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A Socioecological Analysis of Food Insecurity and Implications for Weight Management in Low-Income Populations

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A Socioecological Analysis of Food Insecurity and Implications for Weight Management in Low-Income Populations

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2009

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Abstract

INTRODUCTION: Obesity is one of the greatest health problems currently confronting our nation. The consequences of obesity affect physical, mental, and psychosocial health. Individuals of lowest income are particularly affected by obesity and chronic disease onset. Additionally, individuals belonging to lower socioeconomic statuses are most affected by food insecurity. This study examined correlates of food insecurity through a socioecological framework examining community, home, and individual level associations as well as the relative contribution of food insecurity to weight and weight-related eating behavior over the course of a weight gain prevention program. METHODS: Secondary data from a previous weight gain prevention trial were used. Participants were 119 residents of Cook, Randolph, and Mitchell counties of Georgia; however only 92 participants were included in the longitudinal analyses. Community, home, and individual factors related to food availability and access were assessed via self-report. The BRFSS fruit and vegetable screener and NCI Fat screener were used at three time-points to measure change in weight-related eating behavior. Data from baseline and third time points were used in the current study. RESULTS: Food insecure participants were more likely to be Non-white, have lower education, lower incomes, and live in households with more people (*ps*<.005) than food secure participants. Additionally, food insecure participants more often ranked healthy food as unaffordable and had different priorities in purchasing food ranking cost, convenience, and weight control significantly more important than food secure individuals (*ps*≤.001). Weight status, BMI, and weight in pounds were also significantly different between the

groups (*ps*<.05), as was fruit and vegetable intake (*p*=.007), but the difference in fat intake was not significant. In longitudinal regression analyses, additional household members predicted higher fat intake over time (*p*<.05). No other significant correlates of interest were found in regression analyses. DISCUSSION: Results suggest that food insecurity is an important factor to consider in designing community-based weight gain prevention programs that future practice and research should take into consideration in designing relevant interventions.

Key words: obesity, food insecurity, weight gain prevention, weight management

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CHAPTER I: INTRODUCTION

Obesity

Over a third of adults in the United States are obese and another third are overweight. Data collected from the National Health and Nutrition Examination Survey between 2009 and 2010 estimate the prevalence of obesity in the United States to be 35.5% and 35.8% for men and women, respectively (Flegal, Carroll, Kit, & Ogden, 2012). In affluent countries, rates of obesity tend to be higher in lower-income individuals and ethnic minorities (Kumanyika, Jeffery, Morabia, Ritenbaugh, & Antipatis, 2002). Obesity is associated with myriad diseases including cardiovascular disease, type II diabetes, stroke, and several intestinal and organ cancers (Bray & Bellanger, 2006; Kumanyika et al., 2002), placing individuals from lower income and ethnic minority backgrounds at the highest risk for obesity-related morbidity and mortality (Kumanyika, 2006).

The mode through which income and resources interact with eating behavior and weight is highly complex. Elucidating this relationship is paramount to developing and disseminating effective interventions for weight gain prevention and weight management in underserved populations and addressing corresponding health-related disparities. A proposed explanation for obesity disparities observed across income brackets is that food insecurity plays a causal and maintaining role (Dietz, 1995). Since both food insecurity and obesity are of greater presence in low-income samples and affect low-income individuals at higher rates than the general population, food insecurity may explain differential obesity rates in low income and ethnic minority populations.

Food Insecurity

Historically, food security has been defined as having adequate access to enough food for an active, healthy life. Food insecurity has been defined as lacking adequate access to sufficient food. Recent research has developed a dimensional approach, conceptualizing food insecurity as falling along a continuum. The least severe is having one or two indications of food access problems, typically exemplified by anxiety over food sufficiency or shortage of food, but without any change in diet or food intake (marginal food security). Second is reduced quality, variety, or desirability of food consumption, but not reduced intake (low food security). Third and most severe includes reports of multiple indicators of disrupted eating patterns and reduced food intake because of access problems (very low food security) (USDA, 2012a).

Food insecurity affects approximately 12-17% of people living in the United States every year (USDA, 2012a) and its co-occurrence with obesity has been noted in several studies within the past few decades (Alaimo, Olson, & Frongillo, 2001; Dietz, 1995; Sarlio-Lahteenkorva & Lahelma, 2001; Townsend, Peerson, Love, Achterberg, & Murphy, 2001). Low socioeconomic status appears to be a general risk factor for both food insecurity and obesity, as food insecurity disproportionately affects poverty-level households. In 2005, 11% of households were food insecure, compared to 38% of poverty-level households nationally (Nord, Andrews, & Carlson, 2005).

Several variables have been proposed to explain how food insecurity may be related to variables present at the community, home, and individual level and how these relationships may contribute to obesity. The review in Chapter II will explore the extant

literature to explain relationships between community level factors (e.g. proximity of grocery stores, food offerings at stores, and affordability of healthy food), home level factors (e.g. home food environment like number and variety of foods in the home, household income, number of household members), and individual level differences (e.g. food purchasing decision-making, gender). Additionally, a thorough review of the relationship between food insecurity and eating behavior will be explored towards the end of this chapter, establishing the current gap in the literature and provide justification for the current study.

Food Insecurity and Obesity in Low-Income Populations

Since both food insecurity and obesity disproportionately affect individuals with lower socioeconomic status, there has been a recent proliferation in the number of studies investigating associations between the two conditions. Using nationally representative data from the 2009 Behavioral Risk Factor Surveillance System, Pan et al. (2012) examined the association between food insecurity and obesity was explored among 12 participating states (*N*=66,553 adults). This study found that approximately one in three food insecure adults also met criteria for obesity. Food insecure adults had 32% higher odds of being obese compared to food secure adults. Food insecure adults also had a significantly higher prevalence of obesity among several subgroups including adults over 30, women, non-Hispanic whites, non-Hispanic blacks, adults with some college education and/or a college degree, and those with a household income of under $25,000 or between $50,000-$74,999 (Pan, Sherry, Njai, & Blanck, 2012). Obesity has also been associated with food insecurity and hunger in homeless individuals in a study conducted

on data from the Boston Health Care for the Homeless Program (Koh, Hoy, O'Connell, & Montgomery, 2012), indicating that even in extreme poverty, the association between food insecurity and obesity remains.

There are still many questions to be answered regarding the development of food insecurity in low-income populations and the role it might play in eating behavior before it can be addressed within the contexts of interventions. Specifically, it is important to identify whether food insecurity affects eating behavior within the context of an intervention study aimed at weight management. More broadly, it is important to know what community-level factors and home-level factors contribute to feelings of food insecurity in household members and if food insecurity is a driving force in creating and maintaining obesity disparities.

Gender Differences in Food Insecurity and Eating Behavior

Interestingly, while food insecurity has been associated with obesity, particularly in low-income populations, many of the studies that have been conducted so far have identified this relationship as existing more strongly for women and girls than for men and boys who report experiencing food insecurity (Townsend et al., 2001). In fact, Townsend and associates (2001), Gibson and associates (2003, 2006), and Wilde and Peterman (2006) have demonstrated stronger relationships between food insecurity and obesity in women than in men in their respective studies of this association (Gibson, 2003, 2006; Townsend et al., 2001; Wilde & Peterman, 2006).

Several hypotheses, some of which will be explored in Chapter II, have been suggested as to why women are differentially affected by food insecurity when compared

to men. Proposed explanations include a biological predisposition to gain weight in the face of scarcity due to different hormone production, unique social stressors associated with providing food for their families that reduce self-efficacy and self-worth, and/or earlier altered eating behaviors, referred to as "maternal buffering" sacrificing the quality, amount, and variety of food they eat to provide more for their family (Maxwell, 1996).

Problem Justification

Both food insecurity and obesity are serious conditions with negative health sequelae that affect millions of Americans each year (Nord et al., 2005; Ogden et al., 2006). There have been increasing numbers of people experiencing food insecurity since the economic downturn of 2008, which may hold important implications for population obesity rates (SNAP, 2012; Troy, Miller, & Olson, 2011). Of note, both conditions disproportionately affect those of lower socioeconomic status (Gooze, Hughes, Finkelstein, & Whitaker, 2012; Koh et al., 2012) and ethnic and racial minorities (Flegal et al., 2012; Gordon-Larsen, Adair, & Popkin, 2003a), the same populations affected by the greatest burden of chronic disease (Kumanyika, 2006). Both food insecurity and obesity have been independently linked with chronic disease and their negative physical and psychosocial sequelae making them issues that warrant significant attention.

While interest in food insecurity and obesity has grown, the literature still provides very mixed evidence between the association of food insecurity, eating behaviors, and weight status (P. H. Casey et al., 2006; Mello et al., 2010; Pan et al., 2012). Much of the existing research investigating the associations between obesity and food insecurity has been performed using large national data sets. This has severely

limited the ability of researchers to explain the association or provide targeted recommendations for prevention and treatment. There has been documentation of the co-occurrence of the two problems, but little investigation into how or why the two are related or the specific mechanisms through which the relationship is operating. Additionally, efforts to address the issues have been largely separate, with food insecurity interventions focusing on increased access to foods through expansion of federally funded programs, and obesity interventions focusing on behavioral weight loss.

The majority of interventions for food insecurity focus on food assistance or distribution programs. In the United States, food assistance has been provided through the Supplemental Nutrition Assistance Program (SNAP), the National School Lunch Program, School Breakfast Program, Summer Food Service Program, or Women, Infants, and Children (WIC), and many others. SNAP alone is responsible for feeding over 46 million Americans each month, with costs totaling 78 million dollars a month (USDA, 2012c, 2012d). Food assistance programs operate mainly through two mechanisms. One is through direct service by providing food that must meet specific guidelines as outlined by the United States Department of Agriculture's (USDA) Food Nutrition Service like the school lunch programs (USDA, 2012b). The second is through tokens or coupons that are then used to purchase food, which is how SNAP provides benefits (SDDSS, 2012). Both types of programs are aimed at providing substantial meals with the goal of preventing hunger in children and adults across the country. In contrast, interventions for preventing and treating obesity have largely focused on some combination of individual and group level educational and behavioral strategies to increase fruit and vegetable consumption, decrease fat intake, increase physical activity, and decrease screen time

(West, Elaine Prewitt, Bursac, & Felix, 2008; Wing & Hill, 2001; Wing, Tate, Gorin, Raynor, & Fava, 2006).

Over the past decade there have been several studies documenting that individuals disproportionately affected by obesity are also affected by food insecurity (Alaimo et al., 2001; Dietz, 1995; Koh et al., 2012; Pan et al., 2012). These findings have significant implications for the translation of existing weight management programs and development of new weight management programs for low-income populations. As such, the current study seeks to explore the relationship between food insecurity and obesity within the context of a community-based weight gain prevention program for rural residents in Georgia. The findings have the potential to highlight the importance of food insecurity in designing weight management programs for low-income populations. Additionally they may emphasize the need for a large-scale interventions targeting increased availability of affordable, healthy foods.

Theoretical Framework

Theoretical Framework: Socioecological Model

To understand the multi-level influences that contribute to both food insecurity and obesity, it is helpful to apply the socioecological model (SEM) as a theoretical framework. SEM highlights the different levels of influence that impact health behavior and has been widely applied in a variety of health issues (Richard, Gauvin, & Raine, 2011) including obesity and eating behavior (Robinson, 2008). Eating behavior is influenced by a variety of factors at individual, home, community, and societal/political levels of influence (Davison & Birch, 2001; Story, Kaphingst, Robinson-O'Brien, & Glanz, 2008). Utilizing SEM allows for a closer examination of the structures that shape behavior, recognizing that individual health behaviors are best understood as "reciprocal causation unfolding at multiple individual and environmental levels of influence" (McLeroy, Bibeau, Steckler, & Glanz, 1988). The model is represented by an image with a series of concentric circles to show the distinct, yet equally important factors that influence health behavior including intrapersonal, interpersonal, organizational, community, and societal factors (McLeroy et al., 1988).

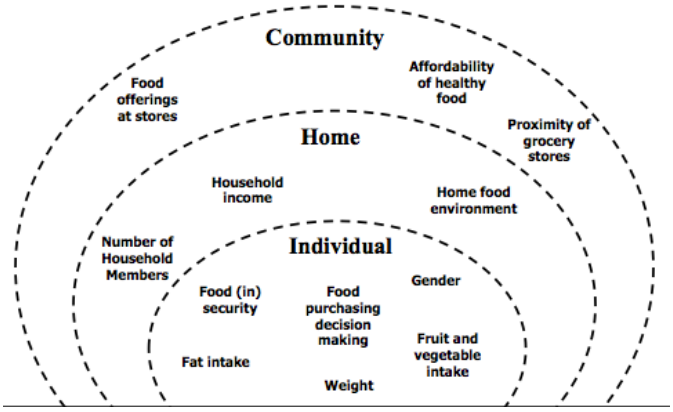


Figure 1: Socioecological Model of Food Insecurity

The socioecological model has been applied extensively to eating (Story et al., 2008) and activity (Richard et al., 2011) behavior, and has been proposed as the most

appropriate model for understanding weight behaviors (Baranowski, Cullen, Nicklas, Thompson, & Baranowski, 2003). The current study utilizes the socioecological framework to examine determinants of food insecurity, as well as the relationships between food insecurity, weight, and weight-related eating behaviors. Notably, studying community level factors (e.g. proximity of grocery stores, food offerings at stores, and affordability of food at stores), home level factors (e.g. foods available in the home, household income, number of individuals in the home), and individual level factors (e.g. food security status, food decision-making, and gender) in relation to food insecurity, weight, and weight-related eating behavior may provide insight relevant for community-based weight gain prevention efforts. Of particular interest is how multi-level factors influence food security status and the potential impact of food insecurity on eating behavior and resultant weight status. For a detailed picture of the various factors involved in eating behavior as it relates to food insecurity and obesity nested within their levels of influence, **see Figure 1**.

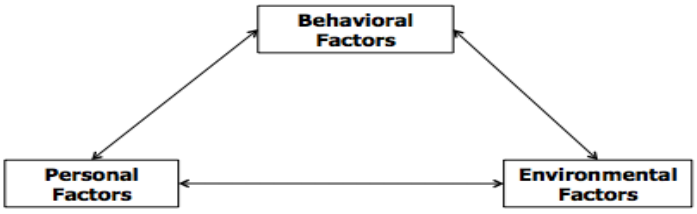
Despite its widespread use, there are a dearth of studies that adequately test weight management interventions across multiple levels of influence (Story et al., 2008). The current study will address this gap in the literature by investigating various factors that relate to weight in a sample of rural, low-income individuals enrolled in a weight gain prevention program. Specifically, the current study seeks to build on the extant literature by examining the relationships between demographic and sociocontextual factors at the community, home, and individual level that are associated with food insecurity. Additionally, the study will examine the potential role food insecurity has on

eating behavior (fat intake and fruit and vegetable intake) and weight outcomes in a weight gain prevention program.

Theoretical Framework: Social Cognitive Theory

As mentioned above, multiple levels of influence, namely community environment, home environment, and personal factors affect eating behavior. These reciprocal relationships contribute to the personal experience of food security or insecurity that ultimately influences eating behavior. The idea of "reciprocal determinism" between environment, personal factors, and behavior is best established through the use of social cognitive theory (SCT). SCT posits that personal (e.g. cognitive, affective) and environmental (e.g. interpersonal, social, and political) factors serve to influence behavior and that behavior exerts a similar influence on cognition and environment (Bandura, 1977). Furthermore, social cognitive theory reinforces the importance of targeting not only behavior, but also environmental factors that play an important role in the formation and maintenance of behavior (**see Figure 2**).

Figure 2: Social Cognitive Theory



Several studies have sought to explain the development and maintenance of eating behavior from the life course perspective and have examined the various influences that determine childhood and adult eating behaviors (Birch, 1999; Birch & Fisher, 1998).

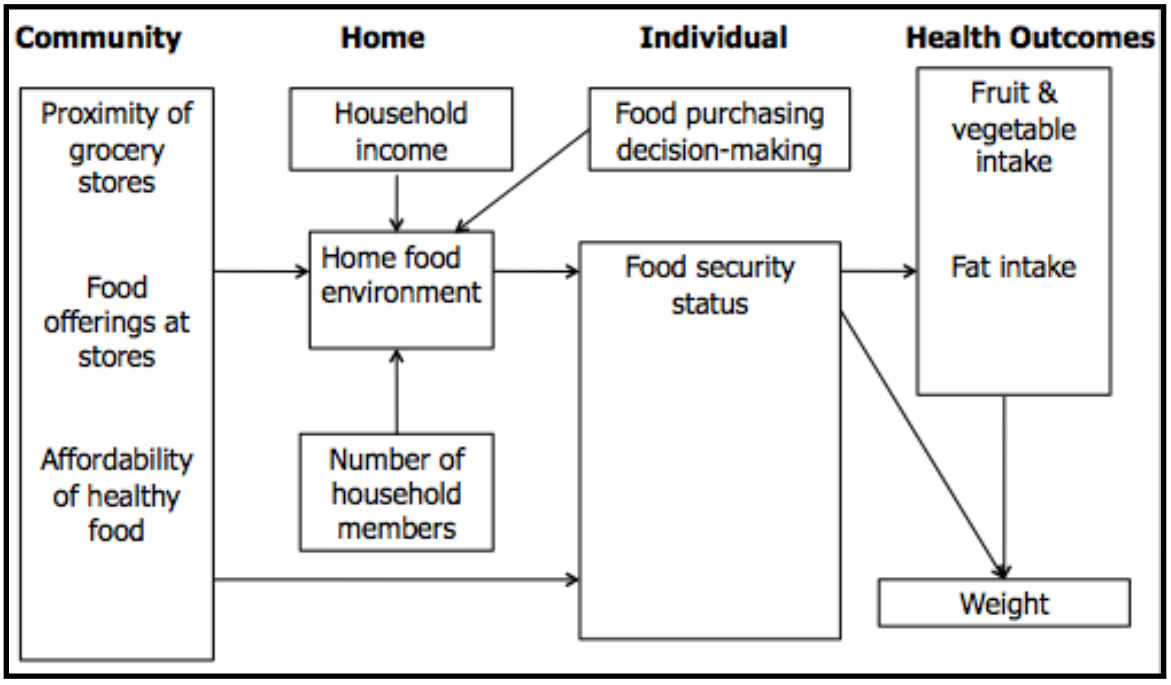
Notably, eating environments exert a strong influence on eating preferences and behaviors. Studies have shown that the development of eating preferences and behaviors are largely dependent on the eating environment (Birch, 1999; Ding et al., 2011; Saelens et al., 2012; Sallis & Glanz, 2009; Story et al., 2008). In particular, the home eating environment may have a strong impact on meal quantity, quality, and frequency (Campbell, Crawford, & Ball, 2006; Campbell et al., 2007; Sallis & Glanz, 2009). As applied to the current research question, repeated exposure to a home without sufficient food (environment) might create feelings of food insecurity (person), which would likely impact eating choices and habits (behavior). Moreover, food insecurity could be the individual-level factor that mediates the relationship between food environment and eating behavior for individuals from low-income rural households, making it an important variable of interest.

Devising a Conceptual Model

Several studies have recently looked at the association of food insecurity and obesity and attempted to explain the relationships between them; however, there is little consensus on the conceptual model that should be applied to understand this relationship. While several have been proposed, no one theoretical model has been fully successful in explaining relationships between environmental variables, interpersonal variables, and individual level variables that contribute to both food insecurity and obesity. As a result, we have built a theoretical model that incorporates multiple levels of influence to help guide the current study (**see Figure 3**). Specifically, this model includes variables measured in the study and important to understanding community, home, and individual

factors related to food insecurity and weight. These factors include proximity of grocery stores, food offerings at stores, and affordability of food at stores at the community level; household income, additional household members, and food available in the home at the home level; and food purchasing decision making, eating behavior, and weight at the individual/behavior levels.

Figure 3: Integrated Conceptual Model of Food Insecurity



Purpose of the Study

The purpose of the study is to explore the relationship between food insecurity, eating behavior, and obesity. The study will explore associations between food insecurity and environmental, home, and individual factors. The study also compares food secure and insecure individuals across these variables. In addition, the study will test the differential effectiveness of the weight gain prevention program, as defined as eating behavior change (fat intake and fruit and vegetable intake) and weight change (in pounds), to determine whether food insecure individuals are less successful in such a program.

The information gained from the study could be used to formulate future interventions to decrease obesity within the population either through large-scale food supply interventions or through tailoring behavioral interventions based on food security status. Providing changes to the way food is supplied nationally is more likely to yield long-term sustainable results that could affect the whole population. Subtle changes to existing weight management programs could improve the efficacy of these interventions and encourage participants to engage in long-term self-management of healthy eating behaviors.

Research Questions

Research Question 1: What demographic characteristics are associated with food insecurity?

Research Question 2: What community, home, and individual factors are associated with food insecurity?

Research Question 3: Does food insecurity predict eating behavior and weight changes over the course of a 6-week time period when controlling for treatment group and baseline characteristics?

CHAPTER II: LITERATURE REVIEW

Introduction

Obesity affects over a third of adults in the United States and is a known risk factor for several chronic conditions including type II diabetes, cancer, hypertension, cardiovascular disease, stroke, arthritis, and poor health-related quality of life (Flegal, Carroll, Ogden, & Curtin, 2010; Miech et al., 2006). In the United States, obesity has remained relatively stable across the population for the past 10 years, but has seen increases significantly among ethnic minority women, including non-Hispanic black women (p=.04) and Mexican American women (p=.05) (Flegal et al., 2012).

Obesity Disparities

Gordon-Larsen and colleagues (2003) examined nationally representative data collected from adolescents (N=13,113) via the National Longitudinal Study of Adolescent Health and found that family income and parental education had a limited effect on the disparities in overweight prevalence in ethnic minorities. Authors concluded that factors beyond socioeconomic status including environmental, contextual, biological, or sociocultural factors might account for the observed differences in obesity rates (Gordon-Larsen, Adair, & Popkin, 2003b). However, Gordon-Larsen et al. did not examine the interplay between socioeconomic statuses, the environment, and other mediating factors (e.g. eating behavior, activity behavior, sedentary behavior, etc.) that could influence weight status.

A study performed by Jackson and colleagues (2005) investigated obesity disparities using a different set of nationally representative data and focused on the residence of the individual surveyed (either urban or rural) as the factor of importance in weight status. The study used data from the Behavioral Risk Factor Surveillance System (BRFSS) for the years 1994-1996 (*N*=342,055) and 2000-2001 (*N*=385,384) and compared obesity prevalence among urban and rural dwelling citizens. Findings demonstrated that the prevalence of obesity had increased for both rural and urban residents, with it increasing more steeply (by 5.5% versus 4.8%) for urban residents. However, rates of obesity were still highest for rural residents with a prevalence of 23.0% compared to 20.5%. Specific states had higher obesity prevalence than others providing evidence for the importance of place and the built environment and context in determining weight-related behaviors and resultant weight status (Jackson, Doescher, Jerant, & Hart, 2005).

Obesity, disparities, and weight management: why food insecurity is a real threat

The realization that obesity disproportionately affects individuals from ethnic minority groups, from rural areas, and with lower incomes has spawned a new generation of weight management interventions tailored to meet the needs of these individuals (Amundson et al., 2009; Eikenberry & Smith, 2004; Perri et al., 2008; Robinson, 2008). Still, several challenges exist in translating evidence-based weight gain prevention programs into populations facing scarcity and hardship. Notably, food insecurity presents a challenge for traditional weight management program goals as it is characterized by the

fear of not having enough food that could contraindicate intervention messages to reduce caloric intake.

In explaining the relationship between food insecurity and obesity, researchers have drawn on dieting theories of restriction and excess to explain how scarcity can easily pair with overweight (Dietz, 1995; Townsend et al., 2001). Of the dieting theories, restraint theory (Polivy, 1996) stands out as the most logical behavioral explanation for food insecurity and obesity. Restraint theory argues that strict regulation of food intake over long periods of time affects the brain such that upon being presented with food an individual is more likely to engage in overeating or binge eating of highly palatable foods, making them likely to weight gain over time (Polivy, 1996). This pattern of feeding and restriction described by restraint theory has been associated with so called "yo-yo dieting" and has been used to explain the binge eating patterns in individuals with bulimia nervosa or binge eating disorder (Polivy, 1996). It has been suggested individuals living in homes with actual restrictions placed on allowed amounts of food because of financial and food security concerns may experience the same psychological correlates associated with self-imposed restrictions in dieters (Dietz, 1995; Sarlio-Lahteenkorva & Lahelma, 2001; Townsend et al., 2001). Therefore, it would be important to understand the prevalence and correlates of food insecurity within a low-income population enrolled in a weight gain prevention program, because they may be confronting psychological and physical comorbidities, like binge eating, that should be addressed in addition to traditional psychoeducational and behavioral weight management targets. The following review will explore the extant literature to explain relationships between community level factors (e.g. proximity of grocery stores, food offerings at stores, and affordability of

healthy food), home level factors (e.g. home food environment, household income, and additional household members) and individual level differences (e.g. weight and eating behavior) that contribute to the development of food insecurity. A review of the relationship between food insecurity and other factors will establish the gap in the literature that the current study seeks to fill.

Obesity and Food Insecurity

Until recently, it was assumed that the relationship between food consumption and weight was always one of excess—those who were overweight consumed more than was required to fuel their bodies (Dietz, 1995). The energy balance equation, which serves as the theoretical basis for most of the weight management programs in existence, attributes excess adiposity to overconsumption of calories and inadequate energy expenditure (Baranowski et al., 2003; Dietz, 1995). As a result, obesity has always been assumed to be associated with excessive energy intake, making the argument for food insecurity and obesity somewhat difficult to comprehend (Baranowski et al., 2003; Drewnowski, 2004; Wing & Hill, 2001).

Several studies have focused a great deal on the relationship between low-income families and obesity, and have pointed to food insecurity as a possible mediator of this relationship (Alaimo et al., 2001; Drewnowski, 2004; Gibson, 2003, 2006; Rose, 1999; Townsend et al., 2001; Troy et al., 2011). Nationally representative data from 1994-1996 Continuing Survey of Food Intakes by Individuals (CSFII) demonstrates associations between the lowest income group, food security status, and overweight.

The aforementioned studies examined weight as a stagnant variable in relation to food insecurity. While this is an important question, weight is a dynamic variable that is constantly changing based on consumption and activity patterns. Furthermore, weight change may be the variable of interest when investigating the relationship between food insecurity and weight status. Using data from the 1999-2000 and 2001-2002 National Health and Nutrition Examination Surveys, Wilde and Peterman (2006) compared individuals in food secure homes with those in food insecure homes to see if there were significant differences in weight change over the same period of time (Wilde & Peterman, 2006). They categorized food security into four ordinal groups (food secure, marginally food secure, food insecure without hunger, and food insecure with hunger) and compared weight change among them by gender. Their findings showed that both food insecure men and women were significantly more likely to gain weight and to be obese. Specifically, women in households that were marginally food secure and food insecure without hunger were much more likely to be obese than women in food secure households. Men in less food secure homes were also more likely to be obese and gain weight, but the effects were smaller in magnitude than for women (Wilde & Peterman, 2006).

These studies present somewhat mixed results, demonstrating strong relationships between food insecurity and weight, but typically showing stronger relationships for subsamples in their population of interest. This may be explained by the strong emphasis on weight status as opposed to a more proximal measure like eating behavior. While weight status can be a cursory measure of under or over nutrition, a more exacting methodology is needed to hone in on the relationship between food insecurity, eating

behavior, weight gain, and obesity. Although the current study does not have a measure of binge eating or overeating, we do have measures of food intake for fruits and vegetables and fat that will be utilized to investigate whether food insecurity is associated with specific food consumption patterns.

Furthermore, several authors have hypothesized that metabolic changes, chronic stress, and binge eating may be implicated in the food insecurity and obesity relationship (Alaimo et al., 2001; Dietz, 1995). However, from a public health standpoint, identifying potential correlates of food insecurity within a socioecological context is more helpful than focusing on individual level behaviors that may influence obesity rates (Story et al., 2008). Investigating the associations between variables at the community, home, and individual level could help elucidate the mechanisms through which a variety of influences contribute to the development of food insecurity, eating behavior, and obesity and may provide direction for future intervention and programming efforts.

Community Level Factors

As discussed above, there is substantial evidence that differences exist between communities with regards to prevalence of obesity (Jackson et al., 2005; Pan et al., 2012). Community environments, while only distally related to the behavior being performed, have been demonstrated to have large affects on health behaviors. In the case of the eating environment, there is substantial evidence that the community plays a decisive role in determining eating behavior (Story et al., 2008). Fruit and vegetable intake and fat intake have been shown to be eating behaviors related to the proximity of grocery stores, food offerings at stores, and pricing of foods (Sallis & Glanz, 2009).

There are several factors that shape eating culture in the United States (i.e. fast food outlets, convenience stores, and the availability of food everywhere from gas stations to classrooms) and provide a backdrop for a "toxic food environment" for almost any resident (Cummins & Macintyre, 2006; Wadden, Brownell, & Foster, 2002). However, there are still important neighborhood differences that shape eating behavior in communities at a local level. Because the current sample is drawn from rural counties within Georgia, special attention has been paid to rural food environments in this literature review and how they can contribute to food insecurity, limited food choices, eating behavior, and ultimately, obesity.

Numerous studies have demonstrated that the built activity and food environment is associated with frequency and social norms surrounding physical activity, healthful eating, and obesity. Notably, residents living in walkable neighborhoods with access to recreation facilities are more likely to be physically active and less likely to be obese, while residents in unsafe or poorly designed neighborhoods are less likely to be active and more likely to be obese (Sallis & Glanz, 2009). Similarly, residents with access to affordable healthy foods have more healthful diets and lower weights than those without access to healthy foods.

In a study conducted by Saelens et al. (2012) researchers assessed neighborhood attributes in King County, Washington and San Diego County, California. Neighborhoods in each county were selected to represent favorable and unfavorable conditions, forming four types of neighborhoods—ones that were favorable in both eating and activity environment, ones that were favorable in eating environment but not physical activity environment, ones that were favorable in physical activity environment but not

eating environment, and ones that were not favorable in either eating or physical activity environment. Pairs of parents and children (*N*=730) were then selected from these neighborhoods and compared to one another on measures of weight and body size. Children from neighborhoods supportive of healthy eating and activity were less likely to be obese (7.7% versus 15.9%, OR=0.44, *p*=.02) and marginally less likely to be overweight (23.7% versus 31.7%, OR=0.67, *p*=.08) than children from neighborhoods low on both measures. In models adjusted for parent weight status and demographic factors, neighborhood environment type remained related to child obesity (high versus low on both measures, OR=0.41, *p*<.03). Parents in neighborhoods supportive of both healthy eating and activity were less likely to be obese (20.1% versus 27.7%, OR=0.66, *p*=.08) (Saelens et al., 2012).

Concordant with these findings, we would expect that certain neighborhoods would provide food environments that increase the likelihood of food insecurity compared to other neighborhoods. The attributes of a food insecure community are likely to be related to decreased availability, accessibility, and affordability of foods, which have been demonstrated to be important in predicting eating behavior (Glanz, Sallis, Saelens, & Frank, 2007). Moreover, we would expect community level factors like proximity of grocery stores, food offerings at stores, and affordability of healthy foods to be associated with food security status.

Proximity of grocery stores and food insecurity

The location of grocery stores relative to an individual's home directly impacts the food options available to them on a daily basis (Saelens et al., 2012; Sallis & Glanz,

2009). In order to consume a certain group of foods or variety of food, that food must be available. The distance and location of different food shopping outlets, in particular, grocery stores, are important variables to consider when understanding the food environment and presence of food insecurity (A. A. Casey et al., 2008). It is hypothesized that the distance of food outlets will be related to food insecurity such that those experiencing food insecurity will be more likely to live farther away from grocery stores. As explained in Bitler and Haider's article about economic determinants of food deserts (2011), this is because having to travel a long distance is inconvenient for many and may influence the frequency with which food is purchased as well as the types of foods that can be purchased due to spoilage. After several weeks of eating food from a single purchase, food options become more limited. Families may start rationing food or may be limited in the variety or type of foods eaten, and this type of shift in food availability could promote food insecurity (Bitler & Haider, 2011).

A study conducted by Kegler and colleagues (2008) explored the relationship between home and neighborhood environments and their importance in contributing to obesity prevention. In-depth interviews were conducted with 60 Caucasian and African American adults in two rural counties in Southwest Georgia. From these interviews, themes were identified and data matrices were used to identify patterns based on gender and race. Participants reported that it was generally easy to get healthy foods, like fruits and vegetables; however, about half of participants described living 15-45 miles away from the grocery store. Additionally, participants identified poor selection of healthy foods at local stores as a barrier to healthy eating (Kegler, Escoffery, Alcantara, Ballard, & Glanz, 2008). Although none of the participants in the study were asked about food

insecurity as part of the interview, we might expect that residents in neighborhoods far from grocery stores and with less frequent shopping patterns, would experience food insecurity as a result of these environmental challenges.

Food offerings at stores and food insecurity

Food shopping outlets serve a pivotal role in the food delivery process. Once manufactured or shipped, food is distributed to local retailers to be sold to the consumer. A study conducted by Hosler (2009) would suggest that community food environment is highly dependent on not only the location of grocery stores, but also the specific foods offered at stores. Hosler (2009) studied the availability of selected foods at various retail locations and explored the ecological relationships between food available and obesity in rural communities. Authors surveyed 182 food stores in rural New York using food inventories. Through cluster analysis and geographic information system (GIS) data, grocery stores were mapped into four different groups. Obesity data were obtained through secondary sources and applied to study-generated maps. Findings revealed foods with high nutrient levels including fresh fruit, vegetables, milk, high fiber bread, and fish were more available in suburban neighborhoods than in rural areas. Additionally, obesity was inversely related to the availability of fresh fruit, vegetables, and low-fat milk (Hosler, 2009). These observed disparities in food availability and obesity, demonstrate the association between the physical availability of certain foods in the community and the effects it can have on weight status.

Affordability of healthy foods at stores and food insecurity

The availability of foods is also directly linked to their affordability. Food pricing is highly sensitive to supply and demand. As applies to other retail items, decreased supply increases demand and consequently the price of the item. Food pricing is even more complex as it is linked not only to supply and demand, but also to policy decisions regulating the price of crops and livestock as well as the availability of certain foods seasonally, market trends, production costs, and transportation costs (White, 2007). Of these, transportation costs most differentially affect rural communities because of the way our food distribution process is structured. Food distribution centers cluster around cities and urban-dwelling residents have easiest access to fresh produce, meats, and dairy, whereas rural towns may have reduced options (Bitler & Haider, 2011). Extra delivery time to rural towns can cost companies quite a bit of money in spoilage, refrigeration, and extra fossil fuels, making transporting fresh foods to rural towns much more expensive. In contrast, foods with lots of added sugars, fats, and preservatives are easier to transport because they travel better and can be stored longer before spoiling. As a result, the food environment in rural areas does not include the same variety and freshness of fruits, vegetables, low-fat dairy, and lean meat found in cities (Hosler, 2009; Kegler et al., 2008). The insufficient supply of healthy foods in rural grocery stores causes a spike in price, which is then shifted to the consumer, impacting purchasing and food consumption decisions (Bitler & Haider, 2011). A participant in the aforementioned study conducted by Kegler and colleagues (2008) expressed, “Because of the price of them, we don’t…[eat them]…you know. I like apples and bananas, and what not, and grapes and all that, but we don’t eat them all the time” (Kegler et al., 2008).

Laboratory studies focusing on food purchasing decision-making have demonstrated the influence of price elasticity on purchasing patterns. Epstein and associates (2007) assigned mothers enrolled in their study to price conditions in which the price of either low energy density foods or high energy density foods was manipulated from 75% to 125% of the reference purchase price. These foods were presented along side the alternative food, which was kept at the reference value. Participants were then asked to select foods and complete purchases for shopping budgets. One budget was set at $15 dollars per family member, and the other at $30 per family member. The number of purchases significantly decreased when the prices were increased for low energy density foods ($p<.01$) and high energy density foods ($p<.001$). Interestingly, maternal BMI interacted with the price to influence food purchases of high energy density foods ($p=.016$) and low energy density foods ($p=.008$) when the price of high energy density foods increased (Epstein, Dearing, Paluch, Roemmich, & Cho, 2007). Results showed that food purchasing decisions were highly sensitive to pricing changes and that altering the price of snack foods and high energy density foods could increase the purchase of healthier, low-energy dense foods for overweight mothers.

Moreover, the differential pricing structure associated with healthy foods in rural stores is likely to make them much less desirable. As a result, this may shift buying and consumption patterns to favor cheaper, higher energy density foods, increasing risk for overweight and obesity. A study conducted by Drewnowski (2004) provided further evidence that healthy foods are often far more expensive per calorie than highly palatable, energy dense foods. He and his research team purchased a variety of foods from one local Seattle grocery store and applied energy-density values from previous

work by Rolls and colleagues (Rolls, 2009). Foods were then plotted against price ($/MJ) and energy density (MJ/kg). Results showed that less energy dense foods such as lettuce and strawberries cost the most per milojoule, while oil, shortening, margarine, and sugar cost the least per milojoule. Some fresh fruits and vegetables were several thousand times more expensive for the amount of energy in the food, requiring a logarithmic scale to determine the relative energy density per dollar (Drewnowski, 2004). This study proved that on a strict per calorie basis, eating low nutrient, high energy density foods is more cost-efficient than consuming high nutrient, low energy dense foods. Drewnowski proposed that since the highest rates of obesity in the United States cluster in groups with the highest poverty rates and least education, the impact of socioeconomic variables might be mediated by the relatively low cost of high energy density foods. Families looking to reduce diet costs may be selecting the highest energy density foods, providing a micro-economic explanation of the observed relationship between obesity and poverty (Drewnowski, 2004).

While consumption of cheaper foods provides the most calories per serving, these calories also tend to be the least satisfying, meaning that individuals who eat these higher energy density foods also experience hunger the soonest after finishing a meal. The body does not adjust appropriately to account for increased consumption of these hyperpalatable foods (Drewnowski, 1998). Therefore, the lowest income individuals consuming these high energy density foods as a money-saving strategy are also most likely to feel hunger sooner and experience food insecurity. This helps explain how individuals experiencing food insecurity, which tend to be energy dense, could easily consume excess calories, making them more vulnerable to develop obesity.

Home Level Factors

Home environments are of commensurate importance in shaping eating behavior. As proposed by social cognitive theory, exposure to a specific eating environment can directly affect eating attitudes and eating behaviors. The home environment has been the target of several family-based obesity treatment and or weight gain prevention programs, including the parent study (Kegler et al., 2012).

Food purchasing decision-making and food insecurity

Food purchasing decision-making relies on several decisional-balance relationships including availability, taste, weight management, and cost. Availability and cost have been discussed extensively above and their influence on point-of purchase decision-making has been well established. This section also highlights perceived barriers and promoters of purchasing and consuming healthy foods exploring the way in which the larger food environment may create taste preferences that encourage choosing unhealthy high energy-dense foods (e.g. cookies, chips, and other snack foods).

Eikenberry and Smith (2004) distributed self-administered surveys to low-income residents (*N*=796) recruited at food programs, grocery stores, and other public places in four Minnesota communities (Eikenberry & Smith, 2004). Surveys were designed to identify definitions of healthy food and motivation, barriers, and promoters of healthy eating. Participants who reported eating healthy foods, said they did so primarily for health, weight, and family concerns. Approximately half of the participants listed time and money as barriers to healthy eating. Promoters of healthy eating included federal or local food assistance programs.

In a study conducted by Walker and Kawachi (2012), concept mapping was used to explore the influence of food security on food buying practices. The study included 67 individuals, 41 of whom were food insecure and compared food secure and insecure participants on basic characteristics and food purchasing decision-making. Participants generated a list of 163 unique or non-overlapping statements that were used to create the following list of eight factors: health consciousness, personal decisions, time factors, special occasions, crime and safety, budget consideration, shopping concerns, and corner convenience (operationalized as close proximity to grocery stores). While there was some variance in ranking of importance, the study found that food insecure and secure individuals generally ranked factors that influenced purchasing decisions as equally important. Convenience ranked as the most important concern and crime and safety ranked as the last by both groups (Walker & Kawachi, 2012).

Factors like convenience, time, and money are often cited as the main reasons why individuals do not purchase and consume healthy foods. There has been a great amount of research to show that taste preferences play a crucial role in determining what is purchased and consumed. Using a developmental systems perspective, Birch (1999) conducted a review of how genetic predisposition interacts with the food environment to form food preferences. Predispositions were defined as unlearned reactions to basic tastes, including a preference for sweet and/or salty and a rejection of sour and bitter foods. Study findings revealed that despite previous dispositions to prefer certain foods, the home eating environment interacted with these dispositions to form food preferences (Birch, 1999). Therefore, the larger food environment can be highly influential in determining taste preferences regardless of genetically programmed preferences.

Moreover, in a home in which there is an overabundance of energy-dense foods laden with fat and sugar, family members will learn to prefer these foods.

The differential pricing structure of healthy foods combined with taste preferences for sweet and salty palatable foods, disproportionately favors the purchase of high energy density food items. For families with low incomes who may be experiencing food insecurity, we would expect to see cost as a focal point in making grocery decisions. This relationship is likely to be of increased salience when taking into consideration household income per person, as those amounts are likely to determine the food-purchasing budget.

Household income per person and food insecurity

Food purchasing decisions are highly sensitive to fluctuations in pricing and set household budgets (Epstein et al., 2007). Household income per person provides a relative scale from which to evaluate the relationship between income, cost of foods being sold, food purchasing decisions, and food insecurity.

Rose (1999) examined the economic and dietary consequences of food insecurity in the United States using the Current Population Study and its definition of food insecurity and hunger. His findings revealed poverty levels and hunger were not directly related, and that more accurate measures of household food budgets and assistance should be assessed to determine true food insecurity and hunger. Analyses revealed that only 13.1% of those living in poverty experienced hunger. Conversely, of those experiencing hunger about 50% of them were above the poverty level (Rose, 1999). Findings indicate that we should not expect a correlative relationship, but perhaps, a curvilinear one, in which the most impoverished do not experience as much food

insecurity or hunger as those slightly better off. Rose explained that households meeting poverty levels are likely to already be the beneficiaries of several assistance programs including food and nutrition assistance, while families just above that level are more likely to have recently experienced stressful life events that tax household budgets including job loss or gaining a family member (Rose, 1999). Therefore, household budget per person is a more accurate measure of the income available to spend on food and we could expect an association between these values and food insecurity; however, we should not expect that relationship to be a one-to-one association.

Interestingly, it is not just recent household income, but past household income and experiences of food restriction that can contribute to food insecurity. Sarlio-Lahteenkorva and Lahelma conducted a study in Finland (2001) that assessed past and present economic disadvantage, food insecurity, and obesity. Using a nationally representative sample of 25-64 year-old Finnish men and women (*N*=6,506), they investigated the relationship between BMI categories (e.g. thin, normal, overweight, and obese), economic disadvantage (e.g. unemployment during the past 5 years and long-term economic problems in childhood), and food insecurity (assessed by five different items about economic fears and food supply). Results indicated that low household income, recent unemployment, and economic problems in childhood were all predictors of food insecurity. Individuals of low or normal weight were most likely to be hungry and showed most food insecurity in five separate items. However, obese individuals reported buying less expensive foods, due to fear of not having enough food, and were more likely to have a history of food insecurity compared to low or normal weight individuals (Sarlio-Lahteenkorva & Lahelma, 2001). The study demonstrated past and present

economic difficulties were associated with food insecurity and highlighted the importance of perception of deprivation in driving eating behavior and obesity.

The relationship between economic disadvantage and food insecurity in the United States has been closely studied. Of particular interest is the association between food insecurity, obesity, and food assistance programs. Household income per person helps determine eligibility for food assistance programs, which may play a mediating role in the relationship between food insecurity and obesity. Participation in SNAP over the previous five years compared to no participation was associated with a 20.5% increase in the probability of current obesity (Gibson, 2003). Speculation has been drawn as to whether economic disadvantage increases food insecurity, which then promotes food assistance enrollment, or whether participation in food assistance programs elevates feelings of food insecurity (Alaimo et al., 2001; Gibson, 2003; Townsend et al., 2001). While we do not have a measure of food assistance participation, explaining the background behind the relationship may help elucidate study findings if a curvilinear relationship were observed between household income/person and endorsement of food insecurity.

Gibson (2003) investigated the relationship between food assistance participation and obesity (defined as a BMI of 30 or higher) among low-income individuals using data from the National Longitudinal Survey of Youth, 1979 (Gibson, 2003). Data were arranged as a panel with multiple observations per individual and findings showed that current and long-term food stamp program participation was significantly related to the obesity of low-income women ($p<.05$), but not of low-income men. For low-income women, current participation in the food stamp program was associated with a 9.1%

increase in the predicted probability of current obesity. Participation in the program for the previous five years compared to no participation over that time period was associated with approximately a 20.5% increase in the predicted probability of current obesity (Gibson, 2003).

Gibson (2006) also explored the relationship between food stamp program participation and overweight and obesity in young girls and their mothers. Gibson showed that the association in mothers accounted for associations between long-term food stamp participation and overweight in daughters (Gibson, 2006). These findings suggest that food insecurity and obesity are related to food stamp participation at a household level. Furthermore, the home food environment may play a significant role in determining feelings of food insecurity for several household members and is likely to influence eating behaviors and attitudes as well as weight outcomes.

Home food environment, food insecurity, and eating behavior

The home food environment plays an integral role in determining food insecurity and eating behavior. The home food environment has shown to be predictive of child, adolescent, and adult eating behavior (Campbell et al., 2007; Ding et al., 2011; Gattshall, Shoup, Marshall, Crane, & Estabrooks, 2008). The type, variety, and amount of food in the home directly impact the choices individual household members make at mealtimes and snack times (Birch & Fisher, 1998; Campbell et al., 2007; Story et al., 2008).

Findings from Campbell et al. (2006, 2007), support this expectation as they found several aspects of the food environment were associated with children's dietary behaviors and weight status (Campbell et al., 2006). In two landmark studies, Campbell

et al. analyzed the home environment in relation to food consumption and weight outcomes in children and adolescents. In the study of 5-6 year olds, frequent television viewing was associated with poorer eating behavior including overall higher caloric intake, consumption of sweet snacks and high-calorie beverages, and deceased vegetable intake (Campbell et al., 2006). In adolescents, overweight was positively associated with presence of snack foods in the home. Specifically, sweet snacks (p=.001) and savory snacks (p<.001) were associated with overweight in girls and the presence of savory snacks was associated with overweight in boys (p=.002) (Campbell et al., 2007). These studies highlighted the importance of the home food environment on weight in youth and provide further evidence that the food in the home exerts a strong influence on food relationships, eating behavior, and weight.

The home food environment was also determined to be an important factor in predicting eating behavior by Ding and colleagues (2011). Ding et al. and showed that fruit and vegetable intake was positively associated with availability of healthful food (r=15 to .27) and was negatively associated with less healthful food in the home (r=-.17 to .18) (Ding et al., 2011). Again, this evidence supports the importance of the home food environment in shaping eating behavior.

In a study conducted by Patterson et al. (1997), participants recruited using random-digit-dial methods were asked to complete a survey assessing the presence of 15 high-fat foods in the home. A randomly selected household member was then asked about eating behavior (N=1,002). Survey results showed that individuals with "low-fat pantries" (i.e. mostly low fat foods present in their pantry) had an average intake of 32% of calories from fat versus 37% for those with "high-fat pantries" (Patterson, Kristal,

Shannon, Hunt, & White, 1997). While not a large difference, the association indicates that household food inventories are a valid and reliable approach to monitoring food intake and dietary behavior in community based studies and suggests that the food that is present in the home may reflect the dietary behavior of household members.

Due to the strong influence home food environments have on eating behavior of household members that reside within them, we would expect that a home without many food options or abundance is likely to feel the effects of limited food choices and experience associated food insecurity. Based on the aforementioned research and guiding theoretical framework, it would be expected that household food environment would be associated with food security status such that having a paucity of food items would be associated with food insecurity, while having an abundance of food would be associated with food security.

Individual Level Factors

While there are some important community and home environment factors that may play a role in the development of food insecurity, there are also more proximal, individual level factors that may predispose certain individuals to exhibit a strong relationship between food insecurity and eating behavior. In particular, gender has emerged as a strong moderator of obesity within food insecure samples. Women are differentially affected by food insecurity and its negative sequelae (Olson, 2005). In some studies, ethnicity has interacted with food insecurity and obesity, such that stronger relationships are observed for ethnic minorities than for Caucasian individuals in the same sample; however, these findings have been inconsistent and it is not clear in what

way race and ethnicity might be related in explaining this relationship (Alaimo, Briefel, Frongillo, & Olson, 1998; Ogden et al., 2006). For this reason, race and ethnicity will be included as covariates in analyses, but will not be considered a prominent part of the research agenda.

Gender and food insecurity

The association between gender and food insecurity has been reported in several studies of nationally representative data in the United States. It is unclear what role historical interpretations of gender stereotypes and norms, biology, or protective behaviors such as "maternal buffering" may play in determining differential effects of food insecurity on female weight status, when compared to food insecure male counterparts. Maternal buffering is defined as a mother protecting her family by being the first individual in the home to reduce either the quality, variety, or amount of food being eaten because there is a shortage (Maxwell, 1996). Maternal buffering is an extremely common practice in both developing nations and in the United States. While we do not have a measure of maternal buffering, it is important to consider in the context of food insecurity and gender.

Nationally representative data from 1994-1996 Continuing Survey of Food Intakes by Individuals (CSFII) showed an association between food insecurity and overweight. Food insecurity was related to overweight status for women, but not for men. Excluding the 11 severely insecure women, the prevalence of overweight among women increased as severity of food insecurity increased (Townsend et al., 2001). Women endorsing mild food insecurity were also 30% more likely to be overweight than those

who were food secure. This was one of the first studies to highlight an association between food insecurity and overweight; documenting that overweight increased as food insecurity severity increased. Notably, the study also identified a gender disparity, with women being more likely to show a stronger relationship between food insecurity and overweight than men.

Similarly, data analyzed from the 1999-2000 and 2001-2002 National Health and Nutrition Examination Surveys showed that compared to individuals in food secure homes, food insecure men and women were significantly more likely to gain weight and to be obese (Wilde & Peterman, 2006). Specifically, women in households that were marginally food secure and food insecure without hunger were much more likely to be obese than women in food secure households (Wilde & Peterman, 2006). Men in less food secure homes were also more likely to be obese, but the effects were smaller in magnitude than for women (Wilde & Peterman, 2006).

In a study conducted by Hermstad and associates (2010), which explored relationships between individual and environmental correlates of dietary intake, the relationship between food environment and obesity was significant for women, but not men (Hermstad, Swan, Kegler, Barnette, & Glanz, 2010). The study collected data from participants (ages 40-70) in four rural Georgia counties (N=527). Participants completed a survey that included several questions about eating habits and influences on eating behavior. Again, the home nutrition environment was associated with dietary fat intake for women but not men, indicating that perhaps home environment played a larger role for women.

Researchers have sought to explain this relationship using various sociological interpretations to account for this differential effect. It has been proposed that women may suffer from unique stressors related to food due to their role as "mother" within the family unit (Ivers & Cullen, 2011; Olson, 2005). This role may include ensuring the family has balanced and regular meals, avoiding conflicts over food, and establishing shared nutrition goals and patterns for the family. Not being able to fulfill these roles in the face of food insecurity, many women may experience a decreased sense of self-efficacy, which may mediate the relationship between food availability and food insecurity.

Additionally, different eating and feeding practices may result in higher feelings of food insecurity. For example, in documenting practices related to food insecurity at the household level, Keenan and colleagues (2001) found that women tend to be the first in the family to reduce the quantity or quality of food consumption through a process labeled "maternal buffering" (Keenan, Olson, Hersey, & Parmer, 2001). As a result, the severity of the food insecurity experienced by women may be more severe than that felt by men or young children. Therefore, women are at particularly high-risk for health-related consequences of food insecurity including increased risk of overweight and obesity (Keenan et al., 2001; Olson, 2005).

Other individual level variables and food insecurity

While not implicated in the literature or represented as part of the theoretical framework, there are several other individual level variables that may be associated with food insecurity because of their influence on economic or home environment factors. As

mentioned earlier, weight, race, age, marital status, education level, income, and number of household members will all be examined, as they are likely to be associated with food insecurity.

Health Outcomes

Health outcomes and behaviors are uniquely tied to both our larger environments and attitudes (Bandura, 1977), and eating behaviors are no different. As evidenced above, the community environment and home environment may play a large role in determining food insecurity status and eating behavior. The purpose of this section is to explore evidence for the effects of food insecurity on specific eating behaviors, namely fruit and vegetable intake and fat intake. Since these behaviors are also highly correlated with cost and home food environment there is likely to be some overlap in concepts. A more in-depth explanation of how specifically these eating behaviors are influenced by food insecurity is warranted. These eating behaviors are consistently associated with weight management outcomes in the literature, making them important variables to consider in our current study in addition to weight alone. The relationship between food insecurity and weight will also be examined. While we would expect to see baseline differences based on previous research, it may be more difficult to detect change since longitudinal analyses will focus on six-weeks and large weight change outcomes are typically reported over the course of a year.

Fat intake and food insecurity

Fat intake is also an important eating behavior to measure to help understand weight status. In a large diabetes and weight management study, those who monitored

their fat intake were more likely to achieve the 7% weight loss when compared to participants who did not monitor their fat intake (Amundson et al., 2009). Since the price of high-fat foods is often lower than low-fat foods (Drewnowski, 2004), food insecure individuals might report higher fat intake than food secure individuals.

Mello and associates (2010) conducted a study to examine the relationship between food insecurity and dietary behaviors among low-income adults. Data were collected on demographics, food security status, fruit and vegetable consumption, and fat-related behaviors. About half the participants reported feeling food insecure. Participants experiencing food insecurity reported a significantly higher fat intake ($p<.05$) than food secure individuals enrolled in the study (Mello et al., 2010). Similarly, a study conducted by Sharkey and colleagues (2012), found that among children ages 6-11, very low food security was associated with greater caloric intake and the percentage of calories from fat and added sugar (Sharkey, Nalty, Johnson, & Dean, 2012). Moreover, we might expect study findings to reveal a similar association such that individuals who reported feelings of food insecurity would be more likely to have higher fat intake than their food secure counterparts. However, it may be difficult to discern to how much this is related to low-income and cost of food and how much is related to food insecurity alone.

Fruit and vegetable intake and food insecurity

The majority of existing studies have found that fruit and vegetable intake is lower among individuals experiencing food insecurity. Fruit and vegetable intake has been recognized to contribute to healthy weight maintenance, largely because of the high water content and fiber content of these foods (Rolls, 2009). Fruits and vegetables also

contribute important nutrients and vitamins to the body which aid in maintenance of health status and body functioning (Slavin & Lloyd, 2012). Independent of weight, food insecurity has been associated with chronic disease, which researchers have speculated might be a result of decreased fruit and vegetable intake (Seligman, Laraia, & Kushel, 2010), making them important targets of investigation in health disparities research.

Kendall and associates conducted a study of 193 women drawn from a random sample of 308 women that had completed a previous census study in rural New York State County. The study examined fruit and vegetable, nutrient intake, and disordered eating behaviors and found that as food insecurity worsened, individuals ate fewer fruits and vegetables and had increased disordered eating behaviors (Kendall, Olson, & Frongillo, 1996).

In a convenience sample of 212 food pantry clients in Hartford, Connecticut from June 2010 to May 2011, food secure participants were twice as likely to eat fruit and vegetables as food insecure participants (Robaina & Martin, 2012). In a similar study conducted by Miewald and colleagues (2012), authors examined whether participation in a food box, which provided fresh fruits and vegetables to homes, had a positive effect on fruit and vegetable consumption and food security (Miewald, Holben, & Hall, 2012). As expected, participants who remained in the food box program had larger fruit and vegetable intake over time, while those who left the program, had declining consumption of fruits and vegetables. Even after several months the intake of fruit and vegetables was lower among those who had left than among those who remained in the program and food insecurity was associated with lower intakes of fruit and vegetables (Miewald et al., 2012).

Conversely, researchers in one study investigating the relationships between food insecurity and eating behavior actually found that fruit intake was significantly greater among food insecure individuals (Mello et al., 2010). Authors of this study attributed this unanticipated finding to faulty study methods and measurement and explained that juice was included in the category of "fruit." They hypothesized the higher fruit intake was likely to reflect a higher intake of fruit juice, which may be independently associated with participation in food assistance programs and obesity.

Weight and food insecurity

The basis for the current study rests largely on the fact that several previous studies have found strong associations between food insecurity and weight status (defined as normal, overweight, obese). While results may vary for findings based on gender or race/ethnicity, consistently studies have found that food insecurity predicts (for at least a portion of the population) higher weight status and BMI using national data sets (Gibson, 2003; Gooding, Walls, & Richmond, 2012; Townsend et al., 2001). Still, additional research is needed to elucidate meditational effects and other nuances in the relationship not previously explored (Franklin et al., 2012). Few studies have looked at food insecurity and obesity in smaller or more specialized samples (Jilcott, Wall-Bassett, Burke, & Moore, 2011; Koh et al., 2012; Martin & Ferris, 2007). As such, the current study will add to the field in a substantial way.

Theoretical Background

Socioecological Model and eating behavior

The relationships between the food environment, food insecurity, and eating behavior can best be understood through the socioecological model of eating behavior. The socioecological model proposes that various levels of influence affect eating behavior (Story et al., 2008). Working from the societal level inwards to the individual level, we see the impact that all of these factors have on the others. It has been argued that in order to effectively address the obesity epidemic, use of the socioecological model is necessary because each of these levels needs to be better investigated, understood, and targeted in order to create sustainable change (Sallis & Glanz, 2009).

There is much support for the use of ecological models in obesity research, particularly for research on childhood obesity and overweight. Davison and Birch (2001) suggest that the development of childhood overweight involves a complex set of factors from multiple contexts that interact with each other to place a child at-risk for becoming overweight (Davison & Birch, 2001). They propose use of Ecological Systems Theory (EST) and argue for the use of ecological frameworks in understanding weight and weight related behaviors because of the importance of considering the contexts or "ecological niche," in which a person is located in order to understand the emergence of a particular characteristic. In their work with children, they explain that a child's case is dependent on the ecological niche established by the family environment and school environment, which are nested within the larger community environment and society at large. This framework can be applied to the adult population as well as individuals of all ages are affected by their socioecological niche.

The socioecological model has also been applied to understanding fruit and vegetable intake. Robinson (2008) utilized a socioecological model to provide a review of 12 studies focusing on fruit and vegetable intake among low-income African Americans (Robinson, 2008). Based on the studies retrieved in the review, dietary behaviors and fruit and vegetable intake among African Americans are the result of a complex interplay of personal, cultural, and environmental factors. The socio-ecological model provided a useful framework for achieving a better understanding of the multiple factors and barriers that impact dietary behaviors.

The importance of socioecological models in sensitively addressing numerous contributing factors to obesity within specific ethnic minority populations has also been noted by work studying obesity within Aboriginal populations. Authors of one study conducted in Canada, promoted the use of the socioecological model to allow for a holistic perspective of the community and interacting variables as well as to account for co-existing frameworks including historical and sociocontextual determinants of health frameworks (Willows, Hanley, & Delormier, 2012). In relation to food insecurity and obesity, the socioecological model provides a holistic perspective and suggests that addressing obesity in low-income populations would also include addressing food insecurity and the factors that cause it by focusing on sociodemographic risk factors (Willows et al., 2012).

In summary, the socioecological model provides a flexible and comprehensive framework for understanding a variety of weight related factors including contextual settings, food insecurity, and eating behavior. To our knowledge, no currently published food insecurity research utilizes the socioecological model. In fact, in all of the literature

we reviewed, existing theoretical frameworks were never employed in developing the conceptual model or justification for the research questions. Since food insecurity is closely related to eating behavior and obesity and these have been highly studied using the socioecological model, we are justified in our choice of the socioecological model to explore this relationship as well. As such, the current study hopes to explain the role of community-level, home-level, and individual-level correlates of food insecurity and the role that food insecurity plays in contributing to eating behavior (e.g. fruit and vegetable intake and fat intake) and weight outcomes.

Social Cognitive Theory and eating behavior

To better understand how variables nested within different levels of the socioecological model may be interacting with one another, social cognitive theory offers an explanation that may be useful. Social Cognitive Theory states that reciprocal relationships exist between the environment, personal attributes, and behaviors, such that each one exerts a force on the other (Bandura, 1977). Social cognitive theory has been used across multiple health behaviors. The theory includes various processes such as self-efficacy, outcome expectations, and perceived environmental barriers and facilitators that help explain relationships between constructs. It is an exemplary theory to use in examining eating behavior within the home environment and has been utilized in previous trials, including the parent study (Kegler et al., 2012).

As an example, formative work in a group of low-income African American adolescents in the lower Mississippi Delta region indicated that personal, behavioral, and environmental influences were important in determining food choices and consumption

patterns (Molaison, Connell, Stuff, Yadrick, & Bogle, 2005). This demonstrated the relevance of these social cognitive theory constructs in determining eating behavior. Since food insecurity affects environmental, behavioral, and attitudinal factors related to eating, which reciprocally determine one another, the inclusion of this theory is important in framing research questions for the current study.

Integration of multiple theories and eating behavior

Importantly, there is a need for more integrated theories and frameworks to better understand eating behavior and its environmental and individual-level correlates. Obesity is likely to be one of the greatest medical challenges of the current generation. Therefore, having flexible and integrative frameworks will be essential in tackling the issue from a multi-level perspective (Baranowski et al., 2003). The socioecological model and social cognitive theory create a strong starting point from which to orient a research study; however, additional variables warrant inclusion into the model as well. In a review of current health behavior change models being utilized for weight gain prevention efforts, Baranowski and colleagues (2003) call for the use of integrative approaches (Baranowski et al., 2003). The authors argue that multiple cross-disciplinary variables are needed to truly understand and address various contributing factors to weight. Moreover, the current study purposefully utilizes concepts from aforementioned theories and goes beyond the limits of these frameworks to address research questions of interest that may elucidate important relationships regardless of having weaker theoretical support.

Summary

Several studies have documented the co-occurrence of food insecurity and obesity and the importance of a variety of factors in eating behavior and weight outcomes; however, these phenomena warrant further investigation. Few studies have looked at the contribution of community, home, and individual level variables in relation to food insecurity and intervention outcomes. The current study aims to identify variables at multiple levels and examine these relationships more closely. Doing so may provide insight as to how to best address co-existing food insecurity and obesity in low-income populations.

CHAPTER III: METHODS

The current study is a secondary data analysis yielded from an intervention study aimed at preventing weight gain among individuals living in rural South Georgia. The parent study was conducted using community-based participatory research (CBPR) methods as part of an existing partnership between the Emory Prevention Research Center (EPRC) and the Cancer Coalition of South Georgia. In adherence with the CBPR model, the community advisory board (CAB) was consulted on all major decisions and served an important role in the research process (Kegler et al., 2012). The CAB helped develop the study design, create the intervention, implement recruitment strategies, and facilitate study delivery. The Emory University Institutional Review Board and the Community Advisory Board approved all study methods.

Participants

The primary study from which this secondary study was drawn employed a quasi-experimental design. Participants were recruited from Randolph, Cook, and Mitchell counties in Georgia. Randolph and Cook counties served as the intervention counties and Mitchell as the comparison county. Participants were recruited from communities in their respective counties using a variety of recruitment methods and sites. All recruitment methods were approved and implemented with help from the CAB (Kegler et al., 2012).

Recruitment followed a three-step process that engaged key stakeholders from various local businesses and organizations to promote enrollment in the study. First, the EPRC Team conducted a preliminary assessment to identify appropriate sites for study

recruitment and advertisement. Locations were selected and the CAB provided input and suggestions about other possibilities for study advertising and recruitment. As a secondary step, study staff utilized key stakeholders within local organizations to promote study enrollment. Information was distributed and study recruitment encouraged by staff at worksites, churches, businesses, community centers, libraries, and health departments. A variety of locations were selected for recruitment to try and achieve a diverse sample within the community. Support was obtained from local organizations and businesses used for recruitment.

Recruitment of primary participants

Primary participants, defined as those individuals in the home who were recruited first to participate in the study, were recruited in-person by trained personnel. Community members were approached by study personnel and informed of eligibility criteria. They were given information about the study and, if interested, screened to determine their eligibility for the study. If eligible, participants were asked to sign consent forms, which included a consent form and a HIPAA authorization clause. Participants were asked if they had questions about the study, and study staff were available to address questions or concerns. After being consented to the study, the participant was given a contact information form to complete and an informational brochure to take home and share with other household members. To enroll in the study, primary participants needed to be: either African-American or Caucasian; 40-70 years old; residents of Cook, Randolph, or Mitchell counties; living in Southwest Georgia for 5 years; living with at least one other

person 18+ years old; able to speak, understand, and read and write English; and accessible via a working home or cell phone number.

Recruitment of secondary participants

Secondary participants were also recruited. These individuals were people living in homes of primary participants who were also willing to provide information about their eating, activity, and lifestyle habits. Secondary participants were recruited while consent and baseline data were collected from primary participants via telephone. More information on secondary participant recruitment can be found in findings published from the parent study (Kegler et al., 2012).

Compensation

All participants were compensated for their time in the amount of $20 for the first and second interviews and $30 for the third interview provided in the form of Wal-Mart gift cards. Participants were informed of the potential risks and benefits as part of the informed consent process.

Procedure

Once enrolled in the study, a home-based intervention was delivered to the Randolph and Cook (intervention group) county homes, while the Mitchell County homes received mailings with information about healthy eating and physical activity. The duration of the intervention was approximately six weeks, and data were collected over the course of four to five months.

Intervention

The home-based coaching included two home visits and two coaching calls both aimed at modifying the home environment to support weight maintenance eating and activity behavior change. Home visits lasted 30-60 minutes and were used to guide participants in selecting new healthy action items from the "Healthy Actions Checklist" and encouraging maintenance of existing healthy actions. Phone calls lasted 15-20 minutes and were designed to maintain contact and provide tips and encouragement to participants.

Both home visits and phone calls served to guide participants in selecting healthy environmental changes, address barriers, brainstorm solutions, connect participants to resources, and provide motivational support for participants to make the changes selected. Healthy eating actions included making sure there were mostly healthy foods in the home, buying healthy foods when grocery shopping, cutting down on unhealthy foods from restaurants, preparing healthy meals at home, and decreasing the amount of meals eaten while watching television. Healthy physical activity actions included decreasing the amount of free-time spent watching television, making physical activity more accessible by having equipment visible and available, identifying and committing to using a new facility in the neighborhood for physical activity, and increasing the number of times the family does physical activity together. Calls and home visits were structured to

incorporate four stages of coaching, which all study coaches were trained on addressing.

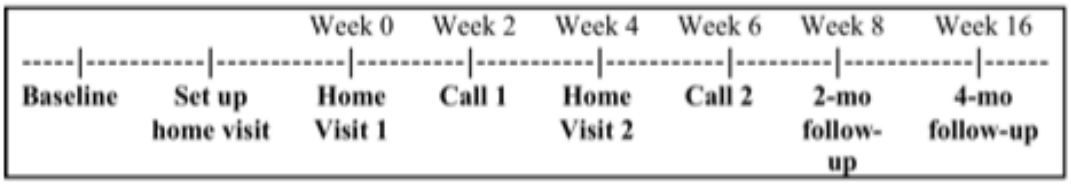


Figure 4: Intervention Study Timeline

The stages were: Connect, Discover, Design, and Activate and had distinct steps and strategies to guide the coach. Home visits were made at Week 0 and Week 4 and calls were made at Week 2 and Week 6. For a view of the study timeline, **see Figure 4**. Baseline data (baseline) and final follow-up data (4-month follow-up data) were used in the current study.

Comparison

The Mitchell County (Comparison) homes received informational mailings about healthy eating and activity. Mailings were sent once during the course of the intervention. Baseline data from the comparison group were used in the current study.

Data Collection

Surveys were administered at three data collection time points: baseline, two-months post-baseline, and four-months post-baseline. Data were collected over the phone by trained interviewers. During these calls, participants answered a variety of questions. Calls typically lasted for 30-45 minutes. The current study only uses a subset of the measures enumerated below.

Measures

Community-level variables

Distance to grocery shopping – Participants were asked to select how far away their regular grocery store was from their homes. Answer options included a few blocks away (less than 10 minute walk), 1-5 miles away, 6-20 miles away, or more than 20 miles away (Inglis, Ball, & Crawford, 2008).

Access to healthy food at stores – Participants were asked to rate the ease of purchasing healthy items in their local neighborhood on a 4-point Likert scale from strongly disagree to strongly agree. Subscale items included how easy it is to purchase fruits and vegetables, if there was a large selection of fruits and vegetables, the ease of purchasing low fat foods, and if there was a large selection of low-fat foods. These items were adapted from previous work (Glanz et al., 2007; Hermstad et al., 2010). Construct validity has been established by earlier studies and reliability analyses were not appropriate since there was only one scale question.

Could not afford healthy foods – Affordability of food was assessed using the following question, "Was there a time in the past month that you wanted to buy the following, but could not because it cost too much? Fruits? Vegetables? Healthy snacks?" (Inglis et al., 2008). Healthy food was considered unaffordable if participants answered "yes" to at least one of the food options.

Home-level variables

Home food environment – Items adapted from Gatschall et al. (Gattshall et al., 2008), Glanz et al. (Glanz et al., 2007), and Patterson et al. (Patterson et al., 1997) were used to ask about availability of fruits and vegetables, healthy snacks, and unhealthy snacks in the home.

Household income – Household income was obtained by asking the following question: "What is your total yearly household or family income from all sources? Would you say less than $10,000; more than $10,000 up to $25,000; more than $25,000 up to $50,000; or more than $50,000?" This question was adapted from the 2005 BRFSS (CDC, 2005).

Additional household members – The number of people in the home was obtained by asking the following question: "In all, how many people live in your household in addition to you?" The answer options included no one, one person, two people, three people, and four or more people. This question was adapted from the 2005 BRFSS (CDC, 2005).

Individual level variables

Food Insecurity – Severe food insecurity was assessed using the following item from Inglis et al. 2008, "Have you ever run out of food in the last 12 months because you could not afford to buy more? Yes or no?" (Inglis et al., 2008). Participants answering in the affirmative were considered to be experiencing food insecurity. This one-item question

was used because of its parsimony in conducting long phone-based questionnaires; however, the limitations of this measure are recognized in the discussion section.

Food purchasing decision-making – Participants were asked the following question: "When you purchase food for you or your family, how important is the following to you? How important is…taste? Nutrition? Cost? Convenience? Weight Control?" Participants were then asked to rate the importance from 1-not important to 5-very important. Items were adapted from work done by Inglis and associates (Inglis et al., 2008) and are supported by additional work by Kirkpatrick (Kirkpatrick, 2012).

Demographic Information – Additional demographic information was assessed at baseline by asking questions adapted from the 2005 Behavioral Risk Factor Surveillance System. Participants were asked about age, gender, race/ethnicity, marital status, and height and weight (which was used to yield a BMI score). One individual self-reported race/ethnicity as "other." This individual was added to the Black/African American to create a "Non-Caucasian" category. The nominal breakdown of race/ethnicity is appropriate for the current analyses and is substantiated by the food insecurity and obesity literature as ethnic minorities are more likely to suffer from both food insecurity (Alaimo et al., 2001; Seligman et al., 2010; Townsend et al., 2001) and obesity (Kumanyika, 2006; Kumanyika et al., 2012; Miech et al., 2006) than Caucasian individuals. Marital status data included the following options: married, not married, but living with a partner, widowed, separated, divorced, and not married. For the purpose of the current study, categories were combined to yield the following tri-level marital status:

(1) married, (2) not married, but living with a partner, and (3) not married or living with a partner. This decision was data-driven as there were very few participants in the remaining categories. Additionally, the decision to collapse categories coordinates with previous decisions for this data set (Kegler et al., 2012).

Health outcome variables

Fat intake – Six items from the National Cancer Institute's Quick Food Scan (Fat Screener) were used to assess percent calories from fat (Thompson et al., 2004). Participants were asked how often they typically eat the following foods: regular fat bacon or sausage; regular fat cheese or cheese spread; French fries, home fries, or hash brown potatoes; regular fat salad dressing; regular fat mayonnaise; and margarine, butter, or oil. Answer options included never, less than once per month, 1-3 times per month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 1 time per day, 2 or more times per day. For each participant, a percent of daily calories from fat was calculated. The scale has been used by a variety of studies and has been shown to be both valid and reliable for calculating mean daily fat intake (Thompson et al., 2007; Thompson et al., 2008; Williams et al., 2008). Values of fat intake were calculated for all data collection time points. Changes in fat intake were calculated by subtracting baseline intakes from intakes measured at the final follow-up time point.

Fruit and vegetable intake – Fruit and vegetable intake was assessed using six items from the 2005 BRFSS (CDC, 2005). Participants were asked how often they typically drink fruit juices and eat fruit, green salad, potatoes, and carrots and other vegetables. Intake

was summed to provide a total fruit and vegetable intake per day for each participant. These questions have been shown to be both valid and reliable measures of fruit and vegetable intake (Serdula et al., 1993; Smith-Warner, Elmer, Fosdick, Tharp, & Randall, 1997). Values of fruit and vegetable intake were calculated for both baseline and post-intervention data collection time points. Changes in fruit and vegetable intake were calculated by subtracting baseline intakes from post-intervention intakes.

Body mass index – Participants were asked to provide self-reported height in feet and inches and self-reported weight in pounds. Values were then converted to meters and kilograms and used to generate a BMI using the following formula: kg/m2.

Body weight status – BMI values were then grouped into weight status categories of underweight, normal, overweight, and obese based on the guidelines provided by the Centers for Disease Control and Prevention in 2011. A BMI below 18.5 was considered underweight, a BMI between 18.5 and 24.9 was considered normal weight, a BMI of 25.0 to 29.9 was considered overweight, and a BMI of 30 or higher was considered obese (CDC, 2011).

Data Analysis

Primary participants with baseline data (*N*=119) were used for research questions one and two for the current study. Due to the longitudinal nature of the third research question, only those participants who had baseline (first data collection time point) and final follow-up (third data collection time point) information on fat intake, fruit and vegetable intake, and weight were included (*N*=92). All analyses were performed using SAS Version 9.3 (Copyright 2013, SAS Institute Inc., Cary, NC). Demographic variables examined included: age, gender, race/ethnicity, marital status, education level, income, and additional family members in home. Study variables were divided into community, home, and individual levels in correspondence to the guiding theoretical framework, the socioecological model. Community-level variables examined, included: distance to grocery shopping, access to healthy food at stores, and affordability of healthy foods. Home environment variables included the home food environment. Individual level factors included food purchasing decision-making, weight status (normal, overweight, and obese), food insecurity, and eating behavior at baseline, post-intervention, and eating behavior change.

Univariate Analyses

Baseline demographic characteristics and study variables for the total sample were performed using the PROC UNIVARIATE function for continuous variables and the PROC FREQ function for categorical variables (Research Questions 1 & 2). Mean and standard deviation, and number and percentage, were reported for continuous and categorical variables respectively.

Bivariate Analyses

Bivariate analyses compared demographic variables and study variables for food secure and food insecure participants (Research Questions 1 & 2). Variables were examined for outliers, equal variances, and normality prior to performing analyses. In cases of unequal variances between groups for t-tests, Satterthwaite estimates were reported and indicated in Table 2. In cases of non-normality, skew and kurtosis were assessed and an appropriate transformation reducing both indicators to acceptable levels was selected. Baseline fat intake, baseline fruit and vegetable intake, and BMI were transformed using 1/original and log transformations respectively. There was one extreme outlier that was removed from change in weight pounds and BMI analyses because the value seemed unrealistic and skewed the results significantly.

After the appropriate transformations were applied, analyses were performed using T-Tests (PROC TTEST), Chi-Square (PROC FREQ/CHISQ), and Fisher's Exact (PROC FREQ/ FISHER) in cases when at least 25% of cell counts were less than 5 and therefore did not meet assumptions of Chi-Square tests. Mean and standard deviation and number and percent are reported for continuous and categorical variables respectively.

Multivariate Analyses

Multivariate analyses examined the relationship of food insecurity to eating behavior and weight-related outcome variables (Research Question 2). Specifically, separate multivariate regression analyses were used to examine each of the continuously measured target variables including: baseline fat intake (**Table 3**), baseline fruit and vegetable intake (**Table 4**), and baseline weight in pounds (**Table 5**). While only baseline

fruit and vegetable intake and baseline weight emerged as significantly different, we have included baseline fat intake, as well, to answer our theoretically driven research questions. Additionally, multivariate analyses were used to examine the relationships between change in fat intake, change in fruit and vegetable intake, and change in weight. Again, while these variables were not significant in baseline analyses, we have chosen to include these analyses and results to satisfy our original research question (Research Question 3).

Research Questions

For the first research question, "What demographic characteristics are associated with food insecurity?" chi-square tests and Fisher's Exact tests were used. The analyses compared the differences between food secure and food insecure individuals across treatment group, gender, race, marital status, education level, income, and additional household members.

The second research question, "What community, home, and individual factors are associated with food insecurity?" consisted of determining whether food security status was associated with various factors nested within levels of the socioecological model. Variables were selected from each level (community, home, and individual) and participants were compared based on food security status across the following variables: distance to grocery shopping, access to healthy food at stores, food affordability, food purchasing reasons, food available in home, weight status, BMI, fat intake, and fruit and vegetable intake eating behavior. To further explore the second research question, regression analyses were performed for baseline fruit and vegetable intake and baseline

BMI while controlling for gender, race, education level, additional household members, and treatment group.

For the third research question, "Does food insecurity predict eating behavior and weight changes over the course of a 6-week time period when controlling for treatment group and baseline characteristics?" three separate multivariate linear regression models were created. All regression models included the following covariates: gender, race, education level, additional household members, and treatment group. Gender and race/ethnicity were chosen from the literature reviewed in Chapter II. Level of education was chosen as a proxy for socioeconomic status. Education has been recognized as a stable and robust predictor of health outcomes (Winkleby, Jatulis, Frank, & Fortmann, 1992) and is typically answered more accurately and more fully than income questions (Matthews & Gallo, 2011). Income was excluded from the model to avoid collinearity. Number of additional household members was included in the regression because of the impact it has on financial security and household eating behavior as well as qualification for nutrition assistance benefits (Jilcott et al., 2011; USDA, 2012d). Additionally, all regression models controlled for treatment group since both comparison and intervention participants were included in the analyses.

The first regression model examined the relative contribution of food insecurity on change in fat intake; the second regression model examined the relative contribution of food insecurity on change in fruit and vegetable intake; and the third regression model examined the relative contribution of food insecurity on change in weight (in pounds). For all research questions, associations were considered significant if $p<.05$.

CHAPTER IV: RESULTS

Sample Characteristics

Table 1 provides demographic information on the participants included in the analyses. Out of the 119 participants, 102 (85.7%) were female. White (48.7%) and Non-White (all Black, except for one "other") (51.3%) were almost equally represented in the sample. The average age was 52.6 (*SD*=7.91) and ranged from 39 to 69. Seventy-two percent of participants were married (*n*=86) and an additional 7.6% percent were not married, but living with a partner. Just over half of the participants had attended some technical school, college, or earned a college or post-baccalaureate degree (57.1%) and the remaining portion had a high school education or less (42.9%). Household income ranged from less than $10,000 (9.7%) to more than $50,000 (43.0%), with a portion of the sample reporting at the middle categories between $10,0001 and $50,000 as well and five participants (4.2%) choosing not to answer. A large portion of individuals lived in households with just one other household member (40.3%), while many others lived in households with two (24.4%), three (25.2%), or even four or more household members (10.1%). Approximately one-fifth (19.33%; *n*=23) had experienced food insecurity in the past year.

Table 2 presents information on the community, home, and individual level factors related to eating behavior and weight in the sample. Distance to grocery shopping varied across the sample with several participants living within only a few blocks (*n*=28, 23.5%) while many others lived within 1-5 miles (*n*=40, 33.6%), 6-20 miles (*n*=35, 29.4%), and over 20 miles away (*n*=16, 13.5%). Access to healthy food at stores hovered

around an average of 2.0 or "disagree" with a standard deviation of approximately 1.0 for all categories with the exception of a good selection of low-fat foods, which had a standard deviation of 2.0. Food affordability was split, with almost half the sample (n= 55) feeling as though they could not afford healthy food. Every food purchasing reason was ranked as important to very important, with average scores falling between 4-5 for each—cost, taste, nutrition, weight control, and convenience. On average, families had 14.4 (SD=4.0) fruits and vegetables, 2.0 (SD=1.3) healthy snacks, and 5.2 (SD=2.0) unhealthy snacks in their homes. Eighty percent of the sample was obese (n=57) or overweight (n=36), and the average body mass index was 31.8 (SD=8.1). Baseline fat intake was 36.2 (SD=4.3) percent of total calories and baseline fruit and vegetable intake was 3.6 (SD=2.0) per day.

Baseline Sample Characteristics Associated with Food Security Status

Table 1 shows results of the research question "What demographic characteristics are associated with food insecurity?" Specifically, it presents differences between participants who were food secure and food insecure across demographic variables of interest. Results suggest there is a statistically significant association between participants' race and food security status χ^2 (1)=11.21, p=.001, with a larger proportion of food insecure individuals identifying as Non-Caucasians (n=19; 82.6%) than Caucasian (n=4; 17.4%). There is also a statistically significant association between participants' level of education and food security status χ^2(1)=18.40, p<.001, with more food insecure individuals indicating a high school education or less (n=19; 82.6%). In

comparison, two-thirds of food secure individuals had attended some college, obtained a college degree, or earned a graduate degree (n=64; 66.7%).

A statistically significant association was observed between income and food security status (Fisher's Exact p<.001), with the majority of food insecure individuals reporting household incomes below $25,000 ($n$=17; 77.3%), with almost half of those reporting household incomes less than $10,000 ($n$=7; 31.8%), while food secure individuals had incomes that skewed higher, and over half reported incomes of more than $50,000 per year ($n$=47; 51.1%). Additionally, a significant difference was observed between food secure and insecure individuals' household composition. In this sample, food insecure individuals were more likely to have a larger number of household members (Fisher's Exact p=.004) with 26.1% indicating they had four or more additional household members and 70.8% having either two or three additional household members. This is compared to only 6.3% of food secure individuals with four or more additional household members and only 46.9% with two or three additional household members. There were no differences observed for treatment group, $\chi^2(1)=1.06$, p=.304, gender $\chi^2(1)=0.036$, p=.850, age $t(117)=.04$, p=.969, or marital status $\chi^2(2)=2.05$, p=.358.

Table 1: Descriptive Statistics and Bivariate Analyses of Sample Characteristics

Demographic Variables	Total (*N*=119)		Food Secure (*n*=96)		Food Insecure (*n*=23)		
	n	**%**	***n***	**%**	***n***	**%**	***p***
Treatment Group							
Comparison	42	(35.3)	36	(37.5)	6	(26.1)	.304
Intervention	77	(64.7)	60	(62.5)	17	(73.9)	
Gender							
Male	17	(14.3)	14	(14.6)	3	(13.0)	.850
Female	102	(85.7)	82	(85.4)	20	(87.0)	
Race/Ethnicity							
White	58	(48.7)	54	(56.3)	4	(17.4)	.001
Non-White	61	(51.3)	42	(43.8)	19	(82.6)	
Age (Mean, SD)	52.6	(7.9)	52.6	(7.9)	52.5	(8.3)	.969
Marital Status							
Married	86	(72.3)	72	(75.0)	14	(60.9)	.359
Not married, but living with a partner	9	(7.6)	7	(7.3)	2	(8.7)	
Not married or living with partner	24	(20.2)	17	(17.7)	7	(30.4)	
Education Level							
High school or less	51	(42.9)	32	(33.3)	19	(82.6)	<.001
Some College or Graduate Degree	68	(57.1)	64	(66.7)	4	(17.4)	
Income							
Less than $10,000	11	(9.7)	4	(4.4)	7	(31.8)	<.001
$10,001-$25,000	22	(19.3)	12	(13.0)	10	(45.5)	
$25,001-$50,000	32	(28.1)	29	(31.5)	3	(13.6)	
More than $50,000	49	(43.0)	47	(51.1)	2	(9.1)	
Did not answer	5	(4.2)					
Additional Family Members							
One	48	(40.3)	45	(46.9)	3	(13.0)	.004
Two	29	(24.4)	22	(22.9)	7	(30.4)	
Three	30	(25.2)	23	(24.0)	7	(30.4)	
Four or more	12	(10.1)	6	(6.3)	6	(26.1)	

Community, Home, and Individual Factors Associated with Food Security Status

Table 2 answers the second research question: "What community, home, and individual factors are associated with food insecurity?" Specifically, the table shows the differences between food secure and food insecure individuals across community (distance to grocery shopping, access to healthy food at stores, food affordability), home (food purchasing reasons, food available in the home), and individual level factors (weight status, body mass index, fat intake, and fruit and vegetable intake).

Community Level Variables

Significant differences were observed in the ratings of the affordability of food $\chi^2(1)=33.17$, $p<.001$, with all of the individuals ($n=23$; 100%) who were food insecure indicating that they could not afford healthy food. In contrast, only one-third of food secure individuals ($n=32$; 33.3%) felt they could not afford healthy food.

However, there were no observed differences between food secure and insecure individuals on distance to food shopping $\chi^2(3)=.99$, $p=.803$, or access to healthy food at stores. Importantly, there was no difference in how easy it was to obtain fruits and vegetables $t(117)=-0.76$, $p=.452$, or the variety of fruits and vegetables available $t(117)=-0.37$, $p=.731$. Similarly, there was no difference in access to low fat foods $t(117)=-0.90$, $p=.368$, or the variety of low fat foods available $t(116)=-1.13$, $p=.259$.

Home Level Variables

There were no differences observed in the numbers of fruits and vegetables $t(117)=1.64$, $p=.104$, healthy snacks $t(117)=1.63$, $p=.107$, or unhealthy snacks $t(117)=0.53$, $p=.594$ in the homes of food secure and insecure individuals.

Individual Level Variables

Significant differences between food secure and insecure individuals were observed in the importance of the following food purchasing reasons: cost $t(95)=-6.91$, $p<.001$, weight control $t(52)=-3.48$, $p=.001$, and convenience $t(48)=-3.73$, $p<.001$. Notably, cost was rated consistently as "very important" by all food insecure participants ($M=5.0$, $SD=0.0$), while food secure participants rated it on average, between important and very important ($M=4.3$, $SD=1.0$). Weight control was, on average, more important among food insecure ($M=4.6$, $SD=0.7$) than food secure individuals ($M=3.9$, $SD=1.1$). Convenience also, on average, was ranked as more important among food insecure individuals ($M=4.7$, $SD=0.7$) than food secure individuals ($M=4.0$, $SD=1.0$). There were no significant differences in the importance of taste $t(117)=-0.40$, $p=.690$ or nutrition $t(26)=0.79$, $p=.438$.

Health Outcome Variables

There was a difference observed in eating behavior, specifically fruit and vegetable intake (with log transformation applied), between food secure and food insecure individuals at baseline $t(26)=2.93$, $p=.007$, with food insecure individuals

consuming fewer fruits and vegetables on average (*M*=2.5, *SD*=2.0) than food secure individuals (*M*=3.8, *SD*=1.9). There were no statistically significant differences in fat intake at baseline between the two groups $t(117)=1.29$, $p=.200$).

There were also significant differences in weight status between food secure and food insecure individuals (Fisher's Exact $p=0.011$), with food insecure individuals reporting weights that classified them as obese more often (*n*=16, 72.7%) than food secure individuals (*n*=41, 43.6%). This relationship was retained when comparing average BMI between groups $t(114)=-2.73$, $p=0.033$, with food insecure individuals reporting a significantly higher BMI on average (*M*=36.3, *SD*=11.0) than food secure individuals (*M*=30.8, *SD*=6.9).

Change in Health Outcome Variables

There were no significant differences in change in health outcome variables over the six-week time period between food secure and food insecure groups. Overall, change scores were minimal, with an average of -2.2 (*SD*=0.3) change in fat intake, +0.3 (*SD*=2.1) change in fruit and vegetable intake, and -2.7 (*SD*=9.7) change in weight in pounds for the whole sample. The magnitude of change was not significantly different between food secure (*n*=72) and food insecure (*n*=72) individuals during this period of time for fat intake $t(90)=1.05$, $p=.298$, fruit and vegetable intake $t(90)=-1.05$, $p=.297$, or weight in pounds $t(89)=1.67$, $p=.098$.

Table 2: Descriptive Statistics and Bivariate Analyses of Community, Home, and Individual Level Variables

Study Variables	Total (*N*=119)		Food Secure (*n*=96)		Food Insecure (*n*=23)		
	M **or *n***	**(*SD*) (%)**	***M*** **or *n***	**(*SD*) (%)**	***M*** **or *n***	**(*SD*) (%)**	***p***
Community Variables							
Distance to grocery shopping							
A few blocks away	28	(23.5)	22	(18.5)	6	(5.0)	.803
1-5 miles away	40	(33.6)	32	(26.9)	8	(6.7)	
6-20 miles away	35	(29.4)	30	(25.2)	5	(4.2)	
>20 miles away	16	(13.5)	12	(10.1)	4	(3.4)	
Access to healthy food at stores							
Easy to get fruits/vegetables	2.3	(1.3)	2.3	(1.3)	2.5	(1.4)	.452
Good selection of fruits/vegetables	2.1	(1.3)	2.1	(1.3)	2.2	(1.2)	.731
Easy to get low fat foods	2.6	(1.4)	2.5	(1.4)	2.8	(1.3)	.368
Good selection of low fat foods	2.3	(2.0)	2.2	(1.3)	2.6	(1.3)	.259
Food not affordable							
No	64	(53.8)	64	(66.7)	0	(0.0)	<.001
Yes	55	(46.2)	32	(33.3)	23	(100.0)	
Home Variables							
Food available in the home							
Fruits/vegetables in household	14.4	(4.0)	14.7	(3.9)	13.2	(4.5)	.104
Healthy snacks in household	2.0	(1.3)	2.1	(1.2)	1.6	(1.3)	.107
Unhealthy snacks in household	5.2	(2.0)	5.3	(2.0)	5.0	(2.0)	.594
Individual Variables							
Food purchasing reasons							
Cost	4.4	(1.0)	4.3	(1.0)	5.0	(0.0)	<.001[S]
Taste	4.7	(0.7)	4.7	(0.7)	4.8	(0.5)	.690
Nutrition	4.5	(0.8)	4.6	(0.7)	4.4	(1.1)	.438[S]
Weight Control	4.1	(1.1)	3.9	(1.1)	4.6	(0.7)	.001[S]
Convenience	4.2	(1.0)	4.0	(1.0)	4.7	(0.7)	<.001[S]
Weight Status							
Underweight	1	(0.9)	0	(0.0)	1	(4.6)	.011
Normal	22	(19.0)	20	(21.3)	2	(9.1)	
Overweight	36	(31.0)	33	(35.1)	3	(13.6)	
Obese	57	(49.1)	41	(43.6)	16	(72.7)	
Body Mass Index (kg/m2)	31.8	(8.1)	30.8	(6.9)	36.3	(11.0)	.033[S]
Eating Behavior							
Baseline fat intake	36.2	(4.3)	35.9	(3.8)	37.5	(6.0)	.200
Baseline fruit/vegetable intake	3.6	(2.0)	3.8	(1.9)	2.5	(2.0)	.007
Change in fat intake[R]	-2.2	(0.3)	-2.0	(4.0)	-3.1	(5.0)	.298
Change in fruit/vegetable intake[R]	0.3	(2.1)	0.2	(1.7)	0.8	(1.7)	.297
Change in weight (in pounds)[R]	-2.7	(9.7)	-1.8	(9.3)	-5.9	(10.4)	.098

S=Satterthwaite estimate used because of unequal variances
R=reduced sample size n=92 for fat intake and fruit and vegetable intake; n=91 for change in weight and BMI)

Examining Correlates of Baseline Fat Intake

Tables 3-5 further explore the relationships between food insecurity and health outcomes at baseline. **Table 3** presents the regression results for fat intake at baseline. The results of the regression indicated the predictors explained only 3.88% of the variance (R^2=.0388, F(6, 118)=0.75, p=.608). Results of the multivariate regression analysis indicate none of the predictors were significant in the model. The R^2 for this model is .0388, indicating that approximately 3.88% of the variance in fat intake can be explained by the predictors included. Notably, food insecurity was not significant when controlling for other covariates (β=1.34, p=.258).

Table 3: Regression Models Examining Correlates of Baseline Fat Intake

Variable	β	95% CI		*p*
Intercept	35.08	28.77	41.38	<.001
Food Insecurity	1.34	-1.00	3.69	.258
Treatment Group	0.81	-0.86	2.48	.339
Gender	0.77	-1.50	3.04	.501
Race	0.29	-1.42	1.98	.740
Education Level	-0.44	-2.21	1.32	.618
Additional Household Members	-0.26	-1.09	0.55	.524

Notes: R^2= .0388, (p=.608)

Examining Correlates of Baseline Fruit and Vegetable Intake

Table 4 displays the regression analysis results for fruit and vegetable intake at baseline. The results of the regression indicated the predictors explained approximately 13.7% of the variance (R^2=.137, F(6, 118)=2.97, p=.010). It was found that being female significantly predicted fruit and vegetable intake at baseline (β= 1.18, p=.020) when controlling for race, food insecurity, treatment group, and education level. Food insecurity was not significant at a p<.05 level, but results demonstrate a trend towards significance and may be considered marginally significant for both food insecurity (β=-.99, p=.061) and additional household members (β=-.36, p=.052).

Table 4: Regression Models Examining Correlates of Baseline Fruit and Vegetable Intake

Variable	β	95% CI		*p*
Intercept	2.15	-0.62	4.91	.128
Food Insecurity	-0.99	-2.01	0.04	.061
Treatment Group	-0.08	-0.82	0.65	.824
Gender	1.18	0.19	2.18	.020*
Race	0.17	-0.58	0.91	.658
Education Level	0.19	-0.58	0.96	.628
Additional Household Members	-0.36	-0.72	0.00	.052

Notes: R^2= .137, (p=.01)

Examining Correlates of Weight in Pounds at Baseline

Table 5 displays the regression results for weight in pounds at baseline. The results of the regression indicated the predictors explained 17.0% of the variance (R^2=.170, F(6, 116)=3.75, p=.002). It was found that gender significantly predicted weight at baseline (β= 26.60, p=.032), as did race (β= 21.09, p=.024) when controlling for food insecurity, treatment group, and education level. Based on the coding convention employed, results suggest that women had lower weights, on average, than men at baseline and that African American/Black participants were more likely weigh more than white participants when controlling for covariates. Food insecurity was not significant when controlling for other variables (β=9.80, p=.447).

Table 5: Regression Models Examining Correlates of Baseline Weight in Pounds

Variable	β	95% CI		*p*
Intercept	208.78	141.14	276.42	<.001
Food Insecurity	9.80	-15.66	35.25	.447
Treatment Group	8.93	-9.01	26.87	.326
Gender	-26.60	-50.92	-2.29	.032*
Race	21.09	2.80	39.39	.024*
Education Level	-12.90	-31.80	6.00	.179
Additional Household Members	5.18	-3.68	14.04	.249

Notes: R^2= .170, (p=.002)

Examining Correlates of Change in Fat Intake

Tables 6-8 present the findings for the third research question, "Does food insecurity predict eating behavior and weight changes over the course of a 6-week time period when controlling for treatment group and baseline characteristics?" For these regression analyses only those participants with data at both baseline and final follow-up were included (*N*=92). Of those 92, 72 (78.26%) were food secure and the remaining 20 (21.74%) were food insecure. Compared to the original sample (*N*=119), a large proportion (86.96%) of food insecure individuals provided data across time points compared to food secure individuals (75.00%).

Table 6 presents the results of the multiple regression analysis for change in fat intake. The results of the regression indicated the predictors explained 10.9% of the variance (R^2=.109, $F(6, 91)$=1.74, p=.122). It was found that additional household members predicted fat intake over time (β= .95, p=.035), suggesting that on average, the more household members one had, the higher the fat intake score. However, food insecurity did not predict change in fat intake (β=-1.30, p=.311).

Table 6: Regression Model Examining Correlates of Change in Fat Intake

Variable	β	95% CI		*p*
Intercept	-4.55	-11.41	2.32	.191
Food Insecurity	-1.30	-3.84	1.24	.311
Treatment Group	-1.41	-3.19	0.36	.117
Gender	0.69	-3.20	1.83	.590
Race	0.14	-1.73	2.02	.879
Education Level	1.01	-0.98	3.00	.317
Additional Household Members	0.95	0.07	1.84	.035*

Notes: R^2= .109, (p=.122)

Examining Correlates of Change in Fruit and Vegetable Intake

Table 7 displays the results of the multiple regression analysis used to examine correlates of change in fruit and vegetable intake. The results of the regression indicated the predictors explained 5.1% of the variance (R^2=.0508, F(6, 91)=0.76, p=.604). Importantly, it was found that food insecurity did not significantly predict change in fruit and vegetable intake when controlling for treatment group, gender, race, and education level (β= .42, p=.518).

Table 7: Regression Models Examining Correlates of Change in Fruit/Vegetable Intake

Variable	β	95% CI		*p*
Intercept	1.26	-2.22	4.74	.472
Food Insecurity	0.42	-0.87	1.71	.518
Treatment Group	0.63	-0.27	1.53	.168
Gender	-0.53	-1.80	0.75	.413
Race	-0.31	-1.26	0.64	.514
Education Level	-0.15	-1.16	0.86	.766
Additional Household Members	0.09	-0.35	0.54	.678

Notes: R^2= .051, (p=.604)

Examining Correlates of Change in Weight

Table 8 depicts the results of the regression analysis for change in weight. Results of the multiple regression analysis indicate that when controlling for food insecurity, treatment group, gender, race, and socioeconomic status, there were no statistically significant predictors for change in weight. The results of the regression indicate that predictors explained 4.2% of the overall variance (R^2=.042, F(6, 91)=0.63, p=.709). Notably, food insecurity did not significantly predict change in fruit and vegetable intake when controlling for treatment group, gender, race, and education level (β= -1.14, p=.804).

Table 8: Regression Models Examining Correlates of Change in Weight (Pounds)

Variable	β	95% CI		*p*-value
Intercept	-7.11	-31.69	17.47	.567
Food Insecurity	-1.14	-10.23	7.95	.804
Treatment Group	-3.11	-9.47	3.25	.333
Gender	0.72	-8.29	9.74	.873
Race	-3.01	-9.71	3.70	.375
Education Level	2.31	-4.83	9.44	.522
Additional Household Members	1.59	-1.58	4.76	.321

Notes: R^2= .042, (p= .709)

CHAPTER V: DISCUSSION

Summary

Food insecurity was associated with many of the eating behavior and weight variables in the bivariate analyses. This is important, particularly in this vulnerable population, since it confirms much of the previous work in this field and further validates that food insecurity and obesity are more of a concern for individuals from low-income and ethnically diverse populations.

For many years, the majority of weight management programs have been clinic based. Interventions have emphasized health education to increase knowledge related to eating and activity and complementary behavioral strategies. These intervention strategies have been largely successful when conducted in clinical settings with intensive designs; however, less is known about the potential for these evidence-based strategies in the community and how they might need to be tailored to meet the needs of the broader population (Amundson et al., 2009; Perri et al., 2008). In particular, since overweight and obesity disproportionately affect individuals of lower socioeconomic status (Kirkpatrick, 2012) and ethnic minority populations (Gordon-Larsen et al., 2003b; Kumanyika et al., 2012), it is important to know how interventions should be tailored to meet the needs of these groups (Kumanyika et al., 2002; Kumanyika et al., 2012).

Recent literature has identified associations between overweight status and food insecurity and highlighted food insecurity as a potential causal and maintaining factor of overweight and obesity, particularly for individuals of lower socioeconomic status (Alaimo et al., 2001; Dietz, 1995; Troy et al., 2011). Food insecurity has already been

examined in relation to overweight and obesity in a variety of cross-sectional studies; however, less is known about the way it may affect weight gain prevention behaviors longitudinally.

The current study serves three complementary purposes. First, it serves to identify the demographic characteristics associated with food insecurity in a community-based sample. Second, it seeks to identify the socioecological determinants associated with food insecurity, namely the community, home, and individual level/behavioral factors. Third, the study examines the relative contribution of food security status to change in eating behavior and weight, while controlling for treatment assignment and relevant covariates. Each of the factors examined has received attention in the literature, but has not been looked at in relation to food insecurity and more specifically, food insecurity within a weight gain prevention program.

Findings

The main findings from this study include that food insecure and food secure individuals differed on several factors that may be related to the development and maintenance of obesity and could affect success in weight gain prevention programs. Race, education level, household income, and additional family members in the household were significantly different between food secure and insecure participants. Overall, findings were consistent with the literature. Food insecure participants were more likely to be Non-White (Alaimo et al., 1998; Seligman et al., 2010; Townsend et al., 2001), have lower educational achievement (Alaimo et al., 1998; Laraia, Siega-Riz, Gundersen, & Dole, 2006; Seligman et al., 2010; Townsend et al., 2001), lower

household income (Laraia et al., 2006; Rose, 1999; Seligman et al., 2010; Townsend et al., 2001; Walker & Kawachi, 2012), and more additional family members (Townsend et al., 2001) than food secure participants. However, gender was not associated with food security status. This is contrary to many previous studies that found food insecurity and weight associations only among females (Gibson, 2003; Gooding et al., 2012; Townsend et al., 2001; Wilde & Peterman, 2006) and studies that have sought to explain this specific gender-food insecurity relationship in more detail (Ivers & Cullen, 2011; Olson, 2005). While anomalous, this study is not the first to find that gender and food insecurity are not associated (Walker & Kawachi, 2012) and our finding may be explained by an overrepresentation of females in the sample.

The study also found that food insecure participants were much more likely to be overweight or obese, even within a sample of participants self-selected to participate in a weight gain prevention program. This finding is consistent with much of the literature that recognizes a paradox in food scarcity and excess adiposity (Dietz, 1995; Koh et al., 2012) and confirms that the findings of large epidemiologic studies are also true of smaller samples, assuaging concerns of ecological fallacies. However, in regression analyses, food insecurity did not predict baseline weight, when controlling for covariates. Notably, the predictors only accounted for 17% of the model, which means there were most likely other variables not included that could have accounted for the differences in baseline weight.

Furthermore, our study found that food insecure participants were more likely to have lower fruit and vegetable intakes at baseline. This is consistent with some previous studies (Miewald et al., 2012; Robaina & Martin, 2012), but discrepant with others

(Mello et al., 2010), and is an issue that warrants further investigation. We did not find any differences in fat intake at baseline, which is not consistent with previous findings (Mello et al., 2010; Sharkey et al., 2012). This discrepancy might be explained by the measure used to assess fat intake, which estimated daily percent fat intake based on foods eaten over various periods of time (Williams et al., 2008) or perhaps relatively high levels of fat intake in the overall sample population.

Food insecurity and perceived affordability of health food

Additionally, food insecure individuals rated perceived healthy food as unaffordable more often than food secure individuals. Drewnowski (Drewnowski, 2004) has argued that high energy dense foods are cheaper per kilojoule of energy delivered compared to low energy. It is possible that food insecure individuals perceive a reality that healthy food is more expensive than unhealthy food. However, since we can assume they are shopping at grocery stores with similar pricing to food secure individuals, since parent study recruitment was conducted by county, it would seem that their perception of cost, which likely is linked to income and other socioeconomic factors, is different and contributes to the statistically significant difference in rating the affordability of healthy food.

Food insecurity and food purchasing decision-making

Food secure and insecure individuals were different in food purchasing reasons with the exception of taste, which was similarly important for both groups. The three differences that emerged in food purchasing reasons were cost, convenience, and weight

control. Food insecure individuals ranked each of these more important than food secure individuals in determining food-purchasing behavior. As expected, cost was ranked most highly by food insecure individuals. In fact, every single participant who was food insecure ranked cost as "very important" yielding no standard deviation at all. Epstein and colleagues have studied the relationship of food purchasing decisions and concluded that food purchasing decisions are highly price elastic (Epstein et al., 2007), a conclusion that is supported by our findings that cost was consistently ranked as "very important" by all food insecure individuals, but not food secure individuals.

Convenience was also more important for food insecure than food secure individuals. This is in contrast with previous work by Walker and colleagues (2012), which found the reasons for food purchasing decisions among food secure and insecure individuals were overall relatively similar, with "corner convenience" (close physical proximity to grocery stores) being a slightly more important factor among food secure individuals (Walker & Kawachi, 2012). Convenience could perhaps be explained by socioeconomic factors that may limit the amount of time an individual has to get food or perhaps their transportation or access to food shopping stores.

Purchasing food for weight control purposes also emerged as a statistically significant difference between food secure and insecure individuals, with food insecure individuals ranking it as significantly more important than food secure individuals. This is most likely explained as a result of their higher average BMI and weight status at baseline. To our knowledge, this is the first study to demonstrate a higher interest in purchasing foods for weight control among food insecure individuals. This finding is important as weight management interventions begin to be translated into community

settings. It demonstrates that, contrary to popular belief, food insecure individuals are even more highly concerned than food secure individuals about purchasing food for weight control reasons, and therefore, are likely to enroll in weight gain prevention programs. The implications of co-occurring food insecurity and obesity are further addressed in the section Implications and Recommendations.

Food insecurity and eating behavior

Importantly, fruit and vegetable intake at baseline was significantly higher for food secure individuals. This may be because fruits and vegetables are more expensive than higher energy density foods. No difference was observed for fat intake at baseline. These findings are in direct contrast to a study by Mello and colleagues (2010) that found food insecure individuals were more likely to consume both more fruits and vegetables and fat than food secure individuals (Mello et al., 2010). However, Mello et al. included juice in their fruit and vegetable count, whereas the measure used for the current study excluded them. In addition, authors of that study attributed differential fat intake to eating behaviors (like removing skin from chicken), a factor not examined in the current study.

Non-significant findings

Interestingly, there was no significant difference in distance to shopping or access to healthy foods, which were hypothesized as being important community level factors in determining eating behavior (A. A. Casey et al., 2008; Saelens et al., 2012; Sallis & Glanz, 2009) and food insecurity. The same was true for the home environment as food secure and food insecure individuals did not differ on the number of fruits and

vegetables, healthy snacks, or unhealthy snacks in the home, which have been well-cited as important influences on eating behavior (Campbell et al., 2006; Campbell et al., 2007; Ding et al., 2011; Story et al., 2008) and were hypothesized to be associated with feelings of food insecurity. It may be that the factors that influence healthy eating are distinct from those that influence food insecurity.

Finally, no significant relationships emerged as a result of the regression analyses that suggest food insecurity contributes to eating behavior or weight. Again, here we included the comparison group in the analyses to have a larger sample size; however, inclusion of this group likely limited the magnitude of change in each of the health outcome variables. Additionally, previous studies of food insecurity and eating behavior and weight have been conducted with much larger sample sizes with greater variance (Townsend et al., 2001). This may help explain, in part, why our findings were not representative of the associations expected based on the existing literature. Previous studies have also conducted logistic regression predicting weight status, which may contribute to differential findings (Gordon-Larsen et al., 2003b; Lohman, Stewart, Gundersen, Garasky, & Eisenmann, 2009; Pan et al., 2012; Townsend et al., 2001). However, it was the decision of the current team to examine weight as a continuous variable. This alternate methodology may have also contributed to our non-significant findings. The baseline regression analyses showed that when controlling covariates, gender emerged as a predictor of fruit and vegetable intake, and gender and race emerged as predictors of weight in pounds. For longitudinal regression analyses, no findings were significant, except that change in fat intake was associated with the number of additional household members. This finding could also be related to the income per household and

cost of food, as stated earlier, higher energy density and higher fat foods are more competitively priced (Drewnowski, 2004) and could explain the observed relationship between increase in fat intake and number of household members.

Food insecurity was not a predictor of change in fat intake, fruit and vegetable intake, or weight when controlling for treatment group and covariates of interest. This is likely the result of several factors. Firstly, only small changes in behavior and weight were observed for the parent study (Kegler et al., 2012). Secondly, the sample size was very small and due to attrition at the follow-up time period, the sample was further restricted, perhaps making it difficult to detect intergroup differences in regression analyses. Thirdly, we included the comparison group in the analyses to have a larger sample size; however, inclusion of this group likely limited the magnitude of change in each of the health outcome variables. Finally, in comparison to previous studies exploring relationships between factors implicated in obesity and eating behavior and weight change, the current study is conducted with a much smaller sample and over a shorter period of time than others (Miewald et al., 2012; Teixeira et al., 2004; West et al., 2008; Wilde & Peterman, 2006), which is likely to limit the significance of findings. Finally, these non-significant regression findings indicate that food insecure individuals were able to achieve a similar (albeit small) amount of success in program objectives, supporting the inclusion of this subsample in future studies and programs.

Limitations

As a secondary data analysis, this study is subject to several limitations. The first is the small sample size from which the current sample is drawn. The small sample size

limits the significance of findings particularly in regression analyses with forced entry of control variables. To expand the sample size both intervention and control were included in analyses, but even so, longitudinal analyses included a small sample (*N*=92). A second limitation is the small magnitude of change for each outcome variable. Because the program is a low-intensity community based intervention there were not many changes in behavior or weight. The six-week intervention was a pilot study and was only half the duration of typical weight management programs. Additionally, we chose to include the comparison group so we could have a larger sample. As a result, observed changes were relatively small when compared to other eating behavior and weight interventions (Amundson et al., 2009; West et al., 2008; Wing & Hill, 2001). Such a small magnitude in change makes it difficult to predict variability in the sample. These limitations in combination with one another reduce our ability to detect significant changes in the regression models; however this does not mean that groups did not differ in terms of success in the program.

Thirdly, as in many studies of this nature, all data collected were self-report and as a result are subject to social desirability and recall bias. In particular, this may have led to underreporting of food insecurity and weight, as it has been previously shown that they may be underreported in community samples (Lyons, Park, & Nelson, 2008).

Fourthly, the measurement of food insecurity itself may have been improved by asking a more nuanced set of questions. The question used in the current study was: "Have you ever run out of food in the last 12 months because you could not afford to buy more? Yes or no?" The depth of the analyses is, in part, limited by the parsimony of the question. Running out of food is typically considered to be at the high threshold of food

insecurity and it is possible that by asking about such an extreme level, we missed capturing more subtle, yet still important, experiences of food insecurity in our sample.

There is still much work to be done in measuring food insecurity, as measurement is inconsistent and somewhat flawed (Webb et al., 2006). We see the measurement of food insecurity as a limitation as not only germane to the current study, but also to the field as a whole. Due to the limitations of the one-item question, it is possible that the prevalence of food insecurity in the current sample may have been underestimated. Furthermore, a more comprehensive measure might have asked a variety of questions and used individual items to generate a mean score that would have placed individuals on a continuum of food insecurity. Again, the parsimony of the question is somewhat limiting, but is likely to reduce the potential for false positives yielding a high specificity.

Notably, there were other measurement issues that limited the current study. There was no measurement of food assistance in the parent study. Several of the articles referenced for the literature review have examined the role that national food assistance programs have on food insecurity and obesity. While income may serve as an indicator of program eligibility, information about enrollment in programs could not be obtained without asking the question directly. As a result, we do not know what percentage of study participants were enrolled in a federal food assistance program. Additionally, there was no measurement of income per household member. Income was collected as non-equal ranges and household members as discrete numbers. We discussed creating our own variable; however, there was no theoretical support for such manipulation. As a result, income and household members had to be analyzed separately, although the literature suggests there is likely a close association between the two in determining food

insecurity. We also did not have a measure of binge eating in the parent study so binge eating could not be explored as a potential mediator between food insecurity and eating behavior and weight outcomes in the current study. Based on the literature, this might have been an important question as it has been suggested that low food environments promote overeating when food is available, which contributes to weight gain because of caloric excess and metabolic changes (Dietz, 1995). Finally, most items were taken from valid and reliable surveys, but had not been tested independently, so there was limited information for the validity and reliability of individual items used.

Delimitations

The study sample was delimited to individuals belonging to Cook, Randolph, and Mitchell Counties of Georgia. These participants were actively enrolled in a study intended to prevent weight gain, which may limit the generalizability of the findings from being applied to naturalistic community settings. However, due to the community-based participatory research framework of the parent study, the current study is well positioned to be relevant to other community samples. Research questions and analyses were limited to baseline only for bivariate associations and to only three change outcome variables for regression analyses. There are equally as interesting questions to ask about the relationships between the various constructs across time points; however, the current study is purposefully delimited to baseline and three weight-related change outcome variables to manage size and scope.

Implications and Recommendations

Recommendations for practice

When devising weight gain prevention programs for low-income individuals, it is important to consider food insecurity as a factor in developing the curriculum or intervention. In the current community-based sample, 19.3% (*n*=23) reported food insecurity at baseline. This proportion is substantial and warrants attention for future community-based weight gain prevention programs.

One suggestion is to have educational components of interventions provide information about food insecurity as well as strategies for low-cost meal preparation and shopping on a budget for a family. Since food insecurity was significantly more prevalent in larger families, the latter suggestion could incorporate information about the cost-effectiveness of buying bulk dry goods as well as tips for proper food storage to avoid spoilage. Incorporating innovative intervention strategies that address food insecurity may enhance the quality of weight management programs and improve nutrition and weight outcomes and the community of interest.

Secondly, there may be ways to engage community stakeholders to address issues of food security in collaboration with already existing initiatives. The sample for the current study was drawn from a parent study that incorporated community-based participatory research methods. To further advance the food insecurity agenda, the community advisory board might want to consider finding resources in the community that can provide families with affordable healthy foods like fruits and vegetables through programs with local farmer's markets or grocery stores.

Finally, as a public health practice community, we need to acknowledge food insecurity remains a structural health problem. Food insecurity and prevention efforts should assess the needs of the community and access to affordable healthy foods before targeting behavioral strategies to reduce weight gain. While we found no significant differences on outcome measures of change in fat intake, fruit and vegetable intake, and weight, these results need to be interpreted cautiously. The literature still strongly suggests that traditional behavioral weight loss strategies may not be as appropriate for individuals who feel as though they do not have sufficient food. Access to affordable healthy foods needs to become a top agenda item for community advocacy and local policy. The benefits of healthy and affordable food extend far beyond maintaining a healthy weight and can directly improve health outcomes and reduce risk for chronic disease (Seligman et al., 2010; Slavin & Lloyd, 2012).

Recommendations for research

The current study identified important relationships between food insecurity, eating behavior, obesity and weight management; however, our work only begins to expose the complexity of the relationships that exist. Currently, there is a paucity of theoretical frameworks from which to develop theory-driven research studies. Future studies should both test existing frameworks as well as create new conceptual models. We propose one model of food insecurity that highlights various levels of the socioecological model that may be helpful in informing future research; however, more comprehensive models are needed. One method of designing a thorough conceptual model would be to conduct qualitative research or other inductive studies elucidate all

factors associated with obesity and food insecurity at various levels of the socioecological model and then use those findings to inform a comprehensive conceptual model.

Secondly, additional research should be aimed at developing evidence-based strategies for targeting food insecurity within weight management interventions. This may mean including a session on proper and safe storage of leftover food to extend one meal into several. As an example, instead of having grilled chicken, rice, vegetables, and beans at one meal, this could be split into two meals: one of grilled chicken and rice and one of rice, vegetables, and beans, so that no food goes wasted. This type of "meal-splitting" is foundational to portion control, which is already an important part of weight management interventions, and should be easily integrated into existing interventions. In addition, eating smaller meals more frequently is likely to improve metabolism, reduce feelings of deprivation, reduce the likelihood of overeating and help with weight maintenance (Wing & Hill, 2001). Testing the effectiveness of these modules could help inform future intervention efforts. While these considerations were outside of the scope of the current study and the parent study, it seems important to consider in future interventions, particularly for community-based study samples comprised of low-income individuals.

Finally, although community level variables were not significant in the current study, additional studies are needed at the community level. As stated in the practice recommendations, food insecurity is not an individual problem and while the struggles are felt at an individual or home level, they are related to larger community and contextual factors. Individual level strategies may be helpful, but are likely to have a much greater impact if nested within larger community studies. Importantly, the goal of

these interventions would extend beyond providing physical access and cover issues related to cost. These community-level studies may choose to subsidize the costs of fruits and vegetables in existing markets or create new food shopping outlets that offer healthy foods at a low cost. This could include building a local farmer's market or community supported agriculture as their intervention target to alleviate symptoms of food insecurity. An interrupted time series design could be used to assess the impact of such a community level change on eating behavior and weight. Such studies can be used to inform sustainable community based interventions to alleviate food insecurity and obesity. Additionally, if effective, these studies may provide the evidence needed to encourage policy makers to reconsider the current food pricing structures to instead emphasize affordable fruits and vegetables.

Conclusions

Over the past several decades our knowledge of nutrition, weight management, and healthy eating behaviors has increased exponentially. As overweight and obesity persist as major contributors to chronic disease, there is a need to extend beyond previously established proximal causes of weight-related behavior and look at more distal determinants of these behaviors. Results from large, nationally representative data seem inconclusive as about how to proceed in understanding the relationship between food insecurity and obesity. To our knowledge, this study is the only one that investigates the relationship between food insecurity, socioecological determinants at multiple levels, and eating behavior and weight outcomes to help explain the relationship between food insecurity and obesity.

Supporting previous research, variables that serve as proxy to socioeconomic status (income, education, etc.) and race were found to be associated with food insecurity as was cost of food, perceived affordability, and convenience. Fruit and vegetable intake was also lower among food insecure individuals at baseline, a finding that is consistent with some studies (Miewald et al., 2012; Robaina & Martin, 2012), but discrepant with others (Mello et al., 2010). This is important not only because fruits and vegetables have been repeatedly demonstrated to help maintain weight (Rolls, 2009), but also because they provide several important nutrients that independently contribute to immune health and overall wellness (Slavin & Lloyd, 2012). To our knowledge, the current study was the first to find food insecure individuals to be more concerned with purchasing foods to control weight and to find that the number of household members predicts change in fat intake over the course of a weight gain prevention program. Further research is needed to determine if incorporating these concepts into comprehensive community and individual-level interventions can significantly impact food insecurity and weight status.

In summation, identifying and targeting factors at multiple levels of the socioecological model is likely to be more helpful in understanding and changing weight-related outcomes than focusing on individual level behaviors alone. Future research and practice should continue to look for factors at the community level that are associated with food insecurity and work on improving access to affordable, healthy food.

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