The benefits of early comprehensive youth obesity prevention strategies outweigh the costs to consumers and reimbursers

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THE BENEFITS OF EARLY COMPREHENSIVE YOUTH OBESITY
PREVENTION STRATEGIES OUTWEIGH THE COSTS TO CONSUMERS AND
REIMBURSERS

by

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THE BENEFITS OF EARLY COMPREHENSIVE YOUTH OBESITY PREVENTION STRATEGIES OUTWEIGH THE COSTS TO CONSUMERS AND REIMBURSERS

AMALIE ALVER

ABSTRACT

The prevalence of obesity in the United States is at the highest it has ever been. Adolescent and adult obesity rates have increased greatly over the past three decades, and those individuals who are already obese continue to gain weight. More recently, levels of obesity have stabilized but the number of obese individuals in the country is still very high. Efforts must be made at reducing these levels of obesity, as obesity is associated with the development of chronic diseases, significant reductions in quality of life, and insurmountable costs. The economic impact of obesity expands beyond direct healthcare costs into the workplace, reducing individual productivity levels and increasing the number of workdays missed as the severity of obesity increases. These realities provide incentives for both governmental and private sectors to take an interest in the prevention of obesity.

The causes of obesity are many, and an appropriate treatment that will reduce obesity on a population level has not been identified. Current literature suggests the most effective population to target for obesity prevention is youth, especially around the ages of five to seven while lifestyle habits are being formed. This is mostly due to the relatively small changes needed to prevent childhood obesity as compared to the more
difficult approach of reducing adult obesity. As opposed to the treatment of adult obesity, the prevention of childhood obesity requires a much smaller correction to daily calorie intake. Furthermore, obese youth tend to maintain their obesity into adulthood. The earlier in age that childhood obesity develops, the more difficult it is to prevent the development of adult obesity. Evidence currently shows that childhood obesity levels are related to the quality of meals and eating habits influenced by parents or caregivers and increased consumption of sugars and high-calorie foods strongly associated with aggressive food and beverage marketing. In addition, decreased levels of physical activity are associated with childhood obesity risk. In these ways, the current social and economic environment in the US strongly promotes childhood obesity.

The most effective obesity prevention strategies involve a holistic modification of the surrounding environment. Studies show that addressing the school environment and thoroughly educating parents about the importance of nutritious eating and physical activity are important components of childhood obesity prevention efforts. While school and community interventions are moderately effective, a rise in BMI does tend to occur during summer months when children are typically on a less structured schedule and may not have encouragement from school programs to eat healthy foods and exercise. Schools also provide the opportunity for extracurricular activities, such as sports programs and other such supportive measures, which may prevent the development of childhood obesity.

Suggested policy actions may modify the community and environment in such a way that obesity reduction is economically favorable. A tax on sugar-sweetened
beverages is estimated to be highly effective in reducing childhood consumption of sugar, and subsequently lowering obesity rates. Other policy interventions that would be effective for reducing childhood obesity include imposing limits on the types of foods sold in school to children, and restricting marketing efforts aimed at children. Implementing a sugared-beverage tax and reducing tax subsidies from advertisements of food and beverage companies would produce positive return-on-investments and raise additional funds for additional adolescent obesity prevention efforts.

Policymakers, local governments, parents, schools, and the community will need to invest time and finances into these modifications for obesity prevention to be effective. Policy changes, specifically sugared-beverage taxes, have recently been enacted in Mexico and in Berkeley, California. Evaluation research will provide additional evidence for the efficacy of these policy actions in obesity prevention. Current projects that will contribute to the gaps in preventive community modification research are in progress in California, Massachusetts and Texas. Additionally, research into the prevention of summer-month BMI increases in children may be beneficial for maintaining appropriate lifestyle modifications when school is not in session.
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LIST OF ABBREVIATIONS

AHA .......................................................... American Heart Association
BMI .......................................................... Body Mass Index
CORD ....................................................... Childhood Obesity Research Demonstration
CDC .......................................................... Center for Disease Control
IMT .......................................................... Intima media thickness
IOM .......................................................... Institute of Medicine
NHANES .................................................. National Health and Nutrition Examination Survey
RCT .......................................................... Randomized controlled trial
ROI .......................................................... Return-on-investment
SES .......................................................... Socioeconomic status
SUS .......................................................... Shape Up Somerville
UI ........................................................... Uncertainty Interval
US ........................................................... United States
INTRODUCTION

The Obesity Pandemic

It is well known that the prevalence of obesity throughout the world has been steadily increasing over the last few decades, with some of the highest rates documented in the United States. What used to be referred to as an epidemic concerning primarily developed countries has gradually transformed into a global issue, with estimated rates of obesity worldwide increasing by nearly 30% among adults and 47.1% among children between 1980 and 2014 (Ng et al., 2014). Serious health consequences accompany the obese state; it has been associated with an increased risk of developing chronic disease during adulthood, including cardiovascular disease, many types of cancers, elevated blood pressure, and type 2 diabetes mellitus (Field et al., 2001). The risk for developing chronic disease increases concurrently with increasing severity of obesity (Field et al., 2001). Even being overweight has health consequences, as overweight women have been found to be at higher risk than normal-weight females for the development of hypercholesterolemia, hypertension and heart disease (Field et al., 2001). In 2010, high body mass index (BMI) accounted for an estimated 3.4 million deaths globally (Lim et al., 2013).

The rates of obesity in the US steadily increased between the 1980’s and early 2000’s, with a particularly significant increase in both adolescent and male obesity between 1999 and 2004 (Ogden et al., 2006). In 1988 the prevalence of obesity for women was between 23% to 35%, depending on ethnicity, and hovered around 22% overall for men, regardless of race (Fryar, Carroll & Ogden 2012). By 2008, the obesity
prevalence increased to approximately 36% in men, and ranged from nearly 33% for Caucasian women to 58.5% for African-American females (Fryar, Carroll & Ogden 2012). As the health consequences of obesity became more known to the population, a number of initiatives were instituted federally in an attempt to curb this epidemic. In November 2000, the US Department of Health and Human Services initiated Healthy People 2010, which had the two major goals of increasing life span and decreasing disparities in health quality throughout the country (National Center for Health Statistics, 2012). One of the goals of this initiative was to reduce the rate of childhood obesity to only 5% by 2010. The goals of Healthy People 2010 relating to the obesity epidemic were not met, as both childhood and adult levels of obesity rose further, the nutritional quality of the average American diet failed to improve, and food insecurity increased (National Center for Health Statistics, 2012). Food insecurity is commonly defined as an inability of a household to obtain food that is healthy over any period of time, and usually is caused by a lack of finances or a lack of availability of healthy foods (National Research Council, 2006). The continuous rise in childhood obesity levels led the former Surgeon General, Richard Carmona, to famously quote in 2004, “Because of the increasing rates of obesity, unhealthy eating habits, and physical inactivity, we may see the first generation that will be less healthy and have a shorter life expectancy than their parents” (HHS – Office of the Surgeon General).

There is mounting evidence to suggest the rates of obesity have begun to level off throughout the US population (Ogden et al., 2008). The rates of obesity have not changed significantly over the past ten years, and obesity rates in some subgroups of the
US population have actually decreased; notably, there has been a mild decrease in obesity rates among low-income preschool-aged children (Ogden et al., 2014). The prevalence of obesity in the US has not significantly increased over the last decade as predicted, however, as of 2012 the rates of obesity were still extremely high at 34.9% for the adult population and 16.9% for youth (Ogden et al., 2014). Figure 1 shows the rise in youth obesity prevalence over the past three decades.

Figure 1. Prevalence of Youth Obesity Rates Between 1971 and 2010. The prevalence of obesity in children and adolescents has increased across all age groups over the past three decades. Obesity during childhood strongly predicts development of adult obesity, and earlier development of childhood obesity leads to a greater severity of obesity later in life. Adapted from Wang & Lim, 2012.

While it is promising and encouraging that overall the prevalence of obesity has not continued to climb, the severity of obesity in already obese individuals in the
population has continued to increase. The rate of severe obesity (a BMI greater than 40) in the US adult population has increased to nearly 7% (Sturm 2013).

This effect has also been seen in the youth population; between 1999 and 2012 there was a significant increase in the levels of severe obesity across all ages between 2-19 years (Skinner & Skelton, 2014). The cutoff points for childhood obesity differ from those used for adults. Instead of using BMI as the sole indicator of obesity, the CDC defines childhood obesity based on the percentiles that the child fits for height and weight. Children in the 5th to 85th percentile are of healthy weight, children in the 85th to 95th percentile are considered overweight, and children in or above the 95th percentile are classified as obese (CDC.gov, 2014). The consequences of obesity will only continue to grow as the population of the country ages and the severity of obesity increases. A single and clear cause of obesity has not been identified, but dozens of contributory and exacerbating factors have been found, including genetic predispositions, diet and physical activity patterns, and the surrounding social and economic environment (Güngör, 2014).

**Childhood Obesity**

In the past it was not believed that adolescent obesity was associated with immediate health risks, however, it has more recently been found to correlate with an increased incidence of non-alcoholic fatty liver disease, a decrease in vascular endothelial integrity, and premature death (Crawford et al., 2010). Other serious medical conditions strongly associated with childhood obesity include asthma, hypertension, ADHD, depression, and sleeping disorders (Pulgarón, 2013). Youth who are overweight or
develop obesity have a greater risk for becoming obese adults (Wang & Beydoun, 2007). The risk for becoming an obese adult as an overweight adolescent is 62% and 73% for males and females, respectively, and rises to 80% and 92% for adolescents who are already obese (Wang et al., 2008). Other studies have confirmed that the risk for developing adult obesity becomes greater with increasing levels of obesity during childhood (Singh 2008). Efforts to prevent and reduce childhood obesity as early as possible are crucial to halting the progression into adult obesity, and with it the myriad of health consequences that can occur (Wang et al., 2007). Three influential periods of life have been identified during childhood for the development of obesity: during gestation, at the time of adiposity rebound, and during adolescence (Dietz 1994). Adiposity rebound occurs typically between the ages of 5 to 7 and represents the period of development when BMI begins to gradually increase after a time of stasis following the initial BMI increase shortly after birth (Rolland-Cachera et al., 2006).

The difference between required and excessive caloric intake is the smallest during childhood and adolescence relative to adulthood, at an estimated average imbalance of 110 to 165 kcal/day (Wang et al., 2006). Based on data from the National Health and Nutrition Examination Survey (NHANES), normal-weight children between the ages of 2 and 7 years have the lowest average difference in excessive calorie intake that can lead to excess weight gain, an estimated 43 kcal/day (Wang et al., 2006). It has also been stressed that as children grow older, the energy deficit needed to prevent excess weight gain becomes larger, so preventing excessive weight gain at a younger age is ideal for the maintenance of a healthy weight (Wang et al., 2006). Relative to the adult or
overweight adolescent population that would require a much greater calorie deficit to offset weight that has already been gained, the caloric imbalance during the ages of 2 and 7 is small and creates an opportunity to intervene that is feasible.

**Dietary Impact**

It has been hypothesized that one of the largest contributors to the rise of obesity has been an increased consumption of unhealthy foods and sugar-sweetened beverages. Between 1977 and 2001, Americans tripled their consumption of sugar-laden drinks, which includes soft drinks and sports drinks (Nielson & Popkin, 2004). For every serving of sugary drink consumed by a child, their relative risk for becoming obese increases by a factor of 1.6, and controlling for all other variables, increased consumption of sugared beverages leads to an increased BMI (Ludwig et al., 2001). By simply substituting sugar-sweetened drinks with water, it is estimated that Americans would be spared an additional intake of 235 kcal per day (Wang et al., 2009). Figure 2 shows the increased rate of sugared-beverage consumption across the US population over the past three decades.

The current food environment surrounding children in the US strongly encourages the consumption of products containing high amounts of added sugars and fat and undermines the consumption of unprocessed, whole foods. Since the late 1970’s, the relative price of vegetables and fruits has increased at a much greater rate compared to sodas and other sugary foods (Brownell & Frieden, 2009). As children are exposed to higher doses of television advertisements for sugar-sweetened, carbonated beverages and
fast foods, an associated increased consumption of these high-calorie items is observable (Andreyeva, Kelly & Harris, 2011). Youth who are obese show higher levels of responsiveness to fast-food television advertisements (McClure et al., 2013). Major food and beverage companies invest an inordinate amount of resources to ensure that their products are exposed to as many children as possible. In 2006, advertising expenditure reports from 44 major food and beverage companies revealed that over $1.5 billion had been spent on marketing their products specifically to youth in the US (Fed. Trade Comm., 2008). By 2009, this amount had increased to $1.9 billion (McClure et al., 2013). Perhaps more surprising is the current enabling role of the government in the marketing of these products to children. Of the $633 million spent by food and beverages companies in 2009 on TV advertisements targeting children, $80 million was subsidized by the US government as an acceptable business expense (Sonneville et al., 2015).

![Figure 2. Average Increased Consumption of Sugared Beverages in the US Population.](image)

The average rate of consumption of sugared-beverages has increased over
the past three decades, leading to an excess intake of calories and potentially contributing to the obesity rate. As children between the ages of 2 and 7 could prevent the onset of obesity by decreasing their calorie content by a reduction in calories of less than 50 kcal/day, decreasing the amount of sugared-beverages consumed by children could be effective in reducing childhood obesity. Adapted from Brownell and Frieden, 2009.

**Physical Activity**

Physical activity level is a crucial determinant of obesity development. Moore *et al.* conducted an 8-year study of 94 children between the ages of preschool and adolescence to determine the role of physical activity on body mass index (2003). Children with higher levels of physical activity at preschool age were found to have a lower BMI during adolescence than children with lower levels of physical activity (Figure 3). The authors hypothesized that this occurrence is possibly due to a dampening or prolongation of the onset of adiposity rebound. This difference was more pronounced in females than males, and additionally the study found that adiposity rebound occurred later in life for children with higher baseline levels of activity (Moore *et al.*, 2003). Previous studies have shown that higher BMIs during early adulthood correlate with a younger age of adiposity rebound (Rolland-Cachera *et al.*, 2006).
Children with the highest levels of physical activity at age four (indicated by the triangle) had lower BMIs as they aged relative to children with low or modest levels of physical activity (indicated by the square and diamond). The similar slopes of the lines in each group indicate the base value of BMI is important in controlling future BMI. This has crucial implications for the prevention of childhood obesity, as working to prevent obesity in children may be most effective before adiposity rebound occurs. Adapted from Moore et al., 2003.

Higher levels of sedentary behavior, such as television viewing, during childhood and adolescence positively correlate with an increased risk of obesity and a higher BMI in adulthood (Hancox, Milne & Poulton, 2004). The amount of television viewing at the age of 10 years can be accurately estimated by the frequency of television viewing when a child is only 5 years of age (Viner & Cole, 2005). Adolescents have been found to consume greater portions of non-nutritive food with increasing amounts of television viewing (Weicha et al., 2006). It has also been shown that BMI at the age of 14 is a strong predictor of the same individual’s BMI at the age of 31 (Laitinen, Power &
Järvelin, 2001). These findings again demonstrate that obesity prevention strategies targeted at very young populations, specifically preschool age or younger, may be more beneficial and effective than strategies aimed at older populations of youth.

*The School Environment: Diet and Physical Activity*

The school environment is a large determinant of both the level of physical activity that children experience and their dietary intake during the school year. Over 60% of children in the US, on average, eat lunch provided by the school, and nearly 20% consume school-provided breakfast on a daily basis (Gordan et al., 2009). A study in 2009 comparing the eating behaviors of students who ate school-provided meals versus students who brought their meals from home interestingly found that the former group consumed significantly fewer sugared beverages during school hours (Briefel, Wilson & Gleason, 2009). The same study confirmed that students who were provided meals by the school consumed around 40% of their daily caloric intake at school. Students in elementary school with provided lunches also consumed fewer calories from candies and most other energy-dense foods. The most significant difference in this study was the amount of calories consumed by students directly from French fries, which was significantly higher for students who chose the school lunch option (Briefel, Wilson & Gleason, 2009).

Another study found that the prevalence of obesity in elementary students was associated with an increased frequency of serving sweets and fried potatoes during lunch (Fox et al., 2009). Middle-schoolers were more likely to be overweight or obese if the
cafeteria was in close proximity to vending machines that carried high-calorie products. Surprisingly, the researchers also found that if similar products were sold individually directly from the school itself, students were more likely to have a healthier weight. There were no associations found in the older population of high school students between vending machine proximity or cafeteria options and individual BMI (Fox et al., 2009).

Partially in response to the childhood obesity epidemic, the Healthy Hunger-Free Kids Act of 2010 aimed to elevate the quality of food served by schools in order to meet nutritional recommendations for children. A more recent study examining the success rate of the nutritional requirements set forward by the Healthy Hunger-Free Kids Act showed improvement in the nutritional quality of meals (Johnson et al., 2016). Johnson and colleagues found that fruit and vegetable selections were more accessible to students (2016).

As previously reviewed, physical activity levels are an important determinant of obesity development. A 2013 national survey of the self-reported physical activity levels of US high school students found that only 20% to 35% of students, on average, participate in vigorous physical activity for at least 60 minutes per day (Kann et al., 2014). However, an accelerometer-based study using the 2003-2004 NHANES data found that only 42% of children between ages of 6 and 11 truly exercised for the recommended amount of time per day (Troiano et al., 2008). The same study found that youth between the ages of 12 and 15 had a much lower physical activity level than their younger counterparts – less than 10% of these youth exercised moderately for 60 minutes every day (Troiano et al., 2008).
Exercise-based school programs, both during and after school hours, have been the focus of much research as potential interventions for childhood obesity. A study in Spain analyzed the effects of an after-school exercise program on BMI levels in fourth and fifth grade students (Vizcaíno et al., 2007). Students were randomly assigned to a control group or intervention group. The children assigned to the intervention group participated in a 24-week exercise program, consisting of 1.5 hours of activity three times weekly. At the end of the study, the students in the intervention group had not significantly decreased their BMI relative to the control group. However, the intervention group did show a modest decrease in female body fat percentage, and decreased levels of apolipoproteins were also found for both sexes (Vizcaíno et al., 2007). While there was no significant decrease in BMI demonstrated in this study, the decreased body fat percentage is encouraging. This study exemplifies the difficulties of obesity prevention, as targeting only one aspect of obesity risk is often unsuccessful to achieve long-term reductions in BMI and obesity rates. The importance of integrating preventive measures into the many levels of the social and ecological environment that influences the health of the population will be discussed in a later section.

*Parental Influence*

Parents have an extremely important role, if not the greatest, in the development of the habits of their children from birth through late adolescence (Lindsay et al., 2006). Children who have at least one obese parent are at a much greater risk for developing obesity; this effect is strongest if the child is still under the age of 10 (Whitaker et al.,
1997). A study in Finland of 6,280 children and their mothers found that children born to mothers with higher BMIs were more likely to have higher BMIs themselves (Laitinen et al., 2001). Parents and other caregivers heavily influence eating habits and physical activity levels of their children, and they are also responsible for providing the food choices in the household (Lindsay et al., 2006). Increases or decreases in the weights of parents, especially in the mother, are associated with concurrent weight changes in children before the onset of adolescence (Andriani, Liao & Kuo, 2015).

Oldstad and McCargar (2009) published a review stressing the importance of childhood obesity prevention in children younger than six years of age. The authors suggest that waiting to initiate obesity prevention strategies until children are of toddler-age is too late, and that the most effective obesity prevention needs to occur in-utero. The authors point to many studies showing the negative impact of certain maternal habits on their offspring’s future BMI, including maternal weight, breastfeeding practices, and smoking status (Oldstad & McCarger 2009).

Another study published in 2004 explored the relationship between changes in parental and child weight during a family-based obesity reduction therapy (Wrotniak et al., 2004). Families with obese children between the ages of 8 and 12 were given nutrition education and strong encouragement to increase physical activity over a two-year period of observation. This study found that decreasing parental BMI z-scores was significantly associated with concurrently decreasing BMI z-scores in their children (Wrotniak et al., 2004).
It is obvious that parents are significant and important targets for implementing obesity prevention strategies, but it is important to continue to provide preventive measures in as many settings as possible as children age and spend more time in school and other social environments. If weight loss is to be maintained from childhood through adulthood, long-term comprehensive lifestyle changes must be adopted and sustained and the surrounding environment must be supportive of these efforts (Limbers, Turner & Varni, 2008).

**Economic Impacts of Obesity**

Obesity is not just an issue of personal health that should only concern the affected individual or the family. Obesity and the associated healthcare costs place a substantial burden on the healthcare system and affect the finances of every taxpayer in America. Nearly twenty years ago the estimated costs associated with obesity accounted for 9% of the annual medical expenses of the US at a price approaching $80 billion (Finkelstein et al., 2003, Finkelstein et al., 2009). The increased rate of obesity since 1987 secondarily increased costs related to diabetes, hyperlipidemia and cardiovascular disease (Thorpe et al., 2004). In 2003, Finkelstein’s research showed that the medical costs related to obesity neared the costs related to tobacco consumption. Because of the chronic nature of obesity-related illness, medical costs do not usually begin accumulating until later in life. This results in state-funded healthcare programs, specifically Medicare and Medicaid, shouldering an extremely large portion of the consequential costs of obesity.
A study in 2012 found that between 32% and 42% of the Medicare and Medicaid budgets respectively go directly to costs attributed to obesity, and it was estimated that there would be a decrease of nearly 10% of current healthcare costs per state if obesity no longer existed (Trogdan et al., 2012). Another study in 2009 found that obese individuals are responsible for an average of $600 more per year per individual in Medicare spending than non-obese persons (Finkelstein et al., 2009). The average increase in the annual medical cost of an obese individual relative to a normal-weight person is approximately $1,429 (Finkelstein et al., 2009). Across the lifetime, it is estimated that the total lifetime costs for a child who develops obesity at a young age and remains obese throughout adulthood is approximately $19,000 greater than a non-obese child who remains at a healthy weight during their lifespan (Finkelstein, Graham & Malhotra, 2014).

The negative consequences of obesity on individual longevity and costs of healthcare are not fully encompassed simply by considering direct medical costs. Two studies recently reviewed reported an estimated cost of between $3.38 billion and $6.38 billion in the United States for lost days of work of obese employees versus non-obese employees (Trogden et al., 2008). Individuals with a higher BMI are more likely to miss work than those with a lower BMI, and the amount of workdays missed increases with increasing severities of obesity (Bungum et al., 2003; Cawley, Rizzo & Haas, 2007). A study of the effects of BMI on work productivity and functionality on 341 factory workers in Kentucky revealed a significant employer cost attributed to workers with a BMI ≥35 (Gates et al., 2008). The researchers found that these workers had an average yearly cost of missed workdays and decreased on-site productivity of $939 per individual
above workers with a BMI of less than 35 (Gates et al., 2008). As the population in the US of adults over the age of 20 with a BMI ≥35 is roughly equal to 14.5%, these numbers should be of high economic significance to employers (Odgen et al., 2014). Obesity accounts for approximately 9% of the total costs of missed workdays in the US (Cawley, Rizzo & Haas, 2007). Overall, it is estimated that $73 billion is spent annually for causes directly related to obesity in fulltime workers (Finkelstein et al., 2010). Figure 4 shows the costs associated with obesity in the workplace across sex-specific weight categories.
Figure 4. Economic Impact of Obesity in the Workplace. Obesity is associated with increased costs resulting from lower productivity (top bar), missed workdays (middle bar), and direct medical expenses (bottom bar). As the severity of obesity increases from normal weight (BMI <30) through grade III obesity (BMI >40), the costs associated with the disease increase concurrently. This shows incentives for employers to consider funding obesity prevention strategies, as it will benefit their company economically. Adapted from Finkelstein et al., 2010.

Designing and funding preventive strategies to reduce the rates of obesity in the US will benefit many aspects of society, both economically and socially, as long as the programs invested in are effective. It’s been estimated that it is more cost-effective to invest in strategies that would decrease obesity levels by one percent in 6-year olds versus accomplishing the same effect in older populations of youth based on the impact on quality of life years and overall lifetime medical costs (Trasande 2010). Private health insurance companies have not been keen to invest in obesity treatment and prevention possibly due to a lack of immediate return on investments, issues with high potential employee turnover rates, and a lack of consistency with private providers (Finkelstein & Brown, 2006). Although state programs fund a larger portion of obesity-related healthcare costs, private companies still spent between $12 and $17 billion annually on the treatment of this disease (Wang et al., 2015).

It has been recommended that long-term rather than short-term return-on-investment (ROI) should be the priority consideration when investing in childhood obesity prevention strategies (Finkelstein & Trogdan, 2008). While all reimbursers would benefit from a reduction in obesity levels, the Medicare program would benefit the most from obesity prevention due to the high cost of care for the obese elderly.
The costs of treating severe obesity in 2013 in the US ranged from $64 million to $9.1 billion depending on the state (Wang et al., 2015). The wide range of costs between states is dependent on a variety of factors, from population in general to costs of healthcare. The state with the highest medical costs relating to severe obesity was California, probably due to the large population of individuals suffering from severe obesity (over 3 million individuals). Wyoming had the lowest number of individuals with severe obesity, and therefore the lowest in medical expenditures related to their treatment (Wang et al., 2015). These figures provide a reasonable incentive for increasing both private and government interest and intervention in preventing childhood obesity and subsequently reducing adult obesity and its associated costs.

**Preventive Measures**

A number of possible effective obesity prevention targets have been identified, including the modification of parental habits, the school environment and influences (such as nutrition education and availability of specific food types), individual physical activity habits, and the marketing strategies of food and beverage companies targeting children (Roblin 2007). In 2005, the Institute of Medicine (IOM) issued a report citing preventive strategies, emphasizing the importance of community modifications and the community’s role in the prevention of adolescent obesity (Koplan et al., 2005). The IOM released an additional report in 2012 stressing the need for government and community involvement in reducing the surrounding obesogenic environment (Glickman et al., 2012). Recommendations from the IOM for the prevention and treatment of obesity
include making healthy and nutritious food options more available and more affordable to the population (2012). Yet, as shown in Figure 5, there are substantial price differences between healthy food choices and products with high amounts of added sugars. These differences in cost are theorized to promote an increased consumption of obesogenic products and discourage consumption of healthier options (Brownell & Frieden, 2009). Second only to a lack of time for preparation, monetary cost has been found to be the second most common deterrent for low-income individuals to eating healthy foods such as fruits and vegetables (Eikenberry & Smith, 2004). In 2005, a study found that families receiving food stamps would have to dedicate nearly 70% of their total food allowance to the purchases of produce in order to obtain the suggested daily intake values (Cassady, Jetter & Culp, 2007).

![Figure 5. Relative Price Increase of Healthy Options Relative to Sugar-containing Food Products.](image)

The price of fruits and vegetables has increased at a much greater rate than food and drinks with high amounts of added sugars, which have been associated
with an increased risk of obesity development. These price differences make it economically more favorable to purchase the sugar-containing products, creating an environment that is likely to promote obesity. Modifying the environment to make healthy choices more economically favorable has been recommended as a potential obesity treatment and prevention strategy. Adapted from Brownell & Frieden, 2009.

Finkelstein and Bilger propose that the most effective method for addressing the childhood obesity epidemic in the US would involve requiring individual states to reimburse the government for the cost to Medicaid of obesity in their state (2012). The proposal cites the authors’ opinions that in order for obesity levels to substantially decrease, maintaining a healthy weight needs to become economically favorable, and that the only way to do this is to offer tax incentives to families and schools who have children within the normal BMI range (Finkelstein & Bilger, 2012).

This literature thesis specifically aims to examine the most recent knowledge and evidence base regarding effective childhood obesity prevention strategies, with consideration of their economic feasibility and potential returns. After evaluating and summarizing the current and most recent literature, future directions in the area of childhood obesity prevention research will be recommended.
PUBLISHED STUDIES

Effective strategies for the prevention of childhood obesity

*Comprehensive Community-based Preventive Strategies*

One of the first attempts at a comprehensive program to reduce or prevent childhood obesity on a larger scale was the Child and Adolescent Trial for Cardiovascular Health, or CATCH (Coleman et al., 2005). The program was conducted in El Paso, Texas with a predominately Latino/Hispanic population of nearly 900 third-grade students in over 800 different elementary schools. Participating schools were randomly assigned to either be a control or treatment school and paired with other schools of similar demographics. Primarily the program required modifications to the physical activity levels of students via increased PE equipment and training, as well as the implementation of minimum nutritional standards for meals provided during lunch.

Some of the primary outcomes of the study included an overall level of fitness, physical activity levels, BMI, and obesity level. In the article, “risk of overweight” is used to denote childhood overweight, and “overweight” is used to denote childhood obesity as the cutpoints for childhood obesity have been revised since CATCH was initiated. The results of the program were promising, as the rate of overweight/obesity for females in the intervention group increased by only 2% relative to an increase of 13% for the control group over a 2-year period. Relative rates of overweight versus obese were not provided and instead were grouped into one category. Male children in the intervention group also saw an increase of 1% in the rate of overweight/obesity relative to the increase of 9% for the male control subjects. Overall, there was an increase in BMI for children in both
intervention and control groups. While it is perhaps discouraging that the rates of overweight and obesity did not decrease but instead increased, it must be acknowledged that the increases seen in the control groups were much greater than those seen in the intervention group. The authors reflected on reasons why the study failed to decrease obesity rates, suggesting a need for more stringent restrictions on classroom snacks and also an increased adherence to physical activity requirements (Coleman et al., 2005).

A cost-effectiveness study was published for the CATCH program in 2007 (Brown et al., 2007). The study assumed that children who would have developed obesity if not for the intervention would maintain their levels of obesity as adults. In their calculations, the authors included direct medical costs attributable to obesity, quality of life years and absenteeism. The authors concluded that the ratio of cost-effectiveness, or the direct medical costs per quality life years gained by preventing obesity, of the CATCH program was approximately $900 in 2004 dollars. The net benefit, which includes the amount saved in medical treatments and in work productivity, was nearly $70,000 in 2004 dollars. Overall, even though the program did not actually reduce the rate of childhood obesity at the time, it was cost-effective and beneficial because it slowed the development of obesity (Brown et al., 2007).

The most successful childhood obesity prevention studies have involved interventions that modify aspects of the child’s life both in school and at home (Wang et al., 2015). A frequently referenced effective community intervention study is the Shape Up Somerville program (Economos et al., 2007). Citing the need to incorporate more aspects of a child’s life in an obesity prevention program, as past programs had been
predominantly ineffective, the researchers attempted to reduce the obesogenic properties of the surrounding community. The goal of the study was to achieve a reduction of 125 kcal/day in elementary school children in grades 1 through 3 via a combination of decreasing caloric intake and increasing physical activity. A total of 1,178 children were enrolled, using Somerville, MA as the intervention community and two separate communities serving as controls. As many areas of impact were addressed as possible, including the school environment, home environment, surrounding restaurants, and aspects of the media. After school programs increased their amount of physical activity offered, restaurants provided “SUS approved” menu items and advertised them to consumers, and there was a very high level of compliance by teachers and administrators to share nutritionally-oriented curriculum in schools. Controlling for all other variables, the BMI z-score (a standardized BMI score) of the intervention population had decreased significantly relative to the pooled control groups at the end of the first 8-month portion of study (Economos et al., 2007). The positive effects of the community-based program on the intervention group also extended to the parents of the targeted children (Coffield et al., 2015). There was a reduction of an average of 0.411 BMI units in the participating parents, showing a secondary population benefit effect from the community-based intervention (Coffield et al., 2015).

The change in BMI z-score of children in the SUS intervention group was sustained through the second year of the program (Economos et al., 2013). Interestingly, intervention and control groups showed a sharp rise in BMI z-score over the few months of summer when the children were not in school (Figure 6). A study assessing the
activities and habits of the intervention group during the summer months showed decreased levels of physical activity and a lower quality of diet consumed (Tovar et al., 2010). The children who spent the least amount of time in activities such as summer camps had the highest levels of inactivity and poor nutritional intake. These findings demonstrate the need to find and impose effective means of decreasing the risk for weight regain during months that are less structured. At least three other long-term high quality studies of one year or longer duration investigating the efficacy of comprehensive community-based child obesity prevention methods have shown positive, albeit somewhat modest, results: the Healthy Living Cambridge Kids study, the Romp & Chomp study in Australia, and a study based in California (Chomitz et al., 2010; de Silva-Sanigorski et al., 2010; Sallis et al., 2003).

No data has been published regarding the total cost of the Shape Up Somerville intervention, but a news article by Lauran Neergaard from the Associated Press estimated a total cost of between $3-$4 per child annually based on a report released by the non-profit organization Trust for America’s Health (2008). When one of the lead researchers of the SUS program was asked about cost-estimates for the study, Dr. Economos stated in an email that her group would be publishing exact cost-estimate data later in 2016 but the information is not currently available to include in this writing (Economos, 2016).
Figure 6. Increases Among BMI z-score Across All Groups During Summer Months. The intervention group showed a significantly decreased BMI z-score relative to control groups during the school years (represented by the line between the first two and last two marks). However, all groups of children, regardless of treatment or control placement, were found to have increases in BMI z-scores during school intersessions (represented by the line between the middle two marks). This shows a possible time of vulnerability for obesity development during childhood. Future research should explore prevention of weight gain during less structured months. Adapted from Economos et al., 2013.

Caregiver Modification

A small randomized controlled trial (RCT) was conducted in Cincinnati with obese preschool-aged children that strove to compare the effectiveness of obesity reduction achieved by one session of pediatrician counseling versus a multi-session home and clinic-based therapy involving both the children and parents (Stark et al., 2011). The
primary outcome was BMI z-score. The children and parents in the treatment group were given a series of nutritional counseling and educational sessions psychology postdoctoral researchers at home and in the clinic over a period of six months, with a focus on providing parents with behavioral management strategies to encourage healthy eating and increase the level of physical activity for their children. The control group was given one visit with a pediatrician for a discussion regarding the child’s weight. At the end of the six-month study, the children and parents in the treatment group showed a significant decrease in BMI z-score while the children in the control group showed increases in BMI z-score. The weight loss seen in the comprehensive treatment group persisted for one year post-intervention (Stark et al., 2011).

Another study conducted in Germany tested a predominantly parental-based treatment approach (Kleber et al., 2009). The primary outcome in this study was BMI. The parents of 84 obese children between the ages of 4 and 7 were given multiple educational sessions that included nutritional and behavioral education relating to their children. The children participated in sessions focused purely on increasing physical activity. There was no control group for this study. At enrollment into the study, the children’s baseline parameters were measured and it was found that their blood pressure, triglycerides, LDL cholesterol levels and intima media thickness (IMT), which is related to the development of atherosclerosis, were all elevated relative to the appropriate average range of values for their age group. At the conclusion of the study, blood pressure, triglyceride levels, insulin resistance, IMT and BMI had significantly decreased from the pre-intervention measurements. Importantly, three years post-intervention,
nearly half of the children who initially enrolled had successfully maintained their weight loss (Kleber et al., 2009).

Policymaker Responsibilities

While combined school- and parental-based comprehensive interventions show promising results, none of the studies have released information about total cost for implementation (Wang et al., 2015). The authors of SUS do report assisting the intervention community in acquiring an additional $1.5 million in funding to assist in improving the accessibility of their area in an effort to increase levels of physical activity (Economos et al., 2007). They also stress that while implementation of their intervention strategies would require a large amount of time and effort initially, it would initiate a community change that could then be maintained (Economos et al., 2007).

Following the evidence behind these studies indicating that comprehensive environmental and community modifications are highly promising childhood obesity prevention methods, it is important to determine the most effective way of implementing these changes. The well-documented decrease in the rate of tobacco consumption in developed countries over the past three decades has been attributed to the policy change implementation of increased taxes, the banning of certain marketing methods, and increased education regarding the consequences of tobacco use (Jha et al., 2006). Using this as a model of a successful population behavior modification system, it would follow that the changes needed to reduce the childhood obesity rate in the US may also be achieved by utilizing similar strategies.
Australia began assessing the cost-effectiveness of its policy-driven adolescent obesity prevention strategies in 2004 (Haby et al., 2006). Using their suggestions as a basis and by translating their applicability to the US population, seven policies that have a high potential for reducing and preventing childhood obesity were evaluated for cost-effectiveness and potential ROI for the US population (Gortmaker & Wang, et al., 2015). The following policies were examined: institution of a tax-per-ounce on drinks with added sugars, the removal of tax deductibles for advertising unhealthy foods and drinks to children, required modification of school lunches to improve nutritional quality, calorie labeling on restaurant menus, restrictions on the type of foods sold in schools, increased nutrition education for young children, and access to bariatric surgery for obese adolescents. Each of these interventions has shown some evidence for reducing childhood obesity burden, but it is important to determine how cost-effective these policy interventions would be for the population in order to realistically and efficiently allocate funding. Of the seven policy changes evaluated, three of them are estimated to have a positive ROI for the US population (Figure 7). It was estimated that by the year 2025, imposing restrictions on the nutritional quality of the food sold in schools would save $4.56 per dollar spent and prevent 345,000 children from developing obesity. Instituting a per-ounce tax on sugared beverages would save $30.78 for every dollar spent and prevent 576,000 cases of childhood obesity. Finally, eliminating the tax deduction allowed to food companies by advertising that targets children would save $32.53 per dollar spent on initiating this action, and 129,000 cases of childhood obesity would be avoided. While instituting these interventions may not show an immediate large decrease
in obesity levels, over time these treatments have strong potential to substantially impact the rates of childhood obesity. Importantly, there was no inclusion in these estimates for the reduction in costs related to the prevention of other chronic diseases that are highly correlated with obesity, such as cardiovascular disease and type 2 diabetes mellitus. These calculations also did not take into account the savings related to other obesity-related indirect costs, such as the effects of obesity on work productivity and absenteeism as previously discussed (Gortmaker & Wang, et al., 2015).

Additional benefits of a sugared-beverage tax include possible consumption reductions in the adult population and subsequent reductions in adult obesity (Kristensen et al., 2014). When estimates for the reductions in type 2 diabetes mellitus and heart disease resulting from a decreased consumption of sugar are included in the calculations for efficacy of a tax on sugar-sweetened beverages, it is estimated that over a 10-year period nearly $20 billion in medical costs would be saved and 26,000 premature deaths would be prevented (Wang & Coxson, et al., 2012). It is important to note that the suggested tax on sugared-beverages would not be a sales tax, but instead would be an excise tax which would inflate retail pricing; this would likely be more effective at reducing purchases of the product than a tax added at the register (Long et al., 2015).

There are also potential financial gains by taxing sugared beverages and eliminating the tax deductible to food corporations (Gortmaker et al., 2015). It has been estimated that a per-ounce tax on beverages would produce revenue of $79 billion over a 5-year period, which could be directed toward further obesity prevention efforts (Wang & Coxson, et al., 2012).
Figure 7. ROI Estimates for Seven Obesity Prevention Strategies. The above figure shows the proposed strategies with their respective return-on-investment, including an uncertainty interval (UI). As shown, the most cost-effective strategies for preventing childhood obesity include a tax on sugared beverages, requiring improvements to the nutritional quality of products sold in schools, and removing the tax break allowed to advertisers for marketing specifically targeting children. These three policy-dependent actions could substantially reduce the obesity rate in the US population while producing revenue for further obesity-prevention research and treatment. Adapted from Gortmaker et al., 2015.

These efficacy estimates are extremely promising and lend confidence to the argument that there are policy actions that could be initiated today that will effectively reduce childhood obesity levels in the US. Understandably, there has been intense opposition from the food and beverage industry to these recommendations. Despite
evidence and strong support from many in the scientific community, by 2008 none of the 74 bills proposed to impose a tax on soda and processed snack foods have been passed (Kumanyika et al., 2008). Most recently, the “Stop Subsidizing Childhood Obesity Act,” which proposes elimination of the tax subsidy for advertising of non-nutritive foods and beverages directed at children, was presented to the Senate in 2014; over the past year and a half, the only action taken on the bill has been to refer it to the Committee on Finance (Blumenthal, 2014).

There are a few critics of the sugar-sweetened beverage tax in the scientific community who question its effectiveness. Fletcher and colleagues found no convincing evidence to support an effect on the BMI of individuals in the states of Ohio and Arkansas in the early 1990’s when a soda-tax was imposed on these states (2015). The data analyzed were gathered from NHANES for individuals over the age of 18 years. The authors conclude that because there was no effect on BMI in these populations, it is highly unlikely that the newly proposed tax will be as effective as other researchers have suggested. They also suggest that a decrease in soda consumption will likely lead to an increase of calories from other sources (Fletcher, Frisvold & Tefft, 2015). Importantly, these authors drew their conclusions based on an analysis of a tax only on soda, and not a tax on all sugared beverages.

Kersch and colleagues stress the importance of understanding the ethical considerations of policy actions for childhood obesity prevention (2011). The authors argue that failure to implement the suggested policy interventions for reasons such as only modest efficacy on an individual level is not a responsible reaction from a public
health perspective. They suggest that while forcing an individual to maintain a healthy lifestyle is unethical, making it easier and more affordable to choose healthy options is an ethical and necessary step in reducing population obesity levels. For obesity prevention to be most effective, integrative preventive measures must be addressed simultaneously (Kersch, Stroup & Taylor, 2011).

**Health Behavior Influences**

Since the release of the Lalonde report in 1974, the scientific community has been aware of the concept of social health determinants and the complexity of public health behaviors (IOM, 2001). The importance of a comprehensive program for the prevention and reduction of obesity in the population is highlighted by the successful results of SUS. Unlike the CATCH program, which only attempted to modify the school environment, SUS involved the family and greater community. Instead of targeting one risk factor while ignoring others, SUS was able to influence numerous aspects that determine the health of the population. A review examining the efficacy of multiple health behavior modifications relative to single-intervention methods was conducted in 2011 (Prochaska & Prochaska). The review found multiple studies showing that improving one aspect of participant health was likely to encourage improvements in other aspects. The authors speculated that when one aspect of an individual’s health is improved, it may increase the likelihood that the person will be more motivated to improve other aspects of their life via an improved sense of self-assurance (Prochaska & Prochaska, 2011). Figure 8 shows a proposed diagram for visualizing public health behaviors in one commonly used
framework, the socio-ecological model. This model is important as it demonstrates the various layers that affect the individual’s behaviors. The model shows that while it is crucial for an individual to make choices to maintain a healthy lifestyle, they are limited by their surrounding environment and the opportunities they have to make those healthy choices. For example, if an individual has a desire to exercise frequently but does not have access to a public recreation area and cannot afford a health club membership, they will not be able to act on their wishes to exercise.

**Figure 8. Socio-Ecological Model of Health Behavior Influences.** When developing programs that will be more likely to effectively change public health behaviors, the socio-ecological model can be used to appreciate the complexity of obesity prevention and treatment. The behaviors of the individual are influenced by their relationships with family and friends, their immediate surrounding environment, their communities, and the broader regulations of society. Changing individual behavior is complicated and prolonged alterations require modifications and support at multiple levels of the socio-ecological model. Adapted from “Cultural Competence”, CDC.gov, 2013.
Future Developments

Evidence of Effective Policy Reform

The effectiveness of policy interventions regarding obesity reform in the US has not yet been fully observed, but recent policy changes have occurred that will allow this evaluation in the future. In an attempt to reduce the prevalence of obesity and type 2 diabetes in their population, Mexico instituted a countrywide tax of nearly 10% on all sugar-sweetened beverages and high-energy foods on January 1, 2014 (GAIN report, 2014). Colchero and colleagues have recently compiled and published data on the impact of this tax on beverage purchases over the first year of implementation (2016). They compared average volume of sugared beverage purchased from the beginning of 2012 (pre-tax) to the end of 2014 (post-tax). Overall, post-tax implementation led to a decrease in sugared-beverage volume purchase by a total of 6% across the population. There was a large difference in purchase tendency between groups of different socioeconomic status (SES), with the largest decrease in taxed-beverage sales evident in those within the lowest SES bracket. The decrease in purchases grew as the year progressed, with a final decrease of 17.4% in purchases during the final months of 2014 by the lowest SES group. The authors stress that their study does not necessarily prove that the new tax is wholly responsible for the decrease in beverage purchase and suggest further research (Colchero et al., 2016), but it is promising that sales decreased, and to a greater extent in the low-income demographic group that is most vulnerable to obesity risk.
To date, the only city in the US that has successfully passed an excise tax on sugar-sweetened beverages is Berkeley, California. This tax went into effect in early 2015 and in November, Falbe et al. released a report documenting the effect of the tax on retail pricing in the city relative to the surrounding area (2015). As discussed previously, the purpose of introducing an excise tax, instead of a sales tax for example, would be to increase retail pricing and discourage purchasing, thereby decreasing consumption rates. It is essential to show that this tax effectively increased retail pricing of sugared beverages to prove the concept of the tax. Initial results calculated by Falbe and colleagues show significantly increased retail pricing of sugared beverages in Berkeley relative to nearby cities three months after the tax was implemented. They authors found that because the change was so recent, many stores had not fully decided on new pricing for sugared beverages, but most stores had increased their pricing or planned on doing so in the future. They also found that some discount stores discontinued sales of sugared drinks altogether (Falbe et al., 2015). Effects on purchase rates in the community post-tax have not yet been evaluated.

CORD Project

Three studies similar to SUS, funded by the Childhood Obesity Research Demonstration (CORD) Project and overseen by the CDC, began implementation in 2011 in the states of Massachusetts, Texas and California (Dooyema et al., 2013). These studies attempt to utilize the socio-ecological model in order to successfully change public health behaviors. Like SUS, the goals of this demonstration project are to
determine the efficacy of community involvement in childhood obesity reduction by evaluating primarily physical activity levels and food behaviors after implementation of multi-level interventions. Unlike SUS, these studies are designed to specifically target low-income populations and aim to impact more than BMI scores; they also aim to generally improve childhood health behaviors (specifically physical activity levels and food intake behaviors, among others) and include these in their primary outcomes. The CDC allotted $18 million for three intervention studies and $4 million for a study to combine and interpret the results of the three interventions over a period of four years. Each location for intervention is similar in its target population and goals, but the methodology differs between states. While the study in California focuses heavily on integrating a familial prevention approach with community health workers, the study in Texas also focuses on extensively incorporating the school environment into the prevention. Massachusetts took an existing program and modified it to incorporate the goals of the study, focusing on using a healthcare setting and primary health providers as the main intervention strategy and partnering with community health workers to increase their overall reach and efficacy (Dooyema et al., 2013).

The CORD interventions specifically target children between the ages of 2 and 12 over a period of two years (Foltz et al., 2015). The goal of the program is to impact as many aspects of the child’s life as possible to solidify obesity prevention, from family interactions to the surrounding environment. In both Texas and Massachusetts, the children are required to have a BMI equal to or greater than 85th percentile in order to participate in the intervention, but there is no minimum BMI for the California study.
Researchers hope that the results of these studies will be more broadly applicable to a diverse population, and expect to learn more about effective obesity prevention in unique communities by comparing experiences across these three locations (Foltz et al., 2015).

Baseline vital information for the communities has been collected and published for each of the three intervention locations. In Massachusetts, the primary outcomes being investigated include the children’s BMI, diet, amount of time spent watching television or on the computer, average length of sleep, and amount of exercise (Davison et al., 2015). Through community modifications such as integrative school programs, extracurricular activities, and familial involvement, researchers aim to increase vegetable and fruit consumption, insure that children are achieving adequate hours of sleep, and reducing sedentary behavior to healthy levels through increased physical activity and reduced television watching. Ultimately by modifying these health behaviors, the goal is to effectively reduce BMI levels. Each community was provided $50,000 to support the modifications in their community required by the study. There are three cohorts: community health centers, WIC-enrolled families, and a school-based group. The intervention population as a whole has a higher obesity rate on average than the US childhood obesity rate, with estimates of up to 25% for groups of children involved in community health centers. Researchers used baseline measurements to confirm that their target intervention communities were of high risk and would benefit immensely from strategies to modify the children’s health behaviors (Davison et al., 2015).

The Texas and California branches have also published baseline vital statistics and methodologies for their respective projects. Texas-CORD has a population
predominantly composed of Hispanic/Latino families (Hoelscher et al., 2015). This community study is important because it may serve to address, in part the growing racial disparities in childhood obesity prevalence, as Latino children have significantly higher rates of obesity than non-Hispanic white children. The Texas study aims to compare different methods of obesity treatment and prevention, utilizing a yearlong RCT after a period of prevention to compare childhood obesity treatment methods. One group in the RCT will undergo an intensive and family-involved prolonged period of treatment including a transition period, and the other group will undergo a less vigorous treatment program using primarily an educational booklet. The primary outcomes of the Texas branch will focus on the same goals as the Massachusetts branch, but additionally will incorporated quality of life into its outcomes (Hoelscher et al., 2015).

The California branch primarily aims to modify four childhood health behaviors, including increasing the quantity of quality sleep, insuring that children are drinking adequate volumes of water, increasing the amount of fruits and vegetables eaten, and reducing sedentary behavior (Ayala et al., 2015). Like the Texas communities, the populations targeted in California are mostly of Latino/Hispanic ethnicity. Unlike the other locations, this study will include children within all BMI levels, which the authors felt was required in order to obtain a population sample that was large enough to conduct their study with sufficient power. The authors do admit that this could potentially be problematic when the data are being analyzed, but are confident that they will still be able to implement their study effectively and gather the desired information (Ayala et al., 2015).
There has been some criticism of the CORD project, specifically of the Massachusetts’ methodology, with skeptics concerned that the interventions they are using in their community have been proven to be fruitless in previous studies (Anchondo et al., 2015). Critics claim that it is necessary and more important to modify parental behavior above all other efforts in order to address childhood obesity risks, and that targeting only children will be insufficient to effect obesity rates (Anchondo et al., 2015). The Massachusetts group has responded in defense of their methods, citing the fact that their study does not simply aim to reduce BMI but attempts to more generally modify childhood health behaviors (Taveras et al., 2015) which, in and of themselves, should constitute measurable differences. As of this writing, intervention results have not been published with regards to any of the CORD studies.
DISCUSSION

In light of the high costs of obesity to society, it is important to determine who should be responsible for investing financially in obesity prevention and treatment. As reviewed, the annual healthcare costs per obese individual are nearly $1,500 per year greater than those for non-obese individuals. Whoever will benefit most from effective reductions in obesity theoretically has the greatest incentive for financial investment. It is not an unreasonable expectation that investment into obesity prevention from the government (Medicare and Medicaid) and also private health insurance companies should be, at a maximum, equal to the cost of the disease burden on the healthcare system. Employers and corporations also have financial motivation to invest in obesity prevention to increase work productivity and reduce absenteeism. If policymakers pass the three recommended policies that are likely to provide large financial returns, the revenue generated can then be allocated to further funding of programs and research into adolescent obesity prevention.

The findings of Fletcher and colleagues suggesting that a tax on sugary beverages would be ineffective are misleading. The data that they analyzed only include taxation on soda and do not include taxation on all other sugar-sweetened beverages included in the suggested policy, such as juices with added sugars or sports drinks. Their main argument hinges on the idea that a potential decrease in soda consumption will only lead to an increased consumption of other sugared beverages; however, the proposed tax that they are opposed to includes all sugar-sweetened beverages. Without accounting for this
fact, their data cannot be used to dismiss the effectiveness of the actual proposed tax discussed by the other reviewed studies.

The tax recently implemented by Mexico on high-calorie foods and sugared beverages lays the foundation for evidence-based and observable effects of community modification on the population’s obesity rate. The cost-effectiveness papers reviewed are all simulations, so evidence that can be supported by physical data may spur quicker policy action. Additionally, the study by Gortmaker and colleagues did not evaluate cost-saving estimates for the possibility of multiple interventions being initiated simultaneously, which may increase efficacy and lead to further cost savings. Gortmaker does not suggest any specific responsible parties to provide the upfront costs of the interventions.

Studies evaluating the effects of increasing prices of sugared drinks in Berkeley, California will contribute to the body of evidence supporting a beverage excise tax. The finding that some discount stores have ceased the sale of sugared beverages altogether is very promising. This proposed excise tax should effectively result in an increased price of sugared beverages in all forms of purchase – from vending machine selections to grocery store shelves. Future areas of research should review the effects, if any, of these newly imposed taxes to confirm or oppose the simulated efficacy estimates. Important data to be collected should include any changes in shopping patterns following the tax, such as possible increases in the purchase of non-taxed beverages.

The CATCH program had moderate success, although it did not necessarily meet the primary goal of reducing the prevalence of childhood overweight/obesity. By
reducing the number of children who developed obesity relative to the controls, it was able to show that a school-based exercise and nutrition program can strongly impact the development of obesity. These early attempts at comprehensive studies were vital to the evaluation of stronger comprehensive programs, such as Shape Up Somerville.

The researchers who conducted Shape Up Somerville have not yet published data on the cost of their program, but estimates will likely be small relative to the cost of obesity treatment. One of the major benefits of the SUS program, which has already been stressed by numerous researchers, is the continuity of the program. While the program would have many upfront costs, it would take very little money to maintain the modifications in the community once they are initiated. This utilizes the same principle as the recommended policy changes discussed earlier, which would effectively begin to alter the community to promote eating and drinking more conscientiously. If the article’s assumption of a $3-$4 cost per child per year are correct, this further incentivizes investment into similar universal community modifications. When the estimates of the total cost per individual for implementation of the SUS program are published, it will be possible to recommend specific distributions of cost between financially responsible parties.

A significant issue with some of the prevention studies lies in the low sample size. The study by Stark and colleagues published in 2011 regarding a clinic-based and home-based combined RCT for preschooler obesity prevention had a very small population. As discussed previously, this study showed a significant decrease in BMI-z score in their intervention versus control group; however, with a total study population of only 18
children initially enrolled and 16 children analyzed at the conclusion, this study has limited generalizability and it is questionable as to whether this method would prove to be an effective obesity treatment throughout the population. A follow-up study involving a larger population of children is warranted to further evaluate potential population effects.

Another potential area for prevention identified by the Shape Up Somerville study is the increased rate of weight gain seen across all groups of children during the summer months when not involved in school or after-school programs. Had SUS been able to prevent weight gain during the summer, the intervention group would have started the second year of the study at a lower baseline BMI, potentially resulting in an even more substantial difference in BMI z-score relative to the control groups over time. An answer to the weight gain discovered during summer months in the SUS intervention may lie in a need for more intense parental education and involvement, with the studies summarized in the Caregiver Modification section as primary effective examples. Children may also have less access to safe and supervised recreational areas during summer months. By combining these intensive parental education techniques with the effective community modifications seen in the SUS intervention, weight maintenance in adolescents during summer months may be more achievable. Future research could examine this possibility, and should focus on investigating how to prevent the excess weight gain during months that offer less traditional daily structure.

It is encouraging that the data show that school lunches are not providing students with as much sugar and fat as meals brought from home. This also reveals a potential
area for dietary improvement, and stresses the importance of greater parental involvement in the nutritional oversight of their children and the home food environment. School meals should continue to provide nutritious, healthy options for children and comply with the newly imposed nutritional standards set by the Healthy Hunger-Free Kids Act. The recent study that reviewed the impact of the newly imposed school menu regulations is also encouraging. This is an excellent example of policy action that effectively has changed a specific population’s behavior in a positive way – students were found to be choosing more fruit and vegetable options during school meals. Further research will need to investigate whether the students are also consuming their choices, and whether there is any increased consumption of high calorie foods at home as a result of choosing lower-calorie options at school.

The modifications in the community that were implemented in Somerville included encouraging healthy eating habits and increasing physical activity. If the cost-effective policy changes were to be passed, these byproducts may very well result in institution of some community modifications that were found to be successful in the SUS study. An important aspect of SUS is the weight loss seen in the parents in the intervention community. As parental weight changes strongly predict child weight changes, decreasing BMI in parents may facilitate obesity reduction and prevention in children. While Finkelstein and Bilger argue that the most effective obesity prevention methods will include a tax reward for schools and families who maintain appropriate BMI levels, this is perhaps not the most ethical approach as it strongly coerces individuals to live a healthy lifestyle. As Kersch and colleagues point out, the most
ethical policy reforms will reduce the obesogenic environment, making it more feasible to maintain a healthy lifestyle, while still allowing the individual to choose their own habits. Community modifications would encourage this healthy lifestyle without negatively impacting individuals who are unable to, or choose not to, improve their health and the health of their children.

Results of the CORD Project have the potential to further support community modifications and multilevel interventions. If the demonstration project is successful, it will have substantial implications for the population at large. Since the project is being implemented in three very different locations with diverse and varied populations, it will perhaps serve as a more realistic model of the US population than the SUS program was able to. In addition, the published CORD studies are anticipated to include cost-effectiveness information, which can be used by policymakers and health insurance providers to determine appropriate investments figures. Positive results from such an inclusive and representative sample of the US should gain the attention of policymakers, communities, and healthcare providers to promote action.

The studies on the effects of the school environment also emphasize the importance of targeting prevention to the youngest generations of children, preferably before adiposity rebound has occurred. Fox and colleagues found that the school food environment more heavily affected the BMI’s of elementary students and middle school students than students in high school. One possibility for this finding may be because by the time adolescents begin high school, their food habits have been established and they have already developed obesity, although this is not always the case. Again, it is
suggested that the crucial period for implementing obesity prevention strategies appears before the teenage years begin in order to have the highest chance of effectiveness.

Another possibility that was has not been addressed in any of the studies that predict cost-effectiveness of obesity reduction and prevention includes a generational effect. Since parental obesity greatly increases the risk of childhood obesity and childhood eating habits strongly predict habits throughout adulthood, it should be considered that by reducing the obesity level of this generation of children, we would also likely be reducing the obesity rate of the following generation of children. In theory, the children who do not develop obesity, but who may have if not for interventions, may develop healthy habits and make lifestyle choices that influence their own children and in turn prevent future cases of childhood and adult obesity. Future cost-effectiveness estimates could include this possibility for even greater returns than initially anticipated.

Finally, it is of interest that multiple co-authors of the AHA statement in 2008 “Population-Based Prevention of Obesity” have financial ties with food corporations that directly contribute to or profit from the obesity epidemic, including Gatorade, Dannon Institute, Weight Watchers International, Mead Johnson Nutritionals, Medifast and Slimfast. The role of food and beverage companies in the prevention of obesity reduction is powerful, however, the depth of this issue is well beyond the scope of this discussion.

Every member of the US population will benefit from active participation in obesity prevention. Reducing the levels of obesity will reduce the burden of cost on taxpayers, employers, and insurance providers. Families may also see an increase in wages as employment opportunities increase. The development of chronic disease will
decrease as obesity levels decrease, and quality of life and life expectancy will increase.
The current evidence is in support of comprehensive community-based interventions that will especially focus on preventing the very young children in the population from developing obesity, while concurrently implementing modifications that will support obesity reduction throughout the population. In accordance with the socio-ecological model of public health behavior, modifying public health policy through the actions discussed may be an effective way of altering the individual’s health behaviors and could lead to reductions in obesity on a population level. It is more affordable to prevent obesity during childhood than it is to treat the consequences of obesity in adulthood, and integrative community efforts are among the most cost-effective forms of obesity prevention.

As discussed, multiple strategies have been proposed that are estimated to benefit the country financially while maintaining ethical obligations. Health insurance providers also need to begin investing resources into these cost-effective programs that are proven to reduce childhood obesity. This could be in the form of supporting the addition of community health workers into at-risk neighborhoods, requiring pediatricians to act more diligently when childhood obesity is suspected, and supporting policies that would result in lower population obesity rates. It is in the best interest of both consumers and reimbursers to financially support efforts to institute these community modifications in order to reduce the rates of obesity in the population now and for future US generations.
REFERENCES


Economos, C. D. “RE: Questions from a Master’s student at BU about SUS.” Message to Amalie Alver. 8 March 2016. E-mail.


CURRICULUM VITAE

AMALIE ALVER

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Educations

2014 – Present

**MS, Medical Science**

Boston University School of Medicine
Division of Graduate Medical Sciences
Expected Graduation: May 2016

2007 – 2012

**BSc., General Biology**

*Minor in Chemistry*

**BA, Swedish Language**

University of Washington, Seattle

Experience

2010 - 2014

University of Washington, Seattle
Veteran’s Administration, Puget Sound Health Care System
*Student Assistant*, Dr. Dianne Lattemann, latte@u.washington.edu

As a student assistant in Dr. Lattemann's lab I participated in many studies relating to Type 1 diabetes mellitus, diabetic co-morbidites and animal behaviorisms. Experiments were conducted using rats as models. I was trained in the proper handling and care of the animals and in many surgical techniques required for the experiments, such as venous catheterization and cranial cannula insertions. I was trained in the sectioning and harvesting of tissues, administration of medications, collection of measurements, processing of samples, and general lab maintenance.

Acknowledgements:

**Moderate High Fat Diet Increases Sucrose Self-Administration In Young Rats.** Appetite 61(1): 19–29.

2015

Cooking Matters, Share Our Strength
East Boston Community Health Center – Boston, MA
Volunteer

The Cooking Matters program is a free program for eligible low-income families that stresses healthy and affordable nutrition education. I am a volunteer for this 6-week cooking class with a nutritionist and chef. Every week we cook a healthy meal with the families and teach them how to provide enough nutrition for their children while maintaining their budget. After each class the families are provided with a bag of groceries containing the ingredients they need to replicate the recipes at home. I assist in teaching, cooking, cleaning, and playing with the children.

2008 - 2009 Veteran's Administration, Puget Sound Health Care System
Emergency Department – Seattle, WA
Volunteer

I assisted nurses in stocking patient rooms with supplies. I cleaned gurneys and beds. I assisted in minor procedures such as wound cleaning. I organized the supply room and transported patients when necessary. I mailed patient samples to the lab and did anything else the nurses asked me to do to assist them.

2006 – 2007 Veteran’s Administration, Portland Health Care System
Patient Transport, Mental Health Day Clinic – Portland, OR
Volunteer

As a volunteer in patient transport I was responsible for transporting patients throughout different wings in the hospital. I also transported samples and specimens to various labs in the hospital. As a volunteer in the day clinic I spent time with outpatients playing board games and engaging in other socially constructive behaviors.