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Beverage Consumption and Hypertension: Findings from the Third National Health and Nutrition Examination Survey.

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ABSTRACT

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The study sample was comprised of 18,953 subjects aged 18 years and older who participated in the Third National Health and Nutrition Examination Survey. Preference for diet soda over regular soda was higher in females as compared to males and in Caucasians as compared to other races. Mean alcohol consumption was almost three times higher in males than in females. Undiagnosed hypertension was more common in males than in females, in 65-90 than in 50-64 year olds, and in people with less than high school education compared to those with higher education. Diastolic pressure was correlated with the level of consumption of diet soda, coffee, tea, and alcohol. Diet soda and alcohol consumption had a statistically significant positive relationship with hypertension even after adjusting for demographic variables and body mass index. The study provides useful information of the patterns of beverage uses and the prevalence of hypertension in the United States.

DEDICATION

I dedicate this thesis to my family for their continuing love and support.

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First of all, I want to thank God for providing in me the dedication and strength to fulfill my dreams. I would like to thank Dr. Tiejian Wu, my advisor, for his continuous help in all my endeavors, without him this marathon task would not have been completed. I also would like to thank Dr. James Anderson, who helped me understand the basics of epidemiological methods and aroused my interest for epidemiological research. I also would like to thank Dr. James Florence for his valuable suggestions. My special thanks go to Dr. Tim Aldrich who made me aware about the interesting world of statistical tests. And last but not the least; I really appreciate the help and support of my beloved friends Bhavesh, Bhavik, Nishant, and Munaf.

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CHAPTER 1

INTRODUCTION

Problem Statement

Hypertension in the U.S. and worldwide has become a major public health concern. Currently, in the U.S. around 30% of the population is hypertensive (National Center for Health Statistics, 2006), while the prevalence of hypertension has been rising over time. Obesity has been linked with hypertension and the rise in the prevalence of obesity is thought to be contributing largely to the rise in the prevalence of hypertension (The Trials of Hypertension Prevention Collaborative Research Group, 1997).

In the U.S., the rise in the consumption of sugar sweetened drinks including soft drinks is thought to be responsible for the rise in the prevalence of obesity and overweight. Though its relationship with obesity is identified in many studies (Liebman et al., 2003; Schulze et al., 2004), the relationship between consumption of soft drinks such as regular and diet soda and hypertension has been rarely studied.

Tea is considered to help reduce blood pressure especially when consumed in moderate amounts (Stensvold et al., 1992). A number of studies found this relationship but some other studies did not. Caffeine present in coffee is claimed to increase blood pressure, but many studies failed to demonstrate a significant correlation especially in the amount consumed usually by Americans (Winkelmayer et al., 2006). Alcohol was found to be associated with an increased risk of hypertension and a reduction in alcohol consumption was shown to reduce blood pressure in hypertensive persons (Miller et al., 2005).

In short, there are still many unanswered questions regarding the relationship between beverage consumption and hypertension. For example, many of the studies performed have attempted to determine whether a relationship exists between hypertension and one type of beverage use, but no study has examined the relationship of hypertension with the simultaneous use of different beverage consumptions including tea, alcohol, coffee, and sweet beverages.

The Third National Health and Nutrition Examination Survey (NHANES III) provides a great dataset for the purpose of examining the relationship between beverage consumption and hypertension. The advantages of NHANES III include a large sample, clearly defined variables, and a national sample with over sampling from low-income persons, persons 60+ years of age, African Americans, and Mexican Americans.

Study Purposes and Research Hypotheses

One study aim was to describe the prevalence of overall hypertension, the prevalence of diagnosed and undiagnosed hypertension, and the status of blood pressure control in hypertensive patients. In this study, the author planned to examine the prevalence of hypertension in different groups defined by gender, race/ethnicity, age, education, and income levels. Similarly, prevalence of beverage use in the U.S. population was also examined.

The second study aim was to examine the relationships between different beverage uses and hypertension. Various types of beverages were analyzed separately and simultaneously to assess their relationships with hypertension.

Specifically, we propose to test the following hypotheses on the relationships between beverage uses and hypertension/blood pressure:

1. Increased consumption of soft drinks (regular and or diet soda) is associated with an increased risk of hypertension.
2. Blood pressure increases as the amount of soft drink consumption increases.
3. Increased consumption of alcohol is associated with an increased risk of hypertension.
4. Blood pressure increases as the amount of alcohol consumption increases.
5. Increased consumption of coffee is associated with an increased risk of hypertension.
6. Blood pressure increases as the amount of coffee consumption increases.
7. Increased consumption of tea is associated with a decreased risk of hypertension.
8. Blood pressure decreases as the amount of tea consumption increases.

Significance of the Study

Hypertension prevalence in the United States has increased during the past 2 decades. Beverage consumption may have played an important role in the trend of increased hypertension. Using a national sample, this study was intended to describe beverage consumption and hypertension status in the United States and examined the relationship between them. The large sample size and the rich data of NHANES III allowed performing a comprehensive analysis for participants as a whole and for sub-groups as defined by gender, race/ethnicity, and age. Patterns of beverage use are changing in the United States as people become more and more aware of their potential

health risks. Therefore, findings of this study would be very useful to the development of public health strategies related to beverage use and for hypertension prevention.

CHAPTER 2

LITERATURE REVIEW

Epidemiology of Hypertension

Hypertension, defined as elevated blood pressure or taking antihypertensive medications, is common in the United States with an overall age-adjusted prevalence of 29.7% in 2001-2004 for those 20 years and older. The prevalence of hypertension increases with age, is higher in women than in men, and higher in African Americans than in Caucasians. For 2001-2004, prevalence of hypertension was 30% of men and 33% of women age 45–54 years as compared to 69% of men and 82% of women age 75 years and over. The highest prevalence was in African American females (44.7%) followed by African American males (41.6%). From 1988-1994 to 2001-2004 prevalence of hypertension in males increased from 23.4% to 24.4% while females had an even greater increase from 20.0% to 26.0% (National Center for Health Statistics, 2006).

The time trend of hypertension prevalence in persons 20 to 74 years has had a variable course. Prevalence for 1960-1962 was 38.1%, followed by an increase to 39.8% for 1971-1974, a marked decrease to 23.9% for 1988-1994, and then an increase to 28.7% for 1999-2000 (National Center for Health Statistics, 2003).

Etiology and Risk factors for Hypertension

Most hypertension (92%-94%) is categorized as essential hypertension (also called primary or idiopathic hypertension). Essential hypertension is defined as cases that have no specific underlying identifiable cause. A number of environmental factors have been implicated in the development of hypertension, including salt intake, obesity, occupation, alcohol intake, family size, and crowding. It has been assumed these factors are important for the increase in blood pressure associated with age that occurs in more affluent societies as compared to the decline in blood pressure with age in less affluent groups. Insulin resistance and/or hyperinsulinemia have been suggested as being responsible for the increased arterial pressure in some patients with hypertension. Hypertension is one of the most common complex genetic disorders, with genetic heritability averaging around 30% (Kasper et al., 2005).

Several factors including age, race, sex, smoking, alcohol intake, serum cholesterol, glucose intolerance, and weight may alter the prognosis of this disease once the hypertension is developed. A positive correlation exists between obesity and arterial pressure. A gain in weight is associated with an increased risk of hypertension in persons with previously normal blood pressure, and weight loss in obese persons with hypertension lowers their arterial pressure. Several factors are associated with adverse outcomes in the hypertensive patient, including smoking and diabetes. The avoidance of them is beneficial to improve the quality of life and survival of a hypertensive patient (Kasper et al., 2005).

Patho-physiology of Hypertension

The main effect of hypertension is on blood vessels. The rise in the pressure unduly stretches the wall of blood vessels and makes them stiff in the long run. It also damages the inside of an arterial wall and leads to accelerated atherosclerosis in conjugation with other factors. (Kasper et al., 2005). This atherosclerosis may lead to coronary heart disease, cerebral vascular disease, peripheral arterial disease and can affect almost every organ of body. The heart has to work more in order to pump the blood through the stiff arterial tree, which ultimately leads to heart failure. This increase in work load, in addition to a reduction in blood supply, leads to an imbalance between supply and demand of nutrients to the heart, which can lead to a heart attack (Kasper et al., 2005).

Other organs are also affected, mainly because of damage to blood vessels. The blood vessels in the retina and central nervous system respond by a reduction in their lumen over time. The smaller stiff vessels may bleed in response to a rise in blood pressure and that leads to a loss of sight and stroke respectively (Kasper et al., 2005).

Arteriosclerotic lesions of the afferent and efferent arterioles and the glomerular capillary tufts are the most common renal vascular lesions in hypertension and result in a decreased glomerular filtration rate and tubular dysfunction. Proteinuria and microscopic hematuria occur because of glomerular lesions, and around 10% of the deaths caused by hypertension result from renal failure (Kasper et al., 2005).

Epidemiology of Overweight and Obesity

Among adults 20–74 years of age, overweight and obesity rates have increased since 1960–1962. These increases are driven largely by increases in the percentage of adults who are obese. From 1960–1962 through 2003–2004, the percentage of adults who are overweight but not obese has remained steady at 32%–34% (age adjusted). During that time period, the percentage of obese adults has increased from 13% to 34% (age adjusted). In 2001–2004, 30% of men and 34% of women 20–74 years of age were obese (age adjusted). The prevalence of obesity among women differed significantly by racial and ethnic group. In 2001–2004, one half of non-Hispanic black women were obese, compared with nearly one third of non-Hispanic white women. In contrast, the prevalence of obesity among men was similar by race and ethnicity (National Center for Health Statistics, 2006).

Beverage Consumption

From 1977 to 2001 for all age groups, sweetened beverage consumption and energy intake from sweetened beverages was increased (Nielsen and Popkin, 2005). Over the period from the late 1970s to mid 1990s, soda consumption has doubled such that teens are now drinking twice as many ounces of soda per day as they do milk (Moore, Rolls, Mennella, & Devaney, 2004). Apart from their possible role in the development of obesity and hypertension, the soda pops have other harmful effects. In adults with diabetes who had one or more drinks of diet soda per day, HbA (1c) level was 0.7 units greater compared with those who drank none (Mackenzie, Brooks, & O'Connor, 2006). Soda pop at meals increases dental caries in children (Marshall et al., 2005). Portion sizes

of commercial energy-dense foods and beverages, and fast food meals rich in fat and/or added sugars increased over time, and in particular in the last 10 years, with a sharp increase of more than 50% in the sales of sugar-sweetened soft drinks (Matthiessen et al., 2003).

Higher caffeine consumption is thought to be associated with higher risk of hypertension. It has been linked with cardiovascular mortality. Major sources of caffeine for Americans are coffee (71%), soft drinks (16%), and tea (12%). Coffee is the major source of caffeine in the diets of adults, whereas soft drinks are the primary source for children and teens (Frary et al., 2005). Although mean caffeine intakes from coffee, tea, and soft drinks in the U.S. population are within recommended safe levels, heavy caffeine consumers might benefit from dietary advice for a reduction in consumption of these drinks (Knight et al., 2004).

In 2003 among current drinkers age 18 years and over, 40% of men and 20% of women reported drinking five or more alcoholic drinks on at least 1 day in the past year (age adjusted). This level of alcohol consumption was most common among young adults 18–24 years of age. Nearly 60% of young men and 42% of young women consumed five or more alcoholic drinks during such a day (National Center for Health Statistics, 2003).

The Obesity Epidemic and Its Relation to Soda Drinking

The U.S. is facing an obesity epidemic and changing patterns of food consumption, such as rising carbohydrate intake particularly in the form of soda and other foods containing high fructose corn syrup, contributes to obesity (Morrill, and Chinn,

2004). Change in food patterns, along with reduction in physical activity, is a major contributing factor for obesity in adults and children.

A lot of attention has recently been given to the effect of soda drinking on childhood obesity, and the studies have shown a positive relationship between soda drinking and childhood obesity (James et al., 2001). Increasing soda consumption predicted the greatest increase of BMI in girls 9-19 years of age (Striegel-Moore et al., 2006). Consumption of sugar-added beverages may contribute to weight gain among adolescents, probably due to their contribution to total energy intake because adjustment for calories greatly attenuated the estimated associations (Berkey et al., 2004). Research is needed to determine whether these results apply to the adult population because there are significant differences between the food pattern, activity level, and metabolism of adults and children.

Increased likelihood of overweight or obesity was associated with greater frequency of drinking sweetened beverages such as soft drinks/soda pop and ordering super sized portions (Liebman et al., 2003). In the persons who had already gained weight, an increased consumption of sugar-sweetened soft drinks was associated with a higher risk of additional subsequent weight gain (Bes-Rastrollo et al., 2006). Weight gain over a 4-year period was highest among women who increased their sugar-sweetened soft drink consumption from one or fewer drinks per week to one or more drinks per day (multivariate-adjusted means, 4.69 kg for 1991 to 1995 and 4.20 kg for 1995 to 1999) and was smallest among women who decreased their intake (Schulze et al., 2004). Contradictorily, one recent cohort study showed that there is no correlation between

consumption of regular soda drinks and obesity, but there is positive correlation between diet soda drink consumption and obesity (Sansom, 2005).

Hypertension: Is Soda Drinking an Independent Cause?

Obesity is recognized as an independent risk factor for hypertension (The Trials of Hypertension Prevention Collaborative Research Group, 1997; He et al., 2000). The JNC-7 (Joint National Committee-7) report recommends the use of lifestyle modification including weight reduction for those who are obese or overweight for prevention of hypertension and for treatment of hypertension apart from anti-hypertensive medication (Lenfant et al., 2003).

Soda drinking may be one of the risk factors for obesity. Soda drinking can directly increase hypertension risk by its solute load, as studies have shown that high amounts of solutes such as sodium in the diet is positively associated with hypertension (Chobanian & Hill, 2000; He et al., 2000). The JNC-7 report recommends the use of lifestyle modification including the salt restriction for the treatment of hypertension (Lenfant et al., 2003). One concern is for the caffeine present in some soft drinks that can also raise blood pressure. (Bichler, Swenson, & Harris, 2006). One recent study done on caffeinated beverages showed that consumption of cola beverages was associated with an increased risk of hypertension, independent of whether it was sugared or diet cola (Winkelmayer et al., 2006).

Association Between Coffee and Hypertension:

The association between hypertension and coffee consumption is controversial. Prospective studies to date have examined the influence of coffee intake on the risk of hypertension development, which present conflicting findings. A study done by Winkelmayer et al., (2006) demonstrated no relationship between coffee intake and incident hypertension in 155,594 US women followed over a period of 12 years. However, in a cohort of 1,017 men followed over a period of 33 years, coffee drinkers had a greater incidence of hypertension in unadjusted analyses and consumption of one cup of coffee significantly raised systolic and diastolic BP by 0.19 and 0.27 mm Hg, respectively, in adjusted models (Knight et al., 2004). Coffee abstainers at baseline had a lower risk of hypertension than did those with a coffee intake of >0-3 cups/d (Uiterwaal et al., 2007). Recent meta-analyses that have examined the influence of coffee and caffeine intake on blood pressure from randomized controlled trials (RCTs) also present conflicting findings. In an analysis of 11 trials, the blood pressure increasing effects of coffee were estimated as 2.4 and 1.2 mm Hg for systolic and diastolic BP, respectively, compared with the non-coffee groups (Jee et al., 1999), which contrasts with smaller effects of 1.22 and 0.49 mm Hg in a larger meta-analysis of 16 studies (Noordzij et al., 2005). Caffeine consumption exhibited a U-shaped mortality curve. Moderate caffeine consumers had a significantly reduced risk of death (for 200-399 mg/day compared with those consuming <50 mg/day). Individuals who drank more than 1 can/week of artificially sweetened (but not sugar-sweetened) soft drink (cola and other) had an 8% increased risk (Paganini-Hill, Kawas, & Corrada, 2006).

Measuring coffee instead of caffeine intake may contribute to a lack of positive findings in studies of coffee as a risk factor for disease occurrence (Brown et al., 2001). There is no clear evidence for a causal relationship between caffeinated coffee and hypertension. Coffee intake appears to have small effects on BP in short-term intervention trials, which may reduce with habitual intake (Hamer, 2006).

Thus, while consumption of coffee was not found to be associated with the development of hypertension in one study (Winkelmayer et al., 2006), it was found to increase blood pressure in another study (Klag et al., 2002), and it was found to reduce mortality in another (Paganini-Hill et al., 2006). The definite relationship between coffee consumption and hypertension is still lacking, and studies are needed to examine the relationship.

Association Between Alcohol and Hypertension

Reducing excessive alcohol intake can produce an average 4 mm Hg reduction in blood pressure (Kodavali & Townsend, 2006). Heavy alcohol consumption (three or more standard drinks per day) is associated with and predictive of hypertension and reduction in alcohol consumption is associated with a significant dose-dependent lowering of mean systolic and diastolic blood pressure (Miller et al., 2005). The measured attributable risk for hypertensive disease from alcohol is 16%. The increase in blood pressure is approximately 1 mmHg for each 10 g alcohol consumed and is largely reversible within 2-4 weeks of abstinence or a substantial reduction in alcohol intake. This increase in blood pressure occurs irrespective of the type of alcoholic beverage. In particular, the postulated effects of vasodilator flavonoid components of red wine to

lessen or reverse alcohol-related hypertension have not been observed in intervention studies (Puddey & Beilin, 2006). Moderate consumption of alcohol, especially red wine, is considered to reduce cardiovascular mortality, but consumption of alcohol beyond certain levels (10-20 gm in males and 10 gm in females) is not recommended.

Association Between Tea and Hypertension

One study found an inverse relationship between tea consumption and hypertension and cholesterol levels. Mean serum cholesterol decreased with increasing tea consumption, the linear trend coefficient corresponded to a difference of 0.24 mmol/liter (9.3 mg/dl) in men and 0.15 mmol/liter (5.8 mg/dl) in women between drinkers of less than one cup and those of five or more cups/day, when other risk factors were taken into account. Systolic blood pressure was inversely related to tea, with a difference between the same two tea groups of 2.1 mm in men and 3.5 mm in women (Stensvold et al., 1992).

Conclusion

Although the relationship between beverage consumption and hypertension has been examined in previous studies, many aspects of the relationships remain uncertain. Furthermore, consumption of the different types of beverage could be correlated with hypertension and assessment of their relationships with hypertension has not been conducted simultaneously. In addition, the relationship between beverage use and hypertension among specific groups such as African Americans, who have a higher risk for hypertension, may need more research attention.

CHAPTER 3

METHODOLOGY

Data Source

National Health and Nutrition Examination Survey (NHANES) has been conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention. The NHANES target population is the civilian, non-institutionalized U.S. population. The Third National Health and Nutrition Examination Survey (NHANES III), 1988-94, collected data for 33,994 persons ages 2 months and older who participated in the survey, using a stratified, multistage probability sampling design. In NHANES III, 39,695 persons were selected over the 6-years with over-sampling of youths, seniors, and minorities. Of those, 33,994 (86%) were interviewed in their homes. All interviewed persons were invited to the Mobile Examination Center (MEC) for a medical examination. Seventy-eight percent (30,818) of the selected persons were examined in the MEC, and an additional 493 persons were given a special, limited examination in their homes.

NHANES III data are available for public use from the website at the National Center for Health Statistic, at the Centers for Disease Control and Prevention. Besides data, the following information is available: personal questionnaire used to collect the data, description of physical examination and laboratory tests, description of how the summary variables were computed, extensive documentation of study procedures, data collection forms, and a full variable dictionary, linking each variable to the form it came from and to the data set where it can be found.

Selection of the Study Sample

Adult participants (n=19,618) of NHANES III (18 years and older) were included in the study. The study sample was then restricted to persons who responded to the following question, "Doctor ever told had hypertension/HBP" (n= 19,426). After that, those persons whose blood pressure was measured were chosen (n= 19,052). Five observations of diastolic blood pressure were less than 20 and a value that was found to be unrealistic. Those extreme observations were excluded. At last, we limited the study sample to people who responded to all the questions on beverage consumption including soda, coffee, tea, and alcohol (n= 18,953). All of the analyses were based on this final sample.

Study Variables

Table 1 show the variables analyzed in this study.

Table 1

Study Variables

Outcome variables	Exposure variables	Other variables	Demographic variables
Self reported hypertension	Diet soda consumption	Weight status	Age
High blood pressure	Regular soda consumption	BMI	Gender
Hypertension	Total soda consumption		Race
Systolic blood pressure (mm Hg)	Coffee consumption		Ethnicity
Diastolic blood pressure (mm Hg)	Tea consumption		Education
	Alcohol consumption		

Outcome Variables:

Blood Pressure and Hypertension

In NHANES III, blood pressure and pulse were measured by trained technicians/examiners. Three sets of blood pressure measurements were taken in the examination center on examinees aged 5-years and over. Blood pressure measurements were also taken by trained interviewers during the household interview on sample persons aged 17-years and over. Both physicians and interviewers took measurements using a mercury sphygmomanometer according to the standardized blood pressure measurement protocols recommended by the American Heart Association. Systolic blood pressure was recorded as K1 and diastolic blood pressure was recorded as K5. Taking anti-hypertension medication was determined by response to the question, "Now taking prescribed medicine for HBP". In this analysis, hypertension was defined as an average BP ≥140/90 mm Hg or if the participant was taking antihypertensive medications.

When blood pressure measurement data were edited, and it was discovered that examinees aged 20 years and over were missing one of a K1/K5 pair of blood pressure measurements, the remaining one was labeled "Blank but applicable;" there were 10 such cases. These subjects were not included in the study sample.

Self-reported Hypertension: It was determined by answer to the question, "Doctor ever told that you had hypertension/high blood pressure?"

High Blood Pressure: It was defined as systolic blood pressure ≥140 and/or diastolic blood pressure ≥90 mm Hg.

Undiagnosed Hypertension: a person was treated as having a previously undiagnosed hypertension in this study if his/her blood pressure was measured in NHANES III as SBP≥140 and/or DBP≥90 and he/she was not told by his physician that he/she had hypertension.

Adequately Treated Hypertension: A person was defined as having an adequately treated hypertension if his/her blood pressure measured in NHANES III was in the normal range (SBP<140 and DBP<90) but he/she was told by his physician that he had hypertension. This may indicate that the pharmacological and/or non-pharmacological treatment of this person was successful in controlling the blood pressure.

Inadequately Treated Hypertension: A person was defined as having inadequately treated hypertension if his/her blood pressure was measured as SBP≥140 and/or DBP≥90 and who was told by his physician that he was hypertensive.

Overweight and Obesity

In NHANES, the body measurements, including height and weight, were recorded for all examinees by a trained examiner in the mobile examination center (MEC). National Center for Health Statistics (NCHS) defines Body mass index (BMI) as weight in kilograms divided by height in meters squared. A healthy weight for adults is defined as a BMI of 18.5 to less than 25; overweight, as greater than or equal to a BMI of 25; and

obesity, as greater than or equal to a BMI of 30. In addition, BMI was used as a continuous variable in separate analysis.

Exposure Variable

Beverage Consumption

Information about the beverage consumption was obtained using the questionnaire. The following question was asked "How often did you have beer, wine, hard liquor, regular soda, diet soda, coffee or tea in the past month?''

For the different types of beverage (soft drink, coffee, tea, and alcohol), consumption was categorized into several levels: excessive consumption, moderate consumption, and none. Excessive consumption was defined as drinking soft drinks, soda, or pop for ≥1/day (30 or more drinks in past month). Moderate consumption was defined as drinking soft drinks, soda, or pop for <1/day (1-29 drinks/month).

Social and Demographic Variables

Age was categorized into 18-49, 50-64, 65-74, and >74 years. There were four categories used to define race: Caucasians, African Americans, other, and Mexican-Americans of unknown race. Four categories used to define ethnicity: Non-Hispanic white, Non-Hispanic black, Mexican-American, and Other. Education Level was categorized into: none, elementary school, middle school, high school, undergraduate, and graduate.

Preparation of Dataset:

In NHANES III, the data were given in ASCII format and it had to be converted to SAS format by the SAS code provided along with the file. The data and corresponding documentation for the survey interview and examination components were given in five separate files: the NHANES III Household Adult Data File, NHANES III Household Youth Data File, NHANES III Examination Data File, NHANES III Laboratory Data File, and the NHANES III Dietary Recall Data Files. The documentation was provided for a complete description of these files.

The first thing in preparing data set was to identify the relevant variables in each of the five data files. Only Adult Data File, Examination Data File, and Laboratory Data File contain the variables of interest. These files were merged to create a working data set that contained only the variables of interest. The first step in merging data was to sort each of the data files by a unique identifier. In NHANES data, this unique identifier is known as the sequence number (SEQN). To ensure that all observations were ordered in the same way in each data file, each data file was sorted by the SEQN variable, then data merging was made.

Data cleaning was performed. The "refused" or "don't know" responses were recoded as missing values. The mean, number of missing values, and minimum and maximum values for the variables in the merged dataset were examined for possible logic errors and extreme values. In most of the variables, there were no missing values in the final dataset. However, education level had 166 missing observations (0.9%).

Some of the questions were skipped based on a certain response to a question in the questionnaire. Some of the variables were necessary to recode based on these skip patterns in order to evaluate proper outcomes.

After completing all of this process, I converted the SAS file in a SPSS dataset in order to simplify the data analysis. All analyses were done using the SPSS software.

Data Analyses:

Data were first checked for inconsistencies and outliers. Missing, minimum and maximum values and cross-tabulations were checked for accuracy of data. Univariate analyses including frequency, percentages, mean, median, standard deviation, and skewness were used to describe the variables of interest. Histograms were used to display distribution of all continuous variables including blood pressure and BMI.

Descriptive Statistics

The social and demographic characteristics including age, gender, race, ethnicity, and education levels were described using descriptive statistics including mean, standard deviation, and proportion. Prevalence of beverage consumption and hypertension were analyzed for the total sample and for different subgroups as defined by sex, race/ethnicity, and age group.

Bi-variate Analysis

Beverage Consumption and Hypertension: Prevalence of hypertension was stratified by the consumption level of a specific beverage. Differences in hypertension prevalence across consumption levels were compared using a Chi-square test.

Beverage Consumption and Average Blood Pressure: Each of the beverage consumptions was used as a categorical variable for this analysis, and systolic and diastolic blood pressures were used as continuous variables. Mean levels of systolic and diastolic blood pressures for various levels of beverage consumption were compared using Analysis of Variance (ANOVA), and pair-group comparison was analyzed by the post-hoc test (LSD).

Beverage Consumption and Weight Status: Weight status as the categorical variable and BMI as the continuous variable were analyzed to assess their relationship with each of the beverage consumption patterns. The analyses followed the same approach as for hypertension/blood pressure described above.

Multivariate Analysis

Multiple logistic regression analysis was used to assess the relationship between beverage consumption and hypertension with adjustment for covariates. The odds ratios (and 95% confidence intervals) of hypertension for the different levels of each beverage consumption were derived from the logistic regression model in order to measure the associations after multivariate adjustment. Different logistic models were built to assess

potential confounding effects. The first set of models included analysis of all the beverage consumption on hypertension variables. The second set of models included effects of beverage consumption adjusting for the social and demographic variables. The third set of models included all different types of beverage use, the social and demographic variables, and weight status.

Multiple linear regression analysis was used to analyze the relationship between the beverage consumption and each of the systolic and diastolic blood pressures with adjustment for covariates. The regression coefficients were used to assess the association. Selection of variables included in the models followed the same pattern as in multiple logistic regressions, to assess possible confounding effects.

CHAPTER 4

RESULTS

Demographic Characteristics of Study Sample:

Table 2 shows the characteristics of the study sample. The majority of the participants were in the age group 18-34 (33%, n=6,263). The percentage of females was higher than that of males (53.4% as compared to 46.6%). Caucasians accounted for 68.4% of the sample population, while African Americans comprised of 28.4%. There were 8,073 non-Hispanic Caucasians (42.6%), 5,219 non-Hispanic African Americans (27.5%), 4,935 Mexican- Americans (26.0%), and 726 subjects from other ethnic groups (3.8%). The majority of study subjects had completed high school (47.8%), 22.6% had undergraduate education, while 5.1% had graduate degrees.

Table 2

Demographic Characteristics of the Study Sample

Characteristic	Subgroups	N	%
Age group	18-34	6,263	33.0
	35-49	4,406	23.2
	50-64	3,313	17.5
	65-74	2,457	13.0
	75-90	2,514	13.3
Gender	Male	8,832	46.6
	Female	10,121	53.4
Race	Caucasians	12,961	68.4
	African Americans	5,385	28.4
	Other	601	3.2
	Mexican-American of unknown race	6	0.0
Ethnicity	Non-Hispanic white	8,073	42.6
	Non-Hispanic black	5,219	27.5
	Mexican-American	4,935	26.0
	Other	726	3.8
Education Level	None	477	2.5
	Elementary school	1,414	7.5
	Middle School	2,604	13.7
	High school	9,051	47.8
	Undergraduate	4,279	22.6
	Graduate	962	5.1
	Total	18,953	100.0

Note: n- number of persons, %- percentage

Beverage Consumption:

Table 3 shows the mean consumption of various beverages in the past 30 days. Mean consumption (drinks during past month) was the highest for coffee (27.95), followed by total soda (mean= 22.54).

Table 3
Beverage Consumption (drinks) during the Past Month

Beverage	Mean consumption	Standard Deviation	Maximum consumption
Diet soda	7.91	21.245	547
Regular soda	14.63	26.217	608
Total soda	22.54	31.256	608
Coffee	27.95	46.222	608
Tea	9.89	22.913	608
Beer	4.62	15.515	365
Wine	1.14	4.421	91
Hard liquor	1.70	8.578	486
Total Alcohol	7.45	19.758	578

Note: Minimum consumption was 0 drinks for all of the beverages.

The beverage consumption for all drinks was categorized as 0 drinks, 1-29 drinks, and >29 drinks in the last month. Table 4 shows that 47.6% of people drank more than one serving of coffee everyday, and 37.2% of people consumed at least one soft drink everyday. Only 18.3% of the people did not consume any amount of soft drink in the last month.

Table 4
Number of People (Percentage) with Different Levels of Beverage Consumption

Beverage	0 drinks	1-29 drinks	>29 drinks
Diet soda	13,048 (68.8%)	3,417 (18.0%)	2,488 (13.1%)
Regular soda	7,235 (38.2%)	7,025 (37.1%)	4,693 (24.8%)
Total soda	3,462 (18.3%)	8,438 (44.5%)	7,053 (37.2%)
Coffee	7,216 (38.1%)	2,716 (14.3%)	9,021 (47.6%)
Tea	10,378 (54.8%)	5,358 (28.3%)	3,217 (17.0%)
Total Alcohol	10,145 (53.5%)	7,072 (37.3%)	1,736 (9.2%)

Variation in beverage consumption between different subgroups: Tables 5, 6 and 7 show the mean consumption of various beverages in different sample subgroups. It is interesting to note that mean consumption of diet soda was significantly higher in age groups 35-49 and 50-65 (10.48 and 10.44 drinks respectively), and it was lower than

average in other age groups. An average female consumed significantly higher quantities of diet soda than an average male (9.17 drinks as compared to 6.46 drinks, p=<.001).

Mean consumption of diet soda was twice as high in Caucasians (9.34 drinks) than that in other races (4.82 drinks) in the past month. An average non-Hispanic white person consumed the highest amount of diet soda among all population subgroups (mean 11.62 drinks). Mean diet soda consumption in people with undergraduate or higher education was almost twice as high (11.53 drinks) as compared to people with less education (6.56 drinks).

The mean consumption of regular soda was highest in the age group 18-34 (22.0 drinks), followed by the age group 35-49. In the other age groups, the mean consumption was lower than average (14.63 drinks). In contrast to diet soda, males consumed higher amounts of regular soda (mean 17.30 drinks) as compared to females (mean 12.30 drinks).

The mean consumption of regular soda was significantly lower than average (14.63 drinks) in Caucasians (mean 13.75 drinks) and non-Hispanic whites (12.94 drinks). The consumption patterns reversed in people with higher education (mean 11.85 drinks) compared to people with high school or lower education (mean 15.70 drinks).

Table 5
Mean (95% CI) Drinks Consumptions during the Last Month for Diet and Regular Soda in Different Sample Subgroups

Population subgroup		Diet soda consumption	Regular soda consumption
		Mean (95% CI)	Mean (95% CI)
Total		7.91 (7.61-8.21)	14.63 (14.26-15.01)
Age group	18-34	6.5 [b c e] (6.00-7.00)	22.00 [b c d e] (21.62-23.19)
	35-49	10.48 [a d e] (9.72-11.24)	16.09 [a c d e] (15.31-16.88)
	50-64	10.44 [a d e] (9. 60-11.28)	9.56 [a b d e] (8.89-10.24)
	65-74	6.96 [b c e] (6.35-7.57)	6.76 [a b c] (6.12-7.41)
	75-90	4.50 [a b c d] (4.02-4.98)	7.11 [a b c] (6.38-7.83)
Gender	Male	6.46 [b] (6.07-6.85)	17.31 [b] (16.73-17.89)
	Female	9.17 [a] (8.72-9.62)	12.30 [a] (11.83-12.78)
Race	Caucasians	9.34 [b c] (8.93-9.74)	13.75 [b c] (13.30-14.19)
	African Americans	4.93 [a] (4.54-5.32)	16.53 [a] (15.81-17.25)
	Other	3.86 [a] (2.97-4.74)	16.87 [a] (14.79-18.94)
	Mexican-American of unknown race	5.17 (-7.61-17.94)	10.67 (-5.13-26.47)
Ethnicity	Non-Hispanic white	11.62 [b c d] (11.04-12.21)	12.94 [b c] (12.31-13.56)
	Non-Hispanic black	5.01 [a d] (4.61-5.41)	16.56 [a c d] (15.83-17.29)
	Mexican-American	5.57 [a d] (5.11-6.04)	15.48 [a b] (14.89-16.06)
	Other	3.29 [a b c] (2.55-4.04)	13.94 [b] (12.20-15.68)
Education level	None	3.18 [c d e f] (2.29-4.07)	10.27 [d] (8.93-11.61)
	Elementary school	4.23 [d e f] (3.56-4.91)	12.51 [d f] (11.39-13.63)
	Middle School	5.30 [a d e f] (4.68-5.93)	12.80 [d f] (11.97-13.63)
	High school	7.46 [a b c e f] (7.03-7.89)	17.32 [a b c e f] (16.69-17.94)
	Undergraduate	11.23 [a b c d f] (10.45-12.02)	12.72 [d f] (12.04-13.40)
	Graduate	12.83 [a b c d e] (11.28-14.38)	7.99 [b c d e] (6.97-9.01)

Post Hoc test analysis: [a] $p<.05$ when compared with grp1, [b] $p<.05$ when compared with grp2, [c] $p<.05$ when compared with grp3, [d] $p<.05$ when compared with grp4, [e] $p<.05$ when compared with grp5, [f] $p<.05$ when compared with grp6

Table 6 shows that the mean total soda consumption was significantly higher than average in age groups 18-34 (28.90 drinks) and 35-49 (26.57 drinks), males (mean 23.77

drinks), Caucasians (23.08 drinks), non-Hispanic whites (24.56 drinks), and people with high school education (24.77 drinks) in the past month.

Coffee consumption was the highest in age group 50-64 (mean 38.94 drinks), and the least in age group 18-34 (mean 16.28 drinks). Mean consumption was higher than average in males (30.57 drinks), Caucasians (33.19 drinks), non-Hispanic whites (37.62 drinks), and people with post graduate education (33.19 drinks) in the past month.

Table 6
Mean (95% CI) Drinks Consumptions during the Last Month for Total Soda and Coffee in Different Sample Subgroups

Population subgroup		Total soda consumption	Coffee consumption
		Mean (95% CI)	Mean (95% CI)
Total		22.54 (22.09-22.98)	27.95 (27.29, 28.60)
Age group	18-34	28.90 [b c d e] (27.28-28.59)	16.28 [b c d e] (15.43-17.13)
	35-49	26.57 [a c d e] (25.59-27.56)	33.85 [a c e] (32.19-35.52)
	50-64	20.00 [a b d e] (19.01-21.00)	38.94 [a b d e] (37.04, 40.85)
	65-74	13.72 [a b c e] (12.89-14.54)	33.07 [a c e] (31.41, 34.73)
	75-90	11.60 [a b c d] (10.76-12.43)	27.15 [a b c d] (25.82, 28.49)
Gender	Male	23.77 [b] (23.11-24.42)	30.57 [b] (29.53, 31.61)
	Female	21.47 [a] (20.86-22.07)	25.65 [a] (24.82, 26.49)
Race	Caucasians	23.08 [b] (22.52-23.63)	33.19 [b c] (32.31-34.06)
	African Americans	21.46 [a] (20.68-22.23)	16.17 [a c] (15.32-17.02)
	Other	20.72 (18.57-22.86)	20.73 [a b] (18.17-23.29)
	Mexican-American of unknown race	15.83 (-.51-32.17)	5.00 (-7.85-17.85)
Ethnicity	Non-Hispanic white	24.56 [b c d] (23.77-25.35)	37.62 (36.37-38.87)
	Non-Hispanic black	21.57 [a d] (20.78-22.36)	15.59 (14.78-16.39)
	Mexican-American	21.05 [a d] (20.36-21.73)	25.42 (24.43-26.42)
	Other	17.23 [a b c] (15.42-19.04)	26.36 (23.21-29.51)
Education level	None	13.44 [b c d e f] (11.93-14.95)	28.32 (25.50, 31.14)
	Elementary school	16.74 [a d e f] (15.52-17.96)	29.19 [f] (27.25, 31.13)
	Middle School	18.10 [a d e f] (17.11-19.09)	28.38 [f] (26.74, 30.01)
	High school	24.77 [a b c f] (24.07-25.47)	27.03 [f] (26.06, 28.01)
	Undergraduate	23.95 [a b c f] (23.00-24.90)	27.94 [f] (26.48, 29.40)
	Graduate	20.82 [a b c d e] (19.14-22.51)	33.19 [b c d e] (30.05, 36.33)

Post Hoc test analysis: [a] $p<.05$ when compared with grp1, [b] $p<.05$ when compared with grp2, [c] $p<.05$ when compared with grp3, [d] $p<.05$ when compared with grp4, [e] $p<.05$ when compared with grp5, [f] $p<.05$ when compared with grp6

Table 7 shows that in the past month, the mean tea consumption was higher than average in the age-group 75-90 (11.59 drinks), females (10.65 drinks) and Caucasians

(11.18 drinks). Non-Hispanic whites had the highest mean tea consumption in all population subgroups (14.04 drinks).

The mean alcohol consumption was almost twice as high in age group 35-49 (8.96 drinks) as that in the age group 75-90 (4.43 drinks). An average male consumed three times more alcohol (mean 11.51 drinks) than an average female (3.91 drinks). The mean alcohol consumption was higher in people with undergraduate and graduate education than that in other people.

Table 7
Mean (95% CI) Drinks Consumptions during the Last Month for Tea and Alcohol in Different Sample Subgroups

Population subgroup		Tea consumption	Total alcohol consumption
		Mean (95% CI)	Mean (95% CI)
Total		9.89 (9.57, 10.22)	7.45 (7.17, 7.73)
Age group	18-34	8.66 [b c e] (8.11-9.22)	7.59 [b e] (7.79, 8.53)
	35-49	10.38 [a e] (9.63-11.13)	8.96 [a c d e] (8.35-9.57)
	50-64	10.48 [a] (9.71, 11.25)	7.67 [b e] (6.97, 8.38)
	65-74	9.62 [e] (8.79, 10.46)	7.16 [b e] (6.21, 8.11)
	75-90	11.59 [a b d] (10.75, 12.43)	4.43 [a b c d] (3.94, 4.92)
Gender	Male	9.03 [b] (8.58, 9.48)	11.51 [b] (10.98, 12.04)
	Female	10.65 [a] (10.18, 11.11)	3.91 [a] (3.67, 4.14)
Race	Caucasians	11.18 [b] (10.75, 11.61)	7.24 [b c] (6.92, 7.56)
	African Americans	6.79 [a c] (6.37, 7.21)	8.25 [a c] (7.64, 8.86)
	Other	10.05 [b] (7.97, 12.14)	4.70 [a b] (3.70, 5.70)
	Mexican-American of unknown race	5.17 (-1.52, 11.85)	13.33 (-2.19, 28.86)
Ethnicity	Non-Hispanic white	14.04 [b c d] (13.42, 14.67)	7.90 [c d] (7.48, 8.32
	Non-Hispanic black	6.86 [a d] (6.43, 7.29)	8.27 [c d] (7.65, 8.89)
	Mexican-American	6.30 [a d] (5.88, 6.73)	6.19 [a b] (5.69, 6.68)
	Other	9.92 [a b c] (7.73, 12.11)	5.18 [a b] (4.10, 6.27)
Education level	None	6.53 [c d e f] (5.14, 7.92)	3.88 [b d e f] (2.61, 5.16)
	Elementary school	7.02 [c d e f] (6.20, 7.84)	5.99 [a d e f] (4.77, 7.22)
	Middle School	9.29 [a b e] (8.33, 10.26)	5.36 [d e f] (4.70, 6.02)
	High school	10.28 [a b] (9.80, 10.75)	7.48 [a b c e f] (7.08, 7.89)
	Undergraduate	10.57 [a b c] (9.84, 11.29)	9.15 [a b c d] (8.52, 9.79)
	Graduate	10.93 [a b] (9.55, 12.31)	9.35 [a b c d] (8.40, 10.31)

Post Hoc test analysis: [a] $p<.05$ when compared with grp1, [b] $p<.05$ when compared with grp2, [c] $p<.05$ when compared with grp3, [d] $p<.05$ when compared with grp4, [e] $p<.05$ when compared with grp5, [f] $p<.05$ when compared with grp6

Blood Pressure and Hypertension

Table 8 shows the statistics for systolic and diastolic blood pressures. The systolic blood pressure curve was slightly skewed to the right (Figure 1), while the diastolic blood pressure curve shows a better approximation to the normal distribution (Figure 2).

Table 8
Blood Pressure Statistics

	Systolic BP	Diastolic BP
Mean	126.41	74.20
Median	122.00	74.00
Mode	113	73
Std. Deviation	20.599	11.058
Skewness	1.004	.267
Std. Error of Skewness	.018	.018
Kurtosis	1.280	1.092
Std. Error of Kurtosis	.036	.036
Minimum	69	20
Maximum	246	142

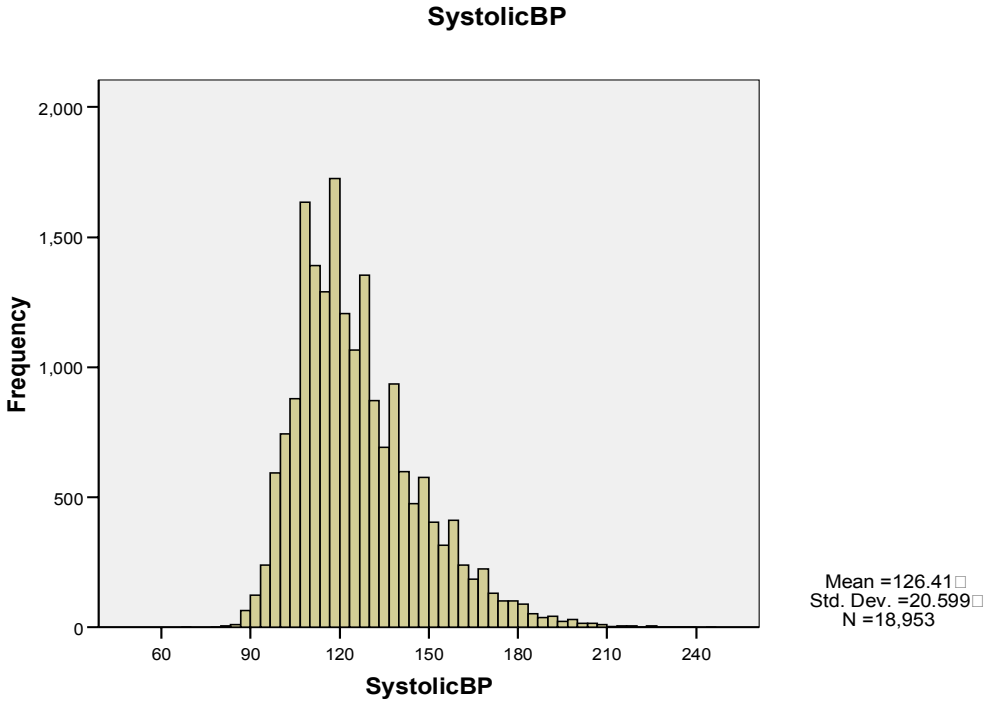

Figure 1. Distribution of Systolic Blood Pressure

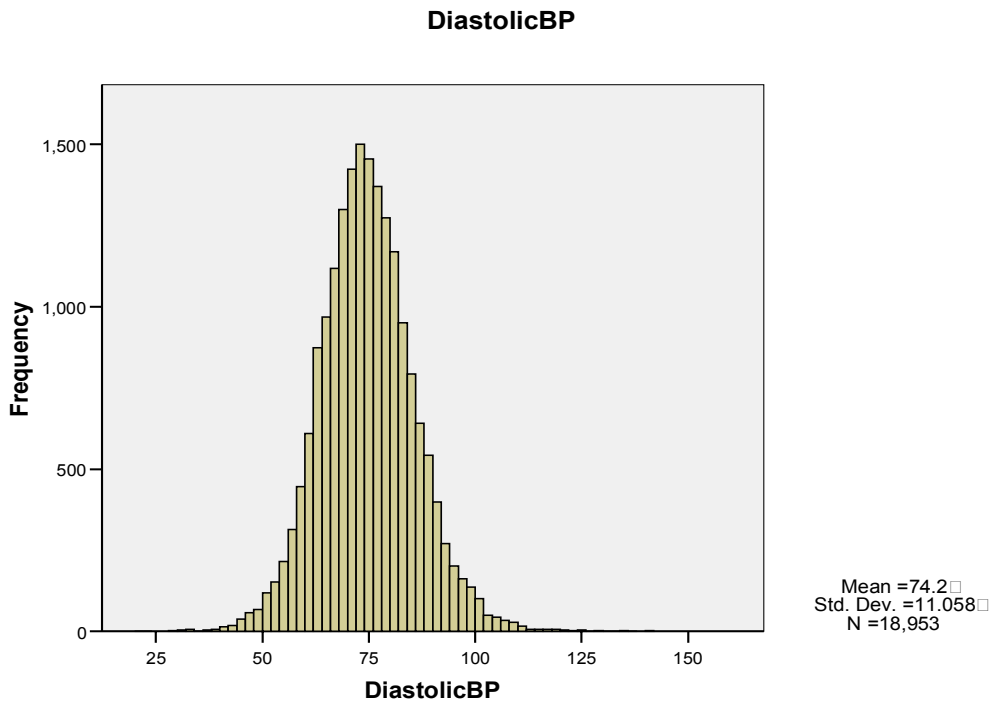

Figure 2. Distribution of Diastolic Blood Pressure

Prevalence of Hypertension: Prevalence of self reported hypertension in this sample was 27.9%, high blood pressure (SBP≥140 and/or DBP≥90) was 25.2%, and total hypertension was 31.7% (Table 9 on page 47). Prevalence of all of the measures was higher in higher age groups. In the age group 75-90, the hypertension prevalence was 70%, as compared to the age group 18-34 (4.8%). In males, prevalence of hypertension was higher than females (32.0% compared to 31.5%, p=.248) which was not statistically significant, but the self-reported hypertension in males was much lower than females (25.2% compared to 30.1%, p<.001). This indicates that males had a higher likelihood of being unaware about their hypertension. The prevalence of hypertension in African Americans (32.7%) was higher than that in Caucasians (31.8%). The hypertension

prevalence (20.6%) in other ethnic groups was lower than both of these ethnic groups. In non-Hispanic whites, the hypertension prevalence (37.9%) was higher than non-Hispanic blacks (33.2%), Mexican-Americans (21.3%), and other ethnic groups (22.3%). In people with high school and higher education, the hypertension prevalence was quite low as compared to people with lower education.

Table 9
Hypertension Prevalence in Total Sample and Subgroups

Population subgroup		N	Self Reported Hypertension		High Blood pressure		Hypertension	
			%	p	%	p	%	p
Total		18953	27.9		25.2		31.7	
Age group	18-34	6263	9.9	<.001	4.1	<.001	4.8	<.001
	35-49	4406	22.0		15.3		19.9	
	50-64	3313	40.2		33.9		46.4	
	65-74	2457	48.8		49.7		62.6	
	75-90	2514	62.0		59.9		70.0	
Gender	Male	8832	25.2	<.001	26.4	<.001	32.0	.248
	Female	10121	30.1		24.0		31.5	
Race	Caucasians	12961	26.9	<.001	25.8	<.001	31.8	<.001
	African Americans	5385	31.3		24.8		32.7	
	Other	601	17.0		18.0		20.6	
	Mexican-American of unknown race	6	33.3		16.7		16.7	
Ethnicity	Non-Hispanic white	8073	30.8	<.001	30.1	<.001	37.9	<.001
	Non-Hispanic black	5219	31.7		25.2		33.2	
	Mexican-American	4935	19.9		18.2		21.3	
	Other	726	22.2		18.6		22.3	
Education level	None	477	33.3	<.001	39.4	<.001	45.9	<.001
	Elementary school	1414	33.6		36.4		43.5	
	Middle School	2604	35.6		34.7		43.1	
	High school	9051	27.1		23.2		29.9	
	Undergraduate	4279	22.6		19.3		24.2	
	Graduate	962	25.8		21.5		27.0	

Note: n is number of persons in particular group. % is the prevalence for that group; p values are calculated by use of chi-square test.

Undiagnosed Hypertension: Table 10 on page 49 shows that prevalence of undiagnosed hypertension in the total sample was 10.4%, so nearly a third of the people who had hypertension were unaware of its presence. The highest prevalence was in the age group 75-90 (26.7%). About 12.4% of males were unaware of their hypertension as compared to 8.6% of females. Contrary to common belief, the prevalence of undiagnosed hypertension was higher in Caucasians and non-Hispanic whites as compared to other racial and ethnic groups (11.1% and 12.8% respectively). The prevalence of undiagnosed hypertension decreased progressively with higher level of education.

Adequately Treated Hypertension: Adequately treated hypertension was defined as a person in whom the blood pressure was not found to be high (SBP<140 and DBP<90), who was told by his/her physician that he/she had hypertension. It is assumed that the pharmacological and/or non-pharmacological treatment of this person was successful in controlling the blood pressure. Table 10 on page 49 shows that prevalence of adequately treated hypertension in the total sample was 13.0 that suggests that in around 40% of hypertensive people the hypertension was adequately treated. The highest prevalence of this was found in the age group 50-64 (19%). About 14.7% of females had adequately treated hypertension as compared to just 11.1% males. In African Americans, the prevalence of adequately treated hypertension (15.3%) was higher than that in Caucasians (12.3%).

Inadequately Treated Hypertension: It was defined as a person in whom blood pressure was recorded as high (SBP≥140 and/or DBP≥90), and was told by physician that he/she

was hypertensive. It is assumed that the pharmacological and/or non-pharmacological treatment of this person was not successful in controlling the blood pressure. Table 10 on page 49 shows that with increasing age, the prevalence of inadequately treated hypertension increased, with the highest prevalence was found in the age group 75-90(33.2%). Females had a higher prevalence (15.4%) than males (14.2%). African Americans had a higher prevalence (16.0%) than Caucasians (14.6%). People with less than a high school education had significantly higher prevalence than others.

Table 10
Prevalence of Undiagnosed Hypertension, Adequately Treated Hypertension, and Inadequately Treated Hypertension in Total Sample and Subgroups

Population subgroup		Undiagnosed Hypertension			Adequately treated Hypertension			Inadequately treated Hypertension		
		n	%	P	N	%	p	n	%	p
Total		1972	10.4		2469	13.0		2810	14.8	
Age group	18-34	160	2.6	<.001	522	8.3	<.001	97	1.5	<.001
	35-49	288	6.5		581	13.2		387	8.8	
	50-64	421	12.7		630	19.0		703	21.2	
	65-74	433	17.6		412	16.8		788	32.1	
	75-90	670	26.7		324	12.9		835	33.2	
Gender	Male	1098	12.4	<.001	978	11.1	<.001	1251	14.2	.017
	Female	874	8.6		1491	14.7		1559	15.4	
Race	Caucasians	1445	11.1	<.001	1595	12.3	<.001	1893	14.6	<.001
	African Americans	471	8.7		823	15.3		864	16.0	
	Other	56	9.3		50	8.3		52	8.7	
	Mexican-American of unknown race	0	.0		1	16.7		1	16.7	
Ethnicity	Non-Hispanic white	1030	12.8	<.001	1086	13.5	<.001	1400	17.3	<.001
	Non-Hispanic black	467	8.9		802	15.4		850	16.3	
	Mexican-American	417	8.4		497	10.1		483	9.8	
	Other	58	8.0		84	11.6		77	10.6	
Education level	None	83	17.4	<.001	54	11.3	.001	105	22.0	<.001
	Elementary school	214	15.1		175	12.4		300	21.2	
	Middle School	353	13.6		378	14.5		550	21.1	
	High school	881	9.7		1241	13.7		1216	13.4	
	Undergraduate	348	8.1		488	11.4		479	11.2	
	Graduate	74	7.7		115	12.0		133	13.8	

Note: p-values are calculated by the use of chi-square test.

Mean Systolic Blood Pressure: Table 13 on page 51 shows that mean systolic blood pressure was higher in higher age groups and was highest in the age group 75-90 (146.20 mm Hg). Males showed significantly higher mean pressure (128.65 mm Hg) than females (124.46 mm Hg). The mean blood pressures in Caucasians and non-Hispanic whites were

significantly higher than that in other races. Mean systolic pressure decreased with a higher level of education.

Mean Diastolic Blood Pressure: Table 13 on page 51 shows that mean diastolic blood pressure was the highest in the age group 50-64 (78.40 mm Hg) and was successively lower in age groups 65-74 (75.27 mm Hg) and 75-90 (72.59 mm Hg). Mean DBP was higher in males (76.57 mm Hg) than in females (72.14 mm Hg). It was higher in African Americans (75.74 mm Hg) than Caucasians (73.61 mm Hg) and other races (73.15 mm Hg). Similarly, non-Hispanic Blacks showed mean DBP of 75.87 mm Hg, which was higher than non-Hispanic whites (73.99 mm Hg) and Mexican-Americans (72.92 mm Hg). Mean diastolic pressure did not show any trends according to level of education.

Table 11
Mean Blood Pressure (in mm Hg) in Total Sample and Subgroups

Population subgroup		Systolic BP		Diastolic BP	
		Mean (95% CI)	SD	Mean (95% CI)	SD
Total		126.41 (126.12, 126.70)	20.599	74.20 (74.04, 74.36)	11.058
Age group	18-34	113.35 [b c d e] (113.07, 113.63)	11.327	69.99 [b c d e] (72.82, 73.24)	10.239
	35-49	120.60 [a c d e] (120.15-121.05)	15.308	77.36 [a c d e] (77.05-77.67)	10.495
	50-64	133.03 [a b d e] (132.39, 133.67)	18.851	78.40 [a b d e] (78.06, 78.75)	10.079
	65-74	140.95 [a b c e] (140.15, 141.75)	20.159	75.27 [a b c e] (74.84, 75.70)	10.899
	75-90	146.20 [a b c d] (145.36, 147.04)	21.530	72.59 [a b c d] (72.14, 73.03)	11.369
Gender	Male	128.65 [b] (128.27, 129.03)	18.377	76.57 [b] (76.34, 76.79)	10.946
	Female	124.46 [a] (124.02, 124.89)	22.174	72.14 [a] (71.93, 72.35)	10.739
Race	Caucasians	127.01 [b c] (126.66, 127.37)	20.743	73.61 [b] (73.43, 73.79)	10.573
	African Americans	125.58 [a c] (125.03, 126.12)	20.348	75.74 [a b] (75.42, 76.06)	12.052
	Other	120.86 [a b] (119.37, 122.35)	18.579	73.15 [b] (72.29, 74.00)	10.659
	Mexican-American of unknown race	127.67 (107.04, 148.29)	19.654	79.00 (68.48, 89.52)	10.020
Ethnicity	Non-Hispanic white	129.28 [b c d] (128.82, 129.74)	21.155	73.99 [b c d] (73.77, 74.22)	10.288
	Non-Hispanic black	125.85 [a c d] (125.30, 126.40)	20.403	75.87 [a c d] (75.54, 76.20)	12.066
	Mexican-American	122.98 [a b] (122.45, 123.52)	19.314	72.92 [a b] (72.61, 73.22)	11.010
	Other	121.84 [a b] (120.42, 123.26)	19.482	73.29 [a b] (72.51, 74.06)	10.631
Education level	None	136.36 [b c d e f] (134.17, 138.55)	24.324	74.14 [f] (73.10, 75.17)	11.500
	Elementary school	134.05 [a c d e f] (132.91, 135.19)	21.793	75.03 [c d e] (74.43, 75.62)	11.375
	Middle School	132.08 [a b d e f] (131.20, 132.96)	22.914	73.89 [b f] (73.46, 74.33)	11.425
	High school	125.14 [a b c e] (124.74, 125.55)	19.700	74.00 [b f] (73.77, 74.23)	11.091
	Undergraduate	122.48 [a b c d f] (121.92, 123.04)	18.704	74.28 [b f] (73.96, 74.60)	10.704
	Graduate	123.97 [a b c e] (122.79, 125.15)	18.645	75.36 [a c d e] (74.71, 76.01)	10.234

Post Hoc test analysis: [a] $p<.05$ when compared with grp1, [b] $p<.05$ when compared with grp2, [c] $p<.05$ when compared with grp3, [d] $p<.05$ when compared with grp4, [e] $p<.05$ when compared with grp5, [f] $p<.05$ when compared with grp6

Bi-variate Analysis

Beverage Consumption and Hypertension: A Chi-square test was used to analyze the association between various categories of beverage consumption and hypertension prevalence (Table 12, page 53). Prevalence of self reported hypertension was the lowest in the 0 drink group and the highest in the >29 drink group of diet soda consumption, but high blood pressure and hypertension defined through combining self-report and blood pressure measurements were highest in the 1-29 drink group. In regular soda consumption categories, the highest prevalence was found in the 0 drink group and was the lowest in the >29 drink group for self-reported hypertension, high blood pressure, and hypertension. Total soda consumption showed similar findings. The coffee and tea consumption categories showed that prevalence of hypertension was less in the 1-29 drinks group as compared to the 0 drink group, but was quite high in the >29 drink group. In the alcohol consumption categories, similar trend was seen, but the prevalence in >29 drinks was less than that in the 0 drink group.

Table 12
Prevalence of Self Reported Hypertension, High Blood Pressure, and Hypertension by Beverage Consumption Categories

Beverage consumption			Self-Reported Hypertension		High Blood Pressure		Hypertension	
		N	%	P	%	P	%	p
Total		18953	27.9		25.2		31.7	
Diet soda	0 drinks	13048	25.7	<.001	24.8	.014	30.3	<.001
	1-29 drinks	3417	31.9		27.2		35.5	
	>29 drinks	2488	33.8		24.6		34.0	
Regular soda	0 drinks	7235	35.4	<.001	32.0	<.001	41.3	<.001
	1-29 drinks	7025	24.8		23.1		28.2	
	>29 drinks	4693	20.9		18.0		22.2	
Total soda	0 drinks	3462	33.8	<.001	34.8	<.001	43.1	<.001
	1-29 drinks	8438	27.6		25.4		31.6	
	>29 drinks	7053	25.2		20.3		26.3	
Coffee	0 drinks	7216	26.6	<.001	21.9	<.001	28.3	<.001
	1-29 drinks	2716	23.0		18.0		23.7	
	>29 drinks	9021	30.3		30.1		36.8	
Tea	0 drinks	10378	27.5	.087*	24.6	<.001	30.9	<.001
	1-29 drinks	5358	27.6		24.3		30.6	
	>29 drinks	3217	29.4		28.9		36.1	
Alcohol	0 drinks	10145	32.5	<.001	29.1	<.001	37.2	<.001
	1-29 drinks	7072	21.4		18.7		23.1	
	>29 drinks	1736	26.8		29.2		34.5	

Note: chi-square indicates Pearson's chi-square calculated for categorized variables. *p not less than 0.05.

Mean Levels of Systolic and Diastolic Blood Pressures by Beverage Consumption Categories (Table 13 on page 54): In the diet soda categories, the mean SBP was the highest in the 1-29 drinks group, followed by that in the >29 drinks group. Mean diastolic blood pressure was the highest in the >29 drinks group and the lowest in the 0 drinks group. For consumption of regular and total soda, the highest mean SBP was in the 0 drink group, and the highest mean DBP was in the 1-29 drinks group. The people who consumed 1-29 drinks/month of alcohol, tea, and coffee had a significantly lower systolic blood pressure, as compared to those who drank none; but the people with >29

drinks/month consumption of these drinks had a significantly higher blood pressure. The mean diastolic blood pressure was the highest in >29 drink group and was the lowest in the people who did not consume these drinks.

Table 13
Comparison of Mean Levels of Systolic and Diastolic blood pressures (mm Hg) by Levels of Beverage Consumption

Beverage consumption			Systolic blood pressure			Diastolic blood Pressure		
			Mean	95% Confidence Interval for Mean		mean	95% Confidence Interval for Mean	
		n		Upper Bound	Lower Bound		Upper Bound	Lower Bound
Total		18953	126.41	126.12	126.70	74.20	74.04	74.36
Diet soda	0 drinks	13048	126.11 [b]	125.75	126.47	73.98 [b c]	73.78	74.17
	1-29 drinks	3417	127.70 [a c]	127.02	128.38	74.54 [a]	74.18	74.90
	>29 drinks	2488	126.21 [b]	125.42	126.99	74.92 [a]	74.51	75.34
Regular soda	0 drinks	7235	130.38 [b c]	129.87	130.89	74.23	73.98	74.48
	1-29 drinks	7025	125.12 [a c]	124.66	125.58	74.42 [c]	74.16	74.68
	>29 drinks	4693	122.22 [a b]	121.69	122.75	73.83 [b]	73.50	74.16
Total soda	0 drinks	3462	131.79 [b c]	131.02	132.55	73.76 [b]	73.39	74.12
	1-29 drinks	8438	126.58 [a c]	126.14	127.01	74.41 [a]	74.18	74.65
	>29 drinks	7053	123.57 [a b]	123.13	124.01	74.17	73.91	74.43
Coffee	0 drinks	7216	124.07 [b c]	123.61	124.54	73.36 [c]	73.10	73.62
	1-29 drinks	2716	122.28 [a c]	121.60	122.96	73.46 [c]	73.04	73.88
	>29 drinks	9021	129.52 [a b]	129.08	129.96	75.10 [a b]	74.88	75.32
Tea	0 drinks	10378	126.27 [b c]	125.88	126.67	73.85 [b c]	73.64	74.06
	1-29 drinks	5358	125.55 [a c]	125.02	126.08	74.52 [a]	74.22	74.81
	>29 drinks	3217	128.28 [a b]	127.55	129.01	74.81 [a]	74.44	75.18
Alcohol	0 drinks	10145	128.46 [b c]	128.03	128.88	73.52 [b c]	73.30	73.73
	1-29 drinks	7072	122.67 [a c]	122.24	123.09	74.50 [a c]	74.24	74.75
	>29 drinks	1736	129.70 [a b]	128.82	130.58	76.99 [a b]	76.48	77.50

Note: p-values are calculated by Analysis of Variance (ANOVA) test. Post Hoc test analysis: [a] $p<.05$ when compared with grp1, [b] $p<.05$ when compared with grp2, [c] $p<.05$ when compared with grp3

Beverage Consumption and Weight Status (Table 14, page 55): More than 90% of underweight people did not consume diet soda, as compared to about 58% of obese persons; the percentage of diet soda consumption was progressively more in higher

weight categories. The reverse pattern was found for regular soda consumption. Coffee, tea, and alcohol consumption did not show such patterns for weight categories.

Table 14
Beverage Consumption and Weight Status

Beverage consumption		Weight status								p
		Underweight		Adequate weight		Overweight		Obese		
		n	%	n	%	N	%	n	%	
Total		426	2.5	6657	38.4	5929	34.2	4326	25.0	
Diet soda	0	384	90.1	5076	76.3	3948	66.6	2515	58.1	<.001
	1-29	29	6.8	938	14.1	1167	19.7	989	22.9	
	>29	13	3.1	643	9.7	814	13.7	822	13.2	
Regular soda	0	123	28.9	2289	34.4	2353	39.7	1774	41.0	<.001
	1-29	166	39.0	2573	38.7	2215	37.4	1537	35.5	
	>29	137	32.2	1795	27.0	1361	23.0	1015	23.5	
Total soda	0	99	23.2	1337	20.1	1076	18.1	607	14.0	<.001
	1-29	180	42.3	2911	43.7	2725	46.0	1925	44.5	
	>29	147	34.5	2409	36.2	2128	35.9	1794	41.5	
Coffee	0	199	46.7	2625	39.4	2076	35.0	1730	40.0	<.001
	1-29	63	14.8	1009	15.2	868	14.6	583	13.5	
	>29	164	38.5	3023	45.4	2985	50.3	2013	46.5	
Tea	0	238	55.9	3626	54.5	3267	55.1	2306	53.3	.477*
	1-29	115	27.0	1892	28.4	1668	28.1	1295	29.9	
	>29	73	17.1	1139	17.1	994	16.8	725	16.8	
Alcohol	0	259	60.8	3236	48.6	3153	53.2	2593	59.9	<.001
	1-29	116	27.2	2722	40.9	2236	37.7	1466	33.9	
	>29	51	12.0	699	10.5	540	9.1	267	6.2	

Note: I=None, II= 1-29 drinks, III= >29 drinks, n=number of people, %=percentage of people with different level of beverage consumption, p-values are calculated by use of chi-square test. * p not <.05

Mean BMI and Levels of Beverage Consumption (Table 15, page 56): For diet soda consumption, mean BMI was the lowest in the 0 drink group and the highest in the >29 drink group. A reverse pattern was found for regular soda and alcohol consumptions.

Table 15
Comparison of Mean Levels of BMI by the Levels of Beverage Consumption

Beverage consumption		N	BMI			
			mean	95% Confidence Interval for Mean		p
				Upper Bound	Lower Bound	
Total		17338	26.984	26.897	27.071	
Diet soda	0 drinks	11923	26.329 [b c]	26.227	26.430	<.001
	1-29 drinks	3123	28.149 [a c]	27.945	28.353	
	>29 drinks	2292	28.809 [a b]	28.553	29.064	
Regular soda	0 drinks	6539	27.402 [b c]	27.262	27.542	<.001
	1-29 drinks	6491	26.760 [a]	26.621	26.899	
	>29 drinks	4308	26.689 [a]	26.507	26.871	
Total soda	0 drinks	3119	26.160 [b c]	26.919	27.222	<.001
	1-29 drinks	7741	26.964 [a c]	26.502	26.950	
	>29 drinks	6478	27.406 [a b]	26.876	27.113	
Coffee	0 drinks	6630	27.070 [b]	26.919	27.222	<.001
	1-29 drinks	2523	26.726 [a c]	26.502	26.950	
	>29 drinks	8185	26.994 [b]	26.876	27.113	
Tea	0 drinks	9437	26.899 [b]	26.784	27.014	<.001
	1-29 drinks	4970	27.123 [a]	26.956	27.290	
	>29 drinks	2931	27.024	26.806	27.242	
Alcohol	0 drinks	9241	27.471 [b c]	27.344	27.598	<.001
	1-29 drinks	6540	26.592 [a c]	26.461	26.723	
	>29 drinks	1557	25.743 [a b]	25.505	25.982	

Note: p-values are calculated by Analysis of Variance (ANOVA) test. Post Hoc test analysis: [a] $p<.05$ when compared with grp1, [b] $p<.05$ when compared with grp2, [c] $p<.05$ when compared with grp3

Multivariate Analysis:

Beverage Consumption and Self Reported Hypertension (Table 16, page 57): Among all the beverages, only diet soda consumption was significantly associated with self-reported hypertension, with and without adjusting for demographic variables (age, gender, ethnicity and education). But, after adjusting for BMI, alcohol consumption also showed significant relationship. After adjusting for all of these variables, the odds ratio of self-

reported hypertension per 10 drink increase of diet soda consumption in the past month was 1.035. For an increase in 10 drinks of alcohol consumption, the odds ratio was 1.021. For age, the odds ratio was 1.543, thus for 10 years of age increase, the risk of self reported hypertension increased by 54.3%. Surprisingly, males had a lower risk of self-reported hypertension (OR .834) than females. Non-Hispanic blacks had a higher risk than non-Hispanic whites (OR 1.606). The odds ratio for one point increase in BMI was 1.090.

Table 16
Risk for Self Reported Hypertension Associated with Beverage consumption (drinks during past month), with and without Adjustment for Demographic Factors and BMI

		OR	95% CI		OR	95% CI		OR	95% CI	
			Lower	Upper		Lower	Upper		Lower	Upper
Diet soda		1.017	1.003	1.032	1.061	1.044	1.078	1.035	1.018	1.053
Regular soda		.900	.885	.916	.993	.978	1.009	.995	.979	1.012
Coffee		1.001	.994	1.008	.994	.986	1.002	.992	.984	1.001
Tea		.995	.981	1.010	.987	.971	1.003	.986	.970	1.004
Alcohol		.980	.962	.998	1.008	.990	1.025	1.021	1.002	1.039
Age (10 years)					1.530	1.498	1.562	1.543	1.508	1.579
Gender	Male				.770	.717	.827	.834	.772	.900
	Female				1	(reference)		1	(reference)	
Ethnicity	Non-Hispanic white				1	(reference)		1	(reference)	
	Non-Hispanic black				1.866	1.705	2.042	1.606	1.457	1.771
	Mexican-American				1.026	.922	1.141	.901	.804	1.010
	Other				1.058	.869	1.289	1.035	.840	1.276
Education	None				.930	.713	1.214	.924	.697	1.225
	Elementary school				1.002	.818	1.227	.961	.774	1.195
	Middle School				1.145	.957	1.371	1.132	.934	1.373
	High school				1.162	.988	1.366	1.111	.934	1.321
	Undergraduate				.987	.832	1.170	.973	.810	1.169
	Graduate				1	(reference)		1	(reference)	
BMI								1.090	1.083	1.097

Table 17 shows that for self-reported hypertension odds ratio progressively increased with higher diet soda consumption, even after adjustment for demographic factors, the risk was statistically significant, but after adjusting for BMI, the effect was not statistically significant. None of the odds ratio was statistically significant after adjustment for demographic factors and BMI except for 1-29 drinks group of regulars soda which showed odds ratio of .866 that shows protective effect.

Table 17
Risk for Self Reported Hypertension Associated with Different Beverage Consumption Categories with and without Adjustment for Demographic Factors and BMI

Drinks in the last month		OR[1]	95% CI		OR[2]	95% CI		OR[3]	95% CI	
			Lower	Upper		Lower	Upper		Lower	Upper
Diet soda	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	1.164	1.035	1.308	1.168	1.032	1.322	1.008	.883	1.150
	>29	1.514	1.162	1.972	1.457	1.102	1.925	1.216	.904	1.637
Regular soda	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	.643	.567	.730	.860	.753	.981	.866	.752	.998
	>29	.707	.540	.925	.971	.731	1.291	.995	.735	1.346
Total soda	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	1.059	.909	1.233	1.172	.998	1.376	1.129	.951	1.341
	>29	.773	.581	1.027	1.115	.826	1.507	1.044	.757	1.438
Coffee	0	1	(reference)		1	(reference)			(reference)	
	1-29	.901	.810	1.002	.945	.844	1.058	.933	.827	1.054
	>29	1.213	1.130	1.301	.866	.803	.935	.848	.781	.921
Tea	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	1.067	.989	1.151	1.086	1.002	1.177	1.048	.961	1.142
	>29	1.060	.969	1.158	.935	.850	1.028	.933	.842	1.032
Alcohol	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	.588	.547	.632	.881	.814	.954	.936	.860	1.020
	>29	.782	.696	.878	.947	.835	1.074	1.048	.915	1.200

1-Unadjusted OR, 2-OR adjusted for age, gender, ethnicity and education 3-OR adjusted for age, gender, ethnicity, education and BMI

Beverage Consumption and High blood pressure : Among all the beverages, only diet soda and alcohol consumption had a significant relationship with high blood pressure after adjusting for demographic factors. But after adjusting with BMI, only alcohol showed a significant relationship with high blood pressure. The odds ratio for an increase in 10 drinks of alcohol consumption was 1.054. The OR for 10 year increase in age was 2.010. The risk was higher in males than in females (OR 1.241). Risk of high blood pressure was significantly associated with BMI (OR=1.060).

Table 18
Risk for High Blood Pressure Associated with Beverage Consumption, with and without Adjustment for Demographic Factors and BMI

		OR	95% CI		OR	95% CI		OR	95% CI	
			Lower	Upper		Lower	Upper		Lower	Upper
Diet soda		.959	.942	.976	1.022	1.003	1.041	1.000	.979	1.022
Regular soda		.875	.859	.892	1.013	.996	1.030	1.013	.995	1.031
Coffee		1.010	1.003	1.017	.997	.988	1.005	.996	.987	1.005
Tea		1.017	1.002	1.031	1.013	.996	1.031	1.015	.997	1.034
Alcohol		1.016	1.000	1.033	1.043	1.024	1.061	1.054	1.034	1.074
Age (10 year)					1.954	1.905	2.004	2.010	1.954	2.066
Gender	Male				1.160	1.073	1.254	1.241	1.141	1.349
	Female				1	(reference)		1	(reference)	
Ethnicity	Non-Hispanic white				1	(reference)		1	(reference)	
	Non-Hispanic black				1.866	1.686	2.065	1.819	1.631	2.027
	Mexican-American				1.249	1.109	1.406	1.211	1.067	1.375
	Other				1.061	.849	1.327	1.143	.904	1.444
Education	None				1.159	.873	1.538	1.140	.847	1.535
	Elementary school				1.141	.914	1.423	1.111	.878	1.406
	Middle School				1.149	.942	1.402	1.114	.901	1.377
	High school				1.296	1.081	1.554	1.242	1.024	1.507
	Undergraduate				1.183	.976	1.433	1.139	.928	1.397
	Graduate				1	(reference)		1	(reference)	
BMI								1.060	1.053	1.068

Table 19 shows that for high blood pressure, after adjusting for BMI, the effect of most of the beverages on high blood pressure is attenuated except that of alcohol. The risk increases with increase in alcohol consumption. The same effect is observed with the soda consumption (regular + diet), but the effect is not statistically significant. Tea also showed risk associated with high blood pressure, but again the effect was not significant in the heavy consumption group (>1 cup/day). Moderate tea consumption (1-29 drinks group) shows statistically significant relationship with high blood pressure.

Table 19
Risk for High Blood Pressure Associated with Different Beverage Consumption Categories with and without Adjustment for Demographic Factors and BMI

Drinks in the last month		OR[1]	95% CI Lower	95% CI Upper	OR[2]	95% CI Lower	95% CI Upper	OR[3]	95% CI Lower	95% CI Upper
Diet soda	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	.979	.864	1.109	.995	.864	1.145	.863	.743	1.002
	>29	1.040	.770	1.405	.967	.691	1.353	.863	.607	1.229
Regular soda	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	.649	.566	.743	.952	.819	1.107	.952	.811	1.117
	>29	.655	.483	.890	.954	.678	1.341	.983	.687	1.407
Total soda	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	.971	.827	1.141	1.138	.951	1.362	1.143	.944	1.385
	>29	.685	.497	.943	1.232	.862	1.761	1.181	.811	1.722
Coffee	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	.856	.762	.960	.915	.803	1.043	.905	.787	1.040
	>29	1.541	1.432	1.659	.960	.882	1.045	.940	.859	1.029
Tea	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	1.060	.979	1.147	1.132	1.035	1.238	1.147	1.043	1.262
	>29	1.204	1.100	1.318	1.061	.958	1.177	1.084	.972	1.210
Alcohol	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	.595	.551	.641	1.056	.966	1.155	1.132	1.029	1.246
	>29	1.007	.898	1.129	1.258	1.101	1.437	1.383	1.198	1.596

1-Unadjusted OR, 2-OR adjusted for age, gender, ethnicity and education 3-OR adjusted for age, gender, ethnicity, education and BMI

Beverage Consumption and Hypertension (Table 20, page 61): Only diet soda and alcohol consumption had significant relationship with hypertension after adjusting for demographic factors. Additional adjustment for BMI attenuated the relationship of diet soda and enhanced the relationship of alcohol with hypertension. The risk increased with age (OR 2.183 for increase in 10 years of age), and males had a higher risk than females (OR 1.108). Non-Hispanic blacks had almost twice as high risk of hypertension as non-Hispanic whites (OR 2.001)

Table 20
Risk for Hypertension Associated with Beverage Consumption, with and without Adjustment for Demographic Factors and BMI

		OR	95% CI		OR	95% CI		OR	95% CI	
			Lower	Upper		Lower	Upper		Lower	Upper
Diet soda		.982	.967	.996	1.052	1.034	1.070	1.028	1.008	1.047
Regular soda		.863	.848	.879	1.009	.993	1.026	1.008	.990	1.026
Coffee		1.006	.999	1.012	.988	.980	.996	.986	.977	.995
Tea		1.014	1.001	1.028	1.007	.991	1.024	1.007	.989	1.025
Alcohol		.999	.983	1.015	1.028	1.010	1.047	1.043	1.023	1.064
Age					2.109	2.057	2.163	2.183	2.123	2.245
Gender	Male				1.027	.952	1.109	1.108	1.021	1.203
	Female				1	(reference)		1	(reference)	
Ethnicity	Non-Hispanic white				1	(reference)		1	(reference)	
	Non-Hispanic black				2.158	1.954	2.384	2.001	1.798	2.228
	Mexican-American				1.093	.974	1.226	1.006	.889	1.139
	Other				.957	.770	1.188	1.019	.812	1.280
Education	None				1.172	.885	1.552	1.184	.881	1.591
	Elementary school				1.181	.950	1.468	1.135	.900	1.432
	Middle School				1.254	1.032	1.522	1.235	1.003	1.521
	High school				1.426	1.198	1.698	1.357	1.125	1.637
	Undergraduate				1.204	1.002	1.448	1.159	.950	1.413
	Graduate				1	(reference)		1	(reference)	
BMI								1.085	1.077	1.092

Table 21 shows that only moderate tea consumption and heavy alcohol consumption were statistically significant after adjusting for demographic factors and BMI. The risk for hypertension increased with increase in alcohol consumption.

Table 21
Risk for Hypertension Associated with Different Beverage Consumption Categories with and without Adjustment for Demographic Factors and BMI

Drinks in the last month		OR[1]	95% CI		OR[2]	95% CI		OR[3]	95% CI	
			Lower	Upper		Lower	Upper		Lower	Upper
Diet soda	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	1.083	.965	1.215	1.108	.969	1.266	.943	.817	1.088
	>29	1.165	.888	1.529	1.080	.792	1.472	.927	.667	1.287
Regular soda	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	.594	.524	.673	.907	.786	1.047	.913	.783	1.063
	>29	.579	.439	.764	.884	.645	1.212	.905	.648	1.265
Total soda	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	.963	.829	1.119	1.139	.958	1.354	1.105	.918	1.329
	>29	.707	.529	.946	1.340	.961	1.868	1.257	.883	1.789
Coffee	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	.871	.784	.968	.931	.822	1.054	.913	.799	1.044
	>29	1.491	1.392	1.598	.857	.789	.931	.834	.763	.911
Tea	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	1.066	.990	1.149	1.145	1.050	1.249	1.144	1.043	1.256
	>29	1.215	1.115	1.324	1.039	.939	1.150	1.047	.939	1.166
Alcohol	0	1	(reference)		1	(reference)		1	(reference)	
	1-29	.537	.500	.576	.980	.899	1.068	1.076	.981	1.180
	>29	.904	.810	1.008	1.145	1.005	1.306	1.282	1.112	1.477

1-Unadjusted OR, 2-OR adjusted for age, gender, ethnicity and education 3-OR adjusted for age, gender, ethnicity, education and BMI

Beverage Consumption and Systolic Blood Pressure (Table 22, page 63): Multiple linear regression analysis was used to calculate the regression coefficient for beverage use and systolic blood pressure. For Diet soda, coffee, and tea showed negative regression coefficient for systolic blood pressure. Only alcohol had a statistically significant positive

relationship with systolic blood pressure that was consistent even after adjusting for demographic factors and BMI. For BMI, the regression coefficient was .148, indicating that with each increase in 1 point BMI, the systolic blood pressure rises by .148 on an average. Regression coefficient for gender is negative indicating females had a lower systolic blood pressure than males. Similarly, with higher education level, the systolic blood pressure is decreased.

Table 22
Association of Beverage Consumption with Systolic Blood Pressure, with and without Adjustment for Demographic Factors and BMI

	Systolic BP					
	Regression coefficient	P	Regression coefficient	P	Regression coefficient	p
Diet soda	-.037	<.001	.006	.273	-.014	.026
Regular soda	-.123	<.001	.020	.001	.018	.004
Coffee	.040	<.001	-.036	<.001	-.040	<.001
Tea	.006	.407	-.010	.095	-.010	.108
Alcohol	.021	.005	.027	<.001	.035	<.001
Age			.609	<.001	.599	<.001
Gender			-.093	<.001	-.106	<.001
Ethnicity			.018	.005	.013	.053
Education level			-.035	<.001	-.032	<.001
BMI					.148	<.001

Beverage Consumption and Diastolic Blood Pressure (Table 23, page 64): Multiple linear regression analysis was used to calculate the regression coefficient for beverage use and diastolic blood pressure. Table 23 shows the regression coefficients for different beverages, demographic factors, and BMI. Adjusting for BMI attenuated the effects of all of the beverages except alcohol, in which the effect was actually enhanced. On an average, with 1 year increase in age, diastolic pressure rises by .154. Regression

coefficient for gender is negative indicating females had a lower diastolic blood pressure than males. With higher education level, the diastolic blood pressure is increased. With each increase in 1 point BMI, the diastolic blood pressure rises by .246 on an average.

Table 23
Association of Beverage Consumption with Diastolic Blood Pressure, with and without Adjustment for Demographic Factors and BMI

	Diastolic BP					
	Regression coefficient	P	Regression coefficient	p	Regression coefficient	p
Diet soda	.017	.020	.035	<.001	.006	.426
Regular soda	-.021	.003	.005	.528	.007	.374
Coffee	.039	<.001	.015	.040	.014	.055
Tea	.018	.011	.021	.003	.018	.011
Alcohol	.089	<.001	.058	<.001	.067	<.001
Age			.165	<.001	.149	<.001
Gender			-.191	<.001	-.213	<.001
Ethnicity			.034	<.001	.021	.010
Education level			.047	<.001	.053	<.001
BMI					.246	<.001

CHAPTER 5

DISCUSSION

Beverage Consumption:

This study analyzed various beverage consumption patterns in the United States as a whole and in different subgroups. Some interesting facts observed in this study are worthwhile to note. The mean consumption of regular soda relative to diet soda was high in young adults (18-34 years of age), in males (compared to females), in Non-Hispanic blacks and Mexican Americans compared to Caucasians. Consumption of diet soda increased with increasing level of education. The findings suggest that people of different backgrounds may have different awareness about the potential health risk from the consumption of regular or diet soda. Based on the cross-sectional data, this study shows that consumption of diet soda was associated with hypertension, which is consistent with Sansom's report (2005). Many people switched or are going to switch from regular soda to diet soda. However, the health effect of diet soda is largely unknown. Cohort studies to verify the association between diet soda consumption and hypertension is warranted.

Concerning coffee and tea intake, it is observed in the results that Caucasians consumed significantly more servings of these beverages than other races. Similarly, mean alcohol consumption increased as the level of education increased. The findings may be explained by the publicity in mass media on the benefit of moderate alcohol drinking and coffee consumption.

Hypertension:

Some of the findings of this study are consistent with those of earlier studies, such as hypertension prevalence was higher in higher age groups, and males had a higher prevalence of hypertension and high blood pressure than females. The prevalence of adequately treated hypertension was 13.0% and inadequately treated hypertension was 14.8%; thus, more than half of the subjects who were aware of their hypertension did not have their blood pressure in control. Self reported hypertension was more prevalent in females than in males, even though the prevalence of total hypertension was higher in males. The reason for this might be that females were more conscious about their health than males. Likewise, the previously undiagnosed hypertension was around 1.5 times more in males as compared to females (12.4% as compared to 8.6%). Earlier research has not tried to focus on treatment status of diagnosed hypertension and previously undiagnosed hypertension in various population subgroups, except in the study done by Garrison et al., 1987. The study by Garrison observed that hypertension treatment rate for the diagnosed hypertension was higher in females than in males. This finding is consistent with the result of this study. These results warrant that the campaigns for hypertension awareness should specifically address issues concerning males, and research should be done to evaluate the discrepancy between the hypertension awareness between males and females.

The prevalence of adequately treated hypertension was highest in the age group 50-64, after that the prevalence was successively decreased in age groups 65-74 and 75-

90, despite the fact that the total hypertension prevalence increased in these age groups. In clinical practice, adequately treated hypertension may not be required to reduce SBP below 140 and DBP below 90, particularly for old people, and age is positively associated with blood pressure. This may cause less adequately treated (defined as in this study) proportions among old age groups. Nevertheless, the higher rates of previously undiagnosed and inadequately treated hypertension in these age groups might be reflected as higher rates of complications of hypertension including cardiovascular and cerebro-vascular diseases. This issue should be further evaluated.

Another serious concern is for people with lower education. The hypertension prevalence is quite high in the people with less than high school education (43.1-45.9%) as compared to the people with high school or higher education (24.2-29.9%). Prevalence of previously undiagnosed hypertension is also significantly greater in these people (13.6-17.4%) as compared to the more educated people (7.7-9.7%). Such disparity has not been identified in the previous research. Public health policies should address this disparity.

Beverage Consumption and Hypertension

Soda Consumption and Hypertension: In one earlier study done on 155,594 women by Winkelmayer et al., 2006, both regular and diet soda consumption were found to be associated with hypertension, but this study showed different results for regular soda consumption. The prevalence of hypertension was greater in people who consumed higher amount of diet soda. After adjusting for demographic factors, diet soda consumption was found to be associated with hypertension and systolic and diastolic blood pressures. The opposite association was observed for regular soda. The

hypertension prevalence decreased with increase in regular soda consumption. The association of regular soda consumption with hypertension and systolic and diastolic blood pressures were not statistically significant. So, research is needed to further evaluate the relationship between type of soda and hypertension to evaluate whether people tend to change their soda consumption after knowing about their hypertension status, or diet soda or some of its component may increase the risk for hypertension.

Coffee Consumption and Hypertension: The association of coffee with diastolic blood pressure is consistently significant, and with increase in coffee consumption, the diastolic pressure increases. In this study also, the consumption of coffee is not statistically associated with hypertension, which was observed in many previous studies. If rise in diastolic pressure associated with coffee consumption is true, reduction in coffee consumption might be needed. Wilkelmayer et al., (2006) did not find increased risk of hypertension with coffee consumption. Klag et al., (2002) showed that with consumption of one cup of coffee significantly raised systolic and diastolic BP by 0.19 and 0.27 mm Hg, respectively, but in that study after multivariate adjustments, the effect of coffee on hypertension was not statistically significant.

Tea Consumption and Hypertension: Tea consumption was also found to be associated with higher risk of hypertension, the finding that is contradictory to the finding that tea is protective for blood pressure in many studies. In the study done by Stensvold et al., (1992), the tea consumption was found to be inversely related to systolic blood pressure. In this study, less consumption of tea (<1 drink/day) showed reduction in systolic blood

pressure, but more than one drink/day tea consumption was associated with higher prevalence of blood pressure. Diastolic blood pressure increased progressively with increase in tea consumption. Most of the studies showing protective effects of tea on hypertension are done outside U.S. The components and consumption pattern of tea in the U.S. differs from that of Norway (Stensvold, 1992) and Australia (Hodgson, 2005).

Alcohol Consumption and Hypertension: In a Japanese study, both the systolic and diastolic blood pressures were progressively higher with higher intake of alcohol (Tsuruta et al., 2000). The findings of this study are consistent with the previous studies. The effect is observed after adjusting for demographic factors (age, gender, ethnicity, and level of education) and even after adjusting for BMI. Reduction in alcohol consumption should be recommended in hypertensive patients.

Modifying Effect of BMI on Beverage Consumption and Hypertension: In literature, BMI is linked with hypertension and the findings of this study show the same association. Inclusion or exclusion of BMI in the analysis could be very important because the beverage consumption has some weight increasing effect. After adjusting for BMI, the effect of most of the beverages on hypertension was attenuated, except that of alcohol, which indicates that body mass could be an intermediate variable in the association between beverage use and hypertension. The effect of alcohol on hypertension is enhanced by BMI.

Limitations of the Study

This study used the survey data from NHANES III. The study findings may be liable to recall bias. For example, the subjects might not remember accurately the type and quantity of beverages they consumed in the last month. Because of the cross sectional nature of the data, the temporality of an association detected can not be obtained. Therefore, it is difficult to determine the direction of a possible causation from an association. For example, a higher level of regular soda consumption was associated with a decreased prevalence of hypertension. This may have resulted from people's reduced consumption after having a hypertension diagnosis rather than from a protective effect of regular soda consumption on hypertension risk. However, the temporality of the relationship can not be resolved from the cross sectional data. Finally, the NHANES III data were collected more than 10 years ago. The results may not reflect well the current situation in the United States. For example, there have been changes in the types of artificial sweeteners (saccharin, aspartame, acesulfame, and sucralose) used in diet soda since NHANES III (Mackenzie et al., 2006), which could not be addressed in our study. Newer NHANES surveys were not used for this study because they did not collect information of beverage consumption other than milk.

Strengths of the study

This study used a nationwide sample with a large sample size. Therefore, the findings from this study could have a very good external validity. The study may be the first of a kind to simultaneously analyze different beverage consumption patterns in a national sample. Stratified analysis of hypertension prevalence in various subgroups

especially for undiagnosed hypertension and analysis of treatment status of hypertension is also a distinguishing aspect of this study. The findings of this study might induce more research attention to beverage consumption and provide preliminary data for future studies with better research design such as cohort studies.

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APPENDIX

Variables Pooled from NHANES Database

Adult Data File

Sequence number ..... SEQN 1-5

Sex ..... HSSEX

Age at interview (screener) -qty ..... HSAGEIR

Race ..... DMARACER

Ethnicity ..... DMAETHNR

Highest grade or yr of school completed HFA8R 1256-1257

Doctor ever told had hypertension/HBP HAE2 1598

Now taking prescribed medicine for HBP HAE5A 1610

Average K1 BP from household and MEC HAZMNK1R 3337-3339

Average K5 BP from household and MEC HAZMNK5R 3342-3344

Diet colas, diet sodas, etc -times/mo HAN6DS 2149-2151

Regular colas and sodas -times/month HAN6ES 2152-2155

Regular coffee -times/month HAN6FS 2156-2159

Regular tea -times/month HAN6GS 2160-2163

Beer and lite beer -times/month HAN6HS 2164-2166

Wine, etc -times/month HAN6IS 2167-2169

Hard liquor -times/month HAN6JS 2170-2172

Exam Data File

Sequence number ..... SEQN 1-5

Race ..... DMARACER 13

Ethnicity ..... DMAETHNR 14

Sex ..... HSSEX 15

Age at interview (Screener) ..... HSAGEIR 16-17

Overall average K1, systolic, BP(age 5+) PEPMNK1R 1423-1425

Overall average K5, diastolic, BP(age5+) PEPMNK5R 1428-1430

Standing height (cm) (2 years and over) ..... BMPHT 1528-1532

Weight (kg) (2 months and over) ..... BMPWT 1508-1513

Body mass index ..... BMPBMI 1524-1527

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