

HEALTH MANAGEMENT OF ADULT HYPERTENSION IN THE UNITED STATES: RESULTS  
FROM THE NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY (NHANES)

BY

HYUN KIM

DISSERTATION

Submitted in partial fulfillment of the requirements  
for the degree of Doctor of Philosophy in Community Health  
in the Graduate College of the  
University of Illinois at Urbana-Champaign, 2016

Urbana, Illinois

Doctoral Committee:

Associate Professor Flavia Andrade, Chair  
Professor Reginald Alston  
Professor Wojtek Chodzko-Zajko  
Associate Professor Elizabeth Powers

## ABSTRACT

This research is a comprehensive study that describes how individuals with hypertension do their health behaviors and how their behaviors change over time based on their diagnostic status and the duration of hypertension.

The Dietary Approaches to Stop Hypertension (DASH) diet is a widely used dietary recommendation for individuals with hypertension. Even though adherence to the DASH diet has been shown to be effective, it is unclear whether hypertension diagnosis has an impact on adherence to the DASH diet and nutrient intake. This study examined the association between hypertension diagnosis and the nutrient intake using the seemingly unrelated regression (SUR) method. The data came from the 2007-2008, 2009-2010 and 2011-2012 cross-sectional National Health and Nutrition Examination Survey (NHANES) which is a sample of the civilian, non-institutionalized adult population in the United States. The outcome was accordance with the DASH recommended intake of nine nutrients (0 to 9 point DASH score). Study findings indicated that, regardless of diagnostic status, individuals with hypertension did not seem to follow the DASH guidelines. Compared to undiagnosed individuals, individuals diagnosed with hypertension were less likely to adhere to the DASH guidelines with higher intake of cholesterol. Individuals both diagnosed and undiagnosed with hypertension showed no difference in their nutrient intake to control their blood pressure, but those diagnosed with hypertension had significantly higher intake of cholesterol than those not diagnosed. Overall, regardless of diagnostic status, individuals with hypertension did not seem to follow the DASH guidelines.

The DASH diet is a widely used dietary recommendation for individuals with hypertension. This study examined how age at hypertension diagnosis and time since its diagnosis were associated with the DASH nutrient intake. The data came from the 2007-2008, 2009-2010 and 2011-2012 cross-sectional National Health and Nutrition Examination Survey (NHANES). Seemingly unrelated regression (SUR) method was used to estimate adherence to the DASH diet by age at hypertension diagnosis and time since diagnosis. The outcome was accordance with the DASH recommended intake of nine nutrients (0 to 9 point DASH score). Age at diagnosis of hypertension was significantly associated with the DASH nutrients. Older age at diagnosis was associated with significant decreases in intake of sodium, cholesterol, saturated fat, total fat, protein, calcium and magnesium and increased intake of fiber. Similarly, duration of hypertension was positively associated with intake of sodium, cholesterol, saturated fat, total fat, protein, calcium and magnesium, and individuals with shorter duration were likely to have lower DASH score and less satisfied the DASH target score of 4.5 points. Despite the study findings that individuals with hypertension improved their diet a little with increased duration of disease, their diet was not still accordant to the DASH diet based on age at diagnosis and its duration. In order to achieve it and deliver more tailored educational messages, it is important to first understand what barriers individuals with hypertension have to engage in healthy diet.

Regular physical activity, smoking cessation, and moderate alcohol consumption are important lifestyle behaviors that can be adopted to manage hypertension. Our goal was to determine the effect of a hypertension diagnosis among individuals with hypertension on their lifestyle behaviors. Data came from the three repeated cross-sectional waves of the National Health and Nutrition Examination Survey (NHANES) in 2007-2008, 2009-2010 and 2011-2012. Lifestyle behaviors in the analysis included smoking status, alcohol consumption,

and physical activity. Multinomial logistic regression models were used to estimate the relative risk (RR) of adopting adequate lifestyle behaviors. A diagnosis of hypertension was positively associated with an individual's past smoking status, but it was not significantly associated with current smoking status. Among individuals with hypertension, a diagnosis of hypertension was not significantly associated with physical activity status. Individuals with diagnosed hypertension were more likely to quit smoking than those with undiagnosed condition, but they tended not to engage in physical activity. The prevalence of current unhealthy lifestyle behaviors is an important predictor of the future burden of these-related diseases such as hypertension and cardiovascular diseases, so a variety of risk factors, many of which are modifiable, play an interactive role in the development of hypertension. Health professionals will be able to help individuals with or at risk for hypertension to adopt long-term healthier lifestyle behaviors through initial directions and guidance about proper management and prevention of other health complications, because behavioral modifications can be the most important for primary and secondary prevention of hypertension.

## ACKNOWLEDGEMENTS

I would not have been able to complete this dissertation without the help of many people. I would like to acknowledge and sincerely thank my advisor and mentor, Dr. Flavia Andrade. Without her guidance and support, I would not have been able to make it through this long journey. I am very grateful to Dr. Andrade for allowing me to be her advisee and for being my mentor through thick and thin. Her word and advice have been really helpful and encouraging in good and hard times. Acknowledgements are also due to the members of my dissertation committee, Dr. Reginald Alston for his kind support with my job search process; Dr. Wojtek Chodzko-Zajko for his valuable help and support on this research providing keen insight into the research subject; and Dr. Elizabeth Powers for her support during the research process and examinations. All of my committee members' expertise and support have helped me to complete this research and are greatly appreciated. I wish to express gratitude to my family and friends for their understanding and support through these graduate school years.

## TABLE OF CONTENTS

Chapter 1: Introduction.....	1
Chapter 2: Diagnostic Status of Hypertension on the Adherence to the Dietary Approaches to Stop Hypertension (DASH) Diet.....	7
Chapter 3: Age at Diagnosis and Duration of Hypertension on the Adherence to the Dietary Approaches to Stop Hypertension (DASH) Diet.....	25
Chapter 4: Effect of a Diagnostic Status of Hypertension on Adherence to Lifestyle Recommendations.....	38
Chapter 5: Conclusions.....	48
References.....	54

## Chapter 1: Introduction

With the onset of the epidemiological transition, the prevalence of infectious diseases decreased throughout the 20<sup>th</sup> century, and public health began to put more focus on chronic diseases such as hypertension. The global prevalence of hypertension in 2008 was 29.2% and 24.8% for males and females, respectively, aged 25 years and older according to the WHO Health Statistics.<sup>1</sup> In the United States, prior to 1990, the prevalence of hypertension and the mortality rate due to cardiovascular diseases had been decreasing.<sup>2</sup> However, the prevalence of hypertension has been increasing since 1990.<sup>3,4</sup> Between 2001 and 2010, prevalence rates for hypertension increased from 29% to 32%. Significant increases in both obesity and unhealthy dietary choices may have contributed to the increasing prevalence of hypertension in recent years.<sup>5,6</sup> The prevalence of hypertension is approximately 45% among African-Americans and 33% among White Americans.<sup>7</sup> In addition, hypertension tends to be more common in men than in women,<sup>8</sup> and older individuals are at higher risk than younger individuals.<sup>3</sup> The risk for and consequences of hypertension increase with age, making its management particularly important for older individuals.<sup>3,9</sup>

Hypertension has been called the silent killer, because it is substantially or completely asymptomatic, and individuals with hypertension may not even realize they have it or may not view their hypertension as a serious problem.<sup>10</sup> If individuals with hypertension do not carefully manage their conditions, they are more likely to experience complications across their lifespan. Hypertension has been associated with an increased risk for developing heart diseases and stroke.<sup>11-13</sup>

The adoption of unhealthy lifestyle behaviors is an important risk factor for developing hypertension and related health consequences. Lifestyle behaviors that can be adopted to manage hypertension include a healthy diet, weight control, regular physical activity, smoking cessation and moderate alcohol consumption.<sup>14-16</sup> These lifestyle changes

can significantly reduce blood pressure among people with hypertension, and the Dietary Approaches to Stop Hypertension (DASH) diet has been recognized as an effective set of dietary recommendations to prevent and manage high blood pressure.<sup>14,17,18</sup> The DASH diet is developed by the National Heart, Lung, and Blood Institute (NHLBI) to provide guidance on managing high blood pressure, and it has also been recommended by the American Heart Association (AHA) for the prevention and treatment of hypertension. This diet generally recommends lower intakes of sodium, sugars and fats than the typical American diet, as well as lower intakes of saturated fat and cholesterol to help lower blood pressure.<sup>19-22</sup> Evidence from public health research has been used to support health education strategies, which encourage individuals to adopt healthier behaviors. Previous studies have shown that adherence to the DASH eating plan reduces the risk of coronary heart disease that can result from hypertension.<sup>23-25</sup> This existing evidence supports a substantial ability for individuals to control their hypertension without the need for medication since healthy diet appears to have a positive long-term influence on cardiovascular risk.<sup>2,26</sup> Even though medical treatment can be effective for hypertension, it can be inconvenient and expensive for some. Thus, behavioral modifications can serve as a good complement and/or alternative to medical treatment.<sup>15</sup> This highlights the importance of a healthy diet and lifestyle recommendations in protecting against high blood pressure.

For this research, the following three main theories have been used to describe how individuals with hypertension engage in health behaviors and how their behaviors change over time based on their diagnostic status of hypertension and its duration. According to Grossman's model of the demand for health, health can be considered a durable good such that an individual can increase his health stock by investing with his/her time and goods.<sup>27</sup> In following with this model, individuals with hypertension can invest more in their health by engaging in better health behaviors such as a healthy diet, more physical activity and

smoking cessation. In addition, individuals will be more likely to take their health behaviors in a healthier direction after a negative health shock (diagnosis of hypertension). Although the diagnosis of a health condition can be positively associated with better health behaviors in Grossman's model of the demand for health,<sup>28,29</sup> there is also evidence that some individuals are more predisposed towards instant rewards, as opposed to adhering to longer-term healthy behaviors.<sup>30,31</sup> The model of rational addiction suggests individuals with hypertension may anticipate that the long-run consequences of having unhealthy behaviors today are sufficiently bad for their health, because they make a forward-looking consumption plan. Therefore, individuals with hypertension recalibrate their dietary choices in response to new information. As discussed earlier, individuals with hypertension are willing to engage in healthier diets if they expect lower prices of healthy food choices in the future. On the other hand, they may not engage in positive health behaviors if they expect lower prices of hypertension medication in the long-term. The hyperbolic discounting framework describes time inconsistent behaviors of individuals. Individuals with hypertension can attempt to quit their unhealthy dietary behaviors multiple times, but they will make inconsistent dietary choices over time. Translating their understanding about a healthy diet does not indicate that they are going to commit to adopting it, so they sometimes engage in healthy diets but sometimes in unhealthy diets. They will change their health behaviors inconsistently over time.

The Health Belief Model (HBM)<sup>32</sup> describes an individual's compliance in health behaviors such as diet, physical activity, and smoking cessation in order to prevent, control or treat disease conditions.<sup>33</sup> This model considers that socioeconomic status and health-related variables are associated with compliance in health behaviors.<sup>34</sup> Based on this model, individuals' beliefs about their health condition affect their behaviors, and their behavioral changes are dependent on the likelihood of getting a disease, the seriousness of the disease,

and the perceived benefits of compliance in health behaviors that will offset perceived barriers of compliance, strategies for change in behaviors, and self-confidence to overcome a disease. The HBM explains its theory with the following theoretical constructs: perceived susceptibility (“How likely are individuals to have hypertension and at what age?”), severity (“Do they have any restrictions in daily activities or physical limitations?”), benefits (“Will they feel better if they engage in a healthier diet?”), and barriers (“How difficult will it be to engage in a healthier diet?”). As a result, individuals weight choosing better health behaviors with their consideration of their own perceived susceptibility and the seriousness of a condition as well as the benefits coming from their health behaviors.<sup>33,34</sup> These perceptions are expected to be affected by the individuals’ demographic and social characteristics which can influence an individual’s willingness to start engaging in healthier dietary behaviors. The HBM is used to study why individuals engage in specific health behaviors, so the second chapter references this framework to explain the compliance with health behaviors for hypertension.<sup>35-40</sup>

Based on these conflicting theories of health behaviors, individuals with hypertension may engage in healthier nutrient intakes and, as a result, have higher DASH accordance scores. On the other hand, they may have lower DASH accordance scores with unhealthier nutrient intakes. This study aims to address the current behavior of nutrient intakes among individuals with hypertension depending on their diagnostic status of hypertension. The NHANES data are analyzed to characterize the association between the diagnostic status of hypertension and nutrient intake, and the DASH accordance score and its nutrient intake are estimated by a system of multivariate regression models.

Health professionals often give their patients instructions and guidance for primary and secondary prevention of hypertension. Primary prevention messages are given to individuals without hypertension and those at higher risk for high blood pressure, and these

messages include healthy eating and lifestyle behaviors.<sup>41</sup> Secondary prevention messages are given to individuals diagnosed with hypertension, and these messages include behavioral modifications and screening tests for other diseases.<sup>42</sup> In this dissertation, we explore the associations between hypertension diagnosis and the adoption of health behaviors based on these health theories. The focus on the diagnostic status and the duration of hypertension is because individuals are expected to have different levels of motivation and compliance with engaging in healthier behaviors for the primary and secondary prevention of hypertension. This dissertation which explains their current health behaviors and readiness to act after the diagnosis has the following three research objectives:

**Research Objective 1:** The first chapter examines the importance of a hypertension diagnosis among individuals with hypertension and shows how diagnostic status is associated with individuals' dietary behaviors. The study tests whether individuals with diagnosed hypertension adopt healthier nutrient intake after being diagnosed with hypertension more often than those with undiagnosed hypertension. The hypothesis is that once an individual is diagnosed with hypertension, the diagnosis would serve as new information that motivates them to make their nutrient intake healthier. This information would help them realize the higher cost of a poor diet making them more willing to invest in good health.

**Research Objective 2:** The second chapter examines the time effect of dietary behaviors based on age at hypertension diagnosis (the duration of hypertension diagnosis). The study tests whether the duration of hypertension following diagnosis is associated with nutrition intake. With its new data availability about age at hypertension diagnosis in the National Health and Nutrition Examination Survey (NHANES) since 2007, this chapter hypothesizes that a longer duration of diagnosis of hypertension provides individuals with hypertension a

motivation for healthy diet, because they are more likely to be aware of adverse consequences of hypertension in the long-term. That is, the longer the elapsed time since a diagnosis of hypertension, diagnosed individuals are more likely to respond positively with changes in dietary behaviors. Since immediate changes in dietary behaviors are known to have barriers such as an individual dietary preference, diagnosed individuals with longer duration of hypertension may be more willing to engage in a healthier diet. Individuals with longer duration may be more aware of concurrent conditions such as obesity, diabetes and heart diseases, so they may be more willing to adopt a healthy diet which can be the easiest approach to be away from the threat of those diseases.

**Research Objective 3:** The third chapter examines the importance of hypertension diagnosis among individuals with hypertension and shows how diagnostic status is associated with individuals' lifestyle behaviors: smoking status, alcohol consumption and physical activity. This study evaluates whether individuals with diagnosed hypertension have better nutrient intake than those with undiagnosed hypertension. In addition, it investigates whether individuals with diagnosed hypertension have healthier lifestyle behaviors, such as smoking cessation, moderate alcohol consumption and active physical activity, than those with undiagnosed hypertension. In following with Research Objective 1, the hypothesis is that once an individual is diagnosed with hypertension, the diagnosis would serve as motivation to influence their lifestyle health behaviors.

## **Chapter 2: Diagnostic Status of Hypertension on the Adherence to the Dietary Approaches to Stop Hypertension (DASH) Diet**

### **Introduction**

In the United States, approximately one-third of adults have high blood pressure.<sup>43</sup> Prior to 1990, the prevalence of hypertension had been decreasing, along with the mortality rate due to cardiovascular diseases.<sup>2</sup> However, significant increases in the prevalence of obesity and changes toward unhealthy dietary choices seem to have contributed to the increasing prevalence of hypertension in recent years.<sup>5,6</sup>

The National Heart, Lung and Blood Institute (NHLBI) and the American Heart Association (AHA) recommend the Dietary Approaches to Stop Hypertension, also known as the DASH diet, for both individuals with hypertension and those who are overweight or obese.<sup>44,45</sup> This diet is rich in protein, potassium, calcium, and fiber and low in total fat, saturated fat, cholesterol, and sodium. The DASH diet is considered by some to be the most effective diet for hypertension management, as it reduces the systolic and diastolic blood pressure of individuals with hypertension.<sup>46,47</sup> Hypertension is a long-term, lifelong condition for most individuals<sup>9,19</sup>; as such, the health behaviors of hypertensive individuals, especially with regard to their diet, have long attracted the attention of health scholars. The recommended diet for those with hypertension generally consists not only of lower sodium, sugar, and fat intake than the typical American diet, but also of a lower saturated fat and cholesterol intake.<sup>44,46</sup> Adherence to the DASH eating plan has been shown to reduce the risk of coronary heart disease, which can result from hypertension.<sup>23,24</sup>

Grossman's model of the demand for health describes an individual's endogenous life span.<sup>27</sup> Within the context of Grossman's framework, health can be considered a durable

good such that an individual can increase his health stock by investing with his/her time and goods. An investment in health includes an individual's own time and healthy behaviors such as diet, physical activity and smoking cessation. Individuals will engage in better health behaviors if they highly value their health and manage long-term health.<sup>48,49</sup> Clark, Etile<sup>50</sup> find that those who have experienced serious illness tend to engage in healthier smoking behaviors such as less smoking or smoking cessation. As Grossman<sup>27</sup> suggests, since smoking can accelerate the depreciation of an individual's endowed health stock over time, individuals start to become concerned about the health risks associated with smoking, and therefore, increase their demand for good health. Falba<sup>51</sup> also finds that as individuals become older, they become motivated to stop smoking after they realize that their current health status is not good. Thus, individuals are more likely to take their diet in a healthier direction upon receiving negative health shocks (e.g. a diagnosis of hypertension in this research) in order to increase their health stock. For individuals with hypertension, a negative health shock (hypertension diagnosis) might motivate them to follow a specific diet regimen in order to augment their health stock or increase their number of healthy days. As a result, individuals diagnosed with hypertension might invest more in their health in order to increase their health stock or decrease their rate of depreciation than those undiagnosed with hypertension. Since an investment in health lowers not only the risk of hypertension but also the risk of many other chronic diseases and complications that can be caused by hypertension, this fact can further increase the incentive for individuals to invest in their health through better lifestyle behaviors.

It is widely known that an individual's risk perception of their health condition is positively associated with their health behaviors<sup>28,29</sup>. However, there is evidence that people are more attracted to immediate rewards that give them higher short-run satisfaction and tend to devalue the future consequences of their current actions<sup>30,31</sup>. Under this framework, one

would expect that individuals with diagnosed hypertension might not try to modify their diet or lifestyle behaviors, because they lack the self-control to change poor lifestyle behaviors. Addictive behaviors could be rational and portray time-consistent preferences. In fact, Becker's rational choice theory<sup>52</sup> suggests that consumers maximize their utility consistently over time and that their stable preferences explain why consumers sometimes engage in potentially harmful and addictive activities such as smoking and eating salty snacks.

Becker and Murphy's model of rational addiction suggests that complementarity between current and future consumption of a behavior, such as smoking and physical activity among individuals with hypertension, can explain addiction to a consumption good.<sup>53,54</sup> For example, Kahn<sup>55</sup> shows that individuals who have been diagnosed with diabetes and who are therefore aware of their condition, have better dietary and lifestyle behaviors than those who are not aware of their health condition. Even more, such behaviors are mainly observed among individuals who place more value in the future and are responsive to harmful future consequences of addictive goods. Although the diagnosis of a health condition can be positively associated with better health behaviors such as adhering to a healthy diet,<sup>56</sup> there is evidence that some individuals are more predisposed towards instant rewards, as opposed to adhering to longer-term healthy behaviors.<sup>30,31</sup> As such, changing health behaviors may be difficult, irrespective of diagnostic status, so the persistence of health behaviors over time explain why some individuals may engage in potentially harmful activities.

However, another possibility is that individuals tend to choose smaller instant-rewards activities rather than larger future-rewards activities. According to this theory of hyperbolic discounting, individuals choose different rewards depending on how close their reward realization is. If they realize their current behaviors produce negative consequences in the long-term, individuals may not want to modify their current behaviors. To increase future utility, individuals need to understand that they are rewarded for engaging in healthier

behaviors relatively soon. For example, older individuals with hypertension might be more willing to modify their current dietary behavior as they are more likely to be affected by negative health conditions (e.g. complications of hypertension such as heart disease and stroke) sooner. In the case of hypertension, according to this theory, individuals might be unwilling to modify their diet to give up what they strongly prefer and consume what they do not like. For example, individuals with hypertension are advised to reduce salt intake since cutting back on salt prevents blood pressure from rising. This particular diet modification might require individuals to either reduce their consumption of salty foods like french fries or steak which might be difficult for those who strongly prefer such foods. In addition, older individuals with hypertension might be more willing to modify their current dietary behavior as they are more likely to be affected by ill health condition (complications of hypertension such as heart disease and stroke) sooner. In the case of hypertension, individuals might be unwilling to consume what they do not like and to modify their diet to give up what they strongly prefer. Diagnosed individuals might not try to modify their diet or lifestyle behaviors, because they lack the self-control to change unhealthy lifestyle behaviors. Based on this framework of time inconsistent hyperbolic discounting, individuals with hypertension would start engaging in healthy lifestyle behaviors tomorrow but not today. This is because the immediate reward from unhealthy behaviors is high. The above theoretical frameworks may help explain why individuals, after being diagnosed with hypertension, may or may not engage in healthier diets. Unfortunately, in this research, we don't know how many individuals have received information about the DASH diet and lifestyle recommendations, and how the information has been emphasized from the NHANES data.

Previous studies have found an association between unhealthy dietary choices, such as increased intake of sodium and cholesterol and an elevated risk of hypertension.<sup>14,57</sup> Other studies have explored the challenges involved in dietary compliance among individuals

diagnosed with hypertension.<sup>18,58,59</sup> However, dietary compliance in response to a hypertension diagnosis has not been fully investigated. An exception has been the study by Slade and Kim<sup>60</sup> who investigated the association between being diagnosed with hypertension and adherence to DASH nutrients and Mediterranean diets. This study, however, failed to include a critical group in their analyses: individuals with hypertension who were on medication who showed normal blood pressure levels during the physical examination conducted by the Centers for Disease Control and Prevention (CDC). The present study extends the previous literature on dietary compliance and the role of hypertension diagnosis by using corrected sampling criterion and more recent data. We focus on DASH accordance and the DASH score to examine overall compliance with the diet by using seemingly unrelated regression (SUR). Our sample included individuals with managed hypertension, and this inclusion enables us to better evaluate adherence to the DASH diet among individuals with hypertension by their diagnostic status.

## **Methods**

The NHANES is a cross-sectional survey conducted by the National Center for Health Statistics for the CDC. The survey is based on a stratified, multi-stage probability sample of the civilian, non-institutionalized population in the United States and includes health status and health-related behavior data derived from at-home interviews, followed by physical examinations and laboratory tests. This study was a secondary data analysis of publicly available data, so it was exempt by the Institutional Review Board at the University of Illinois at Urbana-Champaign.

Data from three two-year cycles (2007-2008, 2009-2010, and 2011-2012) were used in the analyses. The study population was restricted to 17,713 participants aged 20 years and older. A diagnosis of hypertension was defined as that made by a physician or health

professional and reported as such by the participant. The physical examination section contained up to four measurements of systolic and diastolic blood pressure conducted by CDC which were used to define a presence of hypertension in this chapter. Individuals who self-reported being previously diagnosed with hypertension from the personal interview but had normal levels of blood pressure while not on medication at the time of the survey were included for the analyses because of possible effects of white coat hypertension diagnosis in NHANES data. Our analytic data excluded those with missing data on their self-reported hypertension condition from the home interview or their blood pressure measurement from the physical examination ( $n = 1,553$ ). Following the protocol of previous studies, individuals with excessive (greater than 7,000 Kcal/day) and deficient (less than 700 Kcal/day) total energy intake were also excluded ( $n = 1,439$ ) to minimize the problem of dietary reporting errors and to increase the reliability of the analysis for nutrient intake.<sup>61-63</sup> The final sample was composed of 5,653 individuals with hypertension.

*Hypertension Diagnostic Status.* In NHANES, individuals reported if they had ever been diagnosed with hypertension. Following AHA's classification of hypertension, hypertension status was defined as the self-reporting of hypertension or when an average of repeated readings of blood pressure measurement indicated that systolic blood pressure (BP) was 140 mm Hg or higher or that diastolic BP was 90 mm Hg or higher. This classification of hypertension status included participants who reported current use of prescribed medication for hypertension during the home interview.<sup>64</sup> A status of hypertension diagnosis was defined based on an individual's self-reporting of a previous diagnosis of hypertension and blood pressure readings measured from the physical examination. Based on self-reports and four blood-pressure measurements, individuals with hypertension were classified into two groups: (1) those previously diagnosed with the condition; and (2) those not previously diagnosed

with the condition.

*Dietary Variables.* NHANES collected survey participants' food and nutrient intake for two non-consecutive days through 24-hour dietary recall interviews. The first interview was conducted in person, and the following interview was conducted by phone 3 to 10 days later. Dietary data contained detailed information on the nutrients in the diet consumed by the respondent over the 24-hour period(s). These dietary recall data were analyzed by using the United States Department of Agriculture (USDA) Food and Nutrient Database for Dietary Studies (FNDDS) to calculate daily intake of energy and nutrients.<sup>65,66</sup> For intake of total energy and other nutrients, including sodium, cholesterol, saturated and total fat, and fiber, an average intake from the two 24-hour dietary recalls was used for the analysis.

The analyses focused on nine nutrient components that were emphasized in the DASH diet: sodium, cholesterol, saturated fat, total fat, protein, calcium, magnesium, potassium, and fiber. The DASH accordant score ranged from 0 to 9 points generated using the sub-scores from the nine nutrient components. Table 1-1 shows the scoring method for the DASH accordant score. Individuals who reached the DASH goal for the consumption of a given nutrient received 1 point for that nutrient, while those who consumed a given nutrient between the DASH goal and the DASH control diet received 0.5 points, thereby meeting an intermediate target level; otherwise, individuals received 0 points for the nutrient. The score was adopted using a scoring scheme previously developed and used by other studies.<sup>64,67,68</sup> In addition, a score of 4.5 points or higher was defined as being in modest accordant with the diet, so individuals with the DASH accordant score of 4.5 points or higher were considered to be in intermediate accordant with the DASH guidelines in the study.

*Additional Variables* The regression results were adjusted for demographic characteristics,

including age, gender, ethnicity, education, income level, marital status, and health insurance status as well as lifestyle behaviors such as special diet status, smoking and physical activity.

Ethnicity included four categories: non-Hispanic White, non-Hispanic Black, Hispanic, and other racial groups (which include Asian and multi-racial). Education was grouped into four levels: less than high school, completed high school, some college, and college graduate or above. Marital status was dichotomized into 0 for “Not married” and 1 for “Married.” In NHANES, annual household income was grouped into eleven categories, ranging from \$0 to \$75,000 or more. In this study, annual household income was grouped into four levels, below \$20,000, \$20,000-\$44,999, \$45,000-\$74,999, and \$75,000 or more. The health insurance variable was dichotomized into 0 for not having health insurance nor any other health care plan such as Medicare and Medicaid and 1 for having any.

Individuals with a body mass index (BMI) under 18.5 were classified as underweight, those between 18.5 and 24.9 as normal, those between 25.0 and 29.9 as overweight, and those with a BMI 30.0 or greater were classified as obese. Since hypertension was more common in individuals with diabetes than in the general population<sup>69-71</sup>, a dichotomous variable based on self-reported diabetes was included (0 for not having diabetes and 1 for having diabetes). Other self-reported medical conditions (i.e. heart failure, coronary heart disease, heart attack and stroke) were also considered as a dichotomous variable in the study, because hypertension was known as a major risk factor for these conditions. In addition, self-rated health status asked each survey participant’s health in general and had 5 categories with excellent, very good, good, fair, and poor. In the study, this information was categorized into three categories: “excellent,” “very good/ good/ fair” and “poor.”

Lifestyle behaviors which included smoking and physical activity were also considered in the study. Each nutrient intake was adjusted for total energy intake which was the average value from the two-day dietary recalls since dietary recommendations were based

on energy requirements. Individuals who reported being under a special diet for weight loss or other health-related reasons were coded as 1 for “Yes,” whereas those who answered “No” are coded as 0. A dichotomous variable indicating current use of cigarettes was included in the analysis. The survey question on physical activity asked whether an individual did any moderate or vigorous-intensity sports, fitness, or recreational activities that caused an increase in breathing or heart rate for at least 10 minutes continuously each day. This information was a dichotomous variable coded as 0 for “No” and 1 for “Yes.”

*Statistical Analyses.* All statistical analyses were performed with STATA S.E. software (version 11; StataCorp). The associations of the DASH accordance and each nutrient intake with hypertension diagnosis were examined using SUR. The components of the DASH accordance score included nutrient variables, so the system of SUR models were assumed to be related because the error terms of individual regressions were assumed to be correlated. However, nutrient intake consumption across individuals was considered unrelated. That is, the error terms of nutrient intake and the diagnosis of hypertension equations were correlated for a given individual but uncorrelated across individuals. The joint estimates from the analysis were used to test whether a diagnosis of hypertension simultaneously affected nutrient intake, and the regression results were used to predict mean values of outcomes to describe the simultaneous effects of a diagnosis of hypertension. As a result, the study performed a joint test for estimating the following system of multivariate regression models of the DASH nutrient components represented in Equation (1):

$$DASH\ nutrient_{ij} = f_j(X_{ij}, \beta, Hypertension\ diagnosis) + \epsilon_{ij} \quad (1)$$

where  $DASH\ nutrient_j$  = sodium, cholesterol, saturated fat, total fat, protein, calcium,

magnesium, potassium and fiber and  $i = 1, \dots, n$  individuals. The  $X$  vector characterized a set of demographic variables such as age, gender, ethnicity, level of income, education, marital status, and health insurance status and other health behavioral variables such as smoking and physical activity.

Besides the individual nutrient intake, two additional outcome measures were used. The DASH accordance score measured an individual's degree of accordance with the DASH diet based on 9 nutrient targets, and the DASH accordance target level was based on the 4.5 points or more cutoff for satisfying intermediate level of nutrient targets. The study jointly estimates the following system of SUR equations for the DASH accordance represented in Equations (2) and (3):

$$\text{DASH accordance score}_i = f_{10}(X_i, \beta, \text{Hypertension diagnosis}) + \epsilon_{i10} \quad (2)$$

$$\text{DASH accordance target level}_i = f_{11}(X_i, \beta, \text{Hypertension diagnosis}) + \epsilon_{i11} \quad (3)$$

The DASH accordance score measured an individual's degree of accordance with the DASH diet based on 9 nutrient targets, and the DASH accordance status was based on the 4.5 points or more cutoff for satisfying an intermediate level of nutrient targets. The accordance score was analyzed as continuous variables based on the DASH scoring method (Table 1). Each equation had one error component, and these 9 error components from the system were idiosyncratic for each individual. By using SUR, the variance-covariance matrix improved the efficiency of the estimates from the DASH accordance score and the nutrient equations.

## Results

There were 5,653 individuals with hypertension, of which 83.8% had been previously diagnosed with the condition, whereas 16.2% had not. Table 1-2 presents demographic

characteristics of each group of individuals with hypertension based on their diagnostic status. The mean DASH score was 2.61 for individuals diagnosed with hypertension, and only 11% were classified as DASH accordant. The mean score for those undiagnosed with the condition was 2.73, and 12% of those individuals were DASH accordant. The means of energy intake for individuals with diagnosed and undiagnosed hypertension were 1,862.5 Kcal/day and 1,984.3 Kcal/day, respectively.

Individuals with diagnosed hypertension were older than those with undiagnosed hypertension. Approximately 35% of those with diagnosed hypertension were between 50 and 64 years of age, while 48% were over 65. Obesity and diabetes were more prevalent in individuals with diagnosed hypertension than those with undiagnosed hypertension. Self-reported heart conditions, such as heart failure, coronary heart disease, heart attack and stroke were also more prevalent in those with diagnosed hypertension.

Table 1-3 shows the analyses of the DASH nutrients evaluating the degree of association between hypertension diagnosis and DASH accordance, and Table 1-4 shows the predicted mean values of the outcomes from SUR. The association between hypertension diagnosis and the DASH accordance score was not statistically significant. Overall, both groups of individuals were not considered to be DASH accordant. The analyses showed that a diagnostic status of hypertension was positively associated with cholesterol intake ( $\beta = 71.0$ ,  $P$ -value: 0.016). Individuals diagnosed with hypertension had higher daily cholesterol intake than those who were not diagnosed with the condition. In addition, the interactions between hypertension diagnosis and different age groups were significant for cholesterol and fiber intake. Those diagnosed with hypertension were likely to consume less cholesterol but more fiber across different age groups. Diagnosed individuals in the 40-49 years age group engaged in healthier diets by consuming significantly less intake of cholesterol ( $\beta = 94.8$ ,  $P$ -value: 0.006), and those in the 65-80 years age group consumed less cholesterol intake ( $\beta =$

69.4, *P*-value: 0.026) compared to those in the youngest age group. For fiber intake, diagnosed individuals aged 50 years or older were likely to consume more fiber compared to those in younger age groups. Those in the 50-64 years age group had 3.2 grams of increase (*P*-value: 0.029), and those in the 65-80 years age group had 2.8 grams of increase in fiber intake (*P*-value: 0.047). Diagnosed individuals tended to have unhealthier diets, with higher intake of cholesterol than undiagnosed individuals. However, older individuals with diagnosed hypertension were likely to reduce their intake of cholesterol but increase their intake of fiber.

Males consumed more total caloric intake than females and, as a result, they had better DASH accordance scores and were more likely to be in accordance with the DASH guidelines. The DASH accordance score for non-Hispanic Blacks was lower by 0.2 points (*P*-value: <0.001) than for non-Hispanic Whites. Non-Hispanic Blacks had significantly lower intake of protein, calcium, magnesium, potassium and fiber, but they also consumed less sodium, saturated fat and total fat than non-Hispanic Whites. On the other hand, Hispanics were more likely to adopt a healthier diet and adhere to the DASH guidelines than non-Hispanic Whites with significantly lower intake of sodium, saturated fat and total fat and more intake of fiber.

Some demographic characteristics, such as education level, obesity and self-reported health status, were associated with DASH accordance among individuals with hypertension. Education level was positively associated with the DASH diet. High school graduates tended to have lower DASH accordance scores than individuals without a high school degree, and their DASH accordance score decreased by 0.1 points (*P*-value = 0.008). They were also less likely to satisfy the DASH intermediate target by 2.8% (*P*-value = 0.016) than those without a high school degree. However, those with a college or higher degrees were likely to have higher DASH accordance scores ( $\beta = 0.2$ , *P*-value: 0.002) and more likely to be accordant

with the DASH diet ( $\beta = 0.03$ ,  $P$ -value: 0.028) than those without a high school degree.

Accordance with the DASH diet was significantly lower for the obese or diabetic than those only with hypertension. Individuals with hypertension were likely to have lower DASH accordance scores and were considered less likely to be DASH accordant, with higher intake of sodium, cholesterol, saturated fat, and total fat and with lower intake of magnesium and fiber, when they were also obese. Compared to individuals who self-reported their health as “excellent”, those who reported their overall health condition as “good” had lower DASH accordance scores ( $\beta = 0.2$ ,  $P$ -value: 0.020). Lifestyle health behaviors, such as smoking and physical activity, were significantly associated with the overall quality of the DASH diet. If individuals were current-smokers, they were likely to have lower accordance levels with the DASH diet by consuming more cholesterol, saturated fat, and total fat and less calcium and fiber. However, if they engaged in either moderate or vigorous physical activities for at least 150 minutes continuously a week, they were likely to have higher DASH accordance scores and more likely to be considered DASH accordant by consuming more calcium, magnesium, potassium and fiber. In other words, current smoking status was negatively associated with healthier nutrient intake, and current physical activity status was positively associated with healthier nutrient intake among individuals with hypertension.

Table 1-4 reports predictions based on the estimates of SUR multivariate models in order to compare individuals’ nutrient intake to the recommended intake in the DASH diet. These predicted estimates describe the DASH accordance and nutrient intake as a function of diagnosed versus undiagnosed hypertension status. Individuals with hypertension had lower DASH accordance scores, 2.7 for individuals with undiagnosed hypertension and 2.6 for those with diagnosed hypertension. According to the DASH guidelines, individuals with hypertension were recommended to consume 150 milligrams of cholesterol per day. From the SUR estimates for cholesterol, both groups of individuals with hypertension consumed more

than what was recommended. They also consumed about 16 grams of fiber per day, which was only half of the recommended amount. That is, individuals with hypertension, regardless of diagnostic status, had significantly higher intake of cholesterol but lower intake of fiber than recommended in the DASH guidelines.

## **Discussion**

This study found that, regardless of diagnostic status, individuals with hypertension did not seem to follow the DASH guidelines. 10.9% of those with diagnosed hypertension and 12.1% of those with undiagnosed hypertension were predicted to follow the DASH diet. Compared to undiagnosed individuals, those with diagnosed hypertension were less likely to adhere to the DASH guidelines and had higher intake of cholesterol and lower intake of fiber. Our findings paralleled those of recent studies about the dietary guidelines that reported low accordance levels with the DASH diet among individuals with hypertension and diabetes.<sup>18,67,72</sup> In fact, Mellen, Gao, Vitolins and Goff<sup>64</sup> found that individuals with hypertension not only had low DASH scores, but also that the DASH accordance had gotten worse since the introduction of the DASH guidelines. Based on the study results, individuals diagnosed with hypertension were less likely to adhere to a healthy diet in controlling their blood pressure. In particular, individuals diagnosed with hypertension had significantly higher intake of cholesterol than those not previously diagnosed. Overall, individuals with hypertension did not seem to follow the DASH guidelines as part of their hypertension management, regardless of diagnostic status. The results from this study also indicated that fiber intake was lower than its recommended intake in the DASH diet for both groups of individuals with hypertension. The mean daily fiber intake was 16.0 grams per day for those diagnosed with hypertension and 16.5 grams per day for those undiagnosed with the condition, compared to the recommended fiber intake of 30 grams per day. Previous studies

also found lower intake of fiber than recommended among individuals with diabetes and/or hypertension, but they did not study the association of a diagnosis of hypertension with the DASH nutrients and its accordance.<sup>61,64,73</sup> Other studies suggested that higher dietary fiber intake lowered blood pressure and the risk of stroke, but the average daily intake of fiber has not improved in the past decade for the population.<sup>74-76</sup> Most importantly, every 1 gram of increase in fiber intake was associated with a 0.25 kg decrease in body weight in 20-month period, so higher intake of fiber may help reduce body weight and fat gains.<sup>77,78</sup> As a result, with 3.4 grams of difference in fiber intake based on a diagnostic status of hypertension, diagnosed individuals may be able to reduce other health consequences such as obesity and diabetes, over their lifespan. Therefore, health professionals and dietitians need to recommend increased intake of fiber, with increased consumption of fruits, vegetables and whole-grains as a safe dietary approach to reduce blood pressure.

The DASH guidelines recommend a reduced consumption of cholesterol: 150 milligrams per day for those with hypertension and 300 milligrams per day for the general population.<sup>44,45</sup> However, the federal government's Dietary Guidelines Advisory Committee (DGAC) recently dropped the recommendation to reduce cholesterol consumption. A new *Dietary Guidelines for Americans* from the U.S. Department of Health and Human Services and the Department of Agriculture is published in 2016. Based on this new change in dietary recommendations for cholesterol consumption, the current DASH guidelines for hypertension management should be updated accordingly.

There are some empirical limitations to this study that suggests the need for future research. Our study used cross-sectional data from NHANES. However, future studies can benefit from the use of longitudinal data for individuals at risk of hypertension. This would enable scholars to move beyond analyzing current behaviors alone and investigate how individuals with hypertension actually change their health behaviors over time following a

diagnosis. Furthermore, longitudinal data would help assess whether diet and lifestyle habits improve as individuals transition into hypertension status, thereby enabling a better understanding of causal pathways and decision making, as individual-level unobserved heterogeneity would be better accounted for. In addition, NHANES does not provide information about whether individuals with or without hypertension are advised to follow any dietary guidelines including the DASH diet, and about how much the dietary information is emphasized by doctors or health professionals. Data with this information would help further analyze the study results.

Future studies can address the effect of the intensity of the DASH diet instructions and to what extent individuals with hypertension are able to improve their diet. Assessing mean intake of nutrients can be problematic as some nutrients are not consumed daily. We recommend that future studies explore the National Cancer Institute's (NCI) method to address the problem of zero consumption days by modeling within-person and between-person variations to produce usual nutrient intake estimates. This study used the average of the blood pressure measurements obtained at one time point during the NHANES physical examination. Results based on median values and those based on discarding the first measurement may differ slightly, given the NHANES protocol of conducting measurements after participants have rested in a seated position for five minutes.

Self-monitoring tools for blood pressure control should be easy to approach for general population to make individuals aware of their health condition. As a primary prevention strategy for hypertension, screening tests for hypertension are recommended for all individuals aged 20 years and older, every two years for individuals without hypertension and every year for those diagnosed with hypertension.<sup>2,79</sup> Once an individual is diagnosed with hypertension, lifestyle modifications are recommended, with health professionals or dietitians advising patients about the need to adopt the DASH recommendations. Health

practitioners may be in the best position to provide initial direction and guidance to their patients during the course of and after hypertension treatment. Therefore, understanding social and disease patterns in the trajectories of health behavior changes following a diagnosis can help identify opportunities for interventions that decrease morbidity and mortality.

This study found that individuals with hypertension, regardless of their diagnostic status, did not follow the national dietary guidelines. In particular, we noted that individuals who were diagnosed with hypertension did not seem to be engaging in healthy dietary behaviors. Our results may be interpreted as evidence that individuals with hypertension may be insufficiently informed about adequate dietary guidelines or may not be given those guidelines. On the other hand, these individuals seem to be resistant to change their diets, and it can also be interpreted as indicating individual preferences in current food consumption. Thus future studies may establish the standard for examining the DASH compliance and study any barriers for modifying dietary approaches. It indicates that individuals may vary in their readiness to make dietary changes before or after a diagnosis of hypertension, so there are opportunities to identify those who are more ready to make behavioral changes and those at risk for continued unhealthy behaviors and possibly make interventions. Thus, within the spectrum of appropriate hypertension management, opportunities exist to further increase awareness of nutritional recommendations by using messages specifically tailored for those with hypertension. For example, nutrition needs should be addressed based on personal and cultural preferences, access to healthy food options, willingness to adopt healthy eating and barriers to dietary modification. Unless individuals with hypertension realize the importance of managing their health, adjusting to a healthier diet will be difficult for them. Therefore, health education about hypertension management is important in lowering the risk of complications from chronic diseases. Health education can make individuals with

hypertension more willing to invest in good health; therefore, efforts should be made to educate them about the complementary effects of a healthy diet and anti-hypertensive medication, as they may choose medication over a healthy diet. National and community-level efforts at increasing individuals' understanding of hypertension management, as well as their knowledge of nutritional information and recommendations for a healthy diet are critically important in attempting to curtail the various epidemics associated with hypertension.

## **Chapter 3: Age at Diagnosis and Duration of Hypertension on the Adherence to the Dietary Approaches to Stop Hypertension (DASH) Diet**

### **Introduction**

Hypertension, particularly when not carefully controlled, can increase the risk for developing cardiovascular disease (CVD).<sup>80,81</sup> It is well-known that the Dietary Approaches to Stop Hypertension (DASH) diet is a key component of hypertension management as it helps in lowering blood pressure.<sup>14,17,18,82,83</sup> Despite its importance for individuals with hypertension, many individuals with hypertension have diets that are not consistent with recommended dietary guidelines, and it is likely that those with chronic conditions such as hypertension and diabetes may have difficulty achieving an optimal nutrient intake for their long-term health.<sup>58,61,64</sup>

The diagnosis of a chronic health condition can cause psychological distress, which may prompt individuals to reduce any associated risks by promoting good health behaviors.<sup>84,85</sup> According to the Health Belief Model (HBM), individuals' beliefs about their health condition can affect their health behaviors, and their behavioral changes are dependent on the likelihood of getting a disease and its severity.<sup>32,33</sup> As a result, individuals are expected to improve their health behaviors depending on their perceived susceptibility and the seriousness of the disease as well as the benefits that accrue from their behavior.<sup>33,34</sup> This HBM model considers that socioeconomic status and health-related variables are associated with compliance in health behaviors.<sup>34</sup> Previous studies have used the HBM framework to evaluate compliance with health behaviors among individuals at increased risk for cardiovascular diseases, particularly those with obesity, hypertension and diabetes.<sup>35-40</sup>

According to the theoretical framework of HBM, understanding when and how long individuals have been diagnosed with hypertension is important, because it affects the individual's perception of their health condition. For example, individuals with a longer duration of hypertension are more likely to adopt healthy diets, because they are likely to consider themselves more susceptible to concurrent conditions such as obesity, diabetes and heart diseases. Those with shorter duration, on the other hand, were likely to consider that they might not have any threat from those diseases yet. Previous studies about cancer diagnosis showed that more than half of individuals started engaging in healthier diets, such as decreasing the consumption of meat and increasing the consumption of fruits and vegetables, after a cancer diagnosis.<sup>85-90</sup> Bellizzi and colleagues (2005)<sup>2</sup> found that individuals with longer duration of cancer diagnosis had higher smoking rates and lower physical activity levels than those with a more recent diagnosis. This later finding suggested that it would be difficult to continue engaging in healthier behaviors for longer periods of time after a diagnosis. Similarly, the study by Ko and colleagues (2012)<sup>91</sup> showed that individuals with a shorter duration of diabetes were more likely to adopt healthier diet after participating in an education program than those with a longer duration. There was also evidence that individuals who were obese were more motivated to control their diet in addition to their management of hypertension, because they were more likely to perceive the seriousness of their health condition.<sup>38,92-94</sup> Finally, previous studies of cancer survivors highlighted that individuals were likely to adopt dietary interventions after diagnosis when they worked closely with any kind of individualized counseling services.<sup>95</sup>

This study addressed the effects of age at diagnosis and time since diagnosis on nutrient intake. Since 2007, the National Health and Nutrition Examination Survey (NHANES) has made data available on age at hypertension diagnosis. The first hypothesis was that a younger age at diagnosis of hypertension was associated with more compliance to

the DASH diet among individuals with hypertension. The second hypothesis was that a longer duration of diagnosis of hypertension provided individuals with hypertension a motivation for a healthy diet, because they were more likely to be aware of adverse consequences of hypertension in the long-term. That is, the longer the elapsed time since diagnosis of hypertension, diagnosed individuals were more likely to respond positively with changes in dietary behaviors.

## **Methods**

The data came from the 2007-2008, 2009-2010 and 2011-2012 National Health and Nutrition Examination Survey (NHANES). Data are limited to the period after 2007-2008, because age at hypertension diagnosis was available from the personal interview only after that. The study included individuals diagnosed with hypertension aged 20 years and older (n=4,315). Our data excluded those with missing data on the information about age at their diagnosis of hypertension from the home interview (n=165). The final sample was composed of 4,150 individuals with hypertension. This study was a secondary data analysis of publicly available data, so it was exempt by the Institutional Review Board at the University of Illinois at Urbana-Champaign.

*Outcome Measures.* NHANES collected survey participants' food and nutrient intake for two non-consecutive days through 24-hour dietary recall interviews. The first interview was conducted in person, and the following second interview was conducted by phone 3 to 10 days later. Dietary data in NHANES contained detailed composition of the nutrients in the diet consumed by the respondent over the 24-hour period(s).

The outcome measures are based on the recommended DASH diet: 1) Total fat 27 percent of total calories, 2) Saturated fat 6 percent of total calories, 3) Cholesterol 150 mg per

day, 4) Protein 18 percent of total calories, 5) Carbohydrate 55 percent of total calories, 6) Sodium 2,300 mg per day, 7) Potassium 4,700 mg per day, 8) Calcium 1,250 mg per day, 9) Magnesium 500 mg per day, and 10) Fiber 30 g per day. These outcome measures were the same as the ones from the first chapter.

The analyses focused on nine nutrient components that were emphasized in the DASH diet: sodium, cholesterol, saturated fat, total fat, protein, calcium, magnesium, potassium, and fiber. The DASH accordance score was a 9-point score generated using the sub-scores from the nine nutrient components (Table 1-1), and the score ranged from 0 to 9 points generated using the sub-scores from the nine nutrient components. Individuals with the DASH accordance score of 4.5 points or higher were considered to be in intermediate accordance with the DASH guidelines in the study. Individuals who reached the DASH goal for the consumption of a given nutrient received 1 point for that nutrient, while those who consumed a given nutrient between the DASH goal and the DASH control diet received 0.5 points, thereby meeting an intermediate target level; otherwise, individuals received 0 points for the nutrient.

*Age at Diagnosis and Duration of Hypertension.* During an at-home interview, survey participants who were diagnosed with hypertension were asked at what age they were first told that they had hypertension or high blood pressure by a doctor or other health professional. Since NHANES had the participants' current age and age at the first diagnosis, duration of hypertension diagnosis was computed by subtracting age at the first diagnosis from their current age. Duration of its diagnosis ranged from 0.5 years to 76 years and was grouped into four categories: 1) 5 years or less, 2) 6-10 years, 3) 11-20 years, and 4) 21 years or more.

*Statistical Analyses.* All statistical analyses were performed with STATA software (version 11;

StataCorp). In order to address the role of age at diagnosis and duration of hypertension, the sample consisted of only individuals diagnosed with hypertension. The study considered a set of outcomes of 9 nutrient variables as a part of the nutrient composition of the DASH diet rather than focusing on an individual nutrient dimension. Therefore, the associations of the DASH accordance and the individual nutrient intake with hypertension diagnosis were examined using seemingly unrelated regression (SUR). An individual's decisions were presumably correlated across their nutrient intake, but these were not correlated with another individual's decisions.

The components of the DASH accordance score included nutrient variables, so the system of SUR models were assumed to be related because the error terms of the individual regressions were assumed to be correlated. That is, the error terms for nutrient intake and the diagnosis of hypertension equations were correlated for a given individual but were uncorrelated across individuals. By using SUR, the variance-covariance matrix improved the efficiency of the estimates from the DASH accordance score and the individual nutrient equations.

## **Results**

Table 2-1 presents demographic characteristics of the individuals with hypertension. The mean age at diagnosis of hypertension was 49 years, and the mean duration of hypertension was 12 years. Health conditions such as obesity (51.3%), diabetes (30.6%) and heart disease (23.8%) were prevalent among those with hypertension. Only 21% were on special diets for weight control or any other health-related reason. However, 85% of individuals with hypertension reported their overall health status as good.

Table 2-2 shows the association between age at diagnosis of hypertension and the DASH diet. Age at diagnosis was positively associated with the DASH score ( $\beta = 0.003$   $P$ -

value= 0.047), so an older age at diagnosis gave individuals with hypertension an incentive to have a better diet in general. In detail, it was negatively associated with the nutrient intake of sodium ( $\beta = 14.3$   $P$ -value  $< 0.001$ ), cholesterol ( $\beta = 1.1$   $P$ -value  $< 0.001$ ), saturated fat ( $\beta = 0.1$   $P$ -value  $< 0.001$ ), total fat ( $\beta = 0.4$   $P$ -value  $< 0.001$ ), protein ( $\beta = 0.4$   $P$ -value  $< 0.001$ ), calcium ( $\beta = 3.2$   $P$ -value  $< 0.001$ ) and magnesium ( $\beta = 0.4$   $P$ -value= 0.015) and was positively associated with fiber intake ( $\beta = 0.02$   $P$ -value= 0.049). Individuals with older age at diagnosis seemed to have slightly better diet. However, sodium and cholesterol consumptions were above the recommended daily intake for all groups. Intake of calcium and magnesium decreased with older age at diagnosis, and none of the groups met the recommendation levels. On the other hand, intake of fiber increased slightly with older age at diagnosis. Nonetheless, individuals were likely to consume around 50% of the recommended levels.

This study also examined the time effect of duration of hypertension on the DASH diet among individuals currently diagnosed with hypertension. Those with longer duration, 21 years or more, showed a significantly higher DASH score and better adherence to the DASH target level. Shorter duration since hypertension diagnosis, 5 years or less, was negatively associated with the DASH score ( $\beta = 0.168$   $P$ -value= 0.008) and accordance with the diet ( $\beta = 0.043$   $P$ -value= 0.007) compared to longer duration since diagnosis.

Based on the results from four categories of duration of hypertension diagnosis, shorter duration of hypertension was negatively associated with nutrient intake such as sodium, cholesterol, saturated fat and total fat, but also with nutrients such as protein, calcium and magnesium. Compared to individuals with 21 years or more of its diagnosis, those with shorter duration had higher intake of sodium, so those with 5 years or less of its diagnosis had the highest intake ( $\beta = 353.8$   $P$ -value  $< 0.001$ ). Cholesterol intake was positively associated with shorter duration of diagnosis for 5 years or less ( $\beta = 33.9$   $P$ -value  $< 0.001$ ), 6-10 years

( $\beta = 35.5$   $P$ -value  $< 0.001$ ), and 11-20 years ( $\beta = 32.9$   $P$ -value  $< 0.001$ ). Intake of saturated fat also had a positive association with shorter duration for 5 years or less ( $\beta = 3.2$   $P$ -value  $< 0.001$ ), 6-10 years ( $\beta = 2.7$   $P$ -value  $< 0.001$ ), and 11-20 years ( $\beta = 2.2$   $P$ -value  $< 0.001$ ), and total fat had similar trends for 5 years or less ( $\beta = 9.5$   $P$ -value  $< 0.001$ ), 6-10 years ( $\beta = 7.9$   $P$ -value  $< 0.001$ ), and 11-20 years ( $\beta = 7.0$   $P$ -value  $< 0.001$ ). Both intake of saturated and total fat decreased with longer duration, so those with 21 years or more of hypertension diagnosis seemed to have a better diet. Table 2-3 reports predicted mean values of the DASH outcomes based on the four categories of duration of hypertension. These predicted estimates described the choice differentials as a function of duration of hypertension. Only 11% of individuals diagnosed with hypertension were likely to satisfy the DASH intermediate target of 4.5 points. Longer duration of hypertension was associated with lower intake of nutrients such as sodium, cholesterol, saturated fat and total fat, but none of the groups satisfy the recommended guidelines from the DASH diet.

Demographic characteristics such as gender and ethnicity were associated with the DASH score and accordance. Male individuals were likely to have better DASH scores and its accordance with significantly higher intake of the DASH nutrients. Hispanics were more likely to adopt a healthier diet and attain a higher DASH score by having significantly higher intake of magnesium and fiber. They also had lower intake of sodium, saturated fat and total fat compared to non-Hispanic Whites. On the contrary, non-Hispanic Blacks had lower DASH scores with significantly lower intake of nutrients, especially protein, calcium, magnesium, potassium and fiber. The DASH score for Hispanics was increased by 0.5 points per day but decreased by 0.2 points for non-Hispanic Blacks. In addition, education was positively associated with the DASH score with significantly higher intake of healthier nutrients, but it also had positive associations with unhealthier nutrients except cholesterol. Income was positively associated with nutrient intake such as sodium, total fat, protein and

magnesium. The highest income level, in particular, had positive associations with most nutrient intake.

The DASH score was negatively associated with the obesity of individuals with hypertension, and accordance with the DASH diet was also significantly lower among individuals with additional health conditions such as obesity and diabetes. Obese individuals were likely to be less accordant to the DASH diet with less magnesium and fiber, and more sodium, cholesterol, saturated and total fat. If individuals with hypertension were obese, their sodium intake was increased by 126 milligrams and fiber intake was decreased by 1.1 grams. Individuals who were diagnosed with hypertension and heart diseases had significantly lower intake of calcium, magnesium and fiber. Lifestyle behaviors including smoking cessation and physical activity were positively associated with the DASH diet, higher DASH score and better accordance. Individuals with smoking cessation and active physical activity were likely to have higher DASH scores, so they tended to be more accordant to the diet. These healthy lifestyle behaviors also encouraged healthier nutrient intake with better DASH accordance. Those who were smoking had higher intake of saturated and total fat, and they also had lower intake of calcium and fiber than those who were not smoking. Physical activity was negatively associated with saturated fat and positively associated with calcium, magnesium, potassium and fiber.

## **Discussion**

The DASH diet has been recommended for the management of hypertension, and it has been shown as an effective nutritional approach for individuals with hypertension.<sup>17,18,58,82,96</sup>

Current public policies have supported dietary approaches such as the DASH diet, the Dietary Guidelines for Americans and MyPyramid to communicate these dietary guidelines to the public, and as a result, Americans have become more conscious about their health as well as

dietary and lifestyle behaviors.<sup>97</sup> However, not everyone has been informed about adequate diet and lifestyle behaviors, and NHANES did not have the information about whether and how much individuals were advised to engage in the DASH dietary guidelines and healthy lifestyle behaviors from doctors or health professionals.

According to the study results, age at diagnosis of hypertension was significantly associated with a higher DASH score and the DASH nutrients. Older age at diagnosis was negatively associated with intake of sodium, cholesterol, saturated fat, total fat, protein, calcium and magnesium and was positively associated with fiber intake. Individuals with an older age at hypertension diagnosis were likely to have less nutrient intake compared to those with a younger age at diagnosis, so they were more likely to be accordant with the DASH diet. Even though individuals with older age at diagnosis had healthier nutrient intake than those with younger age at diagnosis, the dietary profile of individuals with hypertension was not accordant with the DASH diet. Their dietary quality did not meet the recommendations for all diagnosis age groups. Similarly, duration of hypertension was also negatively associated with intake of sodium, cholesterol, saturated fat, total fat, protein, calcium and magnesium. Individuals with a longer duration were more likely to have a higher DASH score and satisfy the DASH target score of 4.5 points. Individuals with a shorter duration of hypertension were likely to consume more sodium, cholesterol, saturated fat, and total fat than those with longer duration. Overall, individuals with hypertension consumed higher than recommended intakes of sodium, cholesterol, saturated fat and total fat but lower than recommended intakes of protein, calcium, magnesium, potassium and fiber. Consequently, they did not follow the recommended DASH diet suggesting that more tailored dietary approaches would be needed to promote healthy nutrition for their current and future health. These findings were consistent with results from previous studies. Earlier investigations about the DASH accordance indicated that individuals with hypertension and/or diabetes had a low accordance

with the DASH diet, and their dietary quality declined.<sup>61</sup> Most importantly, individuals with hypertension were most likely to be obese, and those with these conditions were less likely to be accordant with the DASH diet with 1.1 grams of decreased fiber intake. If they can have 1 gram of increase in fiber intake which is associated with a 0.25 kg decrease in body weight, an increased intake of fiber will help reduce body weight and fat gains.<sup>77,78</sup>

The HBM was used in this chapter for explaining differences in nutrient intake of individuals with hypertension based on their duration of the condition. The perceived susceptibility and severity combined to form a perceived threat (duration of hypertension), so individuals with longer duration of hypertension were more likely to have healthier nutrient intake since they considered perceived benefits of adopting healthy nutrient intake to manage hypertension and to avoid other health complications as greater than the perceived threat of the condition. Those with a longer duration hypertension were more likely to believe that better nutrition is beneficial to them, so they were more motivated to adhere to the DASH diet. A possible explanation with this study result can be that those with longer duration are more likely to have other chronic diseases such as obesity, diabetes and heart disease, so they may have an increased level of perceived threat from these conditions. In addition, these individuals may consider healthy eating as one of the simplest and the easiest health behaviors they can modify. On the other hand, individuals with a shorter duration of the condition may not have any perceived threat caused from hypertension yet, even though it may be critical for this group of individuals to adopt a healthy diet. Otherwise, they may have hypertension and its complications over their lifespan. As a result, individuals were ready to act and had dietary modifications based on the theoretical constructs of the HBM, so they tended to engage in a healthier diet. Previous studies about the diagnosis and the duration of health conditions such as hypertension and obesity also showed similar results that individuals who perceived the seriousness of the condition were likely to manage their health

with better diet.<sup>38,39,92-94</sup> On the other hand, other studies about the diagnosis of cancer and diabetes found that individuals with shorter duration of the condition were more likely to manage their condition with a healthier diet, lower smoking rates and higher physical activity levels compared to those with longer duration.<sup>91,98</sup>

Secondary prevention of hypertension, which means managing the condition after its diagnosis, has become important since individuals nowadays live longer even after the onset of any chronic conditions. However, individuals with hypertension had a low accordance level with the DASH diet suggesting they did not make dietary changes for their future health. Despite the study findings that individuals with hypertension improved their diet a little with increased duration of disease, their diet was not still accordant to the DASH diet based on age at diagnosis and its duration. It can be challenging to modify one's daily diet even after a diagnosis. Previous studies about cancer and diabetes diagnoses showed that dietary interventions for encouraging a healthy diet were shown to be effective only when intensive individualized educational services were delivered to patients by health professionals.<sup>91,99-101</sup> Individuals with hypertension were likely aware of the DASH diet, but they did not modify their diet. Strategies for bridging the health education and effective dietary interventions should be developed to increase the DASH compliance level. In order to achieve it and deliver more tailored educational messages, it is important to first understand what barriers individuals with hypertension have to engage in a healthy diet such as inaccessible information about what to eat and how to cook. A diagnosis of hypertension may not considered a life-threatening event for individuals with hypertension. However, if it is not properly managed, it will increase the risk of having serious health conditions such as CVD. Non-pharmacological management for hypertension such as a healthy diet is a key component of reducing the risk of developing CVD, so it can be both essential and cost-effective.<sup>102</sup>

A potential source of bias included the use of the dietary data collected from two 24-hour dietary recall interviews, which were self-reported for two non-consecutive days. Since survey participants might have a difficult time remembering their true dietary behaviors, this interview process was subject to recall bias and measurement bias. However, in NHANES, survey participants anticipated subsequent physical measurements of some health conditions such as blood pressure to verify their responses from personal interview. The existence of physical examination was likely to lead respondents to be more truthful when they reported their health conditions. Another potential limitation was from other possible confounders which were not included in the analysis. This study tried to minimize any residual caused from using the cross-sectional data, but it is possible to have any other confounder that could not be addressed in the study. Longitudinal studies would be needed to further investigate individuals' dietary modifications based on their duration of hypertension with their risk of getting other health complications possibly caused by hypertension.

Incidence of new-onset hypertension increases with age,<sup>103</sup> so diet modification may especially benefit aging population. The results of this study suggested that healthy eating should be a main target in efforts to promote healthy aging. Thus, health care professionals should motivate patients of all ages to make them understand the importance and benefits of healthy eating. Strategies for integrating health education and effective dietary interventions should be developed to increase the DASH compliance level. In order to achieve delivering more tailored educational messages, it is important to first understand what barriers individuals with hypertension have to engage in a healthy diet such as scarce information about what to eat and how to cook. A diagnosis of hypertension may not be considered a life-threatening event for individuals with hypertension, but if the condition is not properly managed, it may increase the risk of having serious health conditions such as CVD. Non-pharmacological management for hypertension such as a healthy diet is a key component of

reducing the risk of developing CVD, so it is essential in a cost-effective manner.<sup>102</sup>

## **Chapter 4: Effect of a Diagnostic Status of Hypertension on Adherence to Lifestyle Recommendations**

### **Introduction**

Heart disease, cancer and stroke have been leading causes of death throughout the past three decades in the United States.<sup>104</sup> Hypertension, or high blood pressure, is considered a major risk factor for cardiovascular disease (CVD), primarily coronary heart disease and all-cause mortality.<sup>105-108</sup> Hypertension has also been identified as one of the three leading risk factors for disease burden by the Comparative Risk Assessment module of the global burden of disease 2010 study.<sup>109</sup> Consequently, hypertension is recognized as a main focus of the American Heart Association's (AHA) 2014-2017 strategic plan.<sup>110</sup>

Unhealthy lifestyle behaviors are important risk factors for developing hypertension and its related health consequences.<sup>111-114</sup> According to the WHO, controlling high blood pressure by reducing poor lifestyle behaviors such as excessive drinking and physical inactivity is the first step to prevent cardiovascular diseases.<sup>108</sup> For individuals with hypertension, the AHA and previous studies strongly recommend moderate physical exercise and discourage severe drinking and smoking.<sup>110,115-117</sup> For instance, cigarette smoking and heavy alcohol consumption are known to be associated with the development of hypertension,<sup>118-123</sup> and heavy alcohol consumption, in particular, is known to elevate an individual's blood pressure and lead to an increased risk of stroke as well as cardiovascular disease mortality.<sup>117</sup> On the other hand, the adoption of healthier dietary choices, weight loss or control, regular physical activity, smoking cessation, and moderate alcohol consumption are important lifestyle behaviors to manage hypertension.<sup>14-16,124,125</sup> Dietary and other lifestyle modifications such as increased physical activity can significantly reduce blood

pressure among individuals with hypertension.<sup>14,57,107,126,127</sup> Even though medical treatment can be effective for hypertension, adopting healthy lifestyles can aid treatment by controlling weight and lowering blood pressure. Thus, behavioral modifications such as healthier dietary choices and lifestyle behaviors can serve as good complements and/or alternatives to medical treatment.<sup>15</sup>

Although the diagnosis of a health condition can be positively associated with better health behaviors, such as adhering to a healthy diet,<sup>28,29,87</sup> there is evidence that changing health behaviors may be difficult, irrespective of diagnostic status.<sup>98</sup> This previous study<sup>98</sup> finds that there is no significant difference in smoking status, physical activity and alcohol consumption after diagnosis. However, there exists a downward trend in smoking use and an upward trend in physical activity level. Following up on the first chapter which was about the association between a diagnosis of hypertension and the DASH diet, this study examined how a diagnosis of hypertension affected individuals with hypertension on engaging in healthier lifestyle behaviors. Once individuals were diagnosed with hypertension, this diagnosis would act as new information to influence their health behaviors, and a diagnosis would make them more willing to invest in good health. On the other hand, it might not help them to practice healthier behaviors, because it could be difficult to change current addictive behaviors even after a negative health event.<sup>128</sup> In this case, they would be less likely to engage in changes to their current behaviors such as current physical activity level. Therefore, the purpose of this study was to examine whether individuals with hypertension differ in lifestyle behaviors including smoking, alcohol consumption and physical activity based on their diagnostic status.

## **Methods**

Data come from the 2007-2008, 2009-2010, and 2011-2012 cross-sectional National Health and Nutrition Examination Survey (NHANES). NHANES is a stratified, multistage

probability sample of the civilian, non-institutionalized U.S. population. The analytic data included sections from personal interviews, physical examinations, and demographic information. In addition, NHANES contains detailed information on respondents' food and nutrient intakes of two non-consecutive days, as well as clinical measurements such as repeated blood pressure measurements. Data on lifestyle behaviors and demographic information were also used in the study. This study was a secondary data analysis of publicly available data, so it was exempt by the Institutional Review Board at the University of Illinois at Urbana-Champaign.

The study sample included individuals aged 20 years and older. There were a total of 17,713 survey participants in this age range. Among those, there are 6,670 individuals with hypertension, based on self-reported data on diagnosed hypertension and the physical examination data of blood pressure measurements. The analytic data excluded those with missing data on their self-reported hypertension condition from the personal interviews or blood pressure measurements from physical examinations. After excluding those missing data from the self-reported questionnaire and physical examination, there were 5,539 individuals with hypertension in the study sample.

*Outcome Measures.* Lifestyle behaviors of interest include smoking, binge drinking, and physical activity. In NHANES, each survey participant was asked whether he/she smoked at least 100 cigarettes in his or her entire life and then was asked whether he/she currently smoke cigarettes. The study used these two survey questions to define three groups of individuals with their current smoking status. A nominal outcome variable of current smoking status consisted of three categories: current, past, and non-smokers. Current smokers were those who reported smoking currently either every day or some days. Former smokers were individuals who had smoked at least 100 cigarettes in their entire life but who were not

currently smoking, and non-smokers were those who had not smoked at least 100 cigarettes in their entire life and were not currently smoking.

According to the Dietary Guidelines for Americans by the United States Department of Health and Human Services, individuals are recommended to have only a moderate amount of one drink a day for women and two drinks a day for men. More than one drink a day for women and more than two drinks a day for men was defined as excessive alcohol consumption. An individual's average number of alcoholic drinks per day during the past 12 months was used as a drinking behavior outcome in this study. A nominal outcome variable which had three categories of alcohol consumption included: 1) individuals who reported no alcohol consumption, 2) those with moderate consumption, and 3) those who binge drink.

The 2008 physical activity guidelines for Americans recommends that adults and older adults do 150 minutes of moderate-intensity activities every week such as brisk walking or swimming, 75 minutes of vigorous-intensity activities such as running and basketball every week, or an equivalent mix of the two.<sup>129,130</sup> For an equivalent mix of the two activities, 1 minute of vigorous-intensity activity is counted as 2 minutes of moderate-intensity activity based on the physical activity guidelines. In addition to moderate- and vigorous-intensity aerobic activities, 2 or more days a week of muscle-strengthening activities are also recommended to work all major muscle groups. The survey question on physical activity asked how many days per week an individual does any moderate or vigorous-intensity sports, fitness, or recreational activities, and how much time per day he or she spend doing these activities. From these two questions in NHANES, the total minutes of moderate or vigorous-intensity activities per week were calculated by multiplying time spent per day by the number of days spent on physical activity per week. The three categories reported for this variable were: 1) those with no physical activity, 2) those with physical activity who did not spend the recommended time (less than 150 minutes of moderate-intensity activities, 75 minutes of

vigorous-intensity activities or the equivalent), and 3) those who satisfied the recommended time for weekly physical activity (more than or equal to 150 minutes of moderate-intensity activities or 75 minutes of vigorous-intensity activities).

*Statistical Analyses.* Lifestyle health behaviors including smoking, drinking, and physical activity are multinomial outcomes. Three multinomial logistic regression models are used to test whether a diagnosis of hypertension affects multinomial categories of lifestyle behaviors. The models also estimate relative risk ratios (RRR) by exponentiating the linear functions yielding regression coefficients that are relative risk ratios for a unit change in the predictor variable. In addition, we use predicted probabilities to help us understand the effect of a diagnosis of hypertension for each category based on the individual lifestyle behavior model and the association between age and those behaviors.

For each regression, the hypertension diagnosis variable specifies whether an individual has a diagnosis of his or her hypertension, which allows the study to compare how lifestyle behaviors of individuals with diagnosed hypertension are different from those of individuals with undiagnosed hypertension. All statistical analyses were performed with STATA S.E. software (version 11; StataCorp).

## **Results**

Among individuals with hypertension, 17% of diagnosed individuals were current smokers compared to 20% among undiagnosed individuals (Table 3-1). Among individuals with a diagnosed hypertension, 34% were past smokers compared to 26% among those who were undiagnosed. Among individuals diagnosed with hypertension, 65% did not engage in physical activity, 14% spent less than 150 minutes a week on physical activity, and only 21% spent more than 150 minutes a week. In contrast, 58% of individuals undiagnosed did not

engage in physical activity, 13% engaged in moderate physical activity and 29% met the recommendation of more than 150 minutes of physical activity a week. For alcohol consumption, 45% of those with diagnosed hypertension had no alcohol consumption, 33% of those had moderate consumption, and 22% had excessive consumption. 35% of those with an undiagnosed condition did not consume alcohol, 33% consumed moderately, and 32% consumed excessively.

Overall, the risk ratios of past smoking compared to nonsmoking increased with a diagnosis of hypertension (RR=1.26; 95% CI [1.05, 1.52]; *P*-value=0.014) (Table 3-2), which indicates that a diagnosis of hypertension was positively associated with an individual's past smoking status. However, no statistical differences were found for current smoking status. Moreover, current smoking status was negatively associated with active physical activity, so current smokers were less likely to engage in physical activity than non-smokers. Individuals aged 65 years or older tended to be past smokers and were less likely to be current smokers compared to those aged 20-29 years. Non-Hispanic Blacks and Hispanics were negatively associated with past smoking status, but Hispanics were also less likely to be current smokers than non-Hispanic Whites. Individuals who were on special diets because of their weight management or other health issues were less likely to be current smokers. Those who were obese or had diabetes also tended not to smoke currently.

In Tables 3-2 and 3-3, current alcohol consumption, including moderate and binge drinking, was positively associated with past and current smoking status among adults with hypertension. For example, individuals categorized as binge drinkers were more likely to be past smokers (RR=2.35; 95% CI [1.96, 2.82]; *P*-value<0.001) and current smokers (RR=4.12; 95% CI [3.34, 5.06]; *P*-value<0.001). However, being actively engaged in physical activity was associated with a reduction in the risk of being a current smoker (RR=0.47; 95% CI [0.38, 0.58]; *P*-value<0.001). Based on regression analyses, a diagnosis of hypertension was

not associated with different levels of alcohol consumption and physical activity.

In addition, non-Hispanic Blacks were less likely to have moderate alcohol consumption, whereas Hispanics were more likely to have excessive alcohol consumption than non-Hispanic Whites. Education and income levels were positively associated with moderate alcohol consumption, with college or above-level graduates being more likely to have excessive consumption than any other education group. Those with higher income levels were also more likely to have excessive consumption than other income groups. Age groups were negatively associated with excessive consumption, so older age groups tended not to consume 2 or more drinks per day. Individuals with diabetes and heart diseases were also less likely to have excessive alcohol consumption than those without these conditions. Physical activity was also associated with some socioeconomic characteristics. Individuals who were on special diets were more likely to engage in an active level of physical activity. Age, however, was negatively associated with physical activity, so individuals aged 65-80 years were less likely to have active physical activity than any other age group. Education and income levels were positively associated with active physical activity. Those with higher education and income were more likely to engage in 150 minutes or more of physical activity than other groups. Health conditions such as obesity, diabetes and heart diseases were negatively associated with active physical activity, so individuals with these conditions were less likely to engage in physical activity.

## **Discussion**

A variety of risk factors, many of which are modifiable, play a role in the progression of hypertension including smoking rates, alcohol consumption, physical activity, and diet.<sup>26,131</sup> Intensive non-pharmacologic approaches are therefore essential for the management of high blood pressure. In this study, a diagnosis of hypertension was associated with individuals

with hypertension quitting smoking and decreasing binge alcohol consumption, but they tended not to engage in physical activity.

A recent study about physical activity found that one third of adults in the United States were advised to engage in physical activity after visits to health professionals. This advice about increasing physical activity increased especially for those with hypertension and cardiovascular diseases and for older adults.<sup>132</sup> However, our study found high levels of physical inactivity and no differences in physical activity profiles among those with and without diagnosed hypertension. Our findings were consistent with previous studies which indicated that a large number of adults did not meet the national recommendations for physical activity or did not engage in any type of physical activity in spite of public health efforts to improve lifestyle behaviors.<sup>133,134</sup> Moreover, the prevalence of combining healthy lifestyle behaviors such as non-smoking, physical activity, normal BMI, and a healthy diet has been decreasing.<sup>134,135</sup>

Previous studies have indicated positive results among individuals with diagnosed hypertension or diabetes after receiving advice or counseling from health professionals about adopting healthier lifestyle behaviors with no change being observed among those not receiving these interventions.<sup>136,137</sup> In our study, individuals diagnosed with hypertension were more likely to report being past smokers, which may be associated with higher levels of smoking cessation. Given that diagnostic status was associated with past-smoking status, this may indicate that diagnosis may lead to individuals quitting smoking. In addition, those with diagnosed hypertension (and potentially exposed to counseling and health advice) also reported being less likely to engage in binge drinking. These results are similar to previous studies reporting smoking cessation, reduction in alcohol consumption, and increased physical activity following a diagnosis.<sup>138</sup> However, our study found no differences on physical activity between those diagnosed and undiagnosed with hypertension. Among those

with and without diagnosis, rates of unhealthy behavior were very high such as current smoking, excessive alcohol consumption and no physical activity. Lifestyle behaviors were associated with each other. For instance, individuals who consumed alcohol in moderate and/or excessive levels were more likely to smoke currently. Those engaging in adequate levels of physical activity were less likely to be current-smokers, even though they were more likely to report binge drinking. These positive associations of non-smoking status and physical activity for the management of CVD among individuals with hypertension were also found in previous studies.<sup>135,139,140</sup> Individuals with hypertension following the national recommendation of physical activity were more likely to be male and following special diets with higher education and income levels. Physical activity among those with hypertension was negatively associated with older age and obesity.

Because of the nature of the NHANES data, this cross-sectional study was observational and thus precluded causal inferences, and the self-reported data in NHANES were possibly subject to bias due to measurement error and under-reporting. Future studies can benefit from the use of longitudinal data for hypertensive individuals. Rather than relying on reports of when a patient was diagnosed with hypertension, one would be able to follow individuals with hypertension after they are diagnosed, and observe how they change their health behaviors over time and whether their lifestyle behaviors improve or decline through hypertension diagnostic status. The availability of these data would also enable causal estimates, because individual-level unobserved heterogeneity could be more easily isolated.

There is some indication that individuals with hypertension tended to quit smoking and reduce their heavy alcohol consumption, but there were no differences in physical activity. Barriers to engaging in physical activity could include time constraint, lack of interest, and lack of knowledge on recommendations pertaining to it. As a result, it is important to first understand any barriers to physical activity among those with hypertension

and then develop more frequent counseling services or educational programs. Increasing physical activity is one of the main objectives of the Healthy People 2020 initiative, which seeks to encourage more effective physician counseling and educational programs for exercising.<sup>141</sup> In addition, physical activity has been reported to increase life expectancy by 0.68 years.<sup>142</sup> Therefore, given that 61.9% of individuals with hypertension did not engage in physical activity and only about 24.2% met its recommendations from the study, it is of the highest importance to increase physical activity in this population.

The recently enacted healthcare reform, the Patient Protection and Affordable Care Act (PPACA), now requires health insurance companies to cover all applicants under new minimum standards and by offering the same rates regardless of pre-existing conditions. Since hypertension is considered a pre-existing condition by certain insurers, the PPACA will not only enable more individuals with hypertension to be issued insurance, but will also prohibit dropping or denying coverage for pre-existing hypertension. Certain provisions of the PPACA may help reduce expenditures for clinician visits and for overall hypertension management. The implementation of health-care reform has the potential to increase the number of individuals with regular access to primary care as well as encourage self-monitoring with behavioral changes, which could have a substantial impact on controlling hypertension in the U.S. population. Regular visits and self-monitoring should include tracking blood pressure levels, increased awareness about the importance of hypertension control, and promotion of healthy behavioral modifications.

## Chapter 5: Conclusions

This study found that regardless of diagnostic status, individuals with hypertension did not seem to follow the DASH guidelines. Compared to undiagnosed individuals, those with diagnosed hypertension were less likely to adhere to the DASH guidelines. The results may be interpreted as evidence that individuals with hypertension may be insufficiently informed about the adequate dietary guidelines or may not be given those guidelines. On the other hand, these individuals seem to be resistant to change their diets, and it can also be interpreted as indicating individual preferences in current food consumption. Thus, within the spectrum of appropriate hypertension management, opportunities exist to further increase awareness of nutritional recommendations by using messages specifically tailored for those with hypertension. Unless individuals with hypertension realize the importance of managing their health, adjusting to a healthier diet will be difficult for them; therefore, health education about hypertension management is important in lowering the risk of complications from chronic diseases. On the other hand, results from the second chapter showed that individuals diagnosed with hypertension were more likely to be past smokers, which may be associated with higher levels of smoking cessation. Also, those with diagnosed hypertension, who are potentially exposed to counseling and health advices, also reported being less likely to engage in binge drinking. There were no differences in physical activity based on the diagnostic status of the condition. Barriers to engaging in physical activity could include time constraint, lack of interest, and lack of knowledge on recommendations pertaining to it. As a result, it is important to first understand any barriers to physical activity among those with hypertension and then develop more frequent counseling services or educational programs. The third chapter showed that individuals with longer duration were more likely to satisfy the DASH target score of 4.5 points. Individuals with hypertension had a low accordance level with the

DASH diet so did not promote dietary changes for their future health. Despite the study findings that individuals with hypertension improved their diet a little with increased duration of disease, their diet was still not accordant to the DASH diet based on age at diagnosis and its duration. In order to achieve it and deliver more tailored educational messages, it is important to first understand what barriers individuals with hypertension have to engage in healthy diet for secondary prevention.

Findings from this study suggest that low accordance with the diet is more frequently observed in younger age groups, non-Hispanic Blacks, and current smokers. DASH accordance increased with age, given the lower intake of cholesterol and higher intake of fiber among older individuals, possibly because older adults are more likely to have frequent check-ups for health conditions and, therefore, receive advice from health professionals. Despite higher prevalence rates of hypertension among non-Hispanic Blacks, Non-Hispanic Whites and Hispanics had high accordance with the DASH diet in calcium, fiber, protein, and total fat. Current smoking was associated with a lower DASH accordance level, while physical activity was positively associated with being a current smoker, so individuals with healthier lifestyle behaviors also tended to engage in a healthier diet. Individuals with one or more other health conditions, such as obesity or diabetes, were less likely to adhere to the DASH diet and had lower accordance scores. This finding confirms previous findings by Morton and colleagues, who found that, compared to individuals with hypertension and diabetes, individuals with only diabetes had higher intake of fiber and lower intake of sodium.<sup>46</sup> Therefore, given the higher prevalence of obesity and diabetes among individuals with hypertension, results suggest the need to target those with one or more other chronic conditions to engage in healthier diets to reduce health complications. These results explain that individuals with hypertension, therefore, are given opportunities to target primary and secondary prevention strategies to control their blood pressure. Primary prevention strategies

such as screening tests for hypertension and healthy behaviors, and secondary prevention strategies such as reduced intake of cholesterol and increased intake of fiber and lifestyle modifications to prevent other potential comorbidities should be delivered to those with and without hypertension to maintain good health status and to increase their quality of life. As a result, these strategies should be designed by multiple factors such as a diagnostic status of hypertension, current age, age at diagnosis and concurrent comorbidities.

There are some empirical limitations to this study that suggests the need for future research. These chapters used cross-sectional data from NHANES. However, future studies can benefit from the use of longitudinal data for individuals at risk of and with hypertension. This would enable scholars to move beyond analyzing current behaviors alone and investigate how individuals actually change their health behaviors over time following a diagnosis. Furthermore, longitudinal data would help assess whether diet and lifestyle habits improve as individuals transition into hypertension status, thereby enabling a better understanding of causal pathways and decision making, as individual-level unobserved heterogeneity would be better accounted for. The availability of these data would also enable causal estimates, because individual-level unobserved heterogeneity could be more easily isolated. In addition, NHANES does not provide information about whether individuals with or without hypertension are advised to follow any dietary guidelines including the DASH diet, physical activity, smoking and drinking. Data with this information would help with further analysis of the study results.

Future studies can address the effect of the intensity of the DASH diet instructions and to what extent individuals with hypertension are able to improve their diet. Assessing mean intake of nutrients can be problematic as some nutrients are not consumed daily. We recommend that future studies explore the National Cancer Institute's (NCI) method to address the problem of zero consumption days by modeling within-person and between-

person variations to produce usual nutrient intake estimates. This study used the average of the blood pressure measurements obtained at one time point during the NHANES physical examination. Results based on median values and those based on discarding the first measurement may differ slightly, given the NHANES protocol of conducting measurements after participants have rested in a seated position for five minutes. In addition, there may be possible effects of white coat hypertension diagnosis as some individuals reported a previous diagnosis, but present normal levels despite not being under medication.

According to the DASH guidelines and the *Dietary Guidelines for Americans 2015-2020*, consuming 2,300 milligrams of sodium per day is recommended, with 1,500 milligrams being considered better for lowering blood pressure.<sup>143</sup> A population-wide reduction in sodium of 1,200 milligrams per day has shown to reduce the annual number of new cases of coronary heart disease and stroke.<sup>44,144-146</sup> However, the recommendation to reduce salt consumption has been contested by some studies. One study found that individuals with more than 7,000 milligrams and less than 3,000 milligrams of sodium consumption per day were significantly at an increased risk of cardiovascular disease and mortality.<sup>147</sup> Another study also found that individuals with serious congestive heart failure condition were more likely to be readmitted to hospital when they consume lower levels of sodium than those consuming higher levels of sodium.<sup>148</sup> However, a recent meta-analysis confirmed that 2 grams of sodium intake per day reduced blood pressure levels compared to values equal or above it.<sup>149</sup> The DASH guidelines also recommend reduced consumption of cholesterol: 150 milligrams per day for those with hypertension and 300 milligrams per day for the general population.<sup>44,45</sup> However, the federal government's Dietary Guidelines Advisory Committee (DGAC) recently dropped the recommendation to reduce cholesterol consumption. A new *Dietary Guidelines for Americans* from the U.S. Department of Health and Human Services and the Department of Agriculture was recently published in 2016.

Based on this new change in dietary recommendation of cholesterol consumption, the DASH guidelines for hypertension management should be updated accordingly.

The prevalence of current unhealthy lifestyle behaviors and diet is an important predictor of the future burden of related diseases such as cardiovascular diseases, so a variety of risk factors, many of which are modifiable, play an interactive role in the development of hypertension. Intensive non-pharmacologic intervention is thus essential for the primary prevention of developing high blood pressure. Successful intervention to curb the increased prevalence of hypertension in the United States will therefore require intensive non-pharmacologic strategies targeting the modifiable risk factors of hypertension as well as effective pharmacologic management of blood pressure for individuals with hypertension. In September 2011, as part of national health quality improvement efforts, the U.S. Department of Health and Human Services launched the Million Hearts national initiative to prevent 1 million heart attacks and strokes over the next 5 years.<sup>150</sup> Led by CDC and the Centers for Medicare and Medicaid Services, the Million Hearts initiative aims to improve heart disease and stroke prevention by improving access to effective care, improving the quality of care, focusing more clinical attention on heart attack and stroke prevention, increasing public awareness of how to lead a heart-healthy lifestyle, and increasing the consistent use of high blood pressure and cholesterol medications. Improving the management of hypertension will require further efforts. Barriers to hypertension medication adherence should be addressed (e.g., costs, health literacy, lack of perceived benefit, and multiple co-morbidities) and non-pharmacologic approaches that can reduce blood pressure should be emphasized (e.g., adoption of a healthy diet that includes reduction of dietary sodium intake, increased physical activity, weight loss, smoking cessation, and reduction of alcohol intake).

As a major risk factor for stroke, heart failure and kidney disease, hypertension is an important contributor to the burden of disease, disability and death in the population.

Hypertension control has the potential to prevent a substantial number of deaths, because it affects approximately 30% of the U.S. adult population.<sup>151</sup> Access to and availability of health care has been shown to be an important contributor to health outcomes.<sup>152,153</sup> Comprehensive health care can be integrated with specific population- or community-based programs toward improving social conditions, and such health promotion can include secondary prevention of current hypertension in addition to management and treatment of the condition. The economic costs in the absence of proper health management in the face of an increasing number of individuals with hypertension underscore the urgency for developing behavioral and health care interventions that can facilitate behavioral improvements among those with hypertension as well as those with chronic diseases. Environments and policies should be created for individuals with hypertension to make healthy choices, and they also should be motivated and educated about those choices. Strategies can consist of those related to assessment, education, ensuring personal health services and policy changes. If implementation of health-care reform increases the number of people with regular access to primary care and access to affordable medications, it could have a substantial impact not only on the control of hypertension in the U.S. population but also on opportunities for interventions which can decrease morbidity and mortality caused from chronic conditions. Therefore, we should raise awareness about the importance of hypertension management to prevent chronic diseases and to promote better health behaviors. Public awareness can help enable individuals with or at risk for hypertension to adopt long-term healthier lifestyles through concomitant education about proper treatment and diagnosis of hypertension, because behavioral modifications can be the most important factor for the primary and secondary prevention of hypertension.

## References

1. World Health Organization WHO. World Health Statistics 2012. Geneva: World Health Organization, 2012. *World Health Statistics*. 2012;2012.
2. Chobanian AV, Bakris GL, Black HR, et al. Seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure. *Hypertension*. 2003;42(6):1206-1252.
3. Ezzati M, Oza S, Danaei G, Murray CJ. Trends and cardiovascular mortality effects of state-level blood pressure and uncontrolled hypertension in the United States. *Circulation*. 2008;117(7):905-914.
4. Hajjar I, Kotchen JM, Kotchen TA. Hypertension: trends in prevalence, incidence, and control. *Annu. Rev. Public Health*. 2006;27:465-490.
5. Blanck HM, Gillespie C, Kimmons JE, Seymour JD, Serdula MK. Trends in fruit and vegetable consumption among US men and women, 1994–2005. *Prev Chronic Dis*. 2008;5(2).
6. Colosia AD, Palencia R, Khan S. Prevalence of hypertension and obesity in patients with type 2 diabetes mellitus in observational studies: a systematic literature review. *Diabetes, metabolic syndrome and obesity: targets and therapy*. 2013;6:327.
7. Roger VL, Go AS, Lloyd-Jones DM, et al. Heart Disease and Stroke Statistics—2012 Update A Report From the American Heart Association. *Circulation*. 2012;125(1):e2-e220.
8. Kearney PM, Whelton M, Reynolds K, Whelton PK, He J. Worldwide prevalence of hypertension: a systematic review. *J. Hypertens*. 2004;22(1):11-19.
9. Chobanian AV. Isolated systolic hypertension in the elderly. *N. Engl. J. Med*. 2007;357(8):789-796.
10. Lloyd-Jones D, Adams RJ, Brown TM, et al. Heart disease and stroke statistics—2010 update A report from the American Heart Association. *Circulation*. 2010;121(7):e46-e215.
11. Miniño AM, Murphy SL, Xu J, Kochanek KD. Deaths: final data for 2008. *National vital statistics reports: from the Centers for Disease Control and Prevention, National Center for Health Statistics, National Vital Statistics System*. 2011;59(10):1.
12. Li C, Engström G, Hedblad B, Berglund G, Janzon L. Blood Pressure Control and Risk of Stroke A Population-Based Prospective Cohort Study. *Stroke*. 2005;36(4):725-730.
13. McNeill AM, Katz R, Girman CJ, et al. Metabolic syndrome and cardiovascular disease in older people: The cardiovascular health study. *J. Am. Geriatr. Soc*. 2006;54(9):1317-1324.
14. Blumenthal JA, Babyak MA, Hinderliter A, et al. Effects of the DASH diet alone and in combination with exercise and weight loss on blood pressure and cardiovascular biomarkers in men and women with high blood pressure: the ENCORE study. *Arch. Intern. Med*. 2010;170(2):126.

15. Bacon SL, Sherwood A, Hinderliter A, Blumenthal JA. Effects of exercise, diet and weight loss on high blood pressure. *Sports Med.* 2004;34(5):307-316.
16. Karanja N, Erlinger T, Pao-Hwa L, Miller ER, Bray GA. The DASH diet for high blood pressure: from clinical trial to dinner table. *Cleve. Clin. J. Med.* 2004;71(9):745-753.
17. Siervo M, Lara J, Chowdhury S, Ashor A, Oggioni C, Mathers JC. Effects of the Dietary Approach to Stop Hypertension (DASH) diet on cardiovascular risk factors: a systematic review and meta-analysis. *Br. J. Nutr.* 2015;113(01):1-15.
18. Epstein DE, Sherwood A, Smith PJ, et al. Determinants and consequences of adherence to the dietary approaches to stop hypertension diet in African-American and white adults with high blood pressure: results from the ENCORE trial. *J Acad Nutr Diet.* 2012;112(11):1763-1773.
19. Hajjar IM, Grim CE, George V, Kotchen TA. Impact of diet on blood pressure and age-related changes in blood pressure in the US population: analysis of NHANES III. *Arch. Intern. Med.* 2001;161(4):589.
20. Obarzanek E, Sacks FM, Vollmer WM, et al. Effects on blood lipids of a blood pressure–lowering diet: the Dietary Approaches to Stop Hypertension (DASH) Trial. *Am J Clin Nutr.* 2001;74(1):80-89.
21. Sacks FM, Svetkey LP, Vollmer WM, et al. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. *N. Engl. J. Med.* 2001;344(1):3-10.
22. Appel LJ, Moore TJ, Obarzanek E, et al. A clinical trial of the effects of dietary patterns on blood pressure. *N. Engl. J. Med.* 1997;336(16):1117-1124.
23. Chen ST, Maruthur NM, Appel LJ. The effect of dietary patterns on estimated coronary heart disease risk results from the Dietary Approaches to Stop Hypertension (DASH) trial. *Circ Cardiovasc Qual Outcomes.* 2010;3(5):484-489.
24. Fung TT, Chiuve SE, McCullough ML, Rexrode KM, Logroscino G, Hu FB. Adherence to a DASH-style diet and risk of coronary heart disease and stroke in women. *Arch. Intern. Med.* 2008;168(7):713.
25. Hu FB, Willett WC. Optimal diets for prevention of coronary heart disease. *JAMA: the journal of the American Medical Association.* 2002;288(20):2569-2578.
26. Mozaffarian D, Wilson PW, Kannel WB. Beyond established and novel risk factors lifestyle risk factors for cardiovascular disease. *Circulation.* 2008;117(23):3031-3038.
27. Grossman M. The demand for health: a theoretical and empirical investigation. *NBER Books.* 1972.
28. Kan K, Tsai W-D. Obesity and risk knowledge. *J. Health Econ.* 2004;23(5):907-934.
29. Viscusi WK, Carvalho I, Antoñanzas F, Rovira J, Brana FJ, Portillo F. Smoking risks in Spain: Part III—Determinants of smoking behavior. *J. Risk Uncertainty.* 2000;21(2-3):213-234.

30. Ainslie G, Herrnstein RJ. Preference reversal and delayed reinforcement. *Anim Learn Behav.* 1981;9(4):476-482.
31. Strotz RH. Myopia and inconsistency in dynamic utility maximization. *RvES.* 1955;23(3):165-180.
32. Rosenstock IM. The health belief model and preventive health behavior. *Health Educ. Behav.* 1974;2(4):354-386.
33. Glanz K, Rimer BK, Viswanath K. *Health behavior and health education: theory, research, and practice*: John Wiley & Sons; 2008.
34. Becker MH, Maiman LA. Sociobehavioral Determinants of Compliance with Health and Medical Care Recommendations. *Med. Care.* 1975;13(1):10-24.
35. Harvey J, Lawson V. The importance of health belief models in determining self-care behaviour in diabetes. *Diabet. Med.* 2009;26(1):5-13.
36. Leiva A, Fajó M, Escriche L, et al. Efficacy of a brief multifactorial adherence-based intervention on reducing the blood pressure of patients with poor adherence: protocol for a randomized clinical trial. *BMC cardiovascular disorders.* 2010;10(1):44.
37. Becker MH, Janz NK. The health belief model applied to understanding diabetes regimen compliance. *The Diabetes Educator.* 1985;11(1):41-47.
38. Aubert L, Bovet P, Gervasoni J-P, Rwebogora A, Waeber B, Paccaud F. Knowledge, attitudes, and practices on hypertension in a country in epidemiological transition. *Hypertension.* 1998;31(5):1136-1145.
39. James D, Pobee JW, Brown L, Joshi G. Using the Health Belief Model to Develop Culturally Appropriate Weight-Management Materials for African-American Women. *J Acad Nutr Diet.* 2012;112(5):664-670.
40. Nelson EC, Stason WB, Neutra RR, Solomon HS, McArdle PJ. Impact of patient perceptions on compliance with treatment for hypertension. *Med. Care.* 1978;893-906.
41. Whelton PK, He J, Appel LJ, et al. Primary prevention of hypertension: clinical and public health advisory from The National High Blood Pressure Education Program. *JAMA.* 2002;288(15):1882-1888.
42. Smith SC, Allen J, Blair SN, et al. AHA/ACC guidelines for secondary prevention for patients with coronary and other atherosclerotic vascular disease: 2006 update: endorsed by the National Heart, Lung, and Blood Institute. *J. Am. Coll. Cardiol.* 2006;47(10):2130-2139.
43. Nwankwo T, Yoon S, Burt V, Gu Q. Hypertension among adults in the US: National Health and Nutrition Examination Survey, 2011-2012. *NCHS data brief.* 2013(133).
44. National Heart Lung and Blood Institute. Your guide to lowering your blood pressure with DASH. *NIH publication.* 2006(06-5834).
45. McGuire S. US Department of Agriculture and US Department of Health and Human

- Services, Dietary Guidelines for Americans, 2010. Washington, DC: US Government Printing Office, January 2011. *Adv. Nutr.* 2011;2(3):293-294.
46. Appel LJ, Brands MW, Daniels SR, Karanja N, Elmer PJ, Sacks FM. Dietary approaches to prevent and treat hypertension a scientific statement from the American Heart Association. *Hypertension.* 2006;47(2):296-308.
  47. Couch SC, Saelens BE, Hinn K, et al. Effects of a clinic-initiated behavioral nutrition intervention emphasizing the dash diet on blood pressure control in adolescents with elevated blood pressure. *J Am Soc Hypertens.* 2014;8(4):e116.
  48. Laaksonen M, Luoto R, Helakorpi S, Uutela A. Associations between health-related behaviors: a 7-year follow-up of adults. *Prev. Med.* 2002;34(2):162-170.
  49. Serdula MK, Byers T, Mokdad AH, Simoes E, Mendlein JM, Coates RJ. The association between fruit and vegetable intake and chronic disease risk factors. *Epidemiology.* 1996;7(2):161-165.
  50. Clark A, Etile F. Do health changes affect smoking? Evidence from British panel data. *J. Health Econ.* 2002;21(4):533-562.
  51. Falba T. Health events and the smoking cessation of middle aged Americans. *J. Behav. Med.* 2005;28(1):21-33.
  52. Becker GS. A Theory of the Allocation of Time. *The economic journal.* 1965;75(299):493-517.
  53. Becker GS, Grossman M, Murphy KM. *An empirical analysis of cigarette addiction*: National Bureau of Economic Research;1994.
  54. Douglas S. The duration of the smoking habit. *Econ. Inq.* 1998;36(1):49-64.
  55. Kahn ME. Diabetic risk taking: The role of information, education and medication. *J. Risk Uncertainty.* 1999;18(2):147-164.
  56. Bifulco G, De Rosa N, Tornesello M, et al. Quality of life, lifestyle behavior and employment experience: a comparison between young and midlife survivors of gynecology early stage cancers. *Gynecol. Oncol.* 2012;124(3):444-451.
  57. Hermansen K. Diet, blood pressure and hypertension. *Br. J. Nutr.* 2000;83(1):S113.
  58. Kwan MW-M, Wong MC-S, Wang HH-X, et al. Compliance with the Dietary Approaches to Stop Hypertension (DASH) diet: a systematic review. 2013.
  59. Jiang J, Liu M, Troy LM, Bangalore S, Hayes RB, Parekh N. Concordance with DASH diet and blood pressure change: results from the Framingham Offspring Study (1991–2008). *J. Hypertens.* 2015;33(11):2223-2230.
  60. Slade AN, Kim H. Dietary Responses to a Hypertension Diagnosis: Evidence from the National Health and Nutrition Examination Survey (NHANES) 2007–2010. *Behav. Med.* 2014;40(1):1-13.

61. Morton S, Saydah S, Cleary SD. Consistency with the Dietary Approaches to Stop Hypertension Diet among Adults with Diabetes. *J Acad Nutr Diet*. 2012;112(11):1798-1805.
62. Appleby P, Roddam A, Allen N, Key T. Comparative fracture risk in vegetarians and nonvegetarians in EPIC-Oxford. *Eur. J. Clin. Nutr*. 2007;61(12):1400-1406.
63. Stolley MR, Sharp LK, Tangney CC, et al. Health behaviors of minority childhood cancer survivors. *Cancer*. 2015;121(10):1671-1680.
64. Mellen PB, Gao SK, Vitolins MZ, Goff DC. Deteriorating dietary habits among adults with hypertension: DASH dietary accordance, NHANES 1988-1994 and 1999-2004. *Arch. Intern. Med*. 2008;168(3):308-314.
65. National Health and Nutrition Examination Survey Measuring Guides for the Dietary Recall Interview. Hyattsville, MD: US Department of Health and Human Services, Centers for Disease Control and Prevention.
66. Ahuja J, Montville J, Omolewa-Tomobi G, et al. USDA food and nutrient database for dietary studies, 5.0. *US Department of Agriculture, Agricultural Research Service, Food Surveys Research Group*. 2012.
67. Gao SK, Fitzpatrick AL, Psaty B, et al. Suboptimal nutritional intake for hypertension control in 4 ethnic groups. *Arch. Intern. Med*. 2009;169(7):702-707.
68. Lin P-H, Windhauser MM, Plaisted CS, Hoben KP, McCULLOUGH ML, Obarzanek E. The linear index model for establishing nutrient goals in the Dietary Approaches to Stop Hypertension trial. *J. Am. Diet. Assoc*. 1999;99(8):S40-S44.
69. Fox CS, Coady S, Sorlie PD, et al. Increasing cardiovascular disease burden due to diabetes mellitus The Framingham Heart Study. *Circulation*. 2007;115(12):1544-1550.
70. Almgren T, Wilhelmsen L, Samuelsson O, Himmelmann A, Rosengren A, Andersson OK. Diabetes in treated hypertension is common and carries a high cardiovascular risk: results from a 28-year follow-up. *J. Hypertens*. 2007;25(6):1311-1317.
71. Ferrannini E, Cushman WC. Diabetes and hypertension: the bad companions. *The Lancet*. 2012;380(9841):601-610.
72. León-Muñoz LM, Guallar-Castillón P, Graciani A, et al. Dietary habits of the hypertensive population of Spain: accordance with the DASH diet and the Mediterranean diet. *J. Hypertens*. 2012;30(7):1373-1382.
73. Tangney C, Sarkar D, Staffileno B. Comparison of three DASH scoring paradigms and prevalent hypertension among older Hispanics. *J. Hum. Hypertens*. 2015.
74. King DE, Mainous AG, Lambourne CA. Trends in dietary fiber intake in the United States, 1999-2008. *J Acad Nutr Diet*. 2012;112(5):642-648.
75. Whelton SP, Hyre AD, Pedersen B, Yi Y, Whelton PK, He J. Effect of dietary fiber intake on blood pressure: a meta-analysis of randomized, controlled clinical trials. *J. Hypertens*.

- 2005;23(3):475-481.
76. Threapleton DE, Greenwood DC, Evans CE, et al. Dietary fiber intake and risk of first stroke a systematic review and meta-analysis. *Stroke*. 2013;44(5):1360-1368.
  77. Tucker LA, Thomas KS. Increasing total fiber intake reduces risk of weight and fat gains in women. *The Journal of nutrition*. 2009;139(3):576-581.
  78. Slavin J. Fiber and prebiotics: mechanisms and health benefits. *Nutrients*. 2013;5(4):1417-1435.
  79. Pearson TA, Bazzarre TL, Daniels SR, et al. American Heart Association Guide for Improving Cardiovascular Health at the Community Level A Statement for Public Health Practitioners, Healthcare Providers, and Health Policy Makers From the American Heart Association Expert Panel on Population and Prevention Science. *Circulation*. 2003;107(4):645-651.
  80. Marma AK, Berry JD, Ning H, Persell SD, Lloyd-Jones DM. Distribution of 10-year and lifetime predicted risks for cardiovascular disease in US adults findings from the National Health and Nutrition Examination Survey 2003 to 2006. *Circ Cardiovasc Qual Outcomes*. 2010;3(1):8-14.
  81. Cheng S, Xanthakis V, Sullivan LM, Vasan RS. Blood Pressure Tracking Over the Adult Life Course Patterns and Correlates in the Framingham Heart Study. *Hypertension*. 2012;60(6):1393-1399.
  82. Daskalopoulou SS, Khan NA, Quinn RR, et al. The 2012 Canadian hypertension education program recommendations for the management of hypertension: blood pressure measurement, diagnosis, assessment of risk, and therapy. *Can. J. Cardiol*. 2012;28(3):270-287.
  83. Hinderliter AL, Sherwood A, Craighead LW, et al. The long-term effects of lifestyle change on blood pressure: One-year follow-up of the ENCORE study. *Am. J. Hypertens*. 2014;27(5):734-741.
  84. McBride CM, Clipp E, Peterson BL, Lipkus IM, Demark-Wahnefried W. Psychological impact of diagnosis and risk reduction among cancer survivors. *Psycho-Oncology*. 2000;9(5):418-427.
  85. Demark-Wahnefried W, Peterson B, McBride C, Lipkus I, Clipp E. Current health behaviors and readiness to pursue life-style changes among men and women diagnosed with early stage prostate and breast carcinomas. *Cancer*. 2000;88(3):674-684.
  86. Satia JA, Campbell MK, Galanko JA, James A, Carr C, Sandler RS. Longitudinal changes in lifestyle behaviors and health status in colon cancer survivors. *Cancer Epidemiology Biomarkers & Prevention*. 2004;13(6):1022-1031.
  87. Wayne SJ, Lopez ST, Butler LM, Baumgartner KB, Baumgartner RN, Ballard-Barbash R. Changes in dietary intake after diagnosis of breast cancer. *J. Am. Diet. Assoc*. 2004;104(10):1561-1568.

88. Blanchard CM, Denniston MM, Baker F, et al. Do adults change their lifestyle behaviors after a cancer diagnosis? *American Journal of Health Behavior*. 2003;27(3):246-256.
89. Maunsell E, Drolet M, Brisson J, Robert J, Deschênes L. Dietary change after breast cancer: extent, predictors, and relation with psychological distress. *J. Clin. Oncol.* 2002;20(4):1017-1025.
90. Maskarinec G, Murphy S, Shumay D, Kakai H. Dietary changes among cancer survivors. *European journal of cancer care*. 2001;10(1):12-20.
91. Ko S-H, Park S, Cho J-H, et al. Influence of the duration of diabetes on the outcome of a diabetes self-management education program. *Diabetes & metabolism journal*. 2012;36(3):222-229.
92. Kotchen TA. Obesity-related hypertension: epidemiology, pathophysiology, and clinical management. *Am. J. Hypertens.* 2010;23(11):1170-1178.
93. Kotsis V, Stabouli S, Papakatsika S, Rizos Z, Parati G. Mechanisms of obesity-induced hypertension. *Hypertens. Res.* 2010;33(5):386-393.
94. Onysko J, Maxwell C, Eliasziw M, Zhang JX, Johansen H, Campbell NR. Large increases in hypertension diagnosis and treatment in Canada after a healthcare professional education program. *Hypertension*. 2006;48(5):853-860.
95. Demark-Wahnefried W, Aziz NM, Rowland JH, Pinto BM. Riding the crest of the teachable moment: promoting long-term health after the diagnosis of cancer. *J. Clin. Oncol.* 2005;23(24):5814-5830.
96. Health UDo, Services H. Your guide to lowering your blood pressure with DASH. *Bethesda, MD: National Heart, Lung, and Blood Institute.(NIH Publication No. 06-4082)*. 2006.
97. American Dietetic Association. Nutrition and You: Trends 2011. Available at: [http://www.eatrightpro.org/~media/eatrightpro%20files/media/trends%20and%20reviews/nutrition%20and%20you/nutrition\\_and\\_you\\_trends\\_2011\\_ppt\\_web.ashx](http://www.eatrightpro.org/~media/eatrightpro%20files/media/trends%20and%20reviews/nutrition%20and%20you/nutrition_and_you_trends_2011_ppt_web.ashx). 2011.
98. Bellizzi KM, Rowland JH, Jeffery DD, McNeel T. Health behaviors of cancer survivors: examining opportunities for cancer control intervention. *J. Clin. Oncol.* 2005;23(34):8884-8893.
99. Pinto BM, Trunzo JJ. Health behaviors during and after a cancer diagnosis. *Cancer*. 2005;104(S11):2614-2623.
100. Pierce JP, Newman VA, Flatt SW, et al. Telephone counseling intervention increases intakes of micronutrient-and phytochemical-rich vegetables, fruit and fiber in breast cancer survivors. *The Journal of nutrition*. 2004;134(2):452-458.
101. Djuric Z, DiLaura NM, Jenkins I, et al. Combining Weight-Loss Counseling with the Weight Watchers Plan for Obese Breast Cancer Survivors. *Obes. Res.* 2002;10(7):657-665.
102. Gillett M, Dallosso H, Dixon S, et al. Delivering the diabetes education and self management

- for ongoing and newly diagnosed (DESMOND) programme for people with newly diagnosed type 2 diabetes: cost effectiveness analysis. *BMJ*. 2010;341.
103. Burt VL, Cutler JA, Higgins M, et al. Trends in the prevalence, awareness, treatment, and control of hypertension in the adult US population data from the health examination surveys, 1960 to 1991. *Hypertension*. 1995;26(1):60-69.
  104. Hoyert DL, Xu J. Deaths: preliminary data for 2011. *Natl. Vital Stat. Rep.* 2012;61(6):1-51.
  105. Lowe LP, Greenland P, Ruth KJ, Dyer AR, Stamler R, Stamler J. Impact of major cardiovascular disease risk factors, particularly in combination, on 22-year mortality in women and men. *Arch. Intern. Med.* 1998;158(18):2007-2014.
  106. Vasan RS, Larson MG, Leip EP, et al. Impact of high-normal blood pressure on the risk of cardiovascular disease. *N. Engl. J. Med.* 2001;345(18):1291-1297.
  107. Engberding N, Wenger NK. Management of hypertension in women. *Hypertens. Res.* 2012;35(3):251-260.
  108. World Health Organization WHO. Global action plan for the prevention and control of noncommunicable diseases 2013-2020. 2013.
  109. Lim SS, Vos T, Flaxman AD, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*. 2013;380(9859):2224-2260.
  110. Lloyd-Jones DM, Hong Y, Labarthe D, et al. Defining and setting national goals for cardiovascular health promotion and disease reduction the American Heart Association's Strategic Impact Goal through 2020 and beyond. *Circulation*. 2010;121(4):586-613.
  111. Danaei G, Ding EL, Mozaffarian D, et al. The preventable causes of death in the United States: comparative risk assessment of dietary, lifestyle, and metabolic risk factors. *PLoS medicine*. 2009;6(4):e1000058.
  112. Forman JP, Stampfer MJ, Curhan GC. Diet and lifestyle risk factors associated with incident hypertension in women. *JAMA*. 2009;302(4):401-411.
  113. Pereira MA, Folsom AR, McGovern PG, et al. Physical activity and incident hypertension in black and white adults: the Atherosclerosis Risk in Communities Study. *Prev. Med.* 1999;28(3):304-312.
  114. Gelber RP, Gaziano JM, Manson JE, Buring JE, Sesso HD. A prospective study of body mass index and the risk of developing hypertension in men. *Am. J. Hypertens*. 2007;20(4):370-377.
  115. Artinian NT, Fletcher GF, Mozaffarian D, et al. Interventions to promote physical activity and dietary lifestyle changes for cardiovascular risk factor reduction in adults a scientific statement from the American Heart Association. *Circulation*. 2010;122(4):406-441.
  116. Lichtenstein AH, Appel LJ, Brands M, et al. Diet and lifestyle recommendations revision

- 2006 A scientific statement from the American Heart Association nutrition committee. *Circulation*. 2006;114(1):82-96.
117. Hillbom M, Saloheimo P, Juvela S. Alcohol consumption, blood pressure, and the risk of stroke. *Current hypertension reports*. 2011;13(3):208-213.
  118. Nakamura K, Barzi F, Lam T-H, et al. Cigarette smoking, systolic blood pressure, and cardiovascular diseases in the Asia-Pacific region. *Stroke*. 2008;39(6):1694-1702.
  119. Khalili P, Nilsson PM, Nilsson J-Å, Berglund G. Smoking as a modifier of the systolic blood pressure-induced risk of cardiovascular events and mortality: a population-based prospective study of middle-aged men. *J. Hypertens*. 2002;20(9):1759-1764.
  120. Talukder MH, Johnson WM, Varadharaj S, et al. Chronic cigarette smoking causes hypertension, increased oxidative stress, impaired NO bioavailability, endothelial dysfunction, and cardiac remodeling in mice. *American Journal of Physiology-Heart and Circulatory Physiology*. 2011;300(1):H388-H396.
  121. Briasoulis A, Agarwal V, Messerli FH. Alcohol Consumption and the Risk of Hypertension in Men and Women: A Systematic Review and Meta-Analysis. *The Journal of Clinical Hypertension*. 2012;14(11):792-798.
  122. Ronksley PE, Brien SE, Turner BJ, Mukamal KJ, Ghali WA. Association of alcohol consumption with selected cardiovascular disease outcomes: a systematic review and meta-analysis. *BMJ*. 2011;342:d671.
  123. Halperin RO, Gaziano JM, Sesso HD. Smoking and the risk of incident hypertension in middle-aged and older men. *Am. J. Hypertens*. 2008;21(2):148-152.
  124. Appel LJ, Champagne CM, Harsha DW, et al. Effects of comprehensive lifestyle modification on blood pressure control: main results of the PREMIER clinical trial. *J. Am. Med. Assoc*. 2003.
  125. Higashiyama A, Okamura T, Watanabe M, et al. Alcohol consumption and cardiovascular disease incidence in men with and without hypertension: the Suita study. *Hypertens. Res*. 2013;36(1):58-64.
  126. Go AS, Bauman MA, King SMC, et al. An effective approach to high blood pressure control: a science advisory from the American Heart Association, the American College of Cardiology, and the Centers for Disease Control and Prevention. *J. Am. Coll. Cardiol*. 2014;63(12):1230-1238.
  127. Rossi A, Dikareva A, Bacon SL, Daskalopoulou SS. The impact of physical activity on mortality in patients with high blood pressure: a systematic review. *J. Hypertens*. 2012;30(7):1277-1288.
  128. Becker GS, Murphy KM. A theory of rational addiction. *The Journal of Political Economy*. 1988:675-700.

129. Haskell WL, Lee I-M, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation*. 2007;116(9):1081.
130. Committee PAGA. Physical activity guidelines for Americans. *Washington, DC: US Department of Health and Human Services*. 2008:15-34.
131. Cohen L, Curhan GC, Forman JP. Influence of age on the association between lifestyle factors and risk of hypertension. *J Am Soc Hypertens*. 2012;6(4):284-290.
132. Barnes PM, Schoenborn CA. *Trends in adults receiving a recommendation for exercise or other physical activity from a physician or other health professional*: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics; 2012.
133. Kohl HW, Craig CL, Lambert EV, et al. The pandemic of physical inactivity: global action for public health. *The Lancet*. 2012;380(9838):294-305.
134. Bauman AE, Reis RS, Sallis JF, et al. Correlates of physical activity: why are some people physically active and others not? *The Lancet*. 2012;380(9838):258-271.
135. Ford ES, Li C, Zhao G, Pearson WS, Tsai J, Greenlund KJ. Trends in low-risk lifestyle factors among adults in the United States: findings from the Behavioral Risk Factor Surveillance System 1996–2007. *Prev. Med*. 2010;51(5):403-407.
136. Agborsangaya CB, Gee ME, Johnson ST, et al. Determinants of lifestyle behavior in type 2 diabetes: results of the 2011 cross-sectional survey on living with chronic diseases in Canada. *BMC Public Health*. 2013;13(1):451.
137. Lopez L, Cook EF, Horng MS, Hicks LS. Lifestyle modification counseling for hypertensive patients: results from the National Health and Nutrition Examination Survey 1999–2004. *Am. J. Hypertens*. 2009;22(3):325-331.
138. Gee ME, Bienek A, Campbell NR, et al. Prevalence of, and barriers to, preventive lifestyle behaviors in hypertension (from a national survey of Canadians with hypertension). *The American journal of cardiology*. 2012;109(4):570-575.
139. Malekzadeh MM, Etemadi A, Kamangar F, et al. Prevalence, awareness and risk factors of hypertension in a large cohort of Iranian adult population. *J. Hypertens*. 2013;31(7):1364.
140. Mahmud A, Wadi H, Feely J, Silke B. 7B. 07: CIGARETTE SMOKING REDUCES BLOOD PRESSURE RESPONSE TO ANTIHYPERTENSIVE TREATMENT IN NEWLY DIAGNOSED HYPERTENSIVE PATIENTS. *J. Hypertens*. 2015;33:e94.
141. U.S. Department of Health and Human Services. Healthy People 2020. Washington, DC. 2012. Office of Disease Prevention and Health Promotion.
142. Lee I-M, Shiroma EJ, Lobelo F, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *The*

- Lancet*. 2012;380(9838):219-229.
143. U.S. Department of Health and Human Services, U.S. Department of Agriculture. 2015-2020 Dietary Guidelines for Americans. Accessed on 4/11/2016 at: <http://health.gov/dietaryguidelines/2015/guidelines/>. 2016.
  144. Aburto NJ, Ziolkovska A, Hooper L, Elliott P, Cappuccio FP, Meerpohl JJ. Effect of lower sodium intake on health: systematic review and meta-analyses. *BMJ*. 2013;346.
  145. Graudal NA, Hubeck-Graudal T, Jürgens G. Effects of low-sodium diet vs. high-sodium diet on blood pressure, renin, aldosterone, catecholamines, cholesterol, and triglyceride (Cochrane Review). *Am. J. Hypertens*. 2012;25(1):1-15.
  146. Bibbins-Domingo K, Chertow GM, Coxson PG, et al. Projected effect of dietary salt reductions on future cardiovascular disease. *N. Engl. J. Med*. 2010;362(7):590-599.
  147. O'Donnell MJ, Yusuf S, Mente A, et al. Urinary sodium and potassium excretion and risk of cardiovascular events. *JAMA*. 2011;306(20):2229-2238.
  148. Paterna S, Gaspare P, Fasullo S, Sarullo F, Di Pasquale P. Normal-sodium diet compared with low-sodium diet in compensated congestive heart failure: is sodium an old enemy or a new friend? *Clin. Sci*. 2008;114:221-230.
  149. Aburto NJ, Ziolkovska A, Hooper L, Elliott P, Cappuccio FP, Meerpohl JJ. Effect of lower sodium intake on health: systematic review and meta-analyses. *BMJ*. 2013;346:f1326.
  150. Frieden TR, Berwick DM. The “Million Hearts” initiative—preventing heart attacks and strokes. *N. Engl. J. Med*. 2011;365(13).
  151. Farley TA, Dalal MA, Mostashari F, Frieden TR. Deaths preventable in the US by improvements in use of clinical preventive services. *Am. J. Prev. Med*. 2010;38(6):600-609.
  152. Rasella D, Harhay MO, Pamponet ML, Aquino R, Barreto ML. Impact of primary health care on mortality from heart and cerebrovascular diseases in Brazil: a nationwide analysis of longitudinal data. 2014.
  153. Macinko J, Dourado I, Aquino R, et al. Major expansion of primary care in Brazil linked to decline in unnecessary hospitalization. *Health Aff. (Millwood)*. 2010;29(12):2149-2160.

## Tables

Table 1-1. Nutrient targets for Dietary Approaches to Stop Hypertension (DASH) accordance score<sup>a,b</sup>

DASH Nutrient	DASH score target <sup>c</sup> (1 point)	Intermediate target (0.5 point)
Sodium, mg/d	<2300	2300-2650
Cholesterol, mg/d	<149.1	149.1-224.7
Saturated fat, % of Kcal/d	<6	6 -11
Total fat, % of Kcal/d	<27	27-32
Protein, % of Kcal/d	>18	16.5-18
Calcium, mg/d	>1240	842.3-1240
Magnesium, mg/d	>496.7	330.3-496.7
Potassium, mg/d	>4673.3	3198.3-4673.3
Fiber, g/d	>30.0	19.5-30.0

<sup>a</sup>Adapted from “Your guide to lowering your blood pressure with DASH. DASH eating plan,” National Heart, Lung, and Blood Institute.

<sup>b</sup>Table Source: Morton, Saydah, and Cleary (2012) and Morton, et al. (2008).

<sup>c</sup>DASH score targets are based on 2,100 Kcal/d diet and the linear index model introduced by Lin, et al. (1998). If the DASH nutrient is not meeting a score target or an intermediate target, it is given 0.

Table 1-2. Sample characteristics by hypertension status (mean±sd or %): National Health and Nutrition Examination Surveys (2007-2012)

Characteristic	Undiagnosed hypertension		Diagnosed hypertension		p-value
DASH accordance score	2.72	(1.31)	2.61	(1.27)	0.012
DASH accordance level (%)	12.1%	(0.33)	10.9%	(0.31)	0.293
<i>DASH nutrients</i>					
Total caloric intake	1984.29	(850.56)	1862.53	(727.38)	<0.001
Sodium	3208.60	(1487.01)	3213.87	(1429.80)	0.919
Cholesterol	277.21	(192.16)	278.23	(186.50)	0.879
Saturated fat	23.10	(13.07)	22.55	(12.66)	0.192
Total fat	72.12	(37.66)	72.48	(36.00)	0.785
Protein	76.52	(34.10)	76.09	(32.74)	0.713
Calcium	869.81	(463.45)	868.88	(461.57)	0.955
Magnesium	281.04	(121.33)	276.12	(117.30)	0.246
Potassium	2593.94	(1038.88)	2552.96	(1025.87)	0.268
Fiber	16.52	(9.41)	16.02	(8.47)	0.112
Male (%)	57.5%	(0.50)	49.0%	(0.50)	<0.001
<i>Age in years (%)</i>					
20-29	5.3%	(0.22)	1.1%	(0.10)	<0.001
30-39	9.8%	(0.30)	4.6%	(0.21)	<0.001
40-49	13.3%	(0.34)	11.3%	(0.32)	0.069
50-64	33.2%	(0.47)	35.3%	(0.48)	0.192
65-80	38.4%	(0.49)	47.7%	(0.50)	<0.001
<i>Ethnicity (%)</i>					
Non-Hispanic White	47.2%	(0.50)	47.0%	(0.50)	0.949
Non-Hispanic Black	21.2%	(0.41)	28.5%	(0.45)	<0.001
Hispanic	24.4%	(0.43)	19.3%	(0.39)	<0.001
Other race	7.3%	(0.26)	5.2%	(0.22)	0.010
<i>Education level (%)</i>					
<High school	32.2%	(0.47)	31.6%	(0.47)	0.723
High school	24.5%	(0.43)	24.9%	(0.43)	0.787
Some college	25.1%	(0.43)	26.4%	(0.44)	0.400
College graduate	18.2%	(0.39)	17.1%	(0.38)	0.395
<i>Income level (%)</i>					
<25,000	34.8%	(0.48)	37.5%	(0.48)	0.112
25,000-44,999	24.6%	(0.43)	24.6%	(0.43)	0.977
45,000-74,999	18.3%	(0.39)	18.3%	(0.39)	0.982
≥75,000	22.4%	(0.42)	19.5%	(0.40)	0.049
Married (%)	53.0%	(0.50)	53.8%	(0.50)	0.675
Employed (%)	44.6%	(0.50)	34.6%	(0.48)	<0.001
<i>Body Mass Index category</i>					
Underweight (<18.5)	1.5%	(0.12)	0.9%	(0.09)	0.061
Normal (18.5-24.9)	27.6%	(0.45)	16.5%	(0.37)	<0.001
Overweight (25.0-29.9)	34.2%	(0.47)	31.5%	(0.46)	0.090
Obese (≥30.0)	36.7%	(0.48)	51.3%	(0.50)	<0.001
Diabetes (%)	10.3%	(0.30)	30.6%	(0.46)	<0.001
Heart diseases (%)	6.3%	(0.24)	23.8%	(0.43)	<0.001
Health insurance (%)	75.4%	(0.43)	88.3%	(0.32)	<0.001
<i>Self-reported health (%)</i>					
Excellent	12.4%	(0.33)	5.8%	(0.23)	<0.001
Good	84.5%	(0.36)	85.0%	(0.36)	0.712
Poor	3.1%	(0.17)	9.2%	(0.29)	<0.001
specialdiet (%)	9.6%	(0.30)	21.5%	(0.41)	<0.001

Table 1-2 (cont.). Sample characteristics by hypertension status (mean±sd or %): National Health and Nutrition Examination Surveys (2007-2012)

Characteristic	Undiagnosed hypertension		Diagnosed hypertension		p-value
<i>NHANES survey period (%)</i>					
2007-2008	40.0%	(0.49)	34.8%	(0.47)	0.003
2009-2010	32.8%	(0.47)	36.2%	(0.48)	0.048
2011-2012	27.3%	(0.45)	29.1%	(0.45)	0.279
N	916		4,737		

Table 1-3. Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) accordance and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	DASH accordance score	DASH accordance level	Sodium	Cholesterol	Saturated fat	Total fat
Diagnostic status of hypertension	-0.129 (0.204)	-0.0635 (0.0513)	235.4 (215.6)	71.02* (29.43)	1.457 (1.919)	7.271 (5.450)
Male	0.154*** (0.0344)	0.0212* (0.00866)	838.2*** (36.37)	93.79*** (4.965)	6.249*** (0.324)	19.30*** (0.920)
<i>Age (Years)</i>						
30-39	0.285 (0.216)	0.00403 (0.0545)	136.6 (228.9)	51.68 (31.25)	0.935 (2.038)	3.811 (5.788)
40-49	0.223 (0.207)	0.0105 (0.0523)	416.9 (219.5)	93.98** (29.96)	1.269 (1.954)	8.119 (5.550)
50-64	0.139 (0.189)	-0.0459 (0.0476)	-67.47 (199.7)	38.08 (27.26)	-2.954 (1.778)	-3.004 (5.049)
65-80	0.222 (0.190)	-0.0430 (0.0478)	-371.0 (200.7)	22.26 (27.39)	-3.979* (1.787)	-7.723 (5.074)
<i>Interaction of hypertension diagnosis and age group of</i>						
30-39	-0.0295 (0.250)	0.0154 (0.0630)	-97.09 (264.5)	-65.78 (36.10)	-1.666 (2.355)	-5.574 (6.687)
40-49	0.100 (0.238)	0.0260 (0.0599)	-268.3 (251.7)	-94.83** (34.36)	-1.576 (2.241)	-7.585 (6.365)
50-64	0.199 (0.218)	0.0954 (0.0549)	-101.5 (230.6)	-55.19 (31.48)	0.262 (2.053)	-2.825 (5.831)
65-80	0.0954 (0.216)	0.0904 (0.0543)	-154.0 (228.2)	-69.40* (31.15)	-1.556 (2.032)	-6.626 (5.769)

Table 1-3 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) accordance and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	DASH accordance score	DASH accordance level	Sodium	Cholesterol	Saturated fat	Total fat
<i>Ethnicity</i>						
Non-Hispanic Black	-0.208*** (0.0412)	-0.0171 (0.0104)	-205.1*** (43.65)	21.96*** (5.959)	-2.613*** (0.389)	-3.636*** (1.104)
Hispanic	0.454*** (0.0465)	0.0687*** (0.0117)	-252.4*** (49.29)	4.654 (6.728)	-3.176*** (0.439)	-7.871*** (1.246)
Other race	0.218** (0.0742)	0.0182 (0.0187)	196.1* (78.58)	-17.65 (10.73)	-5.106*** (0.700)	-12.08*** (1.987)
<i>Education level</i>						
High school	-0.122** (0.0460)	-0.0280* (0.0116)	138.1** (48.72)	6.161 (6.650)	1.646*** (0.434)	4.976*** (1.232)
Some college	0.00572 (0.0465)	-0.0103 (0.0117)	192.5*** (49.20)	7.848 (6.716)	2.304*** (0.438)	6.637*** (1.244)
College graduate	0.172** (0.0562)	0.0311* (0.0142)	140.2* (59.56)	-2.090 (8.130)	1.530** (0.530)	5.616*** (1.506)
<i>Income level (\$)</i>						
25,000-44,999	-0.0127 (0.0444)	0.00273 (0.0112)	35.26 (46.97)	10.85 (6.412)	0.323 (0.418)	1.716 (1.188)
45,000-74,999	-0.0213 (0.0505)	0.00865 (0.0127)	59.83 (53.43)	12.00 (7.294)	0.642 (0.476)	3.002* (1.351)
≥75,000	0.0217 (0.0546)	-0.00233 (0.0138)	112.0 (57.84)	14.61 (7.895)	1.045* (0.515)	3.914** (1.462)
Married	0.0187 (0.0360)	0.00437 (0.00909)	-37.54 (38.17)	-4.942 (5.210)	-0.541 (0.340)	-0.716 (0.965)

Table 1-3 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) accordancy and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	DASH accordancy score	DASH accordancy level	Sodium	Cholesterol	Saturated fat	Total fat
Employed	-0.0500 (0.0404)	-0.00288 (0.0102)	173.6*** (42.79)	4.282 (5.842)	0.927* (0.381)	4.394*** (1.082)
<i>Body Mass Index category</i>						
Underweight ( $<18.5$ )	-0.123 (0.178)	-0.0583 (0.0449)	-142.6 (188.5)	-27.44 (25.73)	-1.987 (1.679)	-3.047 (4.767)
Overweight (25.0-29.9)	-0.0619 (0.0478)	-0.0170 (0.0121)	-58.39 (50.66)	0.302 (6.915)	0.113 (0.451)	0.163 (1.281)
Obese ( $\geq 30.0$ )	-0.173*** (0.0466)	-0.0320** (0.0118)	107.5* (49.37)	22.49*** (6.739)	1.218** (0.440)	3.279** (1.248)
Diabetes	-0.0493 (0.0402)	-0.0249* (0.0101)	38.97 (42.54)	8.768 (5.807)	-0.469 (0.379)	-0.226 (1.076)
Heart disease	-0.0676 (0.0445)	-0.0107 (0.0112)	-130.6** (47.15)	-7.571 (6.436)	-1.024* (0.420)	-2.966* (1.192)
Health insurance	-0.0456 (0.0507)	-0.0279* (0.0128)	108.5* (53.68)	-0.363 (7.328)	1.165* (0.478)	2.917* (1.357)
Current smoking status	-0.294*** (0.0458)	- 0.0444*** (0.0115)	82.12 (48.47)	19.58** (6.617)	2.193*** (0.432)	4.807*** (1.226)
Physical activity status	0.235*** (0.0406)	0.0401*** (0.0102)	38.90 (42.96)	-1.362 (5.864)	-0.629 (0.382)	-0.957 (1.086)

Table 1-3 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) accordancy and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	DASH accordancy score	DASH accordancy level	Sodium	Cholesterol	Saturated fat	Total fat
<i>Self-reported health</i>						
Good	-0.151* (0.0648)	-0.0204 (0.0163)	-106.3 (68.60)	-20.01* (9.365)	-0.905 (0.611)	-3.495* (1.735)
Poor	-0.108 (0.0905)	-0.0220 (0.0228)	-162.8 (95.81)	-17.60 (13.08)	-0.852 (0.853)	-4.021 (2.422)
<i>NHANES survey period</i>						
2009-2010	0.0862* (0.0391)	0.00434 (0.00985)	179.9*** (41.36)	-3.916 (5.645)	-0.0441 (0.368)	-0.0291 (1.046)
2011-2012	0.0949* (0.0413)	-0.00232 (0.0104)	219.8*** (43.75)	0.253 (5.972)	0.584 (0.390)	2.703* (1.106)
Constant	2.567*** (0.198)	0.182*** (0.0499)	2554.4*** (209.7)	176.9*** (28.62)	21.00*** (1.867)	58.11*** (5.302)
n	5,653					

<sup>a</sup>Reference groups: Female, Age group of 20-29 years, Non-Hispanic White, Less than high school, Less than \$25,000 annual household income, Normal BMI, Excellent self-rated health status, and NHANES wave of 2007-2008.

\*indicates statistical significance at the 5% level.

\*\*indicates statistical significance at the 1% level.

\*\*\*indicates statistical significance at the 0.1% level.

Table 1-3 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) accordance and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	Protein	Calcium	Magnesium	Potassium	Fiber
Diagnostic status of hypertension	8.084 (4.938)	-23.84 (71.94)	1.565 (18.03)	15.74 (156.7)	-2.435 (1.347)
Male	20.56*** (0.833)	132.6*** (12.14)	53.50*** (3.042)	494.2*** (26.44)	2.511*** (0.227)
<i>Age (Years)</i>					
30-39	6.020 (5.244)	-41.42 (76.40)	17.77 (19.15)	135.8 (166.4)	-0.615 (1.430)
40-49	11.44* (5.028)	-104.4 (73.25)	40.71* (18.36)	305.7 (159.5)	0.978 (1.371)
50-64	-2.350 (4.575)	-182.3** (66.65)	14.16 (16.70)	180.1 (145.1)	-0.194 (1.248)
65-80	-7.921 (4.597)	-230.8*** (66.97)	-0.751 (16.78)	146.7 (145.8)	-0.158 (1.254)
<i>Interaction of hypertension diagnosis and age group of</i>					
30-39	-7.607 (6.058)	0.968 (88.26)	-2.174 (22.12)	-39.89 (192.2)	2.363 (1.652)
40-49	-11.17 (5.766)	68.56 (84.01)	-5.086 (21.06)	29.57 (183.0)	2.121 (1.573)
50-64	-3.764 (5.283)	61.97 (76.97)	12.61 (19.29)	101.9 (167.6)	3.154* (1.441)
65-80	-5.848 (5.227)	51.80 (76.15)	6.776 (19.09)	4.248 (165.8)	2.828* (1.426)

Table 1-3 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) accordance and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	Protein	Calcium	Magnesium	Potassium	Fiber
<i>Ethnicity</i>					
Non-Hispanic Black	-2.813** (1.000)	-183.7*** (14.57)	-31.66*** (3.651)	-371.6*** (31.73)	-1.715*** (0.273)
Hispanic	0.324 (1.129)	-42.75** (16.45)	6.425 (4.122)	-50.70 (35.82)	1.859*** (0.308)
Other race	-3.007 (1.800)	-168.3*** (26.22)	-5.628 (6.572)	-189.4*** (57.11)	0.696 (0.491)
<i>Education level</i>					
High school	2.019 (1.116)	30.65 (16.26)	10.75** (4.075)	105.6** (35.41)	0.193 (0.304)
Some college	3.533** (1.127)	66.18*** (16.42)	24.91*** (4.115)	209.1*** (35.76)	1.440*** (0.307)
College graduate	4.650*** (1.364)	73.74*** (19.88)	39.87*** (4.982)	301.2*** (43.29)	2.877*** (0.372)
<i>Income level (\$)</i>					
25,000-44,999	2.241* (1.076)	2.111 (15.68)	6.263 (3.929)	43.48 (34.14)	0.0197 (0.293)
45,000-74,999	2.679* (1.224)	-1.339 (17.83)	12.72** (4.469)	70.76 (38.83)	0.361 (0.334)
≥75,000	3.786** (1.325)	40.13* (19.30)	16.81*** (4.838)	121.3** (42.04)	0.774* (0.361)
Married	-0.344 (0.874)	-22.23 (12.74)	-3.088 (3.192)	21.14 (27.74)	0.614** (0.238)

Table 1-3 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) accordance and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	Protein	Calcium	Magnesium	Potassium	Fiber
Employed	3.690*** (0.980)	-1.004 (14.28)	6.899 (3.579)	50.69 (31.10)	0.0113 (0.267)
<i>Body Mass Index category</i>					
Underweight ( $<18.5$ )	-5.220 (4.319)	-45.40 (62.92)	-25.89 (15.77)	-283.9* (137.0)	-2.475* (1.178)
Overweight (25.0-29.9)	-0.860 (1.160)	7.979 (16.91)	-6.281 (4.237)	-35.72 (36.82)	-0.768* (0.317)
Obese ( $\geq 30.0$ )	1.817 (1.131)	10.53 (16.48)	-11.55** (4.129)	-49.42 (35.88)	-1.100*** (0.308)
Diabetes	0.599 (0.974)	-16.73 (14.20)	-4.602 (3.558)	-45.53 (30.92)	0.118 (0.266)
Heart disease	-2.664* (1.080)	-44.41** (15.74)	-14.50*** (3.944)	-68.42* (34.27)	-0.755* (0.295)
Health insurance	1.223 (1.230)	34.55 (17.92)	5.167 (4.490)	37.58 (39.02)	-0.0431 (0.335)
Current smoking status	0.741 (1.110)	-33.81* (16.18)	-4.798 (4.055)	-18.72 (35.23)	-1.818*** (0.303)
Physical activity status	1.636 (0.984)	33.81* (14.34)	19.90*** (3.593)	148.4*** (31.22)	1.492*** (0.268)

Table 1-3 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) accordance and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	Protein	Calcium	Magnesium	Potassium	Fiber
<i>Self-reported health</i>					
Good	-3.160*	-34.45	-15.53**	-145.9**	-1.202**
	(1.571)	(22.89)	(5.738)	(49.86)	(0.429)
Poor	-4.813*	-26.05	-19.10*	-246.2***	-2.062***
	(2.195)	(31.97)	(8.014)	(69.63)	(0.599)
<i>NHANES survey period</i>					
2009-2010	2.294*	66.94***	12.13***	118.6***	0.485
	(0.947)	(13.80)	(3.459)	(30.06)	(0.258)
2011-2012	3.466***	80.89***	17.19***	144.7***	1.304***
	(1.002)	(14.60)	(3.659)	(31.80)	(0.273)
Constant	60.92***	940.0***	223.0***	2048.6***	14.70***
	(4.803)	(69.98)	(17.54)	(152.4)	(1.310)
N	5653				

<sup>a</sup>Reference groups: Female, Age group of 20-29 years, Non-Hispanic White, Less than high school, Less than \$25,000 annual household income, Normal BMI, Excellent self-rated health status, and NHANES wave of 2007-2008.

\*indicates statistical significance at the 5% level.

\*\*indicates statistical significance at the 1% level.

\*\*\*indicates statistical significance at the 0.1% level.

Table 1-4. Predicted mean Dietary Approaches to Stop Hypertension (DASH) accordance and nutrient intake among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012) based on diagnostic status of hypertension<sup>a,b,c</sup>

Variable	Undiagnosed hypertension			Diagnosed hypertension			DASH diet
DASH accordance score	2.72	(2.70	2.74)	2.61	(2.60	2.62)	9 points
DASH accordance level	0.12	(0.12	0.13)	0.11	(0.11	0.11)	0.5
Sodium	3208.60	(3168.91	3248.29)	3201.32	(3184.50	3218.14)	2,300 mg
Cholesterol*	277.20	(273.35	281.06)	277.43	(275.82	279.04)	149.1 mg
Saturated fat	23.34	(23.03	23.66)	23.13	(22.99	23.26)	14 g
Total fat	72.12	(71.20	73.04)	72.09	(71.68	72.49)	63 g
Protein	76.52	(75.59	77.46)	75.86	(75.47	76.25)	94.5 g
Calcium	869.82	(860.40	879.24)	863.27	(859.34	867.20)	1240 mg
Magnesium	281.04	(278.10	283.98)	275.53	(274.24	276.83)	496.7 mg
Potassium	2593.94	(2569.38	2618.51)	2548.87	(2537.55	2560.20)	4673.3 mg
Fiber	16.52	(16.33	16.70)	16.02	(15.94	16.11)	30 g
n	915			4,737			

<sup>a</sup>Seemingly unrelated regression model with adjustment for age, gender, ethnicity, education level, income level, marital status, employment status, body mass index, diabetes, health insurance status, self-reported health status, family history of heart attack and diabetes, and NHANES survey period.

<sup>b</sup>Reference groups: Female, Age group of 20-29 years, Non-Hispanic White, Less than high school, Less than \$25,000 annual household income, Normal BMI, Excellent self-rated health status, and NHANES wave of 2007-2008.

<sup>c</sup>This table reports predictions and 95% confidence intervals based on estimates of SUR multivariate models. These predicted estimates describe the choice differentials as a function of hypertension diagnosis status.

Statistical significance of hypertension diagnosis: \* $P < 0.05$ , \*\* $P < 0.01$ , \*\*\* $P < 0.001$ .

Table 2-1. Demographic characteristics (mean (sd) or %) of adults aged 20-80 years with diagnosed hypertension participating in the National Health and Nutrition Examination Surveys (2007-2012) with valid dietary recall interviews<sup>a</sup>

Characteristic	Diagnosed hypertension	
DASH accordance score	2.61	(1.27)
DASH accordance level (%)	10.9%	(0.31)
<i>DASH nutrients</i>		
Total caloric intake	1862.53	(727.38)
Sodium	3213.87	(1429.80)
Cholesterol	278.23	(186.50)
Saturated fat	22.55	(12.66)
Total fat	72.48	(36.00)
Protein	76.09	(32.74)
Calcium	868.88	(461.57)
Magnesium	276.12	(117.30)
Potassium	2552.96	(1025.87)
Fiber	16.02	(8.47)
Age at diagnosis (Years)	47.60	(15.05)
Duration of hypertension (Years)	12.17	(11.52)
<i>Duration in years (%)</i>		
≥5	36.77%	(0.48)
6-10	21.53%	(0.41)
11-20	23.22%	(0.42)
21≤	18.48%	(0.39)
Male (%)	49.0%	(0.50)
<i>Age in years (%)</i>		
20-29	1.1%	(0.10)
30-39	4.6%	(0.21)
40-49	11.3%	(0.32)
50-64	35.3%	(0.48)
65-80	47.7%	(0.50)
<i>Ethnicity (%)</i>		
Non-Hispanic White	47.0%	(0.50)
Non-Hispanic Black	28.5%	(0.45)
Hispanic	19.3%	(0.39)
Other race	5.2%	(0.22)
<i>Education level (%)</i>		
<High school	31.6%	(0.47)
High school	24.9%	(0.43)
Some college	26.4%	(0.44)
College graduate	17.1%	(0.38)
<i>Income level (%)</i>		
<25,000	37.5%	(0.48)
25,000-44,999	24.6%	(0.43)
45,000-74,999	18.3%	(0.39)
≥75,000	19.5%	(0.40)
Married (%)	53.8%	(0.50)
Employed (%)	34.6%	(0.48)

Table 2-1 (cont.). Demographic characteristics (mean (sd) or %) of adults aged 20-80 years with diagnosed hypertension participating in the National Health and Nutrition Examination Surveys (2007-2012) with valid dietary recall interviews<sup>a</sup>

Characteristic	Diagnosed hypertension	
<i>Body Mass Index category</i>		
Underweight (<18.5)	0.9%	(0.09)
Normal (18.5-24.9)	16.5%	(0.37)
Overweight (25.0-29.9)	31.5%	(0.46)
Obese (≥30.0)	51.3%	(0.50)
Diabetes (%)	30.6%	(0.46)
Heart diseases (%)	23.8%	(0.43)
Health insurance (%)	88.3%	(0.32)
<i>Self-reported health (%)</i>		
Excellent	5.8%	(0.23)
Good	85.0%	(0.36)
Poor	9.2%	(0.29)
Status of speical diet (%)	21.5%	(0.41)
<i>NHANES survey period (%)</i>		
2007-2008	34.8%	(0.47)
2009-2010	36.2%	(0.48)
2011-2012	29.1%	(0.45)
n	4,751	

Table 2-2. Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) accordance and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	DASH accordance score	DASH accordance level	Sodium	Cholesterol	Saturated fat	Total fat
Age at hypertension diagnosis	0.00339* (0.00165)	0.000843* (0.000416)	-15.56*** (1.771)	-1.226*** (0.242)	-0.145*** (0.0159)	-0.387*** (0.0448)
Duration of hypertension	-0.224 (0.128)	-0.0654* (0.0321)	674.8*** (136.7)	59.17** (18.71)	7.304*** (1.224)	19.55*** (3.459)
<i>Duration (years)</i>						
≥5	-0.161 (0.127)	-0.0528 (0.0320)	600.0*** (136.4)	60.46** (18.66)	6.747*** (1.221)	17.85*** (3.450)
6-10	-0.184 (0.123)	-0.0459 (0.0309)	534.0*** (131.5)	57.34** (17.99)	6.209*** (1.177)	16.70*** (3.326)
11-20	-0.0600 (0.119)	-0.0242 (0.0299)	344.1** (127.3)	27.10 (17.41)	4.399*** (1.139)	10.81*** (3.219)
Prescribed medication for hypertension	-0.0346 (0.0500)	-0.00651 (0.0126)	-3.996 (53.62)	3.393 (7.336)	-0.717 (0.480)	-1.184 (1.356)
Smoking status	-0.271*** (0.0493)	-0.0403** (0.0124)	56.65 (52.85)	11.35 (7.230)	1.544** (0.473)	3.067* (1.337)
Physical activity	0.266*** (0.0442)	0.0503*** (0.0111)	7.344 (47.35)	-7.558 (6.478)	-1.038* (0.424)	-1.725 (1.198)

Table 2-2 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) adherence and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	DASH adherence score	DASH adherence level	Sodium	Cholesterol	Saturated fat	Total fat
Male	0.177*** (0.0372)	0.0248** (0.00935)	881.1*** (39.82)	98.71*** (5.448)	6.620*** (0.356)	20.16*** (1.007)
<i>Ethnicity</i>						
Non-Hispanic Black	-0.205*** (0.0439)	-0.0156 (0.0111)	-216.2*** (47.10)	18.49** (6.443)	-2.709*** (0.422)	-3.616** (1.191)
Hispanic	0.453*** (0.0501)	0.0703*** (0.0126)	-243.0*** (53.70)	7.257 (7.347)	-3.297*** (0.481)	-8.081*** (1.358)
Other race	0.208* (0.0818)	0.0249 (0.0206)	102.0 (87.62)	-18.68 (11.99)	-5.485*** (0.784)	-12.82*** (2.216)
<i>Education level</i>						
High school	-0.106* (0.0498)	-0.0292* (0.0125)	101.7 (53.36)	3.845 (7.301)	1.436** (0.478)	4.403** (1.350)
Some college	0.00399 (0.0499)	-0.0121 (0.0126)	181.7*** (53.48)	6.332 (7.316)	2.069*** (0.479)	6.042*** (1.353)
College graduate	0.179** (0.0608)	0.0241 (0.0153)	128.4* (65.19)	0.0722 (8.918)	1.494* (0.583)	5.376** (1.649)

Table 2-2 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) adherence and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	DASH adherence score	DASH adherence level	Sodium	Cholesterol	Saturated fat	Total fat
<i>Income level (\$)</i>						
25,000-44,999	-0.00577 (0.0481)	0.00402 (0.0121)	19.55 (51.53)	7.220 (7.050)	0.125 (0.461)	1.079 (1.303)
45,000-74,999	-0.0219 (0.0552)	0.000712 (0.0139)	110.6 (59.21)	20.30* (8.100)	1.020 (0.530)	4.125** (1.498)
≥75,000	0.0236 (0.0596)	-0.00964 (0.0150)	164.7** (63.92)	15.74 (8.745)	1.003 (0.572)	4.025* (1.617)
Married	0.0178 (0.0394)	0.00532 (0.00992)	-68.48 (42.22)	-11.95* (5.776)	-0.849* (0.378)	-1.679 (1.068)
Employed	-0.00572 (0.0432)	0.0138 (0.0109)	220.4*** (46.35)	8.940 (6.341)	1.269** (0.415)	5.612*** (1.172)
<i>Body Mass Index (BMI) category</i>						
Underweight (<18.5)	-0.298 (0.211)	-0.0814 (0.0531)	-218.0 (226.0)	-33.10 (30.92)	-1.591 (2.022)	-2.005 (5.716)

Table 2-2 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) accordancy and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	DASH accordancy score	DASH accordancy level	Sodium	Cholesterol	Saturated fat	Total fat
Overweight (25.0-29.9)	-0.0683 (0.0542)	-0.0283* (0.0136)	-18.35 (58.05)	0.537 (7.942)	0.241 (0.520)	0.848 (1.468)
Obese (≥ 30.0)	-0.156** (0.0526)	-0.0395** (0.0132)	129.4* (56.36)	19.25* (7.711)	1.112* (0.504)	3.117* (1.426)
Diabetes	-0.0649 (0.0421)	-0.0301** (0.0106)	30.20 (45.15)	11.66 (6.177)	-0.511 (0.404)	0.0371 (1.142)
Heart disease	-0.0765 (0.0464)	-0.0138 (0.0117)	-100.2* (49.73)	-6.755 (6.804)	-0.908* (0.445)	-2.493* (1.258)
Health insurance	-0.0672 (0.0554)	-0.0315* (0.0140)	40.84 (59.42)	3.054 (8.130)	1.209* (0.532)	2.825 (1.503)
<i>Self-reported health</i>						
Good	-0.0815 (0.0760)	-0.0113 (0.0191)	-110.3 (81.50)	-15.72 (11.15)	-0.534 (0.729)	-2.671 (2.061)
Poor	-0.0536 (0.0998)	-0.0149 (0.0251)	-146.3 (107.0)	-15.26 (14.64)	-0.172 (0.958)	-2.019 (2.706)

Table 2-2 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) accordance and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	DASH accordance score	DASH accordance level	Sodium	Cholesterol	Saturated fat	Total fat
<i>NHANES survey period</i>						
2009-2010	0.0530 (0.0421)	-0.00708 (0.0106)	181.9*** (45.09)	-3.515 (6.168)	0.0845 (0.404)	0.536 (1.140)
2011-2012	0.108* (0.0451)	-0.00891 (0.0114)	231.1*** (48.37)	0.105 (6.617)	0.559 (0.433)	2.785* (1.223)
Constant	2.703*** (0.159)	0.179*** (0.0401)	2761.7*** (170.6)	222.5*** (23.33)	20.24*** (1.526)	59.63*** (4.314)
n	4,751					

<sup>a</sup>Reference groups: Duration group of 21 years and longer, Female, Age group of 20-29 years, Non-Hispanic White, Less than high school, Less than \$25,000 annual household income, Normal BMI, Excellent self-rated health status, and NHANES wave of 2007-2008.

\*indicates statistical significance at the 5% level.

\*\*indicates statistical significance at the 1% level.

\*\*\*indicates statistical significance at the 0.1% level.

Table 2-2 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) accordance and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	Protein	Calcium	Magnesium	Potassium	Fiber
Age at hypertension diagnosis	-0.389*** (0.0404)	-3.766*** (0.596)	-0.356* (0.147)	-0.974 (1.288)	0.0230* (0.0109)
Duration of hypertension	16.48*** (3.119)	194.3*** (45.97)	9.173 (11.39)	-47.29 (99.43)	-1.026 (0.839)
<i>Duration (years)</i>					
≥5	15.07*** (3.111)	181.4*** (45.85)	12.32 (11.35)	-18.58 (99.17)	-0.918 (0.837)
6-10	13.79*** (2.999)	159.7*** (44.20)	13.31 (10.95)	4.696 (95.60)	-0.713 (0.807)
11-20	7.648** (2.903)	143.3*** (42.79)	2.791 (10.60)	-34.43 (92.54)	-0.636 (0.781)
Prescribed medication for hypertension	0.894 (1.223)	-43.19* (18.03)	-3.965 (4.465)	7.865 (38.99)	0.380 (0.329)
Smoking status	-0.619 (1.206)	-45.54* (17.77)	-6.795 (4.400)	-16.99 (38.43)	-1.810*** (0.324)
Physical activity	0.992 (1.080)	37.88* (15.92)	19.47*** (3.943)	127.9*** (34.43)	1.502*** (0.290)

Table 2-2 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) adherence and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	Protein	Calcium	Magnesium	Potassium	Fiber
Male	21.51*** (0.908)	149.1*** (13.39)	55.47*** (3.316)	520.0*** (28.96)	2.619*** (0.244)
<i>Ethnicity</i>					
Non-Hispanic Black	-3.377** (1.074)	-184.7*** (15.83)	-28.87*** (3.921)	-357.4*** (34.25)	-1.544*** (0.289)
Hispanic	0.980 (1.225)	-34.04 (18.05)	9.656* (4.471)	-34.71 (39.05)	1.968*** (0.329)
Other race	-3.479 (1.999)	-179.0*** (29.46)	-5.513 (7.295)	-191.7** (63.71)	0.795 (0.537)
<i>Education level</i>					
High school	1.790 (1.217)	30.76 (17.94)	14.04** (4.443)	121.8** (38.80)	0.358 (0.327)
Some college	3.029* (1.220)	61.69*** (17.98)	25.56*** (4.453)	204.1*** (38.89)	1.453*** (0.328)
College graduate	4.645** (1.487)	75.69*** (21.92)	39.42*** (5.428)	306.3*** (47.40)	2.681*** (0.400)

Table 2-2 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) adherence and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	Protein	Calcium	Magnesium	Potassium	Fiber
<i>Income level (\$)</i>					
25,000-44,999	1.558 (1.176)	-5.056 (17.33)	3.962 (4.291)	9.017 (37.47)	-0.0378 (0.316)
45,000-74,999	3.887** (1.351)	-1.398 (19.91)	13.85** (4.930)	69.39 (43.05)	0.371 (0.363)
≥75,000	3.906** (1.458)	36.91 (21.49)	17.95*** (5.322)	115.0* (46.48)	0.921* (0.392)
Married	-1.203 (0.963)	-34.86* (14.19)	-5.237 (3.515)	10.41 (30.70)	0.340 (0.259)
Employed	4.512*** (1.057)	12.84 (15.58)	12.69** (3.859)	108.1** (33.70)	0.470 (0.284)
<i>Body Mass Index (BMI) category</i>					
Underweight (<18.5)	-5.794 (5.155)	-134.8 (75.98)	-45.59* (18.82)	-370.0* (164.3)	-3.177* (1.386)
Overweight (25.0-29.9)	-0.585 (1.324)	8.668 (19.52)	-4.922 (4.833)	-20.78 (42.21)	-0.613 (0.356)

Table 2-2 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) accordance and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	Protein	Calcium	Magnesium	Potassium	Fiber
Obese ( $\geq 30.0$ )	1.850 (1.286)	11.29 (18.95)	-11.14* (4.693)	-37.01 (40.98)	-1.050** (0.346)
Diabetes	0.331 (1.030)	-20.81 (15.18)	-3.398 (3.759)	-40.91 (32.83)	0.171 (0.277)
Heart disease	-2.061 (1.134)	-38.97* (16.72)	-14.65*** (4.141)	-64.14 (36.16)	-0.773* (0.305)
Health insurance	0.979 (1.356)	39.09 (19.98)	4.629 (4.948)	30.80 (43.21)	-0.273 (0.365)
<i>Self-reported health</i>					
Good	-2.545 (1.859)	-12.19 (27.40)	-14.24* (6.785)	-165.7** (59.26)	-1.343** (0.500)
Poor	-4.149 (2.441)	2.186 (35.97)	-16.54 (8.908)	-251.1** (77.80)	-1.996** (0.656)
<i>NHANES survey period</i>					
2009-2010	1.709 (1.029)	70.71*** (15.16)	11.25** (3.754)	122.2*** (32.78)	0.509 (0.277)

Table 2-2 (cont.). Independent effect of each variable on Dietary Approaches to Stop Hypertension (DASH) accordance and nutrient intake using seemingly unrelated regression models among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	Protein	Calcium	Magnesium	Potassium	Fiber
2011-2012	3.472** (1.103)	82.25*** (16.26)	18.55*** (4.027)	155.1*** (35.17)	1.383*** (0.297)
Constant	65.35*** (3.891)	811.5*** (57.34)	248.3*** (14.20)	2333.4*** (124.0)	14.47*** (1.046)
n	4,751				

<sup>a</sup>Reference groups: Duration group of 21 years and longer, Female, Age group of 20-29 years, Non-Hispanic White, Less than high school, Less than \$25,000 annual household income, Normal BMI, Excellent self-rated health status, and NHANES wave of 2007-2008.

\*indicates statistical significance at the 5% level.

\*\*indicates statistical significance at the 1% level.

\*\*\*indicates statistical significance at the 0.1% level.

Table 2-3. Predicted mean Dietary Approaches to Stop Hypertension (DASH) accordance and nutrient intake among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012) based on the duration of hypertension<sup>a,b,c</sup>

Outcome variable	Duration ≤ 5 years	6 ≤ Duration ≤ 10 years	11 ≤ Duration ≤ 20 years	Duration ≥ 21 years	DASH diet
DASH accordance score	2.60 (2.59 2.62)	2.65 (2.63 2.67)	2.57 (2.55 2.59)	2.61 (2.59 2.63)	9 points
DASH accordance level	0.11 (0.10 0.11)	0.11 (0.11 0.12)	0.11 (0.10 0.11)	0.11 (0.11 0.12)	0.5
Sodium	3332.13 (3304.09 3360.18)	3228.65 (3191.55 3265.76)	3184.32 (3149.71 3218.93)	3092.73 (3055.48 3129.98)	2,300 mg
Cholesterol	282.36 (279.68 285.04)	284.07 (280.54 287.59)	285.19 (281.79 288.58)	265.58 (261.94 269.21)	149.1 mg
Saturated fat	24.11 (23.87 24.34)	23.34 (23.03 23.64)	23.19 (22.91 23.47)	22.26 (21.96 22.56)	14 g
Total fat	75.02 (74.34 75.70)	72.79 (71.88 73.69)	72.55 (71.72 73.39)	69.08 (68.17 69.98)	63 g
Protein	78.53 (77.88 79.19)	76.78 (75.91 77.65)	76.06 (75.25 76.87)	72.64 (71.76 73.53)	94.5 g
Calcium	892.56 (885.64 899.47)	874.70 (865.65 883.75)	852.67 (844.31 861.03)	848.12 (838.36 857.89)	1240 mg
Magnesium	280.72 (278.64 282.80)	280.91 (278.08 283.74)	277.82 (275.15 280.49)	264.99 (261.96 268.01)	496.7 mg
Potassium	2572.04 (2553.92 2590.16)	2586.38 (2561.68 2611.07)	2572.74 (2549.10 2596.38)	2501.85 (2474.39 2529.31)	4673.3 mg
Fiber	16.21 (16.07 16.34)	16.29 (16.11 16.46)	16.06 (15.88 16.23)	15.60 (15.41 15.79)	30 g
n	1,747	1,023	1,103	878	

<sup>a</sup>Seemingly unrelated regression model with adjustment for gender, ethnicity, education level, income level, marital status, employment status, body mass index, diabetes, health insurance status, self-reported health status, family history of heart attack and diabetes, and NHANES survey period.

<sup>b</sup>Reference groups: Duration group of 21 years and longer Female, Non-Hispanic White, Less than high school, Less than \$25,000 annual household income, Normal BMI, Excellent self-rated health status, and NHANES wave of 2007-2008.

<sup>c</sup>This table reports predictions and 95% confidence intervals based on estimates of SUR multivariate models. These predicted estimates describe the choice differentials as a function of the duration of hypertension. Statistical significance of the duration of hypertension: \* $P < 0.05$ , \*\* $P < 0.01$ , \*\*\* $P < 0.001$ .

Table 3-1. Sample characteristics by hypertension status (mean±sd or %): National Health and Nutrition Examination Surveys (2007-2012)

Characteristic	Undiagnosed hypertension		Diagnosed hypertension		p-value
Smoking status (%)					
Non-Smoker	53.9%	(0.50)	49.1%	(0.50)	0.005
Past-Smoker	26.3%	(0.44)	32.4%	(0.47)	0.001
Current-Smoker	19.9%	(0.40)	18.5%	(0.37)	0.316
Alcohol consumption (%)					
No consumption	35.1%	(0.48)	42.6%	(0.50)	<0.001
Moderate consumption	32.6%	(0.47)	32.7%	(0.47)	0.983
Binge consumption	32.2%	(0.47)	24.7%	(0.43)	<0.001
Physical activity (%)					
No physical activity	57.8%	(0.49)	63.4%	(0.48)	0.001
Physical activity (<150 minutes a week)	13.1%	(0.34)	13.9%	(0.35)	0.458
Physical activity (≥ 150 minutes a week)	29.2%	(0.46)	22.7%	(0.42)	<0.001
n	916		4,737		

Table 3-2. Independent effect of each independent variable on lifestyle behaviors (dependent variables) among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a,b</sup>

	Smoking (Yes/No)		Alcohol consumption (Yes/No)		Physical activity (PA) (Yes/No)	
	Past-smoker	Current-smoker	Moderate consumption	Excessive consumption	PA < 150 minutes	PA ≥ 150 minutes
Diagnostic status of hypertension	0.233* (0.0945)	0.195 (0.116)	0.0203 (0.0984)	-0.167 (0.105)	0.0893 (0.120)	-0.0635 (0.0954)
<i>Smoking status</i>						
Past-smoker			0.470*** (0.0793)	0.855*** (0.0927)	0.123 (0.0976)	0.0140 (0.0820)
Current-smoker			0.361** (0.110)	1.415*** (0.106)	-0.167 (0.123)	-0.758*** (0.112)
<i>Alcohol consumption</i>						
Moderate	0.483*** (0.0793)	0.360** (0.110)			0.239* (0.101)	0.340*** (0.0869)
Excessive	0.865*** (0.0931)	1.405*** (0.107)			0.108 (0.114)	0.324*** (0.0975)
<i>Physical activity</i>						
< 150 minutes	0.126 (0.0975)	-0.145 (0.125)	0.256* (0.101)	0.127 (0.115)		
≥ 150 minutes	0.00763 (0.0821)	-0.766*** (0.115)	0.335*** (0.0869)	0.307** (0.0974)		

Table 3-2 (cont.). Independent effect of each independent variable on lifestyle behaviors (dependent variables) among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a,b</sup>

	Smoking (Yes/No)		Alcohol consumption (Yes/No)		Physical activity (PA) (Yes/No)	
	Past-smoker	Current-smoker	Moderate consumption	Excessive consumption	PA < 150 minutes	PA ≥ 150 minutes
Status of special diet	-0.0568 (0.0838)	-0.605*** (0.121)	-0.120 (0.0889)	-0.176 (0.101)	0.447*** (0.103)	0.273** (0.0933)
Male	0.889*** (0.0695)	0.767*** (0.0874)	0.570*** (0.0728)	0.393*** (0.0796)	-0.0837 (0.0876)	0.418*** (0.0751)
<i>Age (Years)</i>						
30-39	0.422 (0.277)	0.509* (0.221)	0.00248 (0.272)	-0.462* (0.235)	-0.00822 (0.279)	-0.620** (0.206)
40-49	0.704** (0.261)	0.240 (0.213)	-0.0673 (0.259)	-0.569* (0.223)	-0.462 (0.269)	-1.330*** (0.199)
50-64	1.270*** (0.248)	0.0369 (0.204)	0.136 (0.245)	-1.021*** (0.213)	-0.415 (0.256)	-1.326*** (0.187)
65-80	1.670*** (0.253)	-1.086*** (0.221)	-0.182 (0.250)	-2.058*** (0.224)	-0.800** (0.268)	-1.681*** (0.199)

Table 3-2 (cont.). Independent effect of each independent variable on lifestyle behaviors (dependent variables) among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a,b</sup>

	Smoking (Yes/No)		Alcohol consumption (Yes/No)		Physical activity (PA) (Yes/No)	
	Past-smoker	Current-smoker	Moderate consumption	Excessive consumption	PA < 150 minutes	PA ≥ 150 minutes
<i>Ethnicity</i>						
Non-Hispanic Black	-0.459*** (0.0849)	-0.105 (0.0999)	-0.214* (0.0869)	-0.0582 (0.0952)	0.0478 (0.104)	-0.0234 (0.0901)
Hispanic	-0.353** (0.109)	-0.431** (0.142)	-0.247* (0.120)	0.567*** (0.123)	-0.216 (0.142)	-0.133 (0.118)
Other race	-0.168 (0.167)	0.0110 (0.214)	-0.657*** (0.167)	-0.952*** (0.207)	0.143 (0.200)	0.0942 (0.173)
<i>Education level</i>						
High school	-0.287** (0.0941)	-0.329** (0.111)	0.389*** (0.0984)	0.100 (0.104)	0.457*** (0.122)	0.500*** (0.108)
Some college	0.0590 (0.0944)	-0.221 (0.115)	0.734*** (0.0981)	0.136 (0.106)	0.593*** (0.122)	0.859*** (0.106)
College graduate	-0.347** (0.112)	-1.057*** (0.163)	1.084*** (0.117)	0.288* (0.135)	1.047*** (0.140)	1.330*** (0.120)

Table 3-2 (cont.). Independent effect of each independent variable on lifestyle behaviors (dependent variables) among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a,b</sup>

	Smoking (Yes/No)		Alcohol consumption (Yes/No)		Physical activity (PA) (Yes/No)	
	Past-smoker	Current-smoker	Moderate consumption	Excessive consumption	PA < 150 minutes	PA ≥ 150 minutes
<i>Income level (\$)</i>						
25,000-44,999	0.135 (0.0892)	-0.112 (0.108)	0.211* (0.0921)	0.167 (0.101)	0.148 (0.113)	0.149 (0.0994)
45,000-74,999	-0.103 (0.102)	-0.586*** (0.131)	0.594*** (0.105)	0.517*** (0.117)	0.0627 (0.129)	0.269* (0.108)
≥75,000	-0.0164 (0.108)	-0.792*** (0.146)	0.855*** (0.114)	0.724*** (0.128)	0.146 (0.137)	0.418*** (0.114)
Married	0.0480 (0.0719)	-0.410*** (0.0899)	-0.175* (0.0756)	-0.280*** (0.0828)	0.0318 (0.0912)	-0.0468 (0.0778)
Employed	-0.247** (0.0820)	-0.278** (0.0998)	0.238** (0.0847)	0.312*** (0.0901)	0.127 (0.0999)	-0.214* (0.0856)
<i>Body Mass Index (BMI) category</i>						
Underweight (<18.5)	0.245 (0.408)	0.562 (0.382)	-0.243 (0.387)	0.0139 (0.370)	0.128 (0.393)	-1.244* (0.558)
Overweight (25.0-29.9)	-0.0248 (0.0972)	-0.623*** (0.116)	-0.0963 (0.0989)	-0.0458 (0.114)	-0.227 (0.119)	-0.115 (0.0995)
Obese (≥ 30.0)	0.103 (0.0953)	-1.048*** (0.114)	-0.195* (0.0974)	-0.111 (0.110)	-0.433*** (0.116)	-0.584*** (0.0998)

Table 3-2 (cont.). Independent effect of each independent variable on lifestyle behaviors (dependent variables) among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a,b</sup>

	Smoking (Yes/No)		Alcohol consumption (Yes/No)		Physical activity (PA) (Yes/No)	
	Past-smoker	Current-smoker	Moderate consumption	Excessive consumption	PA < 150 minutes	PA ≥ 150 minutes
Diabetes	0.102 (0.0797)	0.0672 (0.107)	-0.281*** (0.0835)	-0.457*** (0.0963)	-0.0639 (0.104)	-0.227* (0.0930)
Heart disease	0.233** (0.0870)	0.580*** (0.114)	-0.0562 (0.0899)	-0.352** (0.110)	-0.158 (0.117)	-0.252* (0.103)
Health insurance	-0.00167 (0.110)	-0.0489 (0.113)	0.101 (0.113)	0.0346 (0.107)	0.278* (0.133)	-0.0416 (0.108)
<i>Self-reported health</i>						
Good	0.346** (0.129)	0.328 (0.185)	-0.178 (0.135)	0.00188 (0.160)	-0.439** (0.164)	-0.854*** (0.127)
Poor	0.642*** (0.185)	0.762** (0.236)	-0.708*** (0.198)	-0.308 (0.214)	-1.339*** (0.265)	-2.013*** (0.242)
<i>NHANES survey period</i>						
2009-2010	-0.00851 (0.0770)	-0.0375 (0.0988)	0.215** (0.0806)	0.335*** (0.0898)	-0.0140 (0.0973)	0.147 (0.0839)
2011-2012	0.00799 (0.0829)	-0.0499 (0.104)	0.132 (0.0866)	0.328*** (0.0957)	-0.0133 (0.104)	0.211* (0.0889)

Table 3-2 (cont.). Independent effect of each independent variable on lifestyle behaviors (dependent variables) among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a,b</sup>

	Smoking (Yes/No)		Alcohol consumption (Yes/No)		Physical activity (PA) (Yes/No)	
	Past-smoker	Current-smoker	Moderate consumption	Excessive consumption	PA < 150 minutes	PA ≥ 150 minutes
Constant	-3.186*** (0.332)	-1.015** (0.348)	-1.122*** (0.333)	-0.492 (0.327)	-1.028** (0.376)	0.660* (0.291)
n	5,539					

<sup>a</sup>Base groups: Non-smokers, No alcohol consumption, and No physical activity.

<sup>b</sup>Reference groups: Female, Age group of 20-29 years, Non-Hispanic White, Less than high school, Less than \$25,000 annual household income, Normal BMI, Excellent self-rated health status, and NHANES wave of 2007-2008.

\*indicates statistical significance at the 5% level.

\*\*indicates statistical significance at the 1% level.

\*\*\*indicates statistical significance at the 0.1% level.

Table 3-3. Relative risk ratio (RRR) of each independent variable on lifestyle behaviors (dependent variables) among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	Smoking (Yes/No)		Alcohol consumption (Yes/No)		Physical activity (PA) (Yes/No)	
	Past-smoker	Current-smoker	Moderate consumption	Excessive consumption	PA < 150 minutes	PA ≥ 150 minutes
Diagnostic status of hypertension	1.262	1.215	1.021	0.846	1.093	0.939
<i>Smoking status</i>						
Past-smoker			1.600	2.351	1.130	1.014
Current-smoker			1.434	4.115	0.846	0.469
<i>Alcohol consumption</i>						
Moderate consumption	1.621	1.433			1.270	1.404
Excessive consumption	2.374	4.076			1.115	1.383
<i>Physical activity</i>						
PA < 150 minutes	1.134	0.865	1.292	1.136		
PA ≥ 150 minutes	1.008	0.465	1.399	1.359		
Status of special diet	0.945	0.546	0.887	0.839	1.564	1.314
Male	2.433	2.153	1.768	1.481	0.920	1.519
<i>Age (Years)</i>						
30-39	1.525	1.663	1.002	0.630	0.992	0.538
40-49	2.023	1.272	0.935	0.566	0.630	0.264
50-64	3.560	1.038	1.146	0.360	0.660	0.266
65-80	5.310	0.337	0.834	0.128	0.449	0.186

Table 3-3(cont.). Relative risk ratio (RRR) of each independent variable on lifestyle behaviors (dependent variables) among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	Smoking (Yes/No)		Alcohol consumption (Yes/No)		Physical activity (PA) (Yes/No)	
	Past-smoker	Current-smoker	Moderate consumption	Excessive consumption	PA < 150 minutes	PA ≥ 150 minutes
<i>Ethnicity</i>						
Non-Hispanic Black	0.632	0.900	0.807	0.943	1.049	0.977
Hispanic	0.702	0.650	0.781	1.763	0.806	0.876
Other race	0.845	1.011	0.518	0.386	1.153	1.099
<i>Education level</i>						
High school	0.751	0.720	1.475	1.105	1.580	1.648
Some college	1.061	0.802	2.083	1.146	1.809	2.361
College graduate	0.707	0.348	2.955	1.334	2.850	3.781
<i>Income level (\$)</i>						
25,000-44,999	1.145	0.894	1.235	1.181	1.159	1.160
45,000-74,999	0.902	0.557	1.812	1.676	1.065	1.308
≥75,000	0.984	0.453	2.351	2.063	1.157	1.519
Married	1.049	0.664	0.839	0.756	1.032	0.954
Employed	0.781	0.757	1.269	1.367	1.135	0.808
<i>Body Mass Index (BMI) category</i>						
Underweight (<18.5)	1.277	1.753	0.784	1.014	1.136	0.288
Overweight (25.0-29.9)	0.975	0.536	0.908	0.955	0.797	0.891
Obese (≥30.0)	1.108	0.351	0.823	0.895	0.648	0.558

Table 3-3(cont.). Relative risk ratio (RRR) of each independent variable on lifestyle behaviors (dependent variables) among adults aged 20-80 years participating in the National Health and Nutrition Examination Surveys (2007-2012)<sup>a</sup>

	Smoking (Yes/No)		Alcohol consumption (Yes/No)		Physical activity (PA) (Yes/No)	
	Past-smoker	Current-smoker	Moderate consumption	Excessive consumption	PA < 150 minutes	PA ≥ 150 minutes
Diabetes	1.107	1.070	0.755	0.633	0.938	0.797
Heart disease	1.263	1.786	0.945	0.703	0.854	0.777
Health insurance	0.998	0.952	1.106	1.035	1.321	0.959
Self-reported health						
Good	1.413	1.388	0.837	1.002	0.645	0.426
Poor	1.900	2.143	0.493	0.735	0.262	0.134
<i>NHANES survey period</i>						
2009-2010	0.992	0.963	1.240	1.398	0.986	1.158
2011-2012	1.008	0.951	1.141	1.388	0.987	1.235
n				5,539		

<sup>a</sup>Base groups: Non-smokers, No alcohol consumption, and No physical activity.