16.918	(37.511)	0.385
Obese Class II (% , SD)	3.377	(18.086)	3.125	(17.409)	0.817
Obese Class III (% , SD)	1.558	(12.402)	1.401	(11.759)	0.832
BMIS [(kg/kh cm²)*1000] (Mean, SD)	32.540	(6.624)	31.593	(7.504)	0.019
Ratio BMIS/BMI (mean, SD)	1.204	(0.168)	1.187	(0.186)	0.109
Waist circumference (Mean cm, SD)	97.563	(11.237)	96.237	(11.779)	0.048
Covariates					
Age (Mean, SD)	77.984	(6.562)	77.610	(6.21)	0.279
Male (% , SD)	48.214	(50.018)	45.812	(49.846)	0.368
Marital Status					
Single (% , SD)	6.548	(24.761)	5.323	(22.459)	0.342
Couple (% , SD)	49.402	(50.046)	53.578	(49.894)	0.119
Separated/divorced (% , SD)	1.984	(13.959)	3.316	(17.913)	0.103
Widowed (% , SD)	41.865	(49.383)	37.784	(48.506)	0.120
Years of education (Mean, SD)	1.785	(1.672)	1.785	(1.944)	0.998
Speaks Maya (% , SD)	26.587	(44.224)	47.208	(49.944)	0.000
Reads a message in Spanish (% , SD)	62.302	(48.511)	54.712	(49.799)	0.004
Lives alone (% , SD)	13.889	(34.617)	13.089	(33.743)	0.663
Household size (mean, SD)	3.480	(2.121)	3.442	(2.16)	0.735
Number of Chronic Diseases (mean, SD)	0.857	(0.958)	0.751	(0.887)	0.035
Exercises	31.746	(46.595)	32.548	(46.876)	0.748
Other					
Below poverty line (% , SD)	90.079	(29.924)	89.791	(30.29)	0.857
Below extreme poverty line (% , SD)	64.881	(47.782)	76.353	(42.51)	0.000
Income (mean, SD)	1188.771	(1427.461)	1358.04	(4605.875)	0.260
Observations	504		1,146		

Abbreviations: BMI, body mass index; SD, standard deviation.

Obesity thresholds: Normal BMI=18.5-24.9 kg/m²; Overweight 25.0-29.9 kg/m²; Obesity class I 30.0-34.9 kg/m²; Obesity class II 35.0-39.9 kg/m²; Obesity class III >40.0 kg/m².

3.6.2 Difference in Differences Estimates

Table 3.5 presents the results of the difference-in-differences models for the overall sample. After controlling for multiple comparisons, the program had no effect on weight, BMI, overweight, obesity and its classes (obesity class I, II and III), BMIS, ratio BMIS/BMI, or in waist circumference. *Reconocer* had a significant positive effect in reducing the prevalence of anemia and increasing the average level of hemoglobin in the treatment group relative to the control group.

Table 3. 5. Difference-in-Differences^a

Outcome	Treatment Baseline	Treatment Follow-up	Difference Treatment	Control Baseline	Control Follow-up	Difference Control	Diff-in-Diff of Means	SE ^b
Hemoglobin	12.000	12.108	0.108	12.170	12.020	-0.149	0.257	(0.106)**
Anemia (hb<13.5g/dl men, <12g/dl women)	0.558	0.489	-0.069	0.535	0.535	0.000	-0.069	(0.035)*
Weight (kg)	58.822	58.205	-0.617	59.897	58.949	-0.949	0.331	(0.207)
BMI (kg/m ²)	26.705	26.630	-0.076	27.447	27.261	-0.187	0.111	(0.120)
Overweight (BMI ≥ 25.0)	0.506	0.442	-0.065	0.506	0.478	-0.028	-0.037	(0.025)
Obese (BMI ≥ 30.0)	0.205	0.205	0.000	0.250	0.230	-0.020	0.020	(0.018)
Obese class I (30.0 ≥ BMI < 35.0)	0.164	0.165	0.001	0.197	0.171	-0.026	0.028	(0.021)
Obese class II (35.0 ≥ BMI < 40.0)	0.032	0.031	-0.001	0.039	0.049	0.010	-0.011	(0.009)
Obese class III (BMI ≥ 40.0)	0.010	0.010	0.000	0.013	0.010	-0.003	0.003	(0.005)
BMIS [(kg/kh cm ²)*1000]	31.563	31.673	0.110	32.651	32.285	-0.365	0.475	(0.359)
Ratio BMIS/BMI	1.187	1.195	0.008	1.200	1.191	-0.009	0.017	(0.013)
Waist circumference (cm)	96.168	96.013	-0.155	97.337	96.607	-0.730	0.576	(0.409)

Control (N=504), Treatment (N=1,146)

Abbreviations: BMI, body mass index; SE, Standard Error.

^aDiff-in-Diff is significantly different from zero after applying Holms Bonferroni's adjustment for multiple comparisons: ** at 0.05 level and * at 0.10 level.

^bStandard errors are clustered at household level.

The analysis by quintile and poverty level is presented in Table 3.6. There were no significant effects of the program on any outcome of interest in people in the first and third quintile. Among the elderly in the fifth quintile of income there was a slight rise in the BMI of beneficiaries relative to the control group.

In the analysis by poverty level there was only one significant effect among the population below the poverty line, a reduction in the prevalence of obesity. Among the non-poor, the program moderately increased weight, BMI, prevalence of obesity, and obesity class 1 in comparison to the control group.

It would seem that results by both quintile of income and poverty level may not provide evidence to support or reject the theory of the inverted U-shaped model.

Table 3. 6. Difference-in-Differences^{ab} by Quintile of Income and Poverty Level^c

Outcome	All	Q1	Q3	Q5	Poor	Non-poor
Hemoglobin	0.257 (0.106)**	0.166 (0.206)	0.353 (0.236)	0.127 (0.215)	0.283 (0.114)**	-0.014 (0.268)
Anemia (hb<13.5g/dl men, <12g/dl women)	-0.069 (0.035)*	-0.063 (0.069)	-0.015 (0.076)	-0.053 (0.077)	-0.072 (0.037)*	-0.036 (0.103)
Weight (kg)	0.331 (0.207)	0.5320 (0.483)	-0.2238 (0.383)	0.7943 (0.444)	0.243 (0.217)	1.2481 (0.670)*
BMI (kg/m ²)	0.111 (0.120)	0.018 (0.306)	0.005 (0.259)	0.543 (0.222)*	0.054 (0.128)	0.632 (0.329)*
Overweight (BMI ≥ 25.0)	-0.037 (0.025)	-0.107 (0.049)	0.016 (0.061)	0.009 (0.056)	-0.038 (0.026)	-0.028 (0.086)
Obese (BMI ≥ 30.0)	0.02 (0.018)	0.078 (0.049)	-0.05 (0.036)	0.054 (0.041)	0.014 (0.019)	0.069 (0.035)*
Obese class I (30.0 ≥ BMI < 35.0)	0.028 (0.021)	0.058 (0.052)	-0.038 (0.037)	0.054 (0.041)	0.023 (0.021)	0.069 (0.035)*
Obese class II (35.0 ≥ BMI < 40.0)	-0.011 (0.009)	0.025 (0.017)	-0.019 (0.017)	-0.014 (0.021)	-0.012 (0.01)	0 (0.020)
Obese class III (BMI ≥ 40.0)	0.003 (0.005)	-0.005 (0.008)	0.006 (0.006)	0.014 (0.014)	0.004 (0.005)	0 (0.000)
BMIS [(kg/kh cm ²)*1000]	0.475 (0.359)	0.408 (0.664)	0.721 (0.693)	0.479 (1.027)	0.455 (0.334)	0.831 (1.897)
Ratio BMIS/BMI	0.017 (0.013)	0.034 (0.025)	0.048 (0.027)	-0.042 (0.036)	0.026 (0.013)	-0.067 (0.056)
Waist circumference (cm)	0.576 (0.409)	1.52 (0.895)	1.381 (0.987)	0.632 (0.906)	0.595 (0.425)	0.348 (1.332)

Control (N=504), Treatment (N=1,146)

Abbreviations: BMI, body mass index; Q1, quintile 1; Q3, quintile 3; Q5, quintile 5.

^aDifference-in-Differences is significantly different from zero after applying Holms Bonferroni's adjustment for multiple comparisons: ** at 0.05 level and * at 0.10 level.

^bStandard errors in parenthesis. They are clustered at household level.

^cPoor is defined below the poverty line equivalent to MXN\$1,941.98 monthly and non-poor is defined as above the poverty line threshold.

3.6.3 Robustness check

In order to corroborate the findings from the difference-in-differences models, I conducted difference-in-differences adjusted by covariates and logit models also adjusted by covariates. Results from those models are presented in the tables below (Tables 3.7 and 3.8). All three models corroborated the significant decrease in anemia in the treatment group in the analysis of the entire population. The difference-in-differences adjusted supported the significant rise in the mean levels of hemoglobin found by the simple difference-in-differences analysis. More important, all models showed that there are no significant effects in any weight-related outcomes.

Table 3. 7. Comparison of Models^{ab}

Outcome	Diff-in-Diff	Diff-in-Diff with Covariates	Logits with Covariates (AME)
Hemoglobin	0.257 (0.106)**	0.254 (0.108)**	
Anemia (hb<13.5g/dl men, <12g/dl women)	-0.069 (0.035)*	-0.069 (0.035)**	-0.069 (0.035)**
Weight (kg)	0.331 (0.207)	0.462 (0.240)	
BMI (kg/m ²)	0.111 (0.120)	0.151 (0.131)	
Overweight (BMI ≥ 25.0)	-0.037 (0.025)	-0.033 (0.025)	-0.033 (0.025)
Obese (BMI ≥ 30.0)	0.02 (0.018)	0.024 (0.019)	0.022 (0.018)
Obese class I (30.0 ≥ BMI < 35.0)	0.028 (0.021)	0.031 (0.021)	0.030 (0.02)
Obese class II (35.0 ≥ BMI < 40.0)	-0.011 (0.009)	-0.011 (0.009)	-0.008 (0.009)
Obese class III (BMI ≥ 40.0)	0.003 (0.005)	0.004 (0.005)	0.005 (0.005)
BMIS [(kg/kh cm ²)*1000]	0.475 (0.359)	0.544 (0.367)	
Ratio BMIS/BMI	0.017 (0.013)	0.017 (0.013)	
Waist circumference (cm)	0.576 (0.409)	0.693 (0.428)	

Control (N=504), Treatment (N=1,146)

Abbreviations: Diff-in-Diff, Difference-in-differences; BMI, body mass index; AME, Average Marginal Effects.

^aDifference-in-Differences is significantly different from zero after applying Holms Bonferroni's adjustment for multiple comparisons: ** at 0.05 level and * at 0.10 level.

^bStandard errors in parenthesis. They are clustered at household level.

By quintile of income, the difference-in-differences adjusted by covariates did not confirm the increase in BMI in the elderly in the fifth quintile of income. However, both the simple and the adjusted difference-in-differences showed no discernable effect on any other outcome by quintile.

In the robustness check of the logit models, the only significant effects found were among people in the first quintile. *Reconocer* decreased their probability of being overweight but increased their probability of being obese.

Table 3. 8. Analysis by Model^{ab} and Quintile of Income

	Diff-in-Diff			Diff-in-Diff with Covariates			Logits with Covariates (AME)		
Outcome	Q1	Q3	Q5	Q1	Q3	Q5	Q1	Q3	Q5
Hemoglobin	0.166 (0.206)	0.353 (0.236)	0.127 (0.215)	0.184 (0.212)	0.277 (0.256)	0.113 (0.224)			
Anemia (hb<13.5g/dl men, <12g/dl women)	-0.063 (0.069)	-0.015 (0.076)	-0.053 (0.077)	-0.069 (0.070)	0.001 (0.079)	-0.05 (0.078)	-0.070 (0.069)	0.004 (0.08)	-0.050 (0.076)
Weight (kg)	0.5320 (0.483)	-0.2238 (0.383)	0.7943 (0.444)	1.2144 (0.598)	-0.3977 (0.543)	0.7986 (0.601)			
BMI (kg/m ²)	0.018 (0.306)	0.005 (0.259)	0.543 (0.222)*	0.240 (0.348)	-0.019 (0.290)	0.429 (0.256)			
Overweight (BMI ≥ 25.0)	-0.107 (0.049)	0.016 (0.061)	0.009 (0.056)	-0.109 (0.050)	0.016 (0.062)	0.023 (0.057)	-0.108 (0.049)*	0.016 (0.061)	0.024 (0.057)
Obese (BMI ≥ 30.0)	0.078 (0.049)	-0.05 (0.036)	0.054 (0.041)	0.099 (0.053)	-0.050 (0.039)	0.043 (0.043)	0.097 (0.049)*	-0.052 (0.036)	0.041 (0.044)
Obese class I (30.0 ≥ BMI < 35.0)	0.058 (0.052)	-0.038 (0.037)	0.054 (0.041)	0.071 (0.055)	-0.035 (0.040)	0.042 (0.044)	0.081 (0.064)	-0.036 (0.035)	0.040 (0.046)
Obese class II (35.0 ≥ BMI < 40.0)	0.025 (0.017)	-0.019 (0.017)	-0.014 (0.021)	0.030 (0.020)	-0.021 (0.017)	-0.012 (0.021)	0.042 (0.024)	-0.026 (0.021)	
Obese class III (BMI ≥ 40.0)	-0.005 (0.008)	0.006 (0.006)	0.014 (0.014)	-0.002 (0.008)	0.006 (0.006)	0.012 (0.013)	0.000 (0.015)	0.233 (0.148)	0.233 (0.148)
BMIS [(kg/kh cm ³)*1000]	0.408 (0.664)	0.721 (0.693)	0.479 (1.027)	0.698 (0.703)	0.668 (0.713)	0.594 (1.062)			
Ratio BMIS/BMI	0.034 (0.025)	0.048 (0.027)	-0.042 (0.036)	0.035 (0.026)	0.050 (0.028)	-0.029 (0.035)			
Waist circumference (cm)	1.52 (0.895)	1.381 (0.987)	0.632 (0.906)	1.954 (0.941)	1.205 (1.095)	0.238 (0.948)			

Control (N=504), Treatment (N=1,146)

Abbreviations: Diff-in-Diff, Difference-in-differences; BMI, body mass index; AME, Average Marginal Effects; Q1, quintile 1; Q3, quintile 3; Q5, quintile 5.

^aDifference-in-Differences is significantly different from zero after applying Holms Bonferroni's adjustment for multiple comparisons: ** at 0.05 level and * at 0.10 level.

^bStandard errors in parenthesis. They are clustered at household level.

Note: There is not enough sample of obese people class II for the estimations.

3.6.4 Sensitivity Analysis

Among older people that were anemic at the baseline, their prevalence of obesity class I significantly increased in the treatment compared to the control locality. The program also decreased the obesity class I in men, but increased obesity class II for the same subgroup. These effects going in contrary directions may suggest that the effect on obesity of this program is not strong; furthermore, they were not found among women or other subgroups.

The program also reduced anemia among men, people obese or overweight, and people below the poverty line and decreased the BMI of people obese at the baseline.

Waist circumference increased approximately by one centimeter in older men, Spanish speakers, and overweight people. This result may be confounded with the metabolism proper of the elderly because it is different from that of the younger people and, as discussed above, the waist circumference naturally tends to increase until the age of 75.

3.6.5 Effect of the Program on Related Outcomes

In order to understand better the mechanism through which the program may affect the weight of the beneficiaries, I conducted the same analysis on three related outcomes: demand for and expenditure on food, frequency of food consumption, and food insecurity (see Table 3.9 for detailed description).

Table 3. 9. Description of Secondary Outcome Variables, ENCAHEY (2008)

Outcome	Question	Unit
Frequency of Food Intake	How often do you eat eggs beans lentil etc..?	1 Never, 2 Sometimes, 3 Usually, 4 Always
	How often do you eat meat poultry or fish?	2 Never, 2 Sometimes, 3 Usually, 4 Always
	How often do you eat fruit or vegetables?	3 Never, 2 Sometimes, 3 Usually, 4 Always
	How often do you eat tortillas bread crackers or other cereals?	4 Never, 2 Sometimes, 3 Usually, 4 Always
Perception of loss weight	In the past three months have you lost weight without trying or dieting?	0 no/ 1 yes
	How much do you think you lost?	Kilograms

Outcome	Question	Unit
Demand for French bread	How much (quantity) did you buy last week of French bread?	Pieces
Demand for tortilla	How much (quantity) did you buy last week of tortilla?	Kilograms
Demand for potato	How much (quantity) did you buy last week of potato?	Kilograms
Demand for onion	How much (quantity) did you buy last week of onion?	Kilograms
Demand for sodas	How much (quantity) did you buy last week of soda?	Liters
Demand for noodles soup	How much (quantity) did you buy last week of noodles soup?	Bags
Demand for eggs	How much (quantity) did you buy last week of eggs?	Pieces
Demand for tomato	How much (quantity) did you buy last week of tomato?	Kilograms
Demand for beans	How much (quantity) did you buy last week of beans?	Kilograms
Demand for rice	How much (quantity) did you buy last week of rice?	Kilograms
Demand for milk	How much (quantity) did you buy last week of milk?	Liters
Demand for sweet bread	How much (quantity) did you buy last week of sweet bread?	Pieces
Expenditure on French bread	How much money did you spend last week on French bread?	Mexican pesos
Expenditure on tortilla	How much money did you spend last week on tortilla?	Mexican pesos
Expenditure on potato	How much money did you spend last week on potato?	Mexican pesos
Expenditure on onion	How much money did you spend last week on <u>soda</u> ?	Mexican pesos
Expenditure on sodas	How much money did you spend last week on sodas?	Mexican pesos
Expenditure on noodles soup	How much money did you spend last week on noodles soup?	Mexican pesos
Expenditure on eggs	How much money did you spend last week on eggs?	Mexican pesos
Expenditure on tomato	How much money did you spend last week on tomato?	Mexican pesos
Expenditure on beans	How much money did you spend last week on beans?	Mexican pesos
Expenditure on rice	How much money did you spend last week on rice?	Mexican pesos
Expenditure on milk	How much money did you spend last week on milk?	Mexican pesos

Outcome	Question	Unit
Expenditure on sweet bread	How much money did you spend last week on sweet bread?	Mexican pesos
Use <i>Reconocer</i> for food	Since you started receiving a pension from RECONOCER have you spent your pension on food?	0 no/ 1 yes
Expenditure on beverages	How much did the household spend last week on beverages that you drank at home?	Mexican pesos
Expenditure on food (pesos)	How much did the household spend last week on food eaten at home	Mexican pesos
Expenditure on food & beverages	How much did the household spend last week on food and beverages consumed out of the home?	Mexican pesos
Food insecurity	How often in the last 3 months have you been worried that food would run out before you got money to buy more?	1 Never, 2 Sometimes, 3 Usually, 4 Always
	How often in the past 3 months, did you or another person in your household ever cut the size of your meals or skip a meal because there wasn't enough money to buy food?	1 Never, 2 Sometimes, 3 Usually, 4 Always
	How often in the past 3 months, did you or another person in your household ever cut the size of your meals or skip a meal because there wasn't enough money to buy food?	1 Never, 2 Sometimes, 3 Usually, 4 Always
	How often in the past 3 months, did you or another adult in your household you eat less than you felt you should because there wasn't enough money to buy more food?	1 Never, 2 Sometimes, 3 Usually, 4 Always
	How often in the past 3 months, were you or other adults in your household hungry but didn't eat because you couldn't afford enough food?	1 Never, 2 Sometimes, 3 Usually, 4 Always
	In the past 3 months, did or someone in your household lose weight because you didn't have enough money to buy food?	1 Never, 2 Sometimes, 3 Usually, 4 Always
	How often in the past 3 months, did you or another person in your household not eat all day because there wasn't enough money to buy food?	1 Never, 2 Sometimes, 3 Usually, 4 Always
	How often in the past 3 months, did you or another person in your household not eat all day because there wasn't enough money to buy food?	1 Never, 2 Sometimes, 3 Usually, 4 Always

Table 3.10 presents results of the difference-in-differences models for each of these complementary outcomes.

Food demand (household level)

Out of the twelve food items recorded in the survey, there was only one food item for which demand significantly changed among the beneficiaries of *Reconocer* in comparison to the control group: tortillas (see Table 3.10). Results of the difference-in-differences estimates indicated that demand for tortillas decreased in the treatment locality relative to the control one for the overall sample (371 grams), for the elderly in the fifth quintile (810 grams), and for both poor (300 grams) and non-poor persons (1,080 grams). This change is also observed in the corresponding per capita food expenses. Beneficiaries of *Reconocer* in the first and third quintiles of income did not diminish their consumption of tortillas, nor did they experience any other effects on their food demand. These estimations suggested that tortillas are an economic inferior good because their consumption decreases when income expands. Furthermore, linking this finding to the decrease of anemia, tortillas may also be an inferior nutritious good because it could have been substituted for food with higher nutritious content as a result of the expansion in income.

When conducting the sensitivity analysis by subgroups of population (see Additional Tables 3.A.3 and 3.A.4), findings from the overall sample held, but in addition I obtained other effects that help to better understand the dynamics of the effects within subgroups. Per capita demand of tortillas decreased in the treatment group among women, men, Spanish speakers, and the overweight elderly. Additionally, male, Spanish speakers, and overweight older persons in the treatment locality slightly decreased their demand for milk. Overweight people in the treatment also decreased their demand for potatoes.

Demand for French bread, sweet bread, onions, sodas, noodle soups, eggs, tomatoes, beans, and rice did not report any significant change.

Table 3. 10. Analysis^{ab} by Quintile of Income and Poverty Level^b

Outcome	All		Q1		Q3		Q5		Poor		Non Poor	
	Diff-in-diff	SE	Diff-in-diff	SE	Diff-in-diff	SE	Diff-in-diff	SE	Diff-in-diff	SE	Diff-in-diff	SE
Per Capita Food Demand												
French bread (pieces)	0.281	(0.487)	0.358	(1.081)	0.662	(1.177)	-0.094	(1.057)	0.5009	(0.516)	-2.0834	(1.326)
Tortilla (kg)	-0.371	(0.104)***	-0.294	(0.172)	-0.3	(0.297)	-0.81	(0.225)***	-0.2971	(0.111)*	-1.0784	(0.292)***
Potato (kg)	-0.111	(0.044)	-0.13	(0.077)	-0.123	(0.133)	-0.033	(0.038)	-0.1158	(0.048)	-0.0482	(0.061)
Onion (kg)	-0.003	(0.016)	0.019	(0.031)	-0.028	(0.038)	0.006	(0.035)	-0.0042	(0.016)	0.0086	(0.059)
Soda (liter)	-0.191	(0.244)	0.504	(0.408)	-0.937	(0.906)	-0.298	(0.698)	-0.166	(0.269)	-0.3808	(0.523)
Noodles soup (packages)	0.095	(0.081)	0.171	(0.213)	0.281	(0.188)	0.034	(0.153)	0.142	(0.088)	-0.2953	(0.172)
Eggs (n)	0.078	(0.514)	1.186	(0.987)	-0.599	(0.871)	2.313	(1.580)	-0.2061	(0.510)	2.5249	(2.270)
Tomato (kg)	0.040	(0.032)	0.12	(0.065)	0.072	(0.079)	0.013	(0.060)	0.0498	(0.034)	-0.0493	(0.079)
Beans (kg)	-0.002	(0.031)	0.053	(0.050)	-0.002	(0.074)	-0.045	(0.059)	0.0079	(0.034)	-0.1019	(0.068)
Rice (kg)	-0.004	(0.027)	0.104	(0.062)	-0.048	(0.071)	-0.015	(0.057)	-0.0007	(0.028)	-0.0293	(0.072)
Milk (liter)	-0.271	(0.110)	-0.171	(0.205)	-0.107	(0.187)	-0.368	(0.291)	-0.2065	(0.107)	-0.8525	(0.538)
Sweet bread (pieces)	-0.014	(0.625)	0.831	(1.411)	-0.52	(1.550)	0.213	(1.105)	0.2359	(0.657)	-3.6513	(1.928)
Per Capita Food Expenditure												
French bread (total pesos)	-1.199	(0.867)	-1.191	(1.532)	-0.094	(1.958)	-1.103	(1.975)	-0.8688	(0.917)	-4.7575	(2.506)
Tortilla (total pesos)	-4.015	(1.026)***	-3.815	(1.698)	-2.993	(2.896)	-8.289	(2.267)***	-3.173	(1.080)**	-12.2584	(3.223)***
Potato (total pesos)	-1.047	(0.398)	-1.023	(0.794)	-1.349	(1.076)	-0.573	(0.547)	-1.1747	(0.436)*	-0.0292	(0.773)
Onion (total pesos)	-0.125	(0.260)	-0.329	(0.631)	0.63	(0.589)	0.083	(0.518)	-0.0981	(0.277)	-0.4977	(0.721)
Soda (total pesos)	-2.014	(1.556)	-2.214	(3.219)	-2.349	(3.067)	-0.296	(3.837)	-2.5214	(1.686)	2.5145	(3.432)
Noodles soup (total pesos)	0.077	(0.343)	0.225	(0.991)	1.03	(0.720)	-0.197	(0.559)	0.139	(0.370)	-0.4585	(0.769)
Eggs (total pesos)	-0.410	(0.625)	1.078	(0.905)	-1.596	(1.234)	2.371	(1.818)	-0.4915	(0.636)	0.3074	(2.511)
Tomato (total pesos)	0.348	(0.317)	0.823	(0.743)	1.102	(0.731)	0.047	(0.642)	0.4366	(0.338)	-0.4545	(0.873)
Beans (total pesos)	-0.811	(0.508)	0.257	(0.901)	-1.501	(1.044)	-0.449	(1.055)	-0.6818	(0.549)	-1.9454	(1.228)
Rice (total pesos)	0.058	(0.390)	1.766	(0.960)	-0.242	(1.021)	0.107	(0.825)	0.0918	(0.414)	-0.3188	(1.073)
Milk (total pesos)	-3.243	(1.825)	-2.57	(4.216)	0.505	(2.632)	-2.928	(3.522)	-2.7254	(1.923)	-7.6015	(6.094)
Sweet bread (total pesos)	-0.195	(1.065)	1.281	(2.146)	-1.262	(2.999)	0.478	(2.219)	0.2564	(1.118)	-6.2804	(3.382)

Control (N=504), Treatment (N=1,146)

Abbreviations: Diff-in-Diff, Difference-in-differences; BMI, body mass index; AME, Average Marginal Effects; Q1, quintile 1; Q3, quintile 3; Q5, quintile 5.

^aDifference-in-Differences is significantly different from zero after applying Holms Bonferroni's adjustment for multiple comparisons: ** at 0.05 level and * at 0.10 level.

^bStandard errors in parenthesis. They are clustered at household level.

^cPoor is defined below the poverty line equivalent to MXN\$1,941.98 monthly and non-poor is defined as above the poverty line threshold.

(Table continues)

(Table 3.10 continued)

Outcome	All		Q1		Q3		Q5		Poor		Non Poor	
	Diff-in-diff	SE	Diff-in-diff	SE	Diff-in-diff	SE	Diff-in-diff	SE	Diff-in-diff	SE	Diff-in-diff	SE
Frequency of Food Intake												
Often eat eggs beans lentil etc., daily-never (1-5)	0.009	(0.073)	0.052	(0.149)	-0.12	(0.137)	0.147	(0.169)	-0.0233	(0.076)	0.1361	(0.139)
Often eat meat poultry or fish, daily-never (1-5)	-0.112	(0.075)	-0.117	(0.149)	-0.019	(0.161)	-0.125	(0.172)	-0.1248	(0.079)	-0.0934	(0.138)
Often eat fruit or vegetables, daily-never (1-5)	-0.036	(0.082)	-0.161	(0.156)	0.07	(0.199)	0.193	(0.153)	-0.0506	(0.088)	0.1366	(0.138)
Often eat tortillas, bread crackers or other cereals, daily-never (1-5)	0.002	(0.034)	0.06	(0.067)	0.109	(0.088)	-0.091	(0.064)	0.0211	(0.035)	-0.0691	(0.046)
Lost weight without trying in last 3 months, yes-no (1-0)	0.006	(0.034)	0.03	(0.068)	0.009	(0.077)	0.031	(0.070)	-0.0111	(0.037)	0.0294	(0.059)
Kilograms lost, perceived	0.024	(0.135)	-0.34	(0.264)	0.014	(0.232)	0.025	(0.355)	0.0064	(0.135)	0.2046	(0.284)
Use of Reconocer												
Use Reconocer for food, yes-no (1-0)	0.621	(0.016)***	0.587	(0.028)***	0.704	(0.032)***	0.553	(0.043)***	0.6288	(0.017)***	0.5556	(0.054)***
Weekly expenditure on beverages (pesos)	-6.476	(3.597)	-6.604	(5.357)	-12.109	(7.077)	-1.963	(7.990)	-7.0282	(3.879)	-3.2308	(7.711)
Weekly expenditure on food (pesos)	0.792	(9.613)	19.876	(15.105)	-1.34	(16.863)	4.531	(20.427)	-2.3161	(10.390)	-16.5733	(27.266)
Weekly expenditure on food & beverages (pesos)	33.976	(67.409)	<0.001	(0.000)	<0.001	(0.000)	127.999	(105.367)	2.3184	(80.313)	134.8583	(85.419)
Food security												
Often worried that will run out of food last 3 months, never-always (1-4)	0.094	(0.072)	0.033	(0.140)	0.066	(0.164)	0.157	(0.149)	0.0794	(0.076)	0.1214	(0.125)
Often run out of food last 3 months, never-always (1-4)	-0.151	(0.059)*	-0.127	(0.102)	-0.299	(0.144)	-0.016	(0.126)	-0.1605	(0.064)*	-0.0149	(0.102)
Often skip a meal last 3 months, never-always (1-4)	-0.05	(0.058)	-0.035	(0.112)	0.042	(0.129)	0.128	(0.120)	-0.0592	(0.063)	0.071	(0.099)
Often eat less last 3 months, never-always (1-4)	-0.077	(0.051)	-0.169	(0.094)	0.011	(0.114)	0.025	(0.102)	-0.0894	(0.055)	0.0379	(0.085)
Often hungry last 3 months, never-always (1-4)	-0.121	(0.042)**	-0.15	(0.086)	-0.234	(0.094)*	0.05	(0.083)	-0.1526	(0.044)***	0.0458	(0.068)
Lost weight for lack of food last 3 months, never-always (1-4)	0.024	(0.031)	0.077	(0.064)	-0.023	(0.078)	0.043	(0.067)	0.0244	(0.032)	0.0043	(0.053)
Often not eat all day last 3 months, never-always (1-4)	-0.151	(0.032)***	-0.179	(0.080)	-0.18	(0.059)**	-0.05	(0.066)	-0.1624	(0.034)***	-0.0553	(0.050)

Control (N=504), Treatment (N=1,146)

^aDifference-in-Differences is significantly different from zero after applying Holms Bonferroni's adjustment for multiple comparisons: ** at 0.05 level and * at 0.10 level.^bStandard errors in parenthesis. They are clustered at household level.^cPoor is defined below the poverty line equivalent to MXN\$1,941.98 monthly and non-poor is defined as above the poverty line threshold.

Frequency of food consumption (individual level)

Reconocer did not affect the frequency of food consumption in the overall population neither by quintile of income or poverty level. When conducting the sensitivity analysis, women were the only group that marginally ($p < 0.10$) increased their frequency of consumption of meat, fish, or poultry.

Food insecurity

The program significantly reduced food insecurity among its recipients. Specifically, it reduced the proportion of people reporting that in the last three months ran out of food, that were hungry and lacked of money to buy food, and that reside in households where someone did not eat all day due to the lack of money. These results among the overall population were also observed in people in the third quintile and below the poverty line, but were not seen among people in the fifth quintile of income, above the poverty line, and surprisingly in the first quintile as well. In the analysis by subgroups, similar results were found among male and Spanish speakers.

Over half of the recipients of the program across all subgroups reported using the extra income to buy food. There was no significant effect on the expenditure of food consumed at home, in beverages, and in both food and beverages of any subgroup; except among men, who reported a slight reduction in the weekly expenditure on beverages.

3.7 Conclusion

The difference-in-differences models indicated that the program reduces food insecurity and decreases the demand of food with high caloric content (tortillas). In addition, it increases hemoglobin levels, reduces anemia, and has no strong consistent short-run effect on obesity levels and demand for other food items.

Also, the results of the models did not reveal any pattern of effects by quintile of income and poverty level at the baseline for any of the weight-related outcomes analyzed. Due to this lack of significant effects by absolute and relative income levels, this study does not provide evidence supporting or rejecting the theory of the inverted U-shape.

I conducted the adjusted difference-in-differences and logit models for the total population and separately by quintile of income and poverty level in order to corroborate the robustness of the general findings of the difference-in-differences models. Results were robust for the demand for tortillas, food insecurity, and use of the program for buying food. Similarly, the adjusted difference-in-differences regressions do not report any significant effect on the levels of hemoglobin, prevalence of anemia, BMI, obesity class I, II and III, BMIS, ratio BMIS/BMI, and waist circumference. Logistic models by quintile of income also provided evidence on the reduction of overweight among people in the first quintile and an increase in their prevalence of obesity and obesity class II. This robustness check aligned with findings from the difference-in-differences models.

3.8 Discussion

This study does not provide evidence to support the hypothesis that a positive income shock increases the short-run consumption of high-calorie food, particularly among the poor, as other studies do (Téllez-Rojo et al., 2013; Hoddinott and Skoufias, 2004; Skoufias, 2005). *Reconocer* had a positive effect on food insecurity and prevalence of anemia in the elderly population, as both decreased. The program reduced the consumption of tortillas across most subgroups, which may suggest that they are an inferior good in economic and nutritious terms. That is, when income expands their demand is reduced and presumably substituted by food more nutritious as suggested by the drop in anemia. However, the program had no strong effect on BMI, overweight, and obesity of the elderly, which mirrors findings from other studies in similar population (Téllez-Rojo et al., 2013; Aguila, Kapteyn and Smith, 2015). An increase in income may not have a short-run impact on BMI; but, it has an impact on health (as indicated by a decrease in anemia) and the quality of food intake (as indicated by a decrease in “tortilla” consumption). Both of these are likely to have a beneficial impact on reducing obesity in the longer-run, if they are sustained. BMI effects may take a much longer time within the older population to materialize than six months, as opposed to effects on anemia or health outcomes, which could be more immediate.

The sensitivity analysis by subgroups of the older population suggests that those with an income below the poverty line are more prone to be affected by the program in outcomes such as food insecurity. Over half of the beneficiaries used the program for buying food, and this

effect was larger for the poor. Beneficiaries' use of part of the program's transfers on food is similar to other studies on the topic (Case and Deaton, 1998; Attanasio and Mesnard, 2006; Skoufias, 2005; Skoufias, Unar and González-Cossío, 2008; Galiani, Gertler and Bando, 2014; Gertler, Martinez and Rubio-Codina, 2012).

In the case of the non-poor and people in the fifth income quintile, the effects of the program were more attenuated. Non-poor elderly reduced their demand for tortillas, as did most other subgroups, but they did not experience any improvement in food insecurity and anemia; moreover, their weight, BMI, and obesity levels marginally increased.

Results of the analysis may not support or reject the theory of the inverted U-shaped income-weight association. In other words, null results suggest that extra income provided by *Reconocer* does not increase the unhealthy food intake, weight, or obesity of beneficiaries. Instead, there is evidence that it diminishes the consumption of food rich in calories (tortillas), even among the poor. It implies that the fear unconditional cash transfers increase obesity rates among the elderly population in poverty could be unfounded.

The main policy implication of this study is that this type of cash transfer programs can be scaled-up among similar populations to ameliorate poverty without being afraid of encouraging negative side effects on the diet and obesity of people in this age group.

There are a few potential explanations for the null effects of the program on the BMI and related outcomes for the overall elderly population in the experiment. One possible explanation could be the physiology of the elderly. As described above, their BMI may take longer than six months to reflect a significant change caused by a modification in food demand. Likewise, the null effects on BMI may be confounded with potential effects of pre-existing chronic diseases. It also could indicate that this study observed a fraction of the total effect of the program on the diet and BMI because the survey recorded data only in regard to twelve homogeneous food items. In addition to that, there is no information about the intra-household allocation of the income boost. Most elderly (66.7%) reside with younger family members, and the final use of the extra income may be influenced or even fully decided by them. In other words, the observed BMI could have no strong association to the use of the cash transfers. Although in the case of elderly living alone or with other older people null

effects on BMI held, the sample may not be enough large to draw conclusions about the observed outcomes.

The lack of significant effects or patterns of effects by quintile of income and poverty level as well as the impossibility to support or reject the inverted U-shaped theory could be due to a few reasons. First, cash transfers like *Reconocer* have several effects influencing the final household income and the intra-household allocation of it. Estimations by quintile and poverty level are based on the per-capita household income reported at the baseline survey. Cash transfers have income and substitution effects that could have increased or decreased the baseline income level. An overall increase in household income is expected assuming that such income and its sources reported at the baseline remained the same or did not have meaningful changes; therefore, the transfer only increases the income level. An overall decrease in income results from a crowding-out effect in which the additional income from the program may have created incentives for the elderly to reduce their labor or to their non-household family members to reduce the transfers to the older persons. In both cases, the per capita income after the program started could have decreased compared to the baseline. In an extreme case, someone classified as non-poor at baseline, could have become poor after the implementation of the program or vice-versa resulting in a misclassification in the analysis by income level.

Second, it is unknown at what specific location on the inverted-U curve the people of the experiment are before or after the cash transfer was implemented. That is, whether everyone (poor and non-poor) or just a fraction of them were located on the slope to the left or right of the threshold, how close they are to the threshold, and if the program resulted in a change in places within the same side of the curve or a switch of sides. Furthermore, this analysis only presents data for two points in time, and they are not enough to draw a curve between BMI and income. That is, with the available information, it is not possible to know how the hypothesized curve looks in the real world for this population.

Third (and related to the previous two points), older people in the localities of the experiment have lower income than the average people in Mexico in the same age group: 89.9% of the first are in moderate poverty, while this number is only 43.5% of older people at national level. In other words, one possible explanation for the lack of findings is that this population is overall poor, not representative of the national conditions, and results for most of them may go in the

same direction, rather than changing along the income level. The cash transfer is substantial (equivalent to 44% of household income) and in the event that it increases the final household income, it may place people on the other side of threshold I^* where the effect goes is in the opposite direction. In this study, I only observed two points over time, and it may be hard to disprove a non-linear relationship that could rely on the long run. In order to accept or reject the theory, we may need more data points.

This study has some limitations. First, data on food demand and expenditure were reported at the household level; therefore, they may not correspond to the actual diet of the elderly, especially for those not living alone. Second, since the food demand was only recorded for twelve food items, changes that may have occurred in other important foods remain unknown. Third, the frequency of food consumption at the individual level classifies food into generic groups; thus, the assessment of any change in the quality of diet of the elderly is not straightforward. And finally, some sub-samples have a small number of individuals that can affect their power to effectively estimate any effect in the sensitivity analysis. Further research in this topic is needed.

3.A. Additional Tables

Table 3.A. 1. T-test of Baseline Characteristics of Older Persons in Motul, ENCAHEY 2008

Variable	Did not receive 70 <i>y mas</i>	Received 70 y <i>mas</i>	SE	p-value
Outcome variables				
Hemoglobin (g/dl, SD)	12.139	12.453	0.130	0.016
Anemic ^a (% , SD)	54.036	47.552	3.786	0.087
Weight (Kg, SD)	59.746	60.470	0.915	0.429
BMI (mean kg/m ² , SD)	27.174	26.946	0.388	0.556
Overweight (BMI $\geq$ 25.0; %, SD)	50.595	48.742	3.585	0.605
Obese (BMI $\geq$ 30.0; %, SD)	23.896	21.285	3.390	0.442
Obese Class I (30.0 $\geq$ BMI < 35.0; %, SD)	18.961	15.663	3.054	0.281
Obese Class II (35.0 $\geq$ BMI < 40.0; %, SD)	3.377	2.008	1.282	0.286
Obese Class III (BMI $\geq$ 40.0; %, SD)	1.558	3.614	1.343	0.127
Waist circumference (Mean cm, SD)	32.540	33.933	0.627	0.027
Covariates				
Age (Mean, SD)	77.984	77.453	0.441	0.228
Male (% , SD)	48.214	56.604	3.565	0.019
Years of education (Mean, SD)	1.785	1.931	0.122	0.230
Marital Status				
Single (% , SD)	6.548	6.289	1.754	0.883
Couple (% , SD)	49.402	53.459	3.583	0.258
Separated/divorced (% , SD)	1.984	3.145	1.161	0.318
Widowed (% , SD)	41.865	37.107	3.493	0.174
Speaks Maya (% , SD)	26.587	26.730	3.172	0.964
Reads a message in Spanish (% , SD)	62.302	68.553	3.387	0.065
Lives alone (% , SD)	13.889	15.094	2.534	0.634
Household size (mean, SD)	3.480	3.431	0.154	0.750
Exercise	31.746	31.132	3.327	0.854
Number of Chronic Diseases (mean, SD)	0.857	0.862	0.067	0.947
Other variables				
Below extreme poverty line (% , SD)	64.881	63.836	3.437	0.761
Below poverty line (% , SD)	90.079	88.365	2.241	0.444
Household income (mean, SD)	1188.771	1291.568	104.979	0.328
Observations	504	318		

Abbreviations: SE, Standard Error; SD, Standard Deviation; BMI, body mass index.

^aAnemia threshold: Low hemoglobin <13.5g/dl men, <12 women.

Table 3.A. 2. Difference-in-Differences^{ab} by Participation in 70 y *mas*, ENCAHEY 2008-2009

Outcome	Did not receive 70 y <i>mas</i>	Received 70 y <i>mas</i>
Hemoglobin	0.257 (0.106)**	-0.1680 (0.248)
Anemia (hb<13.5g/dl men, <12g/dl women)	-0.069 (0.035)*	-0.0990 (0.029)**
Weight (kg)	0.331 (0.207)	1.0945 (0.579)
BMI (kg/m ²)	0.111 (0.120)	0.3695 (0.365)
Overweight (BMI ≥ 25.0)	-0.037 (0.025)	-0.0427 (0.021)*
Obese (BMI ≥ 30.0)	0.02 (0.018)	0.0135 (0.016)
Obese class I (30.0 ≥ BMI < 35.0)	0.028 (0.021)	0.0169 (0.017)
Obese class II (35.0 ≥ BMI < 40.0)	-0.011 (0.009)	-0.0091 (0.008)
Obese class III (BMI ≥ 40.0)	0.003 (0.005)	0.0058 (0.005)
BMIS [(kg/kh cm ²)*1000]	0.475 (0.359)	1.6244 (1.594)
Ratio BMIS/BMI	0.017 (0.013)	0.0069 (0.067)
Waist circumference (cm)	0.576 (0.409)	0.1404 (1.141)

Abbreviations: Diff-in-diff, difference-in-differences; SE, Standard Error; SD, Standard Deviation.

^aDifference-in-Differences is significantly different from zero after applying Holms Bonferroni's adjustment for multiple comparisons: ** at 0.05 level and * at 0.10 level.

^bStandard errors in parenthesis. They are clustered at household level.

Table 3.A. 3. Difference-in-Differences^{ab} by Sex and Language, ENCAHEY 2008-2009

Outcome	Female		Male		Speaks Mayan		Speaks Spanish	
	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE
Health								
Hemoglobin	-0.004	(0.135)	0.549	(0.169)***	0.401	(0.228)	0.157	(0.119)
Anemia (hb<13.5g/dl men, <12g/dl women)	-0.052	(0.048)	-0.088	(0.052)*	-0.046	(0.068)	-0.057	(0.042)
Weight (kg)	-0.205	(0.271)	0.922	(0.310)**	-0.009	(0.349)	0.412	(0.275)
BMI (kg/m ²)	-0.036	(0.161)	0.281	(0.177)	0.084	(0.184)	0.176	(0.168)
Overweight (BMI ≥ 25.0)	0.000	(0.614)	1.104	(0.508)	-0.005	(0.044)	-0.064	(0.031)
Obese (BMI ≥ 30.0)	-0.100	(0.033)**	0.036	(0.037)	0.004	(0.028)	0.036	(0.024)
Obese class I (30.0 ≥ BMI < 35.0)	0.003	(0.025)	0.037	(0.025)	0.025	(0.035)	0.036	(0.026)
Obese class II (35.0 ≥ BMI < 40.0)	-0.004	(0.026)	0.060	(0.027)*	-0.015	(0.013)	-0.009	(0.013)
Obese class III (BMI ≥ 40.0)	0.003	(0.013)	-0.026	(0.013)*	-0.006	(0.004)	0.010	(0.007)
BMIS [(kg/kh cm ²)*1000]	0.004	(0.009)	0.003	(0.003)	0.153	(0.597)	0.451	(0.536)
Ratio BMIS/BMI	0.464	(0.510)	0.519	(0.464)	0.026	(0.023)	0.012	(0.019)
Waist circumference (cm)	0.016	(0.017)	0.019	(0.018)	-0.843	(0.682)	1.325	(0.542)*
Use of <i>Reconocer</i>								
Use <i>Reconocer</i> for food, yes-no (1-0)	0.596	(0.020)***	0.651	(0.021)***	0.688	(0.023)***	0.562	(0.023)***
Weekly expenditure on beverages (pesos)	-5.536	(5.208)	-7.476	(4.180)*	-8.971	(5.521)	-3.895	(5.029)
Weekly expenditure on food (pesos)	-5.798	(12.669)	8.013	(10.872)	-18.901	(11.480)	10.512	(15.516)
Weekly expenditure on food & beverages (pesos)	-32.579	(57.364)	-5.464	(60.582)	0.000	(0.000)	47.453	(102.551)
N	882		768		675		975	

Abbreviations: Diff-in-diff, difference-in-differences; BMI, body mass index; SE, Standard Error.

^aDifference-in-Differences is significantly different from zero after applying Holms Bonferroni's adjustment for multiple comparisons: ** at 0.05 level and * at 0.10 level.

^bStandard errors in parenthesis. They are clustered at household level.

Table 3.A.3. Difference-in-Differences^{ab} by Sex and Language, ENCAHEY 2008-2009 (cont.)

Outcome	Female		Male		Speaks Mayan		Speaks Spanish	
	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE
Per Capita Food Demand								
French bread (pieces)	0.922	(0.551)	-0.476	(0.698)	-0.439	(0.838)	0.657	(0.601)
Tortilla (kg)	-0.344	(0.125)*	-0.410	(0.141)**	-0.135	(0.186)	-0.477	(0.119)***
Potato (kg)	-0.095	(0.047)	-0.130	(0.075)	-0.118	(0.063)	-0.114	(0.059)
Onion (kg)	0.000	(0.022)	-0.008	(0.019)	0.009	(0.027)	-0.006	(0.021)
Soda (liter)	-0.320	(0.312)	-0.049	(0.361)	0.004	(0.553)	-0.351	(0.287)
Noodles soup (packages)	0.113	(0.080)	0.073	(0.144)	0.254	(0.162)	-0.007	(0.093)
Eggs (No.)	0.272	(0.528)	-0.163	(0.790)	0.052	(0.710)	0.094	(0.740)
Tomato (kg)	0.066	(0.044)	0.009	(0.035)	0.031	(0.069)	0.052	(0.037)
Beans (kg)	-0.010	(0.038)	0.003	(0.046)	0.008	(0.057)	-0.021	(0.031)
Rice (kg)	-0.008	(0.032)	-0.003	(0.037)	-0.042	(0.048)	0.003	(0.032)
Milk (liter)	-0.164	(0.139)	-0.422	(0.141)**	-0.097	(0.194)	-0.394	(0.136)**
Sweet bread (pieces)	-0.603	(0.766)	0.676	(0.873)	0.213	(1.040)	-0.174	(0.805)
Per Capita Food Expenditure								
French bread (total pesos)	0.050	(0.964)	-2.666	(1.240)	-2.605	(1.516)	-0.174	(1.063)
Tortilla (total pesos)	-3.714	(1.224)**	-4.444	(1.386)**	-1.671	(1.813)	-4.909	(1.190)***
Potato (total pesos)	-0.446	(0.446)	-1.695	(0.599)*	-0.846	(0.468)	-1.312	(0.585)
Onion (total pesos)	0.038	(0.335)	-0.381	(0.306)	-0.221	(0.409)	0.023	(0.347)
Soda (total pesos)	-0.368	(1.766)	-4.084	(2.367)	-2.064	(3.444)	-1.467	(1.889)
Noodles soup (total pesos)	0.414	(0.336)	-0.312	(0.560)	0.620	(0.510)	-0.320	(0.440)
Eggs (total pesos)	0.348	(0.640)	-1.269	(0.959)	-0.721	(1.012)	-0.252	(0.865)
Tomato (total pesos)	0.523	(0.438)	0.152	(0.364)	0.040	(0.621)	0.525	(0.383)
Beans (total pesos)	-0.978	(0.585)	-0.707	(0.714)	-0.801	(0.886)	-0.839	(0.596)
Rice (total pesos)	-0.051	(0.481)	0.091	(0.524)	-0.802	(0.722)	0.371	(0.466)
Milk (total pesos)	-2.285	(2.251)	-4.479	(2.174)**	0.350	(2.542)	-5.352	(2.352)
Sweet bread (total pesos)	-1.290	(1.190)	1.058	(1.601)	0.757	(1.955)	-0.879	(1.312)

Abbreviations: Diff-in-diff, difference-in-differences; SE, Standard Error.

^aDifference-in-Differences is significantly different from zero after applying Holms Bonferroni's adjustment for multiple comparisons: ** at 0.05 level and * at 0.10 level.

^bStandard errors in parenthesis. They are clustered at household level.

Table 3.A.3. Difference-in-Differences^{ab} by Sex and Language, ENCAHEY 2008-2009 (cont.)

Outcome	Female		Male		Speaks Mayan		Speaks Spanish	
	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE
Frequency of Food Intake								
Often eat eggs beans lentil etc., daily-never (1-5)	0.0213	(0.099)	-0.0052	(0.099)	-0.148	(0.122)	0.089	(0.093)
Often eat meat poultry or fish, daily-never (1-5)	-0.1956	(0.101)*	-0.0195	(0.100)	-0.007	(0.127)	-0.190	(0.094)
Often eat fruit or vegetables, daily-never (1-5)	-0.0102	(0.108)	-0.0643	(0.113)	0.059	(0.157)	-0.115	(0.099)
Often eat tortillas, bread crackers or other cereals, daily-never (1-5)	0.0145	(0.052)	-0.0143	(0.040)	-0.091	(0.063)	0.082	(0.039)
Lost weight without trying in last 3 months, yes-no (1-0)	-0.0657	(0.049)	0.0829	(0.046)*	-0.020	0.0618	0.0238	0.0416
Kilograms lots, perceived	-0.0758	(0.195)	0.1056	(0.198)	0.227	0.2631	-0.0744	0.1601
Food Insecurity								
Often worried that will run out of food last 3 months, never-always (1-4)	0.1214	(0.088)	0.0632	(0.087)	0.168	(0.132)	0.011	(0.087)
Often run out of food last 3 months, never-always (1-4)	-0.0988	(0.071)	-0.2124	(0.075)**	-0.123	(0.118)	-0.203	(0.069)**
Often skip a meal last 3 months, never-always (1-4)	-0.0019	(0.069)	-0.1053	(0.073)	-0.048	(0.103)	-0.062	(0.069)
Often eat less last 3 months, never-always (1-4)	-0.0690	(0.061)	-0.0893	(0.067)	-0.105	(0.091)	-0.079	(0.061)
Often hungry last 3 months, never-always (1-4)	-0.0583	(0.049)	-0.1960	(0.056)***	-0.154	(0.089)	-0.088	(0.046)
Lost weight for lack of food last 3 months, never-always (1-4)	0.0246	(0.038)	0.0235	(0.038)	-0.033	(0.054)	0.039	(0.037)
Often not eat all day last 3 months, never-always (1-4)	-0.1488	(0.037)***	-0.1554	(0.042)***	-0.106	(0.059)	-0.132	(0.035)***

Abbreviations: Diff-in-diff, difference-in-differences; SE, Standard Error.

^aDifference-in-Differences is significantly different from zero after applying Holms Bonferroni's adjustment for multiple comparisons: ** at 0.05 level and * at 0.10 level.

^bStandard errors in parenthesis. They are clustered at household level.

Table 3.A. 4. Difference-in-Differences^{ab} by Sub-groups, ENCAHEY 2008-2009

Outcome	Lives alone		Lives with other elderly		Lives with younger people		Normal Weight		Anemic		Overweight	
	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE
Health												
Hemoglobin	0.1306	(0.333)	0.679	(0.299)**	0.200	(0.121)*	0.064	(0.169)	0.151	(0.142)	0.421	(0.137)***
Anemia (hb<13.5g/dl men, <12g/dl women)	0.083	(0.102)	-0.053	(0.088)	-0.093	(0.041)*	-0.036	(0.051)	0.001	(0.040)	-0.096	(0.050)*
Weight (kg)	0.8674	(0.520)	0.196	(0.472)	0.235	(0.265)	0.490	(0.308)	0.364	(0.284)	0.192	(0.282)
BMI (kg/m ²)	0.2226	(0.282)	0.135	(0.234)	0.109	(0.160)	0.184	(0.167)	0.159	(0.182)	0.034	(0.161)
Overweight (BMI ≥ 25.0)	0.8755	(1.088)	0.999	(0.981)	0.351	(0.512)	-0.024	(0.607)	0.423	(0.602)	0.937	(0.536)
Obese (BMI ≥ 30.0)	-0.061	(0.067)	0.042	(0.053)	-0.043	(0.032)	-0.039	(0.030)	-0.047	(0.036)	-0.034	(0.033)
Obese class I (30.0 ≥ BMI < 35.0)	-0.024	(0.051)	0.063	(0.059)	0.012	(0.020)	0.004	(0.004)	0.048	(0.024)	0.027	(0.027)
Obese class II (35.0 ≥ BMI < 40.0)	-0.048	(0.054)	0.074	(0.067)	0.025	(0.022)	0.004	(0.004)	0.052	(0.025)	0.038	(0.030)
Obese class III (BMI ≥ 40.0)	0.024	(0.017)	-0.030	(0.027)	-0.013	(0.012)	0.000	(0.000)	-0.001	(0.011)	-0.017	(0.014)
BMIS [(kg/kh cm ²)*1000]	0.000	.	0.019	(0.019)	0.000	(0.005)	0.000	(0.000)	-0.003	(0.006)	0.005	(0.007)
Ratio BMIS/BMI	1.5341	(0.918)	-0.311	(0.992)	0.425	(0.425)	1.470	(0.542)**	0.732	(0.535)	-0.160	(0.466)
Waist circumference (cm)	0.0376	(0.039)	-0.024	(0.037)	0.021	(0.015)	0.056	(0.021)***	0.023	(0.019)	-0.002	(0.016)
Use of Reconocer												
Use Reconocer for food, yes-no (1-0)	0.614	(0.043)***	0.642	(0.046)***	0.627	(0.020)***	0.611	(0.022)***	0.624	(0.023)***	0.631	(0.022)***
Weekly expenditure on beverages (pesos)	0.604	(18.369)			-5.868	(3.094)	-8.493	(4.862)	-5.076	(5.612)	-3.779	(4.846)
Weekly expenditure on food (pesos)	22.847	(47.485)			7.415	(6.953)	-7.085	(11.176)	-12.922	(12.207)	8.773	(14.943)
Weekly expenditure on food & beverages (pesos)					12.427	(54.142)	6.285	(94.431)	98.634	(130.252)	61.004	(89.821)
N	199		284		1101		815		760		835	

Abbreviations: Diff-in-diff, difference-in-differences; BMI, body mass index; SE, Standard Error.

^aDifference-in-Differences is significantly different from zero after applying Holms Bonferroni's adjustment for multiple comparisons: ** at 0.05 level and * at 0.10 level.

^bStandard errors in parenthesis. They are clustered at household level.

Table 3.A.4. Difference-in-Differences^{ab} by Sub-groups ENCAHEY 2008-2009 (cont.)

Outcome	Lives alone		Lives with other elderly		Lives with younger people		Normal Weight		Anemic		Overweight	
	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE
Per Capita Food Demand												
French bread (pieces)	-1.155	(1.979)	-0.471	(1.136)	0.914	(0.524)	0.483	(0.691)	0.557	(0.736)	0.094	(0.646)
Tortilla (kg)	-1.069	(0.548)	-0.578	(0.267)	-0.133	(0.098)	-0.222	(0.149)	-0.222	(0.152)	-0.511	(0.128)***
Potato (kg)	0.227	(0.412)	-0.162	(0.062)	-0.085	(0.046)	-0.126	(0.080)	-0.077	(0.028)*	-0.096	(0.031)**
Onion (kg)	0.139	(0.122)	-0.006	(0.041)	-0.011	(0.016)	-0.027	(0.022)	-0.009	(0.022)	0.020	(0.021)
Soda (liter)	-1.971	(1.811)	0.095	(0.614)	-0.024	(0.209)	-0.299	(0.329)	-0.315	(0.337)	-0.080	(0.356)
Noodles soup (packages)	0.854	(0.604)	0.081	(0.174)	0.070	(0.088)	0.118	(0.123)	0.205	(0.153)	0.061	(0.088)
Eggs (No.)	-2.098	(4.664)	-0.197	(1.385)	0.288	(0.476)	0.863	(0.670)	0.377	(0.682)	-0.629	(0.687)
Tomato (kg)	0.128	(0.209)	0.113	(0.136)	0.022	(0.027)	-0.005	(0.039)	0.023	(0.045)	0.082	(0.048)
Beans (kg)	-0.116	(0.238)	0.089	(0.096)	0.006	(0.025)	0.017	(0.047)	0.035	(0.051)	-0.023	(0.040)
Rice (kg)	-0.123	(0.178)	-0.040	(0.072)	0.024	(0.026)	0.053	(0.036)	0.015	(0.040)	-0.055	(0.036)
Milk (liter)	-0.664	(0.574)	-0.801	(0.375)	-0.113	(0.102)	-0.020	(0.150)	-0.063	(0.116)	-0.497	(0.150)**
Sweet bread (pieces)	7.141	(4.119)	0.807	(1.156)	-0.876	(0.548)	0.217	(0.999)	-0.254	(0.894)	-0.284	(0.651)
Per Capita Food Expenditure												
French bread (total pesos)	-2.579	(3.973)	-1.831	(1.971)	-0.239	(0.916)	-1.224	(1.224)	-0.721	(1.252)	-1.174	(1.151)
Tortilla (total pesos)	-11.247	(5.303)	-5.897	(2.689)	-1.873	(0.983)	-2.887	(1.464)	-2.397	(1.496)	-5.068	(1.263)***
Potato (total pesos)	-2.716	(2.381)	-1.082	(1.291)	-0.771	(0.390)	-0.829	(0.630)	-1.101	(0.319)***	-1.276	(0.446)*
Onion (total pesos)	1.473	(1.671)	-0.012	(0.814)	-0.156	(0.229)	-0.262	(0.321)	-0.357	(0.339)	-0.009	(0.386)
Soda (total pesos)	-6.752	(8.694)	-4.122	(3.800)	-0.184	(1.528)	-2.452	(2.031)	-1.015	(2.342)	-1.669	(2.293)
Noodles soup (total pesos)	-3.811	(2.784)	0.555	(0.954)	0.267	(0.350)	0.387	(0.495)	0.634	(0.637)	-0.254	(0.438)
Eggs (total pesos)	-3.412	(4.734)	-0.349	(1.934)	0.071	(0.542)	-0.235	(0.750)	-0.033	(0.772)	-0.524	(0.879)
Tomato (total pesos)	2.248	(1.997)	-0.334	(1.025)	0.374	(0.296)	-0.088	(0.417)	-0.026	(0.419)	0.756	(0.450)
Beans (total pesos)	-4.587	(3.297)	0.501	(1.344)	-0.455	(0.501)	-0.383	(0.754)	-0.695	(0.712)	-1.252	(0.629)
Rice (total pesos)	-0.802	(2.501)	-0.340	(0.978)	0.366	(0.385)	0.581	(0.564)	0.362	(0.608)	-0.413	(0.497)
Milk (total pesos)	-6.258	(7.892)	-11.447	(7.373)	-1.256	(1.593)	-0.228	(2.270)	-0.150	(2.159)	-6.051	(2.629)
Sweet bread (total pesos)	12.232	(6.055)	1.141	(1.969)	-1.426	(0.985)	0.637	(1.656)	-0.666	(1.663)	-1.115	(1.178)

Abbreviations: Diff-in-diff, difference-in-differences; SE, Standard Error.

^aDifference-in-Differences is significantly different from zero after applying Holms Bonferroni's adjustment for multiple comparisons: ** at 0.05 level and * at 0.10 level.

^bStandard errors in parenthesis. They are clustered at household level.

Table 3.A.4. Difference-in-Differences^{ab} by Sub-groups, ENCAHEY 2008-2009 (cont.)

Outcome	Lives alone		Lives with other elderly		Lives with younger people		Normal Weight		Anemic		Overweight	
	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE	Diff-in-Diff	SE
Frequency of Food Intake												
Often eat eggs beans lentil etc., daily-never (1-5)	-0.1192	(0.197)	-0.0945	(0.173)	0.0526	(0.089)	-0.0273	(0.106)	-0.0289	(0.102)	0.0437	(0.095)
Often eat meat poultry or fish, daily-never (1-5)	0.1880	(0.197)	-0.2258	(0.188)	-0.1317	(0.091)	-0.0458	(0.106)	-0.0973	(0.106)	-0.1762	(0.102)
Often eat fruit or vegetables, daily-never (1-5)	-0.2417	(0.248)	0.1506	(0.209)	-0.0316	(0.096)	-0.1264	(0.116)	0.0093	(0.117)	0.0519	(0.110)
Often eat tortillas, bread crackers or other cereals, daily-never (1-5)	-0.0677	(0.088)	0.0085	(0.105)	0.0153	(0.036)	-0.0443	(0.046)	-0.018	(0.054)	0.0462	(0.048)
Lost weight without trying in last 3 months, yes-no (1-0)	0.2009	(0.099)*	-0.0590	(0.091)	-0.0125	(0.041)	0.0333	(0.050)	0.0247	(0.051)	-0.0207	(0.046)
Kilograms lots, perceived	-0.1103	(0.377)	-0.2777	(0.448)	0.1682	(0.143)	0.2089	(0.220)	0.0281	(0.186)	-0.1304	(0.172)
Food Security												
Often worried that will run out of food last 3 months, never-always (1-4)	-0.1398	(0.153)	-0.1200	(0.201)	0.1767	"(0.088)"	0.1381	(0.096)	0.2197	(0.098)**	0.0527	(0.095)
Often run out of food last 3 months, never-always (1-4)	-0.1988	(0.156)	-0.0691	(0.161)	-0.1723	(0.069)*	-0.2110	(0.078)***	-0.09	(0.078)	-0.0945	(0.077)
Often skip a meal last 3 months, never-always (1-4)	0.0035	(0.131)	-0.2148	(0.178)	-0.0061	(0.067)	0.0063	(0.081)	-0.0379	(0.080)	-0.103	(0.071)
Often eat less last 3 months, never-always (1-4)	-0.1885	(0.127)	-0.0669	(0.139)	-0.0567	(0.062)	-0.0535	(0.071)	0.005	(0.067)	-0.1	(0.066)
Often hungry last 3 months, never-always (1-4)	-0.1246	(0.125)	-0.1163	(0.109)	-0.1303	(0.050)*	-0.1526	(0.062)*	-0.0753	(0.057)	-0.0905	(0.051)
Lost weight for lack of food last 3 months, never-always (1-4)	0.0202	(0.075)	-0.0228	(0.080)	0.0262	(0.037)	0.0107	(0.044)	0.0052	(0.043)	0.0358	(0.038)
Often not eat all day last 3 months, never-always (1-4)	-0.1260	(0.088)	-0.2231	(0.108)	-0.1466	(0.034)***	-0.1889	(0.047)***	-0.117	(0.047)*	-0.1138	(0.037)**

Abbreviations: Diff-in-diff, difference-in-differences; SE, Standard Error.

^aDifference-in-Differences is significantly different from zero after applying Holms Bonferroni's adjustment for multiple comparisons: ** at 0.05 level and * at 0.10 level.

^bStandard errors in parenthesis. They are clustered at household level.

Policy Implications

In order to contribute to a reduction in the pandemic of obesity, I explored three important features of obesity and healthy eating in this dissertation: food environment, food choice, and income expansion.

In the first chapter, I examined the association between the number and type of food outlets in neighborhoods of varying radii and dietary intake and body mass index (BMI) among adults in Los Angeles County. I found that there is no strong evidence linking diets and BMI to proximity to food outlets. This result suggests that policies addressing food outlets distribution, in particular food deserts in small neighborhoods, as a way to reduce obesity may need to be reconsidered or analyzed with the specific context and evidence of the geographic area of interest in mind.

In the second chapter, I addressed new pathways involving consumer attitudes toward food as the main mediator between socioeconomic status and BMI, diet quality, and physical activity. I found that among five analyzed consumer attitudes toward food (nutrition, taste, freshness, preparation, and an index of consumer attitudes), the perceived nutrition relative to price and the index including all attitudes were the only two that have significant direct and indirect effects on BMI. The indirect effect is exclusively through diet quality, and it is not associated with physical activity. Furthermore, this study showed that socioeconomic status among different ethnicities, gender, and income levels is a significant predictor of consumer attitudes, diet quality, physical activity, and BMI. These results have two policy implications: 1) overweight and obesity could be reduced by implementing policies aimed at changing the perception of the nutrition of food (assuming price is constant) and 2) improving socioeconomic status, particularly of the most vulnerable, may result in higher diet quality, higher physical activity, and lower obesity levels.

In the third chapter, I analyzed the effects of a cash transfer program on the diet, anemia, and obesity of the elderly in Yucatan, Mexico using an experimental design. Relative to the control site, I found that the positive income shock in the short-run reduced the prevalence of anemia and decreased the demand for tortillas, but had no effect on the BMI and obesity of beneficiaries relative to the control group. Furthermore, food insecurity among elderly in the treatment site also improved. These findings contribute to the debate on whether poor

people's obesity in middle and high-income countries -where the burden of obesity often rests on the poor- is worsened by cash transfers. Evidence suggests that this fear is unfounded; moreover, this program improved short-run dietary quality and hemoglobin levels which may have a beneficial impact on reducing obesity in the long-run.

In general, the findings of this dissertation might indicate that effective policies to reduce obesity need to be more comprehensive and address different factors and different levels of stakeholders (e.g., policymakers, food advocacy groups, food producers, food industry, food outlets, and consumers, among others) affecting healthy eating at the same time. In addition, policies should take into account particular or contextual characteristics of the targeted population (e.g., food preferences and income level by ethnicity and gender).

Results of this research suggest policy implications in four main areas:

1) Reconsider policies of food environment within small geographic areas. The first chapter suggested that regulating or creating incentives to modify the distribution of food outlets may not result in obesity reduction. The main reason is that short distances between residences and food stores do not strongly influence consumption and BMI patterns in some areas, particularly among those with easy access to all types of food and highly-motorized societies. The impact of these types of policies may be low, especially in the short term because they do not modify the status quo of the food environment, and food choices may be strongly influenced by budget constraints and beliefs about food, among other variables.

2) Changing people's perceptions on nutrition. Results of the analysis in the second chapter on consumer attitudes toward food suggest that policies involving different agents that modify people's perception of nutrition at the point of purchase are important to fight obesity. For instance, changing supermarkets' presentation of healthy food (e.g., allocation within the store), modifying food branding and advertisement and food labeling in menus and packages are all possible fruitful avenues to explore, among others. Furthermore, nutrition literacy programs aiming to educate people about nutrition of food and their effects on the body are a particular policy that may change people's perception of nutrition and reduce obesity.

3) Keeping prices low. According to results of the second chapter, the most important factor determining food demand is price. This research supports exploring policies aimed at reducing and/or maintaining low prices for healthy food, such as individual subsidies for purchasing

fruits and vegetables or agriculture incentives to produce more of them. Keeping prices low is a broad area and has many potential policy actions involving different stakeholders that influence price, such as consumers, food outlets, producers, and marketing, among others.

4) Increasing people's income to expand their food options. The second and third chapters highlighted the role of income as one of the determinants of obesity. Expanding people's income or budget constraints is very important and may be a powerful policy tool because it is related to the following consequences. First, it increases people's capacity to afford healthier and more expensive food. Second, it may influence people's perception about the nutritional value of food relative to its price.

In sum, this dissertation sheds light on how food environment, income expansion, and consumer attitudes are related to obesity and healthy eating and how they vary across different ethnic and income groups. Although further research is needed, it provides evidence that may help policymakers and other stakeholders in high- and middle-income countries to promote initiatives that encourage healthy eating and to design better policies to reduce obesity.

Bibliography

- Adams, Kenneth F, Arthur Schatzkin, Tamara B Harris, Victor Kipnis, Traci Mouw, Rachel Ballard-Barbash, Albert Hollenbeck, and Michael F Leitzmann, "Overweight, obesity, and mortality in a large prospective cohort of persons 50 to 71 years old," *New England Journal of Medicine*, Vol. 355, No. 8, 2006, pp. 763-778.
- Aguero, Jorge, Michael Carter, and Ingrid Woolard, "The impact of unconditional cash transfers on nutrition: The South African Child Support Grant," 2006.
- Aguila, Emma, Abril Borges, Ashley Pierson, Rosalba Robles, Jose Eduardo Del Torno, and Beverly A Weidmer, "Distributing Noncontributory Pension Benefits by Debit Card in Mexico," 2014.
- Aguila, Emma, Arie Kapteyn, and James P Smith, "Effects of income supplementation on health of the poor elderly: The case of Mexico," *Proceedings of the National Academy of Sciences*, Vol. 112, No. 1, 2015, pp. 70-75.
- Aitchison, John, and James AC Brown, "A synthesis of Engel curve theory," *The Review of Economic Studies*, 1954, pp. 35-46.
- Akee, Randall, Emilia Simeonova, William Copeland, Adrian Angold, and E Jane Costello, "Young adult obesity and household income: Effects of unconditional cash transfers," *American economic journal. Applied economics*, Vol. 5, No. 2, 2013, p. 1.
- Alemayehu, Berhanu, and Kenneth E Warner, "The lifetime distribution of health care costs," *Health services research*, Vol. 39, No. 3, 2004, pp. 627-642.
- An, Ruopeng, and Roland Sturm, "School and residential neighborhood food environment and diet among California youth," *American journal of preventive medicine*, Vol. 42, No. 2, 2012, pp. 129-135.
- Andajani-Sutjahjo, Sari, Kylie Ball, Narelle Warren, Victoria Inglis, and David Crawford, "Perceived personal, social and environmental barriers to weight maintenance among young women: a community survey," *International Journal of Behavioral Nutrition and Physical Activity*, Vol. 1, No. 1, 2004, p. 15.
- Arroyo, Pedro, Victoria Fernández, Alvar Loría, Jeannette Pardío, Hugo Laviada, Lizardo Vargas-Ancona, and Ryk Ward, "Obesity, body morphology, and blood pressure in urban and rural population groups of Yucatan," *salud pública de méxico*, Vol. 49, No. 4, 2007, pp. 274-285.
- Arroyo, Pedro, Jeanette Pardío-López, Alvar Loria, and Victoria Fernández-García, "The modernization of cooking techniques in two rural mayan communities of Yucatán: the case of lard frying," *Ecology of food and nutrition*, Vol. 49, No. 1, 2010, pp. 61-71.
- Ashwell, M, P Gunn, and S Gibson, "Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis," *obesity reviews*, Vol. 13, No. 3, 2012, pp. 275-286.
- Attanasio, Orazio, and Alice Mesnard, "The impact of a conditional cash transfer programme on consumption in Colombia*," *Fiscal studies*, Vol. 27, No. 4, 2006, pp. 421-442.
- Ausk, Karlee J, and George N Ioannou, "Is Obesity Associated With Anemia of Chronic Disease? A Population-based Study," *Obesity*, Vol. 16, No. 10, 2008, pp. 2356-2361.
- Bader, Michael DM, Jennifer A Ailshire, Jeffrey D Morenoff, and James S House, "Measurement of the local food environment: a comparison of existing data sources," *American journal of epidemiology*, Vol. 171, No. 5, 2010, pp. 609-617.
- Barham, Tania, and Jacob Rowberry, "Living longer: The effect of the Mexican conditional cash transfer program on elderly mortality," *Journal of Development Economics*, Vol. 105, 2013, pp. 226-236.

- Becker, Gary S, "A Theory of the Allocation of Time," *The Economic Journal*, 1965, pp. 493-517.
- Behrman, Jere, and Susan Parker, "The impact of the PROGRESA/Oportunidades conditional cash transfer program on health and related outcomes for the aging in Mexico," 2011.
- Behrman, Jere R, and Anil B Deolalikar, "Will developing country nutrition improve with income? A case study for rural South India," *The Journal of Political Economy*, 1987, pp. 492-507.
- Behrman, Jere R, and John Hoddinott, "Programme evaluation with unobserved heterogeneity and selective implementation: The Mexican PROGRESA impact on child nutrition," *Oxford bulletin of economics and statistics*, Vol. 67, No. 4, 2005, pp. 547-569.
- Beydoun, MA, and Y Wang, "How do socio-economic status, perceived economic barriers and nutritional benefits affect quality of dietary intake among US adults?," *European Journal of Clinical Nutrition*, Vol. 62, No. 3, 2008a, pp. 303-313.
- Beydoun, May A, and Youfa Wang, "Do nutrition knowledge and beliefs modify the association of socio-economic factors and diet quality among US adults?," *Preventive medicine*, Vol. 46, No. 2, 2008b, pp. 145-153.
- Beydoun, May A, and Youfa Wang, "Pathways linking socioeconomic status to obesity through depression and lifestyle factors among young US adults," *Journal of affective disorders*, Vol. 123, No. 1, 2010, pp. 52-63.
- Biloukha, OO, and V Utermohlen, "Healthy eating in Ukraine: attitudes, barriers and information sources," *Public health nutrition*, Vol. 4, No. 02, 2001, pp. 207-215.
- Bliss L, "Why Banning Fast Food in South L.A. Hasn't Helped Reduce Obesity," *From the Atlantic CityLab*, 2015 March 20,. As of April 15, 2015:
- <http://www.citylab.com/politics/2015/03/why-banning-fast-food-in-south-la-hasnt-helped-reduce-obesity/388206/>
- Bogdanovich, Vera, *Self-Determination Motivation and Perceived Barriers in the Vegetable Eating Context*, 2013.
- Boone-Heinonen, Janne, Penny Gordon-Larsen, Catarina I Kiefe, James M Shikany, Cora E Lewis, and Barry M Popkin, "Fast food restaurants and food stores: longitudinal associations with diet in young to middle-aged adults: the CARDIA study," *Archives of internal medicine*, Vol. 171, No. 13, 2011, pp. 1162-1170.
- Bray, George A, Samara Joy Nielsen, and Barry M Popkin, "Consumption of high-fructose corn syrup in beverages may play a role in the epidemic of obesity," *The American journal of clinical nutrition*, Vol. 79, No. 4, 2004, pp. 537-543.
- Case, Anne, and Angus Deaton, "Large cash transfers to the elderly in South Africa," *The Economic Journal*, Vol. 108, No. 450, 1998, pp. 1330-1361.
- Caspi, Caitlin E, Glorian Sorensen, SV Subramanian, and Ichiro Kawachi, "The local food environment and diet: a systematic review," *Health & place*, Vol. 18, No. 5, 2012, pp. 1172-1187.
- Center for Disease Control and Prevention, "National Health and Nutrition Examination Survey (NHANES) 2007-2008 and 2008-2009," 2007. As of June 9, 2015:
- http://wwwn.cdc.gov/Nchs/Nhanes/Search/nhanes_continuous.aspx
- Centers for Disease Control and Prevention (CDC) Division of Nutrition, Physical Activity, and Obesity, "Facts about Physical Activity," 2014.
- <http://www.cdc.gov/physicalactivity/basics/adults/index.htm>
- Cerin, Ester, and Eva Leslie, "How socio-economic status contributes to participation in leisure-time physical activity," *Social science & medicine*, Vol. 66, No. 12, 2008, pp. 2596-2609.

- Chambers, Stephanie, Alexandra Lobb, Laurie T Butler, and W Bruce Traill, "The influence of age and gender on food choice: a focus group exploration," *International journal of consumer studies*, Vol. 32, No. 4, 2008, pp. 356-365.
- Cheng, HL, C Bryant, R Cook, H O'connor, K Rooney, and K Steinbeck, "The relationship between obesity and hypoferraemia in adults: a systematic review," *obesity reviews*, Vol. 13, No. 2, 2012, pp. 150-161.
- Chou, Shin-Yi, Michael Grossman, and Henry Saffer, "An economic analysis of adult obesity: results from the Behavioral Risk Factor Surveillance System," *Journal of health economics*, Vol. 23, No. 3, 2004, pp. 565-587.
- Cohen, Deborah A, and Susan H Babey, "Contextual influences on eating behaviours: heuristic processing and dietary choices," *obesity reviews*, Vol. 13, No. 9, 2012, pp. 766-779.
- CONAPO, "Proyecciones de la Poblacion 2010-2050," *Consejo Nacional de Poblacion, Mexico*, 2011.
- CONEVAL, "La pobreza en la población indígena de México, 2012," 2014.
- Cummins, S. , and S. Macintyre, "Food deserts--evidence and assumption in health policy making.," *Bmj*, Vol. 325, No. 7361, 2002, pp. 436-438.
- Dijkstra, S Coosje, Judith E Neter, Maartje M van Stralen, Dirk L Knol, Ingeborg A Brouwer, Martijn Huisman, and Marjolein Visser, "The role of perceived barriers in explaining socio-economic status differences in adherence to the fruit, vegetable and fish guidelines in older adults: a mediation study," *Public health nutrition*, Vol. 18, No. 05, 2015, pp. 797-808.
- Downs, Julie S, George Loewenstein, and Jessica Wisdom, "Strategies for promoting healthier food choices," *The american economic review*, 2009, pp. 159-164.
- Drewnowski, Adam, and Nicole Darmon, "The economics of obesity: dietary energy density and energy cost," *The American journal of clinical nutrition*, Vol. 82, No. 1, 2005a, pp. 265S-273S.
- Drewnowski, Adam, and Nicole Darmon, "Food choices and diet costs: an economic analysis," *The Journal of nutrition*, Vol. 135, No. 4, 2005b, pp. 900-904.
- Drewnowski, Adam, and SE Specter, "Poverty and obesity: the role of energy density and energy costs," *The American journal of clinical nutrition*, Vol. 79, No. 1, 2004, pp. 6-16.
- Dubowitz, Tamara, Madhumita Ghosh-Dastidar, Christine Eibner, Mary E Slaughter, Meenakshi Fernandes, Eric A Whitsel, Chloe E Bird, Adria Jewell, Karen L Margolis, and Wenjun Li, "The Women's Health Initiative: the food environment, neighborhood socioeconomic status, BMI, and blood pressure," *Obesity*, Vol. 20, No. 4, 2012, pp. 862-871.
- Edwards, Ward, "The theory of decision making," *Psychological bulletin*, Vol. 51, No. 4, 1954, p. 380.
- Eikenberry, Nicole, and Chery Smith, "Healthful eating: perceptions, motivations, barriers, and promoters in low-income Minnesota communities," *Journal of the American dietetic association*, Vol. 104, No. 7, 2004, pp. 1158-1161.
- Elia, Marinos, "Obesity in the elderly," *Obesity Research*, Vol. 9, No. S11, 2001, pp. 244S-248S.
- EUFIC, "The Determinants of Food Choice," *European Food Information Council (EUFIC)*, 2004. As of April 14, 2016:
- <http://www.eufic.org/article/en/expid/review-food-choice/>
- Fernald, Lia CH, Paul J Gertler, and Xiaohui Hou, "Cash component of conditional cash transfer program is associated with higher body mass index and blood pressure in adults," *The Journal of nutrition*, Vol. 138, No. 11, 2008, pp. 2250-2257.
- Ferro-Luzzi, Anna, and Laura Martino, "Obesity and physical activity," *The origins and consequences of obesity. Ciba Foundation Symposium*, 1996, pp. 207-227.

- Friese, Malte, Wilhelm Hofmann, and Michaela Wänke, "When impulses take over: Moderated predictive validity of explicit and implicit attitude measures in predicting food choice and consumption behaviour," *British Journal of Social Psychology*, Vol. 47, No. 3, 2008, pp. 397-419.
- Galiani, Sebastian, Paul Gertler, and Rosangela Bando, *Non-contributory pensions*, National Bureau of Economic Research, 2014.
- Gertler, Paul, and Simone Boyce, "An Experiment in Incentive-based Welfare: The impact of Progreso on health in Mexico," *University of California, Berkeley*, 2001, pp. 30-37.
- Gertler, Paul J, Sebastian W Martinez, and Marta Rubio-Codina, "Investing cash transfers to raise long-term living standards," *American Economic Journal: Applied Economics*, Vol. 4, No. 1, 2012, pp. 164-192.
- Gibson, Diane, "Food stamp program participation is positively related to obesity in low income women," *The Journal of nutrition*, Vol. 133, No. 7, 2003, pp. 2225-2231.
- Giskes, Katrina, Frank van Lenthe, M Avendano-Pabon, and Johannes Brug, "A systematic review of environmental factors and obesogenic dietary intakes among adults: are we getting closer to understanding obesogenic environments?," *obesity reviews*, Vol. 12, No. 5, 2011, pp. e95-e106.
- Gregg, Edward W, Robert B Gerzoff, Theodore J Thompson, and David F Williamson, "Intentional weight loss and death in overweight and obese US adults 35 years of age and older," *Annals of Internal Medicine*, Vol. 138, No. 5, 2003, pp. 383-389.
- Guenther, Patricia M, Kellie O Casavale, Jill Reedy, Sharon I Kirkpatrick, Hazel AB Hiza, Kevin J Kuczynski, Lisa L Kahle, and Susan M Krebs-Smith, "Update of the healthy eating index: HEI-2010," *Journal of the Academy of Nutrition and Dietetics*, Vol. 113, No. 4, 2013, pp. 569-580.
- Guenther, Patricia M, Kevin W Dodd, Jill Reedy, and Susan M Krebs-Smith, "Most Americans eat much less than recommended amounts of fruits and vegetables," *Journal of the American dietetic association*, Vol. 106, No. 9, 2006, pp. 1371-1379.
- Guillaumie, Laurence, Gaston Godin, and Lydi-Anne Vézina-Im, "Psychosocial determinants of fruit and vegetable intake in adult population: a systematic review," *International Journal of Behavioral Nutrition and Physical Activity*, Vol. 7, No. 1, 2010, p. 12.
- Guierrez, Juan Pablo, Juan Rivera-Dommarco, Teresa Shamah-Levy, Salvador Villalpando-Hernández, Aurora Franco, Lucía Cuevas-Nasu, Martín Romero-Martínez, and Mauricio Hernández-Ávila, "Encuesta nacional de salud y nutrición 2012," *Resultados Nacionales. Cuernavaca, México: Instituto Nacional de Salud Pública*, 2012.
- Harper, Sam, and John Lynch, "Trends in socioeconomic inequalities in adult health behaviors among US states, 1990-2004," *Public Health Reports*, 2007, pp. 177-189.
- Hattori, Aiko, "Neighborhood food outlets, diet, and obesity among California adults, 2007 and 2009," *Preventing chronic disease*, Vol. 10, 2013.
- Haynes-Maslow, Lindsey, "A qualitative study of perceived barriers to fruit and vegetable consumption among low-income populations, North Carolina, 2011," *Preventing chronic disease*, Vol. 10, 2013.
- Hedley, Allison A, Cynthia L Ogden, Clifford L Johnson, Margaret D Carroll, Lester R Curtin, and Katherine M Flegal, "Prevalence of overweight and obesity among US children, adolescents, and adults, 1999-2002," *Jama*, Vol. 291, No. 23, 2004, pp. 2847-2850.
- Hiscock, Rosemary, Linda Bauld, Amanda Amos, Jennifer A Fidler, and Marcus Munafò, "Socioeconomic status and smoking: a review," *Annals of the New York Academy of Sciences*, Vol. 1248, No. 1, 2012, pp. 107-123.
- Hoddinott, John, and Emmanuel Skoufias, "The impact of PROGRESA on food consumption," *Economic development and cultural change*, Vol. 53, No. 1, 2004, pp. 37-61.

- House, Jennifer, Jenny Su, and Ryna Levy-Milne, "Definitions of healthy eating among university students," *Canadian Journal of Dietetic Practice and Research*, Vol. 67, No. 1, 2006, pp. 14-18.
- Huff Post, "Food Swamps, Unhealthy Food Access and Moving Beyond Personal Responsibility ", 2014. As of July 25th, 2014:
- http://www.huffingtonpost.com/daniel-j-schultz/food-swamps-unhealthy-foo_b_4632942.html
- Instituto Nacional de Estadística y Geografía (INEGI), "Encuesta Nacional de Seguridad Social (ENESS)," 2013.
- Instituto Nacional de Estadística y Geografía (INEGI), "Encuesta de Ingresos y Gastos de los Hogares (ENIGH)," 2014.
- Instituto Nacional de Salud Pública, "Encuesta Nacional de Nutrición y Salud (ENSANUT)," 2012.
- Janssen, Ian, Steven B Heymsfield, and Robert Ross, "Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability," *Journal of the American Geriatrics Society*, Vol. 50, No. 5, 2002, pp. 889-896.
- Janssen, Ian, Peter T Katzmarzyk, and Robert Ross, "Waist circumference and not body mass index explains obesity-related health risk," *The American journal of clinical nutrition*, Vol. 79, No. 3, 2004, pp. 379-384.
- Jeffery, Robert W, Judy Baxter, Maureen McGuire, and Jennifer Linde, "Are fast food restaurants an environmental risk factor for obesity?," *International Journal of Behavioral Nutrition and Physical Activity*, Vol. 3, No. 1, 2006, p. 2.
- Kearney, JM, and S McElhone, "Perceived barriers in trying to eat healthier—results of a pan-EU consumer attitudinal survey," *British Journal of Nutrition*, Vol. 81, No. S1, 1999, pp. S133-S137.
- Kearney, M, JM Kearney, A Dunne, and MJ Gibney, "Sociodemographic determinants of perceived influences on food choice in a nationally representative sample of Irish adults," *Public health nutrition*, Vol. 3, No. 02, 2000, pp. 219-226.
- Khan, Laura Kettel, Kathleen Sobush, Dana Keener, Kenneth Goodman, Amy Lowry, Jakub Kakietek, and Susan Zaro, *Recommended community strategies and measurements to prevent obesity in the United States*, Vol. 58: US Department of Health & Human Services, Centers for Disease Control and Prevention, 2009.
- Krebs-Smith, Susan M, Patricia M Guenther, Amy F Subar, Sharon I Kirkpatrick, and Kevin W Dodd, "Americans do not meet federal dietary recommendations," *The Journal of nutrition*, Vol. 140, No. 10, 2010, pp. 1832-1838.
- Kuwabara, Akiko, Yoko Ogawa-Shimokawa, and Kiyoshi Tanaka, "Body weight divided by squared knee height as an alternative to body mass index," *Medical hypotheses*, Vol. 76, No. 3, 2011, pp. 336-338.
- LA Office of the City Clerk, "Council File No.10-1843,," *Los Angeles (CA)*, 2010. As of July 12, 2014:
- http://clkrep.lacity.org/online/docs/2010/10-1843_ca_12-08-10.pdf
- Lagerros, Ylva Trolle, and Pagona Lagiou, "Assessment of physical activity and energy expenditure in epidemiological research of chronic diseases," *European journal of epidemiology*, Vol. 22, No. 6, 2007, pp. 353-362.
- Lake, Amelia, and Tim Townshend, "Obesogenic environments: exploring the built and food environments," *The Journal of the Royal society for the Promotion of Health*, Vol. 126, No. 6, 2006, pp. 262-267.

- Lappalainen, R, A Saba, L Holm, H Mykkanen, and MJ Gibney, "Difficulties in trying to eat healthier: descriptive analysis of perceived barriers for healthy eating," *European Journal of Clinical Nutrition*, Vol. 51, 1997.
- Laska, Melissa N, Mary O Hearst, Ann Forsyth, Keryn E Pasch, and Leslie Lytle, "Neighbourhood food environments: are they associated with adolescent dietary intake, food purchases and weight status?," *Public health nutrition*, Vol. 13, No. 11, 2010, pp. 1757-1763.
- Lee, Jung Sun, and Edward A Frongillo, "Understanding needs is important for assessing the impact of food assistance program participation on nutritional and health status in US elderly persons," *The Journal of nutrition*, Vol. 131, No. 3, 2001, pp. 765-773.
- Levy, Dan, and Jim Ohls, "Evaluation of Jamaica's PATH program: final report," *Report prepared*, 2007.
- Liese, Angela D, Natalie Colabianchi, Archana P Lamichhane, Timothy L Barnes, James D Hibbert, Dwayne E Porter, Michele D Nichols, and Andrew B Lawson, "Validation of 3 food outlet databases: completeness and geospatial accuracy in rural and urban food environments," *American journal of epidemiology*, Vol. 172, No. 11, 2010, pp. 1324-1333.
- Loria, Alvar, Pedro Arroyo, Jeanette Pardío, Loredana Tavano-Colaizzi, and Ana Bertha Pérez-Lizaur, "Values of a Body Mass Index Surrogate in Older Adults Using Knee Height Instead of Height," *Journal of the American Geriatrics Society*, Vol. 63, No. 11, 2015, pp. 2413-2414.
- Los Angeles County Health Survey (LACHS), "County of Los Angeles Public Health," *Los Angeles (CA)*, 2011. <http://www.publichealth.lacounty.gov/ha/hasurveyintro.htm>
- Maddock, Jay, "The relationship between obesity and the prevalence of fast food restaurants: state-level analysis," *American Journal of Health Promotion*, Vol. 19, No. 2, 2004, pp. 137-143.
- Maluccio, John, and Rafael Flores, *Impact evaluation of a conditional cash transfer program: The Nicaraguan Red de Protección Social*: Intl Food Policy Res Inst, 2005.
- Manrique-Espinoza, Betty, Karla Moreno-Tamayo, Martha Ma Téllez-Rojo Solís, De la Cruz-Góngora, Vanessa Vianey, Luis Miguel Gutiérrez-Robledo, and Aarón Salinas-Rodríguez, "Short-term effect of physical activity and obesity on disability in a sample of rural elderly in Mexico," *salud pública de méxico*, Vol. 56, No. 1, 2014, pp. 4-10.
- Marshall, Simon J, Deborah A Jones, Barbara E Ainsworth, Jared P Reis, Susan S Levy, and Caroline A Macera, "Race/ethnicity, social class, and leisure-time physical inactivity," *Medicine and science in sports and exercise*, Vol. 39, No. 1, 2007, p. 44.
- Monteiro, Carlos A, Erly C Moura, Wolney L Conde, and Barry M Popkin, "Socioeconomic status and obesity in adult populations of developing countries: a review," *Bulletin of the World Health Organization*, Vol. 82, No. 12, 2004, pp. 940-946.
- Morland, Kimberly, Ana V Diez Roux, and Steve Wing, "Supermarkets, other food stores, and obesity: the atherosclerosis risk in communities study," *American journal of preventive medicine*, Vol. 30, No. 4, 2006, pp. 333-339.
- Moser, Richard P, Valerie Green, Deanne Weber, and Colleen Doyle, "Psychosocial correlates of fruit and vegetable consumption among African American men," *Journal of nutrition education and behavior*, Vol. 37, No. 6, 2005, pp. 306-314.
- Ng, Marie, Tom Fleming, Margaret Robinson, Blake Thomson, Nicholas Graetz, Christopher Margono, Erin C Mullany, Stan Biryukov, Cristiana Abbafati, and Semaw Ferede Abera, "Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013," *The Lancet*, Vol. 384, No. 9945, 2014, pp. 766-781.
- Ng, Shu Wen, and BM Popkin, "Time use and physical activity: a shift away from movement across the globe," *obesity reviews*, Vol. 13, No. 8, 2012, pp. 659-680.

North American Industry Classification System (NAICS), "US Census Bureau," *Washington (DC)*. As of February 8, 2014:

<http://www.census.gov/eos/www/naics/>

O'Dea, Jennifer A, "Why do kids eat healthful food? Perceived benefits of and barriers to healthful eating and physical activity among children and adolescents," *Journal of the American dietetic association*, Vol. 103, No. 4, 2003, pp. 497-501.

Odoms-Young, Angela M, Angela Kong, Linda A Schiffer, Summer J Porter, Lara Blumstein, Stephanie Bess, Michael L Berbaum, and Marian L Fitzgibbon, "Evaluating the initial impact of the revised Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) food packages on dietary intake and home food availability in African-American and Hispanic families," *Public health nutrition*, Vol. 17, No. 01, 2014, pp. 83-93.

OECD, "Obesity Update," 2014. As of April 05, 2015:

<http://www.oecd.org/health/obesity-update.htm>

Office of Disease Prevention and Health Promotion (ODPHP), "Dietary Guidelines 2015-2020," 2015. As of April 04, 2016:

<http://health.gov/dietaryguidelines/2015/guidelines/chapter-2/current-eating-patterns-in-the-united-states/>

Ogden, Cynthia L, Margaret D Carroll, Brian K Kit, and Katherine M Flegal, "Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010," *Jama*, Vol. 307, No. 5, 2012, pp. 483-490.

Osher, Etty, and Naftali Stern, "Obesity in Elderly Subjects In sheep's clothing perhaps, but still a wolf," *Diabetes care*, Vol. 32, No. suppl 2, 2009, pp. S398-S402.

Perez-Cueto, Federico, Wim Verbeke, Carl Lachat, and Anne Marie Remaut-De Winter, "Changes in dietary habits following temporal migration. The case of international students in Belgium," *Appetite*, Vol. 52, No. 1, 2009, pp. 83-88.

Physical Activity Guidelines Advisory Committee, "Physical activity guidelines advisory committee report, 2008," *Washington, DC: US Department of Health and Human Services*, Vol. 2008, 2008, pp. A1-H14.

Pollard, J, SF Kirk, and JE Cade, "Factors affecting food choice in relation to fruit and vegetable intake: a review," *Nutrition research reviews*, Vol. 15, No. 02, 2002, pp. 373-387.

Popkin, Barry M, "The nutrition transition and obesity in the developing world," *The Journal of nutrition*, Vol. 131, No. 3, 2001, pp. 871S-873S.

Popkin, Barry M, "Global nutrition dynamics: the world is shifting rapidly toward a diet linked with noncommunicable diseases," *The American journal of clinical nutrition*, Vol. 84, No. 2, 2006, pp. 289-298.

Popkin, Barry M, "Agricultural policies, food and public health," *EMBO reports*, Vol. 12, No. 1, 2011, pp. 11-18.

Popkin, Barry M, and Samara Joy Nielsen, "The sweetening of the world's diet," *Obesity Research*, Vol. 11, No. 11, 2003, pp. 1325-1332.

Posner, Richard A. , and Tomas J. Philipson, "The Long-Run Growth in Obesity as a Function of Technological Change," *46 Perspectives in Biology and Medicine*, Vol. S87, 2003.

Powell, Lisa M, M Christopher Auld, Frank J Chaloupka, Patrick M O'Malley, and Lloyd D Johnston, "Associations between access to food stores and adolescent body mass index," *American journal of preventive medicine*, Vol. 33, No. 4, 2007, pp. S301-S307.

- Powell, Lisa M, Frank J Chaloupka, and Yanjun Bao, "The availability of fast-food and full-service restaurants in the United States: associations with neighborhood characteristics," *American journal of preventive medicine*, Vol. 33, No. 4, 2007, pp. S240-S245.
- Raja, Samina, Li Yin, James Roemmich, Changxing Ma, Leonard Epstein, Pavan Yadav, and Alex Brian Ticoalu, "Food environment, built environment, and women's BMI: evidence from erie county, New york," *Journal of Planning Education and Research*, 2010.
- RAND-State Government of Yucatan, "Encuesta de Características Socioeconómicas del Hogar en el Estado de Yucatán (ENCAHEY) 2008-2009," 2008.
- Richardson, Andrea S, Janne Boone-Heinonen, Barry M Popkin, and Penny Gordon-Larsen, "Neighborhood fast food restaurants and fast food consumption: a national study," *BMC Public Health*, Vol. 11, No. 1, 2011, p. 1.
- Rose, Donald, J Nicholas Bodor, Paul L Hutchinson, and Chris M Swalm, "The importance of a multi-dimensional approach for studying the links between food access and consumption," *The Journal of nutrition*, Vol. 140, No. 6, 2010, pp. 1170-1174.
- Saguy, Abigail C, and Rene Almeling, "Fat in the Fire? Science, the News Media, and the "Obesity Epidemic" 2," *Sociological Forum*, 2008, pp. 53-83.
- Salinas-Rodríguez, Aarón, and Betty S Manrique-Espinoza, "Effect of the conditional cash transfer program Oportunidades on vaccination coverage in older Mexican people," *BMC international health and human rights*, Vol. 13, No. 1, 2013, p. 30.
- Sallis, James F, and Karen Glanz, "Physical activity and food environments: solutions to the obesity epidemic," *Milbank Quarterly*, Vol. 87, No. 1, 2009, pp. 123-154.
- Samper-Ternent, Rafael, Alejandra Michaels-Obregon, and Rebeca Wong, "Coexistence of obesity and anemia in older Mexican adults," *Ageing international*, Vol. 37, No. 1, 2012, pp. 104-117.
- Schady, Norbert, and Christina H Paxson, "Does money matter? The effects of cash transfers on child health and development in rural Ecuador," *The Effects of Cash Transfers on Child Health and Development in Rural Ecuador (May 1, 2007). World Bank Policy Research Working Paper*, No. 4226, 2007.
- Secretaria de Salud, "Sistema Nacional de Informacion en Salud (SINAIS)," *Mexico*, 2014.
- Shaikh, Abdul R, Amy L Yaroch, Linda Nebeling, Ming-Chin Yeh, and Ken Resnicow, "Psychosocial predictors of fruit and vegetable consumption in adults: a review of the literature," *American journal of preventive medicine*, Vol. 34, No. 6, 2008, pp. 535-543. e511.
- Shier, Victoria, Ruopeng An, and Roland Sturm, "Is there a robust relationship between neighbourhood food environment and childhood obesity in the USA?," *Public Health*, Vol. 126, No. 9, 2012, pp. 723-730.
- Shiv, Baba, and Alexander Fedorikhin, "Heart and mind in conflict: The interplay of affect and cognition in consumer decision making," *Journal of consumer Research*, Vol. 26, No. 3, 1999, pp. 278-292.
- Silliman, Kathryn, Kathleen Rodas-Fortier, and Michelle Neyman, "A survey of dietary and exercise habits and perceived barriers to following a healthy lifestyle in a college population," *Californian journal of health promotion*, Vol. 18, 2004, p. 281.
- Singh, Gopal K, Mohammad Siahpush, Robert A Hiatt, and Lava R Timsina, "Dramatic increases in obesity and overweight prevalence and body mass index among ethnic-immigrant and social class groups in the United States, 1976–2008," *Journal of community health*, Vol. 36, No. 1, 2011, pp. 94-110.
- Skoufias, Emmanuel, *PROGRESA and its impacts on the welfare of rural households in Mexico*, Vol. 139: Intl Food Policy Res Inst, 2005.

- Skoufias, Emmanuel, Mishel Unar, and Teresa González-Cossío, "The impacts of cash and in-kind transfers on consumption and labor supply: experimental evidence from rural Mexico," *World Bank Policy Research Working Paper Series*, Vol. 2008.
- Sobal, Jeffery, and Albert J Stunkard, "Socioeconomic status and obesity: a review of the literature," *Psychological bulletin*, Vol. 105, No. 2, 1989, p. 260.
- Stommel, Manfred, and Charlotte A Schoenborn, "Accuracy and usefulness of BMI measures based on self-reported weight and height: findings from the NHANES & NHIS 2001-2006," *BMC Public Health*, Vol. 9, No. 1, 2009, p. 1.
- Sturm, Roland, and Aiko Hattori, "Diet and obesity in Los Angeles County 2007–2012: Is there a measurable effect of the 2008 “Fast-Food Ban”?, " *Social science & medicine*, Vol. 133, 2015, pp. 205-211.
- Sun, Yu-Hua Christine, "Health concern, food choice motives, and attitudes toward healthy eating: the mediating role of food choice motives," *Appetite*, Vol. 51, No. 1, 2008, pp. 42-49.
- Téllez-Rojo, Martha M, Betty Manrique-Espinoza, Karla Moreno-Tamayo, Vanessa De la Cruz-Góngora, Gustavo Ángeles, and Aarón Salinas-Rodríguez, "Heterogeneous impact of the non-contributory pension programme 70 y más on nutritional status of the elderly in rural Mexico," *The Lancet*, Vol. 381, 2013, p. S143.
- Torres Ornelas, Pompilio, Evangelista Salazar, Juan José, and Homero Martínez-Salgado, "Coexistence of obesity and anemia in children between 2 and 18 years of age in Mexico," *Boletín médico del Hospital Infantil de México*, Vol. 68, No. 6, 2011, pp. 431-437.
- Tucker, Jared M, Gregory J Welk, and Nicholas K Beyler, "Physical activity in US adults: compliance with the physical activity guidelines for Americans," *American journal of preventive medicine*, Vol. 40, No. 4, 2011, pp. 454-461.
- U.S. Department of Agriculture, "Obama administration details healthy food financing initiative," *Washington (DC)*, 2010. As of February 21, 2014:
- <http://www.usda.gov/wps/portal/usda/usdamediafb?contentid=2010/02/0077.xml&printable=true&contentidonly=true>
- U.S. Department of Agriculture, "Food Access Research Atlas Online Tool," *Washington (DC)*, 2013. As of September 10, 2014:
- <http://www.ers.usda.gov/data-products/food-access-research-atlas/go-to-the-atlas.aspx#.U-IVh4BdXMY>
- U.S. Department of Health and Human Services, "Strategic Plan 2010–2015," Updated March 2014. As of November 21, 2014:
- <http://www.hhs.gov/secretary/about/priorities/priorities.html>
- US Census Bureau, "Census 2010," 2010. As of February 8, 2014:
- <http://www.census.gov/2010census>
- Ver Ploeg M, Breneman V, Farrigan T, Hamrick K, Hopkins D, Kaufman P, et al., "Access to affordable and nutritious food — measuring and understanding food deserts and their consequences: report to Congress," *US Department of Agriculture, Washington DC*, Vol. USDA/ERS 2009; Publ AP-036, 2009. As of August 12, 2014:
- http://www.ers.usda.gov/media/242675/ap036_1_.pdf
- Ver Ploeg, Michele, *Access to affordable and nutritious food: measuring and understanding food deserts and their consequences: report to Congress*. DIANE Publishing, 2010.

- Villareal, Dennis T, Caroline M Apovian, Robert F Kushner, and Samuel Klein, "Obesity in older adults: technical review and position statement of the American Society for Nutrition and NAASO, The Obesity Society," *Obesity Research*, Vol. 13, No. 11, 2005, pp. 1849-1863.
- Walker, Renee E, Christopher R Keane, and Jessica G Burke, "Disparities and access to healthy food in the United States: a review of food deserts literature," *Health & place*, Vol. 16, No. 5, 2010, pp. 876-884.
- Wang, Youfa, and May A Beydoun, "The obesity epidemic in the United States—gender, age, socioeconomic, racial/ethnic, and geographic characteristics: a systematic review and meta-regression analysis," *Epidemiologic reviews*, Vol. 29, No. 1, 2007, pp. 6-28.
- Waxman, Amalia, *Why a global strategy on diet, physical activity and health?*, Vol. 95: Karger Publishers, 2005.
- White House Task Force on Childhood Obesity, "Solving the problem of childhood obesity within a generation, Report to the President," *Washington (DC): Executive Office of the President of the United States*, 2010. As of August 12, 2014:
<http://www.letsmove.gov/white-house-task-force-childhood-obesity-report-president>
- Willmore, Larry, "Universal pensions for developing countries," *World Development*, Vol. 35, No. 1, 2007, pp. 24-51.
- World Health Organization (WHO), "Health Topics: Obesity," *Geneva (CH)*. As of February 8, 2014:
<http://www.who.int/topics/obesity/en/>
- World Health Organization (WHO), "Obesity and Overweight. Factsheet No. 311, Geneva (CH).", 2015. As of June 01, 2015:
<http://www.who.int/mediacentre/factsheets/fs311/en/>
- Zamboni, Mazzali, G Mazzali, E Zoico, TB Harris, JB Meigs, V Di Francesco, F Fantin, L Bissoli, and O Bosello, "Health consequences of obesity in the elderly: a review of four unresolved questions," *International journal of obesity*, Vol. 29, No. 9, 2005, pp. 1011-1029.