# The Effect of Obesity on State Health Care Expenditures

An Empirical Analysis

The Honors Program
Senior Capstone Project
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## ABSTRACT

The purpose of this study is to examine the effects of obesity rates on per capita state health care expenditures. A two-stage least square regression model is used. In the first stage of the estimation, factors influencing obesity rates are determined. The determinants of obesity rates are outlined throughout the research process. In the second stage, the impact of obesity rates on per capita health expenditures across states is evaluated. The empirical results indicate that obesity rates do indeed have a direct effect on state health care expenditures. After reviewing the project's results, various solutions are proposed as possible methods to slow and perhaps reverse growing obesity rates with the objective of reducing health care expenditures. The solutions offered may possibly decrease the prevalence of obesity across the nation and in turn lower per capita health care spending.

# INTRODUCTION

Obesity is regularly discussed by today's doctors, families, news anchors and television talk show hosts. Its escalating presence has led to an increased need for investigation of causes and methods of restraining its growth. The research found within this research paper exposes the current health issues caused by increased caloric consumption and decreased rates of exercise, in addition to higher levels of health care spending encountered by obese individuals. The research provides an in-depth assessment of the current state of obesity across the United States, examining a multitude of factors that contribute to the recent trend of rising obesity levels. The conclusions gained from this research will provide the United States with specific knowledge and insight regarding the importance of controlling obesity for the purpose of reducing healthcare expenditures. Moreover, the conclusions derived from the research will provide insight regarding the possibility of decreasing obesity rates through taxes. These results could potentially assist in decreasing the prevalence of obesity across the nation.

Few studies have focused on obesity's effects on health care expenditures. A majority of research has looked at the overall trend of rising health care costs rather than focusing on the impact of lifestyle choices and outcomes on costs. Consequently, the research put forth in this document will contribute a solid foundation of knowledge surrounding the relationship between obesity and health care expenditures.

## The Underlying Definition of Obesity: Body Mass Index

Over the past two decades, obesity rates have risen substantially causing the terms "overweight" and "obese" to become increasingly common in the American everyday language. This growing trend remains a major concern as obesity affects an individual's state of well being, health care costs, productivity levels as well as social stigmatization (U.S. Department of Health). The United States Department of Health and Human Services designates Body Mass Index (BMI) as the standard method for measurement in most weight-related studies. This factor measures body mass based on an individual's height and weight; weight in pounds divided by the square of the height in inches, multiplied by 703. Higher levels of BMI are typically associated with increased mortality in addition to life threatening diseases. To better educate the public, the Dietary Guidelines for Americans established guidelines for healthy weights as well as zones of concern

for obese and overweight individuals centered on the measurement of BMI. The following information explains the breakdown of BMI categories:

- Healthy or normal BMI falls between 18.5 and 25
- Overweight is signified by a BMI between 25 and 30
- BMI's greater than 30 convey obesity
- BMI's greater than 40 measure extreme obesity

In addition to BMI, methods such as measurement of waist circumference, waist-to-hip ratio, and skin-fold thickness are often used to classify overweight and obese individuals. These alternative methods serve to ensure the accuracy of one's BMI calculation. BMI frequently is limited and does not effectively distinguish between fat and lean mass. Consequently, some individuals are wrongly categorized as overweight or obese (Sturm, 2002).

Obesity is often attributed to a variety of reasons. Aside from genetics, one can categorize obesity as a result of two forces:

I. Eating too much.

II. Exercising too little.

Each of these forces holds a direct relationship with obesity rates. The following literature review explores these two concepts in greater depth.

<u>More Food</u>

The growing phenomenon of obesity can be attributed to technological advancements witnessed by society over the past several years. As technology has developed and caused significant change, it "has simultaneously lowered the cost of calories and raised the cost of physical activity" (Lakdawalla et al, 2005). To begin with, one can examine the trend of lowered food costs. A majority of technological enhancements have led to a fall in prices, particularly among food products. According to Jayachandran Variyam (2005), as the price of a preferred good falls, people will choose to acquire more thus sacrificing goods that have remained constant or risen in

price. The ERS Briefing Room on Food Marketing and Price Spreads claims that the ratio of food prices to all other goods has indeed fallen by 12 percent due to the improvements of producing technologies. Thus the law of demand suggests that individuals will increase consumption of items as prices fall, which adds to the notion that society is motivated by low cost to consumer more food.

Agricultural and technological innovations have enhanced suppliers' abilities to provide food at low costs and increased speed. Moreover, improved distribution technologies have decreased the costs associated with food procurement further lowering the overall costs. Mass preparation, deep freezing, increased preservatives, artificial flavors, and microwavable goods have become increasingly popular and cost effective in the recent years. With the growth in convenience technologies, increased accessibility of food has spurred increased consumption of goods thus leader to high levels of obesity. In previous years, consumers used raw agricultural crops to mold into edible food, a process often requiring a significant portion of time to complete. However, in today's society, mass preparation has allowed food manufacturers to cook food in a central location followed by quick shipments to consumers for rapid consumption (Cutler et al, 2003). Consumers' increase in consumption can occur in various ways; increased variety of foods consumed, increased frequency of food consumption, choice to consume high calorie or high flavor foods that had previously been unavailable or increased overall consumption of individual foods (Cutler et al, 2003). Obesity rises with an increased consumption of food, particularly those with high caloric content.

One prime example illustrating Cutler's theory is the rise in popularity of french fries. Potatoes, a prime agricultural good, were frequently considered staples of the American meal, often served baked, boiled, or mashed. Prior to World War II, French fries were a rare commodity due to the labor intensive preparations including peeling, cutting, and cooking. However, in the years following the war, a plethora of innovations and new technologies were introduced to businesses nation-wide, thus increasing the ease of food preparation. French fries were now able to be peeled, cut, and cooked in a select few locations. These locations would then employ new preservation technologies, primarily relying on freeze-packing at 40 degrees. The final portion of the supply chain involves the distribution of these goods to the various consumption points. The french fries are easily reheated – most frequently in deep fryers, but also via ovens or

microwaves. According to Cutler's research, "[f]rom 1977 to 1995, total potato consumption increased by about 30 percent, accounted for almost exclusively by increased consumption of potato chips and [f]rench fries" (2003). Consumption increases as goods become increasingly available such as french fries which potentially leads to increased calories and thus higher levels of obesity.

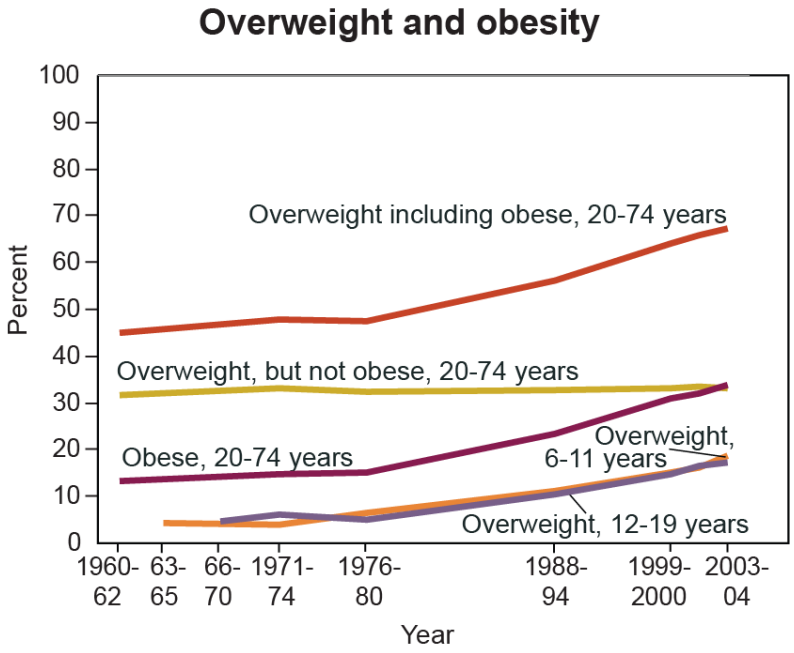
Less Exercise

Americans often use physical activity as a means of offsetting calorie intake. However, in recent years, physical activity has risen in cost. According to researchers, "when home or market production involves manual labor, the worker is paid to exercise" (Lakdawalla et al, 2005). The concept of wages is intended to serve as a form of monetary reward for physically demanding careers. Outside of one's occupation, people pay to exercise via two methods; in the literal sense, money for gym memberships and in economic terms, the opportunity cost of leisure forgone. In general, society has seen a trend of decreased physical activity required to complete a variety of tasks. This reduction can be attributed to the rise in technology as a means of simplifying everyday tasks (Variyam, 2005). In historical eras, a majority of Americans relied on manual labor for income, frequently located in the agricultural industry. Today's economy has witnessed a shift in the focus on agriculture as "less than two percent of the U.S. workforce is in agriculture" (Finkelstein and Zuckerman, 2008). According to Variyam, "these forgone energy expenditures now have to come from voluntary physical activity involving the conscious allocation of time, effort, and sometimes money, as when people join a gym or sports club" (2005). As fewer Americans work in the agricultural and manufacturing sectors, fewer calories are burned in today's stereotypical desk job. With the absence of forced energy expenditures, individuals are left with the burdening choice of whether or not to voluntarily engage in physical activity.

Physical Costs of Obesity

According to the Centers for Disease Control and Prevention (CDC), obesity places Americans at high risk for a plethora of diseases and life-threatening conditions including coronary heart disease, type two diabetes, strokes, cancer, osteoarthritis, and hypertension. According to the Surgeon General's Call to Action to Prevent and Decrease Overweight and Obesity, most of the

costs associated with obesity are resulting from type 2 diabetes, coronary heart disease, and hypertension. In 2000, the United States Department of Health and Human Services identifies that the average American adult male weighed 168 pounds in the early 1960s. Now, however, the same average American adult male weighs nearly 180 pounds. With the increasing prevalence of obesity, it is no wonder that both health care costs and tolls on the human body have been increasing. Obesity places a great deal of strain on the human body forcing a variety of muscles including the human heart to work twice as hard. These health issues induce a tremendous amount of stress onto the body that the body is not used to accommodating. Consequently, obese individuals encounter more frequent needs for doctor visits and checkups. The table below illustrates this growing concern by separating obesity levels according to severity (obese versus overweight) as well as age (ranging from younger children to older adults).




SOURCES: Centers for Disease Control and Prevention, National Center for Health Statistics, *Health, United States, 2006*, Figure 13. Data from the National Health and Nutrition Examination Survey.

A 2001 study by the National Alliance for Nutrition and Activity determined that at least 310,000 Americans face premature death each year as a result of unhealthy eating and inactivity. That same study noted this statistic is five times more than the number of Americans who die prematurely due to guns, HIV/AIDS, and drug use combined. As American society faces this startling statistic, the United States government has been forced to take notice of this growing

issue. Changes in economic incentives have caused the current rise in obesity, thus in order for this trend to reverse, several incentives to eat healthfully and engage in physical activity must also change (Variyam, 2005). Several researchers note that "unless programs aimed at reducing the rise in obesity rates are successfully implemented, overweight and obesity-attributable spending will continue to increase and government will continue to finance a sizable portion of the total" (Finkelstein et al, 2003). As obesity continues to remain a growing epidemic, it is essential that today's society begin the steps to reverse this trend. The following table, adopted from the National Institute of Diabetes and Digestive and Kidney Diseases, outlines the risks and health issues associated with obese individuals.

**Overweight and obesity are known risk factors for:**

- diabetes
- coronary heart disease
- high blood cholesterol
- stroke
- hypertension
- gallbladder disease
- osteoarthritis (degeneration of cartilage and bone of joints)
- sleep apnea and other breathing problems
- some forms of cancer (breast, colorectal, endometrial, and kidney)

**Obesity is also associated with:**

- complications of pregnancy
- menstrual irregularities
- hirsutism (presence of excess body and facial hair)
- stress incontinence (urine leakage caused by weak pelvic floor muscles) psychological disorders, such as depression
- increased surgical risk
- increased mortality

Economic Factors Affecting Obesity

A variety of economic factors can be used to explain behaviors and attitudes of consumers in terms of calorie intake and its direct relationship with obesity rates. These factors were discussed previously in this report. To concisely recap, the law of demand applies to the current

situation facing a majority of obese individuals. As the price of a good decreases, the quantity demanded by consumers increase. In addition, the law of supply states that as technological enhancements are made to lower the costs of producing, suppliers will possess the ability to increase the production and thus supply of goods. As the supply of goods increase, the corresponding prices of these goods decrease. It is important to note as Shin-Yi Chou, Michael Grossman and Henry Saffer mention (2004), "[s]ince no one desires to be obese, it is useful to consider obesity as the byproduct of other goals…" (p. 570). Overall, as the supply and demand factors occur simultaneously, society has witnessed a significant increase in food and caloric consumption.

Demographic Factors Affecting Obesity

Often the existing relationship found between caloric consumption and obesity (and eventually increased health care expenditures) results from the interaction of several demographic variables as claimed by researchers Lisa Mancino, Biing-Hwan Lin, and Nicole Ballenger. In fact, "not everyone is equally at risk of becoming overweight or obese, or at risk for the same reasons" (Mancino et al, 2004). Aside from genetic makeup, much of the variation in body weight seen today can be attributed to behaviors associated with the following variables; price of goods and services, income, time constraints, cooking skills, level of education, gender, age, cultural background, geographic location and race/ethnicity (Mancino et al, 2004). Each of these variables has several sub-groups that can be classified as either directly or inversely related to obesity rates. Often, many of these variables may coincide with one another as "regional variables may also correlate with cultural differences and neighborhood or lifestyle differences" (Mancino et al, 2004). By looking at each of these variables, researchers acknowledge that weight differences are not entirely a function of genetics because many personal choices influence food consumption and thus weight gain.

Chou, Grossman, and Saffer also examined the effect of various factors on both BMI and obesity levels, thus recognizing the idea that not all obese individuals become obese as a result of genetics. Chou, Grossman, and Saffer relied upon a wide range of demographic variables such as marital status, race, education, income and age. Their study sets the foundation for the data gathered and analyzed in this experiment.

Increased Health Care Expenditures

Obesity, resulting from a mix of economic and demographic variables, has a negative impact on individual health. However, the effects of obesity are not limited to an individual's health. Obesity also places a great deal of strain on health care providers. According to Sturm (2002), obesity negatively affects one's health status more so than smoking and drinking. Sturm's research also demonstrates that obesity leads to 36 percent more total health care consumption as well as 77 percent more pharmaceutical consumption. It is important to note that although obesity rates have indeed increased among children, "obesity-attributable medical expenditures for children are presumably only a small fraction of the total because of the chronic nature of many obesity-related diseases" (Finkelstein et al, 2003). Obese individuals frequently face higher health risks and encounter far more health complications associated with being overweight. Consequently, these individuals incur costs not typical of a healthy individual. These aggregate costs comprise a significant portion of healthcare spending otherwise deemed unnecessary.

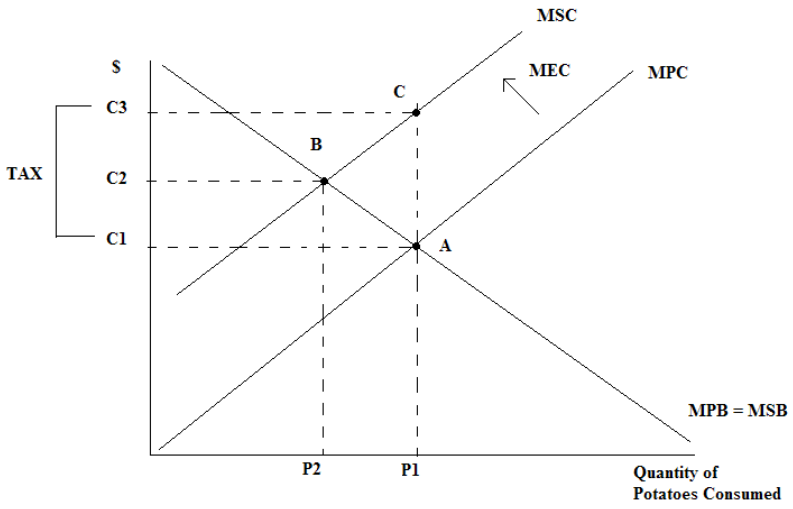
According to Alan Greenblatt (2003), United States Surgeon General Richard Carmona has investigated the upwardly trending costs of obesity stating that "treating obesity-related health problems cost Americans $117 billion annually – an average of $420 per person…consumers also shell out $34 billion on diet products each year." Clearly, health care costs affect consumers across the nation, making obesity a nationwide epidemic in need of resolution. Each year, Americans are required to allocate a portion of their income to federal programs such as Medicaid and Medicare. In supporting programs through tax dollars, Americans take on the responsibilities of offsetting costs for fellow obese individuals. According to a 2005 Thomson Medstat Research Brief, "the national cost of childhood obesity is estimated at approximately three billion dollars for those with Medicaid." These three billion dollars are for children alone – not accounting for the numbers of obese adults covered by Medicaid. It is undoubtedly true that a number of obese individuals are covered by tax-supported programs thus placing an extra cost on society.

Fellow researchers Finkelstein, Flebolkorn, and Wang (2003) confirmed Sturm's conclusions as they estimated that 9.1% of total 2002 United States medical expenditures can be attributed to

obese and overweight individuals. As a negative externality, obesity's costs are not fully recognized by obese individuals. In fact, non-obese individuals are often said to subsidize the obese. This can be explained as "health and life insurance premiums paid [by obese individuals] do not fully reflect their higher medical care costs and their higher probability of death" (Rashad and Grossman 2004, p. 110). While this external cost is partially offset by smaller pension benefits due to decreased life expectancy, the cost is not fully covered. However, rising obesity rates cannot simply be curbed by raising premiums. Rashad and Grossman (2004) suggest that although increased premiums would surely correct the externality, such moves would "raise considerable equity concerns given that obesity has a large genetic component" (p. 110). Ethics take a large role in influencing the policies implemented to address personal image issues due to the fact that on several occasions, obese individuals cannot control their own weight gain. For example, thyroid diseases could potentially affect an individual's diet, hormones, and ability to metabolize nutrients.

Obesity as a Negative Externality

To address the negative externality of obesity, the concept of Pigovian taxes could be implemented to reach a more efficient level of obesity in society. For these taxes to experience relative success, the tax must equal the external cost associated with obesity. For purposes of this example, one specific cause of obesity will be illustrated; increased consumption of potatoes. The following image depicts the negative externality of obesity as a result of increased potato consumption in effect.



In the previous diagram, MPB (marginal private benefit) equals MSB (marginal social benefit). This is a result of all benefits being recognized by society. There is no additional marginal external benefit. It is also important to note the slopes of both MPB and MPC (marginal private cost). MPB is downward sloping due to the decreased benefit associated with increased quantities of potatoes consumed. Although one may derive certain benefits from consuming potatoes such as palate satisfaction and nutritional value, eventually, benefits begin to decrease with each additional unit of potato consumed. For example, after consuming one unit of potato for nutritional value, the next unit does not hold as much value to the consumer due to a decreased need for nutrients. MPC is designated by an upward sloping curve as the cost associated with an additional unit of potato increases as the units continue to increase. Costs associated with increased potato consumption result primarily from the increasing cost industry. As producers must increase the quantity of potatoes supplied, production costs continue to rise. At point A illustrated above, an individual's marginal private costs are equal to the marginal private benefits associated with potato consumption levels of P1 and costs of C1. However, due to the costs imposed on third parties such as higher health insurance premiums related to obesity and higher potato consumption levels, the overall marginal social cost must take into account the marginal external costs. Increased cost levels should subsequently decrease the potato consumption output levels to P2, accounting for costs of C2. However, if potato consumption and thus obesity remains at its current level P1, it encounters high levels of inefficient costs at levels of C3. If Pigovian taxes are implemented equal to the distance between C1 and C3, a net gain to society of triangle ABC would occur.

## HYPOTHESIS

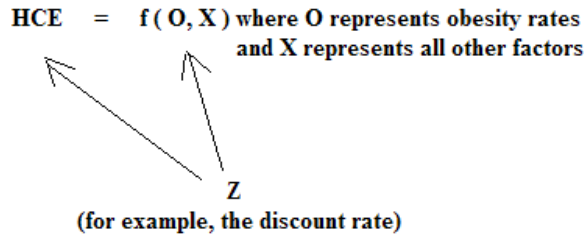
As mentioned earlier, not many studies have investigated the impact of obesity on health care spending. This research paper may be a first step in determining the magnitude of the externality effect. Its results are predicted to demonstrate the increasing need to curb growing obesity levels in order to control both issues detrimental to one's health and health care expenditures.

Prior to analyzing the statistical results, a hypothesis was formed surrounding obesity's effects on state health care expenditures. In examining all relevant literature and prior research, it can be determined that increased levels of obesity produce direct effects on state health care

expenditures. The literature surrounding the extra incurred costs of obesity supports this notion. Consequently, the hypothesis of this research paper is that a direct relationship exists between obesity levels and state health care expenditures. In other words, as obesity levels increase, it can be expected that state health care expenditures will subsequently increase. The estimated coefficient on obesity establishes the magnitude of the relationship of the economic importance of obesity on health care spending.

Issue of Endogeneity Bias

As a two stage model, this research recognizes health care expenditures as a function of obesity and "all other factors;" HCE=f(obesity, all other factors). Observational studies and regression analyses, frequently with multiple stages, are often hindered by the inability to distinguish between causal relationships (that is, cause and effect) and associations (that is, relationships where variables are related but not necessarily cause and effect). In the instance provided in this research report, a direct relationship between obesity and health care expenditures could actually be the fact that both obesity and health care expenditures are jointly influenced by some unobservable factors. For example, individuals with a low discount rate may be obese and also spend very little on health care. People who discount the future very heavily may prefer "living today" by eating excessively and not exercising but also may spend little on medical care which represents a type of investment spending. This study is unable to control for the discount rate in the empirical analysis thus requiring the assistance of instrumental variables, further defined in the next section. The diagram at left illustrates the concept of association rather than causation.




Solution: Instrumental Variables

An instrumental variables approach represents one way of establishing causal relationships. The selected instruments must influence one variable but not the other. In this specific report, four instrumental variables were chosen that were related to obesity but had no relationship with

health care expenditures in any way. These four variables fall under the categories of temperature and precipitation and are as follows:

I. Summer Precipitation

II. Winter Precipitation

III. Summer Temperature

IV. Winter Temperature

Precipitation and temperature are expected to influence obesity levels but not have any impact on health care expenditures. Summer precipitation and winter precipitation are two variables that affect one's decision to exercise. Summer precipitation may influence an individual to partake in outdoor or indoor exercise as well as length of work out. In addition, winter precipitation may reflect an individual's decision to venture outside of the home to a local gym. Temperature levels also exert an influence on one's obesity level. Similar to precipitation, temperature often persuades or dissuades individuals to exercise for certain periods of time. For example, on extremely hot summer days, an individual may be less likely to engage in prolonged periods of exercise due to the discomfort from heat.

These variables are not likely to impact health care expenditures due to their lack of interaction; weather has no impact on state health care expenditures. This necessary property establishes credibility for these variables as instrumental variables. To move onto the second stage of the regression analysis, the focus of the research, the instruments must have plausible signs and be statistically significant.

## DATA AND METHODOLOGY

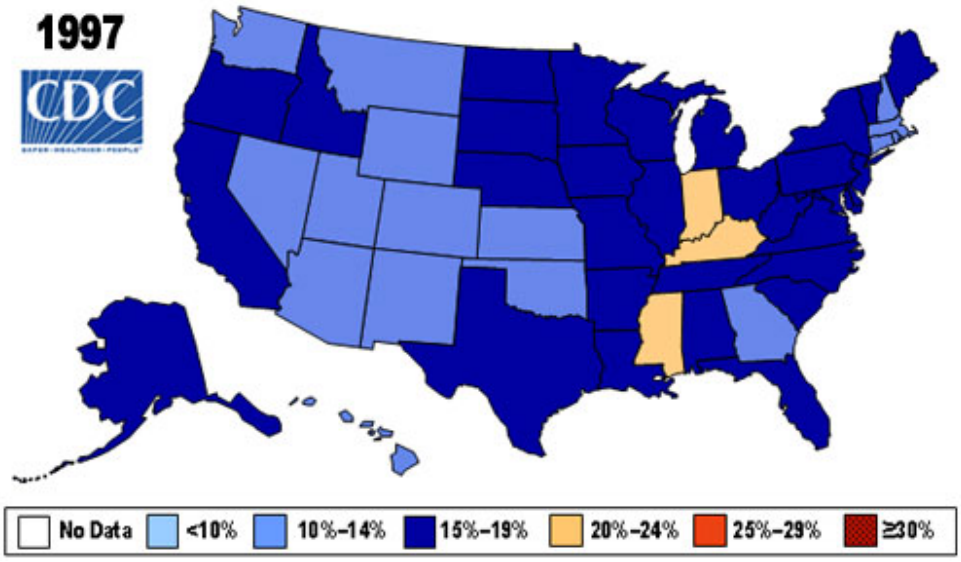
This study examines demographic variables, obesity trends, and health care expenditures across 48 of the U.S. (excluding Hawaii and Alaska due to data availability limitations). The relevant geographical market for this study was determined to span across all of the United States. Obesity, a far reaching epidemic, is not limited to one contained location. Rather, individuals and families have seen and felt the effects of obesity to varying degrees across the nation. While

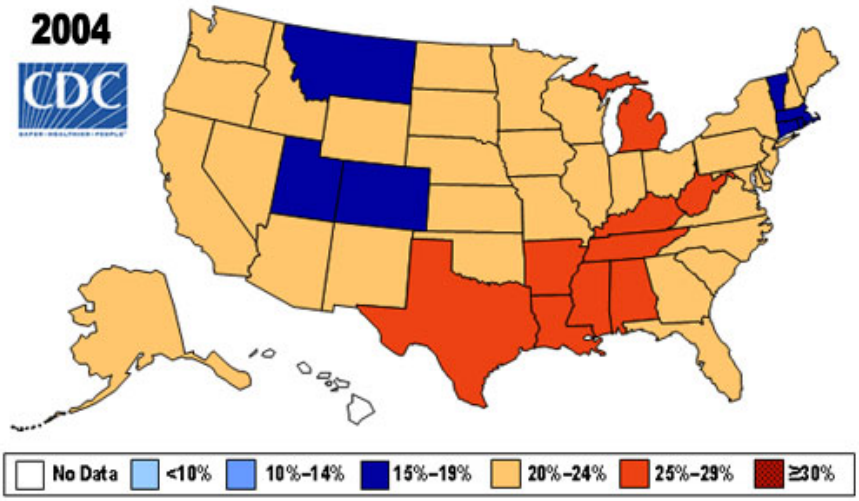
other countries have also seen growing weights among their populations, the United States has undoubtedly witnessed the most substantial weight increase, placing it at levels higher than those recommended by doctors and physicians nationwide. According to 2003 health data gathered by the OECD (Organization for Economic Cooperation and Development), the United States leads other countries with its considerably higher obesity rates. This can be seen in the table of rankings found on the following page, adopted from the OECD.

| Rank | Countries | Obesity Rates |
|---|---|---|
| #1 | **United States**: | 30.6% |
| #2 | **Mexico**: | 24.2% |
| #3 | **United Kingdom**: | 23% |
| #4 | **Slovakia**: | 22.4% |
| #5 | **Greece**: | 21.9% |
| #6 | **Australia**: | 21.7% |
| #7 | **New Zealand**: | 20.9% |
| #8 | **Hungary**: | 18.8% |
| #9 | **Luxembourg**: | 18.4% |
| #10 | **Czech Republic**: | 14.8% |
| #11 | **Canada**: | 14.3% |
| #12 | **Spain**: | 13.1% |
| #13 | **Ireland**: | 13% |
| #14 | **Germany**: | 12.9% |
| #15 | **Portugal**: | 12.8% |
| #16 | **Finland**: | 12.8% |
| #17 | **Iceland**: | 12.4% |
| #18 | **Turkey**: | 12% |
| #19 | **Belgium**: | 11.7% |
| #20 | **Netherlands**: | 10% |
| #21 | **Sweden**: | 9.7% |
| #22 | **Denmark**: | 9.5% |
| #23 | **France**: | 9.4% |
| #24 | **Austria**: | 9.1% |
| #25 | **Italy**: | 8.5% |
| #26 | **Norway**: | 8.3% |

| | | |
|---|---|---|
| #27 | **Switzerland**: | 7.7% |
| #28 | **Japan**: | 3.2% |
| #29 | **Korea, South**: | 3.2% |
| | **Weighted average:** | 14.1% |

For this study, each state's data are gathered over an eight year time frame ranging from 1997 to 2004. While obesity has affected individuals since the earliest eras of history, the most prominent growth in obesity rates has been witnessed over the course of the most recent thirty years. This trend can be seen in the previously displayed chart illustrating obesity rates, found in the former section entitled, "Physical Costs of Obesity." The steepest levels of growth have been found in the past decade thus leading to the collection of data from 1997 to 2004, taking into account all data availability limitations. The above graph displays the level of obesity rates across the country during the 1997 year (graph courtesy of the Surgeon's General Office). The shades of blue illustrate obesity levels at between 10 and 19 percent, a relatively mid-level of obesity. In the next image located on the following page, one can see the same graph displaying obesity data from 2004. The overwhelming presence of peach and orange states signifies the advancing obesity rates across the country, reaching levels between 20 and 29 percent. Thus accordingly, the proposed 1997-2004 time span for this research paper will not only provide an accurate and interesting view of increased obesity levels over time but also will provide data and conclusions relevant to the current time period.






As mentioned previously, research indicates a variety of factors ranging from demographic to environmental trends as influential in determining obesity rates. In creating a sound and reliable regression model, a wide range of factors were controlled for including race, gender, income, education, climate, ethnicity, and employment. In controlling for these variables, the regression model was able to accurately determine each variable's effect on obesity levels across the fifty states. Moreover, by controlling for these variables in the second stage, the study was able to determine the effect of obesity on state health care expenditures while eliminating confounding effects.

Demographic variables including percentage White, Black, Hispanic, elderly, poverty-stricken, female, age, and income are collected by the CDC's Health Promotion's Behavioral Rick Factor Surveillance System. The United States Department of Commerce organizes the National Climatic Data Center, presenting information on various environmental climates across the United States. Using the data collected from this center, the average precipitation for both the summer and winter seasons were gathered in addition to the average winter temperature and summer temperature for each of the 48 states. Each of these factors was analyzed and correlated to determine individual degrees of effect on the percentage of overweight and obese members of a state's population. In calculating the second stage of the least squares regression model, the CDC proved helpful in providing per capita personal health care expenditures per state from 1997-2004. These statistics assisted in determining the overall effect of obesity on per capita health care expenditures.

A two-stage least squares regression model is a method used for studies where a dependent variable is correlated with the cause(s) of the independent variable(s). In this research paper, a two-stage regression model explores the relationship between obesity and per capita health care expenditures. The following table illustrates each of the two stages found in this research project in detail. The two stages found in the model represent a stage in which new dependent variables are created to substitute for original ones followed by a stage in which the regression is computed in a single least squares regression using the newly created variable, predicted obesity levels.

| **Stage One** | **Stage Two** |
|---|---|
| *Time Period:* | *Time Period:* |
| 1997-2004 | 1997-2004 |
| *Dependent Variable*: | *Dependent Variable:* |
| Obesity | Per Capita Health Care |
| *Independent Variables*: | Expenditures |
| Income, Employment, Age, Race, | *Independent Variables:* |
| Sex, Poverty, Ethnicity, | Income, Education, Age, Race, |
| **Instrumental Variables;** | Sex, Poverty, Ethnicity, **Predicted** |
| Precipitation (Summer & Winter), | **Obesity Levels** (from the first |
| Temperature (Summer & Winter) | stage) |

After gathering and organizing all of the necessary data, a statistical program known as E-views computed an analysis of each variable in regards to its isolated correlation with each of the dependent variables. All variables with t-statistics greater than two in absolute terms are said to be statistically significant. The results of these tests are discussed in greater detail in a later section.

The following table examines the descriptive statistics of the data analyzed in this report including mean, maximum values, minimum values and number of observations.

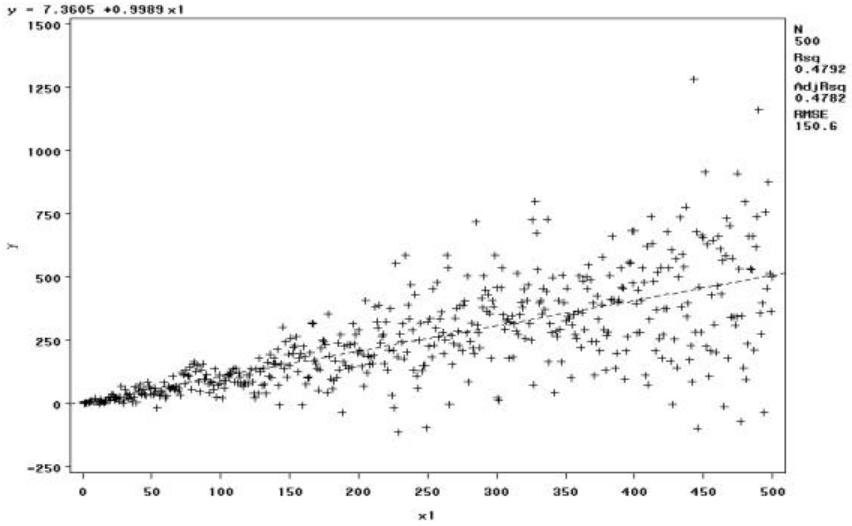
| | Mean | Max | Min | Std. Dev. | Observations |
|---|---|---|---|---|---|
| Summer Precipitation | 10.35 | 27.59 | 0.12 | 5.13 | 384 |
| Winter Precipitation | 8.04 | 23.85 | 0.51 | 4.99 | 384 |
| Summer Temperature | 71.89 | 84.3 | 61.7 | 5.50 | 384 |
| Winter Temperature | 33.64 | 62.6 | 7.6 | 10.35 | 384 |
| Per capita health care expenditures | 4282.5 | 6683 | 2615 | 808. 24 | 384 |
| Per capita income | 28212.79 | 45762 | 18550 | 4821.08 | 384 |
| Poverty rate | 11.79 | 21.2 | 4.5 | 3.16 | 384 |
| Percent with a bachelor's degree | 27.96 | 44.7 | 15.1 | 5.26 | 384 |
| Percent aged 65+ | 17.52 | 24.5 | 12.2 | 2.07 | 384 |
| Percent female | 51.82 | 53.2 | 49.2 | 0.80 | 384 |
| Percent of Spanish origin | 7.18 | 42.1 | 0.5 | 8.38 | 384 |
| Percent of Black origin | 8.07 | 32.4 | 0.1 | 8.33 | 384 |
| Percent of obesity levels | 57.10 | 65.6 | 46.4 | 3.60 | 384 |

Some of the above descriptive statistics are worthy of discussion. The four instrumental variables of summer precipitation, winter precipitation, summer temperature and winter temperature exhibit noticeably varying minimum and maximum values. For example, winter temperature ranges from its maximum value of 62.6 degrees to its minimum value of 7.6 degrees. In addition, the mean summer rain and winter rain vary significantly by more than two inches per year; mean summer rain equaling 10.35 inches/year and mean winter rain equaling 8.04 inches/year. Statistics of per capita health care expenditures also revealed interesting information in the $4,068 difference between the minimum and maximum values. Its standard deviation exposed the wide degree of difference amongst values as it equaled $808.24. Finally,

one additional variable to take note of is the percentage of fat (rate of obesity). The corresponding values of percent of obese individuals range from a minimum of 46.4% to a maximum value of 65.6%. While these statistics are important to review, the results of the two stage least squares regression model are the most essential component of this research.

## EMPIRICAL RESULTS

Two econometric issues that need to be addressed are heteroskedasticity and fixed effect. First, heteroskedasticity refers to a violation of the assumption that an error term has a constant variance due to observations drawn from identical distributions. This experiment features variables over a series of time thus increasing the likelihood of an error term varying or increasing with each observation. The below image illustrates the concept of increasing heteroskedasticity over a set time period.




Each error term can be measured as the distance between the plotted point and the line of best fit. Clearly, the error term increases as the line and data progress right. Throughout this two stage regression analysis, cross-section weights were used in order to correct for the effects of heteroskedasticity.

The second issue is that surrounding fixed effects. Fixed effects allow for the control of unobservable differences that cannot be observed or measured. While a variety of fixed effects do exist for use in econometric models, this research utilized time fixed effects to control for

things unobservable over time. State fixed effects could not be specified because they are highly correlated with the instrumental variables.

Regression Results

In stage one, the four instruments and other variables used in the second stage were analyzed regarding their effects on obesity levels. Eight of the eleven variables were significant at the 5% level while one variable was found to be significant at the 10% level. After conducting stage one, the table of results produced an r-squared coefficient of 0.68 thus communicating a relatively strong fit of data within the regression model. The following chart details each variable and its corresponding level of significance with obesity rate.

| **Variable** | **Coefficient, t-Statistic** |
|---|---|
| Income | -0.000198** (-4.881627) |
| Employed | -.178496** (-3.138009) |
| Age 65+ | 0.276224** (2.887202) |
| Spanish | -0.012024 (-0.608759) |
| Poverty | -0.028530 (-0.454441) |
| Black | 0.161996** (5.979902) |
| Female | -0.510962** (-2.110131) |
| Summer Precipitation | 0.005747 (0.168781) |
| Winter Precipitation | 0.069248* (1.927382) |
| Summer Temperature | 0.215136** (4.248519) |
| Winter Temperature | -0.162654** (-5.517661) |

*Notes:* Coefficient estimates with t-statistics reported in parenthesis

**Indicates statistical significance at the 5% level

* Indicates statistical significance at the 10% level

The following variables were determined to be significant; income, employment, age, race, sex, winter rain, summer temperature, and winter temperature. In other words, each of these variables was deemed to have an impact on obesity levels for a variety of reasons. For example, higher incomes tend to be associated with slightly lower levels of obesity most likely due to

one's ability to afford higher priced food items containing greater nutritional value. In addition, older individuals are associated with a greater prevalence of obesity. This can be attributed to the idea that older individuals are not as active and do not possess the ability to exercise as frequently or rigorously as younger individuals. According to results above, African Americans are associated with higher obesity levels. This is likely due to the fattening nature of the cultural diet including foods high in saturated fat. Females are less likely to face higher levels of obesity. Perhaps this can be attributed to the pressure to remain thin and healthy placed on women in society by portrayals of thin, shapely women across various forms of media.

The Spanish and poverty variable were determined to be insignificant. One can assume various reasons for these variables deemed insignificant. Obesity rates may not vary with the Spanish ethnicity due to the lack of relationship between the Spanish culture and caloric intake. Some families may choose to consume more healthy food due to cultural diets. Despite increased consumption, not all calories will harm the human body, thus refraining from increasing obesity.

Poverty is a unique situation. Obesity is frequently thought to be correlated with poverty. As one becomes poorer, one often cannot afford higher priced nutritional foods. Rather, with a low income, one relies on mass produced, cheaper goods such as the previously discussed example of French fries as well as fast food. However, this research study finds poverty and obesity as insignificantly related as seen by the t-Statistic of -0.45441. Perhaps the reasoning for this lack of relationship is due to impoverished people's inabilities to afford to eat in general. With a lack of monetary funds, those in poverty may eat on extremely limited budgets forcing themselves and family members to frequently remain hungry. With a lack of nutrients and food in general, it is not uncommon to witness the human body wither away to a body structure.

Of more importance to the research at hand are the signs and statistical significance on the estimated coefficients of the instrumental variables. Winter precipitation proved to be significant at the 10 percent level, with a t-Statistic of 1.927382. Winter precipitation may only have a slight impact on obesity due to its lack of influence on the decision to exercise. Most exercise during the winter is conducted indoors due to inclement weather conditions. Consequently, if it is raining outdoors, people are often unaffected by their decision to continue to exercise indoors.

Summer precipitation may have been determined as insignificant because a strong number of people may deem summer rain as refreshing. This therefore may not influence one's decision to exercise. Temperature also possesses a relationship with obesity levels. Summer temperatures and winter temperatures often reach extreme highs and lows, respectively. As a result, one may choose to forego exercise based on uncomfortable levels of heat or cold that may be unsuitable for exercising. In addition, temperature may dictate the type of food one cooks. For example, on warm days one can grill chicken outdoors on a grill which is much healthier and possesses more nutritional value than a fried chicken cutlet. However, winter temperatures may not allow for outdoor grilling thus forcing one to resort to fried chicken cutlets.

Perhaps the most important aspect of the first stage of the regression model was the calculated Wald test. The Wald test is a statistical test often used to test the joint effect of a group of variables. In the first stage of the regression model, the Wald test is able to test for the significance of the four instrumental variables' impact on obesity rates (summer precipitation, winter precipitation, summer temperature, winter temperature). Individually, these four variables can be either significant or insignificant. Individually, these four instrumental measures might be insignificant because of collinearity. The Wald test produced an F-statistic of 7.75 thus illustrating the collective significance of the four instrumental variables. This adds credibility to the model and validity to the instrumental variables.

The second stage of the regression model examines the effects of obesity rates on state health care expenditures while controlling for other variables. Nine variables were analyzed, all but one were determined to be significant at either the 5 or 10 percent level. The primary focus for this stage of the regression analysis was to analyze the effects of obesity rates on per capita health care expenditures. This variable proved to be extremely significant exhibiting a direct relationship, thus supporting the stated hypothesis earlier in this report. After completing the second stage of the regression model, the r-squared coefficient was determined to be 0.752727, thus illustrating a strong fit between the data and the model. The table below outlines each variable as well as its corresponding coefficient and level of significance (as conveyed by the t-Statistic).

| **Variable** | **Coefficient, t-Statistic** |
|---|---|
| Income | 0.072896** (6.614815) |
| Poverty | 44.70755** (3.555403) |
| Bachelor's Degree | 69.30129* (1.892699) |
| Age 65+ | 34.87966* (1.689656) |
| Female | 240.7680** (3.473874) |
| Spanish | -15.44342** (-3.916634) |
| Black | -35.47838** (-3.861453) |
| Employment | -6.177070 (-0.230926) |
| Obesity Levels | 189.4045** (2.504624) |

*Notes:* Coefficient estimates with t-statistics reported in parenthesis

**Indicates statistical significance at the 5% level

* Indicates statistical significance at the 10% level

All variables with the exception of Spanish and Black exhibit direct relationships with per capita health care expenditures; Spanish and Black variables convey inverse relationships. The results of testing the variable for the Spanish ethnicity state that for a one percent increase in Spanish ethnicity, per capital health care expenditures decrease by fifteen dollars per capita. This can be a result of more Spanish people being uninsured and thus paying more out-of-pocket health care expenditures. This same reasoning could also apply to the Black community as the test above illustrates for a one percent increase in Black race, per capita health care expenditures decrease by thirty four dollars.

Females, as dictated by the model results, are directly associated with obesity; a one percentage point increase in "female" population results in approximately a $240 increase in per capita health care expenditures. This can attributed to increased health needs such as child birth. Moreover, females exhibit higher stress levels as well as cases of depression. Each of these contributes to the higher health care expenditures. Income, Poverty, and Age variables each produce direct relationships with expenditures. All three relationships were indeed expected. As one gets older, it can be expected to incur additional costs associated with high medical needs and treatments thus supporting the results of approximately a $35 increase in per capita health

care expenditures for a one percentage point increase in "old age." In addition, higher levels of poverty indicate additional expenses due to increased cases of sickness and disease. Impoverished families often cannot afford nutritional diets or proper treatments to keep one healthy. Consequently, they face increased occurrences of compromised immune systems thus requiring more health care. Both variables of bachelor's degree (education) and income exhibit positive relationships. Higher degrees are associated with an additional $69 in health care spending due to higher knowledge of health and wellness. These individuals are more likely to frequent the doctor and medical locations in order to maintain their health and wellness. For example, those possessing bachelor degrees are more likely to visit AIDS and HIV testing centers as well as routine physical exams and dental exams in order to maintain high levels of health. Higher levels of income also produce higher levels of health care expenditures. This results from one's ability to afford more frequent health care. These individuals are more apt to spend additional disposable money on health care in order to protect one's level of wellness.

Perhaps the most interesting and relevant conclusions to this project can be seen by the final variable: obesity levels. This variable produced a significant coefficient, illustrating a tremendous direct relationship. For every one percentage point increase in obesity levels, per capita health care expenditures increase by approximately $189. Essentially, the original hypothesis of a direct relationship existing between obesity levels and health care expenditures is confirmed through this finding. This relationship exists due to the increased amount of doctor visits, medical expenses and medical complications associated with increased obesity levels.

## SUMMARY AND CONCLUSION

The purpose of this study was to determine the relationship between obesity and health care expenditures. Successful research determined by this study indicates that obesity does indeed directly affect the level of per capita health care expenditures. A sound model was built using a variety of inputs and controls in order to accurately predict obesity's effects. In order to heighten the model's credibility, a larger time period could further be examined in addition to the results put forth in this paper.

As previously stated, in using a variety of controls and instrumental variables, this research determined obesity as directly related to health care expenditures. To reiterate the model's findings, every one percent increase in obesity levels results in approximately a 189 dollar increase in health care expenditures. The following table provides the data necessary to illustrate an interesting concept incorporating the results of this research (where HCX represents health care expenditures).

| | **1997** | **2004** | **Change** |
|---|---|---|---|
| **Average HCX** | $3,455 | $5,337 | $1882 |
| **% Obesity** | 53.21 | 59.95 | 6.74% |

Assuming one percentage point in obesity increases per capita health care expenditures by $189, one can calculate the per capita increase in health care expenditures between 1997 and 2004 by simply multiplying the percentage increase in obesity, 6.74%, by $189 totaling $1,274. According to the statistics provided in the above table, the average increase in health care expenditures per capita overall is $1,882. Therefore, the percent increase attributable to obesity can be determined as $1,274/$1,882 equaling 67.7%. In other words, obesity can be held responsible for 67.7% of the increase found in health care expenditures.

After careful research and analysis, it is clear that obesity is a growing epidemic across the nation. According to the CDC, "although Medicare and Medicaid pay approximately half of obesity-attributable money, each taxpayer is now responsible for a payment of approximately $180 a year for obesity related medical costs for public sector health plans." This supports the conclusions derived in this research paper. A growing concern for Americans of all ages and backgrounds, obesity not only increases health concerns and mortality rates, but also it increases the monetary obligations of individuals. Obesity's wide reaching effects are not to be dismissed but rather should be addressed through active policies geared towards increasing nutrition and exercise along with education and awareness. In using a variety of tools ranging from governmental policies to state based programs, obesity can be better controlled and perhaps even reduced.

Proposed Solutions

As obesity consistently grows more prevalent in society, it is frequently referred to as an uncontrollable epidemic. However, the question remains; is this epidemic truly uncontrollable? As discussed previously, costs of food influence consumers' choices regarding consumption. Perhaps the most obvious solution to propose for a reduction in obesity rates revolved around the implementation of taxes and/or subsidies. Two examples of such taxes and subsidies provided by Jayachandran N. Variyam in "The Price Is Right" are outlined below:

- Taxes placed on fattening foods will increase the price of additional calories thus decreasing consumption.

- Subsidies introduced for employee health club memberships may reduce the price of physical activity, thus encouraging energy expenditure.

While taxes on fattening foods will indeed increase the price of additional calories, the same objective can be reached by removing current subsidies on unhealthy foods. Such foods include soybeans and corn. According to a recent article published in Washington Bureau's News Service, "[g]overnment financial support spurs farmers to plant certain crops, creating an abundant, cheap supply of fat-producing soybean oil and high-fructose corn syrup" (2007). These items serve as the foundations for a variety of high fat foods including sodas and potato chips.

The incentives for farmers to grow unhealthy crops contributing to the rising popularity of unhealthy foods could potentially be offset by a counterbalancing subsidy. An additional subsidy to be explored is the concept of subsidies on healthy food including those high in protein and fiber. Subsidies on items such as vegetables, fruits, and fish may encourage higher spending on these cheaper yet healthier goods. By subsidizing the costs of fruit and vegetables, the government will surely increase incentives for farmers to increase production of such goods. As the supply of these goods increase, prices will reflect the new, more affordable rates. Consumers may then choose to spend more on affordable, more nutritional goods as the price decreases rather than continued spending on more expensive, fattening goods.

U.S. government agencies have already taken a variety of steps towards tackling the issue of obesity prevention. Most federal agencies, in addition to private organizations, have issued guidelines and publications advising society members on various ways to remain healthy and active. Such participating organizations include the American Diabetes Association as well as the United States Department of Agriculture. Recommendations from these credible organizations often revolve around diet and exercise. In addition, it is not uncommon to see such recommendations geared towards preventative measures in elementary and middle schools across the nations. Often these recommendations focus on providing balanced meals and nutritional recommendations to young students. Additionally, federal groups often advocate for legislature promoting accurate food labeling.

The following table adopted from Marion Nestle and Michael Jacobsen (2000) in their publication, "Halting the Obesity Epidemic: A Public Health Policy Approach," portrays the immense advocacy and action geared towards reducing the prevalence of obesity across the nation. While the table information ends for the 1999 time period, the various health associations and societies have certainly continued their efforts in increasing advocacy and action geared towards reducing obesity rates. Efforts include publications in 2005 and 2006 released by the CDC; "Public Health Strategies for Preventing and Controlling Overweight and Obesity in School and Worksite Settings" and "Secondary School Health Education Related to Nutrition and Physical Activity," respectively. The USDA and the Department of Health and Human Services also released an updated 2005 version of Dietary Guidelines for Americans alongside the National Center for Education in Maternal and Child Health's 2002 release of "Bright Futures in Practice: Nutrition." Both federal agencies in conjunction with non-federal agencies and individual researchers have continuously worked hard to tackle the growing issue of obesity.

Figure 1. Examples of policy guidelines published by US government agencies and health organizations for prevention of obesity through diet, exercise, or both

1952 American Heart Association: *Food for Your Heart*[17]
1965 American Heart Association: *Diet and Heart Disease*
1968 American Heart Association: *Diet and Heart Disease*
1970 White House Conference on Food, Nutrition, and Health[19]
1971 American Diabetes Association: *Principles of Nutrition and Dietary Recommendations*
1974 National Institutes of Health: *Obesity in Perspective*
1974 American Heart Association: *Diet and Coronary Heart Disease*
1977 National Institutes of Health: *Obesity in America*[20,22]
1977 US Senate Select Committee on Nutrition and Human Needs: *Dietary Goals for the United States, 2nd Edition*[18]
1978 American Heart Association: *Diet and Coronary Heart Disease*
1979 US Department of Health, Education, and Welfare: *Healthy People: The Surgeon General's Report on Health Promotion and Disease Prevention*
1979 National Cancer Institute: *Statement on Diet, Nutrition, and Cancer*
1979 American Diabetes Association: *Principles of Nutrition and Dietary Recommendations*
1980 US Department of Agriculture and US Department of Health and Human Services: *Dietary Guidelines for Americans*[24]
1984 National Institutes of Health: *Lowering Blood Cholesterol to Prevent Heart Disease*
1984 American Cancer Society: *Nutrition and Cancer: Cause and Prevention*
1985 National Institutes of Health: *Consensus Development Conference Statement*
1985 US Department of Agriculture and US Department of Health and Human Services: *Dietary Guidelines for Americans, 2nd Edition*
1986 American Heart Association: *Dietary Guidelines for Healthy American Adults*
1986 American Diabetes Association: *Nutritional Recommendations and Principles*
1988 US Department of Health and Human Services: *The Surgeon General's Report on Nutrition and Health*
1988 American Heart Association: *Dietary Guidelines for Healthy American Adults*
1988 National Cancer Institute: *NCI Dietary Guidelines*
1988 National Heart, Lung, and Blood Institute: *National Cholesterol Education Program*
1989 National Research Council: *Diet and Health: Implications for Reducing Chronic Disease Risk*
1990 US Department of Agriculture and US Department of Health and Human Services: *Dietary Guidelines for Americans, 3rd Edition*
1991 American Cancer Society: *Guidelines on Diet, Nutrition, and Cancer*
1993 National Heart, Lung, and Blood Institute: *National Cholesterol Education Program*
1994 American Diabetes Association: *Nutrition Principles for the Management of Diabetes and Related Complications*
1995 US Department of Agriculture and US Department of Health and Human Services: *Dietary Guidelines for Americans, 4th Edition*
1996 American Heart Association: *Dietary Guidelines for Healthy American Adults*
1996 American Cancer Society: *Guidelines on Diet, Nutrition, and Cancer Prevention*
1996 American Diabetes Association: *Nutrition Recommendations and Principles*
1997 American Heart Association: *Guide to Primary Prevention of Cardiovascular Diseases*
1997 World Cancer Research Fund and American Institute for Cancer Research: *Food, Nutrition and the Prevention of Cancer: A Global Perspective*
1999 American Heart Association: *Preventive Nutrition: Pediatrics to Geriatrics*

NOTE: References not indicated are available from the authors on request.

Additional, more specific ideas to ponder in regards to reducing obesity rates nation-wide include restricting media advertisements portraying high calorie, low nutrient foods as viable diet intakes for both young children and adults as well as advocating for the provision of funding and incentives for increased bicycle paths, recreation centers, swimming pools, parks and sidewalks – all of which promote various forms of physical activity. To end the current obesity epidemic, the research focus must extend to incorporate all influential techniques to slow obesity growth rates. This extends "beyond genetic, metabolic, and drug development studies to encompass – and emphasize – population based behavioral interventions, policy development, and program

evaluation" (Nestle and Jacobson, 2000, p. 23). A variety of policies, publications, media, and education must be adopted in order to target the wide array of people affected by obesity. Taken together, these programs may in fact reduce the rates of obesity and thus the level of health care expenditures encountered by Americans today.

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