

The Determinants of Childhood Obesity: Child, Parental, Social, and Regional Influences

by
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I hereby recognize and pledge to fulfill my responsibilities, as defined by the Honor Code, and to maintain the integrity of both myself and the College community as a whole.

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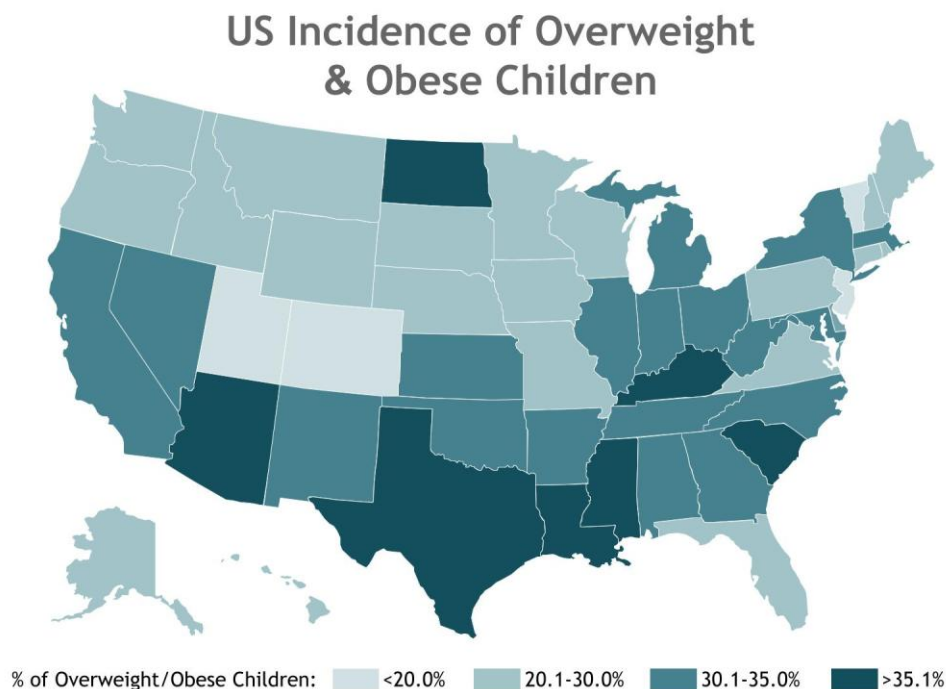
Abstract

With a third of children classified as overweight or obese, the U.S. needs more innovative parenting strategies and governmental policies. This study examines the importance of child (exercise, sleep, hours of television, and religious attendance), parental (marital status, education, income, and weight), societal (family meals, ethnic diversity, families receiving SNAP benefits, Modified Retail Food Environment Index, and families living in safe neighborhoods), and regional (dummy variable for geographic location) characteristics on the likelihood of a child being overweight or obese. An analysis of consumer theory examines household consumption decisions based on a parental understanding of how to maximize long-term utility and avoid the negative consequences of poor nutrition and over-eating. The regression analysis, with a R^2 value of 0.8203, quantifies the impacts of these variables, showing the rate of adult obesity, family meals, food retail environment, living in the South, child sleep, and perceived neighborhood safety are the most significant. These results conform to theory and correlate with past research. The evidence indicates that parents should modify their parenting strategies to focus on maintaining a healthy weight, encouraging their children to get more hours of sleep, and choosing a healthy place to live.

Chapter I - The Determinants of Childhood Obesity: Overview

This paper attempts to correlate several child, parental, social, and regional influences with rates of overweight and obese children in the United States. An analysis of these characteristics may offer an explanation for why one out of every three children ages 10-17 is overweight or obese. The large number of above healthy weight children, shown in Figure 1.1, is a large-scale crisis with urgency rooted in both ethical and economic concerns. First Lady Michelle Obama announced at the launch of her Let's Move campaign that "The physical and emotional health of an entire generation and the economic health and security of our nation is at stake" (Office of the First Lady, 2010).

Figure 1.1 States by Overweight and Obesity Rates among 10-17 Year Olds in 2011/12



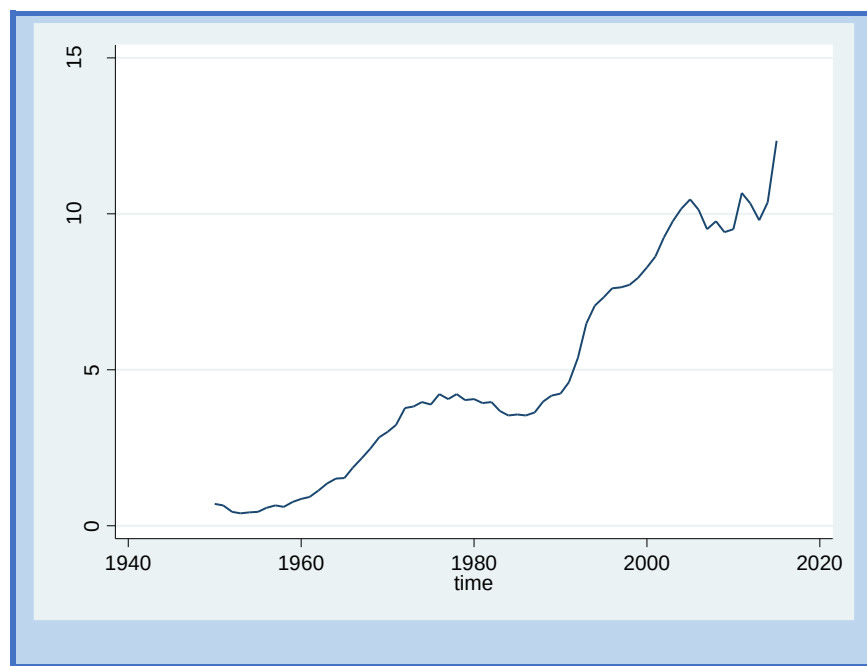
Note. Data from the 2011/2012 National Survey of Children's Health

Whitaker, Wright, Seidel, and Dietz (1997) reaffirm that childhood obesity is a grave disease that affects both health costs and quality of life for adolescents (p. 869). Findings from the Center for Disease Control and Prevention (CDC) states that overweight and obese children are presently at risk for high blood pressure and cholesterol, impaired glucose tolerance, insulin resistance, and type 2 diabetes, breathing problems (sleep apnea and asthma), joint problems and musculoskeletal discomfort, fatty liver disease, gallstones, gastro-esophageal reflux (heartburn), and psychological (low self-esteem, depression), social, and learning problems (2012, p. 1). Cawley and Spiess (2008) found these learning problems include reduced verbal, social, and motor skills in daily activity (p. 388).

These immediate problems transform into long-term consequences, as these children have a much higher likelihood of suffering from heart disease, diabetes, cancers, continued obesity, and other serious medical conditions when they reach adulthood (CDC, 2012, p. 1). According to Cunningham, Kramer, and Narayan (2014), overweight 5-year-olds were four times as likely as normal-weight children to become obese later in life (p. 403).

Many of these expensive, chronic diseases vastly increase individual health care costs. Cawley and Meyerhoefer (2010) found that in 2008, medical expenditures related to obesity averaged \$3,115 per obese person per year, summing to \$185.7 billion for the nation (2008 dollars, p. 1). Figure 1.2 shows the percentage of federal spending designated for health from 1950-2015, which starts at 0.70 percent and increases to 12.35 percent.

Figure 1.2 Percentage of Federal Budget Spent on Health, 1950-2015



Note. Data from the 2014 Economic Report of the President

While the causes of this epidemic are numerous and multifaceted, a large body of research has indicated that the factor most prominently affecting children is their parents (Lindsay, Sussner, Kim, & Gortmaker, 2006, p. 169). Not only do they teach by example, but they supply the type and quantity of food their child consumes. These actions are based on a number of factors that determine parental preferences, such as priorities, knowledge, cultural norms, and budgetary restrictions.

Outside of the home, schools influence consumption habits through nutritional education, school provided lunch and snacks, and access to foods from bake sales or vending machines. Anderson and Butcher found that “a 10 percentage point increase in the probability of access to junk food leads to about a one percent increase in students' body mass index... [suggesting] that the increase in availability of junk foods in schools can account for about one-fifth of the increase in average BMI among adolescents over the last decade (1995-2005)” (2005, p. 1).

Furthermore, the sedentary lifestyle of technology driven entertainment and the constant bombardment of advertising has affected child weight. A study by Gortmaker, Must, Sobol, Peterson, Colditz, and Dietz (1996) found a strong correlation between increased hours watching television and increased body weight amongst adolescents, where children who watched more than five hours of television a day were 4.6 times as likely to overweight compared to children watching less than two hours (p. 356). Another study found that banning television fast-food restaurant advertising messages would decrease the number of overweight children and adolescents by 10-12 percent (Chou, Rashad, & Grossman, 2005, p. 1).



The USDA Food Pyramid used from 1992-2005 supported a grain based diet. Note. Photo from http://en.wikipedia.org/wiki/Food_guide_pyramid

Lastly, the government plays a role through food and nutrition regulation in the form of dietary guidelines, nutritional education, agricultural subsidies, food distribution, and health care. The food pyramid used from 1992-2005 promoted a diet of six to eleven servings of grains and only two to three servings of protein. Studies have shown that this type of diet not only contributed to the

increase in obesity but has created a generational problem (Hite et al. 2010, p. 915). Another study, by Millimet, Tchernis, and Husain (2010), found that the federal School Breakfast Program (SBP) has helped to decrease incidence of childhood obesity, while the National School Lunch Program (NSLP) has, in fact, worsened the epidemic (p. 640).

In order to address these issues, this chapter covers four major topics. Section 1.1 reviews the terminology and measuring techniques related to childhood weight. Section 1.2 presents a preliminary view of the data by examining trends in child weight related to child, parental,

social, and regional factors. Lastly section 1.3 concludes by briefly introducing the connection between parental decisions and utility maximization.

1.1 Childhood Obesity, Defining Terms

Discussing the issue of children weight requires a review of terminology and measuring techniques. The data are usually measured by the Body Mass Index (BMI), which is defined by the CDC as:

Body Mass Index (BMI) is a number calculated from a child's weight and height... [that] correlates to direct measures of body fat. BMI is an inexpensive and easy-to-perform method of screening for weight categories that may lead to health problems. For children and teens, BMI is age- and sex-specific and is often referred to as BMI-for-age (2012, p. 1).

To determine BMI, a parent or physician first measures the height, in inches, and weight, in pounds, of the child and then inputs the measurements into the following formula:

$$BMI = \frac{weight (lb)}{[height (in)]^2} \times 703.$$

John, a ten year old boy, serves as an example. If he is 56 inches tall and weighs 80 pounds, his BMI would be:

$$BMI = \frac{80}{56^2} \times 703 = 18.$$

This number is then used to place John within a specific percentile. The CDC also describes how the BMI is used in terms of percentiles:

After BMI is calculated for children and teens, the BMI number is plotted on the CDC BMI-for-age growth charts (for either girls or boys) to obtain a percentile ranking. Percentiles are the most commonly used indicator to assess the size and growth patterns of individual children in

the United States. The percentile indicates the relative position of the child's BMI number among children of the same sex and age (2012, p. 1).

These percentiles have corresponding weight status categories designated by the CDC, as shown in Table 1.1.

Table 1.1 CDC BMI Percentile Ranges

Weight Status Category	Percentile Range
Underweight	Less than the 5th percentile
Healthy Weight	5th percentile to less than the 85th percentile
Overweight	85th to less than the 95th percentile
Obese	Equal to or greater than the 95th percentile

Note. Information from the CDC's "Basics About Childhood Weight"

Thus to determine his weight category, John's doctor would compare his measurements to the BMI-for-Age Percentile Growth Chart for young boys. As shown in Figure 1.3, this chart contains age on the horizontal axis, BMI on the vertical axis, and a number of curved lines delineating weight percentiles. Tracing a BMI of 18 from the vertical axis, to the age of 10 years on the horizontal axis, shows John within the green zone. This zone represents the healthy weight zone from the 5th to the less than 85th percentile.

As the following calculations show, if John weighed 94 pounds he would be considered overweight, and if he weighed 98 pounds or more he would be considered obese.

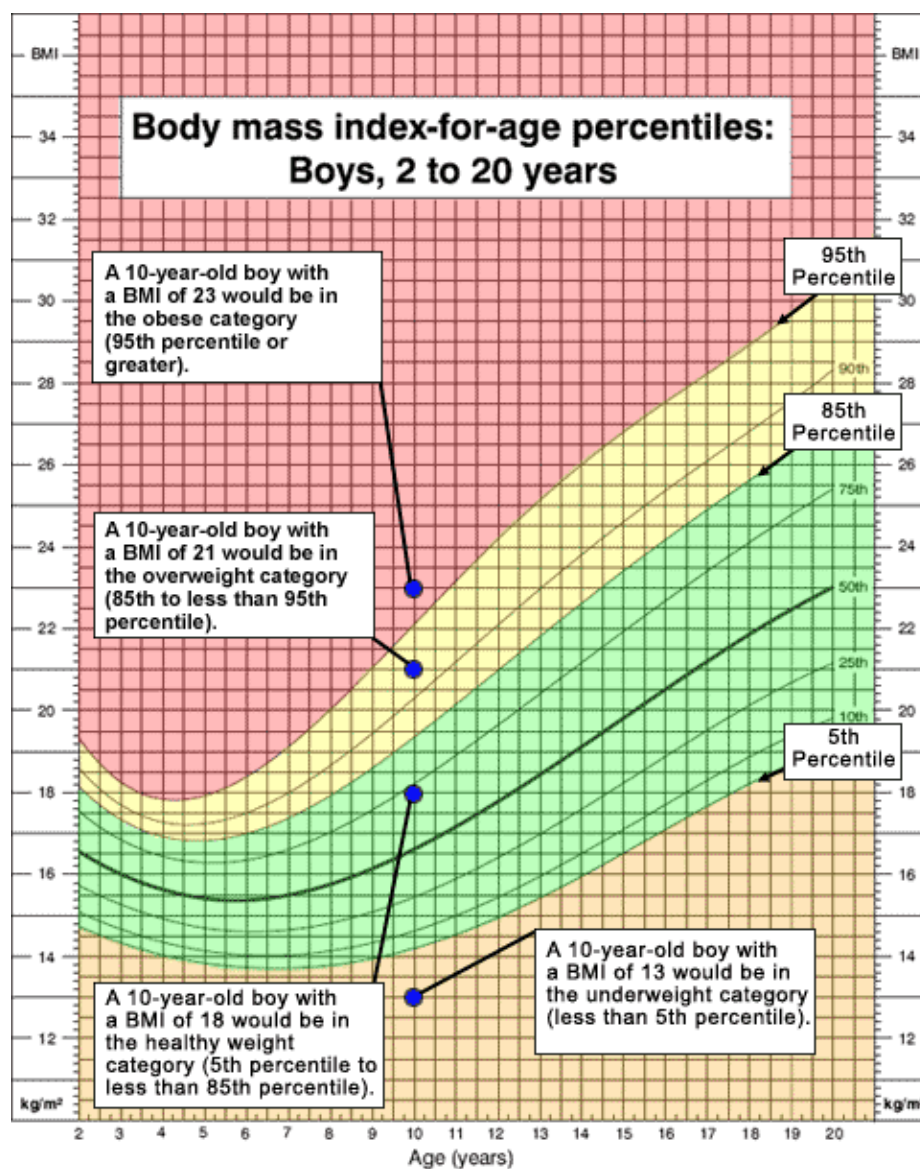
$$BMI = \frac{94}{56^2} \times 703 = 21$$

$$BMI = \frac{98}{56^2} \times 703 = 22$$

Tracing the hypothetical BMIs of 21 and 22 shows that John would first land in the yellow zone (overweight, 85th to 95th percentile) and then the red zone (obese, above 95th

percentile). This study focuses on adolescence within the overweight and obese zones (85th to 100th percentile).

Figure 1.3 Body Mass Index-for-Age Percentiles: Boys, 2-20 Years



Note. Figure retrieved from the CDC's "Basics about Childhood Weight"

1.2 Overweight and Obesity Trends

This section explores the determinants of unhealthy weight among adolescence within the CDC overweight and obese percentiles. These determining factors are subdivided into parental, child, societal, and regional categories. Child exercise, sleep, hours of television, and attendance of religious services are included, in addition to parental education, income, marital status, obesity, and ethnicity. The model also includes frequency of family meals, families receiving SNAP benefits, families living in safe neighborhoods, the Modified Retail Food Environment Index, and a dummy variable for geographic location. The data sources used for the regression model are presented in Chapter III. These various factors thought to affect child weight are referenced throughout this study using the abbreviations shown in Table 1.2.

Table 1.2 Abbreviations

Abbreviations	Definitions
cobrate	Overweight and obesity rate among children
cexrcs7	Child exercises every day of the week
csleep7	Child gets adequate sleep every night of the week
ctvhrcs4	Child watches more than four hours of television daily
crelig52	Child attends religious service weekly
snglrate	Child living in single-parent households
hsedrate	Child living with a parent who has a HS Diploma
mincm	Median income
aobrate	Obesity Rate among adults
peat47	Child in family that eats together 4-7 times a week
white	Percentage of population that is white
snap	Families receiving SNAP assistance
mrfei	Modified Retail Food Environ Index (mRFEI) score
safen	Child living in safe neighborhoods
dummw, dumw, & dums	Location dummy variable for Northeast, Midwest, West, & South

The figures in this section identify the strength and direction of the relationships between adolescent weight and each individual determinant. The horizontal-axes of Figures 1.4 through 1.16 include the fifty states, while the vertical axis varies for each figure to reflect the different determinants. While the raw data is shown in the appendix, Table 1.3 shows a summary of the average, median, range, and standard deviation of the data. The standard deviation measures the level of dispersion within a set of data, showing whether the data are closely grouped around the average or distributed widely (Casler 2013).

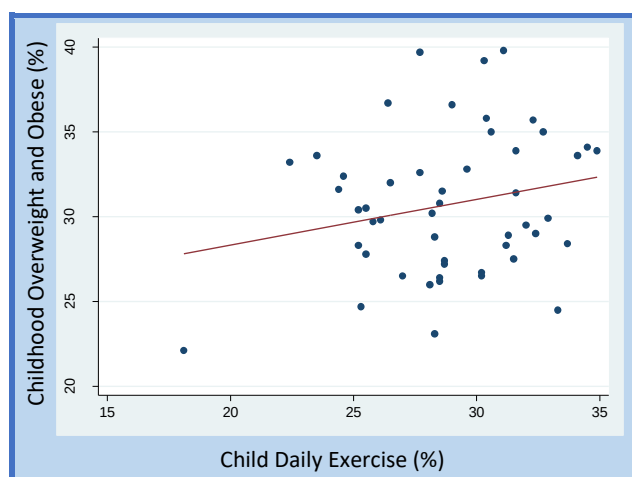
Table 1.3 Obesity Rates and Demographic Characteristics, Summary Measures of the Data

Variables	Average	Median	Minimum	Maximum	Standard Deviation
cobrate	30.704	30.3	22.1	39.8	4.136
ctvhrs4	11.036	11.1	5.7	19.5	2.675
cexrcs7	28.854	28.65	18.1	34.9	3.34
csleep7	57.538	57.7	51.3	65.6	3.216
crelig52	49.526	49.7	21.5	69.3	10.528
snglrate	33.38	33.5	19	46	5.161
hsedrate	86.874	87.5	79.9	91.8	3.378
mincm (\$)	51974.29	50595.284	39591.793	69920.012	7692.581
aobrate	28.066	27.85	20.5	34.7	3.264
peat47	79.308	79.2	73.4	85.3	2.822
white	80.691	83.675	25.66	95.661	12.272
snap	10.328	10.03	5.192	17.367	2.907
mrfei score	10.06	10	5	16	2.319
safen	88.842	88.5	79.9	94.7	3.56

Note. Data sources listed in Chapter III

Figure 1.4 reveals that the relationship between the rate of overweight and obese children (cobrate) on the vertical axis and the rate of children who exercise daily (cexrcs7) on the horizontal axis. The blue dots represent each state, while the red line represents the average trend line. The relationship of the data points around the trend line displays a weak correlation to adolescent weight, despite the fact that exercise is a known component of reaching and maintaining a healthy weight. These data define exercise as a minimum of twenty minutes of physical activity that causes the child to sweat and breathe heavily. As defined, only 28.0 percent of children in the U.S. are exercising daily (The National Survey of Children's Health – NSCH, 2011-12).

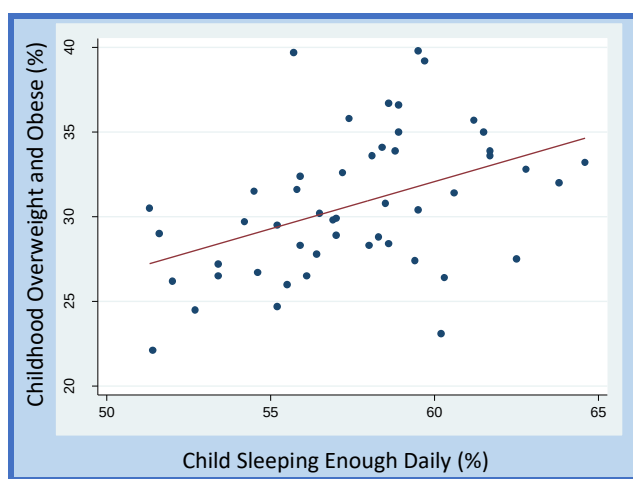
Figure 1.4 Childhood Weight and Exercise



Note. Data from the NSCH, 2011-12

Additionally sleep deprivation is a significant and somewhat overlooked cause of weight gain. Figure 1.5 contains the rate of overweight and obese children (cbrate) on the vertical axis and the rate of children who get sufficient sleep every night (csleep7) on the horizontal. In their analysis of the child weight and sleep routines, Chen, Beydoun, and Wang (2008) found that children who sleep fewer hours are at a 58 percent higher risk of being above healthy weight compared to children sleeping a healthy number of hours each night. This risk increases to 92 percent amongst the most sleep-deprived children. They also determined that, as a child sleeps one additional hour, their risk of being overweight or obese decreases by 9 percent. They list elevated cortisol levels, impaired glucose intolerance, excessive food intake, and insulin resistance as possible contributing factors (p. 265). Additionally tired children are less likely to exercise. In the U.S. only 58.2 percent of children get sufficient sleep every night (NSCH, 2011-12). These results indicate that increasing child sleep duration may be the most cost effective and practical means of preventing and reducing childhood obesity.

Figure 1.5 Child Weight and Sleep

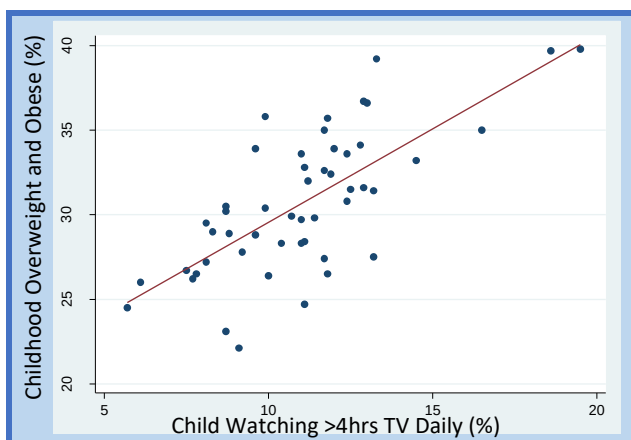


Note. Data from the NSCH, 2011-12

Figure 1.6 shows the rate of child weight (obesity) as a function of the rate of children who watch or play more than four hours of television, movie, and videogame entertainment each week (ctvhrs4). The tightly clustered nature of the blue dots and steeper slope of the red trend line indicate a very strong relationship. The two dots in the upper right-hand corner, Louisiana and Mississippi, represent the extremes of this trend, while the national average is 11.6 percent of children (NSCH, 2011-12).

This variable is important because television is not just a sedentary activity that replaces active playtime, but it contains a massive amount of advertising. It is self-promotional in the sense that it encourages the continued and increased consumption of media, while also endorsing the physical consumption of many processed and unhealthy foods and beverages. Stitt and Kunkel (2008) found that every hour of child television programming contains an average of eleven food ads for “high-calorie, low nutrient food products that should not be part of a regular diet” (p. 573). Lastly, it conveys a cultural stigma against overweight individuals that can have a severe effect on a child’s psychological health and sense of self-worth (Latner, Rosewallb, & Simmonds, 2007, p. 147).

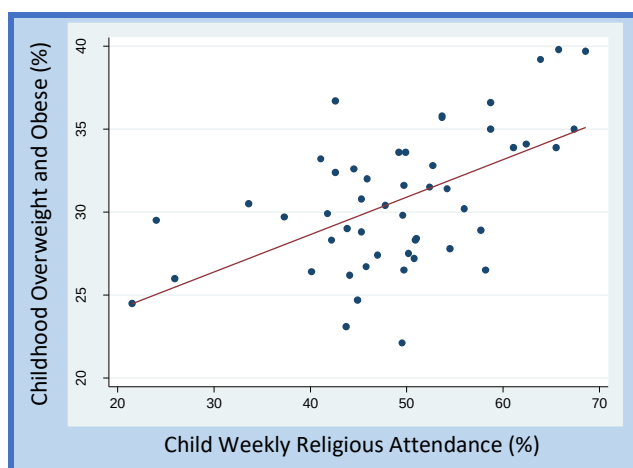
Figure 1.6 Child Weight and Hours of Television



Note. Data from the NSCH, 2011-12

Figure 1.7 displays the relationship between the child weight (cobrate) and the rate of children who attend a religious service weekly (crelig52). Past studies show the impact of religious attendance and increased spirituality has mixed results on weight. In the US, adult church attendance typically correlates with an increased BMI in all states and religions. Researchers have speculated that religion in the U.S. focuses more heavily on the flawed nature of humanity and less on the importance of maintaining good health and avoiding gluttony (Cline & Ferraro, 2008, p. 269). Nonetheless the impact of a close-knit social network may positively influence children's sense of wellbeing and provide more educational opportunities to maintain a healthier lifestyle. Thus the influence of religious attendance on child BMI is somewhat unclear. The data in Figure 1.7 show an overall increase in BMI with an increase in attendance. This variable merits further research, as 50.6 percent of children in the U.S attend a religious service weekly (NSCH, 2011-12).

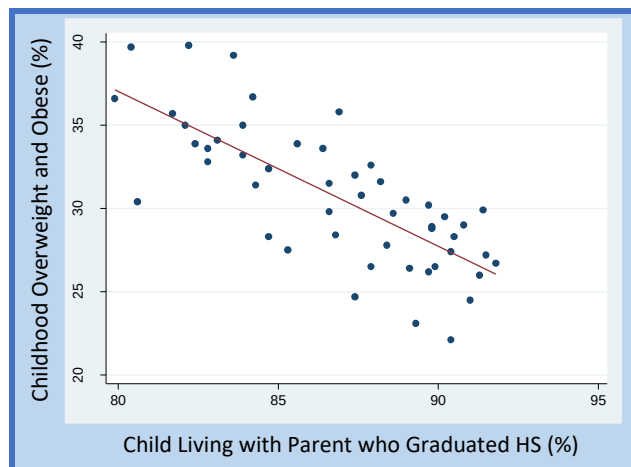
Figure 1.7 Child Weight and Religious Attendance



Note. Data from the NSCH, 2011-12

The previous figures displayed variables directly related to the activities of the children themselves, while the following are related to their parents. Figure 1.8 shows that if at least one parent in the household has attained a high school diploma or higher educational degree, the child is much less likely to be obese or overweight. Child weight (cbrate) and the rate of children living with a parent who has graduated high school (hsedrate) are strongly correlated, as shown by the steep angle of the average trend line. This tight relationship may be negative due to increased awareness about healthy eating and exercise, combined with a higher income for healthier foods.

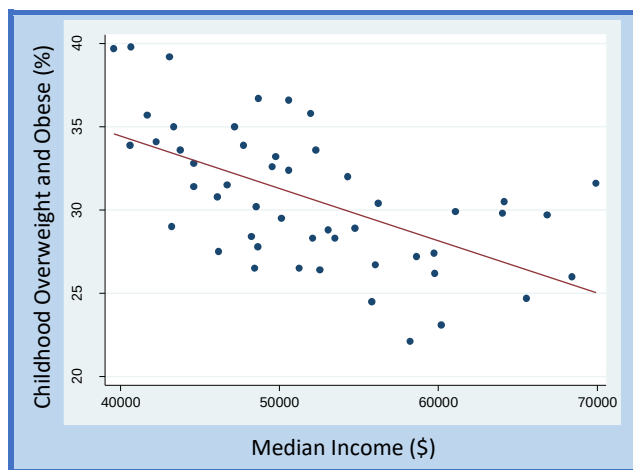
Figure 1.8 Child Weight and Parental Education



Note. Data from the U.S. Census Bureau's 2012 Statistical Abstract and the NSCH, 2011-12

Comparing the median income of the state (mincm - in dollars) and child weight (cobrate), Figure 1.9 shows that income has a strong effect on child weight. When a family lives in a state with a higher median income level there is a decreased likelihood of the child being above healthy weight. The negative relationship of the trend line may be due to increased food budgets, but also living in affluent neighborhoods with less fast food restaurants and better access to nutritious alternatives. Strauss and Knight (1999) documented strong inverse correlations between childhood weight and both family income and parental educational attainment in *Influence of the home environment on the development of obesity in children* (p. e85).

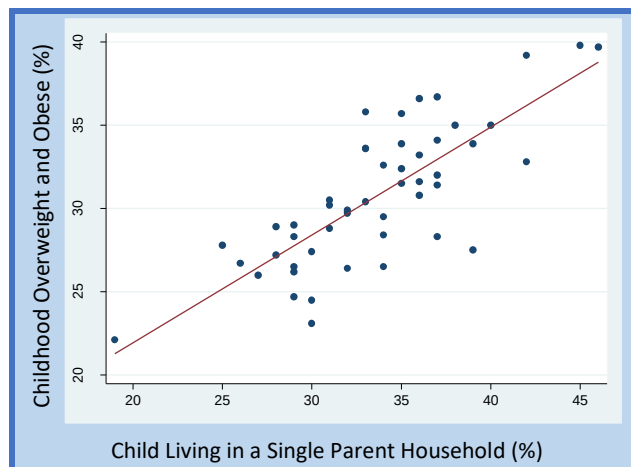
Figure 1.9 Child Weight and Median Income



Note. Data from the U.S. Census Bureau and the NSCH, 2011-12

Figure 1.10 shows that the incidence of children living in single parent households (snglrate) is strongly correlated with increased levels of overweight and obese children (cobrate). Research by Gibson et al. (2007) in their paper, titled *The role of family and maternal factors in childhood obesity*, reaffirm the positive relationship shown with these data (p. 591). Additionally, Huffman, Kanikireddy, and Patel (2010) published findings in their article, *Parenthood—A Contributing factor to childhood obesity*, linking single parent-households to eating fewer meals together, eating foods with higher sugar and fat contents, watching more television, and being more impoverished (p. 2800).

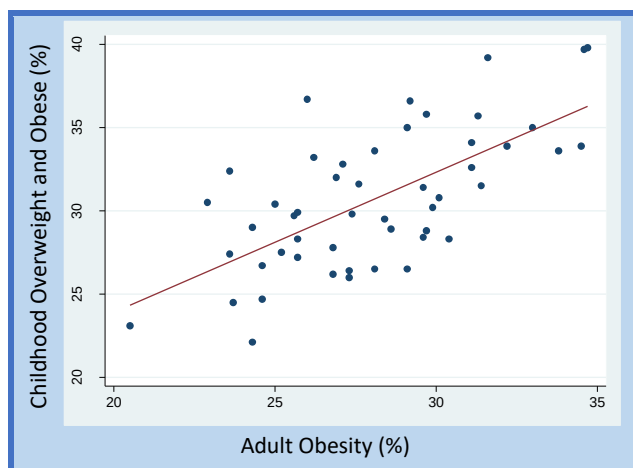
Figure 1.10 Child Weight and Parental Marital Status



Note. Data from the U.S. Census Bureau and the NSCH, 2011-12

Figure 1.11 displays a strong, positive relationship between parental obesity (aobrate) and child weight (cobrate). This relationship indicates that parents cannot successfully say “do as I say, not as I do.” Parents teach by example and control the type and quantity of food that is accessible in the child’s food environment. If a parent purchases doughnuts, potato chips, soda, and fast food, that is what the child will likely consume. They are also likely to miss out on opportunities to learn about healthy food, acquire cooking skills, and establish healthy habits early on in life.

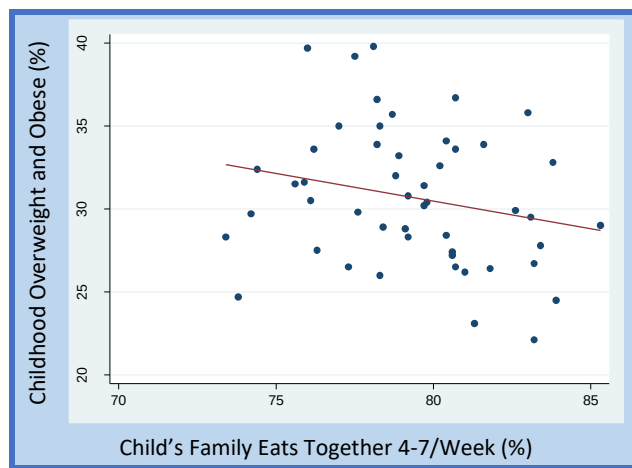
Figure 1.11 Child and Adult Weight



Note. Data from the CDC and the NSCH, 2011-12

This last group of figures shows some social, cultural, and political influences on child weight. Figure 1.12 shows child weight (cobrate) versus the rate of families who eat 4-7 meals together each week (peat47). This variable relates both the types of food and the portion sizes parents are serving or purchasing for their children. The number of meals together measures parental influence over what the child is actually eating.

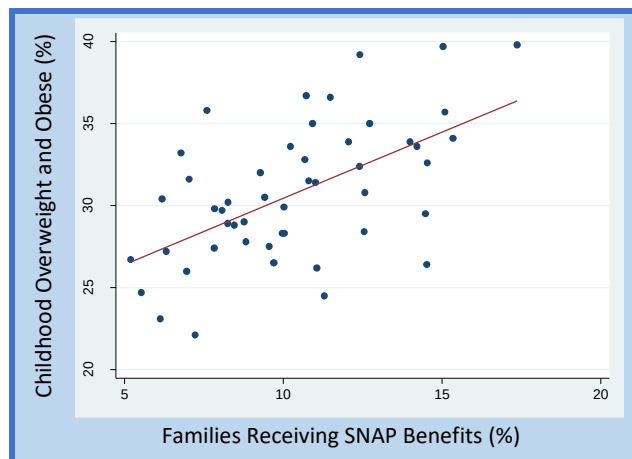
Figure 1.12 Child Weight and Family Meals



Note. Data from the NSCH, 2011-12

Figure 1.13 explores the relationship between child weight (cobrate) and family participation in the federal Supplemental Nutrition Assistance Program (snap). While the dispersal of the data points indicates a weak relationship, a study examining the long-term impact of participation in SNAP found 5-11 years olds to be at a significantly lower risk of being overweight or obese. While the program has more negative outcomes for adults, it is found that SNAP participation is effective in decreasing childhood weight (Schmeiser, 2011, p. 386). This may be due to decreased food insecurity and larger food budgets.

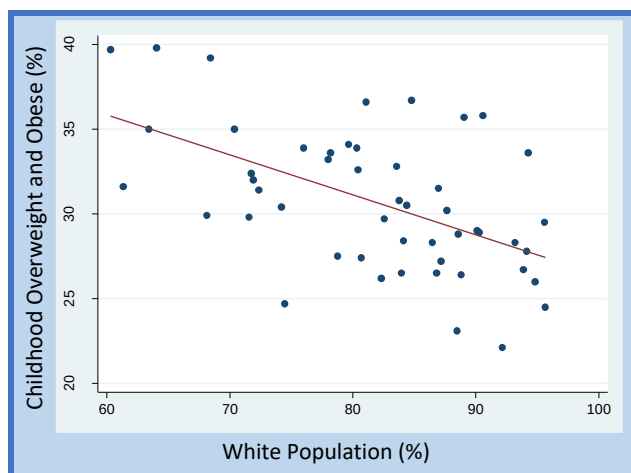
Figure 1.13 Child Weight and SNAP Participation



Note. Data from the U.S. Census Bureau and the NSCH, 2011-12

According to Taveras et al. (2010) racial and ethnic disparities in obesity prevalence are present as early as a child's preschool years (p. 686). Their study found that early-life risk factors, such as maternal depression, rapid weight gain in infancy, premature introduction to solid foods, fewer hours of sleep, and less breastfeeding were more common amongst black and Hispanic children. Additionally, after the age of two, these children are more likely to have a television in their bedrooms and to consume more sugar-sweetened beverages and fast food. These results are confirmed by the negative trend line shown in Figure 1.14 between child weight (obesity) and the percentage of the population that is white (white).

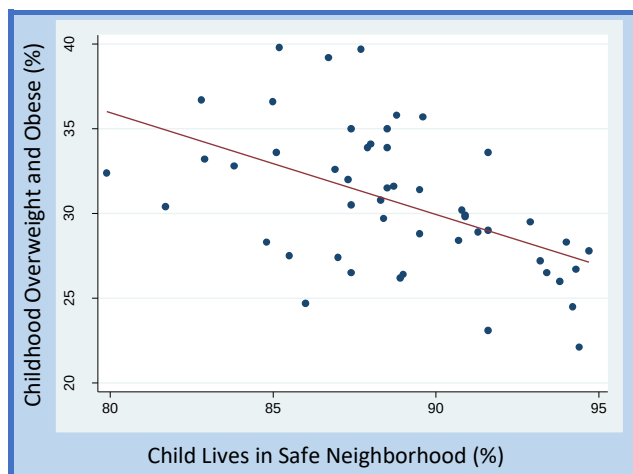
Figure 1.14 Child Weight and Ethnic Diversity



Note. Data from the U.S. Census Bureau and the NSCH, 2011-12

As shown in Figure 1.15, neighborhoods that are considered safe by parents are associated with decreased child weight. These neighborhoods are commonly void of street crime and drug use, allowing parents to feel more comfortable with their children playing outdoors. Thus safer areas correlate with increased outdoor play time. Additionally neighborhoods that are perceived as safer may have well-kept and utilized parks or other gathering areas that lead to close knit friendships and community bonds. Molnar, Gortmaker, Bull, and Buka (2004) show that decreased neighborhood safety and increased social disorder were significantly associated with less physical activity amongst youths in Chicago, IL (p. 378). As their study shows, youths living in urban areas without safe recreational areas may be at a higher risk for obesity.

Figure 1.15 Child Weight and Neighborhood Safety



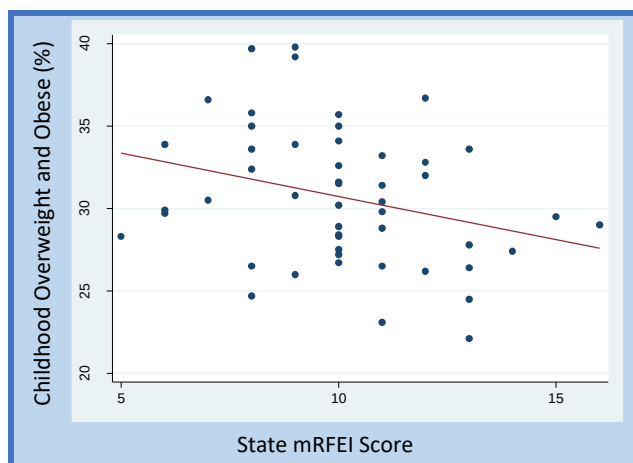
Note. Data from the NSCH, 2011-12

Additionally, a measure of available food options is included to account for each state's food environment. The Modified Retail Food Environment Index, created by the U.S. Census Bureau, constructs a composite score using the following formula:

$$mRFEI \text{ Score} = \frac{\text{Number of Health Retailers}}{\text{Number of Healthy Retailers} + \text{Less Healthy Retailers}} * 100.$$

The Census defines healthy retailers as supermarkets, large grocery stores, supercenters, and produce stores, while less healthy retailers are defined as convenience stores, fast food restaurants, and small grocery stores (Children's Food Environment State Indicator Report, 2011, p. 3-4). Figure 1.16 shows a higher rate of healthy retailers is associated with decreased levels of overweight and obese children. All scores are recorded as whole numbers, thus creating the vertical line patterns shown in the figure.

Figure 1.16 Child Weight and Retail Food Environment



Note. Data from the CDC's 2011 Children's Food Environment State Indicator Report and the NSCH, 2011-12

Finally, an analysis of geographic weight trends by Singh, Kogan, and van Dyck (2008) shows that the Southeastern region of the U.S. has the highest prevalence of overweight and obese children, while the Western region has the lowest (p. 90). The geographic trends may be related to weather factors, like humidity and temperature, or cultural factors, like the importance of appearance or playing sports.

1.3 Conclusion

The data presented in this chapter show that the above healthy weight trend is widespread and related to a variety of characteristics. It is a problem responsible for fostering a



First Lady Michelle Obama speaking at her *Let's Move!* campaign. Choosing to focus on childhood obesity has made her the face of a nationwide movement.

Note. Photo received from <http://libertyresource.com>

disadvantaged generation that faces a lower quality of life, higher medical bills, and decreased productivity (Wolf & Colditz, 1998, p. 97). Michelle Obama also said, "Our kids didn't do this to themselves. They don't decide the sugar content in soda or the advertising content of a television show. Kids don't choose what's served to them

for lunch at school, and shouldn't be deciding what's served to them for dinner at home. And they don't decide whether there's time in the day or room in the budget to learn about healthy eating or to spend time playing outside" (Office of the First Lady, 2010). Many of these factors are based on parental understanding of how to maximize utility for their child, which is illustrated in the next chapter using the theory of the consumer.

As more parents strive to get their child to reach or maintain a healthy weight, they struggle with incomplete information. Parents need to learn about the true costs of buying less nutritious food and find a balance between health, flavor, cost, and immediate satisfaction. They

cannot truly maximizing long-term utility without considering the negative consequences of poor nutrition and over-eating on their child's future.

The chapters that follow initially examine household consumption decisions by analyzing components of the theory of the consumer. This helps discern the possible causes of unhealthy weight among certain children by examining how utility-maximizing decisions are made by their parents. Chapter III justifies the use of each variable and identifies their expected effect on child weight. The chapter continues by employing a regression analysis that quantifies the impacts of key variables, in addition to measuring the strength of the variables and the model as a whole. As shown in Chapter IV, this knowledge can help parents modify their decisions and assist school and government officials in formulating policies to target those in need of nutritious food and increased levels of exercise.

Chapter II - Household Consumption Decisions, Child Weight, and the Theory of the Consumer

The figures and statistics from Chapter I show that child weight is a complex issue with a wide range of determinants. The purpose of this chapter is to examine the main components of the theory of the consumer within a context of parental and household decision-making. Sections 2.1-2.5 cover the model's assumptions, utility curve, budget constraint, optimality rule, comparative static analysis, and the income and substitution, in order to understand the choices parents make.

2.1 The Utility Curve: Fundamental Characteristics

The utility curve, also known as an indifference curve, shows bundles of goods that provide the consumer with equal levels of utility or satisfaction. It exists on an indifference map, which contains a plot with a different good on each axis (Leftwich, 1970, p.70, 99). To demonstrate the curve in the context of healthy eating, this model simplifies household consumption options into two goods, apples (A) and doughnuts (D).

The slope of the curve, known as the marginal rate of substitution, is that rate at which the family must substitute one good for the other, while maintaining the same satisfaction with its purchase (Leftwich, 1970, p.73). As it travels along the curve, the family gives up doughnuts in order to obtain one more apple, while keeping overall utility the same. Mathematically, this slope is the change in doughnut consumption given a one unit change in apple consumption, holding utility constant.

$$\text{Marginal Rate of Substitution (MRS)} = \frac{dD}{dA}.$$

By the Inverse Function Rule, this fraction can be transformed into the fraction of partial derivatives of utility with respect to each good,

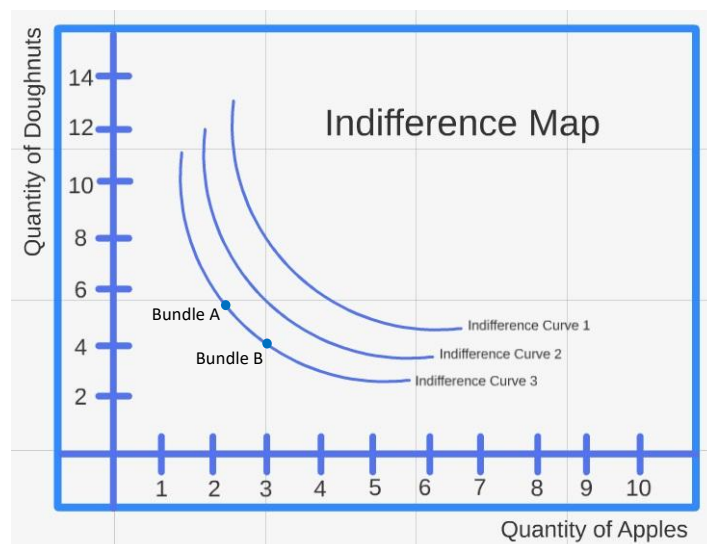
$$\frac{dD}{dA} = \frac{\frac{\partial U}{\partial A}}{\frac{\partial U}{\partial D}}$$

(Teall, p. 6). This in turn is equal to the fraction of marginal utilities. MU_A is the change in utility given a one unit increase in apple consumption, while MU_D is the change in utility given a one unit increase in doughnut consumption (Leftwich, 1970, p. 100). Thus,

$$\frac{\frac{\partial U}{\partial A}}{\frac{\partial U}{\partial D}} = \frac{MU_A}{MU_D} = MRS.$$

Figure 2.1 shows several curves on an indifference map, offering a visual representation of different bundles. A family would be equally content receiving either of the two bundles of goods at point A and B because they lie on the same indifference curve. The other two utility curves to the right represent higher levels of utility, yielding more satisfaction. They are not comparable because they reflect a higher level of consumption.

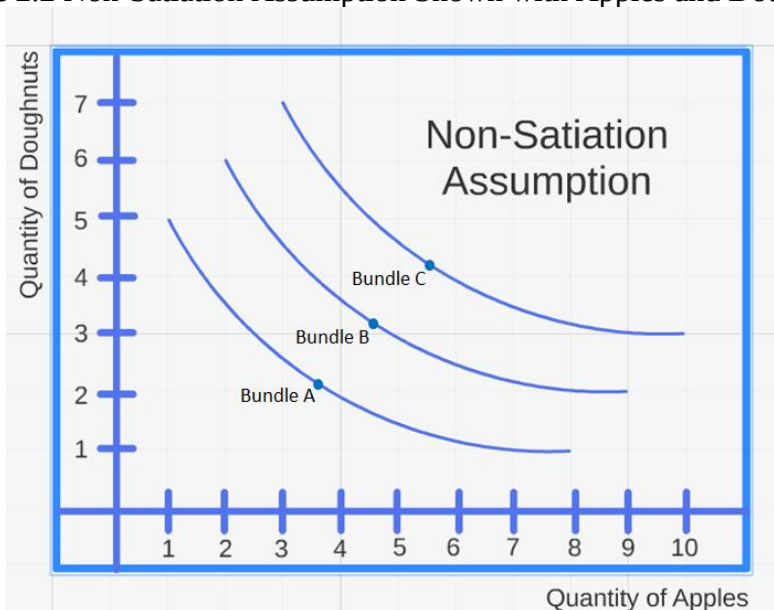
Figure 2.1 Several Indifference Curves for Apples and Doughnuts



Like all consumers, parents responsible for their child's food environment lie on a specific utility curve. According to Leftwich (1970), their utility curve and the bundles of goods they choose to buy are shaped by the three assumptions of consumer choice: preference, non-satiety, and transitivity (p. 70). Firstly, the consumer must have a preference between any two goods and can therefore rank them, one above the other. For example parents must be able to determine whether they prefer apples or doughnuts. Furthermore they need to determine whether fruit or fried foods are the better or worse option for their child.

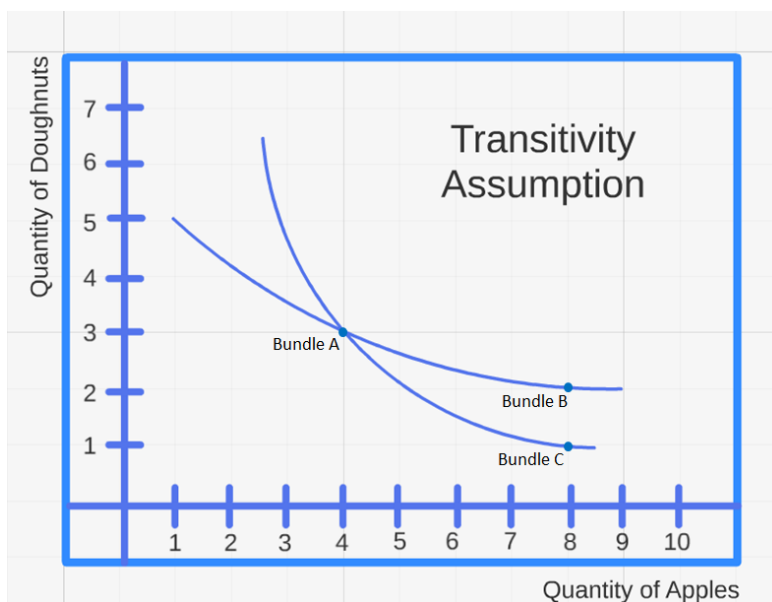
Secondly the non-satiation assumption dictates that consumers always prefer more to less, where there is no point of satiation in the consumption of any good or service. As consumers desire more of both goods they will try and move to a higher indifference curve. Figure 2.2 shows that parents will prefer Bundle C to Bundle B and Bundle B to Bundle A, due to the increasing quantity of doughnuts and apples. While the consumption of both healthy and unhealthy food does reach a desired maximum amount, this notion is neglected in order to simplify the model.

Figure 2.2 Non-Satiation Assumption Shown with Apples and Doughnuts



Lastly the transitivity assumption encompasses the preferences of two or more bundles of goods. The consumer prefers them in a linear fashion, thus being able to rank one bundle above another. For example, in Figure 2.3 there are three bundles of goods, one with three doughnuts and four apples (Bundle A), one with two doughnuts and eight apples (Bundle B), and another with one doughnut and eight apples (Bundle C). Since bundles on the same indifference curve have equal utility, Bundle A is as desirable as Bundles B and C. But, according to non-satiation, consumers always prefer more to less, indicating that Bundle C does not satiate as much as Bundle B. Because Bundle B has more doughnuts and the same quantity of apples as Bundle C, it must be on a higher indifference curve. Thus the transitivity assumption dictates that indifference curves cannot intersect.

Figure 2.3 Transitivity Assumption Shown with Apples and Doughnuts



All three assumptions play a part in maximizing utility, which is the amount of satisfaction or enjoyment the consumer gains by consuming a good or service. Parents receive utility by satisfying their desire to meet the needs of their child.

2.2 The Budget Constraint and Limited Purchasing Options

The next element of consumer theory, the budget constraint, is the limit imposed on household choices by income, wealth, and product prices (Case, Fair, & Oyster, 2012, p. 154). As noted by Leftwich (1970), “the consumer’s purchasing power and the prices of what he wants to buy determine his budget line” (p. 76).

The budget constraint is derived from an equation that shows the share of household income designated to the food budget is equal to the sum of the quantity of each good multiplied by its price.

$$I = A(P_A) + D(P_D)$$

For the quantity of doughnuts, subtract the total value of apples from each side. This value, $A(P_A)$, is comprised of the price of apples multiplied by the number of apples.

$$I - A(P_A) = D(P_D)$$

Finally divide by the price of doughnuts to isolate the quantity of doughnuts.

$$\frac{I}{P_D} - \frac{A(P_A)}{P_D} = D$$

$$D = \frac{I}{P_D} - \frac{P_A}{P_D} * A$$

Table 2.1 Budget Constraint Formula

Budget Constraint: $D = \frac{I}{P_D} - \frac{P_A}{P_D} (A)$
P_A = price of an apple A = quantity of apples consumed P_D = price of a doughnut D = the quantity of doughnuts consumed I = household income

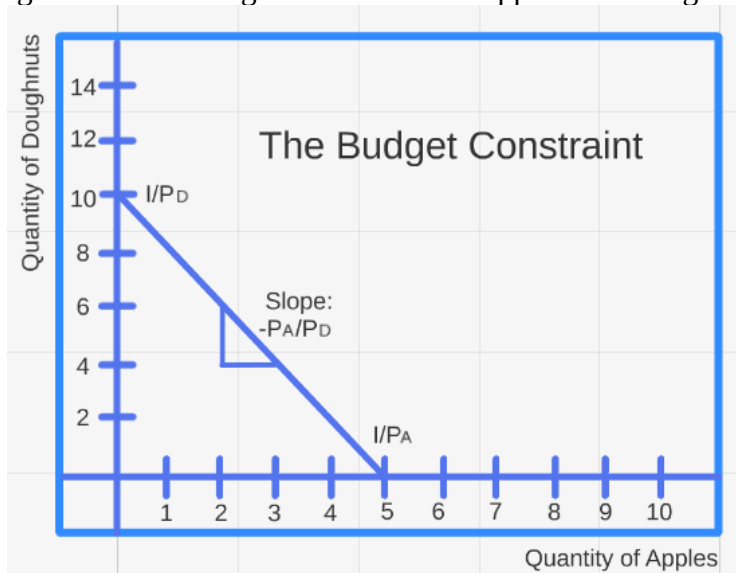
This indicates that the slope of the budget constraint is equal to the ratio of the prices of the two goods, $-P_A/P_D$ (Leftwich, 1970, p. 78). The budget constraint represents all possible combinations of apples and doughnuts given limited income, thereby quantifying the opportunity costs of buying one good instead of the other. The equation can be written as a function of either apples or doughnuts. As shown in the Table 2.1 equation, an increase in the price or quantity of apples leads to a decrease in the amount of doughnuts consumed. In a mathematical example, let the income equal \$10. If apples cost \$2 each and doughnuts costs \$1 each, then:

$$\frac{P_A}{P_D} = \frac{\$2/\text{apple}}{\$1/\text{doughnut}} = \text{consumer gives up 2 doughnuts per apple}$$

Based on these relative prices, the opportunity cost of one apple is two doughnuts and the opportunity cost of one doughnut is half of an apple.

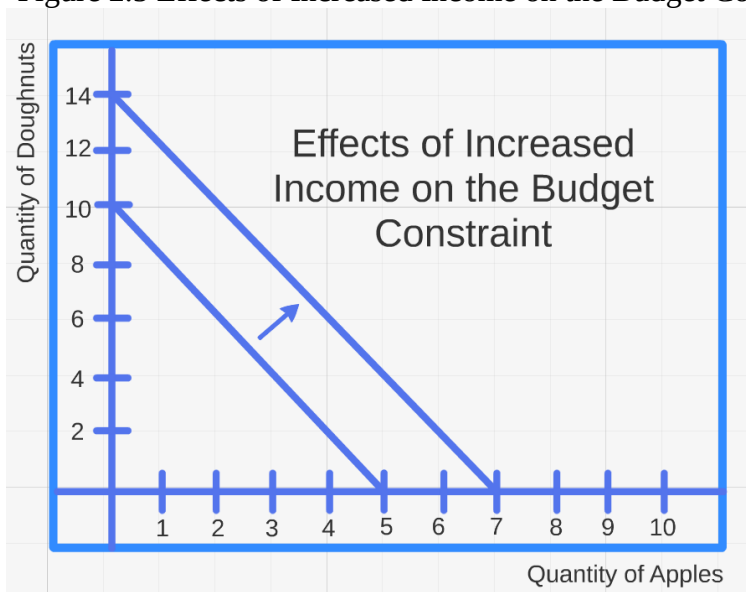
As shown in Figure 2.4, the budget line touches the horizontal axis at I/P_A , which is the maximum number of apples a parent can buy with no doughnuts. Accordingly it touches the vertical axis at I/P_D with the maximum number of doughnuts and no apples. Thus parents needs to decide whether to spend their \$10 to buy five apples, ten doughnuts, or a combination of the two. Possible examples include three apples and four doughnuts or four apples and two doughnuts.

Figure 2.4 The Budget Constraint for Apples and Doughnuts



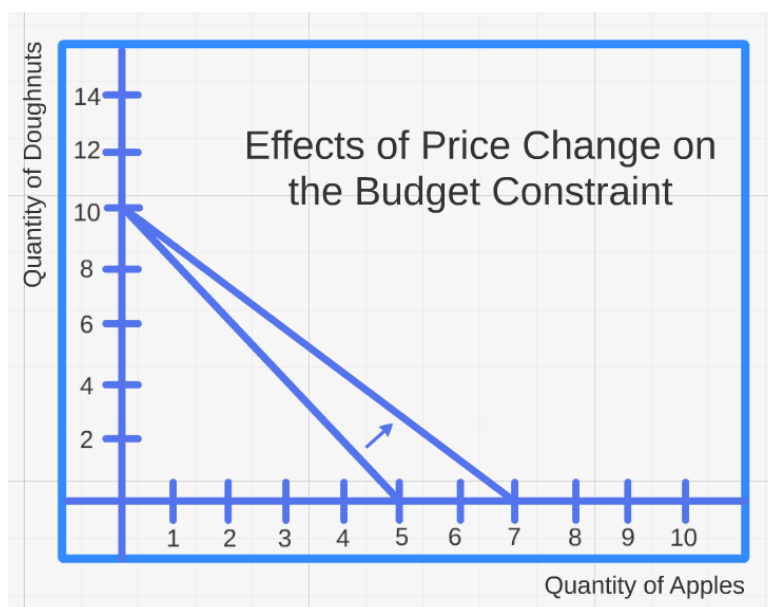
Additionally, the budget line shifts inward or outward with decreases or increases in income, while maintaining the same slope (Leftwich, 1970, p. 78). This shift is displayed in Figure 2.5. As income increases, so too does the consumption of both apples and doughnuts. The family previously had an income of \$10, allowing it to purchase a maximum of ten doughnuts or five apples. When their income increases to \$12, the budget line shifts outward, allowing them to purchase a maximum of twelve doughnuts or six apples.

Figure 2.5 Effects of Increased Income on the Budget Constraint



On the other hand the slope of the budget constraint pivots with a change in the price of apples or doughnuts (Leftwich, 1970, p. 78). Figure 2.6 shows a decrease in the cost of apples, which allows the same amount of money to buy more apples. When apples cost \$2 apiece, the family could buy a maximum of five apples with its income of \$10. When the price of apples decreased to \$1.43, the family could now afford to buy a maximum of seven apples. This does not change the cost of doughnuts and therefore does not affect the intercept. Before and after the price change of apples, the family can afford to purchase a maximum of ten doughnuts. Therefore the decline in the price of apples changes the slope of the budget constraint.

Figure 2.6 Effects of a Price Change on the Budget Constraint

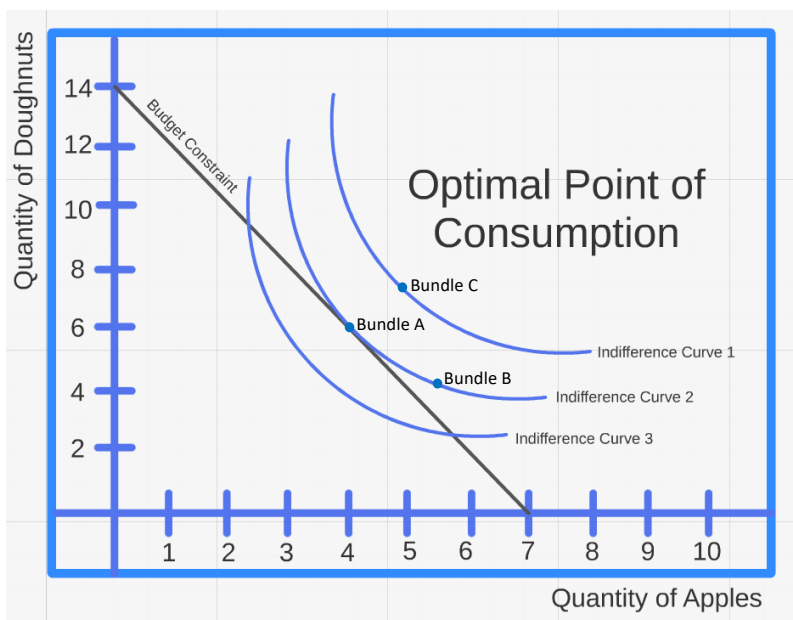


This analysis has major implications for child weight, due to the perceived low cost of many unhealthy foods. As a parent with limited income, it often seems better to buy processed foods for a fraction of the cost of fresh produce. This decision is made based on the utility curve discussed in the next section.

2.3 The Optimality Rule: Getting the Best Bang for Your Buck!

Given the budget constraint and utility curves, the optimality rule explains the point of maximum utility where the highest possible utility curve given income lays tangent to the budget constraint (Teall, p. 8). Figure 2.7 displays the budget constraint mapped on top of several indifference curves. Bundle A, the point of tangency with the second indifference curve, indicates the point of optimal consumption. Both Bundles B and C lay to the right of the budget constraint and therefore exceed the consumer's budget.

Figure 2.7 Indifference Curves, Budget Constraint, and Point of Optimal Consumption



At the point of tangency, the slope of the budget line equals the slope of the utility curve.

Formulaically, at this point

$$\frac{P_D}{P_A} = \frac{MU_D}{MU_A}.$$

Rearranging terms,

$$\frac{P_D}{P_A} \left(\frac{MU_A}{P_D} \right) = \frac{MU_D}{MU_A} \left(\frac{MU_A}{P_D} \right)$$

or

$$\frac{MU_A}{P_A} = \frac{MU_D}{P_D}$$

(Leftwich, 1970, p. 110). Note that the ratio MU_A/P_A equals extra utility per apple divided by dollars per apple or the extra utility per dollar spent on apples. If the Optimality Rule did not hold and $\frac{MU_A}{P_A} > \frac{MU_D}{P_D}$, then the extra utility per dollar spent on apples would be greater than the extra utility per dollar spent on doughnuts. Hence the parent would purchase more apples until they reached the point of tangency and obtained maximum utility.

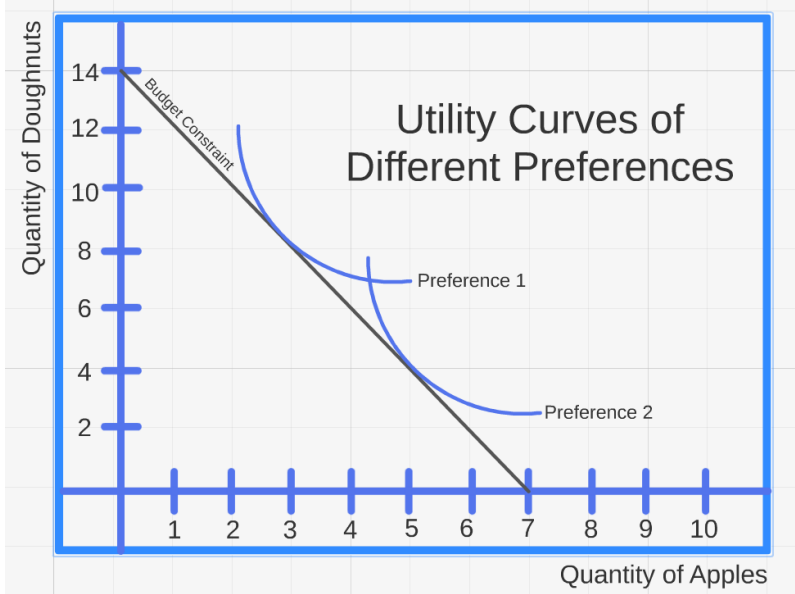
Table 2.2 Utility-Maximizing Rule

Utility-Maximizing Rule: $\frac{MU_A}{P_A} = \frac{MU_D}{P_D}$
MU_A = the marginal utility of the last apple P_A = price per apple MU_D = the marginal utility of the last doughnut P_D = price per doughnut

2.4 Comparative Static Analysis: A Tool to Compare Family Preferences

Given the rationale behind a family's optimal consumption point, it is possible to compare the optimal points of two different families using comparative static analysis. There are three cases to consider—a change in preferences, a change in relative prices, and a change in income (Teall, p. 12). First, holding the budget and all else equal, two different utility curves are drawn to reflect the preferences of the different families. As seen in Figure 2.8, the family with the first utility curve (Preference 1) prefers more doughnuts, while the other on the second utility curve (Preference 2) prefers more apples. Both curves lie on the same budget constraint, indicating that they have the same amount of income to spend on food. Since the slope of the budget constraint remains constant at both optimal points, the marginal rate of substitution is the same for both families. Their preferences simply dictate a different combination of goods. As discussed in Chapter I these differences in preference are dictated by factors such as educational attainment, income level, and geographic location.

Figure 2.8 Utility Curves of Families with Different Preferences



Second, suppose the family is initially consuming three doughnuts and three apples. As shown in Figure 2.9 if the price of apples falls from \$2 to \$1, the budget line will pivot outward on the horizontal axis. If all income is spent on apples, consumption rises from five to ten apples. Thus a decrease in the price of apples leads to increased apple consumption. Consumption of doughnuts can also increase because the decline in the price of apples increases real income. Hence declines in the prices of food products are expected to increase food consumption.

Figure 2.9 Influence of a Price Change on the Budget Constraint and Utility Curve

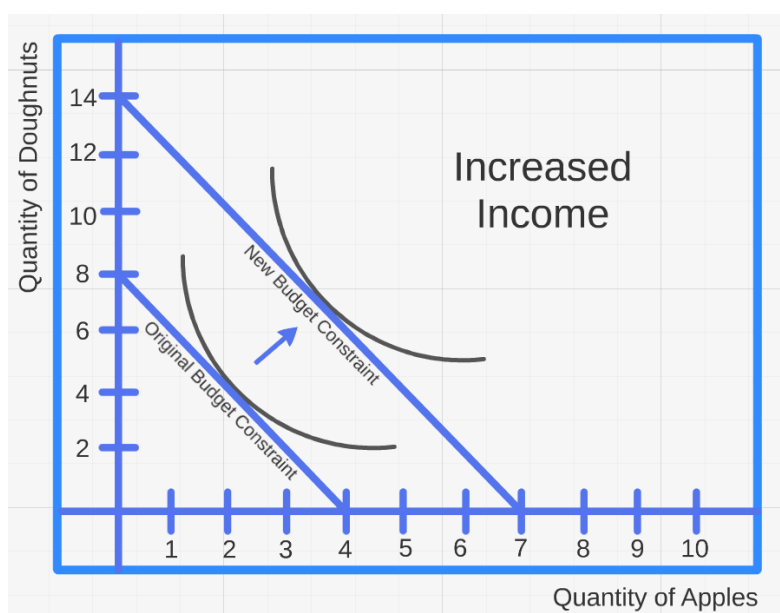


There is an exception to this case, where a special kind of good, called a Griffin good, violates the law of demand. According to Taylor (2012), this phenomenon occurs when an increase in price leads to an increase in demand in a specific good. For example, if an impoverished family sustains itself on an inexpensive staple food, such as bread, potatoes, or rice, then when the cost of the staple increases, the families can no longer afford to buy meat and

vegetables. Thus to maintain a sufficient level of calorie intake they must buy and consume more of the cheap staple good. This may be a problem for extremely low income families in the U.S.

Lastly, suppose the family is initially consuming four doughnuts and two apples, when the family's income increases from \$8 to \$14 and the budget line shifts outward. Actual consumption of both goods will rise to eight doughnuts and four apples as shown in Figure 2.10. Thus increases in income also lead to increased food consumption, if they are normal goods.

Figure 2.10 Influence of an Income Increase on the Budget Constraint and Utility Curve

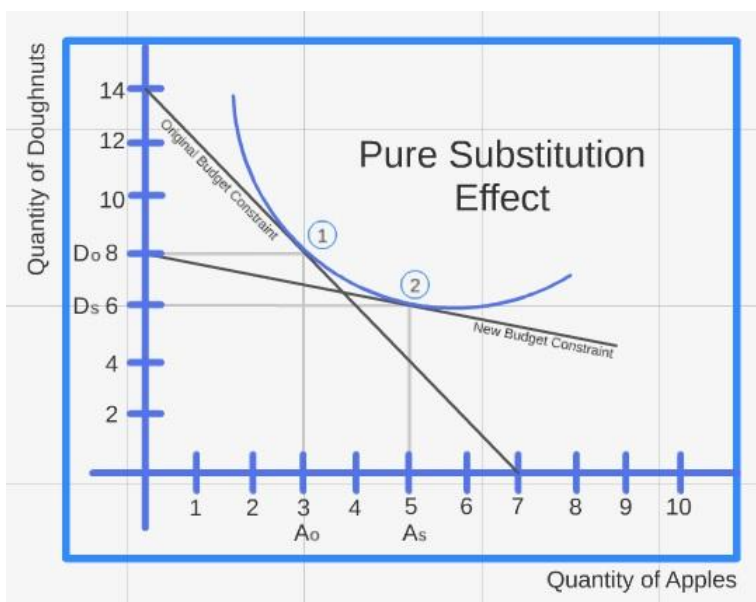


As noted by Leftwich (1970), a normal good is a good for which demand goes up when income is higher (p. 84-85). As parents have more income to allocate to their food budget they will tend to buy more appealing and nutritious foods, such as apples, for their child. On the other hand, an inferior good is a good for which demand tends to fall when income rises (Leftwich, 1970, p. 85). Examples of inferior goods include frozen dinners, canned goods, and fast food.

2.5 Income and Substitution Effects on Food Purchasing Decisions

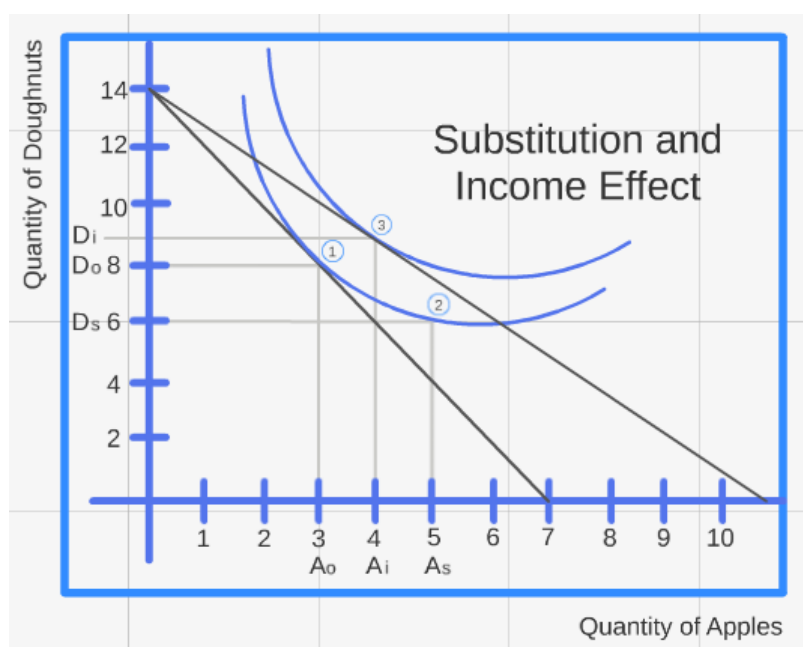
Removing the constant price condition incorporates the income and substitution effects into the model. The substitution effect is the change in the quantity of a good consumed when the budget constraint reflects the new relative prices, but the initial level of utility is held constant (Leftwich, 1970, p. 87). The opportunity costs have changed, causing consumers to gravitate toward the less expensive alternative. Graphically, this means that the original indifference curve is maintained, but the budget line has a new slope and point of tangency. As shown in Figure 2.11, when the price of apples decreases, the family will start to buy more apples. At the first point of tangency with the old budget line, the family purchases three apples and eight doughnuts, but as the price of apples decreases and the budget line shifts, they purchase five apples and six doughnuts.

Figure 2.11 The Pure Substitution Effect with a Decrease in the Price of Apples



The pure substitution effect induces the income effect, which is the change in the quantity of both goods when the budget constraint is shifted. The slope of the sifted curve becomes equal to the new ratio of prices (Leftwich, 1970, p. 86). As shown in Figure 2.12, a new consumption bundle at point 3 is formed on the adjusted budget line tangent to the indifference curve. Thus, if the price has fallen, parents will have more money to spend on both goods. Their induced spending changes will depend on whether doughnuts and apples are normal or inferior goods.

Figure 2.12 The Substitution and Income Effects with a Decrease in the Price of Apples



2.6 Conclusion

In conclusion, parental and household decisions are based on the components of the theory of the consumer. They adhere to the three assumptions of preference, transitivity, and non-satiety. They are restricted by their food budgets, causing parents to shop within their budget constraint. Each time they decide between cooking at home and going out for fast food or

between buying produce or fried foods, they are internally comparing the utility of different choice sets that are available given their budget. This mental calculation attempts to find the utility-maximizing point that will do the most good for their family. Meanwhile these decisions are constantly readjusted given changes in prices and income. Additionally comparative static analyses show that consumption choices for food depend on relative prices and income in addition to consumption tastes which are determined by the variety of social factors mentioned in Chapter I.

If the theory of the consumer is valid and all parents are making judgment calls to benefit their child, it begs the question of why childhood obesity exists. The answer comes in many forms. Firstly they have a different perception of what the best choices are given their own knowledge, perceptions, and experiences. Parents must also consider the relative costs of foods and the amount of money they want to designate for their food budget. Additionally tastes influence parental decisions, as social norms make less healthy foods more acceptable or distort perceptions of food. Parents might also have incomplete information, where they do not know the nutritional value of a food. On the other hand they may not know about the consequences of childhood obesity. Parents may be under both financial and time restraints, where more convenient food may be the less healthy option. It is even possible that the family lives in a food desert and does not have access to fresh, healthy foods. Several of these possible explanations are run through a regression in Chapter III. The empirical analysis strives to quantify how the most important determinants affect child weight.

Chapter III - The Determinants of Childhood Obesity: Empirical Analysis of the Data

As discussed in the first chapter, child, parental, social, and regional factors affect child weight, due in part to the theory of the consumer presented in Chapter II. This theory is now evaluated using a regression model based on cross-sectional data from each of the fifty states. Specifically, a regression is run examining the nature and strength of the relationships between the dependent variable (child weight) and a group of independent variables (child exercise, sleep, hours of television, and religious attendance, parental marital status, education, income, weight, and ethnicity, family meals, SNAP participation, mRFEI, neighborhood safety, and geographic location).

The chapter is divided into six sections. Section 3.1 describes a general regression analysis and details the equation and variables used in this study, while Section 3.2 lists the data sources for childhood obesity and its determinants. Section 3.3 contains the empirical results and an analysis of the expected impact, actual coefficient, t-statistic, and statistical significance for each variable. Sections 3.4 and 3.5 contain hypothesis tests for statistical strength of both the individual determinants and the model as a whole. Section 3.6 analyzes the overall goodness of fit of the model, while Sections 3.7 and 3.8 test for multicollinearity and heteroscedasticity within the model. Lastly Section 3.9 concludes with a final review of the regression.

3.1 Regression Analysis, an Overview

According to Berger, a regression model is a form of data analysis that examines the relationship between a dependent variable and one or more independent variables in order to

make inferences about how changes in one set of variables are related to changes in another (p.

1). Individual relationships between each independent variable and the dependent variable are evaluated with a t-statistic, while the overall goodness of the model is found with a R^2 value. The model is capable of incorporating qualitative and quantitative variables.

The fundamental equation of the regression analysis in this study is:

$$\begin{aligned} \text{cobrate} = & a + \beta_1 \text{cexrcs7} + \beta_2 \text{csleep7} + \beta_3 \text{ctvhrrs4} + \beta_4 \text{crelig52} + \beta_5 \text{sngrate} + \\ & \beta_6 \text{hsedrate} + \beta_7 \text{mincm} + \beta_8 \text{aobrate} + \beta_9 \text{cpeat47} + \beta_{10} \text{white} + \beta_{11} \text{snap} + \\ & \beta_{12} \text{mrfei} + \beta_{13} \text{safen} + \beta_{14} \text{dummw} + \beta_{15} \text{dumw} + \beta_{16} \text{dums} + \varepsilon_i \end{aligned}$$

This equation displays the relationship between the dependent variable, the rate of children categorized as overweight or obese by BMI (cobrate), and the child, parental, social, and regional independent variables discussed in Chapter I. The theoretical model from Chapter II explains why these variables reflect the effects of preferences and income. While these factors cannot be neatly placed in a given category due to their overlapping nature, they have been categorized for organizational purposes. The child related variables are as follows:

1. cexrcs7 is the percentage of children who exercise at least seven times a week for twenty minutes or more. This variable is included in order to capture the positive effects of burning calories.
2. csleep7 is the percentage of children who get a sufficient number of hours of sleep every night. This variable measures the ways in which sleep affects physical activity and weight gain.

3. `ctvhrs4` is the percentage of children who spend more than four hours a week watching television or playing video games. This variable relates to sedentary activity, media influence, and strictness of parenting.
4. `crelig52` is the percentage of children who attend a religious service weekly, incorporating the influence of nonparent adults and strong social networks.

The following parental characteristics are also included:

1. `snglrate` is the percentage of children who live in single parent households, which is included to capture the effects of weakened family structure and parental time restraints.
2. `hsedrate` is the percentage of children whose parents have attained at least a high school diploma. As an indicator of the parents' educational attainment, this variable correlates with a basic understanding of nutrition and budgeting.
3. `mincm` is the median income of the state in which the child resides. This variable captures the effects of a family's socioeconomic level and the size of their food budget.
4. `aobrate` is the percentage of adults who are obese, which is included to show the influence of parental consumption and exercise habits on their child.

There are five societal characteristics:

1. `cpeat47` is the percentage of families who eat meals together four to seven days a week either in or away from the home. This variable is included in order to approximate the influence parents have over the quality and quantity of food their child consumes.
2. `white` is the percentage of the state population that identifies as white. This measure is incorporated to relate childhood weight to ethnic diversity.

3. snap is the percentage of families who qualify for and receive aid from the federal Supplemental Nutritional Assistance Program. This variable is included to measure governmental spending and the success of nutritional programs like SNAP.
4. mrfei is the state score on the Modified Retail Food Environment Index. This index measures the number of healthy and unhealthy retailers to create a composite score. This variable represents both the relative accessibility of healthy foods and the fast food culture of each state.
5. safen is the percentage of children whose parents believe they lives in a safe neighborhood. This encourages outdoor activities, such as walking, riding bicycles, and playing games.

Lastly there is a regional component that subdivides the U.S. into Northeast, Midwest, West, and South. Variable dummw, takes on the value one if the observations are from a state in the Midwest and a value zero otherwise. Similarly dumw and dums take on values of one when observations are from either states in the West and the South. Thus, when all three dummy variables equal zero, the observations must be from the Northeast. The dummy variables were included to measure the regional prevalence of childhood obesity, which could be the results of weather, culture, and other regionally specific factors.

The equation also includes α , the model's intercept, which is the base rate of child weight in the Northeast when all other independent variables equal zero. The error term, ε_i , captures the effects of the factors not included within the independent variables. The coefficient on cexrcs7, β_1 , measures the percent change in the rate of overweight and obese children that is expected given a one percentage point rise in the rate of children whose exercise daily. The coefficient on csleep7, β_2 , measures the percent change in the rate of overweight and obese children that is

expected given a one percentage point rise in the rate of children who sleep an adequate number of hours every night. Similarly the remaining β terms measure the percent change in overweight and obese children that is expected given a one percentage point rise in the associated independent variable. The data sources for these variables are discussed in the following section.

3.2 Data Sources for Child Weight and Determinants

The data sources for this analysis are listed as follows. Data for the rates of overweight and obese children (cobrate), child exercise (cexrcs7), child sleep (csleep7), child television and video game usage (ctvhrs4), child religious attendance (crelig52), family meals (peat47), and neighborhood safety (safen) came from the self-reported 2011 National Survey of Children's Health from the Data Resource Center for Child and Adolescent Health as part of the Child and Adolescent Health Measurement Initiative. Data for parental high school graduation rates (hsedrate) and median income (mincm) came from the 2012 *Statistical Abstract* from the U.S. Census Bureau. Ethnicity (white) data came from the *Annual Estimates of the Resident Population by Sex, Race, and Hispanic Origin for the United States, States, and Counties* for 2010 published by the Population Division of the U.S. Census Bureau. Adult obesity prevalence (aobrate) was provided by the CDC's Behavioral Risk Factor Surveillance System from 2012, while the Modified Retail Food Environment Index scores (mrfei) came from the CDC's *Children's Food Environment State Indicator Report* from 2011. Data for marital status (snglrate) came from the 2012 version of the *Kids Count Data Books* of the Annie E. Casey Foundation. Lastly SNAP recipient data (snap) from 2009 came from the *Food Stamp/Supplemental Nutrition Assistance Program (SNAP) Receipt in the Past 12 Months for Households by State: 2009 and 2010*, an American Community Survey Brief published in

November 2011. All of the data are measured as percentages, with the exception of minimum income in dollars and the mRFEI scores.

3.3 Empirical Results of Child Weight Regression Analysis

Table 3.1 displays the Stata regression results, while an analysis of the expected signs from theory, actual estimated coefficients, t-statistics, and statistical significance of the independent variables are presented in Table 3.2.

Table 3.1 Stata Results of the Regression Analysis

Source	SS	df	MS	Number of obs = 50		
Model	701.649611	16	43.8531007	F(16, 33) =	9.41	
Residual	153.749568	33	4.65907781	Prob > F =	0.0000	
				R-squared =	0.8203	
				Adj R-squared =	0.7331	
Total	855.399179	49	17.4571261	Root MSE =	2.1585	

cobrate	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
cexrcs7	-.1038047	.1455679	-0.71	0.481	-.3999647	.1923554
csleep7	-.2743309	.1458144	-1.88	0.069	-.5709925	.0223307
ctvhrs4	.2678708	.2738577	0.98	0.335	-.2892968	.8250384
crelig52	-.1043911	.0801264	-1.30	0.202	-.2674095	.0586272
snglrate	.2041719	.1581292	1.29	0.206	-.1175444	.5258882
hsedrate	-.1552427	.2279623	-0.68	0.501	-.6190354	.30855
mincm	-.0000579	.0001082	-0.54	0.596	-.000278	.0001621
aobrate	.5155955	.228115	2.26	0.031	.0514922	.9796989
peat47	.5472225	.2523344	2.17	0.037	.0338443	1.060601
white	-.0053406	.0461587	-0.12	0.909	-.0992511	.08857
snap	-.1695729	.2089725	-0.81	0.423	-.5947308	.2555849
mrfei	-.4362833	.203715	-2.14	0.040	-.8507445	-.021822
safen	-.4410419	.2406505	-1.83	0.076	-.9306489	.0485652
dummw	1.915463	1.525308	1.26	0.218	-1.187799	5.018726
dumw	.8523926	1.824374	0.47	0.643	-2.859324	4.56411
dums	3.773489	1.873105	2.01	0.052	-.0373716	7.58435
_cons	47.18942	28.48734	1.66	0.107	-10.7685	105.1473

Table 3.2 Impact, Coefficients, t-Stats, and Significance of Independent Variables

Variable	Expected impact on childhood obesity	Actual Coefficient	t-stat	Statistical Significance
Child Exercise	Negative (-)	-0.1038047	-0.71	No
Child Sleep	Negative (-)	-0.2743309	-1.88	Yes, 10%
Child TV/Video Games	Positive (+)	0.2678708	0.98	No
Child Religious Attendance	Negative (-)	-0.1043911	-1.30	Yes, 20%
Single Parent	Positive (+)	0.2041719	1.29	Yes, 20%
Parent HS Grad	Negative (-)	-0.1552427	-0.68	No
Median Income	Negative (-)	-0.0000579	-0.54	No
Adult Obesity	Positive (+)	0.5155955	2.26	Yes, 5%
Family Meals	Positive (+)	0.5472225	2.17	Yes, 5%
Ethnicity (white)	Negative (-)	-0.053406	-0.12	No
SNAP Participation	Negative (-)	-0.1695729	-0.81	No
mRFEI Score	Negative (-)	-0.4362833	-2.14	Yes, 5%
Neighborhood Safety	Negative (-)	-0.4410419	-1.83	Yes, 10%
Midwest	Positive (+)	1.915463	1.26	Yes, 20%
West	Positive (+)	0.8523926	0.47	No
South	Positive (+)	3.773489	2.01	Yes, 5%

These data are interpreted as follows. If all of the independent variables equal zero, childhood obesity is expected to be 47.19 percent. This is the value that holds for observations in the Northeast. When considering observations in the Midwest the intercept increases by 1.92 percent, while for the West and South see increases of 0.85 percent and 3.77 percent, respectively. Hence the quality of living in the South leads to the largest increase in childhood obesity, holding all other independent variables constant. Additionally a one percentage point rise in the rate of adult obesity (aobrate) is expected to cause the rate of overweight and obese children (cobrate) to rise by 0.52 percentage points, on average, holding all other variables constant. A one percentage point rise in the state mRFEI score (mrfei) is expected to cause child weight (cobrate) to decrease by 0.44 percentage points, on average, holding all other variables

constant. By looking at the sign of the coefficients in Table 3.2, it is possible to determine whether the independent variables conform to theory. While the majority of variables conform, religious attendance and family meals have controversial outcomes.

3.4 Statistical Significance of Child, Parental, Social, and Regional Factors

The third column in Table 3.2 displays the t-statistics for each independent variable. A t-statistic is the ratio of the coefficient (b) to its standard error (S_b), which is a measure of the standard deviation of error terms about the regression plane (Casler 2013). This measure shows the statistical significance, or strength of the relationship, between the independent variable of the coefficient and the dependent variable. As the value increases, the variable becomes more reliable and gains more predictive power. Generally a t-statistic with an absolute value greater than 1.96 is accepted to be significant (5 percent), while those greater than 1.64 and 1.28 are considered nearly (10 percent) and possibly significant (20 percent) respectively. (Berger, p. 8). The rate of adult obesity, family meals, state mRFEI score, and living in the South are statistically significant, while child sleep and perceived neighborhood safety are nearly significant.

Statistical significance is determined using a hypothesis test, where the null hypothesis states that an independent and the dependent variables have no relationship. The following test examines the significance of adult obesity with a null hypothesis stating that a child has an equal likelihood of being overweight or obese whether they live in a state with a high or low prevalence of adult obesity. Conversely the alternative hypothesis states that there is a relationship. In equation form, the null hypothesis is represented as H_0 and the alternative hypothesis is represented as H_1 .

Null hypotheses (H_0): $\beta_0 = 0$

Alternative hypothesis (H_1): $\beta_i > 0$

Theory dictates that the alternative hypothesis predicts $\beta_i > 0$ because the prevalence of overweight and obese children is expected to rise with a rise in adult obesity.

Furthermore the general form of the t-statistic is

$$t_{n-m-1} = \frac{b_i - \beta_i}{S_{b_i}} .$$

n is the number of observations, m is the number of independent variables, b_i is the estimated coefficient, β_i is the value drawn from the null hypothesis, and S_{b_i} is the standard error of the coefficients. In total, $n - m - 1$ is known as the degrees of freedom. In this case the fifty states make up the number of observations, while there are sixteen independent variables. If the null hypothesis is true, b_i will equal zero, on average. Thus, b_i will be large relative to S_{b_i} leading to a large value of t (Casler 2013). Hence the critical region lies to the right. If the value of the test statistic lies within the critical region, the null hypothesis is proven wrong.

$$t_{n-m-1} = t_{50-16-1} = t_{33} = \frac{b_i - \beta_i}{S_{b_i}} = \frac{0.5155955 - 0}{0.228115} = 2.26$$

This value is compared to the t-value with 33 degrees of freedom and a 5 percent level of significance found in a t-distribution table. The level of significance, $\alpha = 0.05$, represents the probability that the null hypothesis is rejected when it is true. This value, $t_{32,0.05} = 1.695$, identifies the critical region in the t-distribution. Since $2.26 > 1.695$, the test statistic lies within the critical region and the null hypothesis that the rate of adult obesity (aobrate) and the rate of

childhood obesity (cobrate) are independent of each other is rejected. This indicates that adult obesity influences childhood obesity in a statistically significant way.

3.5 F-Statistic for the Child Weight Model

The F test is used to determine the significance of a group of regression coefficients and is therefore able to test the significance of the model as a whole (Casler 2013). The null hypothesis (H_0) implies that the explanatory variables do not affect childhood weight.

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \dots = \beta_{16} = 0.$$

The alternative hypothesis states that at least one independent variable has an effect on the dependent variable, childhood weight.

$$H_0: \text{at least one } \beta_i \neq 0$$

By definition the F statistic appears as

$$F_{m,n-m-1} = \frac{SSR/m}{SSE/n-m-1},$$

where SSR is the explained sum of squares and SSE is the unexplained sum of squares. The equation can be transformed into a function of R^2 as follows

$$F_{m,n-m-1} = \frac{SSR/m}{SSE/n-m-1} = \frac{SSR(n-m-1)}{(SST-SSR)m} = \frac{SSR}{(SST-SSR)} * \frac{n-m-1}{m}$$

$$\frac{SSR}{(SST-SSR)} * \frac{1/SST}{1/SST} * \frac{n-m-1}{m}$$

or

$$F_{m,n-m-1} = \frac{R^2}{1-R^2} * \frac{n-m-1}{m}.$$

$$F_{16,50-16-1} = F_{16,33} = \frac{0.8203}{1-0.8203} * \frac{50-16-1}{16} = 9.41$$

(Calser, 2013). At a 5 percent level of significance the critical value is $F_{16,33,0.05} = 1.96$. The critical region is located in the right tail of the graph. If the alternative hypothesis is true the model has explanatory power and a large R^2 value. Considering $F_{m,n-m-1} = \frac{R^2}{1-R^2} * \frac{n-m-1}{m}$, a larger R^2 value leads to a larger F statistic. These larger F statistics lie in the right tail of the F distribution. Since the value of the test statistic lies in the critical region, the null hypothesis that none of the explanatory variables affect childhood weight is rejected.

3.6 Goodness of Fit for the Child Weight Model

In the words of Berger, the R^2 value provides a measure of how well the dependent variable, cobrate, can be predicted from the set of independent variables scores (p. 1). The goodness of fit for a model ranges from zero with no relation to one with a perfect relation. As a model nears one it becomes more valued and significant (Berger, p. 2).

The overall goodness of fit for this model is strong with a R^2 value of 0.8203. This means that 82.03 percent of the variance in child weight from its mean is explained by the independent variables of the model (Casler 2013). In other words, this model can predict the rate of overweight and obese children in any given state using its independent variable measures with an accuracy of 82.03 percent.

3.7 Multicollinearity

To confirm the strength of the model it is necessary to test for multicollinearity, the case in which two or more of the independent variables are linearly related. If the problem is present, the standard error of the affected coefficients will tend to increase, which makes the t-statistic

smaller. Hence, the null hypothesis that β_i equals zero is more likely to be retained when false (Casler 2013). Table 3.3 contains the correlation coefficients between each pair of variables of the model, which measures the strength of the linear relationship between them.

Multicollinearity can be detected by finding correlation coefficients near one. Alternately it can be identified if there is a contradiction between a large R^2 value and low t-statistics.

Table 3.3 Test for Multicollinearity

```
. cor cobrate cexrcs7 csleep7 ctvhrs4 crelig52 snglrate hsedrate mincm aobrate peat
> 47 white snap mrfei safen dummw dumw dums
(obs=50)
```

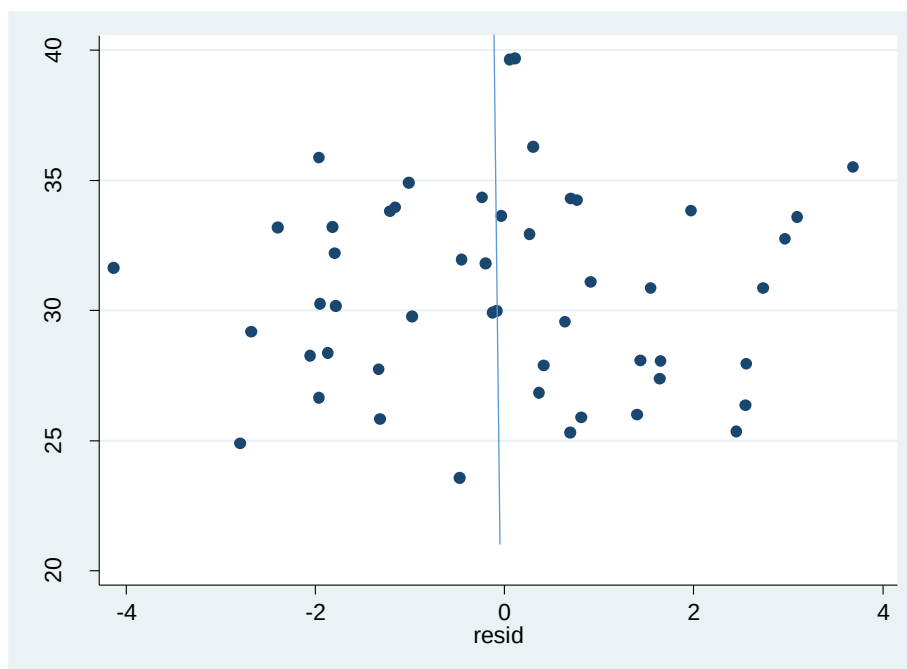
	cobrate	cexrcs7	csleep7	ctvhrs4	crelig52	snglrate	hsedrate
cobrate	1.0000						
cexrcs7	0.2201	1.0000					
csleep7	0.4341	0.1408	1.0000				
ctvhrs4	0.7144	0.0109	0.4758	1.0000			
crelig52	0.5531	0.2236	0.3204	0.5878	1.0000		
snglrate	0.7877	0.2681	0.5657	0.7871	0.4460	1.0000	
hsedrate	-0.7536	-0.0875	-0.5597	-0.7308	-0.5622	-0.7600	1.0000
mincm	-0.5844	-0.4653	-0.3864	-0.4919	-0.5791	-0.5753	0.5817
aobrate	0.6639	0.4382	0.2655	0.5532	0.6428	0.5490	-0.5075
peat47	-0.2280	0.3299	-0.1030	-0.4521	-0.1522	-0.3661	0.3472
white	-0.3113	0.2693	-0.4680	-0.4684	-0.2685	-0.4037	0.4599
snap	0.5673	0.4749	0.2135	0.4926	0.2949	0.5992	-0.4874
mrfei	-0.2943	0.0354	-0.0609	-0.2080	-0.2538	-0.2639	0.2417
safen	-0.5055	0.2757	-0.4926	-0.5441	-0.1591	-0.6176	0.6513
dummw	-0.0662	0.0558	-0.1173	-0.1826	0.1207	-0.2003	0.3034
dumw	-0.3026	-0.2469	0.0058	-0.2074	-0.1986	-0.3271	0.1945
dums	0.5964	0.3436	0.4186	0.5854	0.5856	0.6008	-0.6338
	mincm	aobrate	peat47	white	snap	mrfei	safen
mincm	1.0000						
aobrate	-0.6474	1.0000					
peat47	-0.1457	-0.1381	1.0000				
white	-0.0557	0.1515	0.2617	1.0000			
snap	-0.6886	0.6773	-0.0205	0.1128	1.0000		
mrfei	-0.1127	-0.1739	0.5914	0.1229	-0.0184	1.0000	
safen	0.1858	-0.0167	0.4925	0.7078	-0.1708	0.2867	1.0000
dummw	-0.0754	0.2240	0.0100	0.3326	-0.0746	-0.1357	0.2103
dumw	0.1429	-0.5122	0.5590	-0.2628	-0.3195	0.4566	0.0001
dums	-0.3956	0.5615	-0.2420	-0.2318	0.4442	-0.1472	-0.1453
	dummw	dumw	dums				
dummw	1.0000						
dumw	-0.3331	1.0000					
dums	-0.3855	-0.4066	1.0000				

A review of Table 3.3 shows no correlation coefficients close to one, indicating that the model does not suffer from multicollinearity.

3.8 Heteroscedasticity

Heteroscedasticity is another violation of the model, in which the variance of the error terms is not constant. This causes the least squares estimators to remain unbiased but no longer most efficient. This problem is usually associated with cross sectional data and can be identified by a nonrandom pattern when the predicted values of childhood weight and the residuals are graphed, as shown in Figure 3.1 (Casler 2013).

Figure 3.1 Residual Test for Heteroscedasticity



The horizontal axis, labeled resid, contains the residuals of the error terms. The terms to the left and the right of the resid line sum to equal zero. The lack of any visible trends or patterns indicates the absence of heteroscedasticity in the model.

3.9 Concluding Thoughts on Child Weight Regression Results

These results reveal that child, parental, social, and regional factors impact child weight across the US. These data show the strongest relationships between the rate of overweight and obese children and the rate of adult obesity (aobrate), family meals (peat47), food retail environment (mrfei), and living in the South (dums). Child sleep (csleep7) and perceived neighborhood safety (safen) also show relatively strong impacts on child weight. These results inform parents that maintaining a healthy weight, requiring their child to sleep more, and living in a safer, healthier place can result in a healthier child. The positive correlation between family meals and child weight indicates that eating together is leading to either unhealthy food choices or larger portions. Thus parents need be sure that, whether eating at or away from home, they need to provide healthier alternatives and smaller portions. This can be done through learning the nutritional value of foods and how to cook them, selecting healthier restaurants, encouraging their children to select healthier, smaller options off the menu, and bring leftovers home. The culture of “cleaning your plate” and “getting your money’s worth” needs to change.

With such a low t-statistic and small coefficient, the results indicate that ethnic diversity (white) does not appear to have much of an effect on child weight. The coefficient is near enough to zero that the data indicates almost no relationship whatsoever. That being said these results indicate only the relationship between childhood weight and proxies based on state averages instead of individual households. Thus if the proxy does not approximate the value well, the results will not reflect real world realities. This appears to be the case for the ethnic diversity proxy, seeing as it has proven influential in past studies (Taveras et al., 2010, p. 686). Furthermore median income (mincm) does not necessarily take into account the cost of living or

the degree of inequality within a state. A particularly large sector of impoverished or highly wealthy people would skew the average income.

Furthermore the remaining unexplained 17.97 percent of variance within the model could be explained with the inclusion of more home, school, and governmental indicators or the replacement of the underlying data with actual data for households.

Chapter IV - Determinants of Child Weight: Conclusion

This study set out to identify the variables with the greatest influence on childhood weight, using the trends, theory, and regression analysis results of the previous chapters. A final review of these results includes an analysis of their interconnected nature, a comparison of the results relative to those found in previous literature, and a list of possible parenting strategies and governmental policies to shrink the percentage of overweight and obese children. Lastly, several suggestions for future research are included in hopes of developing a greater understanding of child weight determinates.

One observation of this analysis is the underlying connections found between these variables. Education affects income and income affects neighborhood quality. Living in a better neighborhood indicates higher tax revenues, which leads to wealthier schools that can buy more nutritious food and better playground equipment for recess. Children who are exercising more must be watching less television and are likely getting more sleep. Thus, as these examples show, isolating individual relationships is difficult, and parents need to understand that their decisions have both immediate consequences and a rippling effect on their child's health.

As previously mentioned, the influence of parents cannot be overstated. The regression analysis shows that levels of adult obesity, frequency of family meals, and geographic location have the largest impact on child weight. Thus parents can choose to maintain a healthy weight, prepare or purchase healthier foods in smaller portions, and live in a state with a higher mRFEI score outside of the South. These geographic trends reaffirm the results found by Singh, Kogan, and van Dyck (2008) concerning the high weight prevalence in the Southeastern region of the country (p. 90).

Additionally child sleep, child religious attendance, parental marital status, and neighborhood safety had a slightly less significant influence. Thus parents can try to enable their children to adhere to better sleep routines, attend church or participate in other community building activities, work to stay in a stable relationship, and attempt to live in safer neighborhoods. These results support the assessment by Chen, Beydoun, and Wang (2008) relating fewer hours of sleep and increased BMIs amongst children and the studies mentioned in Chapter I concerning single parents and increased child weight (Gibson et al. 2007, p. 591). While current literature links adult weight and religious attendance in a mostly positive relationship, the results of this analysis indicate a reversal of the trend for children (Cline & Ferraro, 2008, p. 269).

Parents also need to recognize the major lifestyle changes of the last few decades. In large part due to the technological revolution, the daily life of a typical American child has become more sedentary, with increased access to smart phones, tablets, music players, laptop computers, and other electronics. Thus, parents need to step in and limit time spent watching television and playing video games in order to encourage more outdoor playtime and hours of sleep. While this analysis did not show a significant correlation between hours of television and child weight, the relationship cannot be ignored.

As the consumer theory in Chapter II shows, parents also need to gain information about the causes and consequences of unhealthy child weight. Immediate gratification and other short-sighted behaviors need to be substituted for longer-term thinking. Maximizing long-term utility is only possible with full information and the ability to budget for healthier foods, healthcare, gym memberships, higher education, and other determinants of improved health.

Schools also have an impact, where teachers and staff can act as additional role models, provide nutritional education and healthier food alternatives, make students feel safe and supported, and designate time for recess, Physical Education classes, and sports programs.

The federal and state governments also have a place within this movement, justified by the consumption externalities affecting the entire country. As noted in Chapter I, health spending by the federal government has increased eighteen fold in the last sixty-four years, thus making proactive intervention a necessity. Lowering or eliminating corn subsidies that lead to inexpensive high-fructose products, subsidizing fresh produce, investing in educational and nutritional programs, and tackling the food deserts across America are some initial steps that the government can choose to take. When cost, convenience, access, and time are weighed into parental decision-making, the government has the power to reduce opportunity costs for parents by making healthier food cheaper and easier to access. As shown in consumer theory, if healthier foods are less expensive, the change in relative prices would induce both an income and a substitution effect toward better eating and a reversal of childhood obesity trends. This would similarly happen if consumers were to become more educated about nutritious foods and their effects on the body.

Additionally the government can justify spending programs that target families that exhibit behaviors related to childhood obesity, such as single parent and low-income families. Heightened cash and food assistance could be made available through increased funding of the Domestic Hunger Safety Net. This collaboration of programs works with independent state level programs, private groups, and charities to decrease the percentage of overweight and obese children through nutritional assistance and education. The Food Distribution Program, Child Nutrition Program, and Special Supplemental Nutrition Program for Women, Infants, and

Children (WIC) distribute American-grown USDA food to school children and families, while providing nutritional education and healthcare for mothers and children (Programs and Services, 2014). SNAP, the program included in this regression analysis, is the largest and most comprehensive, offering nutritional assistance and program eligibility information through partnerships with state agriculture departments, schools, and neighborhood and faith-based organizations (fns.usda.gov). While the regression results indicate that SNAP has a weak relationship to child weight, its negative correlation indicates that those families receiving aid are less likely to have overweight or obese children.

While the strongest variables have helped to identify effective policies and parenting suggestions to achieve healthier BMIs, there are more factors that could be added to the model. Further studies need to be conducted to include factors such as rural and urban environments, food insecurity, number of siblings, age of parents, number of meals away from the home, and the impacts of The Affordable Care Act.

Additionally it would be interesting to study the effects of the business cycle on child weight. These data were collected in 2011, during the first years of recovery after the Great Recession. Thus the unemployment, underemployment, and other economic struggles of the past years may have affected the food budgets and health of the country's children (Goodman and Mance, 2011, p. 2). Additionally the trends of reemployment may have exaggerated the results found in this regression, because they were focused mainly on more educated, older males who were less likely to be supporting young children (Sahin and Willis, 2013, p 5).

The future holds the potential for progress in making a healthier young population. While the economy is still facing the aftershocks of the Great Recession and the uncertainties of a retiring Baby Boomer population, both time and money needs to be dedicated to health programs

and research for these overweight and obese youths and their parents (Toossi, 2012, p. 3). All adults in positions of authority, whether as parents or officials, need to realize the seriousness of the situation and strive to make change.

Appendix

Table A. Child Characteristics Data

State	cobrate	ctvh4	cexrcs7	csleep7	crelig52
Alabama	35	16.5	32.7	61.5	67.4
Alaska	29.9	10.7	32.9	57	41.8
Arizona	36.7	12.9	26.4	58.6	42.6
Arkansas	33.9	12	31.6	58.8	65.5
California	30.4	9.9	25.2	59.5	47.8
Colorado	23.1	8.7	28.3	60.2	43.7
Connecticut	29.7	11	25.8	54.2	37.3
Delaware	32	11.2	26.5	63.8	45.9
Florida	27.5	13.2	31.5	62.5	50.2
Georgia	35	11.7	30.6	58.9	58.7
Hawaii	27.4	11.7	28.7	59.4	47
Idaho	27.8	9.2	25.5	56.4	54.5
Illinois	33.6	11	23.5	61.7	49.9
Indiana	31.5	12.5	28.6	54.5	52.4
Iowa	28.3	10.4	31.2	55.9	50.9
Kansas	30.2	8.7	28.2	56.5	56
Kentucky	35.7	11.8	32.3	61.2	53.7
Louisiana	39.8	19.5	31.1	59.5	65.8
Maine	29.5	8.1	32	55.2	24
Maryland	31.6	12.9	24.4	55.8	49.7
Massachusetts	30.5	8.7	25.5	51.3	33.6
Michigan	32.6	11.7	27.7	57.2	44.5
Minnesota	27.2	8.1	28.7	53.4	50.8
Mississippi	39.7	18.6	27.7	55.7	68.6
Missouri	28.4	11.1	33.7	58.6	51
Montana	29	8.3	32.4	51.6	43.8
Nebraska	28.9	8.8	31.3	57	57.7
Nevada	33.2	14.5	22.4	64.6	41.1
New Hampshire	26	6.1	28.1	55.5	25.9
New Jersey	24.7	11.1	25.3	55.2	44.9
New Mexico	32.8	11.1	29.6	62.8	52.7
New York	32.4	11.9	24.6	55.9	42.6
North Carolina	31.4	13.2	31.6	60.6	54.2
North Dakota	35.8	9.9	30.4	57.4	53.7
Ohio	30.8	12.4	28.5	58.5	45.3
Oklahoma	33.9	9.6	34.9	61.7	61.1
Oregon	26.4	10	28.5	60.3	40.1
Pennsylvania	26.5	11.8	27	56.1	49.7
Rhode Island	28.3	11	25.2	58	42.2
South Carolina	39.2	13.3	30.3	59.7	63.9
South Dakota	26.5	7.8	30.2	53.4	58.2
Tennessee	34.1	12.8	34.5	58.4	62.4
Texas	36.6	13	29	58.9	58.7
Utah	22.1	9.1	18.1	51.4	69.3
Vermont	24.5	5.7	33.3	52.7	21.5
Virginia	29.8	11.4	26.1	56.9	49.6
Washington	26.2	7.7	28.5	52	44.1
West Virginia	33.6	12.4	34.1	58.1	49.2
Wisconsin	28.8	9.6	28.3	58.3	45.3
Wyoming	26.7	7.5	30.2	54.6	45.8

Table B. Parental Characteristics Data

State	snglrate	hsedrate	mincm (\$)	aobrate
Alabama	40	82.1	43350.03859	33
Alaska	32	91.4	61065.77397	25.7
Arizona	37	84.2	48688.58485	26
Arkansas	39	82.4	40605.98933	34.5
California	33	80.6	56221.86299	25
Colorado	30	89.3	60179.84798	20.5
Connecticut	32	88.6	66843.79442	25.6
Delaware	37	87.4	54306.5431	26.9
Florida	39	85.3	46174.84813	25.2
Georgia	38	83.9	47171.3032	29.1
Hawaii	30	90.4	59747.82658	23.6
Idaho	25	88.4	48640.13868	26.8
Illinois	33	86.4	52284.45218	28.1
Indiana	35	86.6	46706.89473	31.4
Iowa	29	90.5	52109.68094	30.4
Kansas	31	89.7	48537.57445	29.9
Kentucky	35	81.7	41687.13844	31.3
Louisiana	45	82.2	40659.77014	34.7
Maine	34	90.2	50121.31426	28.4
Maryland	36	88.2	69920.01157	27.6
Massachusetts	31	89.0	64153.3372	22.9
Michigan	34	87.9	49549.25638	31.1
Minnesota	28	91.5	58640.63023	25.7
Mississippi	46	80.4	39591.79287	34.6
Missouri	34	86.8	48247.78329	29.6
Montana	29	90.8	43226.06164	24.3
Nebraska	28	89.8	54755.0055	28.6
Nevada	36	83.9	49759.03768	26.2
New Hampshire	27	91.3	68415.23236	27.3
New Jersey	29	87.4	65548.08764	24.6
New Mexico	42	82.8	44604.75297	27.1
New York	35	84.7	50599.53809	23.6
North Carolina	37	84.3	44620.35736	29.6
North Dakota	25	90.1	55672.69483	29.7
Ohio	36	87.6	46092.59565	30.1
Oklahoma	35	85.6	47755.15669	32.2
Oregon	32	89.1	52555.39355	27.3
Pennsylvania	34	87.9	51245.22041	29.1
Rhode Island	37	84.7	53495.46545	25.7
South Carolina	42	83.6	43078.0425	31.6
South Dakota	29	89.9	48461.47167	28.1
Tennessee	37	83.1	42265.83845	31.1
Texas	36	79.9	50591.03012	29.2
Utah	19	90.4	58234.86825	24.3
Vermont	30	91.0	55808.08196	23.7
Virginia	32	86.6	64042.52785	27.4
Washington	29	89.7	59789.57367	26.8
West Virginia	33	82.8	43765.42774	33.8
Wisconsin	31	89.8	53082.90011	29.7
Wyoming	26	91.8	56043.92922	24.6

Table C. Societal Characteristics Data

State	peat47	white	snap	mrfei	safen
Alabama	77	70.35696	12.7227	10.0	88.5
Alaska	82.6	68.12896	10.01661	6.0	90.9
Arizona	80.7	84.76953	10.72246	12.0	82.8
Arkansas	78.2	80.33158	13.99426	9.0	87.9
California	79.8	74.18381	6.179875	11.0	81.7
Colorado	81.3	88.49572	6.122097	11.0	91.6
Connecticut	74.2	82.56127	8.076955	6	88.4
Delaware	78.8	71.91731	9.280616	12.0	87.3
Florida	76.3	78.76508	9.553531	10.0	85.5
Georgia	78.3	63.43054	10.92346	8.0	87.4
Hawaii	80.6	25.65984	7.822727	14.0	87
Idaho	83.4	94.16394	8.825604	13.0	94.7
Illinois	76.2	78.17687	10.23239	8.0	85.1
Indiana	75.6	86.968	10.80346	10.0	88.5
Iowa	79.2	93.21353	10.0439	10.0	94
Kansas	79.7	87.66048	8.261808	10.0	90.8
Kentucky	78.7	89.04969	15.09824	10.0	89.6
Louisiana	78.1	64.03346	17.36726	9.0	85.2
Maine	83.1	95.58877	14.47596	15	92.9
Maryland	75.9	61.33796	7.036106	10.0	88.7
Massachusetts	76.1	84.38073	9.416916	7.0	87.4
Michigan	80.2	80.43086	14.53556	10.0	86.9
Minnesota	80.6	87.17056	6.318203	10	93.2
Mississippi	76	60.30374	15.0338	8.0	87.7
Missouri	80.4	84.12871	12.54768	10.0	90.7
Montana	85.3	90.10668	8.76316	16.0	91.6
Nebraska	78.4	90.30428	8.248468	10.0	91.3
Nevada	78.9	78.00238	6.779744	11.0	82.9
New Hampshire	78.3	94.82335	6.956365	9.0	93.8
New Jersey	73.8	74.46061	5.529734	8.0	86
New Mexico	83.8	83.57661	10.67465	12.0	83.8
New York	74.4	71.73902	12.40377	8.0	79.9
North Carolina	79.7	72.34344	11.01491	11.0	89.5
North Dakota	83	90.56559	7.586716	8.0	94
Ohio	79.2	83.77342	12.57665	9.0	88.3
Oklahoma	81.6	76.01288	12.0569	6.0	88.5
Oregon	81.8	88.83284	14.52239	13	89
Pennsylvania	77.3	83.951	9.719437	11	87.4
Rhode Island	73.4	86.47934	9.966703	5.0	84.8
South Carolina	77.5	68.40852	12.41279	9.0	86.7
South Dakota	80.7	86.79776	9.697194	8.0	93.4
Tennessee	80.4	79.67582	15.34887	10.0	88
Texas	78.2	81.08705	11.48577	7.0	85
Utah	83.2	92.1648	7.219605	13.0	94.4
Vermont	83.9	95.6613	11.29477	13.0	94.2
Virginia	77.6	71.55874	7.828298	11.0	90.9
Washington	81	82.31436	11.05413	12.0	88.9
West Virginia	80.7	94.25357	14.21357	13.0	91.6
Wisconsin	79.1	88.56929	8.45501	11.0	89.5
Wyoming	83.2	93.87608	5.192184	10.0	94.3

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