The Association between Household Food Security and Metabolic Syndrome Among U.S. Children

A thesis presented to
the faculty of
the College of Health Sciences and Professions of Ohio University

In partial fulfillment
of the requirements for the degree
Master of Science

Yu Wang
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This thesis titled
The Association between Household Food Security and Metabolic Syndrome Among
U.S. Children

by

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the School of Applied Health Sciences and Wellness
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David H. Holben
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ABSTRACT

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The purpose of this study was to assess differences across household food security levels in obesity, central adiposity, and metabolic syndrome among children 12 to 18 years of age. Data for 7,435 adolescents between the ages of 12-18 years were downloaded from the National Health and Nutrition Examination Survey (NHANES) 1999-2006. Food security status was assessed using the USDA food security Survey Module. Body mass index (BMI) data were classified into CDC weight categories, and central adiposity was identified based on the International Diabetes Federation (IDF) cut-off for the 90th percentile. Differences were assessed using analysis of covariance and logistic regression, controlling for age, gender, and race. Nearly two-thirds (75.9%, n = 5,643) of the sample were from high food secure (HFS) households, while 7.1% (n = 528), 10.8% (n = 803) and 6.1% (n = 454) were from households that were marginally food secure (MFS), low food secure (LFS) and very-low food secure (VLFS), respectively. There were no significant differences in mean BMI-for-age percentiles by food security status (p = 0.087); however, MFS (44%, Odds Ratio: 1.44 [1.12-1.87]) and LFS (44.0%, Odds Ratio: 1.44 [1.13-1.84]) were significantly more likely to present with a BMI >85th percentile than HFS households. Adolescents from HFS households had significantly lower mean central obesity than those from MFS and LFS households (p <
MFS (52%, Odds Ratio: 1.52 [1.08-2.15]), LFS (42.0%, Odds Ratio: 1.42 [1.11-1.80]) and VLFS (51%, Odds Ratio: 1.51 [1.10-2.08]) were significantly more likely to present with central adiposity than those from HFS households. Only those from HFS households had significantly higher HDL than children from LFS households in our study (\( p = 0.019 \)). There were no significant differences in blood glucose, triglyceride, LDL, systolic blood pressure, diastolic blood pressure, and total cholesterol by food security category. Food insecurity appears to be a risk factor for central obesity and is associated with low HDL levels among U.S. children.

Approved: 

David H. Holben

Professor of Nutrition
ACKNOWLEDGMENTS

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I would like to thank my advisor, Professor David H. Holben, for his great help on my study. Without his guidance and support, I do not think I could have finished my thesis. Dr. Holben is a great advisor and expert in food security. His teaching has prepared me for my future career. Great thanks are also given to my thesis reader, Professor Christopher A. Taylor. Dr. Taylor has experience investigating dietary habits and risk for chronic disease using national nutritional nutrition monitoring data sets, such as the Continuing Survey of Food Intakes by Individuals and the National Health and Nutrition Examination Survey.

I also want to thank Ohio University, which gave me the chance to study and work to get my Master’s degree. This is a very important milestone in my career. I hope I can do something for Ohio University in the future. Also, I would like to thank all the faculty members who have helped me in the past 2 years.
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</tr>
</thead>
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<td>60</td>
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</tbody>
</table>
CHAPTER 1: INTRODUCTION

Extreme forms of food insecurity, which are commonly found in third-world countries, have been virtually eliminated in the United States (Bickel, Nord, Price, Hamilton, & Cook, 2000). However, food insecurity and deprivation in basic need for food, still exists in the United States and remains a cause for concern (Bickel et al., 2000). Definitions of food security, food insecurity, and hunger are shown in Table 1.

Table 1

*Definitions of Food Security and Related Terms*

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Security</td>
<td>“Access by all people at all times to enough food for an active, healthy life. Food security includes at a minimum: (1) the ready availability of nutritionally adequate and safe foods, and (2) an assured ability to acquire acceptable foods in socially acceptable ways (e.g., without resorting to emergency food supplies, scavenging, stealing, or other coping strategies).” (Anderson, 1990, p. 1560)</td>
</tr>
<tr>
<td>Food Insecurity</td>
<td>“Limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways.” (Anderson, 1990, p. 1560)</td>
</tr>
<tr>
<td>Hunger</td>
<td>“Uneasy or painful sensation caused by a lack of food. The recurrent and involuntary lack of access to food. Hunger may produce malnutrition over time.... Hunger ... is a potential, although not necessary, consequence of food insecurity.” (Anderson, 1990, p. 1560)</td>
</tr>
</tbody>
</table>
The most recent national estimates of household food security of the U.S. indicated that 14.6% (17 million households) of U.S. households were food insecure at some time during 2008 (Nord, Andrews, & Carlson, 2009). The remaining 85.4% of U.S. households were food secure throughout the year (Nord et al., 2009). Increasing from 11.1% (13 million households) in 2007, the prevalence of food insecurity in 2008 was the highest observed since nationally representative food security surveys were initiated in 1995 (Nord et al., 2009). Of all U.S. households, 8.9% (11.3 million) had low food security, and 5.7% (6.7 million) had very low food security during 2008 (Nord et al., 2009). Further, 17.9% of households with children were food insecure, compared with 11.3% for households without children (Nord et al., 2009). Among households with children, married-couple families had the lowest rate of food insecurity (14.3%) in 2008 (Nord et al., 2009). In about half of those food insecure households with children, only adults were food insecure (Nord, 2009). The prevalence of very low food security among children increased from 0.8% of households with children in 2007 to 1.3% in 2008 (Nord et al., 2009).

Food insecurity can impact both nutritional and nonnutritional outcomes in adults and children (Bhattacharya, Currie, & Haider, 2004). It can have serious impacts on health, such as physical impairments related to insufficient food (illness and fatigue), psychological issues caused by lack of access to food (feelings of constraints to go against held norms and values; stress at home), and sociofamilial disturbances (modification of eating patterns and related ritual; distortion of the means of food acquisition and management) (Hamelin, Habicht, & Beaudry, 1999). For U.S. children,
several studies have examined food security and chronic diseases such as obesity and overweight. In fact, food insecurity has been shown to be positively related to children’s overweight and obesity in several studies (Casey et al., 2006; Gulliford, Nunes, & Rock, 2006; Holben & Pheley, 2006; Olson, Bove, & Miller, 2007; Wilde & Peterman, 2006). Casey et al. (2006) found that risk for child overweight is associated with familial low income. To that end, childhood poverty may result in adult obesity, due to food deprivation in childhood, which may lead to inappropriate attitudes and behaviors towards food (Olson et al., 2007). However, in other studies, food insecurity and overweight/obesity were not significantly related in children (Gundersen, Lohman, Eisenmann, Garasky, & Stewart, 2008; Gundersen, Lohman, Garasky, Stewart, & Eisenmann, 2008; Martin & Ferris, 2007; Whitaker & Sarin, 2007). Martin and Ferris (2007) found that food insecure adults were significantly more likely to be obese, but food insecurity did not increase the chance of childhood overweight. The likelihood or risk of being overweight was not significantly different for food secure and food insecure children (Gundersen, Lohman, Eisenmann et al., 2008). Finally, Dinour, Bergen, and Yeh (2007) argued that the relationship between food insecurity and overweight is uncertain.

While our understanding of the causes of obesity is not clear, data from the National Health and Examination Surveys show that the prevalence rates of obesity for all age groups have increased dramatically (Ogden & Carroll, 2010). Among preschool-aged children, aged 2–5 years, the prevalence of overweight increased from 5.0% to 12.4% (Ogden et al., 2006; Ogden, Carroll, & Flegal, 2008). Among school-aged children, 6–11
years, the prevalence of overweight increased from 4.0% to 17.0% (Ogden et al., 2006; Ogden et al., 2008). Among school-aged adolescents, aged 12–19 years, the prevalence of overweight increased from 6.1% to 17.6% (Ogden et al., 2006; Ogden et al., 2008). One of seven low-income, preschool-aged children is reported obese (CDC, 2009a). The prevalence of obesity in low-income 2-to-4 year old children increased from 12.4% in 1998 to 14.5% in 2003 and remained almost the same in 2008 (14.6%; CDC, 2009a). The U.S. has made little progress in reducing obesity, and those prevalence figures are more than three times the target prevalence of 5% set in Healthy People 2010 (Ogden & Carroll, 2010). In Healthy People 2020, the proportion of children and adolescents who are overweight or obese is also aimed to be reduced (Department of Health and Human Services, 2010).

Reducing the prevalence of obesity is vital, because it can contribute to negative health outcomes. Obesity in children and adolescents is associated with an increase in cardiovascular risk factors, including hypertension, dyslipidemia, and elevated insulin levels (Anderson, 1990; Burke et al., 2005; Urakami et al., 2005). The clustering of hypertension, dyslipidemia, and impaired glucose tolerance can be summarized as the metabolic syndrome (Reaven, 1991). Development of features of metabolic syndrome, which may start much earlier in life than previously supposed and can be affected by both pre- and postnatal environmental and genetic variations, as well as their interactions (Alberti et al., 2007). The definition of metabolic syndrome in pediatrics has been debated for many years. The existing International Diabetes Federation (IDF) criteria for metabolic syndrome in children and adolescents are used universally for the early
diagnosis of metabolic syndrome (Alberti et al., 2007). According to the IDF criteria, metabolic syndrome can be defined differently by age (Alberti et al., 2007). For children age 10 years or older, metabolic syndrome can be diagnosed with the presence of abdominal obesity and two or more other clinical features, including elevated triglycerides, low HDL-cholesterol, high blood pressure, and increased plasma glucose. The IDF adult criteria can be used for children older than 16 years (Alberti et al., 2007).

The links among obesity, type 2 diabetes, and metabolic syndrome have already been characterized in adult populations (Alberti, Zimmet, & Shaw, 2006). The relationship between obesity and type 2 diabetes was demonstrated in a study from Japan, where a parallel increase in type 2 diabetes and obesity in children has occurred over the past few decades (Urakami et al., 2005). Obesity, especially central (abdominal) obesity, has been identified as an important predisposing cause for type 2 diabetes, as well as cardiovascular disease (Burke et al., 2005). It is essential to note that metabolic syndrome in children is irrevocably linked to obesity (Calcaterra et al., 2008; Rappaport, 2007; Weiss et al., 2004). Therefore, to delay or prevent the development of overt disease, it is important to identify groups at risk of metabolic disorders before clinical manifestations emerge (Alberti et al., 2007). Early detection and treatment is likely to reduce morbidity and mortality in adulthood and help keep to a minimum the global burden of cardiovascular disease and type 2 diabetes mellitus (Alberti et al., 2007). Due to the increasing problem of obesity in children and adolescents, as well as links among obesity, risk factors for cardiovascular disease and for type 2 diabetes, metabolic syndrome needs to be systematically examined (Ice, Murphy, Minor, & Neal, 2009).
Finally, despite the relationship of food insecurity and negative health outcomes, no studies have explored the association between food insecurity and metabolic syndrome among children and adolescents in the U.S. If we could identify that food insecurity is positively related to metabolic syndrome among children and adolescents, corresponding early detection and treatment can lead to a greater awareness to assess those at risk.

Study Objectives, Research Questions, and Research Hypotheses

The overall objective of this study was to examine the association between household food security status and prevalence of metabolic syndrome among U.S. children 12-18 years of age using data from the National Health and Nutrition Examination Survey (NHANES) 1999–2006. The specific research questions and hypotheses for this study are listed in Table 2.

Table 2

Research Questions and Hypotheses

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is the difference in obesity by food security status among children age</td>
<td>There will be a significant difference in obesity by food insecurity in</td>
</tr>
<tr>
<td>from 12 to 18 years?</td>
<td>children from 12 to 18 years old.</td>
</tr>
<tr>
<td>2. What is the difference in central obesity by food security status among children age from 12 to 18 years?</td>
<td>There will be a significant difference in central adiposity by food insecurity in children from 12 to 18 years old.</td>
</tr>
<tr>
<td>3. What is the difference in metabolic syndrome by food security status among children age from 12 to 18 years?</td>
<td>There will be a significant difference in metabolic syndrome by food insecurity in children from 12 to 18 years old.</td>
</tr>
</tbody>
</table>
Table 2 (continued).

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. What is the difference in markers of chronic diseases by food security status among children age from 12 to 18 years?</td>
<td>There will be a significant difference in markers of chronic diseases by food insecurity in children from 12 to 18 years old.</td>
</tr>
</tbody>
</table>

Limitations

This study had several limitations, as noted below.

1. The assessment of cross-sectional data cannot represent a causal relationship. Data represent participant characteristics from a snapshot in time.

2. Some data from cross-sectional surveys are self-reported, and inherent self-reporting and recall bias may have occurred.

3. Some laboratory values for makers of chronic diseases were not collected following an ideal 8-12 hour fast. This will limit the ability to precisely detect the presence of risk, but non-fasting data were carefully assessed to provide conservative estimates of disease risk.

4. Data availability limited the analyses in this study, and this cannot control for all moderating variables in obesity and overall health status.
CHAPTER 2: REVIEW OF LITERATURE

Food Security, Food Insecurity, and Hunger

*Definitions*

Extreme forms of food insecurity, which are commonly found in developing countries, have been virtually eliminated in the United States (Bickel et al., 2000). However, having insufficient resources to obtain food has been a longstanding challenge to U.S. health, nutrition, and social policy (Bickel et al., 2000). Deprivation in basic needs for food, food insecurity, still exists in the United States and remains a cause for concern (Bickel et al., 2000). Conceptual definitions of food security, food insecurity, and hunger were published in 1990 by the Life Sciences Research Office (LSRO) of the Federation of American Societies for Experimental Biology (Anderson, 1990) and were previously summarized in Table 1.

While physical feelings of hunger can occur in a lot of situations, such as dieting and being too busy to eat, food insecurity and hunger due to not having enough food or money to buy food results from financial resource constraints (Bickel et al., 2000).

Hunger has typically and historically been used not only to refer to the physical sensation, but also to a feeling of weakness from not eating (Panel to Review U.S Department of Agriculture's Measurement of Food Insecurity and Hunger, National Research Council, 2006). *Malnutrition* is defined as a condition brought about by insufficient intake of nutrients to meet biological requirements (Panel to Review U.S Department of Agriculture's Measurement of Food Insecurity and Hunger, National Research Council, 2006). Generally the prefix *mal* refers to both over- and underintake.
However, the typical usage of malnutrition based on the bulk of research recently has been directed to understanding inadequate intakes of macro- and micronutrients (Panel to Review U.S Department of Agriculture's Measurement of Food Insecurity and Hunger, National Research Council, 2006). Hunger and malnutrition are potential, although not necessary, consequences of food insecurity (Panel to Review U.S Department of Agriculture's Measurement of Food Insecurity and Hunger, National Research Council, 2006).

Holben (2010) listed a variety of concepts of hunger from different sources. The National Research Council (2006) categorized these concepts into the following four aspects with regard to the definition of hunger: “(1) a motivational drive, need, or craving for food; (2) an uneasy sensation felt when one has not eaten for some time; (3) discomfort, illness, weakness, or pain caused by a prolonged, involuntary lack of food; and (4) the prolonged, involuntary lack of food itself.”

The first and second aspects are not the concerns of the Household Food Security Survey Module (HFSSM) because they indicate a natural phenomenon that all human beings experience regularly (National Research Council, 2006). The fourth is also not useful because it indicates the problem of food insecurity itself (National Research Council, 2006). The third indicates the outcome of food insecurity, which results from a prolonged, involuntary lack of food caused by limited economic resources (National Research Council, 2006). The National Research Council (2006) asserted that the third aspect gives a beginning consideration about what is planned for the HFSSM.
Overview of Food Security Measurement Project

At present, many tools exist to classify the severity of food insecurity caused by income limitations, according to conditions experienced and reported by American households (Bickel et al., 2000). Basing itself on earlier research and working in close collaboration with private-sector experts and the U.S. Census Bureau, a federal interagency working group, the Food Security Measurement Project, was founded in 1992 (Bickel et al., 2000).

Under the leadership of the Food and Nutrition Service (FNS) and Economic Research Service (ERS) of the U.S. Department of Agriculture (USDA), Centers for Disease Control and Prevention (CDC), and National Center for Health Statistics (NCHS) of the U.S. Department of Health and Human Services (DHHS), the project is a cooperative undertaking of federal government agencies and private sector experts (Bickel et al., 2000). The first Food Security Supplement to the Current Population Survey (CPS) was implemented by the U.S. Census Bureau in 1995 (Bickel et al., 2000). The CPS Food Security Supplement, the Food Security Survey Module (FSSM), is thought to be a cornerstone of the Food Security Measurement Project (Bickel et al., 2000), and has been conducted annually since 1995 (CPS, 2010).

Food Security Measurement

Food insecurity is a complex, multidimensional phenomenon that progresses through a series of successive stages (Bickel et al., 2000). The FSSM measures the full range of severity with which the situation of food insecurity is experienced in U.S. and is captured and distinguished by its multiple indicator questions (Bickel et al., 2000). The
18-item FSSM has been shown to be a stable, robust, and reliable measurement tool for evaluating the prevalence of food insecurity among U.S. households (Bickel et al., 2000). An essential strength of this measurement is that data from the FSSM are also accessible from several specialized national surveys, such as the 4th National Health and Nutrition Examination Survey (NHANES-4) conducted by DHHS (see Appendix A; Bickel et al., 2000).

The FSSM was developed through work by Radimer, Olson, and Campbell (1990), who conducted a two-phase research project in order to develop indicators to monitor and assess the extent of hunger. The first phase of their work included interviews of 32 women about their experience with hunger using qualitative methods so as to derive a socially appropriate definition of hunger (Radimer et al., 1990). The second phase was surveys of 189 women who attended food assistance programs and confirmed the conceptualization of hunger developed in the first phase (Radimer et al., 1990). The research identified a subset of items that represented each of the major dimensions and components of hunger as being useful for monitoring and assessing hunger (Radimer et al., 1990).

The conceptualization of hunger is proposed, as shown in Table 3, based upon the interviewed women's descriptions of the hunger experience (Radimer et al., 1990). There are two dimensions to hunger (household and individual) and four components to each of these dimensions (Radimer et al., 1990).
Table 3

*Dimensions and Components of a Conceptual Definition of Hunger*

<table>
<thead>
<tr>
<th>Component</th>
<th>Household</th>
<th>Individual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity</td>
<td>Food depletion</td>
<td>Insufficient intake</td>
</tr>
<tr>
<td>Quality</td>
<td>Unsuitable food</td>
<td>Inadequate diet</td>
</tr>
<tr>
<td>Psychological</td>
<td>Food anxiety</td>
<td>Feeling deprived, lack of choice</td>
</tr>
<tr>
<td>Social</td>
<td>Unacceptable means of food acquisition</td>
<td>Disrupted eating pattern</td>
</tr>
</tbody>
</table>


The items in Table 4 were originally recommended as indicators to measure and assess hunger. Items that could cause confusion or misunderstanding, or didn't assess a component properly, were not included (Radimer et al., 1990). Similar dimensions resulted from the survey analysis as those derived from the first phase of the research (Radimer et al., 1990).
Table 4

*Indicators for Development of a Hunger Assessment Measure by Category*

<table>
<thead>
<tr>
<th>Household hunger</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Do you worry whether your food will run out before you get money to buy more?</td>
<td></td>
</tr>
<tr>
<td>2. The food that I bought just didn't last, and I didn't have money to get more.</td>
<td></td>
</tr>
<tr>
<td>3. I ran out of the foods that I needed to put together a meal and I didn't have money to get more food.</td>
<td></td>
</tr>
<tr>
<td>4. I worry about where the next day's food is going to come from.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Women's hunger</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I can't afford to eat the way I should.</td>
<td></td>
</tr>
<tr>
<td>2. Can you afford to eat properly?</td>
<td></td>
</tr>
<tr>
<td>3. How often are you hungry, but you don't eat because you can't afford enough food?</td>
<td></td>
</tr>
<tr>
<td>4. Do you eat less than you think you should because you don't have enough money for food?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Children's hunger</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I cannot give my child(ren) a balanced meal because I can't afford that.</td>
<td></td>
</tr>
<tr>
<td>2. I cannot afford to feed my child(ren) the way I think I should.</td>
<td></td>
</tr>
<tr>
<td>3. My child(ren) is/are not eating enough because I just can't afford enough food.</td>
<td></td>
</tr>
<tr>
<td>4. I know my child(ren) is/are hungry sometimes, but I just can't afford more food.</td>
<td></td>
</tr>
</tbody>
</table>


From the seminal work by Radimer et al. (1990), the current measure was developed. The 18-item HFSSM is intended to measure the experience of food insecurity.
over a 12-month period (Bickel et al., 2000). Questions in the HFSSM are presented in Appendix A (Bickel et al., 2000). HFSSM contains 18 questions for households with children and 10 questions for households without children, so a complete response should contain 18 or 10 valid answers (Bickel et al., 2000). Therefore, both the number of affirmative answers the respondent has given and whether the household has children (members less than 18 years old) influence the classification of each household (Kapp, 1999). Based on its score on the HFSSM, a household is classified into one of the food security status-level categories. The score is determined by the overall number of positive responses of a household to the set of indicator questions (Bickel et al., 2000).

Table 5 summarizes food security scale values and status classifications (Bickel et al., 2000). The classification of food security status was revised in 2006 and has also been correspondingly transferred into this table (Bickel et al., 2000).
Table 5

*Measurement of Household Food Security Status in the United States: Food Security Scale Values and Status Levels Based Upon Responses to Food Security Survey Module*

<table>
<thead>
<tr>
<th>Number of Affirmative Responses</th>
<th>1998 Food Security Scale Values</th>
<th>Food Security Status Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Out of 18) Households With Children</td>
<td>(Out of 10) Households without Children or Adult Food Security</td>
<td>2000 Label</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>2.4</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>3.0</td>
</tr>
<tr>
<td>6</td>
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<td>3.4</td>
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<td>3.7</td>
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<td>8</td>
<td>5</td>
<td>3.9</td>
</tr>
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<td>9</td>
<td>6</td>
<td>4.3</td>
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<td>10</td>
<td>7</td>
<td>4.4</td>
</tr>
<tr>
<td>11</td>
<td>8</td>
<td>4.7</td>
</tr>
<tr>
<td>12</td>
<td>8</td>
<td>5.0</td>
</tr>
<tr>
<td>13</td>
<td>9</td>
<td>5.1</td>
</tr>
<tr>
<td>14</td>
<td>10</td>
<td>5.5</td>
</tr>
<tr>
<td>15</td>
<td>11</td>
<td>5.7</td>
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<tr>
<td>16</td>
<td>12</td>
<td>5.9</td>
</tr>
<tr>
<td>17</td>
<td>13</td>
<td>6.3</td>
</tr>
<tr>
<td>18</td>
<td>14</td>
<td>6.4</td>
</tr>
</tbody>
</table>
Table 5 (continued).

<table>
<thead>
<tr>
<th>Number of Affirmative Responses</th>
<th>1998 Food Security Scale Values</th>
<th>Food Security Status Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Out of 18) Households with Children</td>
<td>(Out of 10) Households without Children or Adult Food Security</td>
<td>2000 Label</td>
</tr>
<tr>
<td>13</td>
<td>6.6</td>
<td>Food insecure with hunger, severe</td>
</tr>
<tr>
<td>14</td>
<td>7.0</td>
<td>Very low food security</td>
</tr>
<tr>
<td>9</td>
<td>7.2</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>7.4</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>7.9</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>8.7</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>9.3</td>
<td></td>
</tr>
</tbody>
</table>


Overall, as food insecurity worsens, as indicated by an increased number of affirmative responses to the sequence of survey questions, the household food security status can be calculated (Bickel et al., 2000). Numerical values ranging from 0 to 10 indicate the full range of severity measured by the standard U.S. food security scale (Di Napoli & Samara, 1999). A scale value of 0 is assigned when any of the conditions of
food insecurity covered by the FSSM questions has not been experienced by a household, while a scale value close to 10 is assigned when all of the conditions have been experienced by a household (Bickel et al., 2000). That is, the higher the scale value, the more food insecure the household (see Figure 1).

Two measures of households’ food security can be computed from the FSSM data: 1) a scale score (continuous), as summarized above; and 2) a categorical grouping (Bickel et al., 2000) (see Table 5). The relationship between these two forms of the food security measure and the respective ways in which they represent the underlying phenomenon being measured, are shown in Figure 1. Any point on the food security continuum represents a level of food security for a household. Categories of food security status of the households could also be defined by the scale values on the same continuum (Bickel et al., 2000).
### Conditions/Experience/Behaviors Indicative of Food Insecurity and Hunger:

(sequential set of increasingly severe indicator)

<table>
<thead>
<tr>
<th>No Such indications: Presumed food secure</th>
<th>One or two indications: At-risk</th>
<th>Multiple indications: Few or no hunger indicators</th>
<th>More, and more severe indications: Multiple indicators of adult hunger</th>
<th>Many indications, including: Child hunger indicators and more severe adult hunger indicators</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Household Food Security Scale – <em>continuous measure</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household Food Security Status – <em>categorical measure</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>High Food Security</td>
</tr>
</tbody>
</table>

**Figure 1.** Two measures of severity of household food insecurity and hunger.

Conditions of food insecurity are generally believed to affect all household members, though not necessarily to the same extent. As we know, food insecurity is a particularly personal phenomenon—some members of the household may be hungry while others are not (Bickel et al., 2000). In other words, if a household is classified as “very low food security,” what it tells us is that some, but not necessarily all members of the household, are experiencing food insecurity due to insufficiency of household resources (Bickel et al., 2000). Therefore, the food security scale represents the condition of household members as a group, not necessarily the condition of each particular person in the household (Bickel et al., 2000).

Similarly, if a household with children is classified as “very low food security,” the food security measure might only indicate adults' food insecurity but not children's food insecurity (Bickel et al., 2000). The only conclusion that can be confidently inferred from the household food security measurement project for children's food insecurity is that children in food-insecure households are at significantly higher risk of very low food security than children in food-secure households (Bickel et al., 2000). This risk increases markedly as the severity level of the food insecurity experienced in the household increases (Bickel et al., 2000). However, McIntyre et al. (2002) found that very low food security among children is lower than among mothers.

It is often useful to simplify the food security scale into a small set of categories for policy and research reasons. In 2006, an updated classification for describing severity level of food insecurity was introduced by the USDA. These changes happened due to recommendations by an expert panel convened at the Committee on National Statistics
Even though an updated classification has been put forward, the methods used to evaluate households’ food security have remained unchanged (USDA, 2008). With the corresponding categories, data from 2005 and earlier are directly comparable with those from later years (USDA, 2008). Categories and descriptions of food security status defined before and after 2006 are illustrated in Table 6.

In the original classification presented in Table 6, sometimes the last two groups are combined into one broader category and labeled as very low food security (formerly food insecure with hunger) (Bickel et al., 2000).

Table 6

*Combined Categories and Descriptions Before and After 2006*

<table>
<thead>
<tr>
<th>General categories (original and updated labels are the same)</th>
<th>Detailed categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food security</td>
<td>Food security</td>
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<td></td>
<td></td>
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</tbody>
</table>
Table 6 (continued).

<table>
<thead>
<tr>
<th>General categories (original and updated labels are the same)</th>
<th>Detailed categories</th>
<th>Description of conditions in the household for original classification</th>
<th>Updated label</th>
<th>Description of conditions in the household for updated classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food insecurity without hunger</td>
<td>Original label</td>
<td>“Food insecurity is evident in household members’ concerns about adequacy of the household food supply and in adjustments to household food management, including reduced quality of food and increased unusual coping patterns. Little or no reduction in members’ food intake is reported.”</td>
<td>Low food security</td>
<td>“Reports of reduced quality, variety, or desirability of diet. Little or no indication of reduced food intake”</td>
</tr>
<tr>
<td>Food insecurity with hunger (moderate)</td>
<td></td>
<td>“Food intake for adults in the household has been reduced to an extent that implies that adults have repeatedly experienced the physical sensation of hunger. In most (but not all) food-insecure households with children, such reductions are not observed at this stage for children.”</td>
<td>Very low food security</td>
<td>“Reports of multiple indications of disrupted eating patterns and reduced food intake”</td>
</tr>
<tr>
<td>Food insecure with hunger (severe)</td>
<td></td>
<td>“At this level, all households with children have reduced the children’s food intake to an extent indicating that the children have experienced hunger. For some other households with children, this already has occurred at an earlier stage of severity. Adults in households with and without children have repeatedly experienced more extensive reductions in food intake.”</td>
<td></td>
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</tbody>
</table>
Prevalence and Trends of Food Insecurity in the United States

Prevalence of Food Insecurity

The most recent national estimates of household food security of the United States indicated that 14.6% (17 million households) of U.S. households were food insecure at some time during 2008 (Nord et al., 2009). The remaining 85.4% of U.S. households were food secure throughout the year (Nord et al., 2009). Increasing from 11.1% (13 million households) in 2007, the prevalence of food insecurity in 2008 was the highest observed since national representative food security surveys were initiated in 1995 (Nord et al., 2009). Overall, 8.9% (11.3 million) had low food security during 2008 (Nord et al., 2009). The remaining one-third of food-insecure households (6.7 million households, or 5.7% of all U.S. households) had very low food security, up from 4.7 million households (4.1%) in 2007. This level of very low food security was also the highest level observed since 1995 when the survey was established (Nord et al., 2009).

The prevalence of food insecurity among households with children increased from 15.8% in 2007 to 21.0% in 2008 (Andrews & Nord, 2009). The corresponding increase for households without children was from 8.7 to 11.3% (Andrews & Nord, 2009). And the prevalence of very low food security among children rose from 0.8% of
households with children in 2007 to 1.3% in 2008 (Nord et al., 2009). Also among households with children, married-couple families had the lowest rate of food insecurity (14.3%) in 2008 (Nord et al., 2009). In about half of those food insecure households with children, only adults were food insecure (Nord, 2009). Job opportunities, income levels, and less educated workers are likely to be key determinants affecting the food security of children (Nord, 2009).

_U.S. Food Security Trends Since 1995_

As shown in Figure 2 and Table 7, the prevalence of food insecurity and very low food insecurity were higher in 2008 than when the measurement was started in 1995. Initially, the prevalence rates presented an overall decline in food insecurity as well as a 2-year cyclical pattern, which was associated with data collection schedules, from 1995 to 2000 (Andrews & Nord, 2009). From 1999, the prevalence rate of food insecurity began to increase and peaked in 2004, then fell in 2005, when it plateaued for two years. With worsening economic conditions (Andrews & Nord, 2009), it rose in 2008. Overall, very low food security rates mirrored these trends. Essentially, during the economic downturns, food insecurity became more common and severe due to job markets were weak and federal and local government assistance was cut down by tight budgets (Andrews & Nord, 2009). However, the rise in food insecurity during the 2008 recession was larger than in 2001 (Andrews & Nord, 2009).
Figure 2. Food insecurity trends in U.S. households, 1995-2008.

Table 7

*Trends in Prevalence Rates of Food Insecurity and Very low Food Security in U.S. Households, 1995-2008*

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<thead>
<tr>
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<tbody>
<tr>
<td>Percent of households</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food insecurity, unadjusted¹</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>11.79</td>
<td>10.06</td>
<td>10.47</td>
<td>10.69</td>
<td>11.10</td>
<td>11.21</td>
<td>11.95</td>
<td>11.00</td>
<td>10.94</td>
<td>11.10</td>
<td>14.60</td>
</tr>
<tr>
<td>Food insecurity, adjusted for comparability in all years</td>
<td>10.30</td>
<td>10.40</td>
<td>8.70</td>
<td>10.10</td>
<td>8.73</td>
<td>9.09</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Very low food security, unadjusted¹</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>3.71</td>
<td>2.97</td>
<td>3.13</td>
<td>3.26</td>
<td>3.50</td>
<td>3.49</td>
<td>3.94</td>
<td>3.87</td>
<td>3.99</td>
<td>4.10</td>
<td>5.70</td>
</tr>
<tr>
<td>Very low food security, adjusted for comparability in all years</td>
<td>3.90</td>
<td>4.10</td>
<td>3.10</td>
<td>3.51</td>
<td>2.85</td>
<td>2.95</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

*Note.* NA = Not available.

¹Data as collected (unadjusted) in 1995-97 are not directly comparable with data collected in 1998 and later years. Source: Calculated by Economic Research Service based on Current Population Survey Food Security Supplement data.

Outcomes of Food Insecurity

Food insecurity can have both nutritional and nonnutritional consequences in children and adults. It can have serious outcomes on people’s health, such as physical impairments related to insufficient food (illness and fatigue), psychological issues caused by lack of access to food (feelings of constraints to go against held norms and values; stress at home), and sociofamilial disturbances (modification of eating patterns and related ritual; distortion of the means of food acquisition and management) (Hamelin et al., 1999).

Food Insecurity and Diet (Children)

Food insecurity can negatively impact children’s diet. Even though very low food security among children is rare in the United States, lower dietary quality in children, especially older children (and adults), are associated with food insecurity or insufficiency (Kaiser & Townsend, 2005). Although dietary variety of U.S. children (Knol, Haughton, & Fitzhugh, 2004) and the intake of energy and macronutrients (Casey, Szeto, Lensing, Bogle, & Weber, 2001) are not affected by food insufficiency, decreased intake of dark green and other vegetables and increased intake of eggs were found to be associated with food insufficiency. Among adolescents, food insecurity is associated with lower intake of fruits and vegetables (Neumark-Sztainer, Wall, Perry, & Story, 2003). Bhattacharya et al. (2004) found that children in poverty have less healthy diets and were 7% more likely to have low serum values of nutrients. Kaiser et al. (2002) said that food insecurity status is associated with diets not meeting the number of servings recommended by the Food Guide Pyramid.
Food Insecurity and Diet (Adults)

In adults, food insecurity is also related to poor nutritional outcomes (Bhattacharya et al., 2004). Bhattacharya et al. (2004) pointed out that adults from food-insecure households had less healthful diets and were likely to have low serum nutrient values. Olson (2005) reviewed food insecurity in women and reported that women are vulnerable to the consequences of food insecurity due to their roles in organizing family feeding. The Continuing Survey of Food Intakes by Individuals (1989 to 1991) demonstrated that low intakes of vitamins A and C among adult women were associated with household food insufficiency, even with income and other pertinent variables controlled (Rose & Oliveira, 1997). Low intakes of vitamins E and B₆, thiamin, niacin, and magnesium were also shown to be significantly associated with food insufficiency (Tarasuk & Beaton, 1999). Similarly, lower intakes of energy, vitamin A, folate, iron, and magnesium were reported among women from hungry households receiving emergency food assistance in an urban area (Tarasuk & Beaton, 1999). Compared with their food sufficient counterparts, food-insufficient U.S. adults (ages 20 to 59 years) were found to have lower intakes of calcium and were more likely to have calcium and vitamin E intakes below 50% of the recommended amounts (Dixon, Winkleby, & Radimer, 2001). Using a sample of adults from the Third National Health and Nutrition Examination Survey (NHANES), Bhattacharya et al. (2004) assessed the associations among nutritional status, poverty, and food insufficiency. Both poverty and food security were predictive of poor nutrition for adults (18 to 64 years old) and older adults (65 years old and older; Bhattacharya et al., 2004). Gucciardi, Vogt, DeMelo,
and Stewart (2009) asserted that lower fruit and vegetable consumption is associated with household food insecurity.

**Food Insecurity and Physical and Mental Health (Children)**

Bégin, Frongillo, and Delisle (1999) examined child caregiver characteristics and found them to influence children’s nutritional status, as the caregiver can influence child-feeding decisions. Stunting was found less prevalent in older children (Bégin et al., 1999). Cook et al. (2004) pointed out that infants and toddlers under 36 months old living in food insecure households, with or without measurable child food insecurity, were more likely to be of fair or poor health status and be experiencing health problems requiring hospitalization. Gulliford et al. (2006) asserted that compared with food-secure individuals, food-insecure adolescents with the same BMIs engage in less physical activity. Casey et al. (2005) found that food insecurity status is associated with poorer physical function and lower total child health-related quality of life (HRQOL) regardless of gender, ethnicity, age, and family income. Bronte-Tinkew, Zaslow, Capps, Horowitz, and McNamara (2007) asserted that food insecurity is not either directly or indirectly related to toddlers’ length for age. Child level food insecurity was demonstrated to be associated with iron deficiency anemia (Alaimo, Olson, Frongillo, & Briefel, 2001a; Skalicky et al., 2006). Monge-Rojas, Campos, and Rojas (2005) demonstrated that compared with rural lifestyle, urban adolescence with sedentary lifestyles had higher intakes of saturated fat, cholesterol and trans fatty acids. Poorer health of children, as reported by parents, was shown to be more common among children from food-insecure or food-insufficient households than their counterparts in food-secure households.
(Bronte-Tinkew et al., 2007). Alaimo, Olson, and Frongillo (2001a) found that children in food insecure households were found to have more stomach aches, frequent headaches, and colds. Children in food-insecure or food-insufficient households were also reported to have higher hospitalization rates than their counterparts in food-secure households (Cook et al., 2004). Three-year-old children in food-insecure or food-insufficient households were shown to have behavioral problems (Whitaker, Phillips, & Orzol, 2006).

Weinreb et al. (2002) reported that household food insecurity is related to higher number of chronic health conditions and more “internalizing” behavior problems in children. Weinreb et al. (2002) found that severe food insecurity was associated with more anxiety and depression in school-aged children. Alaimo, Olson, and Frongillo (2002) found that food insufficiency is strongly related to depressive disorder and suicidal symptoms in U.S. adolescents. Whitaker et al. (2006) concluded that mental health problems are more common in children when their mothers are food insecure. After further adjustment for maternal major depressive episode and generalized anxiety disorder, the percentage with a behavior problem among children increased as food insecurity increased (Whitaker et al., 2006). Kleinman et al. (1998) pointed out that school-age children in food-insecure households were shown to have poorer psychosocial function and psychosocial development.

Food insecurity is considered to be associated with multiple adverse developmental consequences in children, including poor school performance. Through a longitudinal study, Jyoti, Frongillo, and Jones (2005) found that food insecurity impairs children’s development and particularly impairs social skills, development, and reading
performance in girls. Frongillo, Jyoti, and Jones (2006) concluded that food security helps enhance academic performance and learning among school children by studying the Food Stamp Program (FSP). Alaimo, Olson and Frongillo (2001a) demonstrated that negative academic and psychosocial outcomes are related to household food insecurity, by analyzing the data from NHANES III. Lower math achievement and other achievement gains in kindergarteners were concluded to be associated with household food insecurity (Jyoti et al., 2005; Winicki & Jemison, 2003). Winicki and Jemison (2003) also pointed out that food insecure children aged 6 to 11 years have lower arithmetic scores and a higher likelihood of repeating a grade. However, some studies show that there is no relationship between hunger and academic functioning, including attendance rates, grades and academic achievements by examining homeless and low-income housed mothers and their children (Weinreb et al., 2002).

To improve food insecurity and hunger in the United States, many public and private nutrition assistance programs exist at national, state, and local levels (Bickel et al., 2000). Four out of five low-income, food-insecure households with children received benefits from federal food and nutrition assistance programs in 2007 (Nord, 2009). Food assistance programs will be discussed in a later section.

*Food Insecurity and Physical/Mental Health (Adults)*

Many studies have explored the effects of food insecurity on adults’ physical and mental health. Poorer functional health status was found in food insecure individuals, comparing with food secure respondents (Pheley, Holben, Graham, & Simpson, 2002).
Huddleston-Casas, Charnigo and Simmons (2009) conducted a longitudinal study in rural, low-income families and found that household food insecurity and maternal depression were bi-directionally related. Bronte-Tinkew et al. (2007) pointed out that food insecurity has significant effects on parenting, including both depression and parenting practices, which in turn were significantly associated with infant feeding and toddlers’ overweight. Food insecurity was also shown to influence toddlers’ security of attachment and mental proficiency indirectly through depression and parenting practices (Zaslow et al., 2009). Laraia, Borja, and Bentley (2009) stated that depressive symptoms in women are related to both food insecurity and marginal food security. Casey et al. (2004) showed that maternal depression is associated with household food insecurity through pediatric clinical samples. Food insecurity is demonstrated to be frequent among families with young children, especially when the mother has depression (Melchior et al., 2009). Hadley and Patil (2008) concluded that food insecurity can strongly predict symptoms of anxiety and depression among female caretakers. Mental health problems were shown more common in both mothers and children when mothers are food insecure (Whitaker et al., 2006). Weinreb et al. (2002) found that mothers of children, both preschooler and school-aged children who experienced food insecurity, are more likely to have lifetime diagnosis of posttraumatic stress disorder. Bronte-Tinkew et al. (2007) argued that there are significant effects of food insecurity on parental depression, which can in turn influence physical health. Gucciardi et al. (2009) found that household food insecurity was related to physical inactivity, self-rated general and mental health, dissatisfaction with life, high self-perceived stress, and mood disorder.
Food Insecurity and Birth Defects

Hobel (2004) and Weinstock (2005) argued that children of women who experienced stress while pregnant may have adverse health outcomes. Neural tube defects, orofacial clefts, and conotruncal heart defects were shown to be associated with maternal stressful life events (Adams, Mulinare, & Dooley, 1989; Carmichael & Shaw, 2000; Carmichael, Shaw, Yang, Abrams, & Lammer, 2007; Czeizel & Nagy, 1986; Hansen, Lou & Olsen, 2000; Laumon et al., 1996; Montenegro, Palomino, & Palomino, 1995; Suarez, Cardarelli, & Hendricks, 2003). Carmichael, Yang et al. (2007) demonstrated that certain birth defects can be one of the negative results of food insecurity. Carmichael et al. (2007) showed that more a stressful life can increase the risk of cleft palate, cleft lip with or without cleft palate, d-transposition of the great arteries, and Tetralogy of Fallot (a group of four types of heart defects present at birth). Carmichael et al. (2007) also showed that increased stress may add the risk of spina bifida and anencephaly among women who did not use folic acid supplements.

Food Insecurity and HIV/AIDS in North America

Several studies found that food insecurity is associated with Human Immunodeficiency Virus (HIV)/Acquired Immune Deficiency Syndrome (AIDS) in North America. Normen et al. (2005) conducted a cross-sectional study in British Columbia, Canada and found that individuals with low food insecurity and very low food insecurity were more likely to have a history of recreational injection drug. Weiser, Frongillo et al. (2009) found that half of the HIV-positive urban poor in San Francisco are food insecure. Research performed among HIV-infected marginally housed
individuals also in San Francisco showed that food insecurity is highly prevalent (Weiser, Bangsberg et al., 2009). Vogenthaler et al. (2010) demonstrated that food insufficiency is highly prevalent among HIV-infected urban crack-cocaine users in Atlanta and Miami. Additional studies are needed for further clarify the relationship of HIV to food insecurity.

Relationship between Chronic Disease and Food Insecurity

As previously discussed, many studies demonstrate the association between food insecurity and other chronic diseases are also associated with food insecurity, and will be examined in the next section.

*Food Insecurity and Overweight/Obesity in Children*

The literature on food insecurity’s relationship to overweight/obesity in children is mixed. Food insecurity has been found positively related to childhood obesity in the following studies. Casey et al. (2006) reported that children at risk for being overweight are associated with low family income. In their study, children who lived in families with incomes more than four times the federal poverty level were more likely to be overweight or obese. In a sample of children from the largest U.S.-Mexico border city, Jiménez-Cruz, Bacardi-Gascón and Spindler (2003) showed the coexistence of obesity, hunger, undernutrition and limited food group consumption among migrant children. Gulliford, Nunes, and Rocke (2006) found that food-insecure adolescents with the same Body Mass Indexes (BMIs) as food-secure subjects are more likely to gain weight. Accumulation of body fat in adolescence and adulthood may be triggered by prolonged undernutrition in early life (Kaiser & Townsend, 2005). Some women appeared to
actively avoid food insecurity in adulthood due to their experiences of poverty-associated food deprivation in childhood (Olson et al., 2007). At the same time, research conducted among children younger than 5 years old showed that food insecurity is related to overweight (Metallinos-Katsaras, Sherry, & Kallio, 2009). Smith and Richards (2007) found that food insecurity was associated with overweight by encouraging individuals to overeat when food is available or tasty among homeless youth Minneapolis, Minnesota. Children in poverty aged from 2 to 5 years were shown to be 3% more likely to become overweight, and 2% less likely to have low BMI (Bhattacharya et al., 2004).

However, there are many studies showing a negative relationship between food insecurity and childhood overweight/obesity. Matheson, Varady, Varady, and Killen (2002) reported that food insecurity have negative effects on the children’s BMIs and household food supplies. Compared with elementary-school aged children in high-income families, the BMIs of those in low-income families were significantly lower (Vorster & Kruger, 2007). Results from the 1999-2002 NHANES showed that food insecurity and overweight are not directly associated for children of any age (Gundersen, Lohman, Garasky, Steward & Eisenmann, 2008).

In many other studies, food insecurity has been found not significantly associated with childhood obesity. Martin and Ferris (2007) asserted that food insecurity cannot increase the chance of childhood overweight. There were no significant differences in the prevalence of at risk of overweight or overweight between food secure and food insecure children (Martin & Ferris, 2007). Moreover, Gundersen, Lohman, Eisenmann, Garasky, & Stewart (2008) also found the likelihood or risk of being overweight was not
significantly different for food secure and food insecure children. In the sample used by Gundersen et al. (2008), childhood food insecurity and overweight had no relationship with low income. Food insecurity was found not significantly associated with the weight status of the child at the household level (Gundersen et al., 2008). Gundersen, Lohman, Eisenmann et al. (2008) argued that food security and overweight were not associated in their studies among 10- to 15-year-old low-income youths; however, they also indicated that more research is needed to further explore the relationships between them. Gundersen, Garasky, and Lohman (2009) found that food insecurity is not related to overweight by using multiple measures of obesity during their analysis among children between the ages of 8 and 17 years old.

Dinour, Bergen, and Yeh (2007) argued that the relationship between food insecurity and overweight is uncertain. According to their review, the association between food insecurity and overweight among children was sometimes proved to be significantly related but sometimes not. The influences of gender, age, race, and/or income were considered to be reasons why the data regarding children are conflicting (Dinour et al., 2007). Lyons, Park, and Nelson (2007) found that the relationships between obesity and food insecurity are more significant when using self-reported data than when using measured data.

Food Insecurity and Overweight/Obesity in Adults

Food insecurity has been associated with adult overweight/obesity in some studies. Martin and Ferris (2007) found that food insecure adults were significantly more likely to be obese. Wilde and Peterman (2006) examined data from NHANES 1999-2002
and asserted that weight gain for women is associated with marginal household food
security. Lohman, Stewart, Gundersen, Garasky, and Eisenmann (2009) also
demonstrated that the interaction of food insecurity and maternal stressors is significantly
associated with the risk of overweight/obesity. Olson and Strawderman (2008) stated that
food insecurity does not lead to obesity, but obesity combined with food insecurity
increases the risk of major weight gain in childbearing women. Townsend, Peerson, Love,
Achterberg, and Murphy (2001) also demonstrated that food insecurity is related to
overweight status in women but not for men. In the Appalachian region, rates of obesity
were found significantly higher among people from food-insecure households than
among those from food-secure households, and the rates increased as food insecurity
worsened, especially among women (Holben & Pheley, 2006).

Some studies have found a negative relationship between food insecurity and
adult overweight/obesity. In Isanaka, Mora-Plazas, Lopez-Arana, Baylin, and Villamor’s
(2007) study of Bogotá, Colombia, food insecurity was highly prevalent and predicted
underweight but not overweight in adults. Isanaka et al. (2007) asserted that hunger in
the households and maternal underweight was significantly associated. However, in
many other studies, food insecurity and overweight/obesity were not significantly related
among adults. Whitaker and Sarin (2007) found that in a period longer than 2 years,
changes in food security status and changes in weight among urban women were not
significantly associated.
Food Security and Type 2 Diabetes Risk in Adults

Based on data from NHANES 1999-2002, food insecurity is shown to be associated with diabetes mellitus among people over 20 years of age (Seligman, Bindman, Vittinghoff, Kanaya, & Kushel, 2007). Nelson, Cunningham, Andersen, Harrison, and Gelberg (2001) found that food insufficiency is relatively common among low-income adults with diabetes. In a longitudinal study conducted by Sharkey (2005), food sufficiency status became worse among older adults with diabetes. Gucciardi et al. (2009) found that the odds of household food insecurity were higher for individuals with diabetes than among those without diabetes. No relationship was found between household food insecurity and diabetes management services (Gucciardi et al., 2009). In a study of adults from rural Appalachian Ohio, Holben and Pheley (2006) found that self-reported rates of diabetes among food-secure individuals were greater than those from food-insecure households.

Food Assistance Programs

In the United States, numerous food assistance programs funded by federal government, community, or non-government organizations exist to improve food security status of households. Federal food assistance programs are listed in Table 8. Due to their frequency of use, two programs are briefly discussed in this section, and several related to food assistance and overweight/obesity are highlighted.
Table 8

*Federal Food Assistance Programs in the United States*

<table>
<thead>
<tr>
<th>Program</th>
<th>Website</th>
<th>Target Group</th>
<th>About</th>
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</thead>
<tbody>
<tr>
<td>Supplemental Nutrition Assistance Program (SNAP) (formerly the Food Stamp Program)</td>
<td><a href="http://www.fns.usda.gov/snap/">www.fns.usda.gov/snap/</a></td>
<td>Low-income people and families.                                                Benefits are provided on an electronic card that is used like an ATM card and accepted at most grocery stores. Through nutrition education partners, SNAP helps clients learn to make healthy eating and active lifestyle choices.</td>
<td></td>
</tr>
<tr>
<td>Women, Infants, and Children (WIC)</td>
<td><a href="http://www.fns.usda.gov/wic/">www.fns.usda.gov/wic/</a></td>
<td>Low-income pregnant, breastfeeding, and non-breastfeeding postpartum women, and to infants and children up to age five who are found to be at nutritional risk.</td>
<td>Program serves to safeguard the health of low-income women, infants, &amp; children up to age 5 who are at nutritional risk by providing nutritious foods to supplement diets, information on healthy eating, and referrals to health care.</td>
</tr>
<tr>
<td>WIC Farmers’ Market Nutrition Program (FMNP)</td>
<td><a href="http://www.fns.usda.gov/wic/FMNP/FMNPfaqs.htm">www.fns.usda.gov/wic/FMNP/FMNPfaqs.htm</a></td>
<td>Low-income pregnant, breastfeeding and non-breastfeeding post-partum women, and to infants and children up to 5 years of age, who are found to be at nutritional risk.</td>
<td>Program is associated with the Special Supplemental Nutrition Program for Women, Infants and Children, popularly known as WIC.</td>
</tr>
<tr>
<td>Program</td>
<td>Website</td>
<td>Target Group</td>
<td>About</td>
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</tr>
<tr>
<td>Child and Adult Care Food Program (CACFP)</td>
<td><a href="http://www.nutrition.gov/nal_display/index.php?info_center=11&amp;tax_level=2&amp;tax_subject=394&amp;level3_id=0&amp;level4_id=0&amp;level5_id=0&amp;topic_id=1768&amp;placement_default=0">www.nutrition.gov/nal_display/index.php?info_center=11&amp;tax_level=2&amp;tax_subject=394&amp;level3_id=0&amp;level4_id=0&amp;level5_id=0&amp;topic_id=1768&amp;placement_default=0</a></td>
<td>Children and elderly adults.</td>
<td>Program provides reimbursement for nutritious meals and snacks in child care centers, family child care homes, after school programs, emergency shelters, and adult day care programs.</td>
</tr>
<tr>
<td>Summer Food Service Program (SFSP)</td>
<td><a href="http://www.fns.usda.gov/cnd/Summer/">www.fns.usda.gov/cnd/Summer/</a></td>
<td>Children 18 and younger may receive free meals and snacks through SFSP meals and snacks are also available to persons with disabilities, over age 18, who participate in school programs for people who are mentally or physically disabled.</td>
<td>Program provides free, nutritious meals and snacks to help children in low-income areas get the nutrition they need to learn, play, and grow, throughout the summer months when they are out of school.</td>
</tr>
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Table 8 (continued).

<table>
<thead>
<tr>
<th>Program</th>
<th>Website¹</th>
<th>Target Group</th>
<th>About</th>
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<tbody>
<tr>
<td>School Breakfast Program (SBP)</td>
<td><a href="http://www.fns.usda.gov/cnd/Breakfast/Default.htm">www.fns.usda.gov/cnd/Breakfast/Default.htm</a></td>
<td>School children</td>
<td>Program provides cash assistance to States to operate nonprofit breakfast programs in schools and residential childcare institutions.</td>
</tr>
<tr>
<td>Fresh Fruit and Vegetable Program (FFVP)</td>
<td><a href="http://www.fns.usda.gov/cnd/ffvp/ffvpdefault.htm">www.fns.usda.gov/cnd/ffvp/ffvpdefault.htm</a></td>
<td>School children</td>
<td>Program provides healthier snack choices in schools, including fruits and vegetables.</td>
</tr>
<tr>
<td>Special Milk Program</td>
<td><a href="http://www.fns.usda.gov/cnd/Milk/Default.htm">www.fns.usda.gov/cnd/Milk/Default.htm</a></td>
<td>School children</td>
<td>Program provides milk to children in schools and childcare institutions who do not participate in other Federal meal service programs; reimburses schools for the milk they serve.</td>
</tr>
<tr>
<td>National School Lunch Program (NSLP)</td>
<td><a href="http://www.fns.usda.gov/cnd/lunch/">www.fns.usda.gov/cnd/lunch/</a></td>
<td>School children</td>
<td>NSLP is a federally assisted meal program operating in public and nonprofit private schools and residential child care institutions. It provides nutritionally balanced, low-cost or free lunches to children each school day.</td>
</tr>
<tr>
<td>Seamless Summer Option</td>
<td><a href="http://www.fns.usda.gov/cnd/seamless_summer.htm">www.fns.usda.gov/cnd/seamless_summer.htm</a></td>
<td>Children, 18 years and under, from low-income areas.</td>
<td>School districts participating in the NSLP or SBP are eligible to apply for the Seamless Summer Option. Once approved through their governing state agency, school districts serve meals free of charge to children, 18 years and under, from low-income areas.</td>
</tr>
<tr>
<td>Program</td>
<td>Website¹</td>
<td>Target Group</td>
<td>About</td>
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</tr>
<tr>
<td>Team Nutrition</td>
<td>teamnutrition.usda.gov/Default.htm</td>
<td>Children</td>
<td>Support the Child Nutrition Programs through training and technical assistance for foodservice, nutrition education for children and their caregivers, and school and community support for healthy eating and physical activity. Team Nutrition's Goal is to improve children's lifelong eating and physical activity habits by using the principles of the <em>Dietary Guidelines for Americans</em> and MyPyramid.</td>
</tr>
<tr>
<td>After-School Snack in the NSLP</td>
<td><a href="http://www.fns.usda.gov/cnd/Afterschool/default.htm">www.fns.usda.gov/cnd/Afterschool/default.htm</a></td>
<td>Children</td>
<td>The National School Lunch Program offers cash reimbursement to help schools serve snacks to children in afterschool activities aimed at promoting the health and well-being of children and youth in our communities.</td>
</tr>
<tr>
<td>Nutrition Services Incentive Program (NSIP)</td>
<td><a href="http://www.fns.usda.gov/fdd/programs/nsip/default.htm">www.fns.usda.gov/fdd/programs/nsip/default.htm</a></td>
<td>Older adults</td>
<td>NSIP, formerly the Nutrition Program for the Elderly (NPE), provides incentives to States and Tribes for the effective delivery of nutritious meals to older adults.</td>
</tr>
<tr>
<td>Elderly Nutrition Program (ENP)</td>
<td><a href="http://www.nutrition.gov/nal_display/index.php?info_center=11&amp;tax_level=2&amp;tax_subject=394&amp;level3_id=0&amp;level4_id=0&amp;level5_id=0&amp;topic_id=1772&amp;&amp;place">www.nutrition.gov/nal_display/index.php?info_center=11&amp;tax_level=2&amp;tax_subject=394&amp;level3_id=0&amp;level4_id=0&amp;level5_id=0&amp;topic_id=1772&amp;&amp;place</a> ment_default=0</td>
<td>Older adults</td>
<td>Program provides for congregate and home-delivered meals. These meals and other nutrition services are provided in a variety of group settings, such as senior centers, faith-based settings, schools, as well as in the homes of homebound older adults.</td>
</tr>
<tr>
<td>Program</td>
<td>Website¹</td>
<td>Target Group</td>
<td>About</td>
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</tr>
<tr>
<td>Emergency Food Assistance Program (TEFAP)</td>
<td><a href="http://www.fns.usda.gov/fdd/programs/tefap/">www.fns.usda.gov/fdd/programs/tefap/</a></td>
<td>Low-income needy persons, including elderly people.</td>
<td>TEFAP is a Federal program that helps supplement the diets of low-income needy persons, including elderly people, by providing them with emergency food and nutrition assistance.</td>
</tr>
<tr>
<td>Food Distribution Program</td>
<td><a href="http://www.fns.usda.gov/fdd/">www.fns.usda.gov/fdd/</a></td>
<td>Low-income families.</td>
<td>Mission is to strengthen the nutrition safety net through commodity distribution and other nutrition assistance to low-income families, emergency feeding programs, Indian Reservations, and the elderly.</td>
</tr>
<tr>
<td>Commodity Supplemental Food Program (CSFP)</td>
<td><a href="http://www.fns.usda.gov/fdd/programs/csfp/">www.fns.usda.gov/fdd/programs/csfp/</a></td>
<td>Low-income pregnant and breastfeeding women, other new mothers up to one year postpartum, infants, children up to age six, and elderly people at least 60 years of age.</td>
<td>Program works to improve the health of low-income pregnant and breastfeeding women, other new mothers up to one year postpartum, infants, children up to age six, and elderly people at least 60 years of age by supplementing their diets with nutritious USDA commodity foods. It provides food and administrative funds to States to supplement the diets of these groups.</td>
</tr>
<tr>
<td>Food Distribution Program on Indian Reservations (FDPIR)</td>
<td><a href="http://www.fns.usda.gov/fdd/programs/fdpir/">www.fns.usda.gov/fdd/programs/fdpir/</a></td>
<td>Low-income American Indian and non-Indian households that reside on a reservation, and households living in approved areas near a reservation or in Oklahoma that contain at least one person who is a member of a Federally-recognized tribe.</td>
<td>It is a federal program that provides commodity foods to low-income households, including the elderly, living on Indian reservations, and to Native American families residing in designated areas near reservations.</td>
</tr>
</tbody>
</table>
Table 8 (continued).

<table>
<thead>
<tr>
<th>Program</th>
<th>Website1</th>
<th>Target Group</th>
<th>About</th>
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<tbody>
<tr>
<td>Expanded Food and Nutrition Education Program</td>
<td><a href="http://www.nifa.usda.gov/nea/food/efnep.efnep.html">www.nifa.usda.gov/nea/food/efnep.efnep.html</a></td>
<td>Youth and adults</td>
<td>It is designed to assist limited resource audiences in acquiring the knowledge, skills, attitudes, and changed-behavior necessary for nutritionally sound diets, and to contribute to their personal development and the improvement of the total family diet and nutritional well-being.</td>
</tr>
<tr>
<td>Schools/Child Nutrition Commodity Programs</td>
<td><a href="http://www.fns.usda.gov/fdd/programs/schcnp/default.htm">www.fns.usda.gov/fdd/programs/schcnp/default.htm</a></td>
<td>Schools participating in the National School Program (NSLP) or institutions participating in the Child and Adult Care Food Program (CACFP), or the Summer Food Service Program (SFSP) are eligible.</td>
<td>The USDA's Schools/Child Nutrition Commodity Programs support American agricultural producers by providing cash reimbursements for meals served in schools, but also by providing nutritious, USDA-purchased food.</td>
</tr>
<tr>
<td>Food Distribution Disaster Assistance</td>
<td><a href="http://www.fns.usda.gov/fdd/programs/fd-disasters/default.htm">www.fns.usda.gov/fdd/programs/fd-disasters/default.htm</a></td>
<td>Disaster relief organizations such as the Red Cross and the Salvation Army.</td>
<td>The Federal Emergency Management Agency (FEMA) is responsible for effectively managing the federal response and recovery efforts following any national incident, coordinating relief efforts, and making assistance available to States, communities, businesses and individuals.</td>
</tr>
</tbody>
</table>

1 Website addresses reflect the source of the information for each row of the table. All the website addresses were retrieved on November 3, 2010.
Supplemental Nutrition Assistance Program (SNAP)

To help low-income people and families get the food they need for good health, many federal food assistance programs are built in the United States. The Supplemental Nutrition Assistance Program (SNAP), formerly known as the Food Stamp Program (FSP), is intended to increase the food security level of eligible low-income households (Nord & Golla, 2009). However, it has also been found that households enrolled in SNAP are more food insecure than other low-income households (Nord & Golla, 2009). Researchers hypothesized that it is the timing when food-needy households enroll in SNAP that causes this anomaly; in other words, households decide to enroll in SNAP when they are more severely food insecure, and the initial difference between SNAP participants and nonparticipants is greater than that the program can ameliorate (Nord & Golla, 2009). Researchers have been using various methods to attempt to find out how self-selection impacts the anomaly, so as to better observe the positive effects of SNAP. Nord and Golla (2009) conducted a study to examine households’ food security month by month for several months before and after their initial receipt of SNAP benefits, with the data of annual food security surveys from 2001 to 2006 sponsored by USDA and conducted by the U.S. Census Bureau as supplements to the monthly Current Population Survey (Nord & Golla, 2009). Food insecurity is observed to deteriorate substantially in the months prior to initial receipt of benefits and to be improved shortly after the benefits begins (Nord & Golla, 2009). It was clearly demonstrated that self-selection by households into SNAP at a moment when their food security worsens, and the initial difference in food security between households that self-select into SNAP and those that
do not is larger than the positive effect of SNAP benefits on food security (Nord & Golla, 2009). They also showed the moderate ameliorative effect of SNAP and pointed out that the prevalence of very low food security is reduced by about one-third among recent entrants (Nord & Golla, 2009).

Households with food stamps that lasted the entire month experienced much higher food security and much lower adult food insecurity than those with food stamps that lasted less than 4 weeks (Pérez-Escamilla et al., 2000). Oberholser and Tuttle (2004) asserted that food security status and the number of months households received food stamps were not related. Kasper, Gupta, Tran, Cook, and Meyers (2000) conducted a study among legal low-income immigrants in California, Texas, and Illinois, found that families were more likely to be hungry if they had at least one member who received Food Stamps, Medicaid, at least one public benefit of any kind, or Special Supplemental Nutrition Program for Women, Infants, and Children assistance in eligible households. Cook et al. (2002) demonstrated that young children could experience food insecurity more possibly due to terminating or reducing welfare benefits, but receiving food stamps does not protect them from these effects.

*Feeding America*

Many community programs also exist across the United States to improve food security (Feeding America, 2009). Feeding America is a domestic hunger relief charity in the United States to help solve the hunger crisis, through food banks that are nationwide across the country (Feeding America, 2009). It depends on donations provided by institutes, companies, and individuals to fund local food banks (Feeding America, 2009).
Feeding America was founded in 1979 with the name of “Second Harvest,” but in 1999 the name was changed to “America's Second Harvest” (Feeding America, 2009). Then people thought that “America's Second Harvest” was not well known among the public and brought some misunderstanding of domestic hunger, so in 2008 its name was changed to “Feeding America” (Feeding America, 2009). The organization thought the new name best conveyed their mission of providing food to Americans living with hunger, and that it raised awareness of domestic hunger and their work (Feeding America, 2009). According to the program, each year the network provides food assistance to more than 25 million low-income people facing hunger in the United States, including more than 9 million children and nearly 3 million seniors; more than 2 million pounds of donated food and grocery products are distributed annually (Feeding America, 2009). The network is made up of more than 200 food banks in 2009 and serves 50 states, the District of Columbia and Puerto Rico (Feeding America, 2009). They also conduct extensive studies to provide information on the demographic profiles of emergency food clients and the nature of local agencies in meeting their food security levels (Feeding America, 2009).

*Overweight and Food Assistance Programs in Children*

Food assistance programs are designed to strengthen household food security in the United States. Based upon the current body of literature, the relationship of food assistance programs to overweight/obesity is unclear for children. Jones, Jahns, Laraia, and Haughton (2003) found that girls in food secure households generally had no greater or less risk of overweight if they participated in any or all 3 federal food assistance
programs (Food Stamp Program, National School Lunch, and School Breakfast Program). However, in the same study, boys in both food insecure and food secure households were found at no greater or lesser risk of overweight by participating in any or all of the three programs (Jones et al., 2003). Gibson (2006) asserted that long-term FSP participation was positively related to overweight in young girls and obesity in low-income women, but not significantly related to daughter-only overweight and mother-only obesity.

**Overweight and Food Assistance Programs in Adults**

Ver Ploeg, Mancino, Lin, and Wang (2007) evaluated recent NHANES data (1999-2002) and found no significant differences in the probability of overweight and obesity between adult FSP participants and eligible nonparticipants. The association between food assistance program participation and body weight measures seems to be weak (Ver Ploeg et al., 2007). Townsend et al. (2001) stated that receiving food stamps is a significant predictor of overweight status, and specifically among women who participated in the FSP, the prevalence of overweight increases as the severity of food insecurity worsens. Gibson (2003) demonstrated that participation in FSP is associated with increased probability of being obese for low-income women. Gibson (2006) also asserted that long-term FSP participation is positively related to overweight in low-income women.

Nevertheless, Jones, and Frongillo (2006) asserted that persistent full participation in FSP had no relationship with weight gain among either food secure or insecure women. A rational explanation for this finding is that the small weight change caused by living in food insecurity was counteracted by modifying effects of FSP, after
controlling for other income and health-related risk factors for weight change (Jones & Frongillo, 2006).

In Black et al.’s (2004) study, WIC (Women, Infants & Children) participants had lower rates of food insecurity than households that did not participate in WIC, but the differences were not significant. As with children, more research is needed to fully understand the impact of food assistance on overweight/obesity among adults.

National Health and Nutrition Examination Survey

Since early 1960s, the NHANES has been conducted in the United States. It includes series of surveys focusing on different population groups or health topics, so as to assess the health and nutritional status of adults and children in the United States (CDC, 2009c). The NHANES program collects data on the prevalence of chronic condition and examines the risk factors that may increase the chances of certain diseases, by sampling a representative number of the U.S. population of all ages and also over-sampling persons 60 and older, African American and Hispanics (CDC, 2009c). The NHANES adopts interviews and physical examinations together (CDC, 2009c). The interviews are performed in respondents’ homes by asking demographic, socioeconomic, dietary, and health-related questions (CDC, 2009c). The physical examinations are conducted in mobile centers, which travel to 15 counties across the country each year (CDC, 2009c). The findings from the survey are used not only to assess the nutrition status, but also to determine the prevalence of major diseases and the risk factors for diseases, establish national standards (e.g., height, weight), and be referenced in epidemiological studies and health science research (CDC, 2009c). NHANES has
contributed to researchers, health planners, government agencies and private sector organizations in many ways (CDC, 2009c). For example, the blood lead data were quite instrumental in making policies to eliminate lead from gasoline, soft drink cans, and food (CDC, 2009c). A recent survey shows that the elevated blood lead level has declined more than 70% since the 1970s (CDC, 2009c). With those accomplishments and contributions, the NHANES program is still actively working on some new initiatives, in order to contribute more and accomplish more (CDC, 2009c).

Metabolic Syndrome Among Children and Adolescents

Current Trends of Overweight and Obesity Among Children and Adolescents

According the Centers for Disease Control and Prevention (CDC), obesity in children and adolescents is defined as a BMI-for-age and gender at or above the 95th percentile based on the 2000 sex-specific growth charts, overweight in children and adolescents is defined as a BMI between the 85th and 95th percentile (CDC, 2009b). Due to its associated health consequences and its influence on young people’s psychosocial development, obesity in early life is of particularly serious concern for children and adolescents.

The most recent data estimate that approximately one-third of children in the United States are either overweight or obese (Gundersen & Garasky, 2009). Data from NHANES 1963–1965 through 2007–2008 show that the prevalence rates of obesity for all age groups in the United States have increased significantly (Ogden & Carroll, 2010). Between 1976-1980 and 2007-2008, obesity rates increased from 5 to 10.4% among preschool age children (2 to 5 years old) and from 6.5 to 19.6% among 6 to 11 year olds.
During the same period, obesity increased from 5 to 18.1% among adolescents aged 12 to 19 years (CDC, 2010). One of seven low-income, preschool-aged (2 to 4 years old) children is reported obese (CDC, 2009a). Among low-income children, aged 2 to 4 years, the prevalence of obesity increased from 12.4% in 1998 to 14.5% in 2003 but rose to only 14.6% in 2008 (CDC, 2009a). Prevalence rates and trends in childhood overweight based on NHANES data for various age groups, beginning with NHANES I (1971–1974) and ending with NHANES 2003–2006, are shown in Figure 3. The prevalence of obesity in low-income, two-to-four-year-old children increased from 12.4% in 1998 to 14.5% in 2003 and remained almost the same in 2008 (14.6%; CDC, 2009a). The United States has made little progress in reducing obesity, and those prevalence figures are more than three times the target prevalence of 5% set in Healthy People 2010 (Ogden & Carroll, 2010).
Obesity is of particular concern since it can lead to other chronic diseases, including hypertension, dyslipidemia, and elevated insulin levels (Burke et al., 2005; Urakami et al., 2005). Metabolic syndrome is one concern.

**Definition of Metabolic Syndrome**

There is no uniform definition of metabolic syndrome for children and adolescents. Ford and Li (2008) found 27 publications, in which 40 unique definitions of metabolic syndrome among children and adolescents were utilized. These definitions mostly followed adaptations of the World Health Organization (WHO), the 2001 National Cholesterol Education Program Adult Treatment Panel (NCEP ATP III), and the European Group for the study of Insulin Resistance (EGIR) adult guidelines (Ice et al., 2009).

Metabolic syndrome was usually defined by many components, including some measures of glucose/insulin resistance, additional criteria including some measures of body fat (generally BMI or waist circumference), high-density lipoprotein cholesterol (HDL-C), triglycerides (TRIG), and blood pressure (BP) (Ice et al., 2009). For metabolic syndrome in children, Cruz and Goran (2004) recommended “1) individual components should be similar to those of adults for the sake of comparison and tracking, 2) current recommendations and cut-off values need to be developed or re-evaluated particularly for
waist circumference (WC), dyslipidemia and hyperglycemia, and 3) the use of single cut-off values as opposed to multiple cut-off values based on age/gender may be easier to apply but less sensitive in identifying children at risk” (Ice et al., 2009, p. 24). Cruz and Goran (2004) also pointed out that only overweight children should be screened for metabolic syndrome because metabolic syndrome is relatively uncommon except in overweight youth (Ice et al., 2009). However, which risk factors should be included and how many of those risk factors constitute a definition of metabolic syndrome in children remain uncertain (Ice et al., 2009).

Based on previous studies that used modified adult criteria, the IDF investigated prevalence of metabolic syndrome in children and adolescents. The wide variety of cut-off points among the pediatric definitions shown in Table 9 emphasized the requirement for a single definition that would use a consistent set of criteria, which would be easily measurable, with age-specific and sex-specific cut-off points (Alberti et al., 2007).
## Table 9

*A Range of the Published Metabolic Syndrome Definitions in Pediatrics*

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<td>Three or more of the following:</td>
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<tr>
<td>1 Fasting glucose</td>
<td>Fasting glucose ≥ 110mg/dL</td>
<td>Impaired glucose tolerance (ADA criterion)</td>
<td>Impaired glucose tolerance (ADA criterion)</td>
<td>Fasting glucose ≥ 110mg/dL (additional analysis with ≥ 100mg/dL)</td>
<td></td>
</tr>
<tr>
<td>2 WC &gt; 90\textsuperscript{th} percentile (age- and sex-specific, NHANES III)</td>
<td>WC &gt; 75\textsuperscript{th} percentile</td>
<td>WC &gt; 90\textsuperscript{th} percentile (age-, sex- and race-specific, NHANES III)</td>
<td>BMI-Z score ≥ 2.0 (age- and sex-specific)</td>
<td>WC &gt; 90\textsuperscript{th} percentile (sex-specific NHANES III)</td>
<td></td>
</tr>
<tr>
<td>3 Triglycerides ≥ 110 mg/dL (age-specific, NCEP)</td>
<td>Triglycerides ≥ 90\textsuperscript{th} percentile (age- and sex-specific, NHANES III)</td>
<td>Triglycerides &gt; 95\textsuperscript{th} percentile (age-, sex-, and race-specific, NGHS)</td>
<td>Triglycerides ≥ 110mg/dL (age-specific, NCEP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 HDL-C ≤ 40mg/dL (all ages/sexes, NCEP)</td>
<td>HDL-C &lt; 10\textsuperscript{th} percentile (age- and sex-specific, NHANES III)</td>
<td>HDL-C &lt; 5\textsuperscript{th} percentile (age-, sex- and race-specific, NGHS)</td>
<td>HDL-C &lt; 40mg/dL (all ages/sexes, NCEP)</td>
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<tr>
<td>Three or more of the following:</td>
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</table>

| 5 Blood pressure > 90th percentile (age-, sex and height-specific, NHBPEP) | Blood pressure > 90th percentile (age-, sex and height-specific, NHBPEP) | Blood pressure > 95th percentile (age-, sex and height specific, NHBPEP) | Blood pressure > 90th percentile (age-, sex-, and height-specific, NHBPEP) |


In 1998, the World Health Organization (WHO) published its definition for metabolic syndrome for adults (Goodman et al., 2004). Insulin resistance, known diabetes, or hyperglycemia is required in this definition (Goodman et al., 2004). In addition to this requirement, the presence of two out of three other risk parameters was also required: hypertension, dyslipidemia (hypertriglyceridemia or low HDL-C), and central obesity (high waist circumference, or BMI ≥ 30) (Goodman et al., 2004).

According to the definition published by the Third Report of the National Cholesterol Education Program Expert Panel in 2001 on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (ATP III, NHLBI), the metabolic
syndrome, which is also named as metabolic syndrome phenotype in some literature (Cook et al., 2003; Duncan, Li, & Zhou, 2004), is determined if an adult has three or more of the following five clinical manifestations:

- Waist circumference greater than 102 cm (40 inches) in men and 88 cm (35 inches) in women;
- Serum triglyceride level of 150 mg/dL or higher;
- High-density lipoprotein (HDL) cholesterol level less than 40 mg/dL in men and 50 mg/dL in women;
- Blood pressure of 130/85 mm Hg or higher;
- Fasting glucose level of 110 mg/dL or higher (American Heart Association [AHA], 2004; Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults, 2001).

In order to take preventative measures before the child or adolescent develops diabetes or cardiovascular disease, the IDF developed a definition for metabolic syndrome in children and adolescents based upon a consensus of experts and have been tool for early diagnosis of metabolic syndrome (Alberti et al., 2007). This definition is claimed to be simple and easy to use in clinical practice (Alberti et al., 2007). Due to developmental challenges presented by age-related differences in children and adolescents, the IDF definition is divided according to age-groups: ages 6 years to younger than 10 years; ages 10 years to younger than 16 years; and 16 years or older (Alberti et al., 2007). Because data for children who are younger than 6 years were insufficient, this age-group was excluded from this definition (Alberti et al., 2007).
Metabolic syndrome should not be diagnosed in children younger than 10 years, but for those with abdominal obesity, strong recommendations for losing weight should be given (Alberti et al., 2007). For adolescents aged from 10 to younger than 16 years, the IDF criteria include:

- Waist circumference $\geq$ 90th percentile or adult cut-off if lower;
- Triglycerides $\geq$ 1.7 mmol/L ($\geq$ 150 mg/dL),
- HDL-cholesterol $<$ 1.03 mmol/L ($<$ 40 mg/dL),
- Blood pressure systolic $\geq$ 130/ diastolic $\geq$ 85 mm Hg,
- Glucose $\geq$ 5.6 mmol/L (100 mg/dL) (If $\geq$ 5.6 mmol/L [or known T2DM] recommend an OGTT) (Alberti et al., 2007).

For adolescents aged from 16 to 18 years, the IDF criteria are expressed as below: Central obesity (defined as waist circumference $\geq$ 94cm for Europid men and $\geq$ 80cm for Europid women, with ethnicity specific values for other groups) plus any two of the following four factors:

- Raised triglycerides: $\geq$ 1.7mmol/L;
- Reduced HDL-cholesterol: $<$ 1.03mmol/L ($<$ 40 mg/dL) in males and $<$ 1.29mmol/L ($<$ 50 mg/dL) in females, or specific treatment for these lipid abnormalities;
- Raised blood pressure: systolic BP $\geq$ 130 or diastolic BP $\geq$ 85mm Hg, or treatment of previously diagnosed hypertension;
- Impaired fasting glycemia (IFG): fasting plasma glucose (FPG) $\geq$ 5.6 mmol/L ($\geq$ 100 mg/dL), or previously diagnosed type 2 diabetes (Alberti et al., 2007).
Detailed criteria for diagnosing metabolic syndrome in children and adolescents are shown in Table 10.

Table 10

*International Diabetes Federation Definition of Metabolic Syndrome in Children and Adolescents*

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Obesity (WC)</th>
<th>Triglycerides mmol/L (≥ 1.7)</th>
<th>HDL-C mmol/L (≥ 1.03)</th>
<th>Blood pressure Systolic diastolic (≥ 130/≥ 85 mm Hg)</th>
<th>Glucose(mmol/L) or known T2DM (≥ 5.6 mmol/L (100 mg/dL))</th>
</tr>
</thead>
<tbody>
<tr>
<td>6–&lt;10</td>
<td>≥ 90th percentiles</td>
<td>Metabolic syndrome cannot be diagnosed, but further measurements should be made if there is a family history of metabolic syndrome, T2DM, dyslipidemia, cardiovascular disease, hypertension and/or obesity.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10–&lt;16 Metabolic syndrome</td>
<td>≥ 90th percentile or adult cut-off if lower</td>
<td>≥ 1.7 mmol/L (≥ 150 mg/dL)</td>
<td>&lt; 1.03 mmol/L (&lt; 40 mg/dL)</td>
<td>Systolic diastolic (≥ 130/≥ 85 mm Hg)</td>
<td>5.6 mmol/L (100 mg/dL)</td>
</tr>
<tr>
<td>16+ Metabolic syndrome</td>
<td>Use existing IDF criteria for adults, i.e.: Central obesity (defined as waist circumference ≥ 94 cm for Europid men and ≥ 80 cm for Europid women, with ethnicity specific values for other groups) plus any two of the following four factors: • raised triglycerides: ≥ 1.7 mmol/L • reduced HDL-cholesterol: &lt; 1.03 mmol/L (&lt; 40 mg/dL) in males and &lt; 1.29 mmol/L (&lt; 50 mg/dL) in females, or specific treatment for these lipid abnormalities • raised blood pressure: systolic BP ≥ 130 or diastolic BP ≥ 85 mm Hg, or treatment of previously diagnosed hypertension • impaired fasting glycemia (IFG): fasting plasma glucose (FPG) ≥ 5.6 mmol/L (≥ 100 mg/dL), or previously diagnosed type 2 diabetes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Driven by the growing obesity epidemic in children and adolescents, metabolic syndrome is also appearing with increasing prevalence in this young population (Cook et al., 2003; Cruz et al., 2004; Weiss et al., 2004). Because no uniform definition for metabolic syndrome has been established, the prevalence of metabolic syndrome in children and adolescents varies widely.

Based on modified National Cholesterol Education Program (NCEP) [Adult Treatment Panel III (ATP III)] criteria modified for age and gender, findings on prevalence of metabolic syndrome have been reported. Based on data obtained from the third NHANES (1988-1994), one million 12-19-year-old adolescents in the U.S. were estimated to have the metabolic syndrome, or 4.2% overall (6.1% of males; 2.1% of females; Cook et al., 2003). During 1999-2000, more than two million (6.4%) U.S. adolescents were found to have a metabolic syndrome phenotype (Duncan et al., 2004). The syndrome was more prevalent in male than female adolescents (9.1 vs. 3.7%) and was found in 32.1% of obese adolescents (BMI ≥ 95th percentile for age and sex), compared with 7.1% of adolescents at risk for overweight (BMI between 85th and 95th percentiles) (Duncan et al., 2004). Using a sample of adolescents from NHANES III, the overall prevalence of the metabolic syndrome in moderately obese subjects (a threshold BMI z score of 2.0 to 2.5) was 38.7% and 49.7% in severely obese (a threshold BMI z
score above 2.5) subjects (Weiss et al., 2004). The prevalence of the metabolic syndrome in severely obese Black subjects was 39% (Weiss et al., 2004). Retnakaran, Zinman, Connelly, Harris, and Hanley (2006) reported that 18.6% of 236 children aged 10 to 19 years met the criteria for metabolic syndrome. Twelve percent of adolescents were identified as having the metabolic syndrome (Gungor, Bacha, Saad, Janosky, & Arslanian, 2004). But in the same study, 31.3% were identified as having the syndrome, more than double of those previously found to be at risk, when the ≥ 95th percentile of BMI was used as a cut-off point (Gungor et al., 2004). All of the findings above based on ATP III criteria.

The use of different criteria can account for the varying prevalence rates of metabolic syndrome. According to a school-based, cross-sectional study of 1,513 Black, White, and Hispanic teenagers, the overall prevalence of metabolic syndrome was 8.4% by WHO criteria but only 4.2% by ATP III criteria (Goodman et al., 2004). Also the study found that metabolic syndrome was almost exclusively among obese teenagers in whom prevalence of metabolic syndrome was 19.5% using ATP III criteria but 38.9% using WHO criteria (Goodman et al., 2004). Another study stated that by WHO criteria, metabolic syndrome was more common among girls, and non-White teenagers were more likely to have metabolic syndrome, but by ATP III definition, there were no race or sex differences (Zimmet et al., 2007).
Progression of Metabolic Syndrome in Children

Development of features of metabolic syndrome, which may start much earlier in life than previously supposed, can be affected by both pre- and postnatal environmental and genetic variations and their interactions (Alberti et al., 2007).

It is clear that the adverse links among the risk factors that compose the metabolic syndrome begin in childhood, though less basic and clinical information on childhood metabolic syndrome is available, compared to adult studies (Steinberger et al., 2009). During early childhood, the clustering of obesity, insulin resistance, inflammation, and other risk factors increase risk of getting atherosclerotic cardiovascular disease and type 2 diabetes mellitus (T2DM) (Steinberger et al., 2009). Development of metabolic syndrome and cardiovascular risk are directly related both clinically and epidemiologically to insulin resistance and obesity, especially abdominal obesity (Steinberger et al., 2009). Metabolic syndrome in children is irrevocably linked to obesity (Calcaterra et al., 2008; Rappaport, 2007; Weiss et al., 2004). In addition, the severe, negative effects on children's health and later health outcomes due to clustering of cardiovascular disease risk factors among metabolic syndrome patients should be noticed (Morrison, Friedman, & Gray-McGuire, 2007; Morrison, Friedman, Wang, & Glueck, 2008). Regardless of how metabolic syndrome is defined, there is ample evidence to demonstrate that metabolic syndrome components (including BMI, insulin resistance, TRIG/HDL-C, and BP) cluster across the developmental lifespan (Chen, Srinivasan, Li, Xu, & Berenson, 2007).
The links among obesity, type 2 diabetes, and metabolic syndrome have already been characterized in adult populations (Alberti, Zimmet, & Shaw, 2006). The clustering of hypertension, dyslipidemia, and impaired glucose tolerance can be summarized as the metabolic syndrome (Reaven, 1991). Compared with those without the syndrome, adults with the metabolic syndrome are at twice greater risk of dying from, three times greater risk of having cardiovascular complications (Eckel, Grundy, & Zimmet, 2005; Isomaa et al., 2001), and five times as likely to have type 2 diabetes (Stern, Williams, González-Villalpando, Hunt, & Haffner, 2004).

Obesity in children and adolescents is associated with an increase in cardiovascular risk factors, including hypertension, dyslipidemia, and elevated insulin levels, which are also indicators of metabolic syndrome (Anderson, 1990; Burke et al., 2005; Urakami et al., 2005). Obesity, particularly central (abdominal) obesity, is related with an increase in risk of cardiovascular disease (Burke et al., 2005). An increased risk of CVD morbidity and mortality in adulthood is also related to obesity in children and adolescents (Engeland, Bjørge, Sogaard, & Tverdal, 2003). It is known that many obese children and adolescents concurrently suffer from hypertension, reduced high-density-lipoprotein (HDL) cholesterol, increased triglyceride concentration, and insulin resistance (l’Allemand et al., 2008; Reinehr et al., 2005).

The relationship between obesity and type 2 diabetes can clearly be demonstrated in a study from Japan, where a parallel increase in type 2 diabetes and obesity in children has occurred over the past few decades (Urakami et al., 2005).
Obesity, especially central (abdominal) obesity, has been identified as an important predisposing cause for type 2 diabetes (Burke et al., 2005).

An ever-increasing problem is the increasing prevalence of obesity in childhood and adolescence (Ebbeling, Pawlak, & Ludwig, 2002). Obese children are likely to become obese adults (Ebbeling et al., 2002). Central (abdominal) obesity is also a key component in the IDF definition of metabolic syndrome in adults (Alberti et al., 2006). It is essential to notice that metabolic syndrome in children is irrevocably linked to obesity (Calcaterra et al., 2008; Rappaport, 2007; Weiss et al., 2004). Due to the increasing problem of obesity in children and adolescents, as well as links among obesity, risk factors for cardiovascular disease and for type 2 diabetes, metabolic syndrome needs to be systematically examined (Ice et al., 2009). Governments and society in general should pay more attention to the problems related to obesity and the likelihood of getting metabolic syndrome in children and adolescents (Zimmet et al., 2007).

Type 2 diabetes has been proven to be associated with cardiovascular disease. About 50–80% of almost 250 million adults worldwide with diabetes are at risk of dying from cardiovascular disease (Sicree, Shaw, & Zimmet, 2006). Therefore, to delay or prevent the development of overt disease, it is important to identify groups at risk of metabolic disorders before clinical manifestations emerge (Alberti et al., 2007). The significance of the early identification of children at risk of developing the metabolic syndrome and subsequently progressing to type 2 diabetes and cardiovascular disease in later life must not be ignored (Zimmet et al., 2007). Early detection and treatment is likely to reduce morbidity and mortality in adulthood and help keep to a minimum the
global burden of cardiovascular disease and type 2 diabetes mellitus (Alberti et al., 2007).

Specific treatment targeted at the underlying pathophysiology of the metabolic syndrome does not yet exist, but reducing adiposity, increasing physical activity, and therapy aimed at each of the risk factors present are thought to be helpful (Steinberger et al., 2009).

Table 11 summarizes some effects of metabolic syndrome on children’s health, development, and well-being.

Table 11

*Findings From Selected Studies on the Effects of Metabolic Syndrome on Children’s Health, Development, and Well-Being*

<table>
<thead>
<tr>
<th>Condition studied</th>
<th>Population</th>
<th>Findings</th>
<th>Data</th>
<th>Citation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence of overweight, future cardiovascular risk.</td>
<td>Children age 12-19 years</td>
<td>Metabolic abnormalities and metabolic syndrome are attributable in part to the increasing incidence of overweight. Adolescents with more metabolic abnormalities have higher C-reactive protein (CRP), which may be an indicator of greater metabolic derangement and future cardiovascular risk.</td>
<td>NHANES 1999-2000 and 1988-1994</td>
<td>de Ferranti, Gauvreau, Ludwig, Newburger, &amp; Rifai, 2006</td>
</tr>
<tr>
<td>Serum concentrations of uric acid</td>
<td>Children age 12-17 years</td>
<td>Serum concentrations of uric acid are strongly associated with the prevalence of metabolic syndrome and several of its components.</td>
<td>NHANES 1999-2002</td>
<td>Ford, Li, Cook, &amp; Choi, 2007</td>
</tr>
</tbody>
</table>
Table 11 (continued).

<table>
<thead>
<tr>
<th>Condition studied</th>
<th>Population</th>
<th>Findings</th>
<th>Data</th>
<th>Citation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonalcoholic steatohepatitis (NASH) and nonalcoholic fatty liver disease (NAFLD)</td>
<td>Children age 6-17 years</td>
<td>Metabolic syndrome is common among children with NAFLD and is associated with severity of steatosis, hepatocellular ballooning, NAS, NAFLD pattern, and the presence of advanced fibrosis.</td>
<td>Nonalcoholic Steatohepatitis Clinical Research Network (NASH CRN)</td>
<td>Patton, Yates, Unalp-Arida, Behling, Huang, Rosenthal et al., 2010</td>
</tr>
<tr>
<td>Intima-media thickness (IMT), androgens (testosterone)</td>
<td>Obese healthy postmenarcheal girls age 12-18 years</td>
<td>Testosterone was significantly related to metabolic syndrome and its components in obese adolescent girls.</td>
<td>Local data from Witten, Germany</td>
<td>de Sousa et al. (2010)</td>
</tr>
<tr>
<td>Acanthosis nigricans (AN)</td>
<td>School children in fifth grade</td>
<td>Children with AN who were classified as obese or morbidly obese were at significantly increased odds of having metabolic syndrome</td>
<td>Fifth-grade students in West Virginia Who had mild to severe AN.</td>
<td>Ice et al. (2009)</td>
</tr>
</tbody>
</table>

Food insecurity is one potential factor that may be related to overweight and obesity among children and adolescents (Bhattacharya, Currie, & Haider, 2004; Casey et al., 2006; Gulliford et al., 2006; Jiménez-Cruz et al., 2003; Kaiser & Townsend, 2005; Metallinos-Katsaras et al., 2009; Olson et al., 2007; Smith & Richards, 2007). In addition,
food insecurity may relate to the negative health consequences of overweight and obesity, including metabolic syndrome, which warrants its exploration.

Summary

Food insecurity can impact both nutritional and nonnutritional outcomes in adults and children (Nord, 2006). Reducing the prevalence of obesity is vital, because obesity can contribute to negative health outcomes. Obesity in children and adolescents is associated with an increase in cardiovascular risk factors, including hypertension, dyslipidemia, and elevated insulin levels (Anderson, 1990; Burke et al., 2005; Urakami et al., 2005). The clustering of hypertension, dyslipidemia, and impaired glucose tolerance can be summarized as the metabolic syndrome (Reaven, 1991). Despite the relationship of food insecurity and negative health outcomes, no studies have explored the association between food insecurity and metabolic syndrome among children and adolescents in the United States. The overall objective of this study was to examine the association between household food security status and prevalence of metabolic syndrome among U.S. children 12-18 years of age using data from the NHANES 1999–2006.
CHAPTER 3: METHODOLOGY

Sample Population

This study examined the association between household food security status and prevalence of metabolic syndrome among U.S. children 12-18 years of age. The sample for this study was representative of U.S. children between the ages of 12 and 18 years and drawn from 1999-2006 NHANES datasets. NHANES is a cross-sectional national representative health and nutrition survey conducted by the CDC, NCHS.

NHANES utilizes a complex, stratified, multistage probability sample of the U.S. civilian, non-institutionalized population (Ervin, 2009). The NHANES sample for the survey is selected to represent the U.S. population of all ages and uses oversampling to include hard-to-reach populations, such as low-income, children and adolescents age 12-19 years, older Americans, and minorities (African Americans and Mexican Americans; CDC, 2009d).

For this study, public-use data from the 1999-2006 NHANES were downloaded from the NCHS website and tabulated for analyses. NHANES data were collected in two-year cycles (i.e., 1999-2000, 2001-2002, 2003-2004, 2005-2006) (CDC, 2009d).

Subjects

According to the IDF criteria, metabolic syndrome should not be diagnosed in children younger than 10 years (Alberti et al., 2007). Children aged 10-11 years were not included in this study because of missing data for many of the analyses, especially labs (blood glucose, TG, blood pressure, etc.). Therefore, NHANES data for children and adolescents between the ages of 12 and 18 years old were examined. The sample
included those 12-18 years for both genders (male and female) and for all races (Hispanic, non-Hispanic White, non-Hispanic Black and Mexican American). Females that were pregnant or lactating at the time of data collection were excluded from all analyses.

Table 12

Parameters Collected in This Study

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit or meaning of data measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Year</td>
</tr>
<tr>
<td>Gender</td>
<td>Male/female</td>
</tr>
<tr>
<td>Race</td>
<td>Non-Hispanic White, non-White, non-Hispanic Black, Mexican, Hispanic, other race</td>
</tr>
<tr>
<td>BMI-for-age and gender</td>
<td>percentile</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>percentage of threshold</td>
</tr>
<tr>
<td>Blood glucose</td>
<td>mg/dL</td>
</tr>
<tr>
<td>Glycosylated Hemoglobin (HbA1c)</td>
<td>mg/dL</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>mg/dL</td>
</tr>
<tr>
<td>Triglyceride</td>
<td>mg/dL</td>
</tr>
<tr>
<td>LDL</td>
<td>mg/dL</td>
</tr>
<tr>
<td>HDL</td>
<td>mg/dL</td>
</tr>
<tr>
<td>Systolic blood pressure</td>
<td>mm Hg</td>
</tr>
<tr>
<td>Diastolic blood pressure</td>
<td>mm Hg</td>
</tr>
</tbody>
</table>
Measures

Table 12 summarizes all parameters collected on study participate for this study. Subjects utilized in this study must have waist circumference data plus data for at least one more parameter of interest. Requiring all parameters for participation was impractical in this study due to missing data and was a limitation, as previously noted.

Demographics

For the sample, age, gender, race, and household income were recorded.

Household Food Security Status

For NHANES, household food security status was evaluated using the U.S. Household Food Security Scale (Bickel et al., 2000; see Appendix A). In the NHANES household interview, one adult responded to the U.S. Household Food Security Survey Module questions (18 items for households with children under 18 years). Affirmative responses were used to compute scale scores for household food security status (Bickel et al., 2000). Food security status was assigned using revised categories in Table 7 (USDA, 2007). Since the methods used to evaluate households’ food security have remained unchanged (USDA, 2008), data of 2005 and earlier years and those for later years were directly comparable on the basis of corresponding categories (USDA, 2008).

During tabulation, numerical values ranging from 1 to 2 on the standard U.S. food security scale indicated marginal food security. Numerical values ranging from 3 to 5 for households with children, or from 3 to 7 for households without children, indicated low food security on the standard U.S. food security scale. Very low food security was
categorized by numerical values ranging from 6 to 10 for households with children or from 8 to 18 for households without children.

**Chronic Disease Risk**

Risk factors for type 2 diabetes mellitus were assessed using blood glucose and glycated hemoglobin. Risk for cardiovascular disease was assessed by using blood pressure, serum cholesterol, low density lipoprotein (LDL), high density lipoprotein (HDL) and triglycerides (TG). A fast of at least six hours was necessary to protect against potential false positives from post-prandial effects.

**Weight Status**

**Obesity.** The CDC guidelines (CDC, 2009b) were used to define obesity. Weight status was categorized using the following criteria of BMI-for-age and gender percentile: 1) underweight (< 5<sup>th</sup>); 2) healthy weight (≥ 5<sup>th</sup> to < 85<sup>th</sup>); 3) overweight (≥ 85 to < 95<sup>th</sup>); and 4) obese (≥ 95<sup>th</sup>).

**Central Obesity.** To define central obesity, IDF criteria were used. Central obesity was defined by waist circumference (WC) with race-specific values. If BMI was > 30kg/m², central obesity can be assumed and waist circumference did not need to be measured (IDF, 2010). Detailed standards to define central obesity are summarized in Table 13. In this study, we used the Europid values in the table because the primary race categories in the U.S. sample were primarily White, African American, or Hispanic.
Table 13

*Criteria of Central Obesity*

<table>
<thead>
<tr>
<th>Country/Ethnic group</th>
<th>Waist circumference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europids*</td>
<td>Male ( \geq 94 \text{ cm} )</td>
</tr>
<tr>
<td></td>
<td>Female ( \geq 80 \text{ cm} )</td>
</tr>
<tr>
<td>In the United States, the ATP III values ((102 \text{ cm male}; 88 \text{ cm female})) are likely to continue to be used for clinical purposes</td>
<td></td>
</tr>
<tr>
<td>South Asians</td>
<td>Male ( \geq 90 \text{ cm} )</td>
</tr>
<tr>
<td></td>
<td>Female ( \geq 80 \text{ cm} )</td>
</tr>
<tr>
<td>Based on a Chinese, Malay and Asian Indian population</td>
<td></td>
</tr>
<tr>
<td>Chinese</td>
<td>Male ( \geq 90 \text{ cm} )</td>
</tr>
<tr>
<td></td>
<td>Female ( \geq 80 \text{ cm} )</td>
</tr>
<tr>
<td>Japanese**</td>
<td>Male ( \geq 90 \text{ cm} )</td>
</tr>
<tr>
<td></td>
<td>Female ( \geq 80 \text{ cm} )</td>
</tr>
<tr>
<td>Ethnic South and Central Americans</td>
<td>Use South Asian recommendations until more specific data are available</td>
</tr>
<tr>
<td>Sub-Saharan Africans</td>
<td>Use European data until more specific data are available</td>
</tr>
<tr>
<td>Eastern Mediterranean and Middle East (Arab) populations</td>
<td>Use European data until more specific data are available</td>
</tr>
</tbody>
</table>

* In future epidemiological studies of populations of Europid origin, prevalence should be given using both European and North American cut-points to allow better comparisons.

** Subsequent data analyses suggest that Asian values (male 90cm; female 80cm) should be used for Japanese populations until more data are available.

Exams and Interviews in the Mobile Examination Center

Demographic information was collected during an in-home interview, while dietary intake, laboratory, health history questionnaires, and physical examination data were collected during scheduled visits to the Mobile Examination Center (MEC) (CDC, 2009c). Anthropometric data measured during the MEC visits, age (months), and gender were exported to Epi Info (version 3.3.2, CDC, Atlanta, GA) to generate age- and gender-specific BMI-for-age percentiles based on the 2000 growth charts (release 2000, CDC, Atlanta, GA).

For blood pressure, the average of up to four brachial systolic and diastolic blood pressure readings was used for the systolic and diastolic blood pressure values (CDC, New York City Government, 2010). Standardized techniques were used to obtain the blood pressure measurements. For biochemical parameters, drawing of fasting morning blood samples from the examinee’s arm was conducted by certified phlebotomists to test the blood lipid and glucose assay (CDC, 2004). Detailed descriptions of the anthropometric, venipuncture, and blood pressure measurement procedures are summarized in the anthropometry, laboratory, and physician examination procedures manuals (CDC, 2004).

Metabolic Syndrome

The existing IDF criteria were utilized for identifying metabolic syndrome (Alberti et al., 2007). For diagnosis of metabolic syndrome, the IDF criteria are listed in table 4. These data were collected from the NHANES files to categorize metabolic
syndrome status of participants as previously noted. Blood parameters were used in this study include triglycerides, HDL-cholesterol, and blood glucose.

Statistical Analyses

All statistical analyses were performed according to NHANES analytic guidelines (CDC, 2009c). Public-use data files were downloaded from the NCHS website and converted to PASW (formerly SPSS) data files for tabulation. Statistical analyses of the weighted samples were performed using SPSS Complex Samples, to account for the complex sampling design used in subject selection. Such weighting, using provided interview and mobile exam center weights, allowed for population-based estimates (correction for over- and undersampling), while also providing appropriate statistical standard errors. Data were prepared in PASW (version 17.0) using complex samples. Statistical hypotheses were tested at the $p < .05$ level of significance using a two-tailed $t$ statistic. Bivariate analyses were conducted to test for differences across household food-security levels for obesity, cardiovascular diseases, and metabolic syndrome risks for chronic diseases using analysis of covariance (ANOVA) with Bonferroni post hoc comparisons and the $X^2$ statistics. Logistic regression was controlled for age, gender, and race. Table 14 summarizes the statistical methods used in the study.
Table 14

Research Questions and Statistical Methods

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Statistical Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is the difference in obesity by food security status among children age from 12 to 18 years?</td>
<td>ANOVA, chi-square/logistic regression</td>
</tr>
<tr>
<td>2. What is the difference in central obesity by food security status among children age from 12 to 18 years?</td>
<td>ANOVA, chi-square/ logistic regression</td>
</tr>
<tr>
<td>3. What is the difference in metabolic syndrome by food security status among children age from 12 to 18 years?</td>
<td>ANOVA, chi-square/ logistic regression</td>
</tr>
<tr>
<td>4. What is the difference in markers of chronic diseases by food security status among children age from 12 to 18 years?</td>
<td>ANOVA, chi-square/logistic regression</td>
</tr>
</tbody>
</table>
CHAPTER 4: RESULTS

Survey Response

Data from 7,701 adolescents aged 12-18 years were obtained from the NHANES 1999-2006. Of those, 7,435 adolescents had food security data. In the sample, 266 data points were missing. The population size was estimated to be 26,714,182. All data are presented as unweighted sample size (n) and weighted population percent.

Characteristics of the Participants

Of the sample, 51.4% (n = 3,822) were male, and 48.6% (n = 3,613) were female. The majority of subjects [62.0%, n = 1,900 (unweighted sample)] were non-Hispanic White. Thirty eight% (n = 5,535) were non-White [14.2% (n = 2,366), non-Hispanic Black; 10.8% (n = 2,579), Mexican; 6.2% (n = 283), Hispanic; 6.7% (n = 307), other race]. The mean age of the children in this sample was 14.9 years.

Household Food Security Status

Table 15 summarizes the household food security status of this sample.

Table 15

<table>
<thead>
<tr>
<th>Household food security category</th>
<th>Proportion, n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Food Security</td>
<td>4831</td>
<td>75.9</td>
</tr>
<tr>
<td>Marginal Food Security</td>
<td>751</td>
<td>7.1</td>
</tr>
<tr>
<td>Low Food Security</td>
<td>1206</td>
<td>10.8</td>
</tr>
<tr>
<td>Very low Food Security</td>
<td>647</td>
<td>6.1</td>
</tr>
</tbody>
</table>
Tables 16 and 17 summarize obesity and chronic disease-related factors measured in this study. There were no significant differences in mean BMI-for-age percentiles by food security status ($p = 0.087$). There was a significant difference in mean waist circumference (percent of threshold) by food security status ($p < 0.001$). Post-hoc tests were conducted and children from high food secure households had a significantly lower percentage of individuals with the waist circumference risk factor than those from marginal food secure, low food secure, and very low food secure households. No significant differences were seen across the other levels in waist circumference risk factor ($p > 0.05$).

There was a significant difference in mean HDL level by food security status ($p = 0.019$). Children from high food secure households were found to have significantly higher mean HDL value (lower HDL risk), compared with children from marginal food secure ($p = 0.038$), low food secure ($p = 0.012$), and very low food secure ($p = 0.040$) households. Post-hoc tests were conducted, and children from high food secure households had significantly higher HDL than children from low food secure households. No differences were seen across the other levels in mean HDL value.
Table 16

Markers of Chronic Disease Among U.S. Adolescents 12-18 Years According to Food Security Status

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>High Food Security</th>
<th>Marginal Food Security</th>
<th>Low Food Security</th>
<th>Very Low Food Security</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SE 1</td>
<td>95% CI 2</td>
<td>Mean</td>
<td>SE 1</td>
</tr>
<tr>
<td>BMI-for-age percentile</td>
<td>62.6</td>
<td>0.73</td>
<td>(61.1, 64.0)</td>
<td>66.1</td>
<td>2.50</td>
</tr>
<tr>
<td>Waist Circumference 3</td>
<td>87.9</td>
<td>0.35</td>
<td>(87.2, 88.6)</td>
<td>87.9</td>
<td>1.06</td>
</tr>
<tr>
<td>Glucose</td>
<td>86.4</td>
<td>0.22</td>
<td>(85.9, 86.8)</td>
<td>86.7</td>
<td>0.67</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>160.1</td>
<td>0.75</td>
<td>(158.6, 161.6)</td>
<td>162.2</td>
<td>2.19</td>
</tr>
<tr>
<td>Triglyceride</td>
<td>82.6</td>
<td>1.71</td>
<td>(79.2, 86.0)</td>
<td>84.2</td>
<td>4.09</td>
</tr>
<tr>
<td>LDL</td>
<td>90.5</td>
<td>0.89</td>
<td>(88.8, 92.3)</td>
<td>94.5</td>
<td>2.44</td>
</tr>
<tr>
<td>HDL</td>
<td>51.2</td>
<td>0.22</td>
<td>(50.8, 51.7)</td>
<td>49.6</td>
<td>0.69</td>
</tr>
<tr>
<td>Systolic blood pressure</td>
<td>108.8</td>
<td>0.28</td>
<td>(108.2, 109.3)</td>
<td>109.4</td>
<td>0.59</td>
</tr>
<tr>
<td>Diastolic blood pressure</td>
<td>61.1</td>
<td>0.37</td>
<td>(60.4, 61.9)</td>
<td>60.4</td>
<td>0.58</td>
</tr>
<tr>
<td>Glycosylated Hemoglobin</td>
<td>5.14</td>
<td>0.01</td>
<td>(5.12, 5.16)</td>
<td>5.14</td>
<td>0.02</td>
</tr>
</tbody>
</table>

1Standard Error, 2Confidence Interval, 3Percent of Threshold.
### Table 17

**Percentage and Likelihood of Having Risk Factors for Chronic Disease by Food Security Categories for U.S. Adolescents 12-18 years**

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>High Food Security</th>
<th>Marginal Food Security</th>
<th>Low Food Security</th>
<th>Very Low Food Security</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>OR(^1)</td>
<td>95%CI(^2)</td>
<td>%</td>
<td>OR(^1)</td>
</tr>
<tr>
<td>Overweight</td>
<td>15.0</td>
<td>1.0</td>
<td>Referent</td>
<td>19.2</td>
<td>1.44 (1.12, 1.87)</td>
</tr>
<tr>
<td>Obese</td>
<td>15.5</td>
<td>1.0</td>
<td>Referent</td>
<td>21.3</td>
<td>1.32 (1.01, 1.74)</td>
</tr>
<tr>
<td>Central Obesity</td>
<td>17.6</td>
<td>1.0</td>
<td>Referent</td>
<td>25.4</td>
<td>1.52 (1.08, 2.15)</td>
</tr>
<tr>
<td>Glucose</td>
<td>2.8</td>
<td>1.0</td>
<td>Referent</td>
<td>3.1</td>
<td>1.01 (0.55, 1.86)</td>
</tr>
<tr>
<td>Triglyceride</td>
<td>5.3</td>
<td>1.0</td>
<td>Referent</td>
<td>6.0</td>
<td>1.41 (0.62, 3.23)</td>
</tr>
<tr>
<td>HDL</td>
<td>28.1</td>
<td>1.0</td>
<td>Referent</td>
<td>31.4</td>
<td>1.27 (0.94, 1.72)</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>4.9</td>
<td>1.0</td>
<td>Referent</td>
<td>3.8</td>
<td>0.83 (0.54, 1.28)</td>
</tr>
<tr>
<td>Metabolic Syndrome</td>
<td>2.8</td>
<td>1.0</td>
<td>Referent</td>
<td>3.7</td>
<td>1.41 (0.78, 2.52)</td>
</tr>
</tbody>
</table>

\(^1\)Odds Ratio, \(^2\)Confidence Interval.
Children from marginal food secure (44%, Odds Ratio: 1.44 [1.12-1.87]) and low food secure (44.0%, Odds Ratio: 1.44 [1.13-1.84]) households were significantly more likely to present with overweight than those from high food secure households (see Table 16). Adolescents from very low food secure households were not significantly more or less likely to be overweight than high food secure households.

Children from marginal food secure households were 52% more likely to present with central adiposity than those from high food secure households (Odds Ratio: 1.52 [1.08-2.15]). Children from low food secure households were 42.0% more likely to present with central adiposity than those from high food secure households (Odds Ratio: 1.42 [1.11-1.80]). Finally, children from very low food secure households were 51% more likely to have central adiposity than children from high food secure households (Odds Ratio: 1.51 [1.10-2.08]).

In our study, 3.1 percent (n = 246) of all adolescents had metabolic syndrome. Table 18 summarizes prevalence of having the waist circumference risk factor for metabolic syndrome by weight status and food security category.
Table 18

*Waist Circumference Risk¹ by Weight Status and Food Security Categories for U.S. Adolescents 12-18 Years*

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>High Food Security</th>
<th>Marginal Food Security</th>
<th>Low Food Security</th>
<th>Very Low Food Security</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overweight²</td>
<td>Obese³</td>
<td>Overweight²</td>
<td>Obese³</td>
</tr>
<tr>
<td>Central Obesity</td>
<td>56.1%</td>
<td>87.3%</td>
<td>62.1%</td>
<td>89.5%</td>
</tr>
</tbody>
</table>

¹ Having WC risk factor was based on being at 90th percentile or adult cut-off for waist circumference.
² Body Mass Index-for-age ≥ 85th percentile.
³ Body Mass Index-for-age ≥ 95th percentile.
CHAPTER 5: CONCLUSION, DISCUSSION, RECOMMENDATIONS

This study assessed the differences across household food security levels for obesity, central adiposity, and metabolic syndrome metabolic syndrome components among U.S. adolescent children 12 to 18 years of age. While mean BMI-for-age percentiles did not differ by food security status ($p = 0.087$), those from marginal and low food security households were significantly more likely to present with a BMI > 85th percentile than high food secure households. Adolescents from high food secure households also had significantly lower mean central obesity than those from marginal food secure and low food secure households ($p < 0.001$). However, markers of chronic disease and metabolic syndrome did not differ between groups. Children from high food secure households had significantly higher HDL than other children ($p = 0.019$). Overall, food security appears to be associated with decreased risk for overweight and central obesity among U.S. adolescents and children. This chapter will discuss the implications of these findings.

*Differences in Obesity, Central Obesity by Food Security Status*

Prevalence rates of childhood obesity in the U.S. have increased tremendously during the past three decades (Ogden et al., 2006; Ogden, Flegal, Carroll, & Johnson, 2002; Troiano & Flegal, 1998). The possible underlying causes of childhood obesity are eating more energy-dense high calorie foods, eating more food away from home, eating more prepared foods, walking less to school and other destinations, and spending more time watching television and using computers (Anderson & Butcher, 2006). The relationship of food insecurity to overweight and obesity is still unclear.

In this study, 15.5% children from high food secure households, 21.3% of
children from marginal food secure households, 20.3% of children from low food secure households, and 21.6% of children from very low food secure households were obese. Children from food secure households had lower prevalence of obesity than the national average level, while children from food insecure households had greater prevalence of obesity than the national level (Ogden & Carroll, 2010). This study supports other studies that found food insecurity to be positively related to childhood obesity. One possible explanation is that children who live in high food secure households may have a safer and better environment to play and participate in activities than those live in food insecure households (Babey, Hastert, & Brown, 2007; Farley, Meriwether, Baker, Watkins, Johnson, & Webber, 2007).

The results of this study indicated that children from marginal food secure and very low food secure households were more likely to be obese than their high food secure counterparts, while those from marginal food secure households and low food secure households were more likely to present with overweight than those from high food secure households. However, these are different from findings of other studies (Gundersen, Lohman, Eisenmann et al., 2008; Gundersen et al., 2009). Gundersen et al. (2009) used multiple measures of obesity taken from the NHANES 2001-2004 with a sample of 2,516 children between the ages of 8 and 17 years in very poor households. Gundersen et al. (2009) also controlled all demographic characteristics which were considered as confounders (age, gender, and race) in their study, but found that food insecure children were no more likely to be obese than their food secure counterparts across all measures of obesity. Reasons for the difference in findings between our study
and that of Gundersen et al. (2009) may be the different ages of children examined and the different sampling periods of the two studies. In addition, this present study examined all households with children, but Gundersen et al. (2009) only focused on households with annual incomes < 200% of the poverty line.

The difference between the findings of our study and others may also be attributed to the fact that we controlled for age, gender, and race. Dinour et al. (2007) argued that the relationship between food insecurity and overweight is uncertain. According to their review, the association between food insecurity and overweight among children was sometimes found to be significantly related but not consistently. The influences of gender, age, race, and/or income were considered to be the reason why the results for children are conflicting (Dinour et al., 2007). Alaimo, Olson, and Frongillo (2001b) found that among non-Hispanic White girls aged 8 to 16 years, food insufficient girls were 3.5 times more likely to be overweight than food sufficient girls. No increased rates of overweight were shown among food insufficient girls of other ethnic backgrounds aged 8 to 16 years and food insufficient boys of both age groups, when compared to food sufficient girls and boys (Alaimo, Olson, & Frongillo, 2001).

Bhattacharya et al. (2004) found no relationships between food insecurity and weight status for African American or White children of any age. Self-reports of food insecurity were associated with a significant higher incidence of overweight among 12- to 17-year-old Hispanic children (Bhattacharya et al., 2004).

Other factors may also influence the observed relationship between food insecurity and obesity. For example, Lyons et al. (2007) found that the relationships
between obesity and food insecurity are more significant when using self-reported data than when using measured data in the sample of respondents aged 12 or older by using two versions of Canadian Community Health Survey. Yet, self-reported data might not be as accurate as measured data.

In this study, the mean BMI-for-age percentile of the entire sample was estimated to be at the 63rd percentile. There were no significant differences in mean BMI-for-age percentiles by food security status ($p = 0.087$). This differs from other studies but is consistent with several studies. Martin and Ferris (2007) asserted that food insecurity did not increase the chance of childhood overweight in a cross-sectional retrospective study with a sample of 200 parents and their 212 children aged 2-12 years in Hartford, Connecticut. There were no significant differences in the prevalence of risk of overweight or obesity between food secure and food insecure children (Martin & Ferris, 2007). Gundersen, Lohman, Eisenmann et al. (2008) found the likelihood or risk of being overweight was not significantly different for food secure and food insecure children in a sample of 10- to 15-year-old low income youth. Food insecurity was found not to be significantly associated with the weight status of the child at the household level (Gundersen et al., 2008). The most recent data estimate that approximately one third of children in the United States were either obese or overweight in 2009 (Gundersen & Garasky, 2009). Data from NHANES 1976–1980 and 2003–2006 show that the prevalence rates of obesity for all age groups in the United States have increased dramatically (Ogden & Carroll, 2010). For children aged 12-19 years, prevalence of obesity was 16.9% according to NHANES 2007-2008 (Ogden & Carroll, 2010).
Children from marginal food secure, low food secure, and very low food secure households were found more likely to be centrally obese than their high food secure counterparts in our study. Because central obesity is a prerequisite for metabolic syndrome, this finding may foretell that children from marginal food secure, low food secure, and very low food secure households will be found more likely to have metabolic syndrome than their food secure counterparts. In our sample, those with more food insecurity had higher mean waist circumference percentile and metabolic syndrome risk. Few studies have examined the relationship between central obesity and food insecurity among U.S. adolescents and children. Based on our results, food insecurity appears to be a risk factor for central obesity among 12-18 years old adolescents. However, some adult studies have examined these factors. Shariff and Khor (2005) measured 140 Malay women and 60 Indian women and found that women from food insecure households were significantly more likely to have increasing waist circumference, but not obesity. The results of Shariff and Khor’s (2005) study were similar with the findings of our study. However, because the samples were in different age groups, different countries, and the periods of the studies were different, the consistency of the conclusions may not be very meaningful. However, these trends should be further examined.

As is known, central (abdominal) obesity is also a key component in the IDF definition of metabolic syndrome in adults (Alberti et al., 2006). There are also many diseases related with this risk factor. Central obesity is an independent risk factor for colorectal adenoma (Liu et al., 2010). Koo et al. (2009) found that central obesity is a risk factor for the development of erosive esophagitis. Kim, Doo, Yang, and Song (2010)
asserted that central obesity is the more important predictor of prostate volume and lower urinary tract symptoms than overall obesity.

While our study focused on metabolic syndrome and other related factors, the increased waist circumference associated with food insecurity may point towards increased risk for other chronic diseases. In this study, among obese adolescents in our study, 87% of high food secure, 90% of marginal food secure, 88% of low food secure and 91% of very low food secure adolescents also presented with central obesity. Our study showed that most obese children also presented with central obesity, whether or not they were food secure or food insecure, which is consistent with findings of Oğuz, Temizhan, Abaci, and Kozan (2008). Oğuz et al. (2008) conducted a nationally representative cross-sectional study, in which both urban and rural areas of seven geographical regions of Turkey 2110 men and 2154 women with a mean age of 40.9 ± 14.9 years (range 20-90) were included. Oğuz et al. (2008) found that central obesity was significantly associated with increases in BMI. However, because the samples were in different age groups and the periods of the studies were different, the consistency of the conclusions is not very meaningful. Yet, it supports the need to further examine these trends.

Risk Factors for Metabolic Syndrome

Metabolic syndrome is a clustering of hypertension, dyslipidemia, and impaired glucose tolerance (Reaven, 1991). Since obesity is related to food insecurity as indicated in several studies, the relationships of metabolic syndrome and risk factors to food insecurity were examined. In our study, 3.1% (n = 246) of all adolescents had metabolic
syndrome, which is lower than the national level reported by Cook et al. (2003). The prevalence of a metabolic syndrome has increased significantly in recent years among U.S. adolescents and is particularly prevalent (> 30%) in overweight adolescents (Duncan et al., 2004). Based on data obtained from the third NHANES 1988-1994, one million 12-19-year-old adolescents in the United States were estimated to have the metabolic syndrome, or 4.2% overall (6.1% of males; 2.1% of females; Cook et al., 2003). One possible major reason for this difference is that the former study used the modified National Cholesterol Education Program (NCEP) [Adult Treatment Panel III (ATP III)] criteria, while we used IDF criteria in our study. The samples were in different age groups and the periods of the studies were different. The trends of metabolic syndrome among adolescents should be explored. However, a consistent definition should be utilized.

The IDF developed a definition for metabolic syndrome in children and adolescents (Alberti et al., 2007). Impaired glucose tolerance/insulin resistance is one of clustering components for metabolic syndrome (Reaven, 1991). In the sample of our study, 2.8% of high food secure children, 3.1% of marginal food secure children, 3.7% of low food secure children, and 5.0% of very low food secure children had the glucose risk factor for metabolic syndrome. When food insecurity was more severe, the percentage of having glucose risk factor tended to be greater. However, there were no significant differences in having the glucose risk factor by food security category in this study (p = 0.817).
Based on data from NHANES 1999-2002, food insecurity was shown to be associated with diabetes mellitus among people over 20 years of age (Seligman et al., 2007). Nelson et al. (2001) examined data of adults with diabetes (n = 1,503) from the Third National Health and Nutrition Examination Survey and found that food insufficiency was relatively common among low-income adults with diabetes. In a longitudinal study conducted by Sharkey (2005), food sufficiency status became worse among older adults with diabetes. Gucciardi et al. (2009) analyzed data from Canadians with diabetes aged 12 years or older (n = 6,237) from a population-based cross-sectional survey, and found that the odds of household food insecurity were higher for individuals with diabetes than among those without diabetes. The differences in the findings might because that the samples were in different age groups and the periods of the studies were different.

Glycosylated hemoglobin (HbAlc), another indicator for measuring blood glucose, was also measured in this study. There were also no significant differences in mean HbAlc level by food security status ($p = 0.338$). All food security categories had mean HbAlc in normal range (4.0%-6.0%). In a study conducted in Appalachian Ohio adults, Holben and Pheley (2006) found that random blood glucose, HbA1c, and hemoglobin, and blood pressure in adults did not differ by food security status, which is in accordance with what we found in this study.

Children from high food secure households had significantly higher HDL than children from low food secure households in our study. A reasonable explanation for this is that children from food secure households may have greater levels of physical activity.
These lower levels of physical activity may be due to resource constraints or living in households located in poorer neighborhoods with less infrastructure (Babey et al., 2007). Similarly, the neighborhoods could be unsafe or isolated, limiting physical activity (Farley et al., 2007). Raitakari et al. (1997) found that a high level of physical activity was associated with a high serum high density lipoprotein cholesterol (HDL-C) concentration. Physical activity was found to have an indirect association with serum lipid and lipoprotein values (DuRant et al., 1993). In addition, children from food secure households also have better diet and lower frequencies of eating high fat, high sugar and high energy foods, which may decrease HDL level in the blood. Monge-Rojas et al. (2005) indicated that higher carbohydrate intake was a significant determinant of lower HDL cholesterol. Urban children had also been found to have lower systolic and diastolic blood pressure and higher HDL cholesterol concentrations (Monge-Rojas et al., 2005).

There were no significant differences in mean TG, LDL, systolic blood pressure, diastolic blood pressure, and total cholesterol by food security status, which are consistent with findings of Holben and Pheley (2006). Tayie and Zizza (2009) found intermediate-level food insecurity associated with some indicators of dyslipidemia among adult women but not among men. Compared with the high food secure, women who were marginal food secure were more likely to have abnormal levels of LDL-C and TG/HDL-C ratio (Tayie & Zizza, 2009). Women from low food secure households were more likely to have abnormal levels of TG (Tayie & Zizza, 2009). Studies should focus on children in the future to further explore these trends.
**Household Food Security Status**

The prevalence of household food insecurity from 1999 to 2006 in this sample of U.S. children was 24.1%, which was greater than the national estimates for households with children (Nord et al., 2009). For households with children, the prevalence of food insecurity increased beginning with the recession in 2001, then continued to increase in 2002-2004 in spite of renewed economic growth. It then declined to a level that remained about the same from 2005 to 2007 (Nord, 2009). The prevalence rates of food insecurity among households with children were 14.8% in 1999, 16.1% in 2001, and 16.0% in 2007 (Nord, 2003; Nord, 2009). From 1999 to 2007, the prevalence rates had never exceeded 20% (Nord, 2009). For households with children, the most recent U.S. national data indicated that 21.0% were food insecure during 2008 (Nord et al., 2009).

Several factors may account for the differences seen in this study, compared to national estimates. The national estimates for food insecurity are determined using CPS data of a nationally representative sample (CPS, 2010). As indicated earlier, the National Health and Nutrition Examination Survey also uses a nationally representative sample (CDC, 2009c). More specifically, the NHANES is a sample of individuals, not of households, but the main food security measure in the data is at the household level (Mark Nord, personal communication, July 15, 2010). If person-weighted statistics in the CPS for the same time period are compared, they are similar (Mark Nord, personal communication, July 15, 2010). In principle, the NHANES is nationally representative when weighted; therefore, the Current Population Survey and the NHANES should be in rough agreement (Mark Nord, personal communication, July 15, 2010). Yet, use of the
NHANES data may account for differences seen. In addition, only children 12-18 years were included in our study. The national estimates for households with children include children of all age groups. Older children may be at greater risk for food insecurity, as reported by Nord (2009), which also may account for our results.

Reasons for the difference in prevalence rates of food insecurity still need to be explored. A rational explanation might be that the difference between the national estimates reported by USDA and the prevalence rates measured in this study are due to dissimilar age groups of children studied. The prevalence rates of food insecurity among households with children in the U.S., as indicated by USDA, measured households with children of all ages (Nord, 2009). However, only households with children age from 12 to 18 years were examined in this study. Nord (2009) pointed out that younger children are protected from food insecurity by adults to a greater extent than older children. From 2006 to 2007, very low food security among children was about four times as prevalent in households with teenage children as in households with the oldest child 8 years old or younger (Nord, 2009). Therefore, it is reasonable to believe that it is because older children are less shielded by adults in households, compared with younger ones, that a higher prevalence rate of food insecurity among children was found in this study.

Another explanation for the higher prevalence rate of food insecurity in this study might be the influence of an economic recession. Miech et al. (2006) found that overweight showed a greater increase in households living below the poverty line than households not living below the poverty line among older (15-17 years) but not younger (12-14 years) adolescents. Andrews and Nord (2009) pointed out that there have been
two recessions—one from March to November 2001, and the other began in December 2007. The decline in food insecurity that began in the late 1990s was reversed with the onset of the 2001 recession (Andrews & Nord, 2009). From 1999, the prevalence rate of food insecurity began to increase and peaked in 2004, then fell in 2005, when it plateaued for two years. While not included in the present study, with worsening economic conditions (Andrews & Nord, 2009), food security also rose in 2008. Essentially, during the economic downturns, food insecurity becomes more common and severe due to job markets were weak and federal and local government assistance was cut down by tight budgets (Andrews & Nord, 2009). For general households, worsening economic conditions can be a contributing factor for increased food insecurity. The 2001 economic recession may have contributed to the increased food insecurity prevalence rates seen in this study.

Limitations of the Study

This study had several limitations, as noted below.

1. The assessment of cross-sectional data cannot represent a causal relationship. Data represent participant characteristics from a snapshot in time.
2. Some data from cross-sectional surveys are self-reported, and inherent self-reporting and recall bias may have occurred.
3. Some laboratory values for makers of chronic diseases were not collected following an ideal 8-12-hour fast. This will limit the ability to precisely detect the presence of risk, but non-fasting data were carefully assessed to provide conservative estimates of disease risk.
4. Data availability limited the analyses in this study, and this cannot control for all moderating variables in obesity and overall health status.

Conclusions and Recommendations

The prevalence of food insecurity from 1999 to 2006 in this study was greater than the national average level for households with children (Nord et al., 2009). One rational explanation might be that the difference between the national estimates reported by USDA and the prevalence rates measured in this study is due to dissimilar age groups of children examined. Because older children are less shielded by adults in households, compared to younger ones, a higher prevalence rate of food insecurity among our older children may be expected. The influence of economic recession in 2001 might be another possible explanation contributing to the trends observed.

Children from food secure households had lower prevalence than the national average level for obesity, while children from food insecure households had greater prevalence of obesity than the national level (Ogden & Carroll, 2010). This study showed that food insecurity has been found positively related to childhood obesity. Marginal food secure and very low food secure children were found more likely to be obese than their high food secure counterparts, while marginal food secure and low food secure were more likely to present with overweight than high food secure households. Children from marginal food secure, low food secure, and very low food secure households were found more likely to be central obese than their high food secure counterparts in our study. In our sample, as food insecurity severe, mean waist circumference percentile and metabolic syndrome risk increased. In sum, food secure children in this study were less
likely to present with overweight, obesity, and central obesity, compared to their food insecure counterparts.

Children from high food secure households had higher HDL level than their food insecure counterparts. No significant relationship between chronic disease risk factors such as blood glucose, triglyceride, LDL, systolic blood pressure, diastolic blood pressure, and total cholesterol and food insecurity was found in this study. However, studies should focus on those risk factors, as well as metabolic syndrome, in the future.

Obesity is of particular concern since it can lead to other chronic diseases, including hypertension, dyslipidemia, and elevated insulin levels (Burke et al., 2005; Urakami et al., 2005). Governments and society should pay more attention to the problems related to obesity and the likelihood of developing metabolic syndrome in children and adolescents. The situation of prevalent metabolic syndrome among children has not yet been formed but is already threatening. Actions of preventing and controlling childhood obesity and metabolic syndrome should be taken. That is to say, education and interventions should be taken into consideration and conducted by government, communities, schools, and caregivers. Since central obesity is a serious health risk factor for so many diseases, our findings are alarming for cardio-metabolic complications and underscore the need for population-based strategies to modify lifestyle related risk factors. More activities regarding the health of children should be set up in future.

Future studies should focus on interventions to improve food security among children. Reasons that could explain the differences in obesity and central obesity by food security in this population should be explored. Studies on the relationship between
food insecurity and waist circumference among children, the relationship between diabetes and food insecurity among children, and the relationship between cardiovascular diseases and food insecurity among children are limited so far. Finally, despite the relationship of food insecurity and negative health outcomes, no studies have explored the association between food insecurity and metabolic syndrome among children and adolescents in the U.S. This study will supplement the literature and supports the need for further exploration.
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Research Service:
http://www.ers.usda.gov/Briefing/FoodSecurity/labels.htm#labels


homeless and marginally housed HIV-infected individuals in San Francisco. 


APPENDIX A: U.S. HOUSEHOLD FOOD-SECURITY/HUNGER SURVEY
MODULE: 3-STAGE DESIGN (2 INTERNAL SCREENERS)

**Questionnaire transition into module—administer to all households:** These next questions are about the food eaten in your household in the last 12 months, since (current month) of last year, and whether you were able to afford the food you need.

**General food sufficiency question/screener: Questions 1, 1a, 1b (OPTIONAL: These questions are NOT used in calculating the food-security/hunger scale.)** Question 1 may be used as a screener: (a) in conjunction with income as a *preliminary* screen to reduce respondent burden for *higher income households only*; and/or (b) in conjunction with the 1st-stage internal screen to make that screen "more open"--i.e., provide another route through it.

1.  **[IF ONE PERSON IN HOUSEHOLD, USE "I" IN PARENTHETICALS, OTHERWISE, USE "WE."]**

   Which of these statements best describes the food eaten in your household in the last 12 months: --enough of the kinds of food (I/we) want to eat; --enough, but not always the kinds of food (I/we) want; --sometimes not enough to eat; or, --often not enough to eat?

   
   [1] Enough of the kinds of food we want to eat [SKIP 1a and 1b]  
   [2] Enough but not always the kinds of food we want [SKIP 1a; ask 1b]  
   [3] Sometimes not enough to eat [Ask 1a; SKIP 1b]  
   [4] Often not enough [Ask 1a; SKIP 1b]  
   [ ] DK or Refused (SKIP 1a and 1b)

1a.  **[IF OPTION 3 OR 4 SELECTED, ASK]** Here are some reasons why people don't always have enough to eat. For each one, please tell me if that is a reason why YOU don't always have enough to eat. [READ LIST. MARK ALL THAT APPLY.]

   YES NO DK  
   [ ] [ ] [ ] Not enough money for food  
   [ ] [ ] [ ] Not enough time for shopping or cooking  
   [ ] [ ] [ ] Too hard to get to the store  
   [ ] [ ] [ ] On a diet  
   [ ] [ ] [ ] No working stove available  
   [ ] [ ] [ ] Not able to cook or eat because of health problems

1b.  **[IF OPTION 2 SELECTED, ASK]** Here are some reasons why people don't always have the quality or variety of food they want. For each one, please tell me
if that is a reason why YOU don't always have the kinds of food you want to eat.
[READ LIST. MARK ALL THAT APPLY.]

YES NO DK
[ ] [ ] [ ] Not enough money for food
[ ] [ ] [ ] Kinds of food (I/we) want not available
[ ] [ ] [ ] Not enough time for shopping or cooking
[ ] [ ] [ ] Too hard to get to the store
[ ] [ ] [ ] On a special diet

BEGIN FOOD-SECURITY CORE MODULE (i.e., SCALE ITEMS)

Stage 1: Questions 2-6 —ask all households:

[IF SINGLE ADULT IN HOUSEHOLD, USE "I," "MY," AND "YOU" IN
PARENTHETICALS; OTHERWISE, USE "WE," "OUR," AND "YOUR
HOUSEHOLD;"

IF UNKNOWN OR AMBIGUOUS, USE PLURAL FORMS.]

2. Now I’m going to read you several statements that people have made about their
food situation. For these statements, please tell me whether the statement was
often true, sometimes true, or never true for (you/your household) in the last 12
months, that is, since last (name of current month).

The first statement is “(I/We) worried whether (my/our) food would run out
before (I/we) got money to buy more.” Was that often true, sometimes true, or
never true for (you/your household) in the last 12 months?

[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

3. “The food that (I/we) bought just didn’t last, and (I/we) didn’t have money to get
more.” Was that often, sometimes, or never true for (you/your household) in the
last 12 months?

[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused
4. “(I/we) couldn’t afford to eat balanced meals.” Was that often, sometimes, or never true for (you/your household) in the last 12 months?

[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

[IF CHILDREN UNDER 18 IN HOUSEHOLD, ASK Q5 - 6; OTHERWISE SKIP TO 1st-Level Screen.]

5. “(I/we) relied on only a few kinds of low-cost food to feed (my/our) child/the children) because (I was/we were) running out of money to buy food.” Was that often, sometimes, or never true for (you/your household) in the last 12 months?

[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

6. “(I/We) couldn’t feed (my/our) child/the children) a balanced meal, because (I/we) couldn’t afford that.” Was that often, sometimes, or never true for (you/your household) in the last 12 months?

[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

1st-level Screen ( screener for Stage 2): If AFFIRMATIVE RESPONSE to ANY ONE of Questions 2-6 (i.e., "often true" or "sometimes true") OR response [3] or [4] to Question 1 (if administered), then continue to Stage 2; otherwise, skip to end.

Stage 2: Questions 7-11 --ask households passing the 1st-level Screen: (estimated 40% of hh's < 185% Poverty; 5.5% of hh's > 185% Poverty; 19% of all households).

[IF CHILDREN UNDER 18 IN HOUSEHOLD, ASK Q7; OTHERWISE SKIP TO Q8]

7. "(My/Our child was/The children were) not eating enough because (I/we) just couldn't afford enough food.” Was that often, sometimes, or never true for (you/your household) in the last 12 months?

[ ] Often true
8. In the last 12 months, since last (name of current month), did (you/you or other adults in your household) ever cut the size of your meals or skip meals because there wasn't enough money for food?

[] Yes
[] No (SKIP 8a)
[] DK or R (SKIP 8a)

8a. [IF YES ABOVE, ASK] How often did this happen---almost every month, some months but not every month, or in only 1 or 2 months?

[] Almost every month
[] Some months but not every month
[] Only 1 or 2 months
[] DK or R

9. In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money to buy food?

[] Yes
[] No
[] DK or R

10. In the last 12 months, were you every hungry but didn't eat because you couldn't afford enough food?

[] Yes
[] No
[] DK or R

11. In the last 12 months, did you lose weight because you didn't have enough money for food?

[] Yes
[] No
[] DK or R
2nd-level Screen (screener for Stage 3): If AFFIRMATIVE RESPONSE to ANY ONE of Questions 7 through 11, then continue to Stage 3; otherwise, skip to end.

Stage 3: Questions 12-16 --ask households passing the 2nd-level Screen: (estimated 7-8% of hh's < 185% Poverty; 1-1.5% of hh's > 185% Poverty; 3-4% of all hh's).

12. In the last 12 months, did (you/you or other adults in your household) ever not eat for a whole day because there wasn't enough money for food?

   [ ] Yes
   [ ] No (SKIP 12a)
   [ ] DK or R (SKIP 12a)

12a. [IF YES ABOVE, ASK] How often did this happen---almost every month, some months but not every month, or in only 1 or 2 months?

   [ ] Almost every month
   [ ] Some months but not every month
   [ ] Only 1 or 2 months
   [ ] DK or R

[IF CHILDREN UNDER 18 IN HOUSEHOLD, ASK 13-16; OTHERWISE SKIP TO END.]

13. The next questions are about children living in the household who are under 18 years old. In the last 12 months, since (current month) of last year, did you ever cut the size of (your child's/any of the children's) meals because there wasn't enough money for food?

   [ ] Yes
   [ ] No
   [ ] DK or R

14. In the last 12 months, did (CHILD’S NAME/any of the children) ever skip meals because there wasn't enough money for food?

   [ ] Yes
   [ ] No (SKIP 14a)
   [ ] DK or R (SKIP 14a)

14a. [IF YES ABOVE ASK] How often did this happen---almost every month, some months but not every month, or in only 1 or 2 months?

   [ ] Almost every month
15. In the last 12 months, (was your child/ were the children) ever hungry but you just couldn't afford more food?

[ ] Yes
[ ] No
[ ] DK or R

16. In the last 12 months, did (your child/any of the children) ever not eat for a whole day because there wasn't enough money for food?

[ ] Yes
[ ] No
[ ] DK or R

**User Notes**

(1) **Response Options:** For interview surveys, DK (“don’t know”) and “Refused” are blind responses—that is, they are not presented as response options, but are marked if volunteered. For self-administered surveys, DK is presented as a response option.

(2) **Internal Screeners:** Two levels of internal screening are provided for survey designers who wish to reduce respondent burden for households not manifesting: (a) any level of food insecurity (1st-level screener); or (b) any signs of hunger (2nd-level screener). The optional Q1 also may be used in conjunction with the 1st-level screener to provide an additional, independent basis for passing households through the screen (i.e., making the screen somewhat less stringent).

To further reduce burden for higher-income respondents, a **preliminary** screener may be constructed using Q1 along with a household income measure. Households with income above twice the poverty threshold, AND who respond <1> to Q1 may be skipped to the end of the module and classified as food secure. (This preliminary screen should not be used for lower-income households.) Use of this preliminary screener reduces total burden in a survey with many higher-income households, and the cost, in terms of reduced accuracy in identifying food-insecure households, is slight. Research has shown that a very small proportion of the higher-income households screened out by this procedure will register food insecurity if administered the full module. Consequently, if Q1 is not desired for research purposes, a preferred strategy is to omit Q1 and administer Stage 1
of the module to all households. Administration time for Stage 1 is very nearly the same as administration time for the preliminary USDA food sufficiency question/screener.

(3) Time Reference Period: The scale items may be modified from the 12-month reference period to a shorter time period if required for your research design. The CPS food-security database includes 30-day reference periods for the more severe scale items (Q8-Q18) and other surveys have used the core module with reference periods shorter than 12 months. For example, the questionnaire items may be modified from the 12-month period to the 30-day reference period by changing the “last 12-month” reference in each question to “last 30 days.” In this case, items 8a, 12a, and 14a must be changed to read as follows:

8a/12a/14a: [IF YES ABOVE, ASK] In the last 30 days, how many days did this happen?
   ___ days
   [ ] DK

(4) Food-Security/Hunger Scale: Questions 2-16 provide a complete, validated set of food insecurity/hunger indicator variables for use in: (1) scaled measurement of the severity of household food insecurity and hunger; (2) classification of households according to designated severity ranges; and (3) comparison of food insecurity and hunger prevalence with national benchmark data. See Chapter 3 for detailed guidance on coding household responses and calculating household scale scores and status levels.


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