To the Graduate Council:

I am submitting herewith a dissertation written by Betty Phelps Greer entitled "Health Implications of Food Insufficiency." I have examined the final paper copy of this dissertation and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Human Ecology.

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HEALTH IMPLICATIONS OF FOOD INSUFFICIENCY

A Dissertation
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DEDICATION

To my daughter Ellen Greer Keim, who is not only a
wonderful daughter,
but a good friend,
I dedicate this work with love

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There are many people to whom I am grateful for making it possible for me to achieve this goal. I am especially grateful to my major professor, Paula Carney, who has been patient and understanding as I worked full-time on a job that demanded more than full-time while completing the requirements for this degree. Her guidance on this dissertation has been invaluable. I have benefited from my association with Dr. Carney as well as the rest of the faculty at the University of Tennessee. I would like to thank my dissertation committee, Dr. Michael Zemel, Dr. Betsy Haughton, and Dr. Bill Wallace for their invaluable support and I want to express appreciation to Ann Reed who provided consultation for statistical analysis.

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ABSTRACT

This study examined the relationship between food insufficiency and health outcomes in the third National Health and Examination Survey (NHANES III). The subjects were the food insufficient respondents and a comparison matched for income. The health outcomes in the study were the syndrome X conditions that included BMI, hypertension, and dyslipidemia, and the Global Health Assessment Scale (GHAS).

Subjects were classified as food insufficient if the family respondent reported that the family sometimes or often did not have enough food to eat. Using the multiple logistic regression procedure in SUDAAN, a proportional odds ratio (POR) was estimated to determine the association between health status and food insufficiency as well as between health status and the syndrome X conditions. A logistic regression analysis was used to estimate the association between the syndrome X conditions and food sufficiency. Because to their potential to impact health status, age, educational attainment, marital status, gender and race/ethnicity were included in the model as covariates.

Food insufficient subjects were 1.5 times more likely (CI = 1.06 - 2.06; p= 0.0033) to have fair/poor health status than food sufficient subjects. Overweight females were 2.6 times more likely to be food insufficient (CI = 1.24 - 4.74; p= 0.0026) than normal weight women. This finding did not hold true for the other syndrome X conditions or when men were included in the equation.

Overweight females who were food insufficient were 2.51 times more likely to report fair/poor health status than overweight food sufficient females (CI= 1.37 - 4.60; p= 0.0033). These findings were independent of age, marital status, or educational attainment.

The association between food insufficiency and overweight in women and on the overall health status should be of concern to policymakers and government agencies who provide services to this clientele. There are implications for policies that govern UDSA food supplemental programs as well as community education program. Based on these findings food insufficient subjects may be an added burden to the health care system that potentially could be reduced by focusing attention to reducing food insufficiency.

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PART I

GENERAL INTRODUCTION

INTRODUCTION

Approximately 10 percent of American households experienced some degree of food insecurity during a 12-month period ending August, 1998 meaning that they did not have access to enough food to fully meet basic needs (Bickel and Carlson, 1999). The prevalence of this problem varies considerably across income levels with the greatest prevalence among low-income individuals. Almost 37 percent of households with an income below the poverty level experienced difficulty in securing an adequate diet. However, food insecurity exists among individuals at higher income levels. (Andrews et al.1999).

In the past, it has been difficult to study the relationship between the phenomenon of inadequate food intake and health. There has been a lack of reliable data about the prevalence of this problem and an inability to link individuals who do not get enough to eat with health data. The National Health and Nutrition Examination Survey III (NHANES III) provides valuable data to study this relationship.

The phenomenon of an inadequate food intake due to lack of resources has previously been referred to as hunger. However, there has been no precise definition of hunger, which limited efforts to measure its prevalence in society. In the 1980's and early 1990's, considerable effort was made to establish measurable definitions and reliable instruments for gathering data. An expert-working group of the American Institute of Nutrition developed a conceptual framework for describing situations, which exist pertaining to an inadequate food intake associated with a lack of resources to obtain food. This expert panel developed conceptual definitions for

hunger, food security and food insecurity. These definitions are as follows (Anderson, 1990):

Food security - "*Access by all people at all times to enough food for an active, healthy life.* Food security includes at a minimum: (a) the ready availability of nutritionally adequate and safe foods, and (b) an assured ability to acquire acceptable foods in some socially acceptable ways (e.g., without resorting to emergency food supplies, scavenging, stealing or other coping strategies).

Food insecurity – *limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways.* Food insecurity includes problems with quantity of food, the quality of food, uncertainty about the food supply, and the feelings or emotions one has that is associated with his/her food situation.

Hunger – *The uneasy or painful sensation caused by a lack of food. The recurrent and involuntary lack of access to food.* Hunger is a potential, although not necessary, consequence of food insecurity. Malnutrition is also a potential, although not necessarily a consequence of food insecurity.

Food insufficiency - *An inadequate amount of food due to the lack of resources.* Food insufficiency is the term used in the National Health and Nutrition Examination Survey (NHANES) III as a measure of whether or not households have enough food to eat and, if they do not, the number of days they are without enough food to eat.

The terms used to describe this phenomenon, food insufficiency and food insecurity mean different things and therefore, are not interchangeable. For example, food insecurity captures the dimensions of diet quality and/or the emotional aspects, such as, worry and concern about having enough food to feed the family as well as not having enough food to eat. The term food insufficiency refers to not having enough food to eat (Alaimo et al. 1998; Andrews et al. 1999).

Measuring Food Sufficiency

Early efforts to estimate the prevalence of food insufficiency in the United States though population studies included the Community Childhood Hunger Identification Project (CCHIP) (FRAC, 1988) and the Continuing Survey of Food Intakes by Individuals (CSFII). The food insufficiency questions used in NHANES III were derived from the FRAC's CCHIP studies and through studies conducted at Cornell University (Radimer et. al., 1990; Radimer, et al., 1992). The questions were further refined at the National Center for Health Statistics (NCHS) Cognitive Research Laboratory (Bickel et al., 2000; Woteki et al., 1990; Briefel and Woteki, 1992; Frongillo, 1999). The questionnaire used in the NHANES III survey was pilot tested for external and face validity. External validity was established by positive responses that were found to be related to food expenditure and nutrient intakes (Basiotis,1992; Cristofar et al.,1992). Face validity was established by ascertaining respondent understanding of the question and ability to answer it easily (Briefel and Woteki, 1992; Alaimo, 1997).

The United States of Agriculture's Food and Nutrition Service led a collaborative effort to develop and test a comprehensive measure of the severity and prevalence of inadequate diets. This effort resulted in the food security questions used in the Current Population Survey (CPS) and implemented by the U.S. Bureau of Census. The CPS survey includes the constructs identified by Radimer et al. (1990) that are included in the currently used definition of food security included the dimensions of diet quality, quantity of food, psychological acceptability of available foods and social acceptability of available foods. The CPS

survey has been implemented each year since 1995. Food insufficiency questions dealing having enough to eat were included in the NHANES III survey starting in 1988 and were included in both phases that ended in 1994.

One advantage of using the NHANES III data is that there are numerous health-related variables in the data set. This allows examination of the relationship between food insufficiency and measures of overall health status and chronic disease conditions.

Income and Health

It is well documented that socioeconomic status is associated with increased prevalence of chronic disease (Rosen, 1976; Kitagawa and Hauser, 1973; Fiscella and Franks, 1997; Feldman et al.,1989; Calnan and Johnson, 1985; Dayal et al.,1982; Farmer, 1996; Rothman, 1986). Socioeconomic status is the strongest predictor of food insufficiency (Rose et al., 1998), but is not clear whether those who are food insufficient have poorer health status than individuals from similar socioeconomic levels.

High priority health concerns were identified in Healthy People 2010 (U.S. Department of Health and Human Services, 2000). Among those health concerns that were identified are the increased prevalence of obesity, diabetes, and high blood pressure. Other health concerns identified were an increase in the risk factors for heart disease such as high levels of total cholesterol, high levels of low-density lipoprotein (LDL)- cholesterol and low levels of high-density lipoprotein (HDL)- cholesterol. These are health conditions that are included in the group of metabolic disorders that have been referred to as syndrome X. Syndrome X is a term

that is used to refer to a cluster of metabolic conditions in which the body loses sensitivity to insulin action thus
reducing cellular capacity to remove glucose from the bloodstream (Roberts et al., 2000).

Low-income individuals and certain ethnic/racial groups are at a higher risk for the chronic disease conditions associated with syndrome X although individuals in all racial/ethnic groups and at all income levels are experiencing these problems. Food insufficiency is more common among low-income groups but a few individuals in higher income categories experience food insufficiency as well (Alaimo et al., 1998). It is of interest to study whether there is an association between syndrome X conditions and food insufficiency.

Purpose of the Study

The purpose of this study is twofold: to evaluate the impact of food insufficiency on health status in a nationally representative sample of adults and to study the association between food insufficiency and the chronic disease conditions associated with syndrome X.

Specific Aims of this Study

1. Identify food sufficient and food insufficient individuals at similar poverty income ratios;
2. Identify variables in NHANES III that are indicators of insulin resistance syndrome (also called syndrome X) conditions;
3. Identify the self-reported health status variable. This is called the Global

Health Assessment Scale (GHAS). Also, identify the variable that indicates the physician's impression of the examinee's health status; determine if these measures are independent of each other;

4. Determine if a relationship exists between indicators of insulin resistance and self-reported health status;
5. Determine if food insufficient individuals are more likely to have syndrome X conditions compared to food sufficient individuals; and,
6. Determine if food insufficient individuals are at greater risk for "poor" health when compared to food sufficient individuals in the same income category.

Research Questions

To study whether there is a relationship between food insufficiency, overall health status and syndrome X conditions, the following questions were developed to guide the research.

1. What is the relationship between syndrome X and food sufficiency?
2. Is there an agreement between the self-assessed GHAS and the physician's impression of the examinee's health status?
3. What is the relationship between the presence of syndrome X conditions with the GHAS health status?
4. Is there a difference between the number of syndrome X conditions and the level of GHAS health status?
5. Is there a relationship between food sufficiency and the odds of reporting an "fair/poor" GHAS rating?

Hypotheses

To test whether there is a relationship between food insufficiency, overall health status and syndrome X conditions, the following hypotheses were developed.

Ho:1 There is no relationship between syndrome X conditions and food insufficiency.

Ho:2 There is no agreement between the self-assessed GHAS and the physician's impression of the examinee's health status.

Ho:3 There is no relationship between syndrome X conditions and the GHAS health status.

Ho:4 There is no difference between the number of syndrome X conditions and level of GHAS health status.

Ho:5 There is no relationship between food insufficiency and the odds of reporting "fair/poor" GHAS rating.

REVIEW OF LITERATURE

Introduction

The focus of this study is on the relationship between food insufficiency and health status. Two aspects of health status were chosen. One is the Global Health Assessment Score which is measured by a single question that asks individuals to rate their overall health as "excellent," "very good," "good," "fair" or "poor." The other aspect of health status is the chronic disease conditions associated with insulin

resistance syndrome. This paper is organized into the following sections: Food Sufficiency, Food Insecurity and Hunger; Health Status and Food Insufficiency; Health and Socioeconomic Status; and Syndrome X. Studies were chosen for the literature review because of their focus on poverty, food insufficiency or food insecurity, the Global Health Status and the chronic disease conditions associated with the insulin resistance syndrome.

Food Insufficiency, Food Insecurity and Hunger

Prevalence

Food insufficiency is not evenly distributed in society. It varies among different socioeconomic groups of the population. Hamilton (1997) found that 17 percent of households with incomes less than 50 percent of the poverty level experienced hunger, the severest form of food insecurity, but only 1.4 percent of households with incomes greater than 185 percent of the poverty level experienced hunger. Approximately 36.7 percent of households with incomes below the official poverty level ($16,895 for a family of four in 1999) experienced food insecurity. In terms of individuals, about 31 million persons were food insecure according to data from CPS for the years from 1995 to 1999. Yet, almost two-thirds of those living below the official poverty line were food secure (Andrews et al., 1999).

According to NHANES III data, 4.1 percent of the population, approximately nine to 12 million Americans, lived in families that reported they were not getting enough to eat. About 66 percent of these individuals lived in families that reported they had no food or money to buy food for one or more days.

Four percent of those who reported they had no food or money to buy food said this problem existed for 14 days (Alaimo et al., 1998).

Food insufficient families were more likely than food sufficient families to be headed by a female. Hispanic households were food insufficient at higher rates (15 percent overall prevalence; 25 percent of low-income Hispanics) than other ethnic groups. Almost eight percent of all non-Hispanic blacks (regardless of income level) and approximately 14 percent of low-income non-Hispanic blacks (less than or equal to 185 percent of the poverty level) were food insufficient. Less than three percent of all non-Hispanic white Americans and 12 percent of low-income, non-Hispanic white Americans were food insufficient. Food insufficiency rates did not vary significantly by region of the country (Alaimo et al., 1998). Prevalence of food insecurity as measured by CPS is somewhat higher than the food insufficiency rates reported from the NHANES III survey. According to the 1995 CPS survey, 10.1 percent or approximately 31 million Americans were food insecure (Andrews, et al., 1998) while the NHANES III prevalence rate of food insufficiency is 4.1 percent (Alaimo, et al., 1998). This is probably because food security questions capture the quality of the diet and worry or uncertainty about having enough food as well as actually running out of food; whereas, the NHANES III data captures the dimension of not having enough to eat. The NHANES III data for food insufficiency are more similar to the CPS data for hunger.

Consequences of Food Insufficiency

Campbell (1991) developed a model for the nutrition and health outcomes associated with food insecurity. Two potential consequences of food insecurity are

proposed. One is the potential impact of food insecurity on the physiological mechanisms that are related to the individual's nutritional status. The other potential impact is on social and mental well-being. These factors have the potential to affect overall physical well-being and the quality of life for the individual.

Nutrient Intakes and Food Insufficiency

Data from the Continuing Survey of Food Intake by Individuals (CSFII) show individuals from food insufficient households consume lower intakes for vitamins A, E, C B6 and for magnesium (Rose and Oliveira, 1997; Rose, 1999). A study of food insecurity and nutritional adequacy conducted in Toronto, Canada reported that individuals from food insecure households consumed inadequate amounts of Vitamin A, folate, iron, and magnesium (Tarasuk and Beaton, 1999). In addition, Cristofar and Basiotis (1992) reported food insufficient women differed from food sufficient women in both the amount of food eaten and the type of food eaten.

Health Status and Food Insufficiency

Health consequences of food insufficiency and food insecurity are a concern and have been examined in several studies (Campbell, 1991; Rose, 1999; Olson, 1999). The NHANES III data provide an opportunity to examine the relationship between food insufficiency and health. One of the health variables that is found in the NHANES III data is a widely used epidemiological measure of health status called the Global Health Assessment Scale (GHAS). The GHAS scale is a single item question that asks respondents to rate their overall health as excellent, very

good, fair or poor (Manning, et al., 1980). The global self-evaluation question, or some variant of it, has been used in many major studies including NHANES III.

Self-report is a valuable epidemiological tool that can provide information about the general status of a group. This measure has been used extensively because it can be easily administered and because it provides a succinct way of summarizing the diverse components under the broader health status domain (Krause and Jay, 1994).

Self-reported health using the GHAS measure represents physical, emotional, and social aspects of health and well-being and correlates with the risk of mortality and morbidity (Idler and Ksal, 1991; Kaplan and Camacho, 1983). This measure explains physical health problems, such as limitations in physical functioning, chronic or acute conditions, and to a lesser extent, mental health problems. Younger individuals using this measure tend to consider high-risk behaviors or health related behaviors as a reference frame while older age groups are more inclined to think in terms of health problems (Krause and Jay, 1994). Extensive validation of this measure has been conducted (Idler and Angel, 1990; Idler et al., 1990; Idler and Kasl, 1991; Krause and Jay, 1994; Read et al.,1981; Stewart and Ware, 1992).

Few studies have been done to measure the impact of food insufficiency on self-reported health status. The GHAS measure in the NHANES III data enables researchers to study the overall impact of food insufficiency on overall health status. Sahyoun and Basiotis (2000) examined the relationship between the GHAS measure and food insufficiency in an elderly population in NHANES III. They found the elderly food insufficient group were more likely to report fair or poor health versus

good, very good, or excellent health. However, the authors reported neither the odds ratio nor the significance level of the statistics with their findings.

Health and Socioeconomic Status

The association between socioeconomic status and health is a long-standing epidemiological observation. Rosen (1976) is his book, *A History of Public Health*, discusses a long-standing association between poverty, poor health and mortality that has existed for centuries. This association between socioeconomic status and mortality in the U.S. continues to be of concern (Kitagawa and Hauser, 1973) and it is well documented that differences exist by socioeconomic status for mortality (Fiscella and Franks, 1997; Feldman et al.,1989), self-reported health status (Calnan and Johnson, 1985), survival from cancer (Dayal et al., 1982), and infectious diseases (Farmer, 1996). Most researchers recognize that socioeconomic status is an important determinant of health, illness and mortality. Because of this, socioeconomic status is often included as a control variable in statistical models for measuring some aspect of health (Rothman, 1986).

Inequalities in income and education underlie many health problems in the United States. Income and education are intrinsically related to each other and often serve as proxy measures for each other (Rothman, 1986). In general, the population groups that suffer the worst health status are also those who have the highest poverty rates and least education. Disparities in income and education levels are associated with an increased incidence of a number of chronic diseases including diabetes, hypertension, increased rates of heart disease and obesity (U.S. DHHS, 2000).

Syndrome X

The relationship between the prevalence of the health conditions associated with syndrome X and low-income persons has been studied, but few studies have been done to examine the relationship of these conditions to food insecurity or insufficiency independent of socio-economic status and poverty. Olson (1999) examined the relationship between food insecurity and body weight in a group of women of childbearing age in a rural county in upstate New York. She found that, after controlling for all available and known influences of obesity, household food insecurity was correlated with a higher body mass index (BMI) ($p=0.05$). Other conditions associated with syndrome X have been studied. These are hypertension, dyslipidemia and impaired insulin and glucose function (Reaven, 1988). No studies were found in the literature that examined the relationship between the other syndrome X conditions and food insecurity.

Syndrome X and Food Insufficiency

It appears paradoxical that individuals suffering from an inadequate intake of food would be overweight or obese, but hunger and obesity frequently occur simultaneously among poorer groups in the United States (Moore et al. 1962; Nestle and Guttmacher, 1992; Olson,1999). Dietz (1995) theorized that at least two possibilities could explain the association between inadequate diet and obesity in the same patient. He suggested that the most likely explanation was that foods with high-fat and/or high-sugar content were more easily accessible and consumed more

frequently. These foods may be consumed to prevent hunger at times when the family lacked enough money to buy food. Another possibility was that sporadic episodes of going without food combined with episodes of increased consumption of low-nutrient dense foods may lead to excess storage of fat.

Studies of normal weight and obese women (Manore et al. 1991; Wadden, 1992) and binge eaters found that subjects who had periods of diet restrictions had significantly more body fat than those who did not have periods of diet restriction. The binge eaters who did not restrict food had less body fat. Increased rates of obesity have been observed in a nationally representative sample of women who experienced food insecuity (Townsend et al. 2001). Possibly the metabolic mechanisms that resulted in increased body fat for the binge eaters with periodic diet restriction are the same mechanisms that resulted in increased body in fat food insufficient individuals who experienced periods of involuntary diet restriction.

Syndrome X and Obesity

The association between obesity and insulin resistance has been well established. (Reaven, 1988). Bogardus et al., (1985) found there was a significant decline in insulin action with increasing overweight up to approximately 28 -30 percent of body-fat. However, increases in body-fat beyond these values were not associated with significant changes in insulin action. Ferrannini et al. (1997) found overweight was associated with a statistically significant reduction in insulin sensitivity for overweight subjects with BMI above 25. He also found that 50 percent of overweight persons with a BMI of 28 or above were insulin resistant.

One explanation of insulin's role in weight gain is the effect of insulin on the expression of the human agouti gene in adipose tissue. Mynatt et al. (1997) found that insulin significantly increased weight gain in transgenic mice that express agouti in adipose tissue. The expression of the agouti gene in adipose tissue is a Ca+2 dependent mechanism which modulates energy metabolism and lipogenesis (Zemel et al., 2000).

Syndrome X and Insulin Function

Syndrome X, also called insulin resistance syndrome, is a statistical entity in which an array of metabolic abnormalities appear together in the same individual more than would be expected by chance alone (Valdez, 2000). Insulin has several functions in the human body. The best known is its regulation of carbohydrate, fat, and protein metabolism. It also has a role in the regulation of cell growth and differentiation and in gene expression. In muscle, insulin binds to its cellular receptor which sets off a chain of events that results in the uptake of glucose, phosphorylation, and glycogen storage. When this pathway is impaired muscle glycogen synthesis is reduced, excess insulin may be released, non-esterified fatty acids (NEFA) are increased, and gene expression may be altered (Roberts et al., 2000, Simoneau et al., 1999; Reaven and Law, 1999; Zemel et al., 2000). Many physiological conditions can result in impaired metabolic response to insulin. Some of these conditions are normal, such as aging, starvation, puberty and pregnancy. Some are abnormal physiological conditions and include obesity, diabetes, polycystic ovarian syndrome, Cushing syndrome and acromegaly (Valdez, 2000).

Reaven (1988), suggested that certain metabolic disorders coexist in a state of insulin resistance and introduced the term syndrome X (also called insulin resistance syndrome) to refer to these conditions. Since Reaven first proposed this concept, several epidemiological studies have documented that a clustering of metabolic disorders does coexist in individuals with insulin resistance (Haffner et al.,1992; Srinivasan et al.,1993; Meigs et al.,1997; Mykkanen et al.,1997). The metabolic disorders associated with insulin resistance include impaired glucose tolerance, hyperinsulinemia, dyslipidemia, and hypertension and obesity.

The Framingham Offspring Study (Meigs et al., 1997) used factor analysis to test the hypothesis that these conditions cluster together. They used non-diabetic subjects and collected clinical data, fasting, and 2-hour post-challenge insulin levels and fasting triglyceride and HDL-cholesterol levels, BMI, and waist-to-hip ratio were associated with one factor. Fasting and 2-hour glucose and insulin levels were associated with the second factor. Systolic blood pressure, diastolic blood pressure and BMI were associated with the third factor. The results were similar for men and women and for all subgroups.

Even though these conditions tend to cluster together, it is unclear whether insulin resistance precedes the development of these conditions. Some studies indicate that hyperinsulinemia may play a role in the development of these conditions (Haffner et al., 1992). It should be noted that not all conditions associated with the syndrome are present in all individuals (Barnard et al., 1998).

Resistance to insulin-stimulated glucose uptake is present in the majority of patients with impaired glucose tolerance and the compensatory response to this defect is to secrete more insulin, which leads to a state of hyperinsulinemia. It has

been estimated that one in four Americans may be at risk of developing syndrome X (Reaven, 1988).

Fasting insulin level is a widely used surrogate measure of insulin resistance (Weyer, et al., 2000). However, the most effective measure is the euglycemic hyperinsulinemic clamp. At present, the euglycemic clamp has not been used in large epidemiological studies such as NHANES III. Fasting insulin levels have been used as a proxy for hyperinsulinemia. Laakso (1993) investigated whether fasting insulin levels correlated with insulin resistant values obtained using the euglycemic clamp. He measured insulin response to an oral glucose load and quantified insulin resistance using the euglycemic hyperinsulinemic clamp technique to evaluate the correlation between insulin level and the degree of insulin resistance. Included in the study were subjects with normal glucose tolerance, impaired glucose tolerance, and non-insulin dependent diabetes. He found that in subjects who had normal glucose tolerance and fasting insulin levels less than 4 mU/liter, only 34 percent were insulin resistant. When the fasting insulin levels exceeded 13mU/liter, 74 percent of the individuals with normal glucose tolerance were insulin resistant, and if the fasting insulin level exceeded 18mU/liter all normoglycemic subjects were insulin resistant. Since the majority of the subjects with impaired glucose tolerance and non-insulin dependent diabetes mellitus (NIDDM) generally had low rates of whole-body glucose uptake, the fasting insulin level was not a good indicator of insulin resistance in these individuals. More than 70 percent of the individuals with impaired glucose tolerance and NIDDM were insulin resistant at any fasting insulin concentration and the proportion of subjects increased only moderately at high insulin concentrations.

Syndrome X and Hypertension

Many studies show a correlation between hypertension and hyperinsulinemia (Bhanot et al.,1996; Manicardi, 1986). However, not all patients with hypertension are insulin resistant and not all insulin-resistant patients have hypertension. In some, but not all studies, hypertension and insulin resistance coexist, but the correlation between blood pressure and plasma insulin levels is inconsistent (Jarrett, 1992). The association is strongest for increased systolic blood pressure and obesity (Edwards et al., 1994). The inconsistency of the association between hyperinsulinemia and hypertension has led to disagreement as to whether hypertension should be considered a part of the syndrome. Any effort to define a relationship must take into account the fact that the defects in insulin metabolism may only be relevant to the development of hypertension in a subset of patients with high blood pressure (Reaven, 1997).

In individuals where a relationship between hypertension and hyperinsulinemia is thought to exist, several mechanisms have been proposed to explain the relationship. DeFronzo and Ferrannini (1991) found that infusing normal individuals with insulin increased sodium retention, which included an effect on sympathetic nervous system activity through an increase in plasma catecholamine concentration (Rowe et al., 1981; Christensen et al., 1980). Another proposed mechanism addresses the effect of excess insulin on renal function to promote renal tubular sodium resorption (DeFronzo and Ferrannini, 1991) and at the proximal tubule to increase volume resorption (Baum, 1987). Other proposed mechanisms are through endothelial dysfunction or through reduced nitric oxide production (Banard

et al.,1998). The precise mechanism(s) for the relationship between insulin and hypertension remains unknown.

Syndrome X and Dyslipidemia

Abnormal lipid metabolism, such as increased LDL-cholesterol, decreased HDL-cholesterol and increased triglycerides, is included in the insulin resistance syndrome (Pan et al., 1997; Mitchell et al., 1992; Meigs et al., 1997). The Framingham Offspring Study and the Bogalusa Heart Study used factor analysis to identify variables that cluster in individuals who are insulin resistant and found that triglycerides, HDL-cholesterol, BMI and wiast to hip ratio (WHR) load in factor one. These findings were independent of age, sex or ethnicity (Meigs et al. 1997).

Increases in triglycerides and LDL-cholesterol and decreases in HDL-cholesterol in insulin resistant persons may be the result of a reduction of insulin-mediated glucose uptake and insulin resistant suppression of non-esterified fatty acids (NEFA). Insulin regulates NEFA. Small increases in insulin concentration can suppress NEFA levels. Circulating NEFA are the major substrate for triglyceride synthesis in the liver leading to an increased triglyceride synthesis which results in competition between endogenous and exogenous triglyceride for lipolysis. Increased insulin is also associated with an increase in the cholesterol ester transfer protein (CETP) mass and activity which impacts the neutral lipid transfer of triglycerides from VLDL to HDL and the reciprocal transfer of cholesterol ester to VLDL. This results in a decrease in the protective HDL-cholesterol. There is also an increased transfer of triglycerides from VLDL to LDL particles which leads to an increase in small, dense LDL-cholesterol particles (Reaven and Law, 1999).

SUMMARY

The prevalence of food insufficiency, food insecurity and hunger in America has been well documented but the health implications are unclear. Studies have shown that income is the strongest predictor of food insecurity, but not all low-income individuals are food insecure and some with higher incomes are food insecure. Income is also strongly linked to health status. Low-income individuals have also been reported to have poorer health status than higher-income individuals. It has not been determined if individuals who are food insufficient have poorer overall health status than food sufficient individuals that is independent of socio-economic factors.

The concept of syndrome X or insulin resistant syndrome has been well established and numerous studies have been carried out to elicit the metabolic disorders associated with this condition. Conditions associated with this syndrome include obesity, hypertension, dyslipidemia, high blood glucose, and impaired insulin function. Diet quality is linked to these conditions and it has been established that these conditions are more prevalent in lower socio-economic groups than in high-income groups. It has not been determined if these conditions are more strongly associated with those who report food insufficiency than those who are food sufficient independent of income and other socio-economic factors.

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PART II

FOOD INSUFFICIENCY IS LINKED TO POOR HEALTH STATUS

ABSTRACT

Objectives. The purpose of this study was to examine the association between health status and food insufficiency.

Methods. The food insufficient subjects and a comparison group who were matched for income were chosen from the third National Health and Nutrition Examination Survey. Subjects were classified as "food insufficient" if the family respondent reported that the family sometimes or often did not have enough to eat. Health status was measured using the Global Health Assessment Scale. Using the multiple logistic procedure in SUDAAN, a prevalence odds ratio (POR) was calculated to determine the association between health status and food insufficiency. Age, educational attainment, gender, marital status and race/ethnicity were included in the model as covariates. The association between self-reported health status and the physician's assessment of the examinee's health was calculated using McNemar's test for repeated measures.

Results. Food insufficient subjects were 1.5 times more likely to have poor health status (CI= 1.16-2.06; p=0.0033) than those who are food sufficient. This finding is independent of soicodemographic factors such as education, martial status, gender and income. There was significant agreement between the self-reported health status and the physician's assessment of the examinee's health status (p=0.05).

Conclusions. There is a significant association between food insufficiency and fair/poor self-reported health status. Poorer health associated with food insufficiency has implications USDA food support programs and for public policy related to access to culturally acceptable foods for individuals at risk for food

insufficiency. It may also have implications for reducing the cost of health care in our society

INTRODUCTION

People who do not have enough food to eat may have increased risk for poorer health outcomes compared to individuals with enough food to eat (Olson, 1999; Sahyoun and Basiotis, 2000). Having enough food to eat is a problem that affects approximately 10 percent, or 31 million Americans, but low-income individuals experience this problem at a much higher rate than those with higher incomes (Alaimo et al. 1998; Rose et al. 1998).

There is a long-standing association between socioeconomic status and health. In his book, *A History of Public Health*, Rosen (1976) describes the association between poverty and poor health that has existed. Socioeconomic status is an accepted determinant of health, illness and mortality and is often used as a control variable in statistical models measuring various aspects of health (Rothman, 1986).

One of the most widely used epidemiological measures of health status, the Global Health Assessment Scale (GHAS), asks respondents to rate their overall health as excellent, very good, fair or poor (Manning, et al. 1980). The global self-evaluation question, or some variant of it, has been used in many studies including the National Health and Examination Survey (NHANES). This measure has been used extensively because it can be easily administered and because it provides a

succinct way of summarizing the diverse components under the broader health status domain (Kease and Jay, 1994).

A study of an elderly, food insufficient population in NHANES III examined the relationship between food insufficiency and health status. The elderly individuals from food insufficient households were more likely to report fair or poor health compared to good, very good, or excellent health (Sahyoun and Basiotis, 2000).

The purpose of this study was to examine whether individuals from food insufficient households have poorer health status than individuals who are from food sufficient households in a nationally representative sample of adults.

METHODS

The data used in this study are from the NHANES III survey, which is a cross-sectional representative sample of the US civilian, non-institutionalized population. NHANES III consisted of two components: a household interview conducted in the home and an interview and examination conducted in the mobile examination unit. Standardized protocols were used for all interviews and examinations.

Food Insufficiency Variable

Food sufficiency status was determined by the response to the question "Do you 'always have enough foods to eat,' 'sometimes not enough to eat,' or 'often not enough food to eat?" A survey participant was classified as "food insufficient" if the family "sometimes" or "often" did not get enough to eat. This convention has

been adopted by other researchers studying this phenomenon (Alaimo et al., 1998; Rose and Oliveria, 1997; Cristofer and Basioits, 1992). The food sufficiency questions were tested for reliability. The questions were found to be a reliable measure of "an inadequate food intake due to lack of resources."(Briefel and Woteki, 1992). Findings also showed the respondents understood the question and could answer it correctly (Briefel and Woteki, 1992; Carlson and Briefel, 1995; Alaimo, 1997). In the second phase of the NHANES III survey, 1991 through 1994, questions were added to capture whether it was necessary to cut the size of the meal or skipped meals for the adults and/or children because there was not enough money for food. These questions were not included in this study since they did not cover both phases of NHANES III. A randomly chosen comparison group of food sufficient subjects, matched for income, were selected from respondents who said they always have enough food to eat.

Global Health Status Variable

All NHANES III participants were asked to rate their health status using the Global Health Assessment Scale GHAS). This is a five-category question in which the respondents were asked "Is your health in general excellent, very good, good, fair or poor." The GHAS measure of health status has been used in many major studies including NHANES III, the National Health Interview Survey, the Rand Health Insurance Experiment and the Medical Outcomes Study. The GHAS measure of health correlates with the risk of mortality and morbidity (Idler and Ksal, 1991; Kaplan and Camacho,1983) and captures limitations in physical functioning, chronic or acute conditions and to a lesser extent mental health problems (Krause

and Jay, 1994). Extensive validation of this measure has been conducted (Krause and Jay, 1994; Idler and Angel, 1990; Stewart and Ware, 1992).

Sociodemographic Variables

The sociodemographic variables included in this study were income, race/ethnicity, education, marital status, gender, and educational level. This information was gathered during the household interview.

The total family income for the previous 12 months was reported and a poverty income ratio (PIR) was calculated by the Centers for Disease Control (CDC) using a formula based on the federal poverty line that allows comparison across the span of the survey. For this study, income categories were based on work by Alaimo (1998), who used the federal assistance program eligibility criteria cutoff points. A PIR of less than or equal to 130 percent of the poverty line was considered low income. Low-middle income was a PIR of 131 to 185 percent of the poverty line; middle income was a PIR of 186 to 350 percent of the poverty line and high income was a PIR greater than 350 percent of the poverty line.

As a part of the CDC's data-cleaning phase, age was calculated using the birth date from the household family questionnaire. The race/ethnicity of the subjects was classified as non-Hispanic white, non-Hispanic black, Mexican-American, or Other based on information given at the interview.

Exclusion Criteria

Exclusion criteria included individuals who were 17 years old or younger, pregnant or if the interviewer rated the household family questionnaire as "unreliable."

Statistical Analysis

Descriptive data for the variables was estimated using the CROSSTAB and DESCRIPT procedures in SUDAAN which takes into account the sampling procedure used in NHANES III to provide weighted counts and percentages for the variables. The weighting variable used for analysis of the association of food insufficiency to health status was the total household interview weighting variable. The weighting variable for the agreement between the physician's assessment of the examinee's health and the self-reported health status was the total Mobile Examine Clinic variable. These were chosen to represent the smallest number of subjects in the data for that particular analysis.

To examine the association between self-reported health status and the physician's agreement of the examinee's health status, the CROSSTAB procedure was used. The number who agreed on the health status as well as the number who disagree was determined. The McNemar's test for repeated measures was used to calculate and test the significance difference between the physician's and respondent's assessment of health status (Kuzma, 2001). Prevalence odds ratio (POR) for the impact of food insufficiency on health status and the corresponding 95 percent confidence intervals were estimated by multiple logistic regression analysis with a robust variance estimation method using SUDAAN. All point

estimates were weighted to reflect the population distribution and non-response of some respondents. PORs were adjusted for age and education by including these in the model as continuous variables. Covariates included in the model due their potential impact on overall health status were: gender, marital status, and race/ethnicity.

RESULTS

There was a total of 2,089 subjects in the study (weighed count = 4,233,185) that included 1015 (weighted count = 2,189,256) food sufficient and 1074 (weighted count = 2,043,929) food insufficient subjects. Because some groups were oversampled, there was a smaller number of subjects for the food sufficient subjects but they represented a larger number of people. The average age of all subjects in this study was 44.7 years (sd = 20.2 years). The average age of food sufficient subjects was 49.9 years (sd = 21.5 years) and the average age for food insufficient was 39.9 years (sd = 17.5 years). For all subjects in the study, the average years of school completed was 8.6 years (sd = 4.2) with food sufficient subjects completing an average 9.4 years (sd = 4.1) and food insufficient subjects completing an average of 8.3 years (sd = 4.2) (Table 1).

There was significant agreement between how the physician and the individual rated his/her overall health status. The physicians rated 1114 examinee's health as good or better and 99 as fair or poor. Seventy hundred and seventy-five individuals rated their health status as good or better and 162 rated their health as fair or poor. McNemar's formula was used to test for significance. Using this

formula, a critical X^2 value of 3.841 or more is needed for significance at p=<0.05 (Kuzma, 2001). The equation is given below.

$$X^2 = (b-c)^2/b+c.$$

$$X^2 = (99 - 162)^2/99+162$$

$$X^2 = 15.21$$

Since 15.21 exceeds the critical X^2 value of 3.841, the result is significant at p=<0.05 indicating a significant agreement between the individual's and the physician's assessment of health status.

The results of the multiple logistic regression model showed that food insufficient subjects reported poorer health compared to food sufficient subjects. In Table 2, the POR for food insufficient subjects reporting poor health compared to food sufficient subjects was 1.55 (CI= 1.16-2.06; p= 0.0033). These findings were independent of the socioeconomic factors age, race/ethnicity, educational attainment, gender and marital status. Mexican-American subjects were more likely to report poor health compared to non-Hispanic whites (POR = 2.39; CI=1.78-3.20; p=<.0000). There was no difference in the odds of reporting poor health for non-Hispanic blacks and the Other racial/ethnic group compared to non-Hispanic whites (non-Hispanic blacks: POR = 1.16; CI = 0.89 - 1.53; P = 0.27; Other: POR 1.04; CI= 0.62 - 1.75; P= 0.89).

Table 1 – Comparison of food sufficient and food insufficient subjects in NHANES III for age and educational attainment.

	Total =2089 Sum of weights =4,233,185	Food Sufficient Sum of weights =2,189,256	Food Insufficient Sum of weights=2,043,929
Age (average, years)	44.7 (sd=20.2)	49.9 (sd=21.5)	39.9 (sd=17.5)
Education (average years completed)	8.6 (sd= 4.2)	9.4 (sd= 4.1)	8.3 (sd= 4.2)

Table 2 – Prediction of poor health status for individuals from food insufficient households in NHANES III

	Parameter estimate	SE	POR	95% CI	p-value
Intercept	-4.29	0.30			
Sufficiency status					
Sufficient	0.00	0.00	1.00	.	.
Insufficient	0.44	0.14	1.55	1.16-2.06	0.0033
Race/ethnicity %					
Non-Hispanic white	0.00	0.00	1.00	.	.
Non-Hispanic black	0.15	0.13	1.16	0.89-1.53	0.2655
Mexican-Amer.	0.87	0.15	2.39	1.78-3.20	0.0000
Other	0.04	0.26	1.04	0.62-1.75	0.8667
Gender %					
Male	0.00	0.00	1.00	.	.
Female	0.23	0.12	1.26	0.99-1.62	0.0621
Marital Status					
Married with spouse	0.00	0.00	1.00	.	.
Married no spouse	0.29	0.33	0.65	0.37-1.12	0.1200
Living as married	-0.04	0.25	0.96	0.57-1.63	0.8891
Widowed	-0.37	0.25	1.16	0.72-1.87	0.5400
Divorced	0.46	0.33	0.82	0.45-1.47	0.4941
Separated	0.20	0.49	0.76	0.31-1.84	0.5361
Never married	0.09	0.18	1.03	0.72-1.46	0.8871
Age at interview	0.02	0.01	1.01	1.01-1.04	0.0001
Highest grade completed	-0.11	0.03	0.89	0.84-0.95	0.0011

Age and educational attainment significantly influenced poor health status. For each year of age there was a 1.01 increase in the POR for reporting poor health (CI = 1.01- 1.04; p = 0.0011). Each year of education reduced the likelihood of reporting poor health (POR = 0.89; CI = 0.84 - 0.95: p = 0.0011).

CONCLUSIONS

Based on findings in this study, food insufficient adults have poorer overall health than adults who are food insufficient. Poor health and food insufficiency have common socioeconomic correlates such as income, age, race/ethnicity, education, gender and marital status (Rosen, 1973; Alaimo, 1998, Campbell, 1991) but the association between health status and food insufficiency was independent of these factors. These data do not allow us to identify the specific component that influenced the respondent's assessment of his/her health status. The global nature of the health status measure captures many aspects of health and research has shown that the respondent thinks of specific health problems when asked to rate his/her health. Some think of specific health related behaviors and others consider mental and emotional well-being (Krause and Jay, 1994).

The finding of a relationship between food insufficiency and health status is noteworthy and there are may be many possible explanations. The relationship may be partially explained by the impact of poor diets on the physiological mechanisms that are influenced the nutritional status of the individual. Rose (1999) found that

food insufficient individuals consumed a significantly lower intake of eight different nutrients. Poor nutrition has the potential to diminish the individual's sense of well being even though a specific disease condition cannot be diagnosed, and therefore, may impact how the subject would rate health status on the GHAS scale.

Another potential consequence of food insufficiency is related to social or mental health. These conditions affect the individual's sense of well being and may explain part of the association between self- reported poor health and food insufficiency. When reporting health status, individuals may consider general, non-specific health matters that are impacted by physical or mental conditions. This aspect of the association between reported poor health and food insufficiency is consistent with the model developed by Campbell (1990), in which she identified social and mental well being as a potential consequence of food insecurity.

In this study, Mexican-Americans were significantly more likely to have poorer health status than non-Hispanic whites, non-Hispanic blacks or the "other" group. There was no significant difference in the likelihood between non-Hispanic blacks and non-Hispanic whites for poor health. These findings are supported by Alaimo (1998) who found that Mexican-Americans were twice as likely to be food insufficient as non-Hispanic whites but found no difference in the prevalence of food insufficiency between non-Hispanic blacks and non-Hispanic whites. The poorer health status of Mexican-Americans may be due to several factors. For many Mexican-American immigrants, there is a language barrier that may reduce their

willingness to seek preventive health care. Many may in this country illegally and do not have access to resources that enable them to participate in the health care system or may not seek medical care for fear of disclosure of their illegal status.

As expected, older individuals and those with less education reported poorer health status than younger people or those with more education. This is consistent with numerous studies that have shown a relationship between poor health and education and poor health status and age (Link and Phelan, 1986; Rosen, 1976).

Limitations of the study

Although the NHANES III survey is a representative sample of the non-institutionalized U.S. population, a number of limitations should be considered. Because this is a cross-sectional design, any inferences regarding cause and effect should be made with caution and should be considered preliminary. Use of secondary data has limitations. Analysis is limited to wording of questions in the survey instrument. For example, food security status could not be measured using this data because it did not capture the emotional aspect of worrying about running out of food. This study is limited to a dichotomous, independent variable for food insufficiency rather than the ordinal levels of food insecurity. The questionnaire for measuring food insecurity has been revised since NHANES III was implemented and future NHANES data provide the questions that will measure food insecurity.

Suggestions for Additional Research

Given the cost of health care and the prevalence of food insecurity in this country, more studies are need to examine the specific relationship between health status and food insufficiency. Additional studies are also needed to examine how USDA's food assistance programs can improve services to reduce the prevalence of food insecurity in this country. Studies are also needed to identify the impact that community nutrition education programs have on food insecurity.

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PART III

SYNDROME X CONDITIONS OF INDIVIDUALS FROM FOOD-INSUFFICIENT HOUSEHOLDS

ABSTRACT

Objectives. The purpose of this study was to examine the association between food insufficiency and syndrome X conditions that include impaired glucose metabolism, insulin resistance, hypertension, obesity and dyslipidemia, and to examine the association between these conditions and self-reported health status.

Methods. Data were analyzed from the third National Health and Nutrition Examination Survey. Using data from the household questionnaire, individuals were classified as "food insufficient" if the family respondent reported the family sometimes or often did not get enough food to eat. The syndrome X variables were selected from the household questionnaire, the MEC examination data and the laboratory data. Health status was determined by the response to the Global Health Assessment Scale (GHAS) question. Prevalence odds ratio (POR) for the impact of syndrome X on health status was estimated using the multiple logistic regression procedure using SUDAAN. The POR for the relationship between syndrome X and food insufficiency was estimated using logistic regression analysis in SUDAAN.

Results. Overweight women were 2.6 times more likely to be food insufficient than normal weight women (CI=1.24-4.74; p=0.0026) and were 2.51 times more likely to report poor health status (CI=1.37-4.60; p=0.0033). These findings were independent of age, educational attainment, marital status, and race or ethnicity.

Conclusions. Obesity is significantly associated with food insufficiency and poorer health status. The health consequences of food insufficiency are important considerations for policy makers and health care agencies.

INTRODUCTION

One in four Americans may be at risk for syndrome X (Reaven, 1988), also called insulin resistance syndrome. This metabolic disorder involves impaired glucose metabolism, insulin resistance, hypertension, obesity and dyslipidemia (Reaven, 1988; Chen et al 1999; Pan et al. 1997; Mitchell et al. 1992; Meigs 1997) and is independent of age, sex or ethnicity (Meigs, et al. 1997; Chen, et al. 1999). Not all conditions associated with the syndrome are present in all individuals (Barnard et al. 1998) and it is unclear whether insulin resistance precedes the development of these conditions. The conditions associated with syndrome X have been identified as prevalent among low-income individuals (Rosen, 1993; Kitagawa and Hauser; Fiscella and Franks, 1997; Feldman et al. 1989; Calnan and Johnson, 1985; Ross and Wu; Dayal et al. 1982; Farmer, 1996 and Rothman, 1986).

The most effective measure of insulin resistance is the euglycemic clamp but this technique has not been used in large epidemiological studies such as NHANES III. Fasting insulin levels are used as a proxy for insulin resistance and correlate with insulin resistant values obtained by using the euglycemic clamp. At fasting levels less than 4mU/l, only 34 percent of the subjects were insulin resistant and at levels above 13mU/l, 74 percent of the subjects were insulin resistant (Laakso, 1993).

Food insufficiency is defined as "an inadequate amount of food intake due to a lack of resources." Several studies have been conducted to document the prevalence of this phenomenon (Alaimo et al., 1998; Anderson, 1990; Andrews et al. 1999; Briefel and Woteki, 1992; Campbell, 1990; Nestle and Guttmacher, 1992;

Olson, 1999; and Radimer). Poverty has been found to be the strongest predictor of food insufficiency although individuals at higher income levels have reported not having enough to eat due to lack of money to buy food. When socioeconomic factors such as ethnicity, education and household composition were controlled for, those in poverty were 3.5 times more likely to be food insufficient than those with incomes above the poverty level (Rose et al. 1998).

One of the most widely used measures of health status is the single item, Global Health Assessment Scale (GHAS) that asks respondents to rate their overall health as excellent, very good, good, fair or poor (Manning, et al. 1980). Self-report is a valuable epidemiological tool that can provide information about the general status of a group. This measure has been used extensively because it can be easily administered and because it provides a succinct way of summarizing the diverse components under the broader health status domain (Kaplan and Jay, 1994).

The global self-evaluation question, or some variant of it, has been used in many major studies including the National Health and Examination Survey (NHANES). The GHAS measure has been validated as a reliable measure of health status (Krause and Jay, 1994; Idler and Angel, 1990; Stewart and Ware, 1992).

The association between health status and income has been well established (Moriyama, 1968; Rosen, 1976). The disease conditions associated with syndrome X have been identified as more prevalent among low-income individuals but it is unknown if the conditions associated with syndrome X are more prevalent among food insufficient than food sufficient individuals in the same income categories. The purpose of this study was to examine whether syndrome X conditions were more

prevalent among food insufficient subjects and whether the presence or absence of these conditions was related to overall self-reported health status in a nationally representative sample of adults over age 18 from the NHANES III survey.

METHODS

Study Design and Sample Population

The data used in this study were from the NHANES III survey, which is a cross-sectional representative sample of the U.S. civilian, non-institutionalized population. NHANES III consisted of two components: a household interview conducted in the home and an interview and examination conducted in the mobile examination unit. Standard protocols were used for all interviews and examinations.

Syndrome X Variables

The syndrome X conditions were chosen from the laboratory data, the examination data and the household survey questions. The variables included were glucose, insulin, high density lipoprotein (HDL)-cholesterol, low density lipoprotein (LDL)-cholesterol, systolic blood pressure, diastolic blood pressure and body mass index (BMI). The syndrome X conditions were coded into tertiles, described in Table 1, and were based on clinical recommendations for healthy levels.

Table 1 --Syndrome X variables recoded from ratio variables into three-level ordinal categories.

Health Condition	Optimal	Moderate Risk for condition	Condition Present[a]
BMI[b]	less than 25 kg/m^2	25 to 29.9 kg/m^2	30 or greater kg/m^2
Post hoc analysis	less than 27.3 kg/m^2	27.3 - 29.9 kg/m^2	greater than 30 kg/m^2
Glucose	less than 100 mg/dl	100 to 125 mg/dl	126 mg/dl or greater
Insulin[c]	less than 4 uU/dl	4 to 13 uU/dl	greater than 13
HDL-cholesterol	greater than 60 mg/dl	59 to 40 mg/dl	HDL-cholesterol less than 40
LDL-cholesterol	less than 100 mg/dl	100 to 129 mg/dl	130 mg/dl or greater
Systolic blood pressure	less than 120 mm/Hg	120 to 139 mm/Hg	140 mm/Hg or greater
Diastolic blood pressure	less than 80 mm/Hg	80 to 84 mm/Hg	85mm/Hg or greater

[a] Subjects were included in Level 3 if they were taking medication for the condition or if they reported they had been told by the physician that they had the condition.
[b] Values were based on National Heart Lung and Blood Institute recommendations. Subjects were excluded if they had fasted six hours or less or reported they had consumed coffee, alcohol or smoked a cigarette in the past 30 minutes.
[c] Values were based on recommendations from National Diabetes Data Group. Subjects were excluded if they had fasted six hours or less or reported they had consumed coffee, alcohol or smoked a cigarette in the past 30 minutes.

Food Insufficiency Variable

Food sufficiency status was determined by the response to the question "Do you 'always have enough food to eat,' 'sometimes not enough to eat,' or 'often not enough food to eat?" The household was considered food insufficient if the respondent reported he/she sometimes or often did not have enough food to eat. All subjects from food insufficient households were considered food insufficient and were included in the study. Other researchers studying this phenomenon have used this convention (Alaimo et al. 1998, Rose and Oliveria, 1997; Christofer and Basioits, 1992). A randomly chosen comparison group of food sufficient subjects, matched for income, were selected from respondents who said they always have enough food to eat.

Global Health Status Variable

All NHANES III participants were asked to rate their health status using the Global Health Assessment Scale GHAS). This is a five-category question in which the respondents were asked "Is your health in general excellent, very good, good, fair or poor?" For this study, the five categories were collapsed into three measures that included excellent and very good in one category; good in a second category, and fair and poor in a third category. The GHAS measure of health status has been used in many major studies including NHANES III, the National Health Interview Survey, the Rand Health Insurance Experiment and the Medical Outcomes Study. The GHAS measure of health correlates with the risk of mortality and morbidity (Idler and Ksal, 1991, Kaplan and Camacho,1983) and captures limitations in physical functioning, chronic or acute conditions and to a lesser extent mental health

problems (Krause and Jay, 1994). Extensive validation of this measure has been conducted (Krause and Jay, 1994; Idler and Angel, 1990; Stewart and Ware, 1992).

Sociodemographic Variables

The sociodemographic variables included in this study were income, race/ethnicity, education, marital status, gender, and educational level. This information was gathered during the household interview.

The total family income for the previous 12 months was reported and a poverty income ratio (PIR) was calculated by the Centers for Disease Control (CDC) using a formula based on the federal poverty line that allows comparison across the span of the survey. Alaimo (1998) used the federal assistance program eligibility criteria cutoff points that are based income categories. A PIR of less than or equal to 120 percent of the poverty line was considered low income. Low-middle income was a PIR of 131 to 185 percent of the poverty line; middle income was a PIR of 186 to 350 percent of the poverty line and high income was a PIR greater than 350 percent of the poverty line.

As a part of the CDC's data- cleaning phase, age was calculated using the birth date from the household family questionnaire. The race/ethnicity of the subjects was classified as non-Hispanic white, non-Hispanic black, Mexican-American, or Other based on information given at the interview. Marital status and educational attainment were self-reported.

Exclusion Criteria

Subjects were excluded from the study if they were 17 years old or younger, pregnant or if the interviewer at the household survey rated the questionnaire as "unreliable." Subjects were excluded from the syndrome X conditions, except body mass index (BMI), if they had not fasted for the past six hours or if they had smoked a cigarette or had consumed alcohol or coffee in the past 30 minutes.

Statistical Analysis

Analysis

The average age and average years of educational attainment were calculated using the DESCRIPT procedure in SUDAAN. Using the Statistical Analysis Software (SAS) package, a variable was created to sum the syndrome X conditions. The range of potential scores was one to five syndrome X conditions. This was done to examine the proportion of food sufficient compared to insufficient respondents who experienced any or multiple syndrome X conditions. Using CROSSTAB, an analysis was done to examine the proportion of individuals with any or multiple syndrome X conditions based on food sufficiency status and health status rating.

Prevalence odds ratio (POR) for the impact of syndrome X on health status and the corresponding 95 percent confidence interval were estimated by the MULITLOG procedure with a robust variance estimation method using SUDAAN. All point estimates were weighted to reflect the complex survey design and population distribution. Since age, educational attainment, gender and race/ethnicity

can impact overall health status, these variables were entered into the model as covariates.

The POR for the impact of food insufficiency on syndrome X conditions was estimated using a LOGISTIC analysis with the corresponding 95 percent confidence interval. All point estimates in the LOGISTIC analysis were weighted to reflect the population distribution, and variances were calculated using SUDAAN to take the complex sampling design into account. A failure to account for the weighting and design effects of a complex sample design will result in distortion of estimated and underestimation of variance (Shah et al., 1997). PORs were adjusted for age and education by including these variables in the model as continuous variables. Other covariants included in the model were gender, marital status, and race/ethnicity because of their potential to impact health.

Post Hoc Analysis

A recent study found that food insecure females are more likely to be overweight than normal weight females. This finding did not hold true for males (Townsend, 2001). Based on this new study, a post hoc analysis was conducted to examine the relationship between food insecurity and syndrome X conditions and food insecurity and health status for females in the NHANES III study. BMI classification for the post hoc analysis was based on the consensus statement of the 1985 NIH Development Conference on the Health Implications of Obesity (Najjar and Rowland, 1987). The overweight cutoff point was defined as 27.3 kg/m^2 for women. The obesity cutoff points was 30 kg/m^2 for women. Others have used this convention to study the relationship of obesity to food insecurity (Townsend et al.

2001). Using SUDAAN, a POR analysis was conducted to examine the relationship between the syndrome X conditions and food insecurity for women in the NHANES III survey. POR analysis was also used to examine the relationship between health status and syndrome X conditions.

RESULTS

Findings

The average age for all subjects in the NHANES III data used in this study was 44.7 years (SD= 20.3 years). For the food sufficient subjects the average age was 39.9 years (SD = 17.5 years) and for the food insufficient subjects the average age was 49.9 years (SD= 21.5 years).

Table 2 shows the proportion of food insufficient subjects who experienced the different numbers of syndrome X conditions compared to food sufficient subjects. There was no statistically significant difference in food sufficiency status and the number of syndrome X conditions (p=0.356). Health status was not significantly related to the number of syndrome X conditions (Table 3) (p=0.084).

After controlling for the socioeconomic variables age, educational attainment, gender and race/ethnicity, the odds that food-insufficient subjects are at greater risk for syndrome X conditions were not significantly different from food sufficient subjects (POR = 1.09; CI= 0.77 to 1.54; p= 0.6160). There was no statistically significant difference in self-reported health status based on the number of syndrome X conditions (p=0.0842) after controlling for the socioeconomic variables age, educational attainment, gender and race/ethnicity

Table 2-- Number of syndrome X conditions for the food sufficient and food insufficient subjects in NHANES III

Number of Conditions	Insufficient % (n)	Sufficient %	Total
0	53 (342)	47 (298)	100 (640)
1	55 (360)	45 (296)	100 (656)
2	52 (239)	48 (223)	100 (462)
3	41 (95)	59 (137)	100 (232)
4	38 (35)	62 (57)	100 (92)
5	43 (3)	57 (4)	100 (7)
Total	1074	1015	2089

Table 3-- Number of syndrome X conditions for self-reported health status in NHANES III

Number of Conditions	Excellent Very Good % (n)	Good % (n)	Fair/Poor % (n)	Total
0	47 (301)	33 (213)	20 (126)	100 (640)
1	26 (168)	36 (237)	38 (251)	100 (656)
2	22 (103)	33 (154)	44 (205)	100 (462)
3	18 (41)	28 (65)	54 (126)	100(232)
4	11 (10)	22 (20)	67 (62)	100(92)
5	14 (1)	43 (3)	43 (3)	100 (7)
Total	100 (323)	100 (479)	100 (647)	100 (2089)

Post Hoc Findings

Food insufficiency is related to overweight in women. Overweight women were 2.6 times more likely to be food insufficient (CI= 1.24 - 4.74; p = 0.0026) than normal weight women as shown in Table 4. This effect was significant when all the covariates were held constant at zero. This finding did not hold for the other syndrome X conditions (glucose, insulin, systolic and diastolic blood pressure, or HLD- and LDL-cholesterol). A significant relationship between food sufficiency status and marital status was found for overweight women. Those overweight women who were divorced were 3.16 times more likely (CI= 1.37 - 7.29; p = 0.0081) and separated overweight women were 5.9 times more likely (CI= 1.82 - 19.18; 0.0039) to be food insufficient when compared to overweight women who were married with a spouse living at home. Since marital status was included in the equation as a covariate, the relationship between BMI and food insufficiency for women was independent of marital status.

Overweight females who were food insufficient were 2.51 times more likely (CI = 1.37 - 4.60; p = 0.0033) to report fair/poor health status than overweight food sufficient females (Table 5). There was a significant relationship between ethnicity and health status. Overweight non-Hispanic black females were 2.24 times more likely (CI=1.19-4.21; p=<0.0131) to report fair/poor health than overweight non-Hispanic white females. The relationship between health status and ethnicity/race of overweight females was significant and therefore it was important to enter ethnicity into the model in order to hold this variable constant. The relationship between self-reported health status and BMI was independent of marital status, age, educational attainment and race/ethnicity.

Table 4 – Prediction of food insufficiency status among overweight women in NHANES III

	Parameter estimate	SE	POR	95% CI	p-value
Intercept	2.21	0.69			
BMI	0.95	0.30	2.60	1.24 - 4.75	0.0026
Systolic Blood Pressure	-0.30	0.56	0.74	0.24 - 2.26	0.9874
Diastolic Blood Pressure	1.18	0.56	3.24	0.89 - 11.84	0.0738
Glucose	-0.16	0.39	0.85	0.39 - 1.86	0.6748
Insulin	-0.37	0.40	0.69	0.31 - 1.54	0.3608
LDL	-0.29	0.37	0.75	0.36 - 1.57	0.4362
HDL	0.21	0.25	1.24	0.75 - 2.05	0.3948
Race/Ethnicity					
Non-Hispanic white					
Non-Hispanic black	-0.04	0.21	0.96	0.62 -1.47	0.8402
Mexican-American	0.51	0.27	1.67	0.96 - 2.87	0.0664
Other	-1.34	0.42	0.26	0.11 - 0.62	0.0029
Marital Status					
Married spouse in HH					
Married no spouse	-.016	0.50	0.86	0.31 - 2.35	0.7574
Living as married	0.38	0.52	1.47	0.51 - 4.18	0.4656
Widowed	0.47	0.46	1.60	0.63 - 4.04	0.3158
Divorced	1.15	0.42	3.16	1.37 - 7.29	0.0081
Separated	1.78	0.59	5.90	1.82 - 19.18	0.0039
Never married	0.39	0.40	1.47	0.66 - 3.29	0.3347
Age at interview	-0.08	0.04	0.92	0.86 - 0.99	0.0347
Highest grade completed	-0.03	0.01	0.97	0.95 - 0.99	0.0034

Table 5 -- Prediction of poor health status among overweight women from food insufficient households in NHANES III

Intercept	Parameter estimate	SE	POR	95% CI	p-value
Food Insufficient	0.92	0.30	2.51	1.37 - 4.60	0.0033
Race/Ethnicity					
Non-Hispanic white	0.00	0.00	1.00	.	.
Non-Hispanic black	0.81	0.31	2.24	1.19 - 4.21	0.0131
Mexican-American	0.69	0.40	1.99	0.90 - 4.42	0.0899
Other	0.51	0.84	1.66	0.31 - 8.99	0.5490
Marital Status					
Married with spouse	0.00	0.00	1.00	.	.
Married no spouse	0.84	0.85	2.31	0.42 - 12.74	0.3290
Living as married	-0.43	0.55	0.65	0.22 - 1.95	0.4314
Widowed	-0.28	0.51	1.32	0.47 - 3.70	0.5883
Divorced	-0.53	0.56	0.59	0.19 - 1.81	0.3477
Separated	0.35	0.63	1.42	0.40 - 5.07	0.5858
Never married	0.32	0.42	0.73	0.31- 1.71	0.4579
Age at interview	0.40	0.57	1.01	1.01-1.04	0.4905
Highest grade completed	1.11	0.48	0.89	0.84-0.95	0.2056

CONCLUSIONS

The association between overweight women and food insufficiency is consistent with other studies that found an association between overweight women and food insecurity (Townsend, et al. 2001; Olson, 1999). It seems contradictory that individuals suffering from an inadequate food intake would be overweight or obese. A likely explanation is that high-fat and/or high-sugar foods are easily accessible and are sometimes "comfort foods" that are satisfying during periods when there are not enough resources to purchase food for an adequate diet. Another possibility is that sporadic episodes of going without food combined with episodes of consumption of low-nutrient dense foods, leads to excess storage of body fat (Dietz, 1995). This is consistent with studies that found binge eaters who had periods of diet restriction had significantly more body fat than those who did not have periods of diet restriction (Marcus et al. 1985).

The relationship between overweight and food insufficiency may not be due to eating more calories compared to food sufficient individuals. Rose (1997) found that the adjusted mean energy intake for food insufficient individuals was 12 percentage points lower than the mean intake for those from food sufficient households. In this study, a separate analysis for women showed that food insufficient women were 1.4 times more likely to have energy intakes below 50 percent of the recommended level.

Studies have demonstrated that food insufficiency is associated with poorer health status (Olson, 1999; Sahyoun and Basiotis, 2000). It was expected that the association between overweight and health status would be linked to the association between overweight and such chronic diseases as hypertension, impaired glucose

metabolism or abnormal HDL- or LDL cholesterol levels. This was not a finding in this study. The health status measure captures many aspects of health that includes feelings of mental and emotional well-being as well as physical conditions (Krause and Jay, 1994). There was a significant association between non-Hispanic black women and fair/poor health status. This is consistent with findings that non-Hispanic blacks are at higher risk for poor health than non-Hispanic whites (U.S. DHHS, 2000). The association between health status and overweight was significant when all the covariants (age, educational attainment, and race ethnicity) were held constant. This indicates that individuals who are overweight perceive their health to be poorer than those who are at normal weight whether or not a specific health condition can be identified.

Limitations of the study

Although the NHANES III survey is a representative sample of the non-institutionalized U.S. population, a number of limitations should be considered. Because this is a cross-sectional design, any inferences regarding cause and effect should be made with caution and should be considered preliminary.

Use of secondary data has limitations. Analysis is limited to wording of questions in the survey instrument. For example, food security could not be measured using this data because it did not capture the emotional aspect of worrying about running out of food. This study is limited to a dichotomous, independent variable for food insufficiency rather than the ordinal levels of food insecurity. The questionnaire for measuring food insecurity has been revised since NHANES III

was implemented. Future NHANES III data will provide the questions related to food insecurity.

Suggestions for Additional Research

Additional study should be done to examine the association between overweight and food insufficienty. Given the cost of health care and the prevalence of food insecurity in this country, the association between overweight and food sufficiency has the potential to impact health care costs. Ways to identify and reduce the prevalence of food insufficiency could prove cost effective because of the potential impact on health status of individuals.

Studies should examine ways the USDA's food assistance programs can provide food and community education to reduce food insufficiency and overweight. Any costs for food assistance and education may be offset by the reduced cost for health care. Studies should examine effective program strategies that insure low-income individuals and families have sufficient resources to provide a culturally acceptable, nutritious diet and adequate funding for community nutrition education programs.

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APPENDIX

INTRODUCTION

The purpose of this chapter is to present the detailed methods used to conduct this study. This includes the sample population, study variables, analytical considerations, data collection, methods, research questions and hypotheses, and analysis.

Sample Population for this Study

The study population was selected from the NHANES III data set that included data from the household data set, the examination data set and the laboratory data set. Sampling plan and operational methods used to collect and assemble these data sets have been described elsewhere (U.S. DHHS, 1994). The study population consisted of all subjects from food insufficient households who were 18 years of age or older. A comparison group, matched for income, was randomly selected from food sufficient individuals who were 18 years of age or older.

Food Insufficiency Variable

The food sufficiency status of the household was determined by the responses to the question in the household survey, "Do you have enough food to eat," "sometimes not enough to eat," "or often not enough to eat?" The household was considered food insufficient if the respondent reported they "sometimes did not enough to eat," or "often did not enough to eat." A comparison group, matched for income, was randomly chosen from those who reported food sufficiency. Using

household food sufficiency status questions to study individual outcomes is consistent with studies by Rose (1999), who used data from the Continuing Survey of Food Intake by Individuals (CSFII) and Alaimo (1998), who used the NHANES III household survey to study the prevalence of food insufficiency in individuals. Tarsuk (1999) used a convenience sample of emergency food recipients to study the relationship between household food sufficiency status and nutrient intake by individuals and Olson (1999) used household food security status to study the relationship between household food security status and the Body Mass Index (BMI) of individuals.

Income was reported in NHANES III as a Poverty Income Ratio (PIR). The PIR was calculated by the Centers for Disease Control (CDC) using a formula based on the federal poverty threshold. Because the PIR takes into account such factors as age of the family reference person and the year in which the family was interviewed, comparison across the span of the survey is possible. Poverty threshold values are produced annually by the Census Bureau. These threshold values are based on calendar years and adjusted for change caused by inflation between calendar years. For this study, the PIR values that were calculated by CDC were used as the measure of income.

The PIR variable, which is a ratio variable, was recoded to create a categorical variable. The categories were based on Federal guidelines for participation in food support programs such as food stamps and WIC. A frequency distribution was used to determine the number of food insufficient subjects in each PIR category to determine the number to match in each cell.

For this study, income categories were created using PIR cutoffs which

were based on the eligibility guidelines of the federal assistance programs. The low-income category was a PIR of less than or equal to 130 percent of the poverty level. This income level is approximately less than $20,000 for a family of four. Children can receive free meals at school and families can receive food stamps with incomes at approximately this level. The low-middle income level consisted of a PIR of 131 to 185 percent of the poverty line, which is a family income of approximately $20,000 to $28,000. Children can receive reduced meals in schools and women, infants and children (WIC) who meet nutritional and categorical requirements can receive WIC at this income level. The middle income category was a PIR of 186 percent to 350 percent of the poverty line, or an income of approximately $28,000 to $53,000 for a family of four. Since there were food insufficient people in NHANES III at incomes higher than 350 percent of the poverty level, a high-income group was created. The high-income group consisted of a PIR of 350 or more percent of the poverty level, which is a family income greater than $53,000. While food insufficiency is associated with low-income individuals, some individuals at higher income report not having enough food to eat. This convention has been used in previous studies (Alaimo et al., 1998).

To match participants for income categories, a frequency distribution was determined for all food insufficient subjects based on the PIR categories described above. A random selection was made of food sufficient subjects based on the number of food insufficient subjects in each income category.

Global Health Status Variable

This study investigated the relationship between food insufficiency and health. The NHANES III health related variables include Global Health Assessment Scale (GHAS) and the syndrome X conditions that include dyslipidemia, hypertension, Body Mass Index (BMI), glucose and insulin. Syndrome X is also called insulin resistant syndrome.

There are two global health status variables in the NHANES III data set. One is the self-reported GHAS and the other is the physician's impression of the participant's health status after an extensive health examination. The self-reported GHAS was determined by the response to the question in the adult survey, "Is your health in general: "excellent," " very good," "good," "fair," or "poor." The physician rated the participant's health using a similar scale in which the physician rated the participant's overall health as "excellent," " very good," "good," "fair," or "poor."

The GHAS question has been tested for validity and reliability and has been determined to be an appropriate epidemiological measure of health status (Idler, et al. 1990; Idler, et al. 1991; Krause and Jay 1994; Link and Phalan 1986; Manning et al. 1980). Previous studies have found the self-reported health status to be in agreement with the physician's assessment of health status Maddox, 1962; LaRue et al. 1979; and Idler and Angel 1990). No studies were found that examine the association between the subject's health assessment and the physician's assessment when both the subject and physician report overall health status using an identical five-item scale. A test for independence was used to analyze the relationship of these two measures of health status.

Syndrome X Variables

Conditions associated with syndrome X include dyslipidemia (LDL-cholesterol, HDL-cholesterol), hypertension, obesity (measured by BMI), hyperinsulinemia and impaired glucose metabolism (Reaven, 1988; Edwards et al. 1994; Donohue et al. 1990; Jarrett 1992; Roberts et al. 2000). In the NHANES III data set, these are all ratio variables but they were recoded into tertiles based on clinically recommended values as defined by standards set by expert panels. The National Heart Lung and Blood Institute of the National Institutes of Health recommends the clinical standards for LDL-cholesterol, HDL-cholesterol, BMI, and blood pressure. The National Diabetes Data Group of the National Center for Chronic Disease Prevention at the Centers of Disease Control (Diabetes Data Group, 1979) established values for fasting glucose and insulin. The cutoff points are given in Table 1.

Subjects were excluded from the LDL- and HDL cholesterol, systolic and diastolic blood pressure, glucose, and insulin variables if they had not fasted for six hours or if they had any alcohol, cigarettes or coffee in the past 30 minutes. The National Heart, Lung, and Blood Institute established values for blood pressure and LDL- and HDL- cholesterol and BMI.

Sociodemographic Variables

Because of their potential to impact the health conditions associated with syndrome X and overall health status, age, educational attainment, gender, race and

Table A 1 --Syndrome X variables recoded from ratio variables into three-level ordinal categories.

Health Condition	Optimal	Moderate Risk for condition	Condition Present[a]
BMI [b]	less than 25 kg/m^2	25 to 29.9 kg/m^2	30 or greater kg/m^2
Post Hoc analysis:	less than 27.3 kg/m^2	27.3 - 29.9 kg/m^2	greater than 30 kg/m^2
Glucose[c]	less than 100 mg/dl	100 to 125 mg/dl	126 mg/dl or greater
Insulin[c]	less than 4 uU/dl	4 to 13 uU/dl	greater than 13
HDL-cholesterol[b]	greater than 60 mg/dl	59 to 40 mg/dl	HDL-cholesterol less than 40
LDL-cholesterol[b]	less than 100 mg/dl	100 to 129 mg/dl	130 mg/dl or greater
Systolic blood pressure[b]	less than 120 mm/Hg	120 to 139 mm/Hg	140 mm/Hg or greater
Diastolic blood pressure[b]	less than 80 mm/Hg	80 to 84 mm/Hg	85mm/Hg or greater

[a] Subjects were included in Level 3 if they were taking medication for the condition or if they reported they had been told by the physician that they had the condition.
[b] Values were based on National Heart Lung and Blood Institute recommendations. Subjects were excluded if they had fasted six hours or less or reported they had consumed coffee, alcohol or smoked a cigarette in the past 30 minutes.
[c] Values were based on recommendations from National Diabetes Data Group. Subjects were excluded if they had fasted six hours or less or reported they had consumed coffee, alcohol or smoked a cigarette in the past 30 minutes.

ethnicity and marital status were used as covariates or control variables (Feldman et al. 1989).

As a part of the CDC data-cleaning phase, age was calculated using the birth month data from the household survey questionnaire. The race/ethnicity of the subjects was classified as non-Hispanic white, non-Hispanic black, Mexican-American, and other based on information given at the interview. Marital status and educational attainment were self-reported.

Exclusion Criteria

Subjects were excluded from the study if they were 17 years old or younger, pregnant or if the interviewer at the household survey rated the questionnaire "unreliable." Subjects were excluded from the syndrome X conditions, except body mass index (BMI), if they had not fasted for the past six hours or if they had smoked a cigarette or had consumed alcohol or coffee in the past 30 minutes.

ANALYSIS

Preliminary analysis

The staff at the National Center for Health Statistics cleaned and edited the data prior to its release. A SAS Univariate procedure was used to examine distributions of continuous variables, check for outliers and implausible or missing values. Outliers were identified and data were recoded to eliminate outliers. A value was considered an outlier if greater than six standard deviations from the mean. Missing values were originally coded in the NHANES III data set using a numerical

value. To eliminate the missing value from the statistical analysis, missing values were recoded in SAS to assign a character value. A frequency distribution procedure was used to analyze data to see if a pattern for missing variables existed.

Two software packages, Statistical Analysis Software (SAS)(SAS, 2000) and SUDAAN (Shah, et al. 1997), were used in data analysis. The SAS software provided a variety of specialized applications that were applicable for coding variables, data preparation, and some descriptive statistics. SUDAAN was used for statistical analysis because it was able to take into account the complex sampling method. SUDAAN can deal with the sample weights, which were used to minimize the effects of over sampling and non-response as well as assure that the sample was representative of the population.

Research Questions

To study whether there is a relationship between food insufficiency and overall health status; self-perception of health and the physician's impression of the subjects' health; syndrome X conditions and food sufficiency; and syndrome X conditions and health status, the following research questions were developed to guide the research.

1. What is the relationship between syndrome X and food sufficiency?
2. Is there an agreement between the self-assessed GHAS and the physician's impression of the examinee's health status?
3. What is the relationship between the presence or absence of syndrome X conditions and the GHAS health status?

4. Is there a difference between the number of syndrome X conditions and the level of GHAS health status?
5. Is there a relationship between food sufficiency and the odds of reporting "Excellent" GHAS rating?

Hypotheses

To test whether there is a relationship between food insufficiency, overall health status and syndrome X conditions, the following hypotheses were developed.

Ho:1 There is no relationship between syndrome X conditions and food insufficiency.

Ho:2 There is no agreement between the self-assessed GHAS and the physician's impression of the examinee's health status.

Ho:3 There is no relationship between presence/absence of syndrome X conditions and the GHAS health status.

Ho:4 There is no difference between the average number of syndrome X conditions and level of GHAS health status.

Ho:5 There is no relationship between food insufficiency and the odds of reporting "fair/poor" GHAS rating.

Hypotheses Testing

Hypothesis #1: There is no relationship between syndrome X conditions and food sufficiency. The food sufficiency variable was coded as dichotomous as the subject was either food sufficient or food insufficient. The syndrome X variables

were coded as ordinal, which indicated the level of the condition as describe above in Table 1. A LOGISTIC analysis, using SUDAAN, was used to test the odds of food insufficient subjects having the syndrome X conditions. Food sufficiency was entered into the model as the independent variable along with the dependent variables: BMI, glucose, insulin, HDL-cholesterol, LDL-cholesterol, systolic blood pressure and diastolic blood pressure. Because of their potential to impact health, age, educational attainment, gender, race and ethnicity and marital status were used as covariates or control variables (Feldman et al.1989).

All point estimates in data analysis were weighted to reflect the population distribution and variances were calculated using the total MEC examined sample final weight. The MEC examined sample final weight was chosen because it represented the smallest sample in the data to be analyzed.

Hypothesis #2: There is no agreement between the self-assessed GHAS and the physician's impression of the examinee's health status.

The physicians and the participants both used the five-item GHAS measurement to rate overall health status. Using SUDAAN, a Crosstab procedure was used to determine the number of participants and physicians who agreed on the health status rating as well as the number who did not agree. McNemar's test for correlated proportion was used to determine if there was significant agreement between the physician's and subject's assessment (Kuzma, 2001).

All point estimates in data analysis were weighted to reflect the population distribution and variances were calculated using the total MEC examined sample

final weight. The MEC examined sample final weight was chosen because it represented the smallest sample in the data to be analyzed.

Hypothesis #3: There is no relationship between presence/absence of syndrome X conditions and the GHAS health status.

A MULTILOG procedure in SUDAAN was used to test if subjects who reported fair or poor health status had greater odds of having the syndrome X conditions compared to subjects who reported good or better health status. The GHAS health status variable is an ordinal variable, which has five levels: "excellent," "very good," "good," "fair," or "poor." The GHAS variable was entered into the model as the independent variable. The syndrome X variables were ordinal and entered into the model as the dependent variables. Because of their potential to influence health status, age, education, gender, marital status, and race and ethnicity were used in the model as control variables.

All point estimates in data analysis were weighted to reflect the population distribution and variances were calculated using the total MEC examined sample final weight. The MEC examined sample final weight was chosen because it represented the smallest sample in the data to be analyzed.

Hypothesis 4: There is no difference between the number of insulin resistance conditions and the GHAS health status assessment. To test to see if there is an association between the number of syndrome X conditions each subject had and overall health status, the CROSSTAB procedure in SUDAAN was used. A SAS

procedure was used to create a multiple level variable to identify the subjects who had one or more of the syndrome X conditions.

All point estimates in data analysis were weighted to reflect the population distribution and variances were calculated using the total MEC examined sample final weight. The MEC examined sample final weight was chosen because it represented the smallest sample in the data to be analyzed.

The health status variable was recoded to group the "very good" and "excellent" levels into one category, the "good" category into another category and the "fair" and "poor" into a third category. The CROSSTAB procedure in SUDAAN analyzed whether there was a significant difference between the number of syndrome X conditions and how the subjects reported their health status.

Hypotheses 5: There is no relationship between food insufficiency and the odds of having "Excellent" GHAS rating.

To answer the question of whether food insufficient individuals are at higher risk for poor health status, a MULTILOG procedure in SUDAAN was used to test the odds of food insufficient participants having "poor" health status when compared to food sufficient participants. The GHAS health status was entered into the model as the dependent variable and the food sufficiency status was entered into the model as the dependent variable. Because of their potential to impact overall health status, race and ethnicity, marital status, gender, age and educational attainment were entered into the model as covariates variables.

All point estimates in data analysis were weighted to reflect the population distribution and variances were calculated using the total interviewed sample final

weight. The total interviewed sample final weight was chosen because it represented the sample size of the data to be analyzed.

Manuscripts

These findings from this study were reported in the form of two manuscripts. These manuscripts will be comprise PART II and PART III of this document. PART II will include the findings from hypotheses two and five. PART III will include findings from hypotheses one, three, and four.

PART II FOOD INSUFFICIENCY IS LINKED TO POOR HEALTH STATUS

Ho.2: There is no agreement between the self-assessed GHAS and the physician's impression of the examinee's health status.

Ho: 5: There is no relationship between food insufficiency and the odds of reporting "fair/poor" GHAS rating.

PART III SYNDROME X CONDITIONS OF INDIVIDUALS FROM FOOD INSUFFICIENT HOUSEHOLDS

Ho:1 There is no relationship between syndrome X and food insufficiency.

Ho:3 There is no relationship between presence/absence of syndrome X conditions and the GHAS health status.

Ho:4 There is no difference between the number of syndrome X conditions and level of GHAS health status.

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Variables used in study

NHANES III Variables	Variable Type
Food Sufficiency HFF4 (1377) Do you have enough food to eat, sometimes not enough to eat, or often not enough to eat? (Subjects were food insufficient if reported sometimes or often not enough to eat.)	Coded Dichotomous 1 = food insufficient 2 = food sufficient
Income DMPIR (36) Poverty income ratio (unimputed income)	Coded Ordinal 1 = <130% poverty level 2 = ≥ 130% - 185% poverty level 3 = ≥ 185% - 350% poverty level 4 = >350% poverty level
Demographic DMARETH (12) Race/ethnicity: non-Hispanic White, non-Hispanic Black, Mexican-American, other.	Race: Categorical 1 = Non-Hispanic White 2 = Non-Hispanic Black 3 = Mexican-American 4 = Other
HFA8R (1256) Education. Highest grade in school completed.	Education: Ratio
HGA12 (1258) Marital status.	Marital status: Categorical
HSAGEIR (16) Age at time of interview.	Age: Ratio
HSSEX (15) Sex. 1 = male: 2 = female.	Gender: Dichotomous
Health Status HABI (1451) GHAS In general, how would you rate your health? Excellent, very good, good, fair, poor.	Health Status: Ordinal 1 = Excellent 2 = Very Good 3 = Good 4 = Fair 5 = Poor

NHANES III Variables	Variable Type
Blood Pressure PEPMNKIR (1423) Systolic Blood Pressure. Overall average systolic blood pressure. PEPMNK5R (1428) Diastolic Blood Pressure, Overall average diastolic blood pressure. Exclude if responded "yes to:" PEP6C (1385) Have you had any alcohol, coffee, or cigarettes in the past 30 minutes? 1 = yes; 2 = no. Include if responded "yes" to: HAE5A (1610) Are you now taking prescribed blood pressure medications? HAE2 (1605) Has your doctor told you that you have high blood pressure.	Blood Pressure: Ordinal Systolic: 1= < 120 mm/Hg 2 = 120 - 139 mm/Hg 3 = >140 mm/Hg Diastolic 1 = < 80 mm/Hg 2 = 80 - 85 mm/Hg 3 = >85 mm/Hg
Body Mass Index BMPBMI (1524) Body mass index. . *Post Hoc analysis for women: The overweight cutoff points were 2.3kg/m^2 and the obesity cutoff point was 30 kg/m^2.*	Body mass index: Ordinal 1 = <25 2 = 25 - 29 3 =30 or greater
Blood Lipid HDP (1622) serum HDL-cholesterol (mg/dl) LCP (1615) serum LDL-cholesterol (mg/dl) Included in re-coded variable for LDL-cholesterol and HDL-cholesterol that the subject has the condition if response is "yes" to: HAE9D: To lower your blood pressure, are...taking prescribed medication. 1=yes 2 = no. HAE7: Has your doctor told you that you have high cholesterol? LCP (1615) serum LDL-cholesterol (mg/dl). Exclude if: PHPFAST: Length of Fast is less than 6. PEP6C (1385) Have you had any alcohol, coffee, or cigarettes I the past 30 minutes? 1=yes; 2-no. Exclude if yes.	LDL-cholesterol: Ordinal 1 = <100 mg/dl 2 = 100 - 129 mg/dl 3.= 130 mg/dl or greater HDL-cholesterol: Ordinal 1 =. > 60 mg/dl 2 = 40 - 59 mg/dl 3 = <40 mg/dl
Blood Glucose GIP (1866) Plasma glucose (mg/dl) 1st venipuncture Exclude from glucose if yes response to questions below or if fast less than 6 hours. Include in study if response is "yes" to: HAD6 (1568) Are you now taking insulin? HAD10 (1578) Are you now taking a diabetes pill? HAD1 (1558) Has your doctor told you that you have sugar diabetes? Exclude if "yes":PEP6C (1385) Have you had any alcohol, coffee, or cigarettes I the past 30 minutes? 1=yes; 2=no.	Blood Glucose: Ordinal 1 = <100mg/dl 2 = 100 - 125 mg/dl 3 = 126 mg/dl or greater

Blood Insulin I1P (1918) serum insulin (uU/ml) Exclude from glucose if yes response to questions below or if fast less than six hours. PEP6C (1385) Have you had any alcohol, coffee, or cigarettes in the past 30 minutes? 1=yes 2=no. Exclude if yes. HAD6 (1568) Are you now taking insulin? HAD10 (1578) Are you now taking a diabetes pill? HAD1 (1558) Has your doctor told you that you have diabetes?	Insulin: Ordinal 1. <7uU/dl 2. 7 to 11 uU/dl 3. >12 uU/dl

VITA

Betty Phelps Greer was born in Butler County, Kentucky to Owen Lincoln and Edna Ellen Childers Phelps. Betty graduated from Butler County High School and attended Western Kentucky University where she received a Bachelor of Science Degree in Vocational Home Economics. After college graduation she taught High School Home Economics. She then attended the University of Louisville where she received a Masters of Art in Teaching Degree with a major in Home Economics. She then moved to Knoxville, Tennessee and received a Master of Science Degree. from the University of Tennessee at Knoxville where she majored in Nutrition Science.

Betty worked for the University of Kentucky as an Area Extension Agent for Foods and Nutrition and with the Knox County Health Department as a Public Health Nutritionist and at Tennessee State University as an Assistant Professor and Extension Specialist in Nutrition. She is now employed at The University of Tennessee as an Extension Specialist in the Agricultural Extension Service. Betty has one daughter and one granddaughter.

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