2018

Food Insecurity And Hypertension Prevalence, Awareness, Treatment And Control

Alexandra N. Luttrell
University of South Carolina

Food Insecurity and Hypertension Prevalence, Awareness, Treatment and Control

by

Alexandra N. Luttrell

Bachelor of Science
Virginia Polytechnic Institute and State University, 2015

Bachelor of Arts
Virginia Polytechnic Institute and State University, 2015

Submitted in Partial Fulfillment of the Requirements

For the Degree of Master of Science in Public Health in

Epidemiology

The Norman J. Arnold School of Public Health

University of South Carolina

2018

Accepted by:

Angela D. Liese, Director of Thesis

Michael Wirth, Reader

Andrew Ortaglia, Reader

Cheryl L. Addy, Vice Provost and Dean of the Graduate School

ABSTRACT

Objective: To examine the association between food insecurity and the prevalence of pre-hypertension and hypertension among U.S. adults. Additionally, this project will examine the association between food insecurity and the awareness, treatment and control (ATC) of hypertension.

Design: A cross-sectional study using data from the National Health and Nutritional Examination Survey (NHANES) 2011-2012 and 2013-2014 waves was deployed to examine the association between food insecurity and the prevalence and ATC of hypertension. Food security was measured by the cumulative number of affirmative responses to the 10-item U.S. Household Food Security Survey Module (HFSSM) questionnaire which were graded into four categories; full food security, marginal food security, low food security and very low food security. Blood pressure readings were taken at the mobile examination centers. Blood pressure was categorized into normal, pre-hypertensive and hypertensive based on the eighth Joint National Committee (JNC) guidelines. Patients were excluded from the analyses if they were below the age of 20, were pregnant, and had missing data for blood pressure, food security and body mass index (BMI). Multinomial regression was used to examine the association between food insecurity and the prevalence of hypertension and pre-hypertension.

Logistic regression was then used to examine the levels of ATC among hypertensive individuals and the association with food insecurity.

Results: A total of 9,871 participants were included in the prevalence analysis after exclusion criteria were applied. An elevated odds of hypertension was observed among individuals who were food insecure (Prevalence Odds Ratio = 1.61, 95% CI: 1.31 – 1.99) compared to food secure individuals. The ATC analyses included 3,413 hypertensive individuals. There were decreased odds of having controlled blood pressure among food insecure individuals (POR = 0.80, 95% CI: 0.67-0.96) compared to food secure individuals.

Conclusion: There was an increased odds of being hypertensive among food insecure individuals when compared to normotensive individuals who were food secure. Therefore, food insecure individuals are more likely to be hypertensive and less likely to have their high blood pressure under control. Future research needs to further examine lifestyle and environmental factors to fully understand the mechanisms behind this association.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Hypertension is a major issue in the United States. About 1 in 3 Americans have high blood pressure while only about half of those Americans have the condition under control (1). A history of hypertension can lead to many other chronic diseases, such as cardiovascular disease or kidney failure (1), and is associated with stress, socioeconomic factors and poverty (2). A unique feature of hypertension is the awareness, treatment and control (ATC) method used to describe the medical condition, which informs intervention opportunities. This concept is useful in determining the effectiveness of screening, prevention and treatment methods. This method is extremely important as many individuals are unaware of being hypertensive and without adequate screening measures the condition goes unknown and untreated. The increase in awareness should improve treatment rates in individuals with hypertension. Therefore, with the correct medical care, rates of blood pressure control should increase as well. Overall the level of awareness, treatment and control of hypertension has increased over the years but there is still need for improvement (3).

Food insecurity is characterized by limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways (4). Food insecure households can

experience food insecurity with and without hunger. Both food insecurity and hunger are conditions resulting from financial resource constraint (4). In 2016, in the United States 12.3 percent of households experienced food insecurity (5). Therefore, about 41.2 million people in the U.S. lived in homes that were considered food-insecure (5). With both of these issues relating to diet and affecting millions of Americans it is imperative to look at the relationship between the two factors. The answer to this lingering question is important to future research and policy makers for the health of our communities.

Hypertension is known as the "silent" killer and therefore without shedding a light on high-risk populations we cannot make progress in the ATC of this condition. It is well established that high blood pressure is caused by a combination of factors, largely in part by diet. What is unknown is if food insecurity plays a role in whether or not a person has access to the adequate amount of prevention and treatment for the control of hypertension (6).

Current research on the association between food insecurity and hypertension is scarce. Much research has focused on the linkage between food deserts and food assistance to hypertension (7, 8). While these exposures are similar to food insecurity, they may not pose as great of a barrier to controlling hypertension, as does food insecurity. Other research today focuses on food insecurity and chronic diseases such as cardiovascular disease, kidney disease, or stroke (9, 10). Therefore, examining the relationship between hypertension and food insecurity would give insight into whether food insecure persons would be considered 'high-risk' and would benefit from tailored

interventions (6). Limited research into whether food insecurity impacts the awareness, treatment and control of hypertension is another gap in the literature needing to be examined. By examining the different stages in the ATC model for hypertension, areas needing further effort and intervention to improve hypertension rates in the United States will be identified.

The specific aims of this study are to:

1. To examine whether food insecurity has an impact on the prevalence of hypertension and pre-hypertension by examining the following hypotheses:

   a. Food insecure individuals have increased odds of being hypertensive when compared with food secure individuals.

   b. Food insecure individuals have increased odds of being pre-hypertensive when compared with food secure individuals.

2. Determine if food insecurity impacts the level of awareness, treatment, and control of hypertension by examining the following hypothesis:

   a. Food insecure individuals have decreased odds of awareness, treatment, and control of hypertension when compared to food secure individuals.

CHAPTER 2

LITERATURE REVIEW

2.1 Epidemiology and Definition of Hypertension

In 2016, 1 in 3 American adults had high blood pressure (3). Therefore approximately 75 million adults in the United States were at an increased risk for developing conditions related to hypertension such as cardiovascular disease, kidney failure, heart attack or stroke (1, 2). Since untreated and uncontrolled hypertension can lead to several life threating diseases (1) it is imperative to understand the mechanisms that influence the development and the control of this condition.

Hypertension among people younger than 60 years of age is defined as blood pressure greater than or equal to a systolic pressure of 140 mmHg or a diastolic pressure of 90 mmHg. For persons 60 years of age or older hypertension is defined as a systolic pressure of 150 mmHg or a diastolic pressure of 90 mmHg (11). The higher of the two numbers is the systolic blood pressure and is measured when the heart contracts, while the smaller number is the diastolic blood pressure and is measured when the heart is filling with blood (12). Blood pressure readings higher than the cut-off values should be treated with pharmaceutical and non-pharmaceutical methods until the blood pressure readings are within the controlled range (11).

Blood pressure in adults, or those 18 years of age or older, is split into four categories. The normal range for blood pressure readings consists of a systolic reading of less than 120 mmHg and a diastolic reading of less than 80 mmHg. The pre-hypertension category consists of a systolic reading of 120-139 mmHg or a diastolic reading of 80-89 mmHg. Hypertension is then split into two categories, which consists of hypertension I and II. Hypertension I consists of systolic readings ranging from 140-159 mmHg or a diastolic reading from 90-99 mmHg. While hypertension II consists of systolic blood pressure reading of greater than 160 mmHg or a diastolic reading of over 100 mmHg (11).

2.2 Risk Factors for Hypertension

In general, African Americans are more likely to develop hypertension and die from hypertension-related health conditions compared with their Hispanic and Non-Hispanic White counterparts (13, 14). The U.S. prevalence of hypertension (age adjusted) in adults 20 years of age and older during 2009-2012 was 32.6%. During this time period, the prevalence of HTN in Non-Hispanic white men and women was 32.9% and 30.1% and among Hispanic men and women was 29.6% and 29.9%, respectively. While the prevalence of hypertension for Non-Hispanic Black men and women was much greater at 44.9% and 46.1%(15).

Hypertension affects both men and women, but the weight of the burden is different with age. A study by Zhang and Moran, found that in 2013 to 2014 the unadjusted prevalence of hypertension in the adult U.S. population was 31.6% [95% CI:

29.6%-33.6%]. This prevalence varied greatly by age with hypertension rates at 7.3% [95% CI: 6.2%-8.5%] in adults aged 18 to 39 years old, 32.7% [95% CI: 29.7%-35.7%] in adults aged 40 to 59 years old and 65.6% [95%: 61.6%-69.6%] in those older than 60 years of age (16). Men more commonly have hypertension during young and middle adulthood while women more commonly have hypertension after 65 years of age (12).

Many do not know they have hypertension since people generally do not have symptoms. The condition goes unnoticed until the blood pressure is taken at a physician's office or more serious problems present themselves. Sometimes, the damage caused by hypertension may be advanced by the time a person develops symptoms such as a headache, dizziness and/or a heart attack. Since hypertension is known as the 'silent killer' many are unaware of their high blood pressure, therefore it is necessary to know the risk factors for this condition (17).

Risk factors for hypertension include age, race, family history, lifestyle, stress, other chronic conditions and being overweight or obese (12, 17). Lifestyle behaviors that increase the likelihood of developing hypertension include lack of physical activity, poor diet, alcohol consumption and tobacco use. Chronic conditions such as diabetes or kidney disease may impact blood pressure levels (12). Lifestyle behaviors such as consuming a low sodium diet can prevent the development of hypertension and improve quality of life (18). During examination of these factors it is important to look upstream to aspects such as socioeconomic status and food access that may influence health behaviors (2, 7, 8).

2.3 Awareness, Treatment and Control

While the prevalence of hypertension in the U.S. population has remained stable over the past several decades the awareness, treatment and control of hypertension has increased (3, 16). This feature of managing hypertension assists in understanding the progress being made to reduce the burden of hypertension but also the shortcomings in public health efforts.

The first step in managing hypertension is for an individual to be aware they have the condition. Promoting yearly check-ups and educating people, especially high-risk groups, on risk factors of the condition can help to increase awareness. In 2012, the overall prevalence of hypertension in the U.S. was 29.1% and it was estimated that roughly 83% were aware of their condition (3).

The second step in managing hypertension is to receive treatment for the condition. Promoting regular visits to physician offices' and affordable medications can assist in raising treatment levels. In 2012, it was estimated that in the United States, 76% of hypertensive individuals were taking medication to lower their blood pressure (3).

The third and finally step in current medical practice is controlling high blood pressure in those with hypertension. Facilitating an environment where access to appropriate treatments are available and routinely checked, as well as educating the population that treatment is not always equivalent to control could improve the rates of

controlled individuals. In 2012, only about 52% of individuals with hypertension were considered to have the condition under control (3).

By looking at the rates of hypertensive people either considered aware, treated or controlled, it can be seen that there is much room for improvement. While there have been great strides in the past decades, underlying factors may delay the control of hypertension in the United States. Controlling hypertension includes both pharmaceutical and non-pharmaceutical methods. A potential hindrance in the control and treatment of high blood pressure is the inability of an individual to afford health expenses and the recommended low-sodium diets (8, 19-21).

2.4 Food Insecurity

Food insecurity is defined by the United States Department of Agriculture as times during the year when households are uncertain of having, or unable to acquire, enough food to meet the needs of all their members because they had insufficient money or other resources for food (5). In 2016, an estimated 12.3% of U.S. households were considered food insecure (5). This means roughly 41 million people in the United States have inadequate amounts of food on a day-to-day basis (5).

Household food insecurity varies by geographical areas, race, marital status and socioeconomic status (5). In 2016, the prevalence of food insecurity was highest for individuals living in the southern region of the United States (13.5%) as well as those living in nonmetropolitan areas (15.0%). Households headed by Hispanic and Non-Hispanic Black persons had higher than national average rates for food insecurity at

22.5% and 18.5% respectively. This also was true for households headed by a single woman (31.6%) and by a single man (21.7%). In 2016, one-fourth of all food insecure households were homes with household incomes less than 185% below the poverty line or $24,339 for a family of four (5). The statistics from the USDA report show low and very low socioeconomic status as a major risk factor of food insecurity (5). Populations that fall into the lower SES categories are vulnerable to the negative feedback loop associated with the risk of food insecurity (22). As we can see in Figure 2.1, which was adapted from the framework created by Weiser et al., food insecurity impacts lifestyle habits that then have an effect on the development of chronic diseases (22). Assets are then lowered by expenses incurred by visits to the doctor, cost of medication, and income lowered by taking time off from work, and impairment in physical abilities (22).

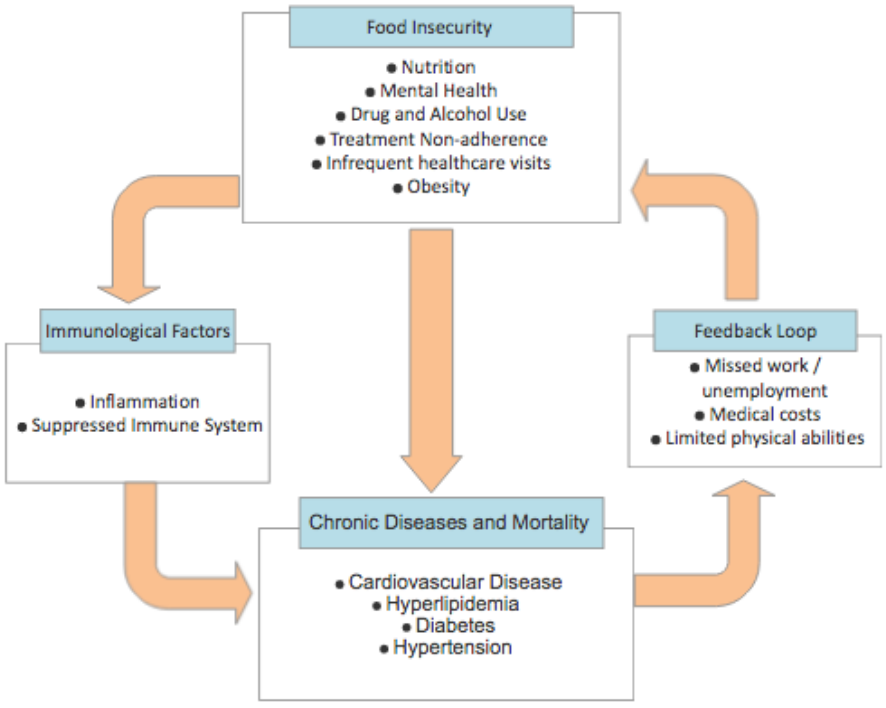

Figure 2.1 Food insecurity impact on health

For example, by not knowing where the next meal will come from individuals in a household may experience anxiety, stress or depression (22). Limited funds for food enable the nutritional behavior of buying cheaper, less nutritious foods for the household (22). Deficiencies in nutrients can affect mental health and obesity rates increasing the need for medical treatment. Bills from doctor appointments and decreased income from missed work add to the burden of the individuals in the household further exacerbating the stress and depression (22). To cope with this financial struggle, individuals may alter their behavior by avoiding further medical treatment and maintaining a less expensive and unhealthy diet. Eventually, all of the components experienced by the household members impact the individual's risk of developing chronic diseases, including hypertension (22).

Socioeconomic status plays a large role in determining lifestyle behaviors of people and can impact stress levels (2). A study conducted in 2011, assessed socioeconomic indictors and self-reported hypertension among United States adults (2). The findings from this study suggest that states with a median household income of $43,225 (OR = 1.16, 95% CI: 1.08-1.25) or states with a greater proportion of citizens living at or below the poverty line (OR = 1.14, 95% CI: 1.04-1.24) had a significantly higher prevalence of self-reported hypertension compared with affluent areas where the majority of citizens were considered above the poverty line (2).

Food-insecure persons also have greater healthcare expenditures compared to their food-secure counterparts (21). In 2017, a longitudinal retrospective cohort study found that food-insecure persons had $1,863 ($6,072 vs. $4,208, $p < 0.0001$) more

healthcare expenditures each year than food-secure persons (21). Excess expenditures such as these create the inertia for the negative pathway between food insecurity and health (22).

A major barrier for successful management of diet-sensitive diseases such as hypertension is food insecurity (6). For example, one of the main lifestyle interventions used to treat hypertension is the Dietary Approaches to Stop Hypertension (DASH) diet. DASH is a diet rich in fruits, vegetables, and low to nonfat dairy. It promotes the intake of whole grains, lean meats, nuts and beans while minimizing fat and sodium intake (23). This diet along with low sodium intake was significantly effective at lowering systolic blood pressure rates (p-value < 0.001) when compared with a high-sodium control diet in a randomized feeding study (24).

Many people with low socioeconomic status rely on food assistance programs to obtain adequate amounts of food from government-funded projects (25). In 2014, roughly 14.6% of the United States population received assistance from food banks (25). While 74% of households using these programs funded by Feeding America reported choosing between food and medication due to financial constraints (25). Similarly, 83% of households receiving the service reported buying inexpensive, unhealthy foods to cope with limited funds (25). Also, more than half (57.8%) of households participating in one of the programs had at least one person with hypertension in the home (25).

Along with food assistance, another somewhat related concept is food deserts. A food desert is defined as locations where there is a lack of fresh fruit, vegetables and

other healthful whole foods, usually occurring in poverty stricken areas (26). Another study using National Health and Nutrition Examination Survey (NHANES) data linked with the census tract found that individuals living in food deserts without access to healthy foods due to geographical or financial difficulties had higher systolic blood pressure rates (OR = 1.54 mmHg higher, 95% CI: 0.41, 2.66) than those not living in a food desert (7).

A behavioral intervention study was carried out in 2012-2013 in New York City to test the effectiveness of a treatment program among food-secure and food-insecure individuals (6). Participants were randomized into two intervention groups and a six-month change in systolic blood pressure was examined. Those who were food secure experienced significant reductions in blood pressure (p-value < 0.001), while there was no significant change among those who were food-insecure (p-value = 0.14). This pilot trial shows that different interventions may be needed to treat hypertension based on food-security levels (6).

Another study by Seligman et al., used NHANES (1999-2004 waves) to examine the association between food insecurity and chronic diseases and found the association between food insecurity and hypertension to be significant (19). The weighted prevalence of hypertension among the eligible, low-income participants was 24.5% (19). Food insecurity was significantly associated with self-reported hypertension [Adjusted Relative Risk = 1.20, 95% CI: 1.04-1.38] and with laboratory or examination evidence of hypertension [ARR = 1.21, 95% CI: 1.04-1.41] (19). The findings above suggest a need

for the examination of the prevalence of hypertension among those with and without food insecurity. While there is evidence that food insecurity impacts the prevalence of hypertension (6, 19, 27), the association needs to be examined further to obtain a better understanding of the results. Since roughly twenty years have passed, an updated study needs to be conducted to examine if this association still exists in today's population. A limitation to the study is that the four food security levels were dichotomized into food secure and food insecure categories (19), thus making it imperative to examine all four levels of food security in future research.

2.5 Gaps in the Literature

To our knowledge the relationship between food insecurity and pre-hypertension has not been previously examined. Therefore a large portion of the population that is at a heightened risk of developing hypertension has not been studied. Another gap in the literature is that awareness, treatment and control of hypertension in relation to food insecurity has not been examined. Therefore the ATC of hypertension needs to be evaluated amongst those considered food-insecure. By examining where differences occur in managing hypertension in this group, research can better identify underlying issues and promote policy and intervention changes in the future.

CHAPTER 3

METHODS

The aim of this thesis project is to examine the relationship between food insecurity and the prevalence of hypertension and pre-hypertension within the United States. Also, the odds of awareness, treatment and control of hypertension will be examined for significant differences by food security status.

3.1 Study Design and Population

NHANES is a major program of the National Center for Health Statistics funded by the Center for Disease Control and Prevention. The purpose of NHANES is to provide statistics related to health and demographic information of adults and children within the United States (28). NHANES has been collecting data on the U.S. population from continuous two-year cycles since its inception in 1999 (28).

To answer the research questions, the two most recent consecutive cycles with available data from 2011-2012 and 2013-2014 were analyzed. NHANES randomly selects approximately 5,000 participants each year from 15 counties across the U.S. using a sampling algorithm (32). NHANES is a multistage, national area probability survey with fixed sample-size targets for sampling domains defined by race/ethnicity, age, sex,

and socioeconomic status (32). The sampling procedure takes place in four stages: the sampling of counties, census blocks, dormitories or dwelling units and households (32). This survey procedure allows the sample to be representative of the United States population. NHANES conducts a thorough evaluation process including a standardized questionnaire administered during a home interview and a physical examination completed at the mobile examination center (MEC). Participants selected to participate in the extensive medical examination undergo blood pressure testing, dental screening, lab testing of blood and urine, and body measurements by trained medical staff following strict protocols at a local MEC (29).

A total of 11,329 participants, 20 years of age or older, were interviewed and examined by NHANES during the 2011-2012 and 2013-2014 cycles. After missing data from item non-response on blood pressure readings, food security, BMI and pregnant women were excluded from the study; a total of 9,871 participants were included for the prevalence analysis. After the exclusion criteria was applied, along with item non-response among the covariates, the study population included for the ATC analyses was 3,413 participants (Table 4.4)

3.2 Assessment of Hypertension

Three consecutive blood pressure readings were taken at the MECs during the physical examination (13). Certified blood pressure (BP) examiners conducted the measurements after the participants had rested for five minutes and following a standardized protocol (14). The three readings were then used to calculate the mean

systolic and diastolic blood pressure measurement for each participant. Having a mean blood pressure reading with a systolic pressure between 120-139 mmHg or a diastolic pressure between 80-89 mmHg was categorized as pre-hypertension (11). A mean systolic blood pressure reading ≥ 140 mmHg or a diastolic blood pressure reading ≥ 90 mmHg was categorized as hypertension (11). Blood pressure measurements within these medically accepted ranges or taking anti-hypertension medications was considered hypertensive. Thus, prevalence of hypertension will be calculated using the number of individuals with elevated blood pressure levels $\geq$ 140/90 mmHg or taking anti-hypertensive medication in the numerator, divided by the study population.

For the determination of awareness, treatment and control the following procedure will be used. Questionnaires were used to collect self-reported data on the awareness and treatment of this condition while controlled hypertension was determined as a mean blood pressure reading (<140/90 mmHg) collected at the MEC amongst hypertensive individuals. Awareness of hypertension was determined by [1] an affirmative response to the question, "Have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?" or [2] the participant reported taking hypertension medication (30). To calculate the percent of the sample that are aware of their hypertension, the number of affirmative responses to the previous question along with those taking anti-hypertensive medication will be divided by all hypertensive persons. Hypertensive persons are defined as individuals with a mean blood pressure reading of 140/90 mmHg and above or taking anti-hypertensive medications (30).

The treatment of hypertension was determined by an affirmative response to both questions, “Because of your high blood pressure/hypertension, have you ever been told to take prescribed medicine?” and, “Are you now taking prescribed medicine?”. Thus, to calculate the percent of individuals treated for hypertension, the numerator will consist of subjects taking antihypertensive medications and will be divided by all hypertensive persons. Controlled high blood pressure was determined by a blood pressure reading below the hypertensive threshold (11) among a person with hypertension, which is a systolic blood pressure reading of < 140 mmHg and diastolic blood pressure reading of < 90 mmHg. Thus, the percent with controlled hypertension will be calculated as a blood pressure reading in the medically determined non-hypertensive range (<140/90 mmHg) divided by all hypertensive persons. Similar to calculations used for the prevalence, awareness and treatment of hypertension, hypertensive persons are defined as individuals with a mean blood pressure reading of 140/90 mmHg and above or taking anti-hypertensive medications (30). Control of hypertension was measured with all hypertensive persons as the denominator similar to prior research on the topic (3) allowing results to be comparable.

3.3 Measures of Food Security

Food insecurity was measured by affirmative responses to the U.S. Household Food Security Survey Module (HFSSM) questions (4) during the home interview process. The survey consists of 18 items for households with children under the age of 18 years and 10 items for adult members within the households (4). For the purpose of the study,

the 10-item questionnaire was used, as only adults are included for analysis. Household food security is graded by severity into four categories: full food security, marginal food security, low food security and very low food security (4). The questions listed below in Table 3.1 were used to categorize households into the different food security levels.

Table 3.1 NHANES food security questions

Food Security Survey Module Questions Adult Household Food Security (10 questions)	
"In the last 12 months…"	*Response options:*
"…Were you worried food would run out before you got money to buy more?"	Often True Sometimes True Never True
"…Did the food that you bought just didn't last, and you didn't have money to get more?"	Often True Sometimes True Never True
"…I/we couldn't afford to eat balanced meals."	Often True Sometimes True Never True
"…Did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?"	Yes No
"If adults cut or skipped meals, how often did this happen?"	Almost every month, Some months but not every month, Only 1 or 2 months
"…Did you ever eat less than you felt you should because there wasn't enough money to buy food?"	Yes No
"…Were you ever hungry but didn't eat because you couldn't afford enough food?"	Yes No
"…Did you lose weight because you didn't have enough money for food?"	Yes No
"…Did you or other adults in your household ever not eat for a whole day because there wasn't enough money for food?"	Yes No
"If adults did not eat for a whole day, how often did this happen?"	Almost every month, Some months but not every month, Only 1 or 2 months

Food security is graded by severity into the four categories by the cumulative number of affirmative responses to the questions listed in Table 3.1 (4). Full food security was determined by having no affirmative responses to the household food security questionnaire. Marginal food security was classified as having 1 or 2 affirmative responses. Affirmative answers were considered on the HFSSM questionnaire were "Yes", "Sometimes True" and "Often True". Subset questions asked after affirmative answers to certain questions were used to further determine the grade of household food insecurity. Low food security was determined by having 3-5 affirmative answers to the 10-item questionnaire while very low food security was determined by having 6-10 affirmative answers.

3.4 Covariates

Covariates examined in this analysis were age, sex, race/ethnicity, income, education, smoking status, health insurance, frequency of healthcare visits and body mass index (BMI). Age was calculated by the date of birth collected from the screening interview and was reported as a continuous variable until the age of 80, afterwards the age was simply coded as "80". Therefore in the analysis, all adults 20 years of age and above will be examined. Sex was classified as male or female through self-report. Race/Ethnicity was identified by self-report in the demographic survey by responses given to the following questions, "Do you consider yourself to be Hispanic, Latino, or of Spanish origin?" and "What race do you consider yourself to be?". Race/Ethnicity of the individual was assigned into one of the following categories: Mexican American, Non-

Hispanic White, Non-Hispanic Black, Non-Hispanic Asian, other Hispanic and other race including multi-racial groups. Other Hispanic and multi-racial were collapsed into one category 'other/multi-racial' due to small sample sizes within the groups. Race/Ethnicity and sex were examined for interaction due to findings in other studies (12, 31) but results were not significant.

The reference person's education level for the household was obtained by the following question, "What is the highest grade or level of education you have completed?". Education attainment was categorized into the following: less than 9^{th} grade, 9^{th}-11^{th} grade, High school graduate/GED, some college or AA degree, and college graduate or above. Education attainment for less than 9^{th} grade and 9^{th}-11^{th} grade was collapsed into 'Some HS/No Diploma' due to small sample sizes within the groups. Income information also was collected within the demographics questionnaire. Income was determined with annual household income reported in approximately $5,000 increments. For the purpose of the study, income was categorized into four categories: $0-$19,999, $20,000-$49,999, $50,000-$99,999, and $100,000 and over. Smoking status was collected during the in-home questionnaire by asking the respondent, "Have you smoked at least 100 cigarettes in your entire life?" with dichotomous answer choices, yes and no, as the possible options.

Health insurance coverage was determined by an affirmative response to the question, "Are you covered by health insurance or some other kind of health care plan?". Frequency of healthcare visits over the past year was determined by the

question, “How many times have you seen a doctor or other health care professional about your health at a doctor’s office, clinic or some other place?” This variable does not measure overnight hospital stays, home visits, or over-the-phone care or emergency room visits. The frequency of healthcare visits over the past year were coded and grouped into intervals after the first healthcare visit. Height was collected in centimeters and weight was collected as kilograms, both were reported as continuous variables. BMI was determined by the collection of height and weight at the MEC by trained staff. BMI was calculated as height in kilograms divided by weight in meters squared. BMI was then categorized into the following groups: under/normal weight, overweight and obese.

3.5 Statistical Analysis

All analyses were performed using SAS version 9.4 (Cary, North Carolina, USA). Survey sampling weights provided by NHANES were used to account for complexities such as demographic domains and oversampling of subgroups within the NHANES study design (33) for the first aim analyses. Thus, aim 1 analyses are thought to be representative of the US population. For the second aim analyses, however, weighting was not considered because the sample was restricted to exclusively hypertensive adults, which represent only 30% of adults sampled by NHANES during the 2011-2014 waves.

The exposure variable is food insecurity (categorical). The outcome variables are hypertension (categorical), prehypertension (categorical), awareness of hypertension

(categorical), treatment of hypertension (categorical) and the control of hypertension (categorical). Sample characteristics of covariates and potential confounders are presented in Tables 4.1 and 4.4.

Before statistical analysis began, all potential confounders were identified using a conceptual modeling technique, which can be seen in Figure 3.1. Variables on open, backdoor paths leading in to the exposure in the directed acyclic graph (DAG) below, created using DAGitty version 2.3, will be included in the final model as potential confounders regardless of significance. Other variables lying on closed pathways or colliders will not impact results unless further controlled on and therefore will not need to be included in the final model.

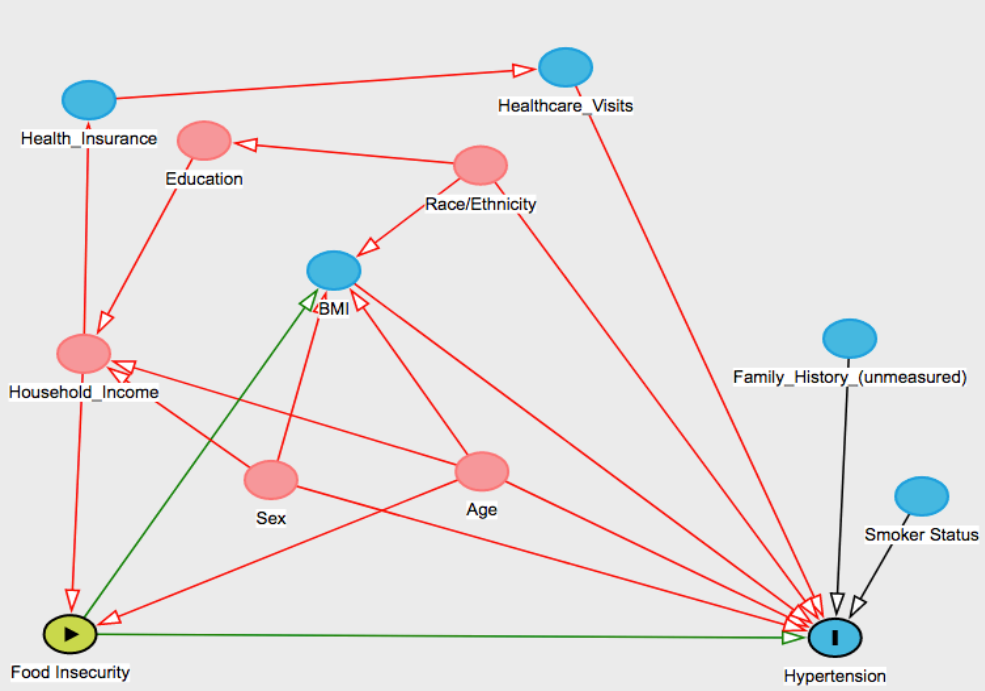

Figure 3.1 Directed acyclic graph of conceptual model

Through the conception of the DAG, two causal pathways between the exposure and the outcome were identified. BMI acts as an intermediate variable between food insecurity and hypertension on one path, while the other path is the direct pathway of interest between exposure and outcome. Since the estimated effects of the association may be impacted through adjustment for BMI, two adjustments were presented. The first did not adjusted for BMI and allowed us to estimate the total effect while the second adjusted for BMI and allowed us to estimate the direct effect. Both adjustments controlled for age, sex, household income and race.

Once the full model was determined, regression assumptions were assessed. For aim 1 analyses, multinomial regression was used to calculate the prevalence odds ratios (POR) and the 95% confidence intervals for prevalence of pre-hypertension and hypertension. Individuals with a mean blood pressure reading in the pre-hypertension and hypertension ranges were compared to the referent group of individuals with a normal mean blood pressure reading. Full food security was used as the referent level for the exposure in the main analyses. In the dichotomized food security analyses full food security and marginal food security were collapsed into the food secure category while low food security and very low food security were collapsed into the food insecure category (4, 19). Therefore in the dichotomized food security analyses food secure was used as the referent level.

For aim 2 analyses, logistic regression was then performed to determine the prevalence odds ratios for the awareness, treatment and control of hypertension by food insecurity. Regression was first performed using all hypertensive individuals and

those on anti-hypertension medications to determine the POR of awareness of the condition (30) among US adults in 2011-2014. Secondly, hypertensive individuals and those on anti-hypertensive medications were included in the analysis for treatment of hypertension (30). The POR was then calculated for treated individuals by food security level. Finally, the POR for the control of hypertension was calculated by dividing individuals with a controlled blood pressure reading (<140/90 mmHg) by all hypertensive individuals (30) for each food security level.

CHAPTER 4

RESULTS

4.1 Description of the Study Population

The study population was 19,931 for the 2011-2012 and 2013-2014 waves of NHANES. After excluding individuals less than 20 years of age, the population was 11,329. Next, pregnant women were excluded from the study resulting in a remaining 11,207 participants. Finally, after deleting missing data due to item non-response on the outcome, 10,479 participants remained and the sample characteristics of these individuals are displayed in Table 4.1. After the exclusion criterion was applied, along with item non-response among the covariates, the study population included for analysis was 9,871 participants (Table 4.2 & Table 4.3).

In the overall study population the mean age in years was 47.8, with males making up 49.2% of the population while females contributed 50.8%. The majority of participants were non-smokers (56.3%) and had health insurance (77.7%). Within the study population 36.5% of individuals were obese, the majority were either Non-Hispanic white (40.1%) or Non-Hispanic Black (23.4%), had some college (30.4%) or had a college degree or higher (25.3%). The vast majority of participants were considered fully food secure (69.2%).

All covariates in Table 4.1 were significantly different ($p < 0.001$) when compared by hypertension status. Hypertensive individuals were older with a mean age of 60.5 years when compared with pre-hypertensive individuals at 46.7 years and normotensive individuals at 39.1 years. Non-Hispanic Whites and Non-Hispanic Blacks made up 63.9% and 8.9% of normotensive individuals. This percentage increased to 66.5% of Non-Hispanic Whites and 11.3% of Non-Hispanic Blacks when looking at pre-hypertensive individuals. Also the percentage of Non-Hispanic Whites and Non-Hispanic Blacks increased in the hypertension category to 69.9% and 14.7%, respectively. Hypertensive individuals had a higher percentage of obese individuals (49.1%) and individuals with health insurance (90.4%) when compared with normotensive and pre-hypertensive individuals. Individuals with hypertension visited healthcare facilities with greater frequency with only 6.3% not receiving healthcare in the past year compared with 19.9% of pre-hypertensive and 17.7% of normotensive individuals. Also, food security ($p = 0.02$) differed significantly by hypertension status. The percentage of individuals considered fully food secure was higher in the hypertensive category (77.5%) than that in the pre-hypertension (74.0%) and normal categories (74.1%).

After excluding participants who were not hypertensive, under 20 years of age, pregnant women, and observations with missing data on the outcome, exposure and BMI the study population for the ATC portion of the analyses included 3,413 individuals. Sample characteristics of these individuals for awareness, treatment and control were not weighted and are displayed in Table 4.4. Hypertensive individuals that were aware of their condition had a mean age of 62.3 years while those that were unaware had a

mean age of 57.1 years. The majority of hypertensive individuals that were aware of their condition was female (53.8%), obese (50.3%) and had health insurance (89.6%) when compared with hypertensive individuals that were unaware of their condition. Hypertensive individuals that were being treated for their condition had a mean age of 63.0 years compared to a mean age of 56.1 years for untreated individuals. Similar to the awareness characteristics, the majority of hypertensive individuals that were being treated for their condition was female (54.9%), obese (50.4%) and had health insurance (90.6%) when compared with hypertensive individuals that were untreated for their condition.

Hypertensive individuals that achieved control of their blood pressure had characteristics of being obese (52.3%), female (54.9%), and had health insurance (91.1%) when compared with individuals that did not have their condition controlled. The mean age between controlled individuals (61.8 years) and uncontrolled individuals (61.5 years) was similar. Of the 3,413 individuals with hypertension, only 3,000 were aware of their condition, 2,781 were being treated and 1,910 were considered to have their blood pressure controlled (<140/90 mmHg).

4.2 Prevalence of Hypertension and Food Insecurity

In adjustment 1 the odds of being pre-hypertensive among marginally food secure (as compared to fully food secure) individuals was 1.24 (95% CI: [1.02-1.50]) times the odds of having a normal blood pressure after adjusting for household income, sex, age, and race. In adjustment 2 the odds of being pre-hypertensive among

marginally food secure (as compared to fully food secure) individuals was 1.22 (95% CI: [1.01-1.48]) times the odds of having a normal blood pressure after adjusting for household income, sex, age, race and BMI. There was an increased odds of having pre-hypertension among individuals with low food security in adjustment 1 (POR = 1.41, 95% CI: [1.15-1.73]) and in adjustment 2 (POR = 1.36, 95% CI: [1.09-1.69]). The association between very low food security and pre-hypertension was not statistically significantly in either adjustment.

In adjustment 1, there was an elevated odds of hypertension among all food insecurity levels when compared to the referent levels (Table 4.2). After controlling for BMI in adjustment 2, the association between hypertension and marginal food security (POR = 1.32, 95% CI: [0.98-1.78]) became statistically insignificant. This also occurred with the association of hypertension and very low food security (POR = 1.22, 95% CI: [0.89-1.68]) as it also became smaller and insignificant. Adjustment 2, controlling for BMI, attenuated the results of adjustment 1, not controlling for BMI, changing the odds of the previous two associations. Even so, a higher odds of being hypertensive among individuals with low food security is still present after adjusting for the effects of BMI.

Table 4.3 displays the food security categories collapsed into dichotomous levels, food secure and food insecure. The odds of being pre-hypertensive among individuals who were food insecure was elevated in adjustment 1 (POR = 1.23, 95% CI: [1.05-1.44]) when compared with referent levels. The association between pre-hypertension and food insecurity was attenuated in adjustment 2 and was no longer statistically

significant. There was an increased odds of hypertension among food insecure individuals in adjustment 1 (POR = 1.61, 95% CI: [1.31-1.99]) when compared with referent levels. An increased odds between hypertension and food insecurity was also present in adjustment 2 (POR = 1.44, 95% CI: [1.13-1.82]) when comparing to referent levels, even after controlling for BMI.

4.3 Food Insecurity and Awareness, Treatment and Control

The association between food insecurity and the ATC of hypertension was examined using three separate logistic regressions. The results from these analyses are displayed in Table 4.5. Due to similar results for adjustments 1 and 2, results of adjustment 2 will only be discussed. There was an increased odds of awareness for individuals with marginal food security in adjustment 2 (POR = 1.14, 95% CI: [0.78-1.66]) compared to unaware individuals with full food security but this was not statistically significant. In the dichotomized food security model (Table 4.6) the odds of being aware were lower among food insecure individuals in both adjustments, but these associations were not statistically significant.

Marginally food secure individuals had heightened odds of being treated when compared with referent levels but was not statistically significant. While individuals with low food security and very low food security had lower odds of being treated when compared with referent levels this also was not statistically significant (Table 4.5). In the dichotomized food security model (Table 4.6) the odds of being treated was lower

among food insecure individuals compared to food secure individuals in both adjustments, but again, these associations were not statistically significant.

Lastly, the odds of having controlled blood pressure was higher for marginally food secure individuals in both adjustments, while the odds of having controlled blood pressure were lower for low food secure and very low food secure individuals. The odds of having controlled blood pressure among very low food secure individuals was reduced (POR = 0.70, 95% CI: [0.53-0.92]) when compared to individuals that were fully food secure. In the dichotomized food security model (Table 4.6) the odds of having controlled blood pressure was lower among food insecure individuals (POR = 0.80, 95% CI: [0.66-0.96]) when compared with food secure individuals. Similarly amongst the different management levels of hypertension, there were reduced odds of ATC among individuals that fell into the low and very low food security categories (Table 4.5).

Table 4.1 Characteristics by hypertension status from 2011-2012 and 2013-2014 NHANES waves

Sample Characteristics	All n=10,479)	Non-Hypertensive (n=3,976)	Pre-Hypertensive (n=2,842)	Hypertensive (n=3,661)	P-Value
Food Security (n, %)					
Full Food Security	7,250 (69.2)	2,705 (74.1)	1,948 (74.0)	2,593 (77.5)	
Marginal Food Security	1,181 (11.3)	464 (9.9)	336 (10.0)	381 (8.0)	
Low Food Security	1,111 (10.6)	412 (7.9)	302 (8.6)	397 (8.3)	0.02
Very Low Food Security	863 (8.2)	351 7.2)	239 (6.9)	273 (5.8)	
Missing	74 (0.7)	40 (1.0)	17 (0.6)	17 (0.4)	
Age, mean (SE)					
20-80+	47.8 (0.5)	39.1 (0.5)	46.7 (0.5)	60.5 (0.3)	<0.001
Sex					
Male	5,156 (49.2)	1,687 (42.6)	1,702 (58.6)	1,767 (47.9)	
Female	5,323 (50.8)	2,289 (57.4)	1,140 (41.4)	1,894 (52.1)	<0.001
Missing	0 (0.0)				
Race/Ethnicity (n, %)					
Mexican American	1,213 (11.6)	552 (10.7)	338 (8.3)	323 (5.3)	
Non-Hispanic White	4,206 (40.1)	1,562 (63.9)	1,139 (66.5)	1,505 (69.9)	
Non-Hispanic Black	2,452 (23.4)	671 (8.9)	644 (11.3)	1,137 (14.7)	<0.001
Non-Hispanic Asian	1,316 (12.6)	647 (6.6)	351 (4.8)	318 (3.8)	
Other/Multi-Racial	1,292 (12.3)	544 (10.0)	370 (9.1)	378 (6.2)	
Missing	(0.0)				
Adult BMI (n, %)					
Under/Normal Weight	3,216 (30.7)	1,656 (41.1)	825 (27.1)	735 (17.6)	
Overweight	3,316 (31.6)	1,276 (33.5)	926 (33.8)	1,114 (31.4)	<0.001
Obese	3,821 (36.5)	1,016 (24.9)	1,069 (38.7)	1,736 (49.1)	
Missing	126 (1.2)	28 (0.5)	22 (0.4)	76 (0.9)	
Insurance (n, %)					
Yes	8,140 (77.7)	2,873 (76.9)	2,048 (77.0)	3,219 (90.4)	
No	2,327 (22.2)	1,099 (23.0)	791 (22.9)	437 (9.5)	<0.001
Missing	12 (0.1)	4 (0.1)	3 (0.1)	5 (0.1)	
HC Visits (n, %)					
None	1,669 (15.9)	796 (17.7)	637 (19.9)	236 (6.3)	
1	1,889 (18.0)	890 (22.0)	643 (22.4)	356 (9.2)	
2 to 3	2,903 (27.7)	1,117 (29.2)	760 (28.7)	1,026 (29.3)	<0.001
4 to 9	2,610 (24.9)	761 (20.5)	540 (19.3)	1,309 (35.3)	
10 or more	1,403 (13.4)	411 (10.7)	259 (9.7)	733 (19.9)	
Missing	5 (0.0)	1 (0.0)	3 (0.0)	1 (0.0)	

Column percentages may not equal 100% due to rounding. Sample characteristics within table are weighted. P-values for categorical variables are derived from the X^2 test. The p-value for age is derived from a t-test. **Definitions**: Normal blood pressure is defined as a BP reading <120/80 mmHg. Pre-hypertension is defined as a systolic reading between 120-139 mmHg and a diastolic reading 80-89 mmHg. Hypertension is defined as a systolic or diastolic BP reading of ≥ 140/90 mmHg or taking anti-hypertensive medication. **Abbreviations:** BMI = Body Mass Index, HC = Healthcare, SE = Standard Error

Table 4.1 (Continued) Characteristics by hypertension status from 2011-2012 and 2013-2014 NHANES waves

Sample Characteristics	All (n=10,479)	Non-Hypertensive (n=3,976)	Pre-Hypertensive (n=2,842)	Hypertensive (n=3,661)	P-Value
Household Annual Income (n, %)					
$0-$19,999	2,247 (21.4)	720 (13.6)	587 (14.5)	940 (17.7)	
$20,000-$49,999	3,285 (31.4)	1,221 (26.4)	868 (26.5)	1,196 (30.5)	
$50,000-$99,999	2,631 (25.1)	1,031 (29.6)	745 (30.4)	855 (28.2)	<0.001
$100,000 and over	1,824 (17.4)	816 (26.6)	517 (25.6)	491 (20.2)	
Missing	492 (4.7)	188 (3.8)	125 (3.1)	179 (3.5)	
Education (n, %)					
Some HS/ No Diploma	2,356 (22.5)	718 (13.4)	613 (15.7)	1,025 (19.4)	
High school grad/GED	2,278 (21.7)	767 (18.7)	632 (21.6)	879 (23.3)	
Some College or AA	3,189 (30.4)	1,261 (32.3)	880 (32.7)	1,048 (32.3)	<0.001
College graduate or above	2,649 (25.3)	1,227 (35.5)	716 (30.0)	706 (24.9)	
Missing	7 (0.1)	3 (0.1)	1 (0.0)	3 (0.1)	
Smoking Status (n, %)					
Yes	4,569 (43.6)	1,497 (38.6)	1,281 (45.7)	1,791 (50.0)	
No	5,904 (56.3)	2,478 (61.4)	1,558 (54.2)	1,868 (49.9)	<0.001
Missing	6 (0.1)	1 (0.0)	3 (0.0)	2 (0.0)	

Column percentages may not equal 100% due to rounding. Sample characteristics within table are weighted. P-values for categorical variables are derived from the X^2 test. The p-value for age is derived from a t-test. **Definitions**: Normal blood pressure is defined as a BP reading <120/80 mmHg. Pre-hypertension is defined as a systolic reading between 120-139 mmHg or a diastolic reading 80-89 mmHg. Hypertension is defined as a systolic or diastolic BP reading of ≥ 140/90 mmHg or taking anti-hypertensive medication. **Abbreviations:** BMI = Body Mass Index, HC = Healthcare, SE = Standard Error

Table 4.2 Prevalence odds ratio by hypertension status for 2011-2012 and 2013-2014 NHANES waves

Effect (N = 9,871)	Pre-Hypertension vs. Normal		Hypertension vs. Normal	
	POR* Estimate	P-value*	POR* Estimate	P-value*
Food Security				
Full FS Adjustment 1 (n=7,250)	**1.0**	-	**1.0**	-
Full FS Adjustment 2 (n=7,250)	**1.0**	-	**1.0**	-
Marginal FS Adjustment 1 (n=1,181)	1.24 (1.02-1.50)	0.03	1.35 (1.02-1.78)	0.04
Marginal FS Adjustment 2 (n=1,181)	1.22 (1.01-1.48)	0.04	1.32 (0.98-1.78)	0.07
Low FS Adjustment 1 (n=1,111)	1.41(1.15-1.73)	0.02	1.97 (1.53-2.54)	<0.001
Low FS Adjustment 2 (n=1,111)	1.36 (1.09-1.69)	0.01	1.82 (1.37-2.41)	0.001
Very Low FS Adjustment 1 (n=863)	1.17 (0.93-1.46)	0.17	1.44 (1.09-1.90)	0.01
Very Low FS Adjustment 2 (n=863)	1.09 (0.85-1.38)	0.49	1.22 (0.89-1.68)	0.21

P-values are derived from the X^2 test. Results in table are weighted using 4-year weights. **Definitions**: Normal blood pressure is defined as a BP reading <120/80 mmHg. Pre-hypertension is defined as a systolic reading between 120-139 mmHg or a diastolic reading 80-89 mmHg. Hypertension is defined as a systolic or diastolic BP reading of ≥ 140/90 mmHg or taking antihypertensive medication. **Adjustments:** Adjustment 1 shows the total effect by controlling for covariates minus BMI. Adjustment 2 shows the direct effect and controls for covariates plus BMI. **Abbreviations:** BMI =Body Mass Index, POR = Prevalence Odds Ratio, FS = Food Security, BP = Blood Pressure

Table 4.3 Prevalence odds ratio for hypertension status by dichotomized food security levels from 2011-2012 and 2013-2014 NHANES waves

Effect (N = 9,871)	Pre-Hypertension vs. Normal POR* Estimate	P-value*	Hypertension vs. Normal POR* Estimate	P-value*
Food Security				
Food Secure Adjustment 1 (n=8,431)	**1.0**	-	**1.0**	-
Food Secure Adjustment 2 (n=8,431)	**1.0**	-	**1.0**	-
Food Insecure Adjustment 1 (n=1,974)	1.23 (1.05-1.44)	0.01	1.61 (1.31-1.99)	<0.001
Food Insecure Adjustment 2 (n=1,974)	1.17 (0.99-1.39)	0.06	1.44 (1.13-1.82)	0.004

P-values are derived from the X^2 test. Results in table are weighted using 4-year weights. **Definitions**: Normal blood pressure is defined as a BP reading <120/80 mmHg. Pre-hypertension is defined as a systolic reading within the range of 120-139 mmHg or a diastolic reading 80-89 mmHg. Hypertension is defined as a systolic or diastolic BP reading of ≥ 140/90 mmHg or taking antihypertensive medication. **Adjustments:** Adjustment 1 shows the total effect by controlling for covariates minus BMI. Adjustment 2 shows the direct effect and controls for covariates plus BMI. **Abbreviations:** BMI = Body Mass Index, POR = Prevalence Odds Ratio, BP = Blood Pressure

Table 4.4 Non-weighted characteristics of awareness, treatment and control of hypertension from 2011-2012 and 2013-2014 NHANES waves

Sample Characteristics	**Hypertensive (n=3,413)**	**Aware (n=3,000)**	**Unaware (n=413)**	**Treated (n=2,781)**	**Untreated (n=632)**	**Controlled (n=1,910)**	**Uncontrolled (n=1,503)**
Food Security (n, %)							
Full Food Security	2,415 (70.7)	2,126 (70.9)	289 (70.0)	1,986 (71.4)	429 (67.9)	1,374 (71.9)	1,041 (69.3)
Marginal Food Security	364 (10.7)	325 (10.8)	39 (9.44)	303 (10.9)	61 (9.7)	211 (11.0)	153 (10.2)
Low Food Security	376 (11.0)	325 (10.8)	51 (12.3)	297 (10.7)	79 (12.5)	201 (10.5)	175 (11.6)
Very Low Food Security	258 (7.6)	224 (7.5)	34 (8.2)	195 (7.0)	63 (10.0)	124 (6.5)	134 (8.9)
Age, mean (SE)							
20-80+	61.7 (0.2)	62.3 (0.2)	57.1 (0.8)	63.0 (0.2)	56.1 (0.6)	61.8 (0.3)	61.5 (0.4)
Sex							
Male	1,640 (48.1)	1,387 (46.2)	253 (61.3)	1,254 (45.1)	386 (61.1)	862 (45.1)	778 (51.8)
Female	1,773 (51.9)	1,613 (53.8)	160 (38.7)	1,527 (54.9)	246 (38.9)	1,048 (54.9)	725 (48.2)
Race/Ethnicity (n, %)							
Mexican American	295 (8.6)	249 (8.3)	46 (11.1)	230 (8.3)	65 (10.3)	162 (8.5)	133 (8.8)
Non-Hispanic White	1,421 (41.6)	1,268 (42.3)	153 (37.0)	1,188 (42.7)	233 (36.9)	853 (44.7)	568 (37.8)
Non-Hispanic Black	1,062 (31.1)	949 (31.6)	113 (27.4)	880 (31.6)	182 (28.8)	564 (29.5)	498 (33.1)
Non-Hispanic Asian	287 (8.4)	235 (7.8)	52 (12.6)	212 (7.6)	75 (11.9)	153 (8.0)	134 (8.9)
Other/Multi-Racial	348 (10.2)	299 (10.0)	49 (11.9)	271 (9.7)	77 (12.2)	178 (9.3)	170 (11.3)
Adult BMI (n, %)							
Under/Normal Weight	689 (20.2)	560 (18.7)	129 (31.2)	515 (18.5)	174 (27.5)	299 (15.7)	390 (25.9)
Overweight	1,053 (30.9)	931 (31.0)	122 (29.5)	863 (31.0)	190 (30.1)	612 (32.0)	441 (29.3)
Obese	1,671 (49.0)	1,509 (50.3)	162 (39.2)	1,403 (50.4)	268 (42.4)	999 (52.3)	672 (44.7)
Health Insurance (n, %)							
Yes	3,005 (88.0)	2,685 (89.6)	320 (77.5)	2,519 (90.6)	486 (76.9)	1,740 (91.1)	1,265 (84.2)
No	406 (11.9)	313 (10.4)	93 (22.5)	260 (9.3)	146 (23.1)	168 (8.8)	238 (15.8)

Column percentages may not equal 100% due to rounding. Sample characteristics within table are not weighted. Covariates not included in analysis may not add up to sample total due to missing. **Definition**: Hypertension is defined as a systolic or diastolic blood pressure reading of ≥ 140/90 mmHg or taking antihypertensive medication. **Abbreviations:** BMI = Body Mass Index, HC = Healthcare, SE = Standard Error

Table 4.4 (Continued) Non-weighted characteristics of awareness, treatment and control of hypertension from 2011-2012 and 2013-2014 NHANES waves

Sample Characteristics	**Hypertensive (n=3,413)**	**Aware (n=3,000)**	**Unaware (n=413)**	**Treated (n=2,781)**	**Untreated (n=632)**	**Controlled (n=1,910)**	**Uncontrolled (n=1,503)**
HC Visits (n, %)							
None	220 (6.4)	123 (4.1)	97 (23.5)	63 (2.3)	157 (24.8)	33 (1.7)	187 (12.4)
1	338 (9.9)	266 (8.9)	72 (17.4)	225 (8.1)	113 (17.9)	149 (7.8)	189 (12.6)
2 to 3	953 (27.9)	848 (28.3)	105 (25.4)	793 (28.5)	160 (25.3)	537 (28.1)	416 (27.7)
4 to 9	1,227 (36.0)	1,139 (38.0)	88 (21.3)	1,096 (39.4)	131 (20.7)	756 (39.6)	471 (31.3)
10 or more	675 (19.8)	624 (20.8)	51 (12.3)	604 (21.7)	71 (11.2)	435 (22.8)	240 (16.0)
Household Annual Income (n, %)							
$0-$19,999	915 (26.8)	821 (27.4)	94 (22.8)	768 (27.6)	147 (23.3)	502 (26.3)	413 (27.5)
$20,000-$49,999	1,169 (34.3)	1,027 (34.2)	142 (34.4)	949 (34.1)	220 (34.8)	653 (34.2)	516 (34.3)
$50,000-$99,999	847 (24.8)	741 (24.7)	106 (25.7)	691 (24.8)	156 (24.7)	481 (25.2)	366 (24.4)
$100,000 and over	482 (14.1)	411 (13.7)	71 (17.2)	373 (13.4)	109 (17.2)	274 (14.3)	208 (13.8)
Education (n, %)							
Some HS/ No Diploma	934 (27.4)	814 (27.2)	120 (29.1)	756 (27.2)	178 (28.2)	489 (25.6)	445 (29.6)
High school grad/GED	813 (23.8)	706 (23.6)	107 (25.9)	653 (23.5)	160 (25.3)	437 (22.9)	376 (25.0)
Some College or AA	984 (28.8)	890 (29.7)	94 (22.8)	829 (29.8)	155 (24.5)	588 (30.8)	396 (26.3)
College graduate or above	679 (19.9)	587 (19.6)	92 (22.3)	540 (19.4)	139 (22.0)	394 (11.5)	285 (19.0)
Smoking Status (n, %)							
Yes	1,668 (48.9)	1,467 (48.9)	201 (48.8)	1,364 (49.0)	304 (48.1)	940 (49.2)	728 (48.4)
No	1,744 (51.1)	1,533 (51.1)	211 (51.2)	1,417 (51.0)	327 (51.7)	970 (50.8)	774 (51.5)

Column percentages may not equal 100% due to rounding. Sample characteristics within table are not weighted. Covariates not included in analysis may not add up to sample total due to missing**. Definition**: Hypertension is defined as a systolic or diastolic blood pressure reading of ≥ 140/90 mmHg or taking antihypertensive medication. **Abbreviations:** BMI = Body Mass Index, HC = Healthcare, SE = Standard Error

Table 4.5 Non-weighted prevalence odds ratio for awareness, treatment and control of hypertension from 2011-2012 and 2013-2014 NHANES waves

	Aware vs. Unaware among HTN individuals (n=3,413)		**Treated vs. Untreated among HTN individuals** (n=3,413)		**Controlled vs. Uncontrolled among HTN individuals** (n=3,413)	
Effect	POR Estimate	P-value	POR Estimate	P-value	POR Estimate	P-value
Food Security						
Full FS Adj. 1 (n=2,415)	1.0	-	1.0	-	1.0	-
Full FS Adj. 2 (n=2,415)	1.0	-	1.0	-	1.0	-
Marginal FS Adj. 1 (n=364)	1.19 (0.82-1.73)	0.35	1.19 (0.87-1.62)	0.28	1.06 (0.84-1.34)	0.64
Marginal FS Adj. 2 (n=364)	1.14 (0.78-1.66)	0.50	1.14 (0.83-1.57)	0.40	1.03 (0.82-1.31)	0.78
Low FS Adj. 1 (n=376)	0.90 (0.64-1.26)	0.54	0.87 (0.65-1.17)	0.36	0.88 (0.70-1.11)	0.27
Low FS Adj. 2 (n=376)	0.90 (0.64-1.27)	0.55	0.87 (0.65-1.17)	0.35	0.88 (0.70 -1.10)	0.26
Very Low FS Adj. 1 (n=258)	0.99 (0.66-1.49)	0.96	0.78 (0.56-1.09)	0.14	0.71 (0.54-0.94)	0.02
Very Low FS Adj. 2 (n=258)	0.95 (0.63-1.44)	0.83	0.75 (0.54-1.06)	0.10	0.70 (0.53-0.92)	0.01

P-values are derived from the X^2 test. Results are not weighted. **Definitions**: Hypertension is defined as a systolic or diastolic BP reading of ≥ 140/90 mmHg or taking antihypertensive medication.
Adjustments: Adjustment 1 shows the total effect by controlling for covariates minus BMI. Adjustment 2 shows the direct effect and controls for covariates plus BMI.
Abbreviations: BMI = Body Mass Index, POR = Prevalence Odds Ratio, FS = Food Security, HTN = Hypertensive, Adj. = Adjustment, BP = Blood Pressure

Table 4.6 Non-weighted prevalence odds ratio for awareness, treatment and control of hypertension by dichotomized food security levels from 2011-2012 and 2013-2014 NHANES waves

	Aware vs. Unaware among HTN individuals (N=3,413)		**Treated vs. Untreated among HTN individuals** (N=3,413)		**Controlled vs. Uncontrolled among HTN individuals** (N=3,413)	
Effect	POR Estimate	P-value	POR Estimate	P-value	POR Estimate	P-value
Food Security						
Food Secure Adjustment 1 (n=2,779)	1.0	-	1.0	-	1.0	-
Food Secure Adjustment 2 (n=2,779)	1.0	-	1.0	-	1.0	-
Food Insecure Adjustment 1 (n=634)	0.90 (0.68-1.19)	0.46	0.80 (0.64-1.01)	0.07	0.80 (0.67-0.96)	0.02
Food Insecure Adjustment 2 (n=634)	0.90 (0.68-1.19)	0.45	0.80 (0.63-1.01)	0.06	0.80 (0.66-0.96)	0.02

P-values are derived from the X^2 test. Results are not weighted. **Definitions**: Hypertension is defined as a systolic or diastolic BP reading of ≥ 140/90 mmHg or taking antihypertensive medication. **Adjustments:** Adjustment 1 shows the total effect by controlling for covariates minus BMI. Adjustment 2 shows the direct effect and controls for covariates plus BMI. **Abbreviations:** BMI = Body Mass Index, POR = Prevalence Odds Ratio, FS = Food Security, HTN = Hypertensive, BP = Blood Pressure

CHAPTER 5

DISCUSSION

5.1 Summary of Results

The findings from the analyses examining the association between food insecurity and the prevalence of pre-hypertension and hypertension supported our first hypothesis. All levels of insecurity were at increased odds of being pre-hypertensive. The association between pre-hypertension and marginal food security and low food security were statistically significant in both adjustments. While in the dichotomized food security model, food insecurity was associated with increased odds of pre-hypertension in both adjustments, but this association was only statistically significant in adjustment 1.

Similarly, there were increased odds of being hypertensive among all levels of food insecurity. Marginally food secure, low food secure and very-low food secure individuals were all at an increased odds of being hypertensive in adjustment 1. In contrast, in adjustment 2, which controlled for BMI, all levels of food insecurity had increased odds of being hypertensive but only individuals that experienced low food security were statistically significant. In the dichotomized food security model, food insecurity was associated with increased odds of hypertension in both adjustments.

Therefore it is apparent that food insecurity plays a role in heightening the odds of an individual being pre-hypertensive or hypertensive. Though the associations between food insecurity and pre-hypertension and hypertension were weakened in adjustment 2, several of the associations remained significant, demonstrating a direct association between food insecurity and increased blood pressure.

To address the second hypothesis the ATC of hypertensive individuals was examined by food security status. The findings from our analyses did not yield expected results. The associations between awareness and treatment of hypertension and levels of food insecurity were not statistically significant. Furthermore the odds of awareness and treatment of hypertension were not significantly associated with food insecurity in the dichotomized food security models either. However, the association between controlled blood pressure and very low food security was statistically significant in both adjustments. The association between controlled blood pressure and food insecure individuals also was apparent in the dichotomized food security model. Thus, the results from this portion of the analyses partially supported our second hypothesis, which was that food insecure individuals would have decreased odds of awareness, treatment, and control of hypertension compared to food secure individuals.

5.2 Discussion of Results

Our findings were similar to the limited prior literature on food insecurity and the prevalence of hypertension. The study by Seligman et al. found that food insecurity was significantly associated with self-reported hypertension [ARR = 1.20, 95% CI: 1.04-

1.38] and with laboratory or examination evidence of hypertension [ARR = 1.21, 95% CI: 1.04-1.41] (19). When comparing the dichotomized food security models between studies the results were similar with evidence of increased odds of hypertension among food secure individuals when compared with food secure individuals (19). The study by Seligman et al. used both self-reported and objective measured blood pressure as outcomes for hypertension while our study used only the objective measure of blood pressure. Both studies have significant results but our study included two adjustments in an attempt to address BMI as a potential intermediate variable within our conceptual model. The results from our study support the conclusion that food insecurity is associated with increased odds of being pre-hypertensive and hypertensive.

The findings for the odds of pre-hypertension and food insecurity allow insight into how decreased access to food resources and nutritious meals impact the development of chronic diseases. A possible reason why the associations between pre-hypertension and marginal food security and low food security were significant is that food insecurity impacts lifestyle habits that have an effect on the development of chronic diseases (22). This significant association was not seen between pre-hypertension and individuals with very low food security. A potential explanation for the lack of statistical significance between this level of food insecurity and pre-hypertension could be due to differences in lifestyle or dietary habits (22) when compared with the other food insecurity levels. Adults that fall into the very low food security category often report going whole days without eating due to insufficient resources (4). This

extreme lack of access to food or other necessities may act as a counterweight in the development of pre-hypertension.

Further understanding of the direct association between food insecurity and hypertension came from the two adjustments. In adjustment 2, controlling for BMI, the associations between food insecurity and hypertension were slightly attenuated and in some cases were statistically insignificant. The results between the two adjustments were similar and therefore the association between food insecurity and an individual's blood pressure was hardly influenced by BMI. Still, it is important to note since food insecure individuals are more likely to eat less nutritious, higher caloric foods (22, 25) which impact BMI and in turn may influence blood pressure rates.

To our knowledge this is the first study to examine the association between the awareness, treatment and control of hypertension and food insecurity. Prior research has concluded that the treatment and control of hypertension can be impeded by financial inability to pay for necessary healthcare and the recommended low-sodium diets (6, 8, 19-21). The results from our analyses on the ATC of hypertension and food insecurity did not indicate a statistically significant difference in the odds of awareness and treatment of hypertension between food insecure and food secure individuals. Our findings did show however, that food insecure individuals had reduced odds of having reached blood pressure control compared with food secure individuals. These results coincide with a previous behavioral intervention study that found food insecure

individuals might need alternative treatment methods to reduce blood pressure to control levels (6).

A potential explanation for the similarity in the awareness and treatment phases between food insecure and food secure individuals could be the effective, inexpensive screening efforts and educational information available for hypertension. Blood pressure is taken at most doctor visits and hypertension is relatively simple to screen for and diagnose. Therefore, food insecurity might not be a barrier for the awareness and treatment phases of hypertension management. Other possible explanations that could help explain the associations seen would be information on whether the individual received help from food assistance programs or if the individual resided in a food desert. The majority of households using food assistance programs have at lease one person in the household with hypertension (25) and those living in food deserts also have higher reported rates of hypertension (7). The inclusion of these parameters into our study may have further explained the relationship between food insecurity and hypertension but was not accessible through NHANES.

5.3 Generalizability

Our weighted prevalence of hypertension was 34.9%, which was slightly higher than what has previously been found in other studies using NHANES data (3, 16). From our study, the non-weighted percentages of hypertensive individuals that were aware of their condition (87.9%) and were being treated (81.5%) also were higher than the previously reported national average for the United States (3). High prevalence rates for

the awareness and treatment of hypertension show the dedication healthcare professionals have placed on education and treatment for individuals with high blood pressure. Also, our study found that 56.0% of hypertensive individuals were considered controlled, while the estimated percentage of controlled hypertension in the U.S. was 52.0% (3). The prevalence rate for the control of hypertension was considerably below those of the awareness and treatment of hypertension. Due to this sizable difference there is much room for improvement in order to prevent chronic diseases associated with uncontrolled hypertension.

The amount of missing data in our study is a considerable limitation. NHANES guidelines suggest a 10% item nonresponse rule for results to be generalizable to the United States population. Our study was missing 11.9% of the data for the first aim and therefore the generalizability of our results may be somewhat impacted. Despite the fact of missing data, our study population was relatively large and should still be representative of the U.S. population for 2011-2014 for aim 1 analyses. Once the exclusion criteria were applied for the ATC analyses (aim 2) all weighting was removed from this portion of the study due to a large drop in sample size from the original NHANES population. This non-weighting procedure limits the generalizability of the ATC results in the sense that it is no longer statistically representative of the U.S. population but has the benefit of being internally valid (whereas inappropriate weighting could lead to bias).

The methods used to measure the exposure and outcome of interest were strengths within our study. Food insecurity was measured by questions from the U.S. Household Food Security Survey Module (HFSSM), which is considered the gold standard for measuring food security levels (4). While this is the 'gold-standard' for measuring food security, issues stemming from recall bias or respondent bias may have impacted misclassification of the exposure. Blood pressure was measured by objective means following a strict protocol by trained staff (13, 14). By using this objective method misclassification of the outcome is highly unlikely because we did not rely on self-report that can be prone to error due to recall bias.

A previously mentioned limitation to the study is the lack of information on parameters such as food deserts and access to food assistance programs. Reverse causality is another major limitation within our study. NHANES uses a cross sectional study design that collects data simultaneously (33) therefore we cannot differentiate which condition came first, the exposure or the outcome.

CHAPTER 6

CONCLUSION

There was an increased odds of hypertension among individuals who experienced food insecurity. An increased odds of pre-hypertension also was present among individuals that experienced food insecurity when not controlling for BMI. The study's results indicate that food insecurity was associated with a person's hypertensive status. Future research needs to examine potential lifestyle and environmental factors that may impact dietary decisions that lead to this increase in hypertension rates. Examining the association further will facilitate understanding on the mechanisms at work in this high-risk group.

The results from this study support findings from previous research on hypertension and food insecurity (19). Also, the prevalence of awareness, treatment and control (ATC) of hypertension within the U.S. is similar to prior research (3). Therefore the findings from this study can assist in monitoring the success level of the ATC method used in public health and medical practice. Future studies with access to data on food deserts and information regarding food assistance programs may assist in determining individuals in need of specialized interventions or education on risk factors for hypertension.

REFERENCES

1. Yoon SS, Fryar C, Carrol M. Hypertension prevalence and control among adults: United States, 2011–2014. National Center for Health Statistics data brief, November 2015;(220):1–8

2. Fan AZ, Strasser SM, Zhang X, Fang J, Crawford CG. State socioeconomic indicators and self-reported hypertension among US adults, 2011 behavioral risk factor surveillance system. Prev Chronic Dis. 2015 Feb 26;12:E27.

3. Nwankwo T, Yoon SS, Burt V, Gu Q. Hypertension among adults in the United States: National Health and Nutrition Examination Survey, 2011-2012. NCHS Data Brief. 2013 Oct;(133):1–8.

4. Bickel G, Nord M, Price C, Hamilton W, Cook J. Guide to measuring household food security [Internet]. USDA, Food and Nutrition Service; 2000 [cited 2018 Feb 27]. Available from: https://fns-prod.azureedge.net/sites/default/files/FSGuide.pdf

5. Coleman-Jensen A, Rabbitt MP, Gregory CA, Singh A. Household Food Security in the United States in 2016 [Internet]. USDA, Economic Research Service; 2017 [cited 2018 Feb 27]. Available from: https://www.ers.usda.gov/webdocs/publications/84973/err-237.pdf

6. Grilo SA, Shallcross AJ, Ogedegbe G, Odedosu T, Levy N, Lehrer S, et al. Food insecurity and effectiveness of behavioral interventions to reduce blood pressure, New York City, 2012-2013. Prev Chronic Dis. 2015 Feb 12;12:E16.

7. Kelli HM, Hammadah M, Ahmed H, Ko Y-A, Topel M, Samman-Tahhan A, et al. Association Between Living in Food Deserts and Cardiovascular Risk. Circ Cardiovasc Qual Outcomes. 2017 Sep;10(9).

8. Suarez JJ, Isakova T, Anderson CAM, Boulware LE, Wolf M, Scialla JJ. Food Access, Chronic Kidney Disease, and Hypertension in the U.S. Am J Prev Med. 2015 Dec;49(6):912–20.

9. Banerjee T, Crews DC, Wesson DE, Dharmarajan S, Saran R, Ríos Burrows N, et al. Food Insecurity, CKD, and Subsequent ESRD in US Adults. Am J Kidney Dis Off J Natl Kidney Found. 2017 Jul;70(1):38–47.

10. Crews DC, Kuczmarski MF, Grubbs V, Hedgeman E, Shahinian VB, Evans MK, et al. Effect of food insecurity on chronic kidney disease in lower-income Americans. Am J Nephrol. 2014;39(1):27–35.

11. James PA, Oparil S, Carter BL, Cushman WC, Dennison-Himmelfarb C, Handler J, et al. 2014 Evidence-Based Guideline for the Management of High Blood Pressure in Adults: Report From the Panel Members Appointed to the Eighth Joint National Committee (JNC 8). JAMA. 2014 Feb 5;311(5):507–20.

12. Bell K, Twiggs J, Olin, BR. Hypertension: The Silent Killer: Updated JNC 8 Guideline Recommendations [Internet]. Alabama Pharmacy Association; 2015 [cited 2018 Feb 27]. Available from: https://c.ymcdn.com/sites/aparx.site-ym.com/resource/resmgr/CEs/CE_Hypertension_The_Silent_K.pdf

13. National Center for Health and Statistics. Health of Black or African American non-Hispanic Population [Internet]. 2017 [cited 2018 Feb 27]. Available from: https://www.cdc.gov/nchs/fastats/black-health.htm

14. Thorpe RJ, Brandon DT, LaVeist TA. Social context as an explanation for race disparities in hypertension: findings from the Exploring Health Disparities in Integrated Communities (EHDIC) Study. Soc Sci Med 1982. 2008 Nov;67(10):1604–11.

15. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M et al. Heart disease and stroke statistics-2015 update: A report from the American Heart Association. Circulation. 2015 Jan 27;131(4):e29-e39. Available from, DOI: 10.1161/CIR.0000000000000152

16. Zhang Y, Moran AE. Trends in the Prevalence, Awareness, Treatment, and Control of Hypertension Among Young Adults in the United States, 1999 to 2014. Hypertens Dallas Tex 1979. 2017;70(4):736–42.

17. Nesbitt S, Palomarez RE. Review: Increasing Awareness and Education on Health Disparities for Health Care Providers. Ethn Dis. 26(2):181–90.

18. Palar K, Sturm R. Potential societal savings from reduced sodium consumption in the U.S. adult population. Am J Health Promot AJHP. 2009 Oct;24(1):49–57.

19. Seligman HK, Laraia BA, Kushel MB. Food insecurity is associated with chronic disease among low-income NHANES participants. J Nutr. 2010 Feb;140(2):304–10.

20. Berkowitz SA, Berkowitz TSZ, Meigs JB, Wexler DJ. Trends in food insecurity for adults with cardiometabolic disease in the United States: 2005-2012. PloS One. 2017;12(6):e0179172.

21. Berkowitz SA, Basu S, Meigs JB, Seligman HK. Food Insecurity and Health Care Expenditures in the United States, 2011-2013. Health Serv Res. 2017 Jun 13;

22. Weiser S, Palar K, Hatcher A, Young S, Frongillo E, Laraia B. Food Insecurity and Health: A Conceptual Framework. In 2015. p. 23–50.

23. National Heart, Lung, and Blood Institute (NHLBI). Dash Eating Plan[Internet]. [cited 2018 Feb 27]. Available from: https://www.nhlbi.nih.gov/health-topics/dash-eating-plan

24. Juraschek SP, Miller ER, Weaver CM, Appel LJ. Effects of Sodium Reduction and the DASH Diet in Relation to Baseline Blood Pressure. J Am Coll Cardiol. 2017 Dec 12;70(23):2841–8.

25. Weinfield NS, Mills G, Borger C, Gearing M, Macaluso T, Montaquila J, et al. Hunger in America: National Report [Internet] Feeding America; 2014 [cited 2018 Feb 27]. Available from: http://help.feedingamerica.org/HungerInAmerica/hunger-in-america-2014-full-report.pdf

26. American Nutrition Association. USDA Defines Food Deserts [Internet]. [cited 2018 Feb 27]. Available from: http://americannutritionassociation.org/newsletter/usda-defines-food-deserts

27. Pérez-Escamilla R, Villalpando S, Shamah-Levy T, Méndez-Gómez Humarán I. Household food insecurity, diabetes and hypertension among Mexican adults: results from Ensanut 2012. Salud Publica Mex. 2014;56 Suppl 1:s62-70.

28. Zipf G, Chiappa M, Porter KS, Ostchega Y, Lewis BG, Dostal J. National health and nutrition examination survey: plan and operations, 1999-2010. Vital Health Stat Ser 1 Programs Collect Proced. 2013 Aug;(56):1–37.

29. National Health and Nutrition Examination Survey (NHANES). NHANES Participants Homepage [Internet]. [cited 2018 Feb 27]. Available from: https://www.cdc.gov/nchs/nhanes/participant.htm

30. Maahs DM, Kinney GL, Wadwa P, Snell-Bergeon JK, Dabelea D, Hokanson J, et al. Hypertension prevalence, awareness, treatment, and control in an adult type 1 diabetes population and a comparable general population. Diabetes Care. 2005 Feb;28(2):301–6.

31. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, et al. Heart disease and stroke statistics--2015 update: a report from the American Heart Association. Circulation. 2015 Jan 27;131(4):e29-322.

32. National Health and Nutrition Examination Survey (NHANES). NHANES Sample Design, 2011-2014 [Internet]. [cited 2018 Mar 1]. Available from: https://www.cdc.gov/nchs/data/series/sr_02/sr02_162.pdf

33. National Health and Nutrition Examination Survey (NHANES). NHANES: Plan and Operations, 1999-2010 [Internet]. [cited 2018 Mar 1]. Available from: https://www.cdc.gov/nchs/data/series/sr_01/sr01_056.pdf

APPENDIX A

ADDITIONAL TABLES

Table A.1 Prevalence odds ratio for hypertension status by dichotomized food security levels including all covariates from 2011-2012 and 2013-2014 NHANES waves

	Pre-Hypertension vs. Normal		**Hypertension vs. Normal**	
Effect (N = 9,853)	POR Estimate	P-value	POR Estimate	P-value
Food Security				
Food Secure Adjustment 2	**1.0**	**-**	**1.0**	**-**
Food Insecure Adjustment 2	0.91 (0.76-1.10)	0.28	0.73 (0.59-0.90)	0.01

P-values are derived from the X^2 test. Only results for adjustment 2 are shown. Analysis controlled for all covariates in directed acyclic graph. Results in table are weighted using 4-year weights. **Definitions**: Hypertension is defined as a systolic or diastolic BP reading of ≥ 140/90 mmHg or taking antihypertensive medication.
Adjustments: Adjustment 2 shows the direct effect and controls for covariates plus BMI.
Abbreviations: BMI = Body Mass Index, POR = Prevalence Odds Ratio, BP = Blood Pressure

Table A.2 Prevalence odds ratio for hypertension status by dichotomized food security levels excluding smoking from 2011-2012 and 2013-2014 NHANES waves

Effect (N = 9,858)	Pre-Hypertension vs. Normal		Hypertension vs. Normal	
	POR Estimate	P-value	POR Estimate	P-value
Food Security				
Food Secure Adjustment 2	**1.0**	**-**	**1.0**	**-**
Food Insecure Adjustment 2	0.92 (0.77-1.10)	0.34	0.74 (0.61-0.92)	0.01

P-values are derived from the X^2 test. Only results for adjustment 2 are shown. Analysis controlled for all covariates in directed acyclic graph except smoking. Results in table are weighted using 4-year weights. **Definitions**: Hypertension is defined as a systolic or diastolic BP reading of ≥ 140/90 mmHg or taking antihypertensive medication.
Adjustments: Adjustment 2 shows the direct effect and controls for covariates plus BMI.
Abbreviations: BMI = Body Mass Index, POR = Prevalence Odds Ratio, BP = Blood Pressure