PREVALENCE OF ELEVATED BLOOD PRESSURE LEVELS IN OVERWEIGHT AND OBESE YOUNG POPULATION (2 – 19 YEARS) IN THE UNITED STATES BETWEEN 2011 AND 2012

By:

Lawrence O. Agyekum

A Dissertation Submitted to Faculty of the School of Health Related Professions, Rutgers, The State University of New Jersey in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Biomedical Informatics

Department of Health Informatics

Spring 2015

RUTGERS
School of Health Related Professions

Final Dissertation Approval Form

PREVALENCE OF ELEVATED BLOOD PRESSURE LEVELS IN OVERWEIGHT AND OBESE YOUNG POPULATION (2 – 19 YEARS) IN THE UNITED STATES BETWEEN 2011 AND 2012

BY

Lawrence O. Agyekum

Dissertation Committee:

Syed Haque, Ph.D., Committee Chair

Frederick Coffman Ph.D., Committee Member

Shankar Srinivasan, Ph.D., Member

Approved by the Dissertation Committee:

_____ Date: _____

_____ Date: _____

_____ Date: _____

ABSTRACT

Prevalence of Elevated Blood Pressure Levels in Overweight and Obese Young Population (2 -19 Years) in the United States between 2011-2012

By

Lawrence Ofori Agyekum

Several studies have reported hypertension prevalence in children and adolescents in the United States (US) using regional or local population-based samples but few have reported national prevalence. The present study estimates national hypertension prevalence in US children and adolescents for 2011-2012. A convenient sample size of 4,196 (population aged ≤ 19) representing 43% of 9,756 (total survey respondents) was selected and stratified by age groups; "Children" and "Adolescents" using the 2007 Joint National Committee recommended definitions. Next, hypertension distribution was explained by gender, race, age, body weight, standing height and blood serum total cholesterol. Variations in BP levels were measured and expressed in percentiles for nominal variables and by means and standard deviations for continuous variables. Estimated national hypertension prevalence in the US for the 2011-2012 analysis period were 3% in children aged (2<=11 years) and 14% in adolescents aged (12<=19 years). Rates were highest among adolescent boys (4%) stage 1 and (7%) stage 2 and lowest among adolescent girls (2%) stage 1 and (0.86%) stage 2. Adolescent Blacks had highest relative rate (21% SE <1) compared to lowest rate of 8% in Non-Hispanic Asians. The highest BP risk factor was body weight with a t-value of 7.75 and (p<.0001). 05 significance. In conclusion, 4 of 10 (46%) US adolescents who had hypertension were either overweight or obese. The findings in this report suggest that overweight and obese children and adolescents might have increased risk of hypertension. Therefore,

interventions that decrease obesity in children such as healthy eating and good exercise and those that decrease elevated BP levels in children and adolescents must be broad based and focused on children and adolescents at the risk of high BP. The major limitation of this study is that regression models used in this study assume constant variability across subpopulations and constant time between analysis periods. Therefore, interpretation of estimates from this study must be made only after a careful consideration of the methods used. The results confirm hypertension risk in children with associated prevalence of obesity. Therefore, comprehensive hypertension intervention programs can positively improve population health. Future studies should focus on assessing the impact of intervention programs.

Keywords: Pediatric hypertension, hypertension and obesity, hypertension prevalence in children, hypertension definition in children, blood pressure measurement in children, hypertension risk factors.

ACKNOWLEDGEMENTS

There are many people who contributed their time, shared their knowledge and experiences to make this work successful. I would like to thank Faculty of the Department of Health Informatics, Rutgers School of Health Related Professions for their support and encouragement. Especially, Drs. Syed Haque, Frederick Coffman and Shankar Srinivasan for their enormous help and counseling accorded me throughout this research process. Special thanks goes to Ms. Kim Gadsden-Knowles, Associate Science Director for the Division of Health Informatics, Centers for Disease Control and Prevention (CDC), for her invaluable technical guidance and patience during on-site supervision. This work would not have been successful without Drs. Haque and Srinivasan and Ms. Gadsden-Knowles's expertise and meaningful contributions. I also want to thank Ms. Yvonne Rolley and all staff of the Department of Health Informatics for their enormous assistance in coordinating counseling sessions.

This work is dedicated to my spouse Margie Enele and two sons Clifford and Michael Agyekum whose love and support strengthened me to go through tedious days and nights of extensive reading in conducting this research and preparing this report.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF EQUATIONS

CHAPTER I

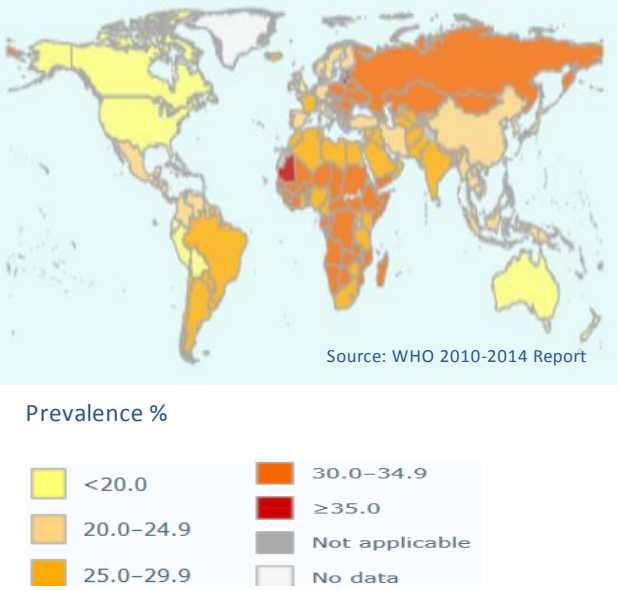
INTRODUCTION

1.1 Statement of the Problem

While hypertension awareness, treatment, and control in adults have improved in the past 10 years, its prevalence in children and adolescents is on the rise. [1] The rising number of hypertension cases in children and adolescents will result in rising number of associated risk factors and cardiovascular morbidity and mortality rates. Blood pressure (BP) has remained a major risk factor for cardiovascular diseases and mortality. [2] High blood pressure also known as hypertension has been identified as the leading cause of death among all cardiovascular diseases, and was ranked third as a cause of disability-adjusted life-years. [3] Hypertension strains the heart and damages the blood vessels. Severe hypertension conditions can accelerate development of other complications.

Figure 1:

Prevalence of Elevated Blood Pressure*, Ages 18+, 2010-2014
(Age Standardized Estimate)
***Systolic Blood Pressure ≥ 140**
And Diastolic Blood Pressure ≥ 90 Mmhg.



At the global level, the predicted number of adults with hypertension is estimated to increase by 60% to a total of 1.56 billion by the year 2025.[4] Figure 1 beside, shows the distribution of age-adjusted global prevalence of elevated blood pressure levels for 2010-2014.

According to the American Heart Association, about 78 million adults as of 2014 were diagnosed with hypertension. Evidence from previous studies has shown that adult cardiovascular diseases can be traced back to childhood hypertension. [5] In children and adolescents, hypertension directly causes end-organ damage, primarily, left ventricular hypertrophy which can be associated with early atherosclerotic changes. [6] Over the past years, persistent high blood pressure has been far more common with adults but the rate among children is on the rise. An estimated 3% of children between the ages of 6 - 12 years have high blood pressure. Evidence show that high BP from childhood is associated with cardiovascular diseases risk factors such as hyperlipidemia and diabetes mellitus in adulthood. [7-8]

1.2 Historical Background

Increasing rates of new and existing hypertension conditions in children and adolescents have been observed worldwide.[9-11] Several population-based cross sectional studies conducted in persons aged 19 years and younger reported findings of associations between elevated blood pressure levels and risks factors such as body weight, standing height, blood serum cholesterol levels, age, sex and race. However, submitted evidence have focused on local and regional population-based samples. [12-14] Although blood pressure risk factors in children are well familiar,[15-16] variability exist in the assessments of hypertension in children.[17,18] Since systemic blood pressure gradually increases with age and correlates with weight and height throughout childhood and adolescence, reference standards have been used to define, measure and interpret blood pressure values obtained during physical examinations. In 2004 for example, the National Blood Pressure Education Program also known as the "Working Group" released blood pressure data on

children. The release classified high blood pressure levels for population (2-17 years) as "children" and "adolescents". Later in 2007, the Working Group introduced the concept of "pre-hypertension" to re-classify blood pressure in children and adolescents. (See Table 1 on Page 4). By changing the definition of early hypertension, the Working Group is believed to have increased hypertension awareness and created efforts to improve communication about the condition in children. The use of break-points to determine hypertension severity levels has been associated with percentiles for age and height. Although the 2004 hypertension norms in the US were determined by using data on more than 60,000 children, the group's update included data from the 1999-2000 NHANES survey. The Working Group published normative percentiles for hypertension categories in children. These were the 50^{th}, 90^{th}, 95th, and 99^{th} percentiles for systolic and diastolic blood pressure in children (Aged 2-17) who are at the 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, and 95^{th} percentiles for height. (See Appendix A, Tables 42 and 43).

The usefulness of identifying children with high blood pressure has been challenged.[19-20] However, evidence suggest the presence of end-organ damage at the time of diagnosis in most children. It is therefore critical to guide the determination of high blood pressure in children by severity levels. More likely than not, definable cause of high blood pressure levels are identified in younger children than in older children. For instance, children who are 10 years and older are less likely to develop definable hypertension (primary hypertension) than secondary hypertension based on several risk factors such as obesity and family history. As a result, some studies [21] have suggested that ascertainment of blood pressure elevation in children should include a child's medical history, prescribed medication, family history, sleep patterns, diet and

Table 1

Classification of Hypertension in Children and Adolescents with Measurement Frequency and Therapy Recommendations

	SBP or DBP Percentile*	Frequency of BP Measurement	Therapeutic Lifestyle Changes	Pharmacologic Therapy
Normal	<90th	Recheck at next scheduled physical examination.	Encourage healthy diet, sleep, and physical activity.	—
Prehypertension	90th to <95th or if BP exceeds 120/80 mmHg even if below 90th percentile up to <95th percentile†	Recheck in 6 months.	Weight-management counseling if overweight, introduce physical activity and diet management.‡	None unless compelling indications such as CKD, diabetes mellitus, heart failure, or LVH exist
Stage 1 hypertension	95th percentile to the 99th percentile plus 5 mmHg	Recheck in 1–2 weeks or sooner if the patient is symptomatic; if persistently elevated on two additional occasions, evaluate or refer to source of care within 1 month.	Weight-management counseling if overweight, introduce physical activity and diet management.‡	Initiate therapy based on indications in Table 6 or if compelling indications as above.
Stage 2 hypertension	>99th percentile plus 5 mmHg	Evaluate or refer to source of care within 1 week or immediately if the patient is symptomatic.	Weight-management counseling if overweight, introduce physical activity and diet management.‡	Initiate therapy.§

BP, blood pressure; CKD, chronic kidney disease; DBP, diastolic blood pressure; LVH, left ventricular hypertrophy; SBP, systolic blood pressure

* For sex, age, and height measured on at least three separate occasions; if systolic and diastolic categories are different, categorize by the higher value.

(Adapted from: The 4TH report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. US Department of Health and Human Services. National Institute of Health. Revised: May 2005;05-5262.)

activity level. Others have suggested that clinicians should consider a patient's use of stimulants for the treatment of attention deficit disorders which in some individuals tend to increase blood pressure although studies[22] have shown evidence of only 5 mmHg or less. The caveats for screening children with extremities of both systolic and diastolic blood pressure to determine risk of blood pressure coarctations have been supplemented over the course of years by the Working Group and much of the evidence submitted by subsequent studies have been based on these blood pressure caveats. For example, blood pressure examination procedures such as: evaluation of coexisting conditions (fasting lipid panel and blood glucose); evaluation of target-organ damage (echocardiography); retinal examination, ambulatory blood pressure monitoring; determination of plasma renin activity or level (to determine aldosterol level); renovascular imaging or isotopic scintigraphy; plasma and urinary steroid levels and urinary catecholamines have been useful in generating sufficient evidence that suggested prevalence of high blood pressure levels in children and adolescents.

There is no consensus on best approaches to address areas of uncertainties associated with blood pressure determination for coarctations in children. Some studies have reported challenges such as existence of sparse longitudinal data regarding outcomes in children with hypertension partly due to the lack of data from clinical trials for tracking long term intervention effects, adherence to medication, maintaining lifestyle changes and effective strategies for improving adherence. The present analysis does not suggest identification of possible reasons that might explain or fill gaps to prove existence of sparse longitudinal data. This is because, the NHANES was designed to capture indicators for measuring health status of US civilian population.

The American Academy of Pediatrics (AAP) recommends routine measurement of a child's blood pressure at every visit starting at age 3. Per the AAP's recommendation, one elevated blood pressure reading is not sufficient to diagnose a patient with hypertension. Rather, blood pressure readings must show sustained elevations and must be taken more than once. Only then can a patient be diagnosed with tentative high blood pressure. In addition, the AAP further recommends that blood pressure readings for children with congenital heart disease, birth complications, urinary tract infections or malignancy should start at an earlier age than 3. By thinking differently, breaking the paradigms towards having generally acceptable forms of high blood pressure diagnosis in children can boost collective efforts to tackle some of the toughest challenges encountered during the planning and implementation of blood pressure intervention programs in public health.

It is an overstatement to emphasize that a national commitment to deliver exceptional care by pediatricians to reduce occurrences of high blood pressure in children extends to the quality of diagnosis. One school of thought is that blood pressure monitoring in children does not begin at the point of care and does not end when patients leave the point of care. Rather, it encompass holistic evaluation of historical, current and potential developments/signs of congenital heart problems (born with a problem in the structure of one's heart). While some congenital heart defects in children such as a small hole between the heart chambers can close on its own, others tend to be more complex and may require series of surgeries performed over a time period. High blood pressure in children with congenital problems if identified early can help avoid further complications. It was therefore reasonable for the AAP to have recommended early

screening of blood pressure associated risk factors for all children who present with congenital heart diseases, birth complications, urinary tract infections or malignancy to start at an earlier age than 3. Early screening is a central view of preventive cardiology in which clinicians identify and medically manage blood pressure risk factors particularly abnormal cholesterol and excess weight in children that eventually lead to cardiac events in adulthood. Controlling blood pressure risk factors during childhood helps to reduce cardiovascular diseases later in life. As good practice, the issuance of appropriate standards to help in determining effective ways of measuring and monitoring blood pressure to efficiently evaluate and treat hypertension risk in children cannot be ignored. Public health resonates very well with the concept of preventive cardiology especially in advocating for young patient management through comprehensive intervention programs. Through the use of multidisciplinary approach, clinicians develop comprehensive plans for children based on underlying causes of their abnormal cholesterol or blood pressure to include a weight loss component that incorporates healthy eating and exercise. Multidisciplinary approaches have included provision of a carefully coordinated specialty care to serve multiple needs of individuals with varieties of cardiac genetic conditions. As of today, blood pressure diagnostic modalities and related risk factors have well been documented and practitioners can access latest updates from a vast network of multi-specialty care.

Methods used to take blood pressure readings in children for the NHANES are consistent with methods of additional evaluation during which ambulatory blood pressure monitoring occurs. For instance, in order to ensure careful and accurate measurement of blood pressure readings for the NHAHES, four separate readings are taken at different

times to determine whether there is sustained elevation of blood pressure in children. Oscillometric devices are used to take blood pressure readings for those who participate in the NHANES. If readings are found to be high, manual measurements are obtained with appropriate-sized cuffs. Taking a patient's blood pressure reading this way helps to avoid abnormal diurnal blood pressure patterns also known as "white-coat" or stress related blood pressure. Blood pressure readings in the NAHANES are therefore reliable and useful for conducting analysis to estimate national hypertension prevalence in children in the United States. The NHANES did not provide information on probable cause of blood pressure extremities. Therefore, the results from this analysis cannot be interpreted to suggest any indication of rapid evaluation. Adding to this, there was no sufficient information in the NHANES to indicate ambulatory blood pressure monitoring (which is elevated blood pressure most of the time) or white coat (which is elevated blood pressure in the physician's office but normal elsewhere), except for four repeated blood pressure readings which imply that ambulatory blood pressure evaluation was conducted. However, the NHANES gave a variable for masked blood pressure variance (which is normal blood pressure in the physician's office but elevated somewhere else).

1.3 Study Purpose, Goals and Objectives

While evidence of hypertension prevalence have been well recorded previous study analysis have focused on local and regional population-based samples.[4] Conducting a new study to estimate current national hypertension prevalence in children and adolescents in the United States using the most recent data from a nationally representative population-based survey cannot be underestimated. The proposed study results will inform decisions around strategizing approaches to improve population

health.[23] Therefore, the study goal was to estimate current national prevalence of elevated blood pressure in US children and adolescents and to determine the distribution of the disease. Specific objectives were to:

1. Identify and apply validated high blood pressure definitions, measurements and evaluation techniques and apply them to descriptive and comparative analysis;
2. Determine the distribution of elevated BP in US children and adolescents for 2011 - 2012; and
3. Estimate the likelihood of BP occurrence in US children and adolescents based on their demographic characteristics.

1.4 Study Hypothesis

The underlying assumption for conducting this secondary analysis was that:

'Being an overweight or obese child or adolescent increase the risk of hypertension"

To test the above presumptive statement, an analytic model was used to determine whether acceptance or rejection of the assumption was influenced by other predictors such as age, race, body measurement, and total blood serum cholesterol. If so, what was the magnitude of the associations between blood pressure and its risk factors among children and adolescents in the US? The following precise questions were addressed:

1. Among US children and adolescents, what was the highest risk factor contributing to elevated blood pressure?
2. Was total blood serum cholesterol a good predictor of elevated blood pressure levels in US children and adolescents?
3. What is the likelihood of high blood pressure in children versus adolescents, boys versus girls, and one race versus the other?

4. Is NHANES data sufficient to sample only children and adolescents to estimate national hypertension prevalence in children?

1.5 Study Significance

The present analyses include the latest two years of NHANES data which provide new insights into the degree of hypertension conditions in overweight and obese US children and adolescents. Estimation of hypertension prevalence by several studies have been conducted based on local and regional population-based samples. Little is known about the national prevalence determined from a nationally representative population-based survey such as the NHANES. It is imperative to explore the use of data from the NHANES to estimate the current national hypertension prevalence in overweight and obese US children and adolescents; and to determine extent of the associations between childhood obesity and the risk of hypertension. Results from the study will be useful for informing decisions around the establishment of comprehensive programs aimed at reducing the increasing rate of hypertension conditions in children and adolescents which is also responsible for type 2 diabetes. More so, by identifying segments of US children and adolescents who are at the risk of developing hypertension will facilitate proper evaluation required for preventing serious long-term complications associated with hypertension. In addition, early intervention can help prevent high blood pressure complications such as left ventricular hypertrophy and atherosclerosis.[24-25]

The present study tests the effectiveness of previous concepts, theories, principles, definitions, and appropriate blood pressure measurement and data analysis techniques to further conceptualize the underlying framework of blood pressure modalities for further research. As such, blood pressure measurement, identification of well-known severity

thresholds and implications from applied concepts should be well understood. The present study also provides critical pathways to effective, consistent and better fit models for data analysis. The results will be useful for determining extent of the disease and economic burden of hypertension in US children and adolescents. This can trigger discussions around new policy formulation and allocation of economic resources.

1.6 Related Theories

Over two decades ago, Barker et al. (1989) [26] developed a concept known as the "fetal origins of adult disease" (FOAD) or "fetal programming" to describe the relationship between birth size and subsequent risk of cardiovascular disease and insulin resistance (Type 2 diabetes mellitus). Some criticized the concept on the grounds that the answers lay within genetics and the gene. Other critics said Barker's original epidemiological interpretations were flawed. As of today, it is apparent that the landmark observation (Barker's concept) had far-reaching implications when it comes to human health and lifestyle choices. The FOAD has explained the rapid societal rise in diabetes and obesity and has covered areas such as osteoporosis, depression and sedentary behaviors. From the wisdom of hindsight, it is now clear that the underlying causes of chronic diseases such as heart disease, diabetes and stroke could not be solely explained by genetic inheritance and lifestyle behavior such as diet and exercise but also gene-environment interactions. The FOAD now known as "developmental origins of adult disease" (DOHaD) has taken into account its influence over an expanded period of time-frame. The evolution of human health and disease has attracted a new way of thinking which others refer to as "predictive adaptive response". As a marker of hypertension conditions in children and adolescents, birth size was never really considered causal in

the pathway to heart disease risk. Birth size has always been misunderstood by both critics and supporters alike since it has been known to have its own limitations. Some critics have explained that age and growth are both influenced by environmental and genetic factors. Nevertheless, birth size and weight continue to remain the most accessible parameters to consider in the assessment of early developmental risk factors for hypertension. An alternative hypothesis to the FOAD is that both small size at birth and later disease have a common genetic aetiology. Adding to low birth weight, maternal obesity and gestational diabetes can occur as a result of fetal "over nutrition" and eventually lead to an increased risk of later obesity and type 2 diabetes. The evidence show that accelerated body mass index gained during childhood, and adult obesity, are additional risk factors for cardiovascular disease and diabetes.

One theory known as the "Mosaic" suggests that, after an existing factor acts to raise an outcome (blood pressure), multiple factors may sustain the elevation. Even though the Mosaic Theory did not specify age and growth as conditions under which the statement can be true, related risk factors such as body weight and standing height can be explored to test the concept. It wasn't contentious for a previous study's conclusion to suggest that excess weight increases strain on the heart, raises blood cholesterol and triglyceride levels, and lowers good cholesterol (HDL) levels. The present study attempted to validate the associations between body weight, blood serum total cholesterol and blood pressure in children to determine the associated risk factor-to-blood pressure probabilities in population aged 2-19 years. By classifying the study population into "children" and "adolescents" as suggested by the Working group (The 4th Report), this paper sought to determine whether elevated blood pressure will be sustained from

childhood to adolescence after weight, height, and high bad cholesterol trigger the elevation.

1.7 Intended Results

The intended goal was to estimate current national hypertension prevalence in overweight and obese US children and adolescents for 2011-2012 using sample from the NHANES. Specific objectives were to determine whether the NHANES has sufficient data to sample only children and adolescents to estimate national hypertension prevalence; whether with a nationally representative sample of young population (aged 2-19 years), the relationship between obesity and elevated blood pressure levels will be evident; whether high densities of lipoprotein cholesterol levels in children will correlate with elevated high blood pressure levels; whether there was an interplay between elevated blood pressure levels, age, gender and race/ethnicity; whether the analysis would help determine the highest risk factor/predictor for hypertension in children other than obesity; and whether sufficient evidence could be generated to test the effectiveness of previous concepts, theories, principles, definitions, and appropriate blood pressure measurement and data analysis techniques to further conceptualize the underlying framework of blood pressure modalities for further research.

Intended analytical models were: logistic regression to evaluate the relationship between nominal variables, and the multivariate linear regression to evaluate the relationship between elevated blood pressure levels, lipoprotein cholesterol levels and obesity. In the end, the submitted presumptive statement was: "**Being an overweight or obese child or adolescent increases the risk of developing hypertension**"

CHAPTER II

RELATED LITERATURE

2.1 Disease and Economic Burden of High Blood Pressure

Hypertension or persistent high blood pressure is a major risk factor for cardio vascular and kidney diseases in the world.[27] According to the World Health Organization (WHO), one billion hypertension conditions worldwide lead to heart attacks and strokes of which 9.4 million deaths occur every year.[28-29] The report also identifies hypertension to have accounted for at least 45% of all deaths from heart diseases and 51% of deaths from stroke in 2013. Cardiovascular diseases in general account for more than 30% of all deaths worldwide. The Harvard School of Public Health assessed the global economic burden of non-communicable diseases (NCDs) in 2011. [30] In its review, the school reported an estimate of $63 trillion representing more than 75% total loss to the World's Gross Domestic Product (GDP) from NCDs in 2010. Cost tally of major NCDs revealed that, cost estimates of NCDs will increase from $863 billion in 2010 to $1.04 trillion by 2030. Regardless of the several notable global and regional efforts to reduce incidences of hypertension, the condition continues to remain a major challenge to both wealthy and resource-challenged nations. In terms of losses from man hours, it was reported that men with NCDs such as cardiovascular diseases worked 6.1% fewer hours and women with NCDs worked 3.9% fewer hours in 2011. [31] Although hypertension risk factors appear to be more common in developing countries than developed countries, the macroeconomic impact of hypertension risk factors such as diabetes is generally large. For example, a release in 2010 by the US Institute of Medicine (IOM) concluded that annual estimates of direct medical cost of obesity-related conditions, coronary heart diseases, hypertension

and stroke range between $ 3 billion and $ 72 billion in treatment and productivity losses for China and Brazil. [32-33] The total global expenditure on health in 2009 was reported as $5.1 trillion. However, the entire annual GDP of low income countries was reported to be less than $1 trillion.[34]

In the US, one in every three American adults has high blood pressure (HBP) representing 31% (67 million of the total population) with more than 348,000 deaths.[35] Between 1999-2006, seven percent and 14% of all US adolescents aged 12-19 years were reported to have pre-hypertension and hypertension conditions respectively. [36] Over the past years, persistent high blood pressure has been far more common with adults but the rate among children is on the rise. An estimated 3% of children between the ages of 6 - 12 years have high blood pressure. The annual economic burden of HBP in the US was projected at $93.5 billion in healthcare services, medications and missed days of work in 2010. [37] Chronic heart failure, first heart attack and stroke have significantly been associated with high blood pressure. [38]

2.2 Surveillance Definitions for Hypertension Prevalence and Control in Adults

Appropriate and consistent definitions of hypertension are crucial to guide diagnosis, treatment and surveillance. A variety of definitions have been used in the past which have resulted to variations in reported hypertension prevalence even when same datasets are used. Crim et al. (2012) [39] assessed the variety of published hypertension surveillance definitions and reported rates of prevalence based on studies that used NHANES data from 2003-2004 survey cycle. The authors identified 19 studies to have used different criteria and parameters for defining and measuring hypertension for

subpopulations. The reported age-standardized hypertension prevalence rate ranged from 28.9% to 32.1% and hypertension control from 35.1% to 64%. (See Table 2 below)

Table 2:

Crude and Age-Adjusted Hypertension Prevalence: NHANES 2007-2008 (N=5645)

Hypertension Prevalence	Crude % (SE)	Age Adjusted With 3 Age Groups, % (SE)*	Age Adjusted With 4 Age Groups, % (SE)†
RD for hypertension‡	30.7 (0.89)	29.6 (0.65)	29.8 (0.62)
RD including pregnant women	30.4 (0.9)	29.5 (0.65)	29.7 (0.62)
RD including individuals who have ever been told§	36.2 (1.04)	35.1 (0.71)	35.2 (0.78)
RD including individuals who have been told twice‖	34.0 (0.99)	33.0 (0.66)	32.9 (0.73)
RD excluding first blood pressure measurement¶	30.4 (0.89)	29.3 (0.63)	29.4 (0.60)

NHANES indicates National Health and Nutrition Examination Surveys; RD, recommended definition.

*Percentages were age adjusted to the 2000 US standard population (age groups of 18–39, 40–59, and ≥60 years).

†Percentages were age adjusted to the 2000 US standard population (age groups of 18–39, 40–59, 60–74, and ≥75 years).

‡The RD for *hypertension* was systolic blood pressure (SBP) ≥140 mm Hg, diastolic blood pressure (DBP) ≥90 mm Hg, or taking antihypertensive medication, averaging all blood pressure measurements.

§Defined as SBP ≥140 mm Hg, DBP ≥90 mm Hg, taking medication, or ever been told that they have hypertension.

‖Defined as SBP ≥140 mm Hg, DBP ≥90 mm Hg, taking medication, or told ≥2 times that they have hypertension.

¶If there were 2 measurements, exclude the first measurement; if there were all 3 measurements, average the second and third measurements.

(Adapted from: Crim MT, Yoon SS, Ortiz E et al. National surveillance definitions for hypertension prevalence and control among adults. Circulation: Cardiovascular Quality and Outcomes. 2012;5:343-351.)

They then assessed the effects of varying definitions of hypertension, parameters of age adjustment, and the inclusion of subpopulations on NHANES data from both 2007-2008 and proposed for standard surveillance definitions and age adjustments parameters to be put in place for hypertension and hypertension control. By using their recommended approach with 2007-2008 NHANES data, the age-standardized prevalence of hypertension in the United States was 29.8% with a standard error of 0.92% and the rate

of hypertension control was 45.8% with a standard error of 4.03%. The authors concluded that, surveillance definitions of hypertension and hypertension control vary in literature therefore meaningful comparisons and monitoring of hypertension trends in adults basically depends on standard definitions and parameters for age-adjustments.

Estimation of disease prevalence can be made from the NHANES utilizing clinically-based assessments. In accordance with the American Heart Association recommended protocol released since 1999 [40] blood pressure measurement have been strictly standardized for the NHANES.

2.3 Definition of Hypertension: Perspectives from the 2007 Joint National Committee (JNC 7) Release

The American Society of Hypertension Working Group came up with a new definition of hypertension [41] after the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure was released. [42] (See Table 3 below).

Table 3:

Classification of Blood Pressure (BP) by the JNC 7

Classification	Systolic BP (mmHg)	Diastolic BP (mmHg)
Normal	< 120	And < 80
Prehypertension	120-139	Or 80-89
Stage 1 hypertension	140-159	Or 90-99
Stage 2 hypertension	>= 160	Or >= 100

BP, blood pressure.
Data from National Heart, Lung, and Blood Institute: www.nhlbi.nih.gov/guidelines/hypertension/ (accessed April 25, 2013).

The new definition reclassified hypertension solely by discrete blood pressure thresholds. This is implied that hypertension is a high risk state without high blood pressure. Some have argued that although the definition seems to provide a forward motion, the approach has limited its usefulness. Critics of the new definition are of the view that hypertension is a progressive cardiovascular syndrome determined by early markers which are often present before blood pressure elevation is observed. Therefore, by defining hypertension solely by discrete blood pressure thresholds, there is the likelihood to conclude that individuals who have several traits that predict, with varying certainty, that stroke, cardiac disease, or renal failure are more likely to occur in their future. To imply that hypertension is solely a high risk factor is medically incorrect because it presents a state of vague hypertensive conditions in individuals who never had increased blood pressure. [43] There are gray zones near this consensus-derived thresholds. To label any adult as hypertensive with an average blood pressure of 125 mmHg without considering other potential risk factors is inaccurate. This is because, blood pressure levels may be due to inherent variability within an individual and certainly in populations as well. The critics conclude that, for appropriate evaluation of an individual's risk of developing a cardiovascular disease, several risk factors must be merged to provide a comprehensive approach of determining levels of risk rather than basing definitions solely on blood pressure thresholds.

Based on JNC 7 (in Table 3), individuals with sustained blood pressure elevations are further categorized into stage 1 and 2 hypertension. The JNC 7 recommended blood pressure reduction goal of <140/90 mmHg for patients with hypertension and even more intense blood pressure reduction goal of <130/80 mmHg for patients with diabetes and

kidney disease. However, recent clinical trials performed in patients with diabetes and kidney diseases have failed to demonstrate the clear benefits of intense clinical trial reduction. For example, the Hypertension in the Very Elderly (HYVET) trial was conducted to determine whether anti-hypertensive therapy in older patients with hypertension will decrease the risk of developing severe hypertension. [44] The results were that, lowering blood pressure in patients with hypertension lowered the risk of both stroke and all-cause mortality. While the HYVET seemed to have proven associations between blood pressure reduction in the elderly and decreased blood pressure levels, another trial failed to prove any associated benefits with intense blood pressure reduction in hypertensive patients with kidney disease. [45] This is indicative that defining hypertension solely based on blood pressure risk factor thresholds is misleading. In another trial known as "Action to Control Cardiovascular Risk in Diabetes (ACCORD),[46] hypertensive patients with diabetes who were treated to lower-than conventional blood pressure goals did not show any benefits of lowering blood pressure levels in these patients. The new information according to the experts will be addressed in JNC 8.

An estimated 70 million Americans have pre-hypertension. The Framingham study demonstrated that untreated hypertension can degenerate. Non-pharmacologic measures such as lifestyle modifications have been recommended. These include weight reduction, increased physical activity and reduced intake of added salt, fats and sugar. A clinical trial known as the "Trial of Preventing Hypertension" (TROPHY) was conducted to determine whether temporary treatment of pre-hypertension patients with antihypertensive agents could reduce future risk of developing hypertension. [47] In this trial, patients were randomly selected and assigned to candesartan (16 mg daily; n = 391)

treatment using single-blinded model. The matching placebo was (n = 381) and treatment was administered over a two year period. After a four year follow-up hypertension was noted to have developed less frequently in participants who were initially assigned to take candesartan (53.2% vs 63.0%, RR, 0.84: $p<0.007$). The overall relative risk of hypertension in candesartan was reduced (RR, 0.58; $p<0.001$).

2.4 Hypertension Definition in Children

Hypertension in children or pediatric hypertension (HTN) is defined as the sustained elevation of either the systolic or diastolic blood pressure at or above the 95th percentile of BP for a child's age, gender, and height percentile. According to this definition, HTN is characterized by sustained presence of blood pressure elevation and for that reason all elevated blood pressure measurements should be confirmed by repeated measurements conducted by manual auscultation, with the average of all measurements used to determine the category of HTN. The severity of the elevation will dictate how many measurements are needed before diagnosis and evaluation.[48] Updated gender, age, and height percentile-specific 50th, 90th, 95th, and 99th percentile systolic and diastolic BPs for children aged 1 to 17 years was published in 2004.[49] The normative values compiled from more than 60,000 healthy children in the United States, were based on their first auscultatory blood pressure measurement obtained during screening. These are used to classify children into one of the following BP categories:

- Normal BP: Both systolic and diastolic BPs is less than the 90th percentile or less than 120/80 mmHg, whichever is lower.
- Pre-hypertension: Systolic or diastolic BP is between the 90th percentile and the 95th percentile, or between 120/ 80 mmHg and the 95th percentile, if 120/80 mmHg

happens to be higher than the reported 90th percentile for the individual child based on his or her age, gender, and height percentile.

- Stage I HTN: Systolic or diastolic BP between the 95th percentile and the 99th percentile þ 5 mmHg.
- Stage II HTN: Systolic or diastolic BP above the 99th percentile þ 5 mmHg.

In the same provision, the NHLBINIH provides a graph of the 95th percentile of blood pressure for boys and girls of different ages and heights. Adolescents and young adults aged 18 to 21 years should be classified as follows:

- Pre-hypertension: Systolic or diastolic BP ≥120/80 and ≤139/89 mmHg
- Stage I HTN: Systolic or diastolic BP ≥140/90 and ≤159/99 mmHg
- Stage IIHTN: Systolic or diastolic BP ≥160/100mmHg

2.5 High Blood Pressure Symptoms in Children and Adolescents

Most children with high blood pressure may not have other health problems and do not show any symptoms of high blood pressure. Hypertensive condition in children is very rare but can be very life threatening. Rising arterial stiffness, or loss of elasticity, a change generally associated with aging, has been detected in pediatric patients with high blood pressure. Other conditions such as obesity, diabetes mellitus, and dyslipidemia have been linked with cardiovascular diseases. Even subtle cognitive changes, in areas of executive function, are now described in children with hypertension. [50] Although severe arterial hypertension in children is also rare, its complications have been reported in children. Among such complications are facial paresis, acute hemiplegia and hypertensive encephalopathy. Children presenting with phaeochromocytoma may have

headache, vomiting, impaired vision and apraxia. These symptoms are compatible with both hypertensive encephalopathy and lucunar infarction. [51]

End organ response such as left ventricular hypertrophy and retinal vascular abnormalities has been identified in persons aged 5 months to 20 years. Results from a previous study showed that some children aged less than 12 months for example, present with polydipsia, polyuria and visual inattention resulting from malignant hypertension due to unilateral renal artery stenosis.[52] Infants and young children may show identifiable cardiac, renal or endocrine disorders.[53] When hypertension develops from an obstruction to blood flow in the renal artery or its branches, it is described as Renovascular hypertension. Renovascular diseases (RVD) account for 10% of severe hypertension in children.[54-55] Co-arctation of aorta and FMD are among the non-Syndromic causes of hypertension in children. In infants, genetic disorders such as neurofibromatosis, Williams syndrome and tuberous sclerosis may be associated with RVDs. [56] Other symptoms include restlessness and hyperactivity.[57]

Idiopathic intracranial hypertension (IIH) may be found in extremely obese adolescents. IIH is a disorder typically diagnosed by the presence of papilledema and elevated intracranial pressure in the absence of infectious, vascular and structural causes. The disorder presents with headache and blurred vision. Once perceived as uncommon, IIH is becoming common with an incidence rate of 19-19 cases per 100,000 among overweight or obese adults especially women.[58] Conflicting results have been submitted by studies that sought to examine the relationship between pediatric IIH and obesity.[59] Some studies suggest that obesity is only a risk factor for IIH in post pubertal age children.[60]

2.6 Link between High Blood Pressure and Obesity in Children

Pediatric hypertension (HTN) once affecting only 1% of all children, is now affecting almost 5% of all children. Some experts say the trend of high blood pressure in children is linked to the concurrent rise in pediatric obesity which affects 17% of all US children. [61] One study in particular determined the association between high blood pressure in children and obesity. [62] The researchers used a school-based cohort of 78,114 children. Overweight and obesity were defined using Chinese specific reference data. In their methods, the researchers stratified the study participants by their age and body mass index validated definitions of hypertension and standards. They then classified blood pressure levels under "Low", "Normal" and "High". Results from their study indicated that blood pressure levels significantly increased in overweight and obese groups. The conclusions were that being overweight and obese greatly increased the risk of having high blood pressure levels in Chinese children.

A dramatic increase in childhood obesity among children in the US means more and more children are at risk of having cardio vascular diseases in their adult life. Bibbins-Domingo et al. (2007) [63] estimated the prevalence of obese 35-year olds in 2020 on the basis of adolescent overweight in 2000 and historical trends. The authors used a coronary heart disease (CHD) policy model; a state transition computer simulation of US residents 35 years and older to project annual excess incidence and prevalence of CHD, the total number of excess CHD events and excess deaths from both CHD and other causes attributable to obesity from 2020 to 2035. They also modeled the effect of treating obesity-related increase in blood pressure and dyslipidemia. They concluded that, prevalence of obesity-related CHDs will increase among future young and middle-aged adults, resulting in substantial morbidity and mortality in 2020. The authors explained

that prevalence of CHD in particular will rise by a range of 5% - 16%, with more than 100,000 excess cases that can be attributed to increased obesity. Since 1970, the prevalence of overweight US children between ages two and five has doubled, and that of children and adolescents between ages 6 – 19 years has tripled affecting more than 9 million children and adolescents.[64-67]

A prospective cohort study [68] measured childhood and adulthood body mass index using age and sex-specific cut-off points for overweight and obese children. Data used for their analysis included 6,328 subjects. Subjects with consistently high obesity status from their childhood were compared to subjects who currently have normal body mass index and were non-obese when they were children. It was found out that, Overweight or obese children who were obese as adults had increased risks of type 2 diabetes, hypertension, dyslipidemia, and carotid-artery atherosclerosis. The risks of these outcomes among overweight or obese children who became non obese by adulthood were similar to those among persons who were never obese. Hypertension relative risk was 2.7%; 2.2 to 3.3 95% confidence.

Studies of cardiovascular risk factors involved tracking of children from childhood into adulthood. The Bogalusa heart study for instance examined whether a change from overweight obese subjects from childhood to a non-obese status in adulthood was associated with a reduced risk of hypertension and other cardiovascular diseases.

From the Bogalusa Heart study [69] secular trends in body mass index and blood pressure among children and adolescents were examined. A total of 24, 092 examinations were conducted among 11, 478 children and adolescents (aged 5–17 years) from 1974 to 1993 in the Bogalusa Heart Study (Louisiana). Freedman et al. (2012), [70] examined whether

these secular changes in body mass index were accompanied by increases in blood pressure levels. Results from the Freedman study reported prevalence of obesity to have increased from 6% to 17% during this period. In contrast, Freedman et al reported that only small changes were observed in levels of systolic blood pressure (SBP) and diastolic blood pressure (DBP), and neither mean nor high (based on the 90th percentile from the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents) levels increased over the 20-year period. They concluded that levels of DBP and SBP among children in this large sample did not increase despite the increases that were seen in obesity indicates that changes in blood pressure levels in a population do not necessarily parallel changes in obesity. Other studies of cardiovascular risk factors also involved tracking children from childhood into adulthood to determine associations of cardiovascular risks factors: the Bogalusa Heart Study (conducted in the United States), [71] (the Muscatine Study (United States), [72] the Childhood Determinants of Adult Health (CDAH) study (Australia), [73] and the Cardiovascular Risk in Young Finns Study (YFS, Finland).[74] Key findings included associations between childhood and adulthood hypertension. Khang Y et al. (2011) [75] observed important population declines in blood pressure in Korea over a 10-year period in children 10 to 19 years of age. The decreases were observed among all age and socioeconomic groups and were not explained by secular changes in childhood obesity (body mass index and waist circumferences), health behaviors (cigarette smoking and physical activity), nutritional factors (sodium, potassium, total energy, protein, and fat intake), psychological factors (perceived stress and sleep duration), and socio-demographic factors (annual household income and family size). Dong B et al. (2014) [76] investigated increase in the prevalence of

obesity in Chinese children without a corresponding increase in BP rates. In their methods, Dong et al. conducted body mass index and blood pressure measurements of 391,982 children aged 7-17 years from 2005 -2010. The mean change and 95% confidence interval of blood pressure were calculated and the association between body mass index and BP were assessed by using analysis of covariance and direct adjustments of the 2005 body mass index survey variable. They authors concluded that blood pressure in Chinese children and adolescents was on the rise from 2005 to 2010, which was consistent with the hypothesis that the rise in blood pressure was in part attributable to the rise in body mass index.

2.7 High Blood Pressure from Childhood to Adulthood

Some studies have established significant associations between adulthood hypertension and childhood hypertension. More evidence has shown that hypertensive children are very likely to develop hypertension in adulthood.[77-79] Increase in the number of hypertension cases in children and adolescents will not only result to increases in the number of associated risk factors, but also that of cardiovascular morbidity and mortality rates.[80] Blood pressure values in children are important biomarkers for cardiovascular risk later in life, regardless of fact that definitions of hypertension and pre-hypertension during childhood are based on percentile distribution by age, sex, and height, and not on events. [81-82] Pathophysiological and epidemiological studies have indicated that childhood blood pressure was closely associated with blood pressure in later life. [83] A longitudinal cohort of 1,505 subjects was conducted from two cross-sectional surveys less than 15 years apart to track elevated blood pressure from childhood to adulthood and its progression to essential hypertension. [84] In their methods, the researchers controlled for

body mass index. The results were that, the expected number of subjects whose levels were in the highest quartile at childhood still had highest levels 15 years later. Although the results varied by race, sex and age; the findings proved strong associations between childhood and adulthood hypertension. Conclusions from these studies although valid have been derived from clinical experiences as applied to population-based surveys therefore, less precise.

There are still no long-term population-based outcome data to relate blood pressure in childhood to cardiovascular risk in adulthood. However, the long term natural history of BP in children is not well understood although norms for blood pressure and hypertension definitions in children have been revised. [85] The proportion of children with primary hypertension (hypertension not caused by any known disease) may decrease as these children revert to normal blood pressure overtime without any intervention. There is no validated approach for determining the proportion of children with primary hypertension who will continue to have hypertension in adulthood. Furthermore, the variables for blood pressure risk factors are better understood in adults than in children since hypertension definitions in adults are purely based on quantitative thresholds.

2.8 Blood Pressure Measurement in Children

Blood pressure measurement has become a routine part of pediatric care. Symptoms of elevated blood pressure (EBP) have been detected in children during primary care. Children may be over-diagnosed with hypertension. To avoid hypertension over-diagnosis, the criterion set to categorize a child as having hypertension must place the average of repeated blood pressure levels at or over the 95th percentile. [86] Although asymptomatic blood pressure detection has become a routine process for all children who

receive primary care, value for the yield is not clear for children with non-hypertension symptoms. Stewart et al (2008) [87] determined the value of triage blood pressure in diagnosing hypotension and true hypertension in children less than 3 years who presented non-urgent problems at the emergency. The researchers defined hypertension as BP >95th percentile for sex, age and height measured on three occasions. They found out that, the yield of measuring blood pressure in non-asymptomatic children was extremely low compared to that of asymptomatic children. The 2004 National Blood Pressure Education PROGRAM (NHBPEP) Working Group 4th Report recommended for blood pressure measurements to be performed in all children over 3 years at the point of care. The rational for this recommendation is early identification of treatable pre-symptomatic hypertension conditions in children. Does the NHBPEP Working Group Report recommendation meet the criteria for good screening test? Using the NHBPEP criteria, measuring BP is the way to determine whether a patient has hypertension or not. Friedman (2008) commented on Stewart et al. Friedman stated that changes in blood pressure unlike many other conditions can occur at almost any age therefore there is the need to keep measuring BP levels in children at all ages. [88] Hypertension is distinctively different from other conditions where screening tests can immediately be followed with definitive test. Other studies expressed blood pressure measurements based on height. One study in 2013 evaluated feasibility and accuracy of the blood pressure-to-height ratio (BPHR) for identifying hypertension in children. [89] The researchers proposed optimal thresholds for identifying hypertension in Han children aged 7 – 12 years. Using the NHBPEP definition as gold standard definition, equations were set for systolic and diastolic BP. Systolic BP was equated to SBP (mm HG)/height (cm) and diastolic BP

equated to DBP (mmHg)/height (cm). They then performed receiver operating characteristic curve analysis to assess accuracy of SBPHR and the DBPHR as diagnostic test for elevated SBP and DBP. The study results were that, by defining hypertension in terms of BPHR, sensitivities for both boys and girls were above 95%; and specificity were also above 95% for both boys and girls. The authors concluded that, the BPHR is an accurate index for measuring BP in children. Waist circumference and neck size are other indexes by which blood pressure screening test can be based. A cross-sectional study reported associations between children's waist circumference (WC) and neck size; and the risk of having elevated BP.[90] In this study, Choi et al (2011) measured height, weight, neck and waist circumference, and BP in regular health examinations among children in grade 1(aged 6-7 years) at six elementary schools in Taipei County, Taiwan. They defined elevated BP in children as having mean systolic or diastolic blood pressure greater than or equal to the gender-, age, and height-percentile-specific 95^{Th} percentile blood pressure value. Conclusions from their results were that, waist circumference is an index for determining elevated blood pressure levels in children.

CHAPTER III

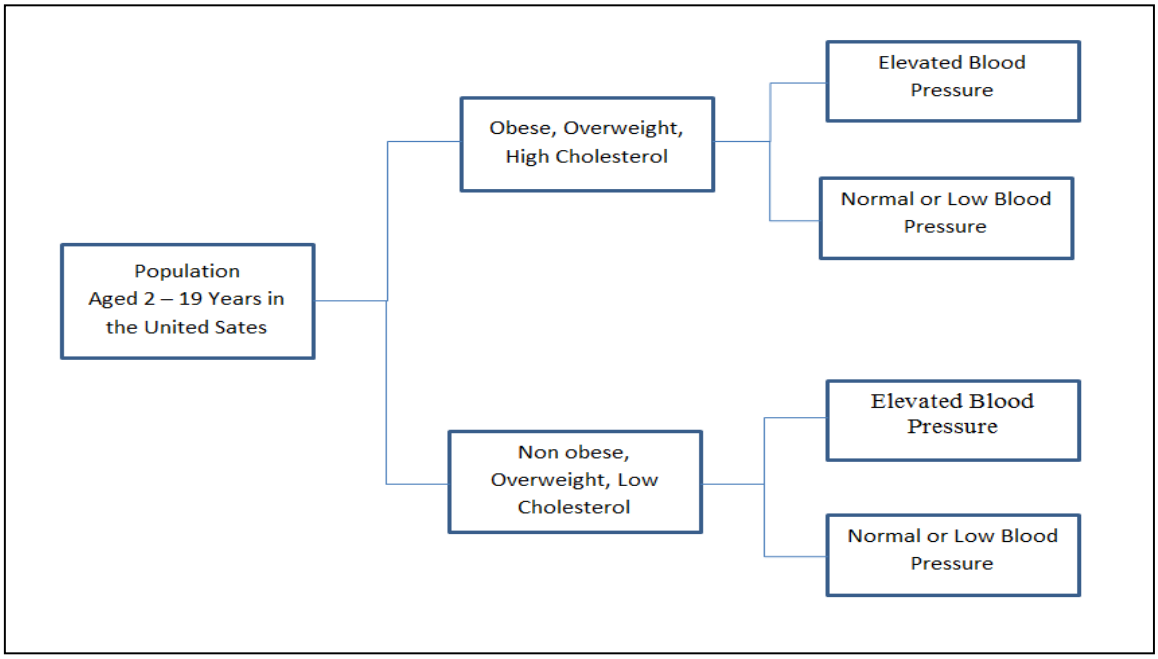
RESEARCH METHODOLOGY

3.1 Study Design

This report is a secondary data analysis conducted to explore the associated risk factors of elevated blood pressure levels in overweight or obese US children and adolescents. A population-based cross sectional study of children aged 2-19 years who participated in the 2011 – 2012 National Health and Nutrition Examination Survey of the US civilian population was conducted. The study population consisted of 9,756 total respondents of which 4,196 consisted of children and adolescents aged 19 years and younger.

Figure 2

A Cross Sectional Study Design:
Prevalence of Elevated Blood Pressure in Population
Aged 2 – 19 Years in the United States (NHANES 2011-2012)



As shown in Figure 2, the resultant variable is blood pressure level. The exposure variables are being overweight or obese and having high cholesterol or normal to low cholesterol. The study goal was to determine whether blood pressure levels in children and adolescents could be predicted by factors such as body mass index and blood serum total cholesterol. Eligible children were sampled and stratified by their age, gender and race. Estimation of hypertension prevalence was made and compared among children and adolescents. Analytical models were logistic regression for nominal variables and the multivariate general linear model for continuous variables.

3.2 Data Sources and Data Elements

Data source for this study was from the NHANES. The NHANES is a nationally representative, continuous cross-sectional survey of the health and nutritional status of the United States civilian noninstitutionalized population. Every year, more than 6000 participants from 50 states and the District of Columbia in the United States are selected to participate in the NHANES using a multi stage probability design. NHANES surveys are released every two years. Limitations of previous NHANES data were that, certain sub-groups were under-represented therefore; subsequent NHANES surveys after 2007 were designed to oversample low income people, non-Hispanic blacks and all Hispanics.

The NHANES is useful for addressing questions about subpopulations because of its robust stratification and multistage probability cluster sampling design that makes data analysis more feasible. The cross sectional analytic design of the NHANES permits statistical inferences of results on the entire US population. However, complex design of the NHANES must be accounted for in order to infer valid conclusions. Blood pressure measurements were conducted in the Medical Examination Centers (MEC) by a

physician using manual sphygmomanometer with the survey participant in a seated position with his/her back supported and both feet on the floor after five minutes of rest.

Three (3) consecutive blood pressure readings were obtained using the same arm with thirty-second interval between measurements. Should a measurement be interrupted or become unobtainable, a fourth reading was taken. By this protocol, a minimum of three readings were made available for analysis. The analytical dataset consisted of release data from 2011-2012. In these releases, participants completed household interviews, and detailed physical examination and blood pressure measurements were taken. Written informed consents were required from participants who were 18 years and older and from the parents of participants who were less than 18 years.

3.3 Data Collection

Trained interviewers obtained information on participants' weight and blood pressure examination. Hypertension history and treatment were ascertained using survey questionnaires. The survey consisted of individual household interviews with follow up examinations by the MEC. The purpose of MEC was to allow better standardization of examination procedures and measurements. Gender and age were self-reported and were classified by weight status as either overweight or obese using the Centers for Disease Control and Prevention (CDC) age and gender percentiles for body mass index (BMI).[91] For race and ethnicity, classifications were non-Hispanic white, non-Hispanic black, Mexican American, Asian, Other Hispanic and mixed race. Four datasets; demographic (DEM_G), blood pressure (BPX_G), body measurement (BMX_G) and total cholesterol (TCL_G) were copied to create permanent SAS data files.

3.4 Study Population

The study population consisted of noninstitutionalized civilian population of the United States. In this study population, respondents were asked about their demographic information such as age, sex, race and household income. Data were also collected about their body measurements, laboratory and nutritional intake. Participants received medical examinations that included standardized measurements of pulse, blood pressure, body weight, height and cholesterol. Specific subgroups such as the non-Hispanic Blacks and Mexican Americans were oversampled since these subgroups were under represented in previous NHANES surveys. Every year, about 6,000 participants are selected to take part in the NHANES.

3.5 Selected Sample

The selected sample was drawn using a two phase approach. First, age was used as a criteria for selecting the targeted group (persons aged 19 years and below). Then, the sampling frames were defined to include children and adolescents who have their blood pressure taken and lived in the US during the period of analysis (2011 - 2012). Also included in the sample were participants without any hypertension associated medical conditions. The combined sample of the 2-year datasets included 9,756 total survey respondents, out of which 4,196 met the selection criteria. Excluded from the analyses were participants who reported to have used anti-hypertensive medication and those diagnosed with renovascular, polycystic kidneys and co-morbid hypertensive conditions.

To correct the measurement of errors and outliers, participants with extremely high or low blood pressure readings were excluded from the analyses as well. The combined dataset was weighted to account for variations arising out of the complex survey design

and non-responses. The selected sample was then cleaned to get rid of null values of continuous variables using the multinomial and jackknife approach in SAS processes.

3.6 Variable Selection and Categorization

As shown in Table 4 below, 28 out of 89 variables were selected for the secondary analysis. Variable selection were based on relevance.

Table 4:

Table of Selected Variables

#	Variable	Type	Len	Label
1	SEQN	Num	8	Respondent sequence number
2	RIDSTATR	Num	8	Interview/Examination status
3	RIAGENDR	Num	8	Gender
4	RIDAGEYR	Num	8	Age in years at screening
5	RIDRETH1	Num	8	Race/Hispanic origin
6	RIDRETH3	Num	8	Race/Hispanic origin w/ NH Asian
7	RIDEXAGY	Num	8	Age in years at exam - 2 to 19 years
8	WTINT2YR	Num	8	Full sample 2 year interview weight
9	WTMEC2YR	Num	8	Full sample 2 year MEC exam weight
10	SDMVPSU	Num	8	Masked variance pseudo-PSU
11	SDMVSTRA	Num	8	Masked variance pseudo-stratum
12	INDHHIN2	Num	8	Annual household income
13	INDFMPIR	Num	8	Ratio of family income to poverty
14	PEASCST1	Num	8	Blood Pressure Status
15	BPXSY1	Num	8	Systolic: Blood pres (1st rdg) mm Hg
16	BPXDI1	Num	8	Diastolic: Blood pres (1st rdg) mmHg
17	BPXSY2	Num	8	Systolic: Blood pres (2nd rdg) mmHg
18	BPXDI2	Num	8	Diastolic: Blood pres (2nd rdg) mm Hg
19	BPXSY3	Num	8	Systolic: Blood pres (3rd rdg) mm Hg
20	BPXDI3	Num	8	Diastolic: Blood pres (3rd rdg) mmHg
21	BPXSY4	Num	8	Systolic: Blood pres (4th rdg) mm Hg
22	BPXDI4	Num	8	Diastolic: Blood pres (4th rdg) mmHg
23	BMXWT	Num	8	Weight (kg)
24	BMXHT	Num	8	Standing Height (cm)
25	BMXBMI	Num	8	Body Mass Index (kg/m**2)
26	BMDBMIC	Num	8	BMI Category - Children/Adolescents
27	BMXWAIST	Num	8	Waist Circumference (cm)
28	LBXTC	Num	8	Total Cholesterol(mg/dL)

The selected variables were categorized into three: exposure, resultant and characteristic. Table 5 on page 35 shows the listed variables under their analytical headings. Grouping the variables this way facilitated the setting of analytical models for the dataset. Exposure variables included being overweight and having blood serum total cholesterol level as "high" or "normal-to-low". Resultant variables were blood pressure levels and characteristic variables were: age, gender, race/ethnicity and poverty to income ratios.

Table 5:

Table of Variable Category:
(Resultant, Exposure and Characteristic)

Resultant	Exposure	Characteristic
Systolic Blood Pressure (1st rdg) mmHg	Weight (kg)	Gender /Sex
Systolic Blood Pressure (2nd rdg) mmHg	Standing Height (cm)	Age in Years at Screening
Systolic Blood Pressure (3rd rdg) mmHg	Body mass Index (kg/m**2)	Race/Ethnicity
Systolic Blood Pressure (4th rdg) mmHg	Waist Circumference (cm)	Age (Years) at Exam
Diastolic Blood Pressure (1st rdg) mmHg	Total Cholesterol (mg/dL)	Annual Household Income
Diastolic Blood Pressure (2nd rdg) mmHg		Poverty Ratio to Income
Diastolic Blood Pressure (3rd rdg) mmHg		
Diastolic Blood Pressure (4th rdg) mmHg		

More so, by categorizing the variables allowed comparison of the relationships between the outcome variable (BP levels) and exposure variables (being overweight or obese and having high or normal to low bad cholesterol) among the sub groups. Comparisons were made between boys and girls, children and adolescents, one race versus another and so on. Other variables were considered as non-analytic. Records in the NHANES are ordered in sequence represented by a respondent's sequence number. The sequence number is to sort out datasets. Other relevant non-analytic variables were; full sample year weight, masked variance pseudo stratum, and interview / examination status.

3.7 Analytic Variables, Exposures and Outcomes of Interest

Variables were also defined as analytic versus non analytic. This is because NHANES survey participants are assigned with unique sequence numbers. The sequence numbers are used to sort records in the order in which they were created. The usefulness

of this variable becomes critical when creating syntax and formulas to clean data with extreme values, generate survey frequencies, and run regressions. Most often, data need to be sorted either by ascending or descending order in a syntax using the unique sequence variable "seqn". As shown in Table 6, other non-analytic variables included: interview/examination status, full sample 2 year interview weight, full sample 2 year MEC exam weight, masked variance pseudo-PSU, and masked variance pseudo-stratum.

Table 6:

Analytic Versus Non-Analytic Variables

Analytic	Non-Analytic
Annual household income	Respondent sequence number
Ratio of family income to poverty	Interview/Examination status
Weight (kg)	Full sample 2 year interview weight
Standing Height (cm)	Full sample 2 year MEC exam weight
Body Mass Index (kg/m**2)	Masked variance pseudo-PSU
Waist Circumference (cm)	Masked variance pseudo-stratum
Total Cholesterol(mg/dL	Blood Pressure Status
Systolic: Blood pres (1st-4th rdg) mm Hg	BMI Category - Children/Adolescents
Diastolic: Blood pres (1st-4th rdg) mm Hg	

* Only analytic continuous variables were shown in Table 6 above. Other variables used in the analysis were: age, race, and gender.

For statistical accuracy and to reduce sampling and analysis bias, the NHANES oversample under-represented subpopulations such as Hispanics, Non-Hispanic Blacks, Non-Hispanic Asians, and other Race-including Multi-Racial. The two year interview weight factor was multiplied to the selected sample during the analysis so that results from the sample analysis can be compared to the general population. Similarly, the MEC exam weight factor was multiplied to values recorded under body measurements to

account for biases arising from body examination. In the same way, the pseudo mask variance was multiplied as a weighted factor to indicators such as blood pressure readings that might show inconsistencies under the period of evaluation. For example, a patient's blood pressure may be normal during examination but high anywhere else. Lastly, the pseudo-stratum variance was applied for appropriate stratification of the selected sample.

3.7.1 Resultant Variable

The measure of blood pressure level was based on the National High Blood Pressure Education Program (NHBPEP) gold standard definition. In this definition, blood pressure classification guidelines were based on age, gender and height [86]. Normative blood pressure data collection guidelines were provided in the 4Th Report for children and adolescents by the NHBPEP. The 4th report presented a reclassification of blood pressure levels in children and introduced the concept of pre-hypertension in children and adolescents. The pre-hypertension concept was nothing new since it had first been introduced by the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC) for adults in 2003. [92] This was later republished in 2007. According to the JNC, an individual's BP level often follows a given rate of measurement overtime. Therefore, one can only be diagnosed with high blood pressure only when there is evidence of sustained elevation overtime. For this reason, it was recommended that blood pressure readings in individuals be taken for at least three consecutive times. The data analyzed consisted of four blood pressure readings taken at different dates and times. By blood pressure readings, it is meant to consist of both systolic and diastolic BP readings. Systolic BP refers to the maximum arterial pressure of a person's BP reading. Systolic BP is used to refer to the amount of force exerted on the

arteries as the heart pumps blood to the rest of the body. SBP is measured in millimeters of mercury (mm Hg). At the lower end of a person's arterial pressure as a result of expansion and contraction of the heart as one breathes is what is called diastolic BP. It is also measured and expressed in millimeters of mercury (mm Hg).

3.7.2 Exposure Variables

From the presumptive statement, determinants of the health state of interest, high blood pressure were being overweight or obese and having high bad cholesterol levels. Obesity status and cholesterol levels were considered as exposure variables because an individual can control his/her weight and improve on nutritional intake to reduce the level of bad cholesterol. Since obesity in children is determined by body mass index which is calculated from standing height (cm) and body weight in (kg), the unit of measurement for body mass index is kilograms per centimeter (kg**/Cm). In other countries other than the United States, blood cholesterol is measured in millimoles per liter of blood (mmol/L). Generally in adults when low-densities of lipoprotein (LDL) are found in the blood serum, cholesterol is referred to as bad and when high densities of lipoprotein (HDL) are found in the blood serum above 1mmol/L, cholesterol is referred to as bad as well. In children and adolescents, a ratio of total cholesterol is determined as total cholesterol divided by HDL level. When this ratio is above four (4), the individual is said to have a higher ratio and stands the risk of heart diseases. From the NHANES, cholesterol is already calculated and expressed in milligrams per deciliter (mg/dL).

3.7.3 Covariates

The importance of defining continuous variables as covariates is for the purpose of conducting appropriate data analysis. Covariates for this study included continuous variables such as body weight, standing height, body mass index and ratio of family income to poverty. These variables were set in a model to measure variations in blood pressure levels among US children and adolescents using the general linear model in SAS. It became significant not to use single analysis of variance (ANOVA) to determine extent of the associations between blood pressure levels and continuous explanatory variables and measure variability. This was because, each record of the selected dataset presented with varying missing variables. ANOVA assumes that all groups have the same sample size. Therefore, it was only prudent running the general linear model of covariates for one-sided hypothesis testing.

3.8 Data Organization and Cleaning

Downloaded SAS Files were sorted using their unique identifier known as the sequence number (SEQN). Sorting the data helped to ensure that observations were ordered in the exact order in which they are contained in the file. A sample that has only the needed variables was drawn from the study population using the KEEP command at DATA step in SAS. The sorted files were then merged into a single file using their unique sequence numbers. After, the PROC CONTENTS procedure with the VARNUM option was used to generate a list of the contents of the merged file to order the variables according to their positions in the dataset. Then, the mean number of missing values, minimum and maximum values for each of the variables were determined using the PROC MEANS procedure with "N Nmiss min max maxdec = **2"** options. Categorical

variables were created to help standardize cross tabulations of the dependent variable, Blood Pressure Levels (Y), and its associated risks factors or covariates (X_{ys}), mainly; age, gender, race/ethnicity, ratio of family income to poverty, weight, standing height, body mass index, body mass index category for children and adolescents, waist circumference and total serum cholesterol. Two age groups were identified as age group <= 11 years (children) and age group <=19 years (adolescents) via data step programming using SAS procedures such as "If then, else" statements. Other selected variables were re-coded for the purpose of grouping them by class labels. The classification was useful for standardizing calculations. The dependent variable, blood pressure levels and the independent variables; body mass index, gender, race and age were all classified to facilitate generation of cross tabulations. The body measurement variable, body mass index, was classified by the National Pediatric Association's Body Mass Index stratification definitions and demographic variables, age, gender and race/ethnicity by the US Population Census Estimates stratification. Mixing values and null responses for all nominal variables were coded with a period (.) to exclude them from quantitative analysis (counts) and non-missing values with numeric representations. In order not to bias analysis of the selected sample, weights were applied to the selected sample variables to account for sampling inequalities emanating from the sampling procedure. In the absence of these adjustments, it would have been statistically invalid to infer results of the analysis on the entire US population. Generic confounders such as household income and education were dropped. This is because, in the US, children's education is a legal requirement. On the question of income adjustments, a ratio of household income to national poverty levels was used instead since children do not earn

income. Regardless of the foregoing statistical adjustments, it was still unclear whether respondents' geographical location could have been used to explain variations in the distribution of blood pressure levels among children and adolescents aged between 2-19 years in the US.

3.9 Analysis of Data

In the following section, estimates were age adjusted using the Joint National Commission 7 definition of young population. This definition groups young population into "children" and "adolescents". The age group definition would be used to present summaries of all estimates throughout this report. In some cases, estimated summaries are presented by sex, race/ethnicity. NHANES data are based on multi-stage probability sampling of the US civilian population and are therefore subject to sampling errors. For this reason, standard errors are reported to indicate the reliability of the estimates. Standard errors are shown for all percentages in the tables but not for frequencies. Estimates which had relative standard errors of more than 30% and less or equal to 50% were considered statistically unreliable indicated by a hyphen (-).

The principal observation in this analysis was elevated BP levels in persons 2-19 years. A weighting factor was applied to each record to account for non responses and missing values. Statistical Analytical Software (SAS), a software package for statistical analysis was used to sample and determine estimate of the weighted prevalence and standard errors for elevated blood pressure levels. Differences in proportions were considered statistically significant if their probability values were less than .05 that is, ($P<0.05$). Frequencies of selected nominal variables were then generated from the weighted sample to describe the distribution of high blood pressure in the targeted group.

Probabilities for lager sample variables with less than 15% of missing data were generated using the Chi-square, and Fisher's and the Wald test statistics for smaller sample variables.

3.9.1 Descriptive Statistics

As explained in the data cleaning and organization section of this report, assessment of the frequency distribution and normality of the selected sample was made to determine whether parametric or non-parametric methods should be used for the analysis. Data was re-coded to account for extreme values and outliers. Records which had extreme values were deleted. The following SAS statements were used:

- **Checking of Frequency Distribution and Normality**

1. Order variable lists according to their position in the dataset using the varnum option.

   proc contents data=<data> varnum;

2. Determine the mean number of missing values.

   proc means data=<data> N NMiss min max maxdec=**2**;

```
/*identify outliers and compare estimates with and without
outliers*/
/*Compare the mean values for continuous variables with the
outliers included in the data and excluded from the data*/
data <data);
set <data>;
if seqn in (record2, record2, record3,….. etc,) then delete;
run;
```

3. Clean and recode data

```
/*Count Number of Nonmissing Systolic Blood Pressure (SBP)*/
data <data>;
set <data>;
      n_sbp = n(of bpxsy1-bpxsy4);
      n_dbp = n(of bpxdi1-bpxdi4);
*Set SBP values of 0 as missing for calculating average;
array _SBP bpxsy1-bpxsy4;
do over _SBP;
if (_SBP = 0) then _SBP = .;end;
```

4. Since four blood pressure readings were taken, find the average:

```
*Calculate mean SBP;
mean_sbp = mean(of bpxsy1-bpxsy4);
```

Derived variables were created to re-categorize variables in the selected sample to classify the data and facilitate cross tabulations. Derived variables were created using if then statements. Next, PROC FORMAT was used to format data references and their variable labels as shown in the following SAS statements:

```
proc format;
value Age 1='Children(2 <= 11 Years)'
          2='Adolescents(12 <= 19 Years)';
value SBP 1='Pre-hypertension (<=120 mmHg)'
          2='Stage 1 Hypertension (<=124 mmHg)'
          3='Stage 2 Hypertension (Systolic >124 mmHg)';
value DBP 1='Pre-hypertension (<=90 mmHg)'
          2='Stage 1 Hypertension (<= 99 mmHg)'
          3='Stage 2 Hypertension (>99 mmHg)';
value TCL 1='Desirable (<=200 Mg/dl)'
          2='Borderline (<= 240 Mg/dl)'
          3='Very High (>240 Mg/dl)';
value BMI 1='Underweight (5TH %)'
          2='Normal Weight (85TH %)'
          3='Overweight (95TH %)'
          4='Obese (100+)';
value Gender 1='Boys'
             2='Girls';
value PL 1='Low (0 <= 4.99)'
         2='High (>5)';
value Race 1='Mexican American'
           2='Other Hispanic'
           3='Non-Hispanic White'
           4='Non-Hispanic Black'
           5='Non-Hispanic Asian'
           6='Other Race - Including Multi-Racial';
format Age Age. SBP SBP. DBP DBP. TCL TCL. BMI BMI. Race Race.
Gender Gender. PL PL.;
run;
```

Only then were frequencies generated. The following syntax is an example that shows how a 2 year weighted factor was multiplied to the dataset to generate weighted percentages and frequencies:

SAS syntax for multiplying the weighted factor:

```
proc surveyfreq data = <data> varmethod=taylor;
weight wtint2yr;
cluster sdmvpsu;
tables Age*Gender*SBP;
format Age Age. Gender Gender. SBP SBP.;
run;
```

Frequency estimates and their associated errors were approximated using the Taylor series approximation technique. The Taylor series approximation expansion was used because it slowly converges to the exact results.

- **Percentiles**

Relative positions of individual records within the two year dataset were determined. Raw scores of records by their variables were ranked within the distribution. When a raw is identified by its percentile rank, the score is called a percentile. Since the two year weight was multiplied to the sample, the generated percentiles were also weighted. Unweight values do not provide enough information about the relative position of a score. For example whether a score is within the highest or the lowest. Therefore, it is much more reasonable to transform raw scores into percentile ranks such as 90th, 75th, 50th and so on. Weighted percentiles are the accurate estimation of the general population characteristics. The PROC SURVEYFREQ returns numeric values of observed scores together with their weighted percentiles. As shown in Tables 7-22 "Frequency Tables" observed scores were also associated by their weighted percentiles.

- **Means**

In this section of descriptive statistics, a sample weight is associated with each sample record. This is because, the NHANES is a multi-stage probabilistic sample and therefore the use of a simple arithmetic mean will bias the entire analysis. Instead, a weighted arithmetic mean is calculated by applying a sample weight (W_1). The PROC MEANS procedure as shown in the syntax below, returns values that measure the number of records in the general population represented by that specific record.

SAS syntax for arithmetic mean:

```
proc means data=<data> mean stderr maxdec=2;
var  bmxwt;
class Age Gender Race SBP;
label Age = 'Children versus Adolescents';
title "Mean of Body Weight by Age and Sex Category";
format Age Age. Gender Gender. Race Race. SBP SBP.;
run;
```

Generating means without applying the sample weight only returns sum of the values Xi divided by the population size. This is known as the arithmetic mean:

$$A = \frac{1}{n} * \sum_{i=1}^{n} x_i$$

Where:

A = average (or arithmetic mean);

n = the number of terms (e.g., the number of items or numbers being averaged);

x_1 = the value of each individual item in the list of numbers being averaged;

SAS Syntax for Weighted Arithmetic Mean:

```
proc means data=<data> mean stderr maxdec=2;
var  bmxwt;
class Age Gender Race SBP;
weight wtmec2yr;
label Age = 'Children versus Adolescents';
```

```
title "Mean of Body Weight by Age and Sex Category";
format Age Age. Gender Gender. Race Race. SBP SBP.;
run;
```

From the syntax above, the applied weight variable is "wtmec2yr". The statistical accuracy of the weighted arithmetic estimate which is the mean was specified as "stderr" also known as standard error. "maxdec" specify the number of decimal places to return the requested results.

$$\bar{x} = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i},$$

Where: $\bar{x}$ = weighted sample mean, and W_1 = Weight factor. Figure 3 below shows plots of the mean distribution of systolic blood pressure by weight and standing height.

Figure 3:

Scatter Plot of the Distribution of Mean Systolic Blood Pressure as Predicted by Body Weight and Standing Height in US Population (Aged 2≤19 Years) for 2011-2012

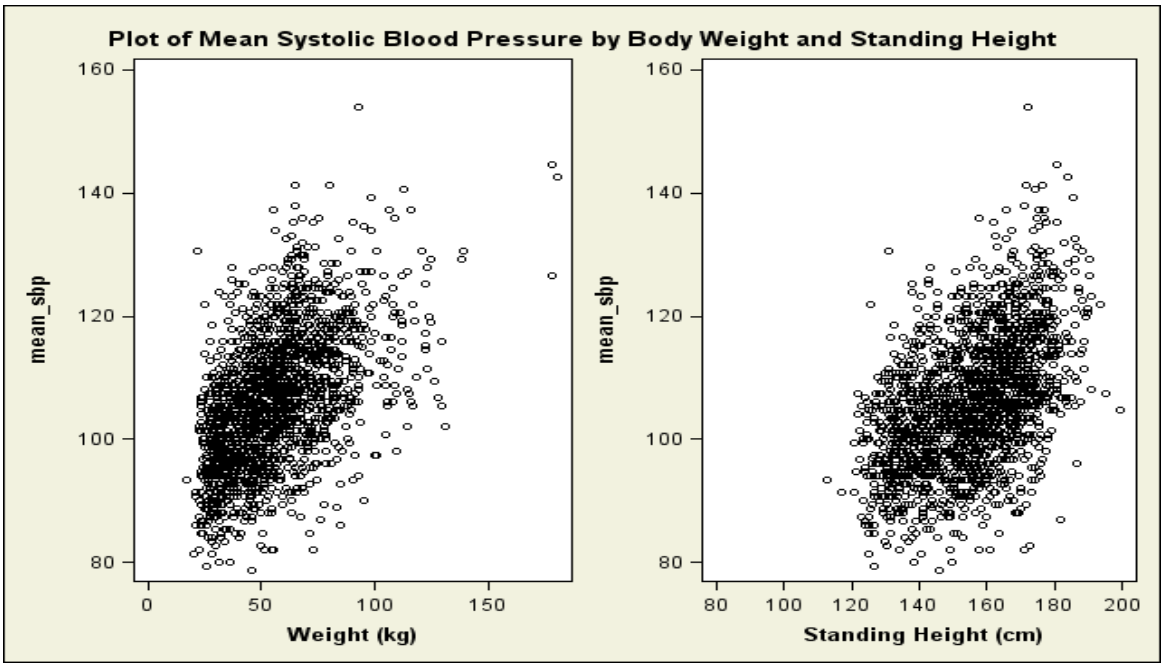


Figure 4:

Scatter Plot of the Distribution of Mean Systolic Blood Pressure as Predicted by Body Mass Index and Blood Serum Total Cholesterol Levels in US Population (Aged 2≤19 Years) for 2011-2012

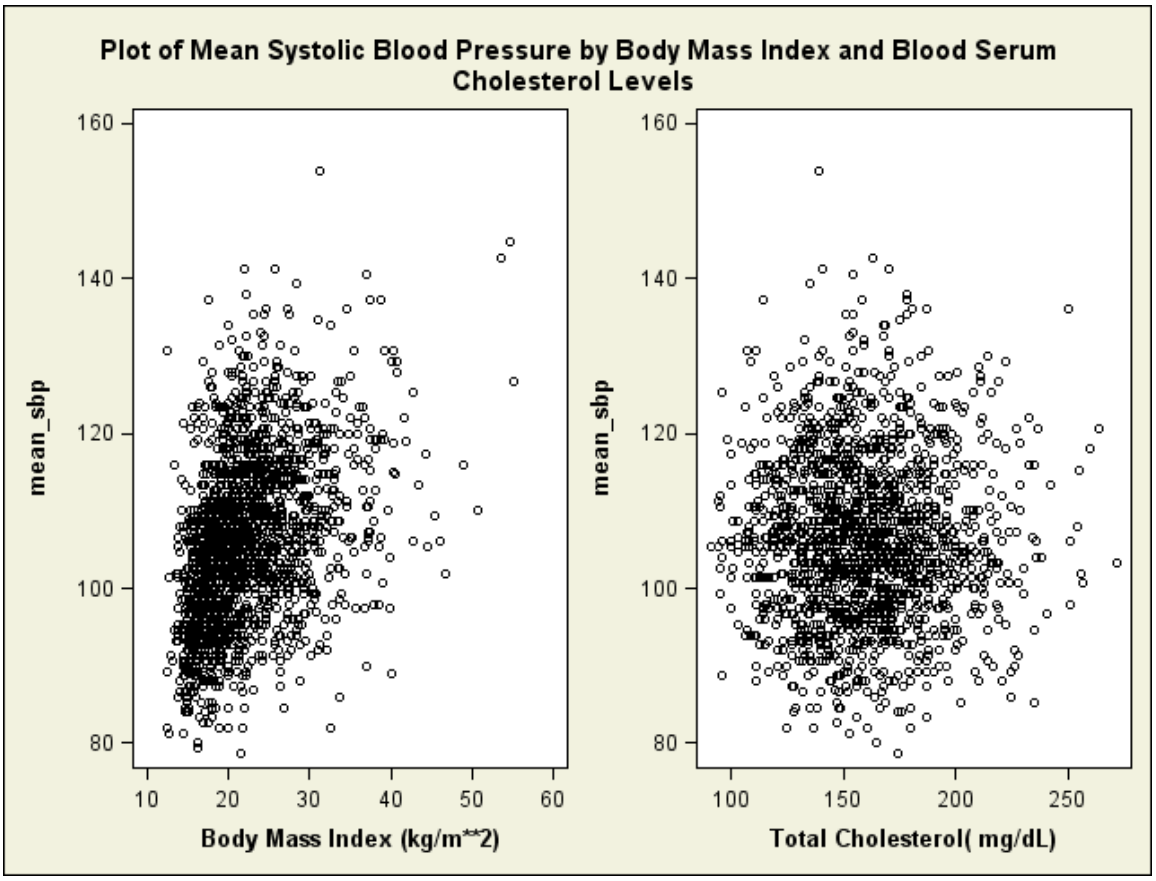


Figure 4 above, shows higher densities of mean body mass index along with increase in blood pressure levels. On the other hand, the densities spread out as mean systolic blood pressure levels increase along with blood serum total cholesterol.

Figure 5:

Scatter Plot of Mean Systolic Blood Pressure by Age, Gender and Race as Predicted by Body Mass Index and Blood Serum Total Cholesterol Levels in US Population (Aged 2≤19 Years) for 2011-2012

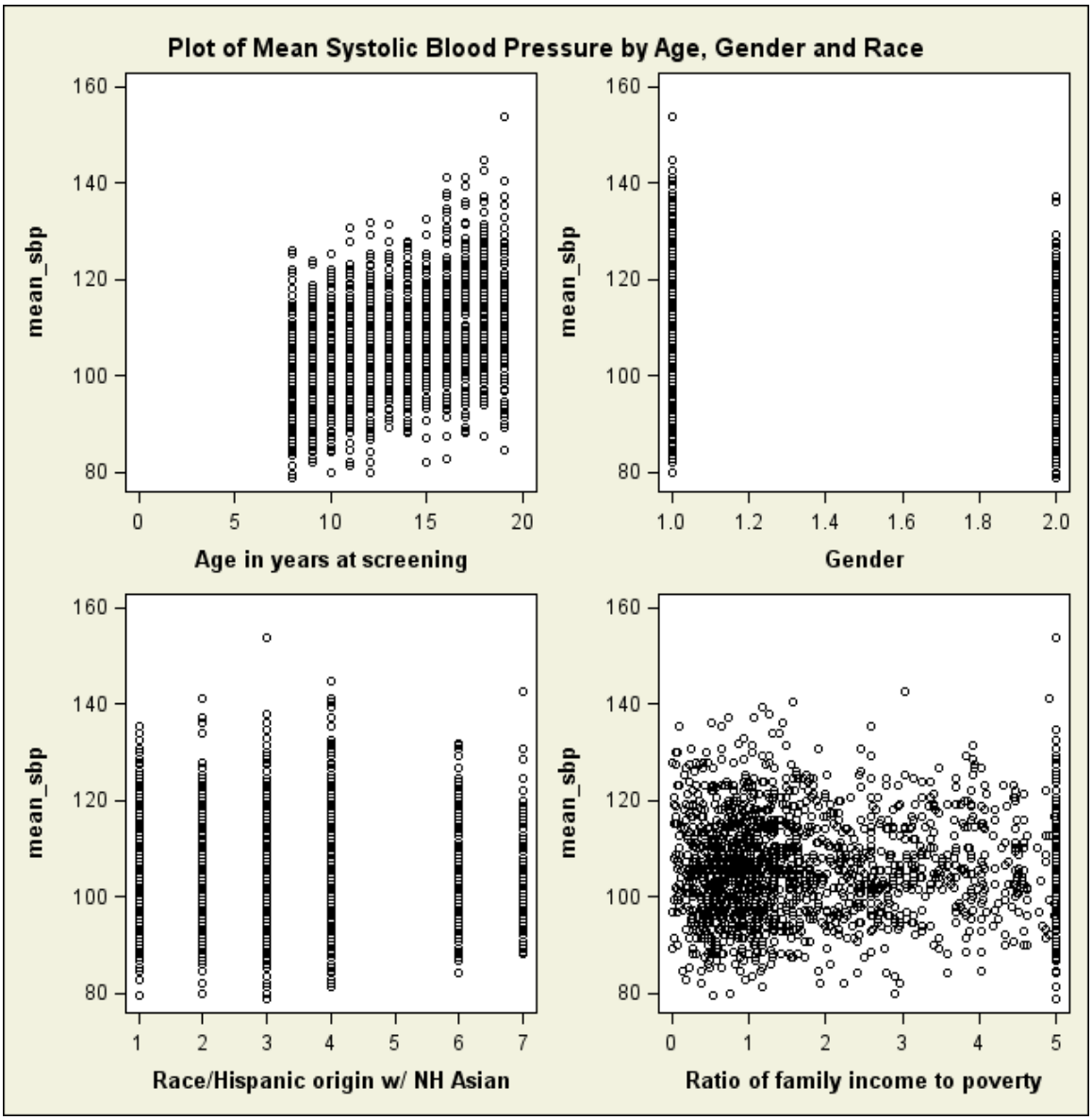


Figure 5 above shows that, linearization of age, gender and race variables is not a good fit for estimating values to measure systolic blood pressure variability in children and adolescents. Multiple logistic regression is a better fit. This is explained in much detail on page 50.

- **Proportions**

Prevalence estimates of elevated blood pressure levels in children and adolescents were determined based on the following blood pressure definition:

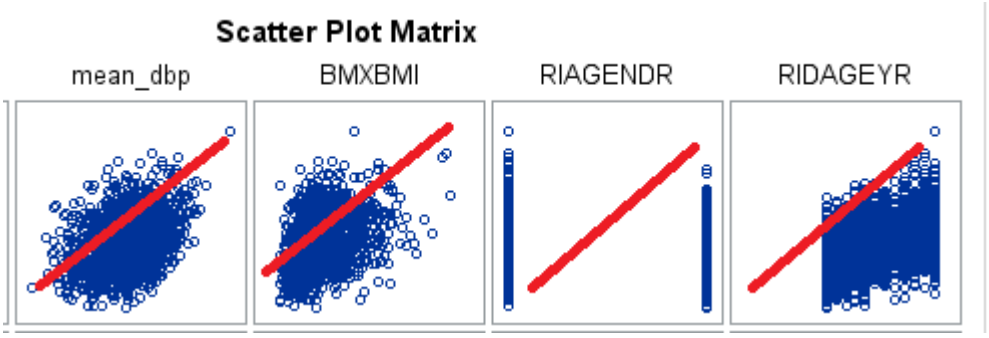
- Normal blood pressure: Both systolic and diastolic BPs is less than the 90th percentile or less than 120/80 mmHg, whichever is lower.
- Pre-hypertension: Systolic or diastolic BP is between the 90th percentile and the 95th percentile, or between 120/ 80 mmHg and the 95th percentile, if 120/80 mmHg happens to be higher than the reported 90th percentile for the individual child based on his or her age, gender, and height percentile.
- Stage I HTN: Systolic or diastolic BP between the 95th percentile and the 99th percentile þ 5 mmHg.
- Stage II HTN: Systolic or diastolic BP above the 99th percentile þ 5 mmHg.

3.9.2 Variance Estimation and Significance Testing of Blood Pressure Risk Factors

In this section of the dissertation, a binary outcome analysis on blood pressure status is described. (Whether a patient had a sustained high blood pressure "hypertension" or whether the blood pressure level was below the break point "pre-hypertension) and what are the predictors?. From Figure 21 on page 121, variables that can be measured in units are listed as "continuous" and those that can only be described as "nominal". For the purpose of this analysis, the resultant variable (blood pressure level) and the exposure variables (body weight, height and blood serum cholesterol levels) are all continuous variables. Demographic variables such as age, sex/gender, race/ ethnicity are all characteristic and therefore considered as nominal variables. To determine whether a straight line will be a good fit to describe variance estimation, a scatter plot of the variables can be generated. First, one must consider fitting a straight line for the nominal

variables compared to fitting a straight line for continuous variables. In Figure 21 (Page 121), it is clear that an upward line flowing from the left to the right will not be a good fit for variables such as gender, race and age group. The line fits the data better for blood pressure and body mass but not age and gender. For this reason, the straight line module (Linear Model) is the best fit for all continuous variables and conversion (Logistic regression) will be the best fit for all nominal variables. (See Fig. 21 Page 121). A section of Figure 21 is shown below for the reader's convenience:

Determination of Best Fit Model for Variables



mean_dpb = mean of diastolic blood pressure, BMXBMI = Body Mass Index;
RIADAGEYR = Age in years, and RIAGENDR = Gender/Sex

As shown in the illustration above, a straight line is a good fit for blood pressure and body weight but not gender and age. The outcome must be transformed for age and gender. This is known as logit.

Logit = 1n (p/ 1-p) Where: (**1-p**) = 1 minus probability

Logistic Regression

Logistic regression provides information about the relationship between an individual risk factor, in this case "being overweight or obese" or protective factor, "Not- being overweight or obese" and high blood pressure. Logistic regression can therefore be used to calculate predicted probabilities of a receiver operating characteristic (ROC) curve. The ROC is used to reflect the discriminatory ability of the entire model.

Individual Risk Factors Beta Coefficients:

The slopes from a logistic regression are known as Beta coefficients. In this dissertation, they will be interpreted as odds ratios, which are measures of relative risk.

Equation of the logit model:

Logit (High BP) = (Being overweight, obese or having high cholesterol)
→ **Equation 1**

Logit (High BP) = (Being overweight, obese or having high cholesterol) * (Age, Race/ethnicity, and gender/sex)
→ **Equation 2**

If the slope of age for example, is exponentiated, it will yield the adjusted odds ratio for *children* versus *adolescents.* In SAS, a syntax can be created using this model.

Model 1 $\boldsymbol{Y = \alpha\,(bmxbmi)_{wt} + \beta(lbxtc)_{wt} + ridageyr}$ → where ridageyr = age variable

Where age is assumed to be evenly distributed with a mean of zero and constant variance using the Fisher's Expansion Transformations. As written, the coefficients in Model 1 have both wt as subscripts indicating that the weighted factor has been applied for body mass index (bmxbmi) and blood serum total cholesterol (lbxtc).

A cross sectional analysis will help us estimate the relationship in Model 1 using another model in the form:

Model 2 $\boldsymbol{Y = \alpha_{wtt} + \beta_{wt} + ridageyr}$ → where ridageyr = age variable

Model 2 assumes coefficients of the weighted factor to be the same given the same variable age. (Thus α= αwt and β= βwt). This is an assumption that is needed otherwise the number of coefficients needed to estimate will exceed the number of observations. A second assumption is made in Model 2 because model 2 implies that coefficients are also constant. (α= αwt and β= βwt). This assumption is made when inferences are thought to be applicable to analysis periods other than the current (selected) sample period. There is the need to explain this phenomenon since several studies have published results from the NHANES using these regression techniques without addressing their limitations. Per the JNC7 recommended definition for blood pressure analysis for population aged 2-19 years, age must be classified as a range "children" and "adolescents". Applying the same weighted factor in both models is a statistical crime. It is therefore important to run binary regression analysis on public health data rather than running multiple analysis of variance. The model can be set in SAS as follows:

The logistic procedure- PROC LOGISTIC, a binary example:

```
proc logistic data=<data>;
class BMI SBP;
model SBP = BMI / expb roc;/*roc option to generates odds ratio*/
weight wtmec2yr;
label BMI = 'Body Mass Index';
label SBP = 'Systolic Blood Pressure';
title "Regression of Body Mass Index from Systolic Blood
      Pressure";
format BMI BMI. SBP SBP.; run;
```

The logistic regression can be used to estimate the probability that an obese child or adolescent will develop an elevated high blood pressure. When variances are high, adjusted risk ratios should be used instead through poison regression analysis. The logistic regression analysis in this dissertation did not show vast variances.

The General Linear Model

In the analysis of variance, I partitioned variations in continuous variables between "children" and "adolescents". Several of the variables for a single record shown variations in terms of sample sizes. Since ANOVA assumes that all variable samples are of the same size, a general linear model for an unbalanced ANOVA was used instead to generate interaction plot of the resultant variable, blood pressure levels and by predictor variables, obesity and blood serum cholesterol:

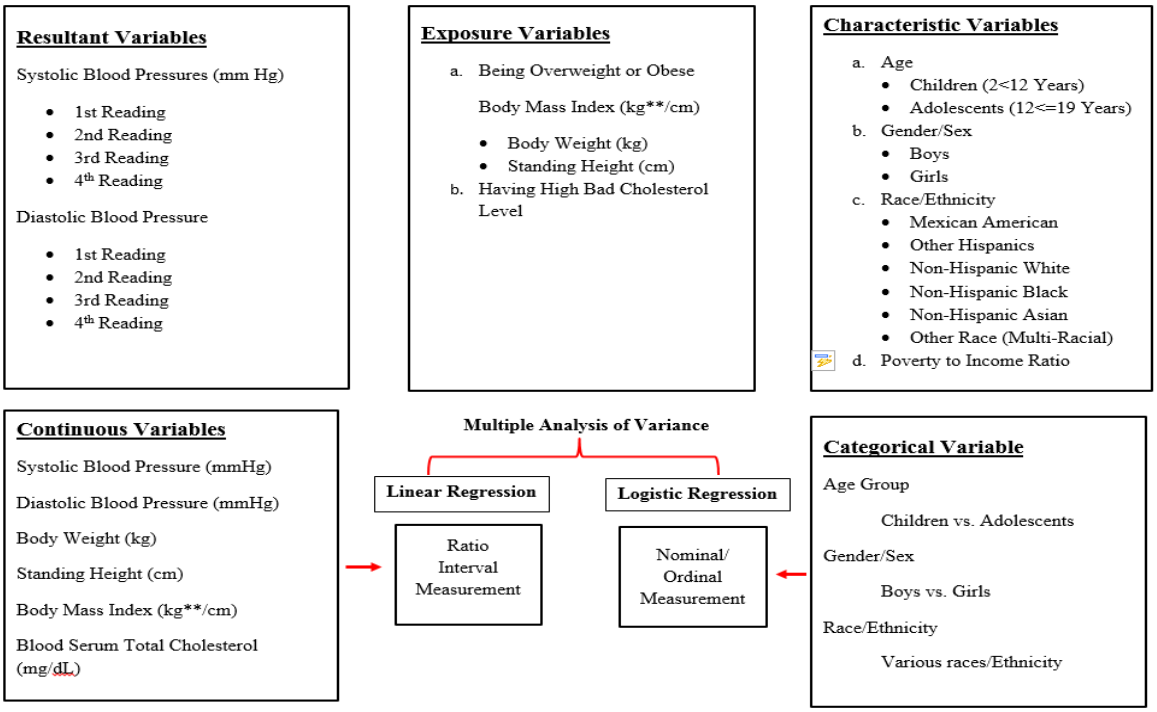
SAS Syntax for PROC GLM for Unbalanced ANOVA

```
/*Linear equation of the dependent variable SBP to the independent
variable Body Mass Index and Blood Serum Total Cholesterol*/
      ods graphics on;
      proc glm data=Selected;
      class SBP;
      model SBP=bmxbmi lbtc1 SBP*bmxbmi SBP*lbtc1;
      label SBP = 'Systolic Blood Pressure';
      format BMI BMI.;
      title 'Analysis of Covariance for Systolic by Body Mass Index
            , Ratio of Poverty to Family Income and Blood Serum Total
            Cholesterol";
      run;
      ods graphics off;
```

The statistical significance of differences between point estimates was evaluated using the one-sided Fisher's exact transformation method at the level of 0.05 assuming independence. Estimates and standard errors were calculated using SAS. The model parameters were treated as random variables.

Figure 6:

Statistical Modeling for Analytic Variables and Covariates



As shown in Figure 6, logistic regression will be run for all categorical variables and the general linear model for continuous variables. Correlations between the outcome variable, blood pressure levels and covariates will be run using the Fisher's exact transformation. This will allow closer-to- exact approximation of strengths of the associations between covariates that presented with smaller sample sizes. Of a particular significance is determination of the relationship between derived diastolic BP and other exposure variables. For instance, the number of subjects classified under stage I and II hypertensive children and adolescents using diastolic BP was less than 5 needful for exacting the transformation.

A total of 4,196 of children and adolescents (boys and girls) aged 2-19 years representing 43% of total respondents of 9,756 were selected for this analysis. In order to determine whether the distribution of blood pressure levels in boys and girls were

explained by body weight, height, waist circumference, body mass index was calculated from height in centimeters and weight in kilograms. From the NHANES, the variable label for BMI (calculated) was given as Body Mass Index (kg/m**2). Relatively high BP status was defined as systolic blood pressure and or diastolic blood pressure >=95th percentile for age and gender. Characteristics of the sample population were then compared with the general population to show if there were variations or justify how the sample population represented the general population. The characteristic tables (Tables 7-22) show how levels of blood pressure are distributed among children and adolescents by their age, gender, race, cholesterol and BMI. Categorical values in these table were shown as frequencies and expressed by weighted percentages. Next, the proportion of children and adolescents at the risk of hypertension conditions and high cholesterol stratified by body mass index and age categories were determined. Values for continuous variables such as body weight, standing height, blood serum total cholesterol, and poverty ratio to family income were expressed by their means and standard deviations (See Tables 24-28 on pages 99-116). Third, differences in the prevalence of each hypertension conditions among children and adolescents were compared using likelihood ratios and 2 X 2 tables based on BMI. Finally, magnitude of the determined correlations between hypertension risk factors and the sample characteristics were assessed. Generally in these analyses, hypertension prevalence was expressed as a function of weight status and demographic factors using the exact Fishers test for variable samples less than five (See Table 35 on pages 130-132).

Figure 7:

Plot of Mean Systolic Blood Pressure by Body Mass Index with Quadratic Regression Fitting and Confidence Intervals

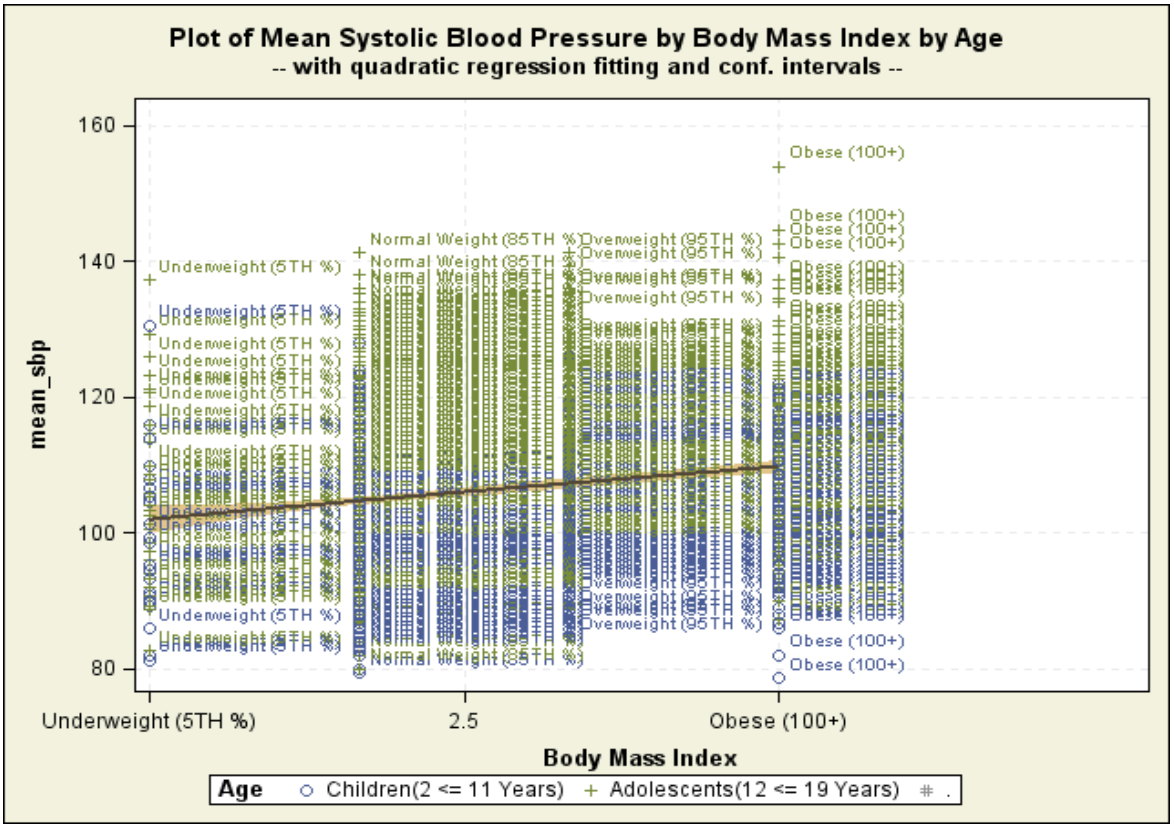
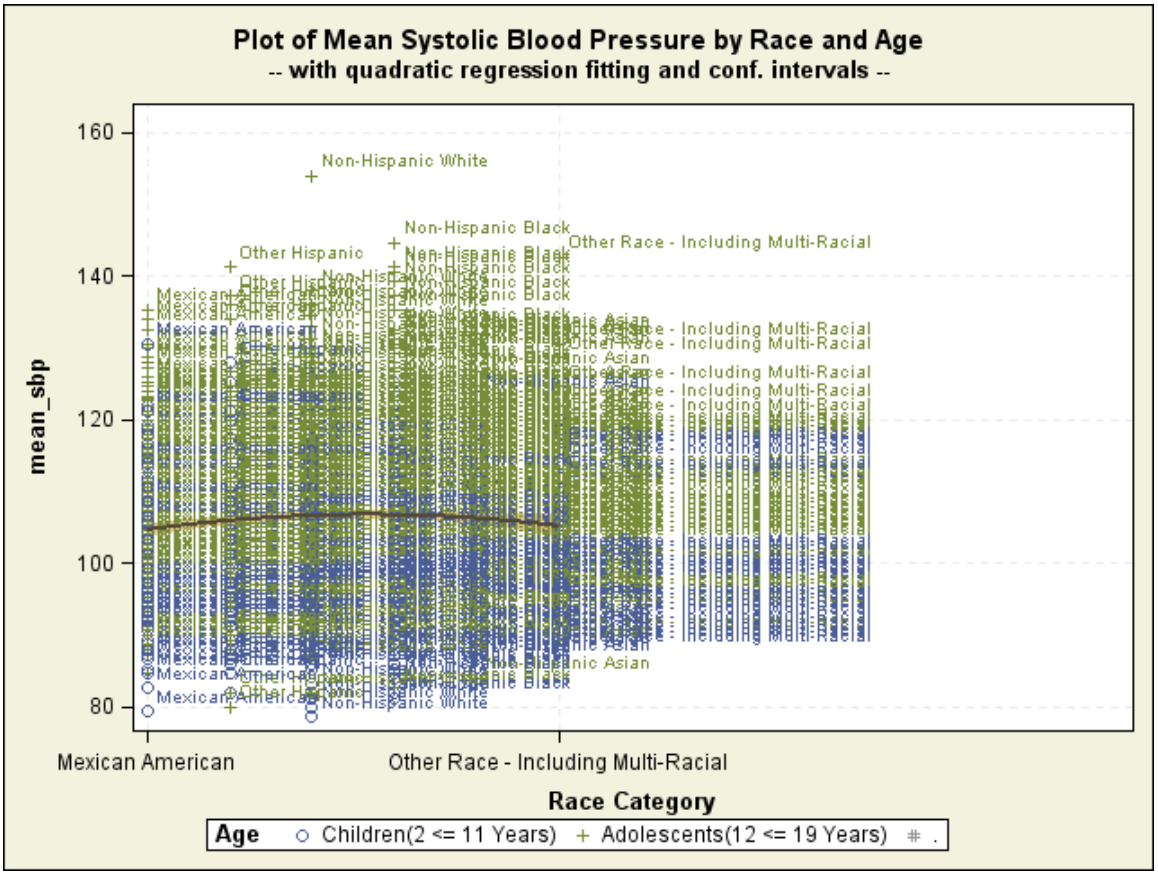


Figure 7 above fits a quadratic curve to visualize slope of regression between means systolic blood pressure levels in US children and adolescents and body mass index. The regression curve flows upward from left to the right indicating that equating the response variable mean systolic blood pressure to fit body mass index as an explanatory variable is a good fit. Blood pressure levels increase with body mass index. Therefore, the variability is explained.

Figure 8:

Plot of Mean Systolic Blood Pressure by Race with Quadratic Regression Fitting and Confidence Intervals



As shown in Figure 8 above, a curve of the regression model runs almost parallel to the y-axis indicating that variability in mean systolic blood pressure levels in US children and adolescents was not explained solely by race. A binary analysis between the response variable and race is not a good model. A multi-variate binary logistic regression will be the best fit for a model to derive a proportional estimate of the variable (race) to explain variability in mean systolic blood levels among different race/ethnic groups.

Figure 9:

Plot of Mean Systolic Blood Pressure by Body Mass Index and Age with Quadratic Regression Fitting and Confidence Intervals

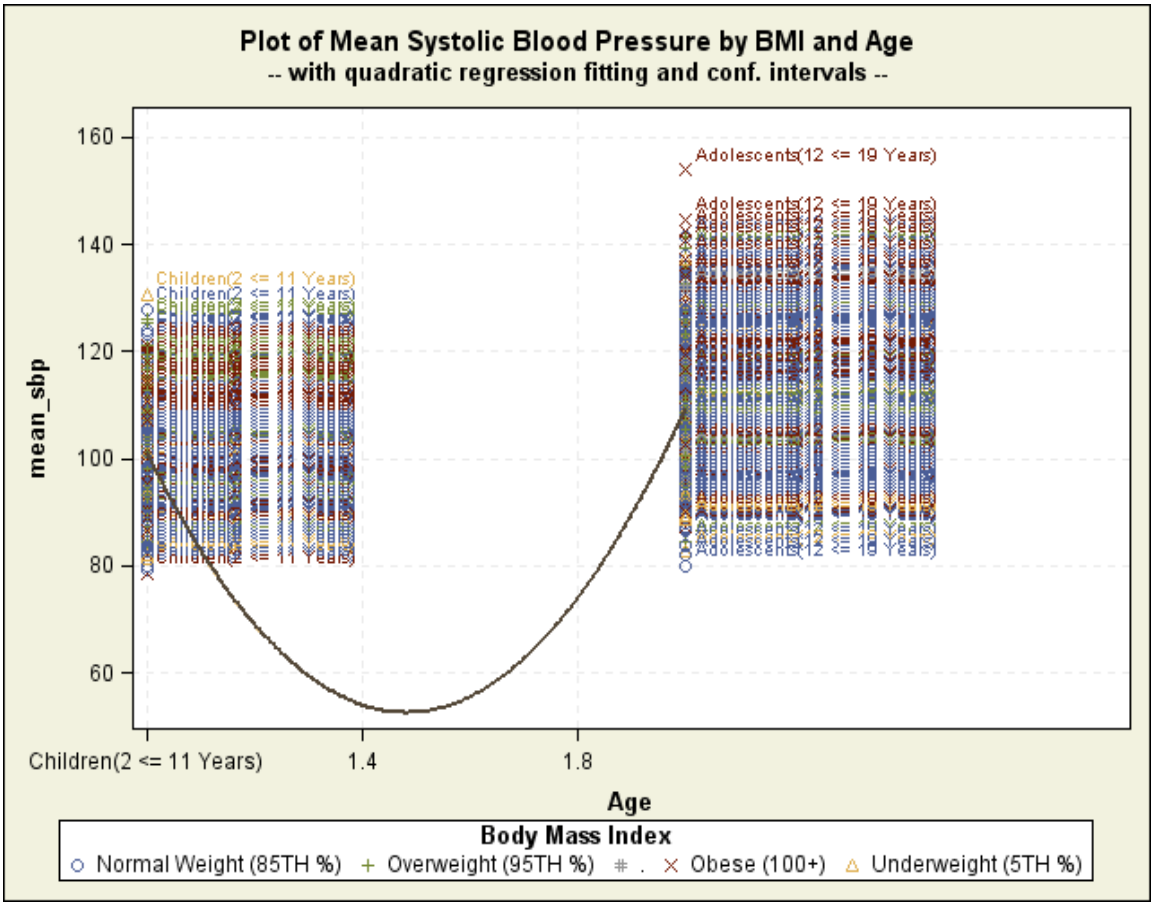


Figure 9 above shows the relationship between mean systolic blood pressure levels, body mass index and age for children and adolescents. As depicted by the quadratic regression curve, slope of the mean systolic blood pressure curve in children aged 2≤11 years is negative from 0 - 1.5 on the x-axis (the cutting limit for normal weight). The curve assumes a positive slope (rises with age and body mass index) at the point where overweight begins. The figure also shows brown (obese), green (overweight), and blue (normal weight) Xs within the adolescent group indicating that it is possible for an obese or overweight adolescent to have normal blood pressure and vice versa.

Figure 10:

Plot of Mean Systolic Blood Pressure by Body Mass Index and Age with Quadratic Regression Fitting and Confidence Intervals: Correlations

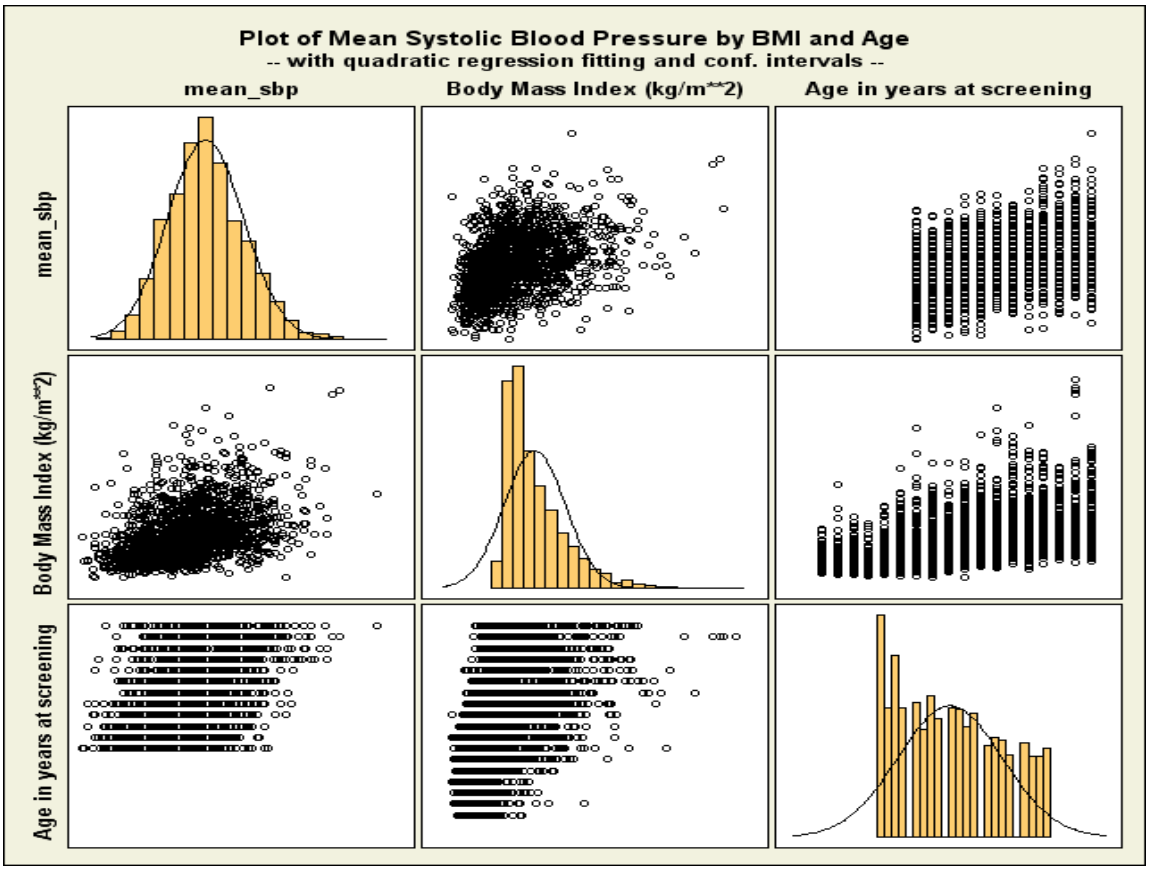


Figure 10 above, fits a quadratic curve to describe the distribution and correlations between mean systolic blood pressure, body mass index and age.

3.10 Measurements and Definitions of Cardiovascular Risk Factors

3.10.1 Classification of Body Mass Index (BMI)

Using height, weight, waist circumference, gender and age reported through the 2011-2012 NHANES release, participants were classified as children and adolescents. Obesity as a risk factor was defined using the Centers for Disease Control and Prevention (CDC) age and gender specific percentiles for body mass index (BMI).[51] By this

standard, overweight was defined as having a BMI percentile of ($\geq 85^{th}$ $<95^{th}$) percentiles. Normal weight was defined as having a BMI percentile of ($\geq 5^{th}$ $<85^{th}$) percentiles. Underweight defined as having a BMI of ($<5^{th}$) percentile. BMI was measured in kilograms (kg) / meters (m).

3.10.2 Classification of Blood Pressure Levels

Since the definition of hypertension in children is too complex and is based on age, gender and height, a recommended algorithm [50] was used to classify hypertensive conditions in the selected sample. Stages of hypertension development were categorized under pre-hypertension and hypertension. Systolic and diastolic BP was used to identify children and adolescents who fall under categories such as pre-hypertension and hypertension conditions. These were determined by the means of three readings that were performed during visits for body measurements and BP level evaluations.

Pre-hypertension among adolescents aged 12-17 years were defined according to the guidelines provided in the National Heart, Lung and Blood Institute. The definitions set in these guidelines were based on age, gender and height. According to these guidelines, pre-hypertension is defined as having a SBP or DBP reading ($\geq 90^{th}$ $<95^{th}$) percentiles; and as having hypertension if SBP or DBP reading ($\geq 95^{th}$) percentile. For those aged 18-19 years, pre-hypertension is defined as having a SBP reading ($\geq$120 mm HG $\leq$139 mmHg) or a DBP reading ($\geq$80 mm HG $\leq$89 mmHg) and hypertensive if SBP reading ($\geq$140 mm HG) or DBP reading ($\geq$90 mm HG).

3.10.3 Classification of Cholesterol Levels

Classification standards per the National Cholesterol Education Program and the American Heart Association, which were incorporated in the American Academy of Pediatrics (AAP) lipid screening, were used [93]. According to the standards, abnormal lipid levels for determining cholesterol can be classified as borderline, high and low. Children and adolescents were classified as having borderline high if their level (≥110 <129 mg/dL) or high if their level (≥130 mg/dL) or low if their level (<35 mg/dL).

Risk scores for evaluating patients at highest 10 year risk of cardiovascular diseases were published through the Framingham study. [94] In the past, evaluators have relied on cholesterol concentrations as a surrogate marker for the risk of atherosclerosis in children without familial hypercholesteromia. Unfortunately, there are no risk scores available for children. More so, no data exist to support a particular childhood cholesterol to predict the risk of adult cardiovascular diseases. Therefore, varying views and conclusions have been made regarding thresholds for identifying children and adolescents with abnormal lipid and lipoprotein concentrations. For this reason, the present analysis will be based on AAP's recommendations for screening children with the risk of high cholesterol.

CHAPTER IV

RESULTS

4.1 Prevalence of Elevated Blood Pressure Levels in Us Children and Adolescents by Gender / Sex

For the 2011-2012 analysis period, the analysis results show current national hypertension prevalence of 3% for US children aged (2<=11 years) and 14% for adolescents aged (12<=19 years). The rates are consistent with previous estimates.[31]

Table 7:

Table of Systolic Blood Pressure by Gender
Controlling for Age=Children (2 <= 11 Years)

Gender	Systolic Blood Pressure Level Status	Freq.	Weighted Frequency	Std Dev.of Wgt. Freq	Percent	Std Err of Percent
Boys	Pre-hypertension (<=120 mmHg)	380	6807786	2165219	46.4848	2.2769
	Stage 1 Hypertension (<=124 mmHg)	6	68888	35943	0.4704	0.1268
	Stage 2 Hypertension (Systolic >124 mmHg)	2	68825	68825	0.4700	0.4495
	Total	388	6945499	2221024	47.4252	2.4346
Girls	Pre-hypertension (<=120 mmHg)	380	7479584	3056720	51.0720	2.5905
	Stage 1 Hypertension (<=124 mmHg)	6	189783	98168	1.2959	0.3314
	Stage 2 Hypertension (Systolic >124 mmHg)	2	30315	30315	0.2070	0.1980
	Total	388	7699682	3148459	52.5748	2.4346
Total	Pre-hypertension (<=120 mmHg)	760	14287370	5215706	97.5568	1.0806
	Stage 1 Hypertension (<=124 mmHg)	12	258670	134099	1.7662	0.4581
	Stage 2 Hypertension (Systolic >124 mmHg)	4	99140	99140	0.6769	0.6474

Gender	Systolic Blood Pressure Level Status	Freq.	Weighted Frequency	Std Dev.of Wgt. Freq	Percent	Std Err of Percent
	Total	776	14645181	5361559	100.000	

78 out of 1,117 adolescents (girls and boys) representing 6.18% show prevalence of stage 1 hypertension and 95 out of 1,171 (girls and boys) representing 7.92% had stage 2 hypertension. The rates for adolescent boys with stage 1 and 2 hypertension were 3.99% and 7.06% respectively compared to 0.47% in children. Percentiles for girls were 2.19% for stage 1 hypertension and 0.86% for stage 2 hypertension. Particularly, the rate of stage 2 hypertension in adolescent boys was five times the rate for adolescent girls. In comparison to hypertension rates in children, the results show very rare hypertensive prevalence in children aged 11 years and younger. Out of 776, 12 observations representing 1.76% with standard error percent of 0.45 were identified with stage 1 hypertension and 4 of 776 observations representing 0.67% with standard error percent of 0.64 had stage 2 hypertension.

Figure 11:

Distribution of Systolic Blood Pressure by Age Group

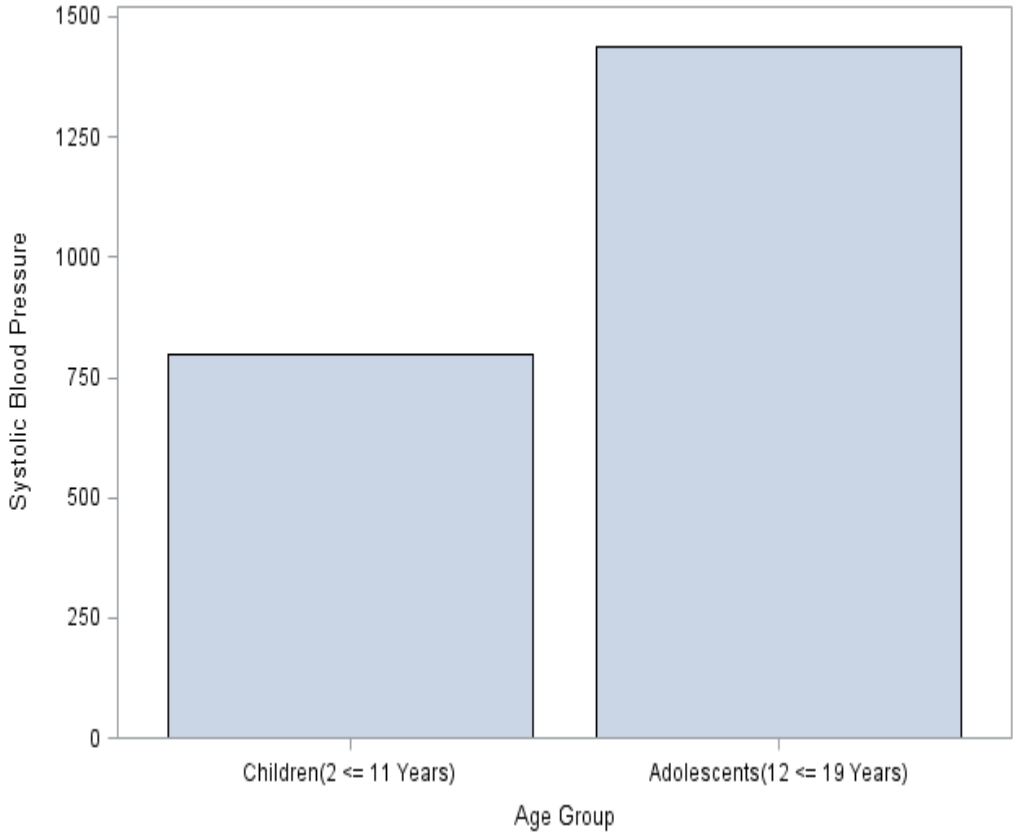


Figure 11, above, shows that hypertension is more prevalent in US adolescents aged from 12 to 19 years than in children 2 to 11 years. The results show 3% hypertension prevalence in US children (2≤11 years) compared to 14% in US adolescents (11≤19 years).

Table 8:

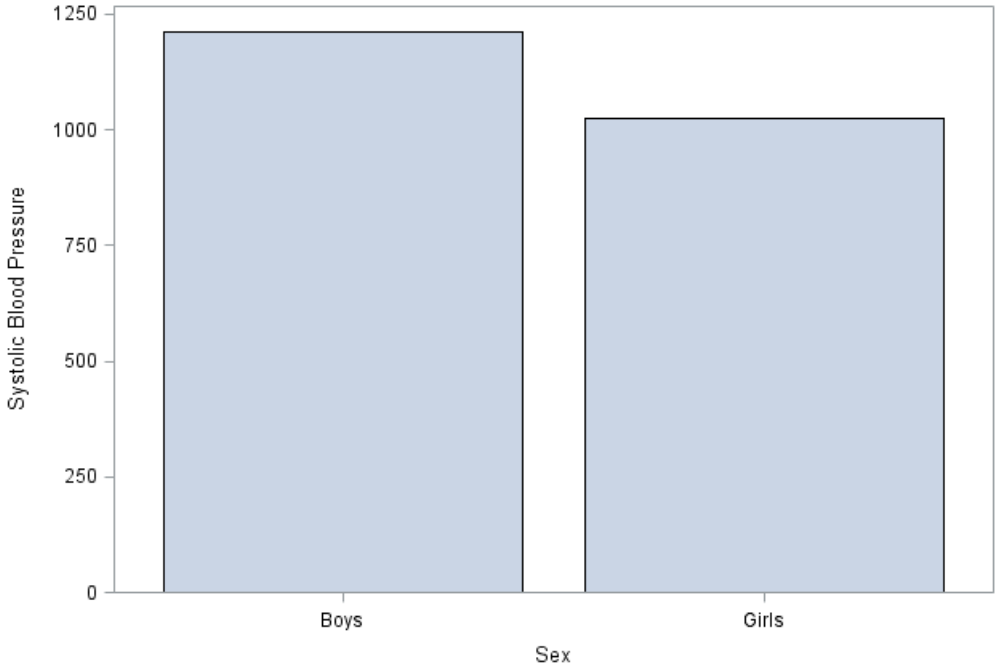
Table of Systolic Blood Pressure by Gender
Controlling For Age=Children (12 <= 19 Years)

Gender	Systolic Blood Pressure Level Status	Freq	Weighted Frequency	Std Dev.of Wgt. Freq.	Percent	Std Err of Percent
Boys	Pre-hypertension (<=120 mmHg)	471	12665076	5383417	40.4982	1.0638
	Stage 1 Hypertension (<=124 mmHg)	51	1248322	664493	3.9917	0.3651
	Stage 2 Hypertension (Systolic >124 mmHg)	80	2208269	1013491	7.0612	0.1338
	Total	602	16121668	7057753	51.5511	0.6526
Girls	Pre-hypertension (<=120 mmHg)	527	14196628	6342097	45.3956	0.5971
	Stage 1 Hypertension (<=124 mmHg)	27	685748	415008	2.1928	0.4439
	Stage 2 Hypertension (Systolic >124 mmHg)	15	269117	113380	0.8605	0.3515
	Total	569	15151492	6808439	48.4489	0.6526
Total	Pre-hypertension (<=120 mmHg)	998	26861704	11717928	85.8938	0.6266
	Stage 1 Hypertension (<=124 mmHg)	78	1934070	1074776	6.1844	0.7821
	Stage 2 Hypertension (Systolic >124 mmHg)	95	2477386	1078388	7.9218	0.2364
	Total	1171	31273160	13861359	100.000	

As shown in Table 8, hypertension rates were highest among adolescent boys (4%) stage 1 and (7%) stage 2 and lowest among adolescent girls (2%) stage 1 hypertension and (0.86%) stage 2.

Figure 12:

Distribution of Systolic Blood Pressure by Gender/Sex



As shown in Figure 12, elevated blood pressure level distribution was higher in boys than in girls. The rates were higher in adolescent boys than in adolescent girls. Relative rates were highest in Non-Hispanic Black adolescents (21%) (SE < 1) compared to lowest rate of (8%) in Non-Hispanic Asians.

4.2 Prevalence of Elevated Blood Pressure Levels in US Children and Adolescents by Race/ Ethnicity

Non-Hispanic White Adolescents' rates accounted for 2.65% stage 1 hypertension and 3.86% stage 2 hypertension. Non-Hispanic Black adolescent rates were 1.46% and 1.89% with standard error percentiles of 0.32% and 0.49% for stage 1 and 2 respectively. Mexican American rates were 0.72% for stage 1 hypertension and 1.08% for stage 2 hypertension. No significant differences were observed between the rates for Mexican

American and Other Hispanics. The rates for Non-Hispanic Asians were 0.18%, stage 1 hypertension and 0.17% stage 2 hypertension. In children, Non-Hispanic Blacks had the highest rate (0.33%) for stage 1 hypertension compared to a minimum rate of 0.04% for Non-Hispanic Asians. (See Table 9 on Pages 67-68 and Table 10 on Pages 70-71).

Table 9:

Table of Systolic Blood Pressure by Race
Controlling for Age=Children (2 <= 11 Years)

Race	Systolic Blood Pressure Level Status	Freq.	Weighted Frequency	Std. Dev. Of Wgt. Freq.	Percent	Std. Err of Percent
Mexican American	Pre-hypertension (<=120 mmHg)	160	2301616	550718	15.7159	4.7650
	Stage 1 Hypertension (<=124 mmHg)	2	27798	27798	0.1898	0.1815
	Stage 2 Hypertension (Systolic >124 mmHg)	1	13927	13927	0.0951	0.0910
	Total	163	2343342	590723	16.0008	4.9599
Other Hispanic	Pre-hypertension (<=120 mmHg)	82	1089330	567508	7.4381	2.9505
	Stage 1 Hypertension (<=124 mmHg)	2	23691	11913	0.1618	0.0316
	Stage 2 Hypertension (Systolic >124 mmHg)	2	30315	30315	0.2070	0.1980
	Total	86	1143336	605650	7.8069	3.1732
Non-Hispanic White	Pre-hypertension (<=120 mmHg)	190	7760092	3658695	52.9873	10.6333
	Stage 1 Hypertension (<=124 mmHg)	2	152633	76639	1.0422	0.1528
	Stage 2 Hypertension (Systolic >124 mmHg)	1	54898	54898	0.3749	0.3585
	Total	193	7967622	3719539	54.4044	10.2720
Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	211	2001096	1030337	13.6639	4.4396
	Stage 1 Hypertension (<=124 mmHg)	5	48693	32932	0.3325	0.1841

Race	Systolic Blood Pressure Level Status	Freq.	Weighted Frequency	Std. Dev. Of Wgt. Freq.	Percent	Std. Err of Percent
	Stage 2 Hypertension (Systolic >124 mmHg)	0	.	.	.	.
	Total	216	2049789	1062026	13.9963	4.6233
Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	71	552153	126977	3.7702	0.9160
	Stage 1 Hypertension (<=124 mmHg)	1	5856	5856	0.0400	0.0320
	Stage 2 Hypertension (Systolic >124 mmHg)	0	.	.	.	.
	Total	72	558009	132793	3.8102	0.9249
Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	46	583082	313636	3.9814	1.0325
	Stage 1 Hypertension (<=124 mmHg)	0	.	.	.	.
	Stage 2 Hypertension (Systolic >124 mmHg)	0	.	.	.	.
	Total	46	583082	313636	3.9814	1.0325
Total	Pre-hypertension (<=120 mmHg)	760	14287370	5215706	97.5568	1.0806
	Stage 1 Hypertension (<=124 mmHg)	12	258670	134099	1.7662	0.4581
	Stage 2 Hypertension (Systolic >124 mmHg)	4	99140	99140	0.6769	0.6474
	Total	776	14645181	5361559	100.000	

As shown in Table 9, accuracy of the relative position of Non-Hispanic Whites in the distribution of pre-hypertension in children (aged 2≤11 years) is not reliable given a weighted percentile of 52.98% (SE 10.83). The 13.66% (SE 4.44) pre-hypertension rate in Non-Hispanic Blacks is more accurate compared to that of Non-Hispanic Whites. It is evident from the distribution that hypertension prevalence in US children (aged 2≤11 years) at the national level is very rare although previous studies have recorded evidence

that indicate hypertension in this age group using local and regional population-based samples. Proper adjustments must be made to accurately determine accurate weight factors that must be applied to this age group national estimates.

Figure 13:

Relative Distribution of Systolic Blood Pressure by Race/Ethnicity

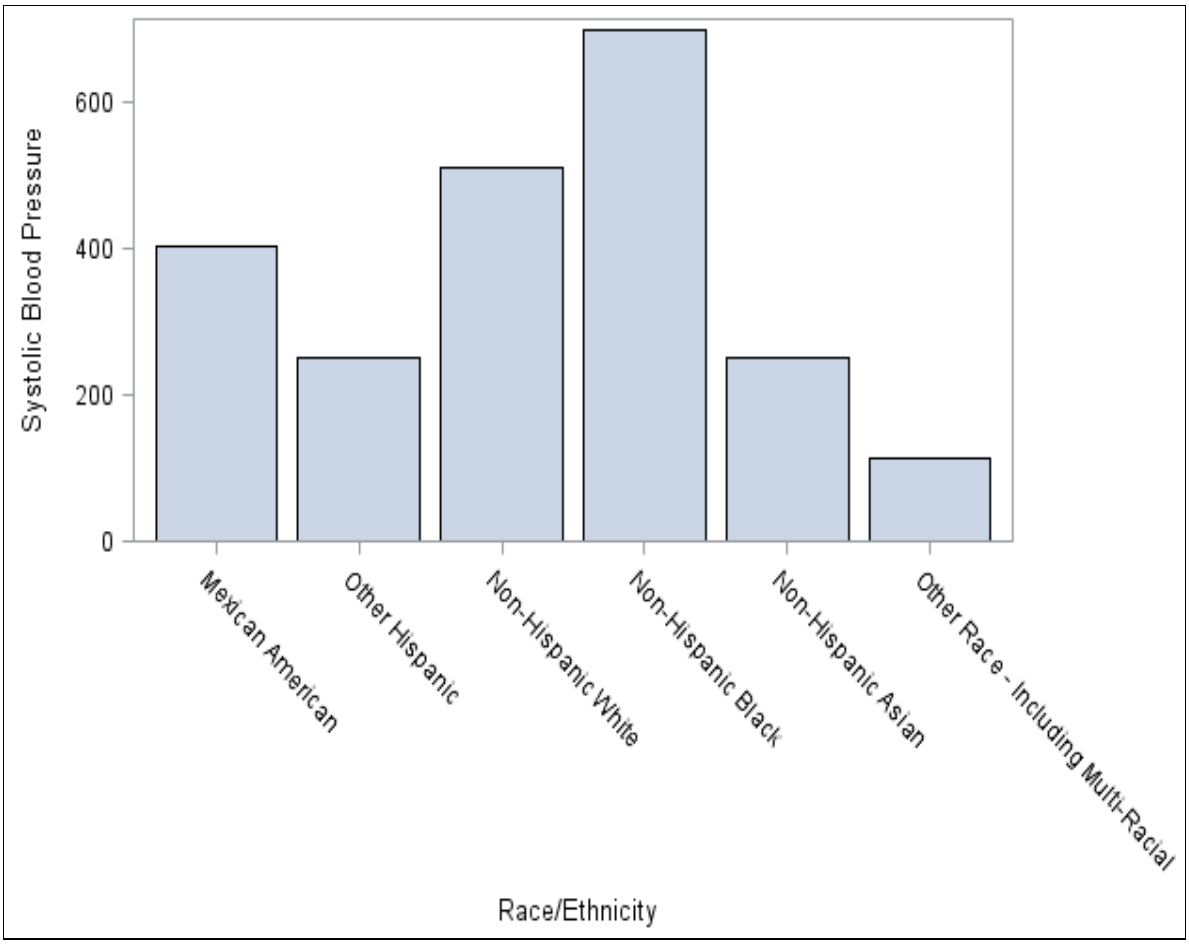


Figure 13 above shows that Non-Hispanic Blacks had the highest relative distribution of hypertension with Other Race-Including Multi Racial having the lowest.

Table 10:

Table of Systolic Blood Pressure by Race
Controlling for Age=Children (12 <= 19 Years)

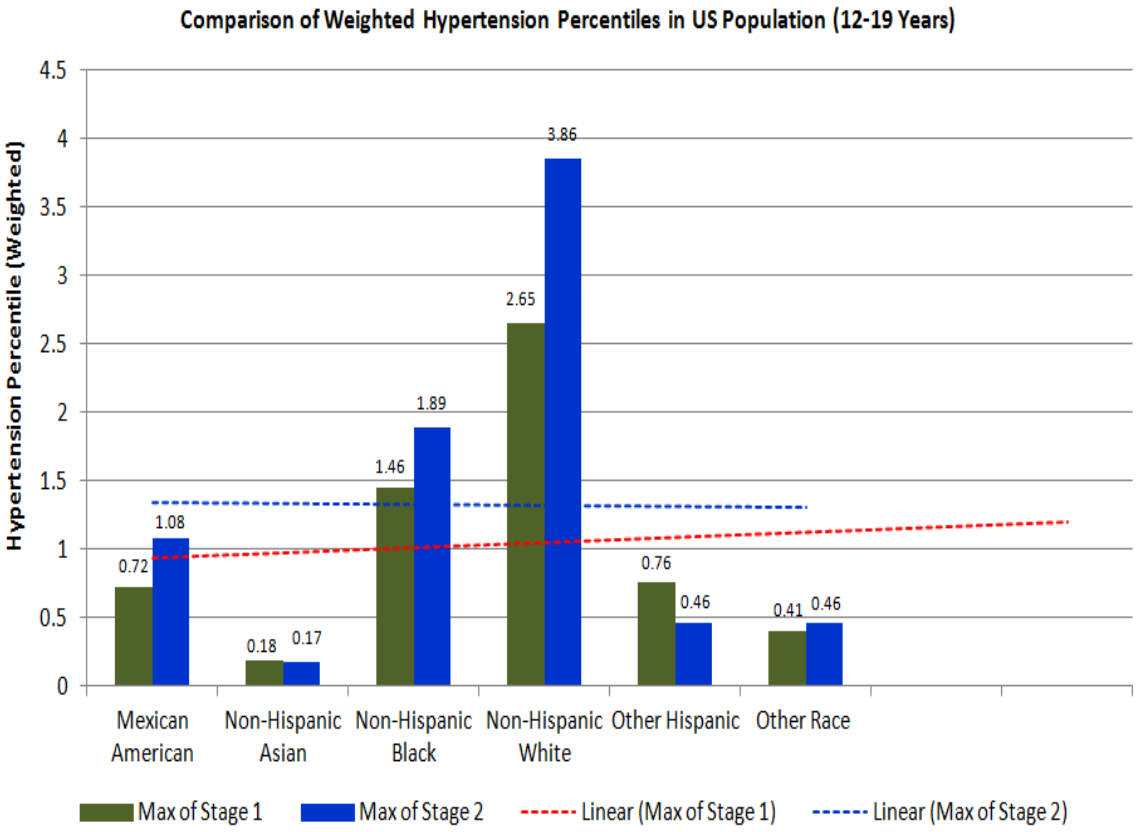
Race	Systolic Blood Pressure Level Status	Freq.	Weighted Frequency	Std. Dev. Of Wgt. Freq.	Percent	Std Err of Percent
Mexican American	Pre-hypertension (<=120 mmHg)	176	3702348	816800	11.8387	3.8371
	Stage 1 Hypertension (<=124 mmHg)	10	225750	166419	0.7219	0.2841
	Stage 2 Hypertension (Systolic >124 mmHg)	14	337245	117133	1.0784	0.1052
	Total	200	4265343	982287	13.6390	3.6755
Other Hispanic	Pre-hypertension (<=120 mmHg)	115	2004223	1015593	6.4088	3.2482
	Stage 1 Hypertension (<=124 mmHg)	11	238787	124906	0.7636	0.0655
	Stage 2 Hypertension (Systolic >124 mmHg)	8	143393	32155	0.4585	0.1004
	Total	134	2386403	1100378	7.6308	3.2904
Non-Hispanic White	Pre-hypertension (<=120 mmHg)	223	15136389	9071562	48.4006	10.6155
	Stage 1 Hypertension (<=124 mmHg)	15	829675	471841	2.6530	0.3772
	Stage 2 Hypertension (Systolic >124 mmHg)	20	1206452	714730	3.8578	0.7009
	Total	258	17172515	10249263	54.9114	11.6529
Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	283	3809230	2044541	12.1805	5.2608
	Stage 1 Hypertension (<=124 mmHg)	33	455016	228546	1.4550	0.3238
	Stage 2 Hypertension (Systolic >124 mmHg)	43	590779	274170	1.8891	0.4957
	Total	359	4855024	2519389	15.5246	6.0681
Non-Hispanic	Pre-hypertension (<=120	150	1292801	240980	4.1339	1.0634

Race	Systolic Blood Pressure Level Status	Freq.	Weighted Frequency	Std. Dev. Of Wgt. Freq.	Percent	Std Err of Percent
Asian	mmHg)					
	Stage 1 Hypertension (<=124 mmHg)	6	57809	43228	0.1849	0.0753
	Stage 2 Hypertension (Systolic >124 mmHg)	6	54378	32039	0.1739	0.0307
	Total	162	1404988	312882	4.4926	1.0057
Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	51	916713	599843	2.9313	1.0956
	Stage 1 Hypertension (<=124 mmHg)	3	127034	113605	0.4062	0.2626
	Stage 2 Hypertension (Systolic >124 mmHg)	4	145141	81231	0.4641	0.3917
	Total	58	1188887	643780	3.8016	1.0668
Total	Pre-hypertension (<=120 mmHg)	998	26861704	11717928	85.8938	0.6266
	Stage 1 Hypertension (<=124 mmHg)	78	1934070	1074776	6.1844	0.7821
	Stage 2 Hypertension (Systolic >124 mmHg)	95	2477386	1078388	7.9218	0.2364
	Total	1171	31273160	13861359	100.000	

Although the 2011-2012 survey over-sampled under-represented sub-populations to account for sampling bias, the weighted factor for the selected sample did not accurately reflect estimates in the general population. Regardless of this fact, actual hypertension estimates were associated with lesser standard errors compared to errors associated with pre-hypertension. This could be due to definitional constraints which will be highlighted in the discussion section of this dissertation.

Figure 14:

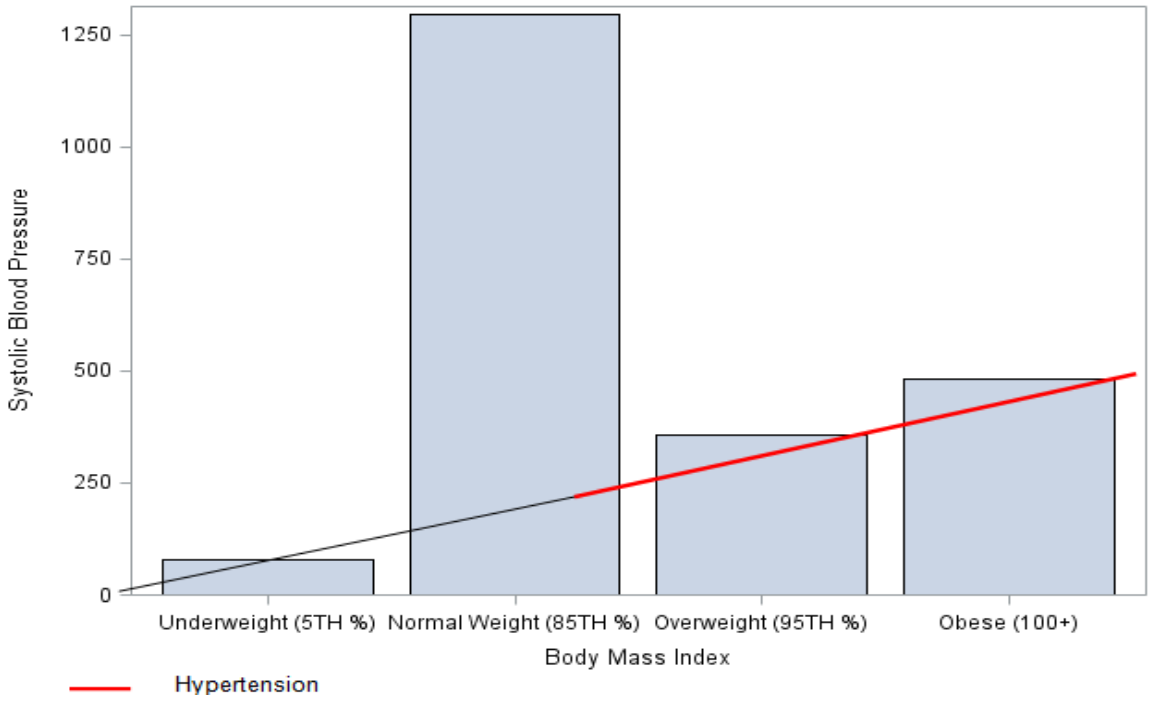
Comparison of the Weighted Percentiles by Race



As shown in Figure 14**,** once an overweight and obese child or adolescent develops stage 1 hypertension it is more likely to degenerate to stage 2 hypertension if not intervened. The blue dotted line depicts the linear trend of stage 2 hypertension and the red dotted line depicts the linear trend of stage 1 hypertension. Children and adolescent diagnosed with stage 1 hypertension can benefit from intervention programs.

Figure 15:

Distribution of Systolic Blood Pressure by Body Mass Index



As shown in Figure 15, the risk of developing hypertension increases from normal, and overweight to obese children. Body mass index positively correlates mean systolic blood pressure. The red section of the growth curve indicates that it is possible for an individual who has a normal weight to develop hypertension.

4.3 Prevalence of Elevated Blood Pressure Levels in US Children and Adolescents by Body Mass Index

The study goal was to estimate national hypertension prevalence in overweight and obese US children and adolescents. The results indicate rare hypertension prevalence in obese and overweight children aged 11 years and younger. Out of 776 children, 760 (97.55%) were pre-hypertensive (SBP <=120mmHg); 12 (1.76%) had stage 1 hypertension (SBP<=124 mmHg); and 4 (0.67%) had stage 2 hypertension (SBP>124mmHg). 16 (2.4%) of all children 2-11 years were observed as having either stage 1 or stage 2 hypertension, 7 (0.01%) of which were either overweight or obese. The same pattern was not observed in adolescents aged 2-19 years. Out of a total of 1,149 adolescents, 171 (14%) either had stage 1 or 2 hypertension compared to 2.4% in children. 80 (46%) of 171 hypertensive adolescents were either overweight or obese. (See Tables 11 and d 12)

Table 11:

Table of Systolic Blood Pressure by Body Mass Index Controlling for Age=Children (2 <= 11 Years)

Body Mass Index Status	Systolic Blood Pressure Level Status	Freq.	Weighted Frequency	Std. Dev. Of Wgt. Freq.	Percent	Std Err of Percent
Underweight (5TH %)	Pre-hypertension (<=120 mmHg)	22	520871	162007	3.5566	0.4281
	Stage 1 Hypertension (<=124 mmHg)	0	.	.	.	.
	Stage 2 Hypertension (Systolic >124 mmHg)	1	13927	13927	0.0951	0.0910
	Total	23	534798	170507	3.6517	0.5076
Normal Weight	Pre-hypertension (<=120 mmHg)	446	8373616	3103061	57.1766	0.8043

Body Mass Index Status	Systolic Blood Pressure Level Status	Freq.	Weighted Frequency	Std. Dev. Of Wgt. Freq.	Percent	Std Err of Percent
(85TH %)						
	Stage 1 Hypertension (<=124 mmHg)	7	139479	84973	0.9524	0.2895
	Stage 2 Hypertension (Systolic >124 mmHg)	1	15166	15166	0.1036	0.0990
	Total	454	8528262	3185608	58.2325	0.7723
Overweight (95TH %)	Pre-hypertension (<=120 mmHg)	129	2730740	1004830	18.6460	2.5966
	Stage 1 Hypertension (<=124 mmHg)	1	13927	13927	0.0951	0.0910
	Stage 2 Hypertension (Systolic >124 mmHg)	2	70047	70047	0.4783	0.4574
	Total	132	2814714	1001836	19.2194	2.0693
Obese (100+)	Pre-hypertension (<=120 mmHg)	163	2662143	1027352	18.1776	0.5084
	Stage 1 Hypertension (<=124 mmHg)	4	105264	89115	0.7188	0.5578
	Stage 2 Hypertension (Systolic >124 mmHg)	0	.	.	.	.
	Total	167	2767407	1070279	18.8964	0.9832
Total	Pre-hypertension (<=120 mmHg)	760	14287370	5215706	97.5568	1.0806
	Stage 1 Hypertension (<=124 mmHg)	12	258670	134099	1.7662	0.4581
	Stage 2 Hypertension (Systolic >124 mmHg)	4	99140	99140	0.6769	0.6474
	Total	776	14645181	5361559	100.000	

Table 12: Table of Systolic Blood Pressure by Body Mass Index Controlling for Age=Children (12 <= 19 Years)

Body Mass Index Status	Systolic Blood Pressure Level Status	Freq.	Weighted Frequency	Std. Dev. Of Wgt. Freq.	Percent	Std Err of Percent
Underweight (5TH %)	Pre-hypertension (<=120 mmHg)	36	929729	350156	3.0238	0.2413
	Stage 1 Hypertension (<=124 mmHg)	4	77469	54576	0.2520	0.0889
	Stage 2 Hypertension (Systolic >124 mmHg)	3	169062	146419	0.5498	0.4761
	Total	43	1176260	442172	3.8256	0.3762
Normal Weight (85TH %)	Pre-hypertension (<=120 mmHg)	620	16903266	7640509	54.9754	0.5858
	Stage 1 Hypertension (<=124 mmHg)	40	1072037	586908	3.4866	0.3847
	Stage 2 Hypertension (Systolic >124 mmHg)	44	1148474	653197	3.7352	0.7962
	Total	704	19123778	8844329	62.1973	1.4931
Overweight (95TH %)	Pre-hypertension (<=120 mmHg)	145	3677684	1472954	11.9611	0.8906
	Stage 1 Hypertension (<=124 mmHg)	15	358241	217470	1.1651	0.2431
	Stage 2 Hypertension (Systolic >124 mmHg)	15	367023	100212	1.1937	0.2214
	Total	175	4402948	1775316	14.3199	0.8393
Obese (100+)	Pre-hypertension (<=120 mmHg)	177	4841184	1999013	15.7452	0.6432
	Stage 1 Hypertension (<=124 mmHg)	18	417044	213538	1.3564	0.1044
	Stage 2 Hypertension	32	785770	344015	2.5556	0.3732

Body Mass Index Status	Systolic Blood Pressure Level Status	Freq.	Weighted Frequency	Std. Dev. Of Wgt. Freq.	Percent	Std Err of Percent
	(Systolic >124 mmHg)					
	Total	227	6043998	2532765	19.6572	0.4586
Total	Pre-hypertension (<=120 mmHg)	978	26351863	11439740	85.7055	0.6710
	Stage 1 Hypertension (<=124 mmHg)	77	1924791	1066962	6.2601	0.7955
	Stage 2 Hypertension (Systolic >124 mmHg)	94	2470328	1076831	8.0344	0.1915
	Total	1149	30746983	13574380	100.000	

Approximately 4 of 10 US adolescents with either stage 1 or stage 2 hypertension is also obese or overweight. 80 (46%) of 171 hypertensive adolescents were either overweight or obese.

4.4 Prevalence of Elevated Blood Pressure Levels in US Children and Adolescents by Blood Serum Total Cholesterol Levels

Of 616 children aged (2<=11 years), 13 representing (2.15%) were defined as having either stage 1 or stage 2 hypertension. 2 representing (1.10%) had either stage 1 or 2 hypertension with desirable cholesterol levels. 10 representing 1.5% children were identified as having stage 1 hypertension with very high cholesterol levels. Only one (0.12%) was identified as having stage 2 hypertension with very high cholesterol level. Similar patterns were not seen in adolescents. By the applied definition, 171 (14%) of all adolescents had either stage 1 or stage 2 hypertension 14 (9.25%) of which had blood serum total cholesterol between 110 (Mg/dL) and 129 (Mg/dL) or “borderline”. None of the 171 adolescents had blood serum total cholesterol greater than (130 Mg/dL) or “very high”. (See Tables 13 and 14).

Table 13:

Table of Systolic Blood Pressure by Blood Serum Total Cholesterol Controlling for Age=Children (2 <= 11 Years)

Total Cholesterol Level	Systolic Blood Pressure Level Status	Freq.	Weighted Frequency	Std. Dev. Of Wgt. Freq.	Percent	Std Err of Percent
Desirable (<=110 Mg/dl)	Pre-hypertension (<=120 mmHg)	13	138502	70073	1.1936	0.1859
	Stage 1 Hypertension (<=124 mmHg)	0	.	.	.	.
	Stage 2 Hypertension (Systolic >124 mmHg)	0	.	.	.	.
	Total	13	138502	70073	1.1936	0.1859
Borderline (<= 129 Mg/dl)	Pre-hypertension (<=120 mmHg)	64	1329755	410234	11.4595	0.8710
	Stage 1 Hypertension (<=124 mmHg)	1	72263	72263	0.6227	0.5737
	Stage 2 Hypertension (Systolic >124 mmHg)	1	54898	54898	0.4731	0.4359
	Total	66	1456916	454014	12.5553	0.6051
Very High (>130 Mg/dl)	Pre-hypertension (<=120 mmHg)	526	9816802	3449885	84.5986	0.2288
	Stage 1 Hypertension (<=124 mmHg)	10	177828	95404	1.5325	0.3290
	Stage 2 Hypertension (Systolic >124 mmHg)	1	13927	13927	0.1200	0.1106
	Total	537	10008557	3547883	86.2511	0.4486
Total	Pre-hypertension (<=120 mmHg)	603	11285058	3923936	97.2517	0.9670
	Stage 1 Hypertension (<=124 mmHg)	11	250091	128141	2.1552	0.4671
	Stage 2 Hypertension (Systolic >124 mmHg)	2	68825	68825	0.5931	0.5465
	Total	616	11603974	4070104	100.000	

Although trends in the results show high cholesterol levels in children aged (2<=11 years), the analyzed data do not explain whether hypertension in these children were primary or secondary. The analysis indicate that total cholesterol and mean systolic blood pressure are not correlates. (See Table 35, Pages 130-132 for correlations).

Table 14:

Table of Systolic Blood Pressure by Blood Serum Total Cholesterol Controlling for Age=Children (12 <= 19 Years)

Total Cholesterol Level	Systolic Blood Pressure Level Status	Freq.	Weighted Frequency	Std. Dev. Of Wgt. Freq.	Percent	Std Err of Percent
Desirable (<=110 Mg/dl)	Pre-hypertension (<=120 mmHg)	29	815168	409128	21.9180	2.0522
	Stage 1 Hypertension (<=124 mmHg)	1	11463	11463	0.3082	0.2996
	Stage 2 Hypertension (Systolic >124 mmHg)	3	56860	31651	1.5288	0.9612
	Total	33	883491	418372	23.7551	1.6279
Borderline (<= 129 Mg/dl)	Pre-hypertension (<=120 mmHg)	117	2491572	939959	66.9928	3.7988
	Stage 1 Hypertension (<=124 mmHg)	9	150213	82639	4.0389	0.6705
	Stage 2 Hypertension (Systolic >124 mmHg)	5	193889	116682	5.2132	2.1245
	Total	131	2835674	1100676	76.2449	1.6279
Very High (>130 Mg/dl)	Pre-hypertension (<=120 mmHg)	0	.	.	.	.
	Stage 1 Hypertension (<=124 mmHg)	0	.	.	.	.
	Stage 2 Hypertension (Systolic >124 mmHg)	0	.	.	.	.
	Total	0	.	.	.	.
Total	Pre-hypertension (<=120 mmHg)	146	3306740	1347024	88.9108	3.0664
	Stage 1 Hypertension (<=124 mmHg)	10	161676	84482	4.3471	0.5055

Total Cholesterol Level	Systolic Blood Pressure Level Status	Freq.	Weighted Frequency	Std. Dev. Of Wgt. Freq.	Percent	Std Err of Percent
	Stage 2 Hypertension (Systolic >124 mmHg)	8	250749	143153	6.7421	2.9671
	Total	164	3719165	1518398	100.000	

This explanation is supported by the evidence of non-correlations between blood serum total cholesterol and blood pressure levels.

4.5 Estimates of Overweight or Obese US Children and Adolescents by Gender/Sex

A total of 2,150 records were observed for children aged (2<=11) years using body mass index classifications. 82 children representing (3.40%) were "underweight" (had BMI within the 5^{TH} percentile; 1,419 children (66.70%) were "healthy weight" (had BMI within the 85^{th} percentile; 297 (15.60%) were "overweight" (had BMI within the 95^{TH} percentile); and 352 (14.28%) were "obese" (had BMI 100+). For adolescent boys and girls aged (12<=19 years), a total of 1,196 records were analyzed. 44 (3.70%) were within the 5^{TH} percentile (Underweight); 731 (62.35%) 85^{th} percentile (Healthy Weight), 182 (14.05%) 95^{TH} percentile (Overweight) and 239 (19.89%) 100+ (Obese). (See Table 15 and 16 on pages 81 and 82). The percentiles for overweight and obese adolescent boys were 7.62% and 10.55% respectively compared to that of adolescent girls which were 6.42% and 9.33%. Compared to children, over all percentiles for overweight and obese adolescents were 14.05% and 19.89% compared to that of children which were 15.60% and 14.28% for overweight and obese children respectively.

Table 15:

Table of Body Mass Index by Gender
Controlling for Age=Children (2 <= 11 Years)

Gender	Body Mass Index Status	Freq.	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
Boys	Underweight (5TH %)	41	641259	239123	1.6446	0.5399
	Normal Weight (85TH %)	711	13165739	4880871	33.7655	0.7356
	Overweight (95TH %)	154	3138268	1170500	8.0485	0.1767
	Obese (100+)	186	2751878	975374	7.0576	1.4569
	Total	1092	19697144	7036878	50.5162	1.8764
Girls	Underweight (5TH %)	41	686105	432731	1.7596	0.5933
	Normal Weight (85TH %)	708	12844367	5519707	32.9412	1.6248
	Overweight (95TH %)	143	2945380	1073551	7.5539	0.3015
	Obese (100+)	166	2818746	1070664	7.2291	0.3998
	Total	1058	19294598	8037431	49.4838	1.8764
Total	Underweight (5TH %)	82	1327365	534788	3.4042	0.0643
	Normal Weight (85TH %)	1419	26010106	10400312	66.7067	1.5829
	Overweight (95TH %)	297	6083647	2243532	15.6024	0.4781
	Obese (100+)	352	5570624	2002200	14.2867	1.8473
	Total	2150	38991742	15047598	100.000	

Hypertension rates were lower in overweight and obese US children compared to the rates in US adolescents for the analysis period (2011-2012). However, there were no differences in terms of significance of the associations between obesity and hypertension in both children and adolescents.

Table 16:

Table of Body Mass Index by Gender
Controlling for Age=Children (12 <= 19 Years)

Gender	Body Mass Index Status	Freq.	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
Boys	Underweight (5TH %)	31	894169	357208	2.7956	0.3725
	Normal Weight (85TH %)	369	9981450	4563809	31.2063	0.6468
	Overweight (95TH %)	93	2439100	1003993	7.6257	0.3659
	Obese (100+)	126	3375145	1424531	10.5521	0.2461
	Total	619	16689865	7328282	52.1796	0.4837
Girls	Underweight (5TH %)	13	289441	95724	0.9049	0.1171
	Normal Weight (85TH %)	362	9962655	4720753	31.1475	1.7786
	Overweight (95TH %)	89	2056429	862862	6.4293	1.1754
	Obese (100+)	113	2987012	1267228	9.3387	0.1827
	Total	577	15295537	6844259	47.8204	0.4837
Total	Underweight (5TH %)	44	1183610	444723	3.7005	0.3946
	Normal Weight (85TH %)	731	19944105	9262331	62.3538	1.6942
	Overweight (95TH %)	182	4495530	1807136	14.0549	1.0580
	Obese (100+)	239	6362158	2691312	19.8908	0.4016
	Total	1196	31985403	14169789	100.000	

In adolescent boys, body mass index average for pre-hypertension was 23.11 kg/m**2 ± (0.24) and 27.10 kg/m**2 ± (0.93) for stage 2 hypertension with significant value of (p<.0001). These compared to body mass index average in girls which were 23.65 kg/m**2 ± (0.25) for pre-hypertension and 31.85 kg/m**2 ± (3.46) for stage 2 hypertension with a significant value less than one (p<.0001).

4.6 Estimates of Overweight or Obese US Children and Adolescents by Race

Out of a total of 2,150 observations analyzed for children aged (2<=11 years), highest rates of 8.63% and 5.19% for overweight and obesity were observed for Non-Hispanic White children compared to minimum rates of 0.40% and 0.29% for Non-Hispanic Asians. The results show similar trends in adolescents with rates of 6.44 % for overweight Non-Hispanic Whites and 10.01% for Obese Non-Hispanic Whites compared to 0.59% and 0.49% for overweight and obese Non-Hispanic Asians respectively. This is contrary to findings from previous studies which reported highest obesity rates in Non-Hispanic Blacks. (See Tables 17 and 18).

Table 17:

Table of Body Mass Index by Race
Controlling for Age=Children (2 <= 11 Years)

Race	Body Mass Index Status	Freq.	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
Mexican American	Underweight (5TH %)	10	132765	69184	0.3405	0.0461
	Normal Weight (85TH %)	251	3553545	967154	9.1136	2.4675
	Overweight (95TH %)	76	1118265	271685	2.8680	1.1620
	Obese (100+)	93	1347212	182889	3.4551	1.0387
	Total	430	6151786	1433387	15.7772	4.5520
Other Hispanic	Underweight (5TH %)	6	94484	33447	0.2423	0.0398
	Normal Weight (85TH %)	151	1962087	1117510	5.0321	2.4054
	Overweight (95TH %)	40	523336	300344	1.3422	0.7140
	Obese (100+)	58	763915	547102	1.9592	1.2850
	Total	255	3343822	1962670	8.5757	4.3670
Non-Hispanic White	Underweight (5TH	15	693866	278157	1.7795	0.0308

Race	Body Mass Index Status	Freq.	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
	%)					
	Normal Weight (85TH %)	319	14256362	7492192	36.5625	8.7412
	Overweight (95TH %)	73	3368438	1893896	8.6388	2.4803
	Obese (100+)	57	2025315	1148465	5.1942	1.2877
	Total	464	20343981	10778731	52.1751	12.4750
Non-Hispanic Black	Underweight (5TH %)	28	232998	107874	0.5976	0.0510
	Normal Weight (85TH %)	422	3786769	2019399	9.7117	3.7463
	Overweight (95TH %)	78	742172	391509	1.9034	0.7913
	Obese (100+)	113	1071345	646676	2.7476	1.3220
	Total	641	5833283	3133167	14.9603	5.8784
Non-Hispanic Asian	Underweight (5TH %)	18	131606	58182	0.3375	0.0548
	Normal Weight (85TH %)	186	1383942	424417	3.5493	0.5717
	Overweight (95TH %)	21	159435	44433	0.4089	0.1130
	Obese (100+)	14	114656	45037	0.2941	0.0851
	Total	239	1789639	541857	4.5898	0.6798
Other Race - Including Multi-Racial	Underweight (5TH %)	5	41646	8753	0.1068	0.0563
	Normal Weight (85TH %)	90	1067401	555180	2.7375	0.6802
	Overweight (95TH %)	9	172003	116821	0.4411	0.1844
	Obese (100+)	17	248181	91490	0.6365	0.2876
	Total	121	1529231	730592	3.9219	1.0205
Total	Underweight (5TH %)	82	1327365	534788	3.4042	0.0643
	Normal Weight (85TH %)	1419	26010106	10400312	66.7067	1.5829

Race	Body Mass Index Status	Freq.	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
	Overweight (95TH %)	297	6083647	2243532	15.6024	0.4781
	Obese (100+)	352	5570624	2002200	14.2867	1.8473
	Total	2150	38991742	15047598	100.000	

Table 18:

Table of Body Mass Index by Race
Controlling For Age=Children (12 <= 19 Years)

Race	Body Mass Index Status	Freq	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
Mexican American	Underweight (5TH %)	4	95702	27487	0.2992	0.1036
	Normal Weight (85TH %)	126	2630876	576172	8.2252	2.2095
	Overweight (95TH %)	33	722656	247568	2.2593	0.8385
	Obese (100+)	49	1073681	249859	3.3568	0.8553
	Total	212	4522915	1054605	14.1406	3.8738
Other Hispanic	Underweight (5TH %)	5	95293	11213	0.2979	0.1061
	Normal Weight (85TH %)	85	1502428	794890	4.6972	2.2734
	Overweight (95TH %)	22	355580	235001	1.1117	0.7755
	Obese (100+)	26	499264	149562	1.5609	0.3182
	Total	138	2452565	1151802	7.6678	3.3806
Non-Hispanic White	Underweight (5TH %)	10	732473	366333	2.2900	0.3891
	Normal Weight (85TH %)	171	11511897	6981514	35.9911	7.8690

Race	Body Mass Index Status	Freq	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
	Overweight (95TH %)	31	2062495	1150924	6.4482	1.3357
	Obese (100+)	50	3203611	2073279	10.0159	2.8889
	Total	262	17510476	10490242	54.7452	11.7726
Non-Hispanic Black	Underweight (5TH %)	11	146085	81528	0.4567	0.0569
	Normal Weight (85TH %)	205	2792341	1421816	8.7300	2.9655
	Overweight (95TH %)	63	859763	486000	2.6880	1.1567
	Obese (100+)	84	1103638	610548	3.4504	1.8543
	Total	363	4901827	2532995	15.3252	5.9117
Non-Hispanic Asian	Underweight (5TH %)	12	89383	36336	0.2794	0.2368
	Normal Weight (85TH %)	111	966239	291306	3.0209	0.5294
	Overweight (95TH %)	21	190210	39659	0.5947	0.1399
	Obese (100+)	19	158937	46034	0.4969	0.2198
	Total	163	1404768	300515	4.3919	1.0187
Other Race - Including Multi-Racial	Underweight (5TH %)	2	24674	24674	0.0771	0.0550
	Normal Weight (85TH %)	33	540325	343448	1.6893	0.6502
	Overweight (95TH %)	12	304826	192696	0.9530	0.4063
	Obese (100+)	11	323027	124530	1.0099	0.0593
	Total	58	1192852	663856	3.7294	1.1106
Total	Underweight (5TH %)	44	1183610	444723	3.7005	0.3946
	Normal Weight	731	19944105	9262331	62.3538	1.6942

Race	Body Mass Index Status	Freq	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
	(85TH %)					
	Overweight (95TH %)	182	4495530	1807136	14.0549	1.0580
	Obese (100+)	239	6362158	2691312	19.8908	0.4016
	Total	1196	31985403	14169789	100.000	

4.7 Cholesterol Levels in US Children and Adolescents by Gender/Sex

Table 19 below shows that total records of 976 were observed for children aged (2<=11 years). 15 (1.03%) had blood serum total cholesterol levels less or equal to 110 (Mg/dl) "desirable", 97 (11.39%) had cholesterol levels less or equal to 129 (Mg/dl) "borderline", and 864 (87.57%) had cholesterol levels of more than 130 (Mg/dl) "very high" (See Tables 19 and 20).

Table 19:

Table of Blood Serum Total Cholesterol by Gender
Controlling for Age=Children (2 <= 11 Years)

Gender	Total Cholesterol Level	Frequency	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
Boys	Desirable (<=110 Mg/dl)	10	105343	57040	0.5770	0.1107
	Borderline (<= 129 Mg/dl)	54	1100639	336992	6.0285	0.4017
	Very High (>130 Mg/dl)	431	8122255	2735479	44.4877	1.6824
	Total	495	9328237	3127788	51.0931	1.9651
Girls	Desirable (<=110 Mg/dl)	5	83970	46591	0.4599	0.0996
	Borderline (<= 129 Mg/dl)	43	978910	481051	5.3617	0.8619
	Very High (>130 Mg/dl)	433	7866198	3169239	43.0852	1.3311
	Total	481	8929078	3680150	48.9069	1.9651

Gender	Total Cholesterol Level	Frequency	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
Total	Desirable (<=110 Mg/dl)	15	189312	103593	1.0369	0.2101
	Borderline (<= 129 Mg/dl)	97	2079549	811913	11.3902	0.6886
	Very High (>130 Mg/dl)	864	15988454	5904560	87.5729	0.8608
	Total	976	18257315	6806233	100.000	

In adolescents (12<=19 years), 171 observations were analyzed for blood serum total cholesterol. 33 (23.13%) had "desirable" blood serum total cholesterol, 138 (76.86%) had "borderline" cholesterol, and none had "very high" cholesterol. Adolescent boys had higher rate of borderline cholesterol (47.11%) than adolescent girls (29.74%). The relationship between blood serum total cholesterol levels and elevated blood pressure are shown in the correlations tables (See Tables 31-35, Pages 122 to 132).

Table 20:

Table of Blood Serum Total Cholesterol by Gender
Controlling for Age=Children (12 <= 19 Years)

Gender	Total Cholesterol Level	Freq.	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
Boys	Desirable (<=110 Mg/dl)	23	473145	265103	12.3893	3.2077
	Borderline (<= 129 Mg/dl)	87	1799401	659177	47.1175	3.2002
	Very High (>130 Mg/dl)	0	.	.	.	.
	Total	110	2272546	892081	59.5068	0.5402
Girls	Desirable (<=110 Mg/dl)	10	410346	199392	10.7450	2.4137
	Borderline (<= 129 Mg/dl)	51	1136077	466700	29.7483	2.1205
	Very High (>130 Mg/dl)	0	.	.	.	.
	Total	61	1546423	637013	40.4932	0.5402
Total	Desirable (<=110 Mg/dl)	33	883491	418372	23.1343	1.7606
	Borderline (<= 129 Mg/dl)	138	2935478	1111238	76.8657	1.7606
	Very High (>130 Mg/dl)	0	.	.	.	.

Gender	Total Cholesterol Level	Freq.	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
	Total	171	3818969	1528949	100.000	

As shown in Table 20, the applied definitions yielded insignificant number of cases of high cholesterol levels in US adolescents. 33 (23.13%) had “desirable” blood serum total cholesterol, 138 (76.86%) had “borderline” cholesterol, and none had “very high” cholesterol.

4.8 Cholesterol Status in US Children and Adolescents by Race/Ethnicity

In children aged (2<=11 years), Mexican Americans had the highest rate of "desirable" blood serum total cholesterol levels (0.41%) compared to the least rate (0.03%) for Non-Hispanic Asians. Non-Hispanic Whites had the highest rate (7.19%) of "borderline" blood serum total cholesterol compared to the least rate (0.37%) for Non-Hispanic Asians. Non-Hispanic Whites had the highest rate of "very high" blood serum cholesterol with the least rate of (3.21%) for Non-Hispanic Asians.

Table 21:

Table of Blood Serum Total Cholesterol by Race
Controlling for Age=Children (2 <= 11 Years)

Race	Total Cholesterol Level	Freq.	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
Mexican American	Desirable (<=110 Mg/dl)	6	74987	41558	0.4107	0.0885
	Borderline (<= 129 Mg/dl)	15	218910	52543	1.1990	0.1596
	Very High (>130 Mg/dl)	189	2768539	914929	15.1640	4.4879
	Total	210	3062436	971627	16.7737	4.4971

Race	Total Cholesterol Level	Freq.	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
Other Hispanic	Desirable (<=110 Mg/dl)	1	9391	9391	0.0514	0.0487
	Borderline (<= 129 Mg/dl)	8	102643	67110	0.5622	0.4255
	Very High (>130 Mg/dl)	100	1335142	687878	7.3129	2.4282
	Total	109	1447175	740593	7.9265	2.8397
Non-Hispanic White	Desirable (<=110 Mg/dl)	2	57242	57242	0.3135	0.2530
	Borderline (<= 129 Mg/dl)	28	1312170	637363	7.1871	1.4978
	Very High (>130 Mg/dl)	199	8258666	3579178	45.2348	7.8292
	Total	229	9628077	4268138	52.7355	9.5499
Non-Hispanic Black	Desirable (<=110 Mg/dl)	5	41837	30609	0.2292	0.1419
	Borderline (<= 129 Mg/dl)	30	269905	188594	1.4783	0.8984
	Very High (>130 Mg/dl)	251	2366607	1208493	12.9625	3.6828
	Total	286	2678350	1407474	14.6700	4.7014
Non-Hispanic Asian	Desirable (<=110 Mg/dl)	1	5856	5856	0.0321	0.0259
	Borderline (<= 129 Mg/dl)	8	66936	47292	0.3666	0.1972
	Very High (>130 Mg/dl)	74	585920	155627	3.2092	0.5979
	Total	83	658712	206234	3.6079	0.7369
Other Race - Including Multi-Racial	Desirable (<=110 Mg/dl)	0	.	.	.	.
	Borderline (<= 129	8	108985	76369	0.5969	0.3463

Race	Total Cholesterol Level	Freq.	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
	Mg/dl)					
	Very High (>130 Mg/dl)	51	673580	378339	3.6894	1.0191
	Total	59	782565	445893	4.2863	1.3368
Total	Desirable (<=110 Mg/dl)	15	189312	103593	1.0369	0.2101
	Borderline (<= 129 Mg/dl)	97	2079549	811913	11.3902	0.6886
	Very High (>130 Mg/dl)	864	15988454	5904560	87.5729	0.8608
	Total	976	18257315	6806233	100.000	

In adolescents aged (12<=19 years), Non-Hispanic Whites had the highest rates of desirable (11.06) and borderline (31.74%) cholesterol levels compared to the lowest "desirable" rate of (0.79%) for Non-Hispanic Asians and (3.15%) "Borderline" rate for Other Race-Including Multi-Racial. (See Table 22 below). By defining cholesterol levels in children per the American Pediatrics Association guidelines, the analysis results suggest non-existing very high cholesterols in US adolescents during 2011-2012.

Table 22:

Table of Blood Serum Total Cholesterol by Race
Controlling for Age=Children (12 <= 19 Years)

Race	TCL	Freq.	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
Mexican American	Desirable (<=110 Mg/dl)	6	139625	81270	3.6561	1.5553
	Borderline (<= 129	25	505167	88940	13.2278	3.7992

Race	TCL	Freq.	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
	Mg/dl)					
	Very High (>130 Mg/dl)	0	.	.	.	.
	Total	31	644792	124140	16.8839	3.5106
Other Hispanic	Desirable (<=110 Mg/dl)	3	54058	31191	1.4155	0.5690
	Borderline (<= 129 Mg/dl)	14	231572	149784	6.0637	4.3289
	Very High (>130 Mg/dl)	0	.	.	.	.
	Total	17	285631	175355	7.4793	4.8384
Non-Hispanic White	Desirable (<=110 Mg/dl)	6	422288	215601	11.0576	1.2382
	Borderline (<= 129 Mg/dl)	19	1212150	973103	31.7402	17.1901
	Very High (>130 Mg/dl)	0	.	.	.	.
	Total	25	1634438	1147063	42.7979	17.5418
Non-Hispanic Black	Desirable (<=110 Mg/dl)	10	123641	66190	3.2376	1.0046
	Borderline (<= 129 Mg/dl)	55	742938	495459	19.4539	11.0895
	Very High (>130 Mg/dl)	0	.	.	.	.
	Total	65	866580	556892	22.6915	12.0740
Non-Hispanic Asian	Desirable (<=110 Mg/dl)	3	30027	4219	0.7863	0.2043
	Borderline (<= 129 Mg/dl)	15	123241	24905	3.2271	1.6262
	Very High (>130 Mg/dl)	0	.	.	.	.

Race	TCL	Freq.	Weighted Frequency	Std Dev of Wgt Freq	Percent	Std Err of Percent
	Total	18	153269	23852	4.0134	1.8168
Other Race - Including Multi-Racial	Desirable (<=110 Mg/dl)	5	113851	72731	2.9812	0.9530
	Borderline (<= 129 Mg/dl)	10	120408	41028	3.1529	1.7263
	Very High (>130 Mg/dl)	0	.	.	.	.
	Total	15	234260	94622	6.1341	2.0242
Total	Desirable (<=110 Mg/dl)	33	883491	418372	23.1343	1.7606
	Borderline (<= 129 Mg/dl)	138	2935478	1111238	76.8657	1.7606
	Very High (>130 Mg/dl)	0	.	.	.	.
	Total	171	3818969	1528949	100.000	

*Variable sample sizes less than 5 were not evaluable and represented as .

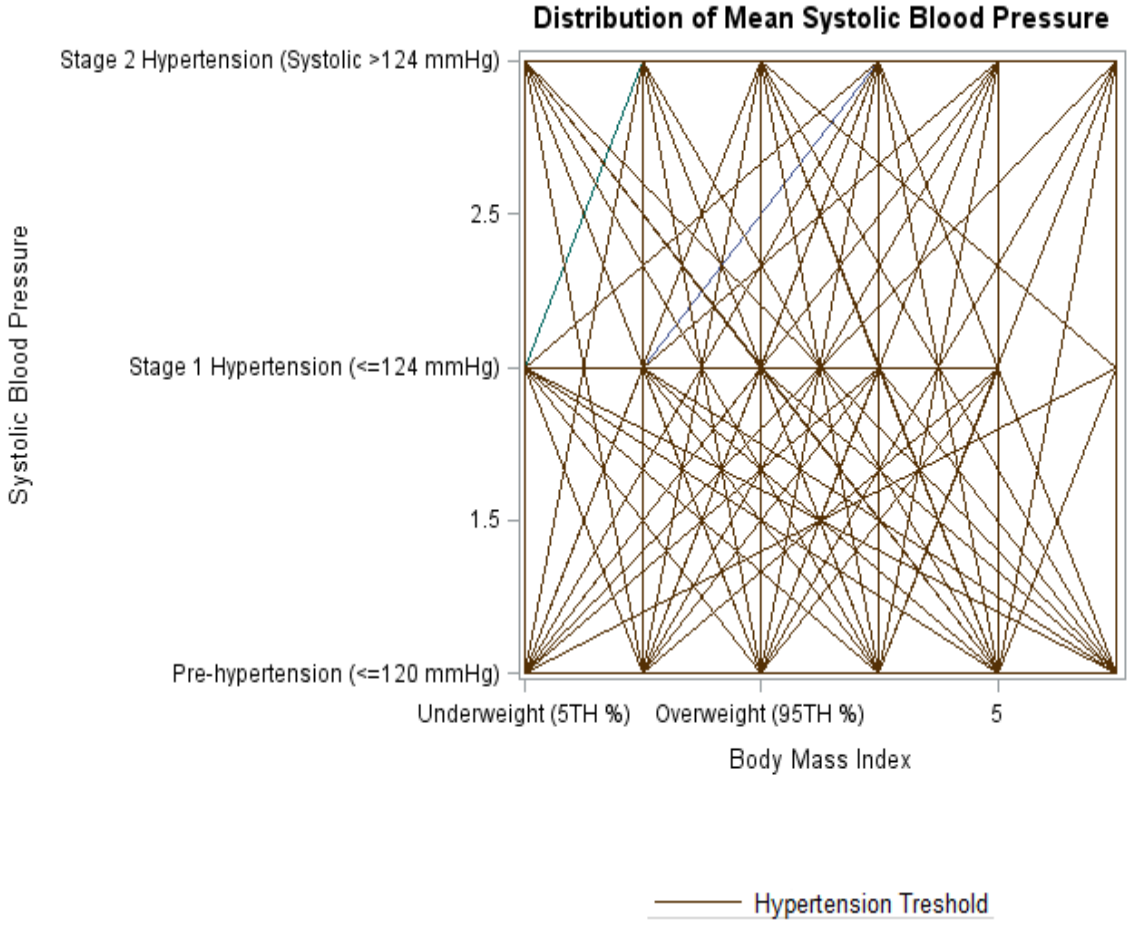
4.9 Comparison of the Distribution of Mean Systolic Blood Pressure by Gender in US Children and Adolescents (Aged 2-19)

The purpose of this study was to estimate current national prevalence of hypertension in US population aged (2<=19 years). As shown in Table 23, (Page 86), hypertension distribution was explained by age, gender, race, body weight, standing height, body mass index, total blood serum cholesterol levels and ratio of poverty to family income. In children, the mean weight for boys (2<=11 years) with pre-hypertension was (38.25 kg) ± (0.64) compared to (40.83 kg) ± (0.66) for girls. For this same group, mean standing height for boys was (140.62 cm) ± (0.50) but (142.30 cm) ±

(0.51) for girls; body mass index was (19.00 kg/m**2) ± (0.22) and (19.86 kg/m**2) ± (0.24) for girls; blood serum total cholesterol for boys was (160.81 mg/dL) ± (1.64) and (160.70 mg/dL) ± (1.51) for girls. Mean of the ratio of poverty to family income for boys was (2.15) ± (0.08) compared to (2.52) ± (0.09) for girls. (Maximum ratio of 5). For stage 1 hypertension, the mean weight for boys (2<=11 years) was (45.41 kg) ± (5.72) compared to (51.08 kg) ± (7.24) for girls.

Figure 16:

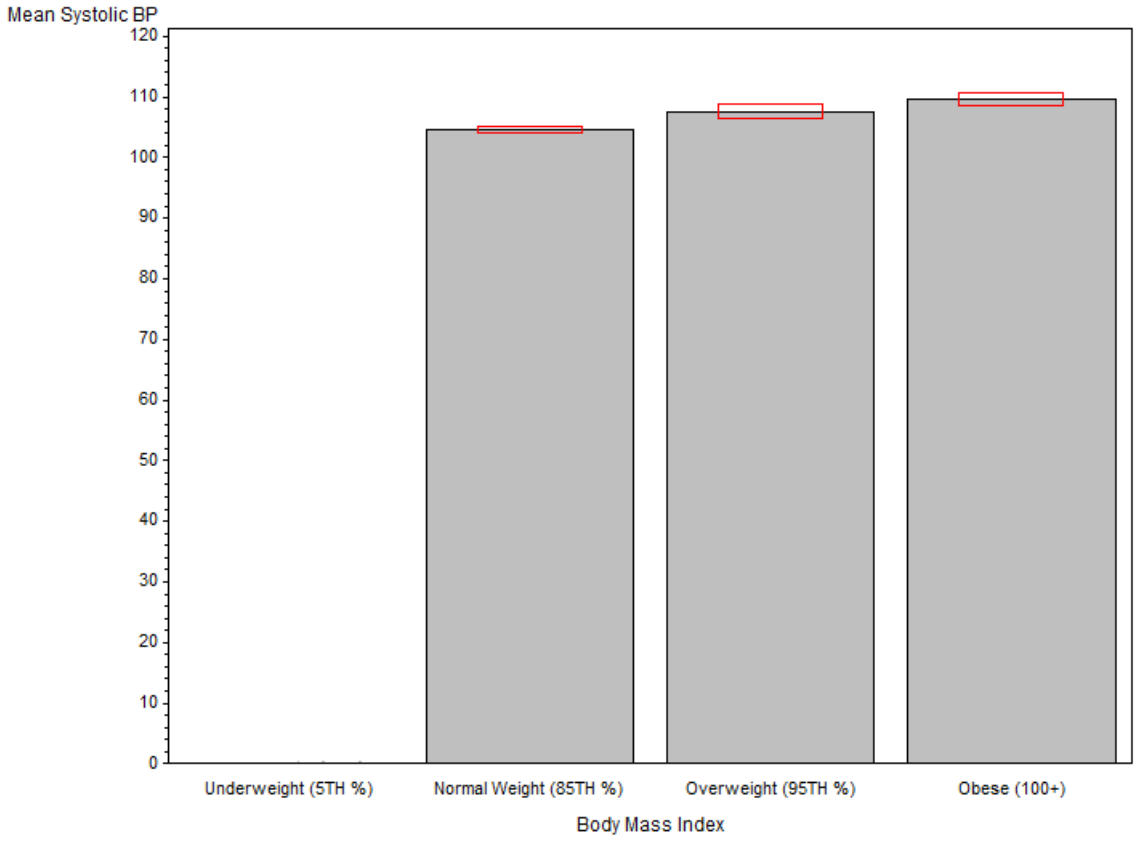
Plot of the Mean Systolic Blood Pressure in Overweight and Obese Young US Population (2-19 Years) for the (2011-2012) Analysis Period



As shown in the line-series plot of the mean distribution above, connected points are higher in the pre-hypertension and stage 1 zone than between stage 1and stage 2 hypertension for children within the 95th percentile.

Figure 17:

Comparison of Mean Systolic Blood Pressure by Body Mass Index



As shown in Figure 17 above, the red bars represent the size of systolic blood pressure means in normal, overweight and obese children and adolescents respectively. From the figure, systolic blood means for overweight and obese children and adolescents were higher than the systolic blood pressure mean for normal weights.

Figure 18:

Comparison of Means Systolic Blood Pressure by Age

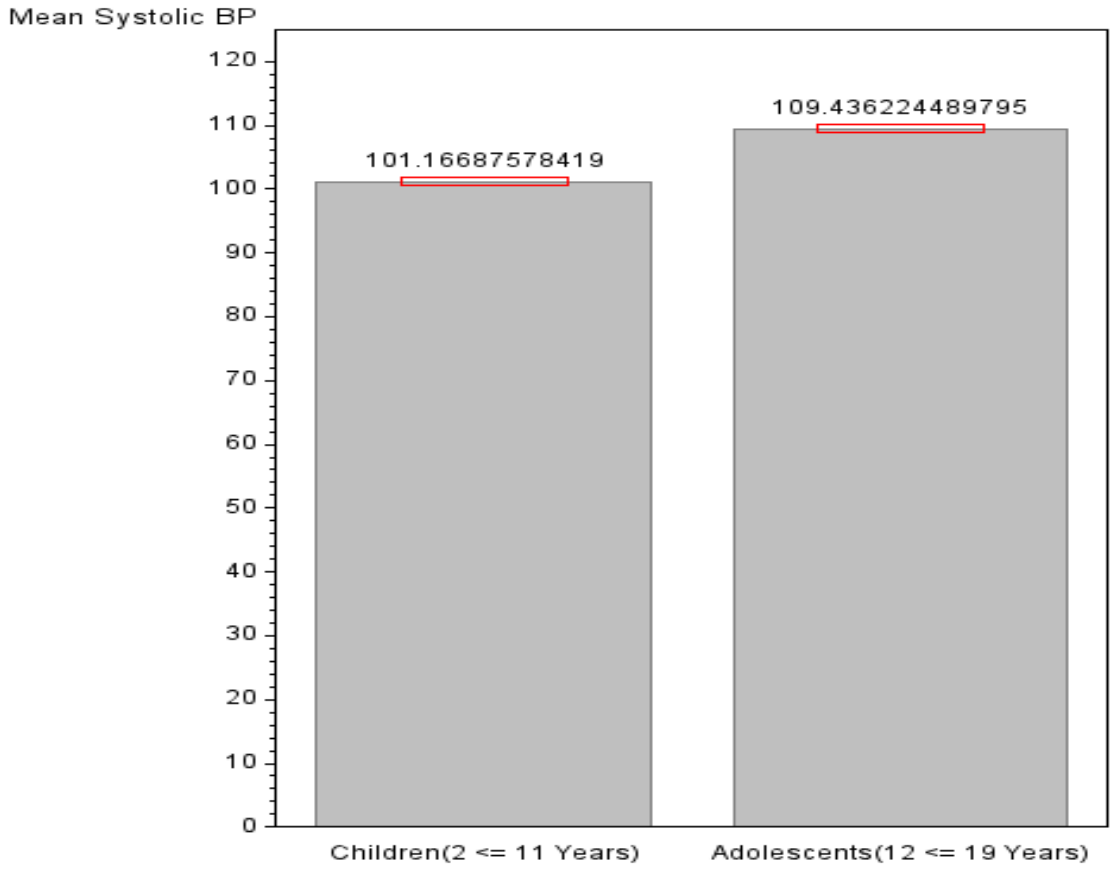


Figure 18 above indicates that the mean systolic blood pressure in adolescents was generally higher in adolescents (aged 12≤19 years) than the mean systolic blood pressure in children (aged 2≤11 years). Table 23 (Page 98) compares the mean systolic blood pressure in children and adolescents. Deviations in the means are expressed as standard errors. The standard errors show accuracy of the mean estimates therefore interpretation of the systolic blood pressure means must be made along with the standard errors.

Figure 19:

Comparison of Mean Systolic Blood Pressure by Gender/Sex

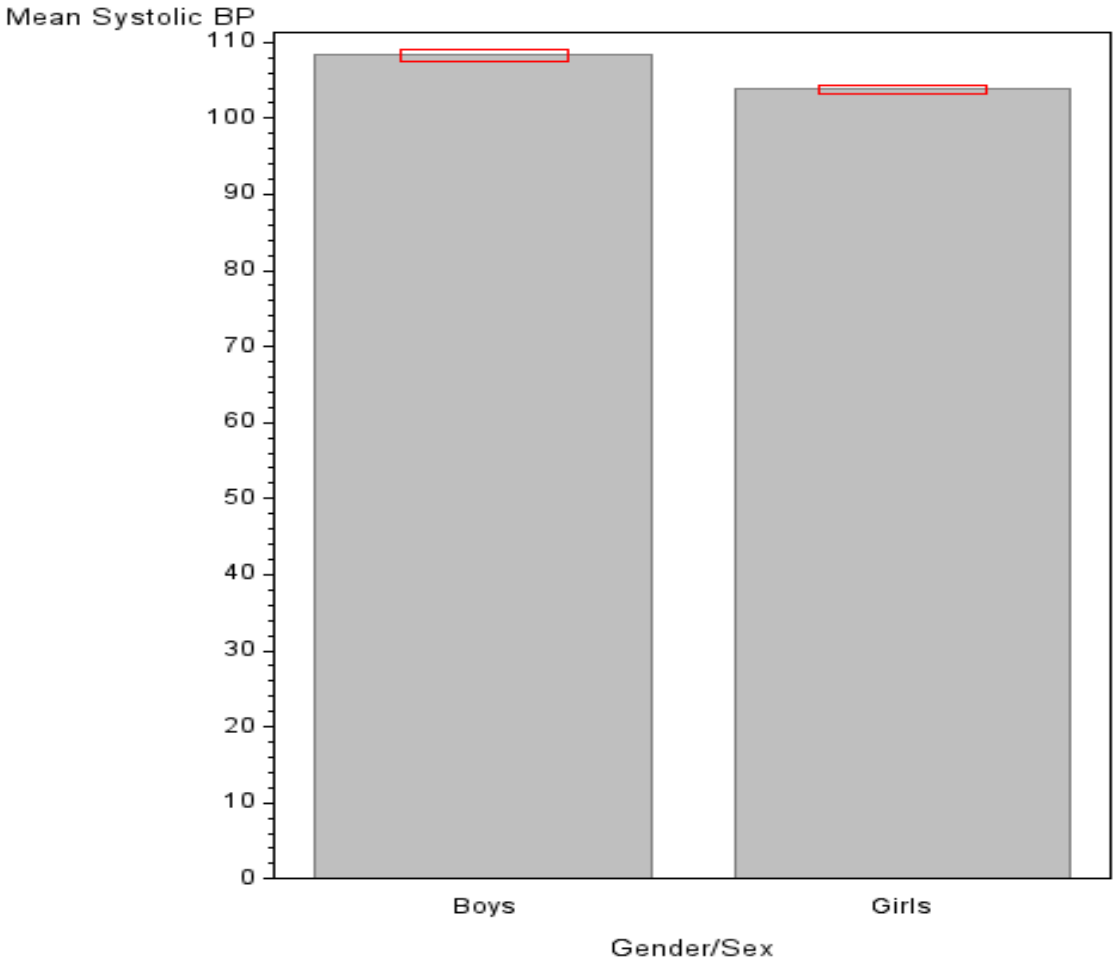


Figure 19 above shows that the mean systolic blood pressure for boys in general is slightly higher than for girls. Table 23 in the next page shows detail of mean comparisons between adolescent boys versus adolescent girls, boys and between adolescents and children in general together with associated standard errors for these groups.

Table 23:

Comparison of Systolic Blood Pressure Risk Factors Means by Gender in US Children and Adolescents (Aged 2-19)

	Children (2 < 12 Years)				Adolescents (12 < 19 years)			
	Pre-Hypertension	**Stage 1 Hypertension**	**Stage 2 Hypertension**		**Pre-Hypertension**	**Stage 1 Hypertension**	**Stage 2 Hypertension**	
	Systolic <=120 mmHg)	**Systolic <=124 mmHg**	**Systolic >124 mmHg**	**p-value**	**Systolic <=120 mmHg)**	**Systolic <=124 mmHg**	**Systolic >124 mmHg**	**p-value**
Boys								
Body Weight (kg)	38.25 ± (0.64)	45.41 ± (5.72)	33.91 ± (6.11)	P<.0001	66.90 ± (0.84)	71.48 ± (2.37)	83.84 ± (3.19)	P<.0001
Standing Height (cm)	140.62 ± (0.50)	142.27 ± (4.33)	140.31 ± (4.69)	P<.0001	169.53 ± (0.46)	174.61 ± (1.40)	175.66 ± (0.86)	P<.0001
Body Mass Index (kg/m**2)	19.00 ± (0.22)	22.10 ± (2.28)	17.02 ± (2.21)	P<.0001	23.11 ± (0.24)	23.36 ± (0.17)	27.10 ± (0.93)	P<.0001
Total Serum Cholesterol (mg/dL)	160.81 ± (1.64)	155.32 ± (10.86)	127.36 ± (13.02)	P<.6225	152.88 ± (1.30)	160.22 ± (3.97)	156.39 ± (2.86)	P<.1218
Ratio of Poverty to Income	2.15 ± (0.08)	1.65 ± (0.58)	1.67 ± (0.11)	-	2.58 ± (0.08)	1.87 ± (0.20)	2.84 ± (0.20)	P<.1395
Girls								
Body Weight (kg)	40.83 ± (0.66)	51.08 ± (7.24)	38.40 ± (1.40)	P<.0001	61.52 ± (0.75)	68.35 ± (2.83)	78.92 ± (7.73)	P<.0001
Standing Height (cm)	142.30 ± (0.51)	155.73 ± (3.26)	140.59 ± (2.70)	P<.0001	160.84 ± (0.28)	160.61 ± (1.18)	158.49 ± (1.46)	P<.0001
Body Mass Index (kg/m**2)	19.86 ± (0.24)	20.63 ± (2.19)	19.45 ± (1.45)	P<.0001	23.65 ± (0.25)	26.66 ± (1.19)	31.85 ± (3.46)	P<.0001
Total Serum Cholesterol (mg/dL)	160.70 ± (1.51)	135.97 ± (11.09)	-	P<.6225	161.54 ± (1.35)	174.56 ± (7.48)	204.84 ± (14.01)	P<.1573
Ratio of Poverty to Income	2.52 ± (0.09)	3.87 ± (0.65)	0.01 ± (0.00)	-	2.44 ± (0.07)	1.67 ± (0.25)	2.21 ± (0.49)	P<.1395

Table 24:

Table of Means of Body Weight for Systolic Blood Pressure by Age, Gender and Race

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
Children(2 <= 11 Years)	Boys	Mexican American	Pre-hypertension (<=120 mmHg)	81	41.58	1.56
			Stage 1 Hypertension (<=124 mmHg)	2	36.07	10.95
			Stage 2 Hypertension (Systolic >124 mmHg)	1	21.40	.
		Other Hispanic	Pre-hypertension (<=120 mmHg)	48	38.79	1.72
			Stage 1 Hypertension (<=124 mmHg)	2	59.47	1.35
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	92	36.48	1.14
			Stage 2 Hypertension (Systolic >124 mmHg)	1	36.90	.
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	103	41.31	1.42
			Stage 1 Hypertension (<=124 mmHg)	1	45.20	.
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	39	35.66	1.52
			Stage 1 Hypertension (<=124 mmHg)	1	34.00	.
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	17	39.86	4.36
	Girls	Mexican American	Pre-hypertension (<=120 mmHg)	79	40.55	1.34
		Other Hispanic	Pre-hypertension (<=120 mmHg)	34	40.97	1.86
			Stage 2 Hypertension (Systolic >124 mmHg)	2	38.40	1.40
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	98	40.58	1.32

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
			Stage 1 Hypertension (<=124 mmHg)	2	51.20	14.78
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	108	43.86	1.48
			Stage 1 Hypertension (<=124 mmHg)	4	50.57	12.07
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	32	35.84	1.71
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	29	40.22	2.28
Adolescents(12 <= 19 Years)	Boys	Mexican American	Pre-hypertension (<=120 mmHg)	83	67.75	1.70
			Stage 1 Hypertension (<=124 mmHg)	8	66.52	7.08
			Stage 2 Hypertension (Systolic >124 mmHg)	11	73.83	3.47
		Other Hispanic	Pre-hypertension (<=120 mmHg)	46	63.62	2.97
			Stage 1 Hypertension (<=124 mmHg)	6	75.52	10.21
			Stage 2 Hypertension (Systolic >124 mmHg)	8	81.23	7.85
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	111	67.09	1.82
			Stage 1 Hypertension (<=124 mmHg)	10	71.87	3.65
			Stage 2 Hypertension (Systolic >124 mmHg)	17	76.11	3.44
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	129	68.66	1.67
			Stage 1 Hypertension (<=124 mmHg)	21	71.85	4.36
			Stage 2 Hypertension (Systolic >124 mmHg)	34	90.96	5.40
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	75	62.13	1.84
			Stage 1 Hypertension	4	79.14	9.37

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
			(<=124 mmHg)			
			Stage 2 Hypertension (Systolic >124 mmHg)	6	78.02	8.57
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	27	66.31	2.30
			Stage 1 Hypertension (<=124 mmHg)	2	67.36	20.27
			Stage 2 Hypertension (Systolic >124 mmHg)	4	144.40	27.64
	Girls	Mexican American	Pre-hypertension (<=120 mmHg)	93	59.75	1.78
			Stage 1 Hypertension (<=124 mmHg)	2	69.10	2.35
			Stage 2 Hypertension (Systolic >124 mmHg)	3	51.76	3.72
		Other Hispanic	Pre-hypertension (<=120 mmHg)	69	59.55	1.46
			Stage 1 Hypertension (<=124 mmHg)	5	68.16	4.80
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	112	60.81	1.53
			Stage 1 Hypertension (<=124 mmHg)	5	70.23	7.70
			Stage 2 Hypertension (Systolic >124 mmHg)	3	61.06	4.19
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	154	66.34	1.64
			Stage 1 Hypertension (<=124 mmHg)	12	69.31	5.73
			Stage 2 Hypertension (Systolic >124 mmHg)	9	74.89	7.44
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	75	53.75	1.28
			Stage 1 Hypertension (<=124 mmHg)	2	57.16	0.30
		Other Race - Including Multi-	Pre-hypertension (<=120 mmHg)	24	65.97	3.69

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
		Racial				
			Stage 1 Hypertension (<=124 mmHg)	1	60.10	.

Mean of the ratio of poverty to family income for boys was (2.15) ± (0.08) compared to (2.52) ± (0.09) for girls. (Maximum ratio of 5). For stage 1 hypertension, the mean weight for boys (2<=11 years) was (45.41 kg) ± (5.72) compared to (51.08 kg) ± (7.24) for girls. Mean standing height for boys was (142.27 cm) ± (4.33) compared to (155.73 cm) ± (3.26) for girls. Body had body mass index average of (22.10 kg/m**2) ± (2.28) compared to (20.63 kg/m**2) ± (2.19) for girls. Means of blood serum total cholesterol were (155.32 mg/dL) ± (10.86) for boys compared to (135.97 mg/dL) ± (11.09) for girls. Mean of the ratio of poverty to family income under stage 1 hypertension was (1.65) ± (0.58) for boys compared to (0.01) ± (0.00) for girls.

The mean weight for boys (2<=11 years) with stage 2 hypertension was (33.91 kg) ± (6.11) compared to (38.40 kg) ± (1.40) for girls with a significance value of (p<.0001). Six deviations from the average ‘’± (6.11)” is suggestive of huge variations indicating extreme distribution of stage 2 hypertension in children. The average standing height of boys with stage 2 hypertension was (140.31 cm) ± (4.69) compared to (140.59 cm) ± (2.70) for girls. Boys had lower body mass index average of (17.02 kg/m**2” ± (2.21) compared to “19.45 kg/m**2” ± (1.45) for girls. Mean of blood serum total cholesterol for girls was not evaluable due to small sample size but the mean for boys was (127.36 mg/dL) ± (13.02). Average of the ratio of poverty to family income was (1.67) ± (0.11) for boys compared to (0.01) ± (0.00) for girls.

In adolescents aged (12<=19 years) with pre-hypertension, the mean weight for boys was (66.90 kg) ± (0.84) compared to (61.52 kg) ± (0.75) for girls. Average standing height of boys with was (169.53 cm) ± (0.46) and (160.84cm) ± (0.28) for girls. Boys had lower body mass index average of (23.11kg/m**2) ± (0.24) compared to (23.6511kg/m**2) ± (0.25) for girls. Boys had a lower a lover blood serum total cholesterol mean of (152.88 mg/dL) ± (1.30) compared to (161.54 mg/dL) ± (1.35) for girls. Average ratio of poverty to family income was (2.58) ± (0.08) for boys compared to (2.44) ± (0.07) for girls.

Table 25:

Table of Means of Standing Height for Systolic Blood Pressure by Age, Gender and Race

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
Children(2 <= 11 Years)	Boys	Mexican American	Pre-hypertension (<=120 mmHg)	81	140.68	1.00
			Stage 1 Hypertension (<=124 mmHg)	2	135.62	9.80
			Stage 2 Hypertension (Systolic >124 mmHg)	1	130.70	.
		Other Hispanic	Pre-hypertension (<=120 mmHg)	48	137.77	1.36
			Stage 1 Hypertension (<=124 mmHg)	2	144.88	5.94
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	92	140.89	1.05
			Stage 2 Hypertension (Systolic >124 mmHg)	1	142.60	.
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	103	141.58	0.93
			Stage 1 Hypertension (<=124 mmHg)	1	154.00	.
		Non-Hispanic	Pre-hypertension	39	138.98	1.41

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
		Asian	(<=120 mmHg)			
			Stage 1 Hypertension (<=124 mmHg)	1	140.50	.
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	17	141.58	2.78
	Girls	Mexican American	Pre-hypertension (<=120 mmHg)	79	140.22	1.04
		Other Hispanic	Pre-hypertension (<=120 mmHg)	34	143.25	1.71
			Stage 2 Hypertension (Systolic >124 mmHg)	2	140.59	2.70
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	98	142.63	1.01
			Stage 1 Hypertension (<=124 mmHg)	2	156.73	5.79
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	108	144.43	0.96
			Stage 1 Hypertension (<=124 mmHg)	4	151.72	6.12
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	32	139.12	1.69
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	29	141.64	1.55
Adolescents(12 <= 19 Years)	Boys	Mexican American	Pre-hypertension (<=120 mmHg)	83	166.90	0.90
			Stage 1 Hypertension (<=124 mmHg)	8	169.53	1.10
			Stage 2 Hypertension (Systolic >124 mmHg)	11	171.78	2.11
		Other Hispanic	Pre-hypertension (<=120 mmHg)	46	166.06	1.37
			Stage 1 Hypertension (<=124 mmHg)	6	169.86	3.14
			Stage 2 Hypertension (Systolic >124 mmHg)	8	171.64	2.79
		Non-Hispanic	Pre-hypertension	111	170.43	1.01

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
		White	(<=120 mmHg)			
			Stage 1 Hypertension (<=124 mmHg)	10	179.10	3.03
			Stage 2 Hypertension (Systolic >124 mmHg)	17	176.02	1.86
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	129	171.34	0.81
			Stage 1 Hypertension (<=124 mmHg)	21	173.51	2.56
			Stage 2 Hypertension (Systolic >124 mmHg)	34	177.32	1.24
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	75	167.59	0.97
			Stage 1 Hypertension (<=124 mmHg)	4	171.78	7.00
			Stage 2 Hypertension (Systolic >124 mmHg)	6	167.05	3.88
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	27	168.55	1.73
			Stage 1 Hypertension (<=124 mmHg)	2	166.01	4.93
			Stage 2 Hypertension (Systolic >124 mmHg)	4	181.99	1.86
	Girls	Mexican American	Pre-hypertension (<=120 mmHg)	93	157.85	0.58
			Stage 1 Hypertension (<=124 mmHg)	2	159.63	1.20
			Stage 2 Hypertension (Systolic >124 mmHg)	3	155.17	2.45
		Other Hispanic	Pre-hypertension (<=120 mmHg)	69	158.31	0.84
			Stage 1 Hypertension (<=124 mmHg)	5	161.08	2.71
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	112	161.73	0.58
			Stage 1 Hypertension (<=124 mmHg)	5	157.45	2.29

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
			Stage 2 Hypertension (Systolic >124 mmHg)	3	159.99	2.68
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	154	161.91	0.56
			Stage 1 Hypertension (<=124 mmHg)	12	163.01	2.07
			Stage 2 Hypertension (Systolic >124 mmHg)	9	163.95	1.17
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	75	158.12	0.75
			Stage 1 Hypertension (<=124 mmHg)	2	162.40	1.93
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	24	162.71	1.77
			Stage 1 Hypertension (<=124 mmHg)	1	168.90	.

In adolescents with stage 1 hypertension, the average weight of boys was (71.48 kg) ± (2.37) compared to (68.35kg) ± (2.83) for girls. Mean standing height were (174.61 cm) ± (1.40) for boys and (160.61cm) ± (1.18) for girls; body mass index (23.36 kg/m**2) ± (0.17) for boys, (26.66 kg/m**2) ± (1.19) for girls; blood serum total cholesterol (160.22 mg/dL) ± (3.97) for boys, (174.56 mg/dL) ± (7.48) for girls and ratio of poverty to family income (1.87) ± (0.20) for boys, (1.67) ± (0.25) for girls.

Comparison of means were made in adolescents with stage 2 hypertension. Mean weight for adolescent boys with stage 2 hypertension was (83.84 kg) ± (3.19) compared to (78.92 kg) ± (7.73) for girls. The average standing height of boys was (175.66 cm) ± (0.86) but (158.49 cm) ± (1.46) for girls. Boys had lower body mass index average of (27.10 kg/m**2) ± (0.93) than girls (31.85 kg/m**2) ± (3.46). Generally, adolescent girls

had higher blood serum total cholesterol (204.84 mg/ dL) ± (14.01) than adolescent boys (156.39 mg/dL) ± (2.86). The ratio of poverty to family income for adolescent boys with stage 2 hypertension was (2.84) ± (0.20) compared to (2.21) ± (0.49) for girls.

Table 26:

Table of Means of Blood Serum Total Cholesterol for Systolic Blood Pressure by Age, Gender and Race

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
Children(2 <= 11 Years)	Boys	Mexican American	Pre-hypertension (<=120 mmHg)	81	158.99	3.87
			Stage 1 Hypertension (<=124 mmHg)	2	150.54	18.50
			Stage 2 Hypertension (Systolic >124 mmHg)	1	154.00	.
		Other Hispanic	Pre-hypertension (<=120 mmHg)	48	161.72	4.12
			Stage 1 Hypertension (<=124 mmHg)	2	161.09	25.45
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	92	159.43	2.96
			Stage 2 Hypertension (Systolic >124 mmHg)	1	121.00	.
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	103	163.11	3.82
			Stage 1 Hypertension (<=124 mmHg)	1	134.00	.
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	39	159.97	5.86
			Stage 1 Hypertension (<=124 mmHg)	1	194.00	.
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	17	178.25	7.55
	Girls	Mexican American	Pre-hypertension (<=120 mmHg)	79	161.89	3.20
		Other Hispanic	Pre-hypertension	34	159.24	3.90

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
			(<=120 mmHg)			
			Stage 2 Hypertension (Systolic >124 mmHg)	2	.	.
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	98	159.57	3.09
			Stage 1 Hypertension (<=124 mmHg)	2	128.04	11.49
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	108	161.65	2.89
			Stage 1 Hypertension (<=124 mmHg)	4	177.51	12.71
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	32	166.33	5.08
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	29	157.78	5.52
Adolescents(12 <= 19 Years)	Boys	Mexican American	Pre-hypertension (<=120 mmHg)	83	155.55	3.40
			Stage 1 Hypertension (<=124 mmHg)	8	148.65	6.40
			Stage 2 Hypertension (Systolic >124 mmHg)	11	156.84	9.46
		Other Hispanic	Pre-hypertension (<=120 mmHg)	46	154.39	5.08
			Stage 1 Hypertension (<=124 mmHg)	6	184.20	16.25
			Stage 2 Hypertension (Systolic >124 mmHg)	8	154.58	9.37
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	111	153.70	2.38
			Stage 1 Hypertension (<=124 mmHg)	10	158.06	7.13
			Stage 2 Hypertension (Systolic >124 mmHg)	17	155.67	5.91
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	129	150.05	2.70
			Stage 1 Hypertension (<=124 mmHg)	21	161.71	7.99

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
			Stage 2 Hypertension (Systolic >124 mmHg)	34	160.03	5.17
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	75	157.28	3.30
			Stage 1 Hypertension (<=124 mmHg)	4	171.95	16.42
			Stage 2 Hypertension (Systolic >124 mmHg)	6	153.90	4.87
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	27	133.14	4.34
			Stage 1 Hypertension (<=124 mmHg)	2	150.44	6.29
			Stage 2 Hypertension (Systolic >124 mmHg)	4	152.16	10.63
	Girls	Mexican American	Pre-hypertension (<=120 mmHg)	93	161.45	2.94
			Stage 1 Hypertension (<=124 mmHg)	2	162.23	12.50
			Stage 2 Hypertension (Systolic >124 mmHg)	3	157.03	11.00
		Other Hispanic	Pre-hypertension (<=120 mmHg)	69	164.67	3.13
			Stage 1 Hypertension (<=124 mmHg)	5	178.35	13.77
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	112	161.96	2.78
			Stage 1 Hypertension (<=124 mmHg)	5	192.13	19.76
			Stage 2 Hypertension (Systolic >124 mmHg)	3	202.49	23.15
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	154	162.38	2.60
			Stage 1 Hypertension (<=124 mmHg)	12	154.75	10.89
			Stage 2 Hypertension (Systolic >124 mmHg)	9	177.37	10.76
		Non-Hispanic	Pre-hypertension	75	164.18	3.76

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
		Asian	(<=120 mmHg)			
			Stage 1 Hypertension (<=124 mmHg)	2	160.82	13.88
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	24	150.26	6.45
			Stage 1 Hypertension (<=124 mmHg)	1	150.00	.

Table 27:

Table of Means of Poverty Ratio to Family Income for Systolic Blood Pressure by Age, Gender and Race

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
Children(2 <= 11 Years)	Boys	Mexican American	Pre-hypertension (<=120 mmHg)	81	1.33	0.13
			Stage 1 Hypertension (<=124 mmHg)	2	1.20	0.13
			Stage 2 Hypertension (Systolic >124 mmHg)	1	1.90	.
		Other Hispanic	Pre-hypertension (<=120 mmHg)	48	1.60	0.20
			Stage 1 Hypertension (<=124 mmHg)	2	2.26	1.07
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	92	2.55	0.16
			Stage 2 Hypertension (Systolic >124 mmHg)	1	1.61	.
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	103	1.57	0.13
			Stage 1 Hypertension (<=124 mmHg)	1	0.03	.
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	39	3.18	0.27
			Stage 1 Hypertension (<=124 mmHg)	1	4.32	.

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	17	2.25	0.39
	Girls	Mexican American	Pre-hypertension (<=120 mmHg)	79	1.30	0.11
		Other Hispanic	Pre-hypertension (<=120 mmHg)	34	1.74	0.29
			Stage 2 Hypertension (Systolic >124 mmHg)	2	0.01	.
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	98	3.15	0.16
			Stage 1 Hypertension (<=124 mmHg)	2	4.51	0.46
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	108	1.58	0.13
			Stage 1 Hypertension (<=124 mmHg)	4	1.28	0.71
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	32	2.62	0.28
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	29	2.19	0.32
Adolescents(12 <= 19 Years)	Boys	Mexican American	Pre-hypertension (<=120 mmHg)	83	1.61	0.14
			Stage 1 Hypertension (<=124 mmHg)	8	1.60	0.31
			Stage 2 Hypertension (Systolic >124 mmHg)	11	2.27	0.40
		Other Hispanic	Pre-hypertension (<=120 mmHg)	46	1.56	0.20
			Stage 1 Hypertension (<=124 mmHg)	6	0.81	0.13
			Stage 2 Hypertension (Systolic >124 mmHg)	8	1.42	0.38
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	111	3.05	0.16
			Stage 1 Hypertension (<=124 mmHg)	10	1.74	0.43

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
			Stage 2 Hypertension (Systolic >124 mmHg)	17	3.59	0.42
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	129	1.85	0.14
			Stage 1 Hypertension (<=124 mmHg)	21	2.72	0.40
			Stage 2 Hypertension (Systolic >124 mmHg)	34	1.91	0.32
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	75	2.84	0.22
			Stage 1 Hypertension (<=124 mmHg)	4	1.33	0.53
			Stage 2 Hypertension (Systolic >124 mmHg)	6	1.99	0.54
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	27	2.95	0.37
			Stage 1 Hypertension (<=124 mmHg)	2	2.01	1.00
			Stage 2 Hypertension (Systolic >124 mmHg)	4	2.41	0.73
	Girls	Mexican American	Pre-hypertension (<=120 mmHg)	93	1.46	0.14
			Stage 1 Hypertension (<=124 mmHg)	2	0.98	0.48
			Stage 2 Hypertension (Systolic >124 mmHg)	3	1.20	0.89
		Other Hispanic	Pre-hypertension (<=120 mmHg)	69	1.87	0.20
			Stage 1 Hypertension (<=124 mmHg)	5	1.80	0.55
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	112	2.90	0.15
			Stage 1 Hypertension (<=124 mmHg)	5	1.78	0.69
			Stage 2 Hypertension (Systolic >124 mmHg)	3	1.10	0.27
		Non-Hispanic	Pre-hypertension	154	1.66	0.13

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
		Black	(<=120 mmHg)			
			Stage 1 Hypertension (<=124 mmHg)	12	1.69	0.41
			Stage 2 Hypertension (Systolic >124 mmHg)	9	1.52	0.47
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	75	2.95	0.20
			Stage 1 Hypertension (<=124 mmHg)	2	1.15	0.72
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	24	2.44	0.33
			Stage 1 Hypertension (<=124 mmHg)	1	.	.

Table 28:

Table of Means of Body Mass Index for Systolic Blood Pressure by Age, Gender and Race

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
Children(2 <= 11 Years)	Boys	Mexican American	Pre-hypertension (<=120 mmHg)	81	20.57	0.53
			Stage 1 Hypertension (<=124 mmHg)	2	19.06	3.15
			Stage 2 Hypertension (Systolic >124 mmHg)	1	12.50	.
		Other Hispanic	Pre-hypertension (<=120 mmHg)	48	20.10	0.66
			Stage 1 Hypertension (<=124 mmHg)	2	28.41	1.70
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	92	18.10	0.39
			Stage 2 Hypertension (Systolic >124 mmHg)	1	18.10	.

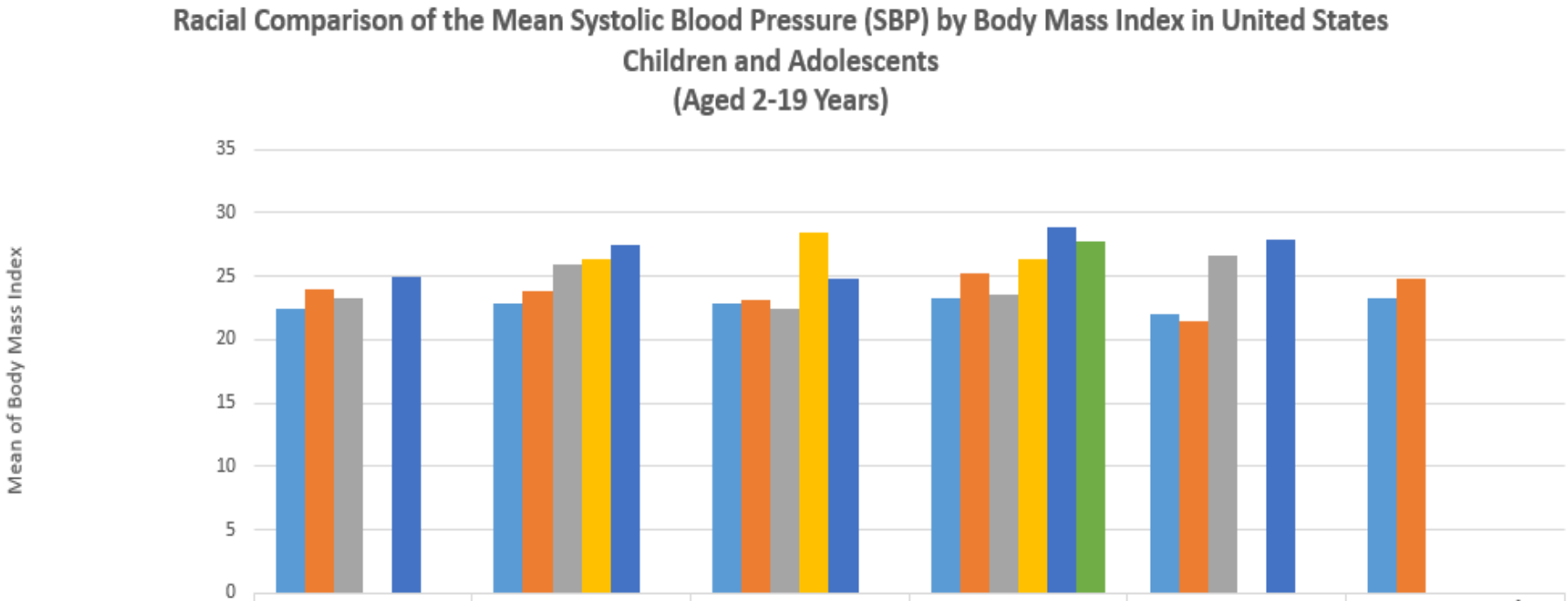
Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	103	20.19	0.50
			Stage 1 Hypertension (<=124 mmHg)	1	19.10	.
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	39	18.22	0.53
			Stage 1 Hypertension (<=124 mmHg)	1	17.20	.
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	17	19.13	1.17
	Girls	Mexican American	Pre-hypertension (<=120 mmHg)	79	20.33	0.49
		Other Hispanic	Pre-hypertension (<=120 mmHg)	34	19.77	0.68
			Stage 2 Hypertension (Systolic >124 mmHg)	2	19.45	1.45
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	98	19.61	0.45
			Stage 1 Hypertension (<=124 mmHg)	2	20.49	4.49
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	108	20.82	0.62
			Stage 1 Hypertension (<=124 mmHg)	4	21.21	3.59
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	32	18.24	0.55
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	29	19.76	0.91
Adolescents(12 <= 19 Years)	Boys	Mexican American	Pre-hypertension (<=120 mmHg)	83	24.40	0.55
			Stage 1 Hypertension (<=124 mmHg)	8	23.22	2.51
			Stage 2 Hypertension (Systolic >124 mmHg)	11	24.92	0.88
		Other Hispanic	Pre-hypertension (<=120 mmHg)	46	22.78	0.91

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
			Stage 1 Hypertension (<=124 mmHg)	6	25.86	2.96
			Stage 2 Hypertension (Systolic >124 mmHg)	8	27.39	2.21
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	111	22.85	0.49
			Stage 1 Hypertension (<=124 mmHg)	10	22.41	1.14
			Stage 2 Hypertension (Systolic >124 mmHg)	17	24.75	1.26
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	129	23.24	0.49
			Stage 1 Hypertension (<=124 mmHg)	21	23.57	1.16
			Stage 2 Hypertension (Systolic >124 mmHg)	34	28.83	1.60
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	75	21.99	0.59
			Stage 1 Hypertension (<=124 mmHg)	4	26.56	1.99
			Stage 2 Hypertension (Systolic >124 mmHg)	6	27.83	2.50
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	27	23.32	0.72
			Stage 1 Hypertension (<=124 mmHg)	2	24.12	5.21
			Stage 2 Hypertension (Systolic >124 mmHg)	4	43.31	7.81
	Girls	Mexican American	Pre-hypertension (<=120 mmHg)	93	23.90	0.63
			Stage 1 Hypertension (<=124 mmHg)	2	27.12	1.35
			Stage 2 Hypertension (Systolic >124 mmHg)	3	21.48	1.30
		Other Hispanic	Pre-hypertension (<=120 mmHg)	69	23.78	0.52
			Stage 1 Hypertension	5	26.30	1.74

Age Group	Gender	Race	SBP	N Obs	Mean	Std Error
			(<=124 mmHg)			
		Non-Hispanic White	Pre-hypertension (<=120 mmHg)	112	23.11	0.50
			Stage 1 Hypertension (<=124 mmHg)	5	28.42	3.14
			Stage 2 Hypertension (Systolic >124 mmHg)	3	23.99	2.39
		Non-Hispanic Black	Pre-hypertension (<=120 mmHg)	154	25.17	0.57
			Stage 1 Hypertension (<=124 mmHg)	12	26.28	2.35
			Stage 2 Hypertension (Systolic >124 mmHg)	9	27.70	2.45
		Non-Hispanic Asian	Pre-hypertension (<=120 mmHg)	75	21.43	0.45
			Stage 1 Hypertension (<=124 mmHg)	2	21.67	0.64
		Other Race - Including Multi-Racial	Pre-hypertension (<=120 mmHg)	24	24.81	1.05
			Stage 1 Hypertension (<=124 mmHg)	1	21.10	.

In adolescent boys, body mass index average for pre-hypertension was 23.11 kg/m**2 ± (0.24) and 27.10 kg/m**2 ± (0.93) for stage 2 hypertension with significant value of (p<.0001). These compared to body mass index average in girls which were 23.65 kg/m**2 ± (0.25) for pre-hypertension and 31.85 kg/m**2 ± (3.46) for stage 2 hypertension with a significant value less than one (p<.0001). Figure 10 on page 106 shows a graphical comparison of BMI for in population aged (2-19 years).

Figure 20:



	Mexican American	Other Hispanic	Non-Hispanic White	Non-Hispanic Black	Non-Hispanic Asian	Other Race-Including Multi-Racial
Pre-Hypertension Boys	22.4	22.78	22.85	23.24	21.99	23.32
Pre-Hypertension Girls	23.9	23.78	23.11	25.17	21.43	24.81
Satge 1 Hypertension Boys	23.22	25.86	22.41	23.57	26.56	-
Satge 1 Hypertension Girls	-	26.3	28.42	26.28	-	-
Stage 2 Hypertension Boys	24.92	27.39	24.75	28.83	27.83	-
Stage 2 Hypertension Girls	-	-	-	27.7	-	-

Table 29:

Comparison of the Mean Distribution of Body Mass Index by Race in Pre-Hypertensive and Hypertensive US Population (Aged 2-19)

	Children (2 < 12 Years)			Adolescents (12 < 19 years)		
	Pre-Hypertension	**Stage 1 Hypertension**	**Stage 2 Hypertension**	**Pre-Hypertension**	**Stage 1 Hypertension**	**Stage 2 Hypertension**
	Systolic <=120 mmHg)	**Systolic <=124 mmHg**	**Systolic >124 mmHg**	**Systolic <=120 mmHg)**	**Systolic <=124 mmHg**	**Systolic >124 mmHg**
Boys						
Mexican American	20.57 ± (0.53)	-	-	24.40 ± (0.55)	23.22 ± (2.51)	24.92 ± (0.88)
Other Hispanic	20.10 ± (0.66)	-	-	22.78 ± (0.91)	25.86 ± (2.96)	27.39 ± (2.21)
Non-Hispanic White	18.10 ± (0.39)	-	-	22.85 ± (0.49)	22.41 ± (1.14)	24.75 ± (1.26)
Non-Hispanic Black	20.19 ± (0.50)	-	-	23.24 ± (0.49)	23.57 ± (1.16)	28.83 ± (1.60)
Non-Hispanic Asian	18.22 ± (0.53)	-	-	21.99 ± (0.59)	26.56 ± (1.99)	27.83 ± (2.50)
Other Race-Including Multi-Racial	19.13 ± (1.17)			23.32 ± (0.72)	-	-
Girls						
Mexican American	20.33 ± (0.49)	-	-	23.90 ± (0.63)	-	-
Other Hispanic	19.77 ± (0.68)	-	-	23.78± (0.52)	26.30 ± (1.74)	-
Non-Hispanic White	19.61 ± (0.45)	-	-	23.11 ± (0.50)	28.42 ± (3.14)	-
Non-Hispanic Black	20.82 ± (0.62)	-	-	25.17 ± (0.57)	26.28 ± (2.35)	27.70 ± (2.45)

4.10 Measures of the Association between Blood Pressure, Obesity and Cholesterol Levels

We determined extent of the strengths of the associations between mean systolic and diastolic blood pressure and predictors using paired-wise calculations. The results suggest that mean systolic blood pressure is significantly associated with body mass index, gender, age, body weight and standing height with significant value of .0001. There were no significant associations between mean systolic blood pressure, blood serum total cholesterol ($p<.6225$), and ratio of poverty to family income ($p<.4753$) using Fisher's optimization scoring test. Although race was associated with mean systolic blood pressure, using Pearson, Spearman, Kendall Tau and Hoeffiding correlation coefficients, there was no association using Fisher's exact transformation (.1163) (See Table 35 on pages 130-132). The associations for diastolic blood pressure were not evaluable due to missing values. There were significant relationships between body mass index, age, body weight and standing height, all with significant values of ($p<.0001$). Results from the Fisher's exact transformation list-wise calculation indicate significant value of .0001 between mean systolic blood pressure, body mass index, age, body weight, and standing height. Trends exhibited in the Fisher's exact test were not different from those suggested by the Pearson pared-wise results.

Table 30

Measures of the Association between Blood Pressure, Obesity and Cholesterol Levels (Simple Statistics)

Variable	N	Mean	Std Dev	Median	Minimum	Maximum	Label
mean_sbp	1973	106.09579	10.50214	105.33333	78.66667	154.00000	Mean systolic blood pressure
mean_dbp	1947	57.47783	11.39708	58.00000	16.00000	102.00000	Mean diastolic blood pressure
BMXBMI	3356	19.97405	5.56483	18.20000	12.40000	57.10000	Body Mass Index (kg/m**2)
RIAGENDR	4186	1.49498	0.50003	1.00000	1.00000	2.00000	Gender
RIDAGEYR	4186	8.14405	5.76344	8.00000	0	19.00000	Age in years at screening
RIDRETH3	4186	3.35643	1.73269	3.00000	1.00000	7.00000	Race/Hispanic origin w/ NH Asian
BMXWT	3977	36.20050	25.03710	28.90000	3.60000	180.60000	Weight (kg)
BMXHT	3354	137.02129	27.07846	139.00000	82.00000	199.50000	Standing Height (cm)
LBXTC	2063	159.50994	28.30511	157.00000	91.00000	272.00000	Total Cholesterol(mg/dL)
INDFMPIR	3807	1.95422	1.55359	1.34000	0.01000	5.00000	Ratio of family income to poverty

Figure 21:

Measures of the Association between Blood Pressure, Obesity and Cholesterol Levels in US Children and Adolescents

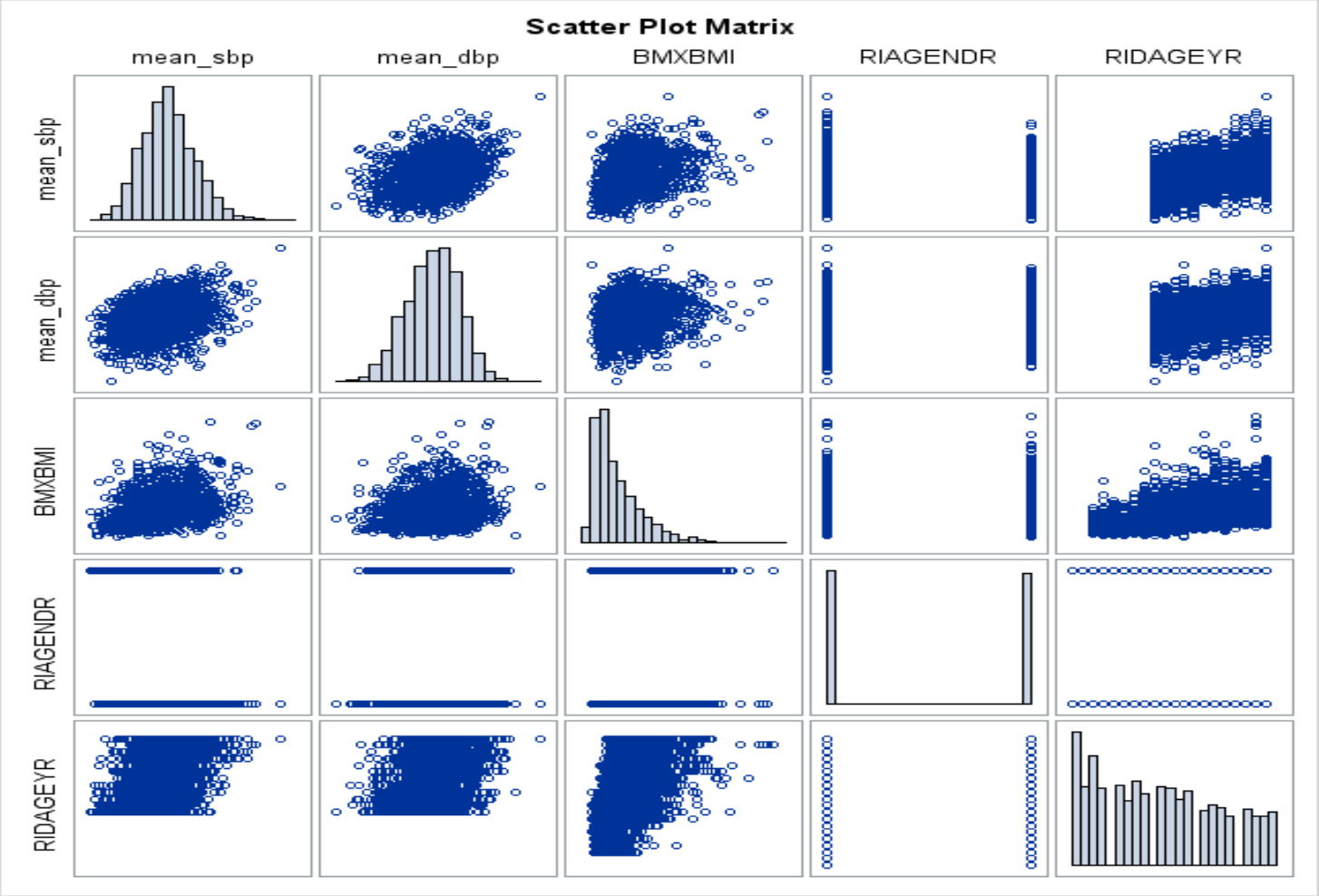


Table 31:

Measures of Association: Pearson Correlations Coefficients

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations	mean_sbp	mean_dbp	BMXBMI	RIAGENDR	RIDAGEYR	RIDRETH3	BMXWT	BMXHT	LBXTC	INDFMPIR
mean_sbp	1.00000	0.31892	0.39701	-0.21019	0.43509	0.02688	0.51750	0.49137	-0.00760	0.00146
		<.0001	<.0001	<.0001	<.0001	0.2326	<.0001	<.0001	0.7549	0.9507
	1973	1947	1961	1973	1973	1973	1954	1962	1689	1796
mean_dbp	0.31892	1.00000	0.19557	0.04434	0.32471	0.05628	0.27950	0.32321	0.06044	0.07146
	<.0001		<.0001	0.0505	<.0001	0.0130	<.0001	<.0001	0.0136	0.0026
	1947	1947	1935	1947	1947	1947	1928	1936	1666	1774
BMXBMI Body Mass Index (kg/m**2)	0.39701	0.19557	1.00000	0.00988	0.57350	-0.06045	0.88483	0.57849	0.02411	-0.05986
	<.0001	<.0001		0.5671	<.0001	0.0005	<.0001	<.0001	0.2755	0.0009
	1961	1935	3356	3356	3356	3356	3348	3353	2048	3054
RIAGENDR Gender	-0.21019	0.04434	0.00988	1.00000	-0.01364	0.01310	-0.05697	-0.07897	0.09791	-0.01011
	<.0001	0.0505	0.5671		0.3777	0.3969	0.0003	<.0001	<.0001	0.5329
	1973	1947	3356	4186	4186	4186	3977	3354	2063	3807
RIDAGEYR Age in years at screening	0.43509	0.32471	0.57350	-0.01364	1.00000	0.04530	0.87484	0.93934	-0.02629	0.02306
	<.0001	<.0001	<.0001	0.3777		0.0034	<.0001	<.0001	0.2326	0.1549
	1973	1947	3356	4186	4186	4186	3977	3354	2063	3807

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations										
	mean_sbp	**mean_dbp**	**BMXBMI**	**RIAGENDR**	**RIDAGEYR**	**RIDRETH3**	**BMXWT**	**BMXHT**	**LBXTC**	**INDFMPIR**
RIDRETH3 Race/Hispanic origin w/ NH Asian	0.02688 0.2326 1973	0.05628 0.0130 1947	-0.06045 0.0005 3356	0.01310 0.3969 4186	0.04530 0.0034 4186	1.00000 4186	0.01940 0.2212 3977	0.02241 0.1944 3354	0.00512 0.8162 2063	0.21128 <.0001 3807
BMXWT Weight (kg)	0.51750 <.0001 1954	0.27950 <.0001 1928	0.88483 <.0001 3348	-0.05697 0.0003 3977	0.87484 <.0001 3977	0.01940 0.2212 3977	1.00000 3977	0.86876 <.0001 3345	-0.03284 0.1380 2041	0.01738 0.2956 3622
BMXHT Standing Height (cm)	0.49137 <.0001 1962	0.32321 <.0001 1936	0.57849 <.0001 3353	-0.07897 <.0001 3354	0.93934 <.0001 3354	0.02241 0.1944 3354	0.86876 <.0001 3345	1.00000 3354	-0.09809 <.0001 2049	0.06842 0.0002 3052
LBXTC Total Cholesterol(mg/dL)	-0.00760 0.7549 1689	0.06044 0.0136 1666	0.02411 0.2755 2048	0.09791 <.0001 2063	-0.02629 0.2326 2063	0.00512 0.8162 2063	-0.03284 0.1380 2041	-0.09809 <.0001 2049	1.00000 2063	0.02002 0.3830 1900
INDFMPIR Ratio of family income to poverty	0.00146 0.9507 1796	0.07146 0.0026 1774	-0.05986 0.0009 3054	-0.01011 0.5329 3807	0.02306 0.1549 3807	0.21128 <.0001 3807	0.01738 0.2956 3622	0.06842 0.0002 3052	0.02002 0.3830 1900	1.00000 3807

Table 32:

Measures of Association: Spearman Correlations Coefficients

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations	mean_sbp	mean_dbp	BMXBMI	RIAGENDR	RIDAGEYR	RIDRETH3	BMXWT	BMXHT	LBXTC	INDFMPIR
mean_sbp	1.00000	0.29880	0.43609	-0.19959	0.43168	0.04501	0.53116	0.49615	-0.01946	0.00707
		<.0001	<.0001	<.0001	<.0001	0.0456	<.0001	<.0001	0.4242	0.7646
	1973	1947	1961	1973	1973	1973	1954	1962	1689	1796
mean_dbp	0.29880	1.00000	0.19991	0.04258	0.32033	0.05598	0.29571	0.31319	0.06285	0.04788
	<.0001		<.0001	0.0603	<.0001	0.0135	<.0001	<.0001	0.0103	0.0438
	1947	1947	1935	1947	1947	1947	1928	1936	1666	1774
BMXBMI Body Mass Index (kg/m**2)	0.43609	0.19991	1.00000	0.00622	0.65072	-0.08275	0.84699	0.66879	0.00964	-0.03766
	<.0001	<.0001		0.7187	<.0001	<.0001	<.0001	<.0001	0.6628	0.0374
	1961	1935	3356	3356	3356	3356	3348	3353	2048	3054
RIAGENDR Gender	-0.19959	0.04258	0.00622	1.00000	-0.01492	0.01255	-0.04634	-0.08589	0.09598	-0.01270
	<.0001	0.0603	0.7187		0.3344	0.4168	0.0035	<.0001	<.0001	0.4334
	1973	1947	3356	4186	4186	4186	3977	3354	2063	3807
RIDAGEYR Age in years at screening	0.43168	0.32033	0.65072	-0.01492	1.00000	0.04960	0.94605	0.95253	-0.03519	0.02937
	<.0001	<.0001	<.0001	0.3344		0.0013	<.0001	<.0001	0.1101	0.0700
	1973	1947	3356	4186	4186	4186	3977	3354	2063	3807

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations										
	mean_sbp	**mean_dbp**	**BMXBMI**	**RIAGENDR**	**RIDAGEYR**	**RIDRETH3**	**BMXWT**	**BMXHT**	**LBXTC**	**INDFMPIR**
RIDRETH3 Race/Hispanic origin w/ NH Asian	0.04501 0.0456 1973	0.05598 0.0135 1947	-0.08275 <.0001 3356	0.01255 0.4168 4186	0.04960 0.0013 4186	1.00000 4186	0.02732 0.0849 3977	0.02977 0.0848 3354	-0.00543 0.8052 2063	0.14804 <.0001 3807
BMXWT Weight (kg)	0.53116 <.0001 1954	0.29571 <.0001 1928	0.84699 <.0001 3348	-0.04634 0.0035 3977	0.94605 <.0001 3977	0.02732 0.0849 3977	1.00000 3977	0.94601 <.0001 3345	-0.05567 0.0119 2041	0.02524 0.1288 3622
BMXHT Standing Height (cm)	0.49615 <.0001 1962	0.31319 <.0001 1936	0.66879 <.0001 3353	-0.08589 <.0001 3354	0.95253 <.0001 3354	0.02977 0.0848 3354	0.94601 <.0001 3345	1.00000 3354	-0.10866 <.0001 2049	0.07437 <.0001 3052
LBXTC Total Cholesterol(mg/dL)	-0.01946 0.4242 1689	0.06285 0.0103 1666	0.00964 0.6628 2048	0.09598 <.0001 2063	-0.03519 0.1101 2063	-0.00543 0.8052 2063	-0.05567 0.0119 2041	-0.10866 <.0001 2049	1.00000 2063	0.02602 0.2570 1900
INDFMPIR Ratio of family income to poverty	0.00707 0.7646 1796	0.04788 0.0438 1774	-0.03766 0.0374 3054	-0.01270 0.4334 3807	0.02937 0.0700 3807	0.14804 <.0001 3807	0.02524 0.1288 3622	0.07437 <.0001 3052	0.02602 0.2570 1900	1.00000 3807

Table 33:

Measures of Association: Kendall Tau b Correlations Coefficients

Kendall Tau b Correlation Coefficients Prob > |tau| under H0: Tau=0 Number of Observations										
	mean_sbp	**mean_dbp**	**BMXBMI**	**RIAGENDR**	**RIDAGEYR**	**RIDRETH3**	**BMXWT**	**BMXHT**	**LBXTC**	**INDFMPIR**
mean_sbp	1.00000	0.20636	0.30326	-0.16447	0.30953	0.03276	0.37330	0.34516	-0.01263	0.00487
		<.0001	<.0001	<.0001	<.0001	0.0483	<.0001	<.0001	0.4431	0.7608
	1973	1947	1961	1973	1973	1973	1954	1962	1689	1796
mean_dbp	0.20636	1.00000	0.13632	0.03506	0.22681	0.04099	0.20139	0.21300	0.04303	0.03258
	<.0001		<.0001	0.0603	<.0001	0.0140	<.0001	<.0001	0.0094	0.0428
	1947	1947	1935	1947	1947	1947	1928	1936	1666	1774
BMXBMI	0.30326	0.13632	1.00000	0.00510	0.45556	-0.06053	0.65334	0.45660	0.00649	-0.02550
Body Mass Index (kg/m**2)	<.0001	<.0001		0.7186	<.0001	<.0001	<.0001	<.0001	0.6625	0.0366
	1961	1935	3356	3356	3356	3356	3348	3353	2048	3054
RIAGENDR	-0.16447	0.03506	0.00510	1.00000	-0.01251	0.01121	-0.03787	-0.07018	0.07879	-0.01044
Gender	<.0001	0.0603	0.7186		0.3344	0.4167	0.0035	<.0001	<.0001	0.4334
	1973	1947	3356	4186	4186	4186	3977	3354	2063	3807
RIDAGEYR	0.30953	0.22681	0.45556	-0.01251	1.00000	0.03701	0.81811	0.83309	-0.02495	0.02061
Age in years at screening	<.0001	<.0001	<.0001	0.3344		0.0014	<.0001	<.0001	0.1027	0.0650
	1973	1947	3356	4186	4186	4186	3977	3354	2063	3807

Kendall Tau b Correlation Coefficients Prob > |tau| under H0: Tau=0 Number of Observations										
	mean_sbp	**mean_dbp**	**BMXBMI**	**RIAGENDR**	**RIDAGEYR**	**RIDRETH3**	**BMXWT**	**BMXHT**	**LBXTC**	**INDFMPIR**
RIDRETH3 Race/Hispanic origin w/ NH Asian	0.03276 0.0483 1973	0.04099 0.0140 1947	-0.06053 <.0001 3356	0.01121 0.4167 4186	0.03701 0.0014 4186	1.00000 4186	0.01983 0.0868 3977	0.02191 0.0822 3354	-0.00448 0.7817 2063	0.10905 <.0001 3807
BMXWT Weight (kg)	0.37330 <.0001 1954	0.20139 <.0001 1928	0.65334 <.0001 3348	-0.03787 0.0035 3977	0.81811 <.0001 3977	0.01983 0.0868 3977	1.00000 3977	0.80466 <.0001 3345	-0.03766 0.0112 2041	0.01721 0.1230 3622
BMXHT Standing Height (cm)	0.34516 <.0001 1962	0.21300 <.0001 1936	0.45660 <.0001 3353	-0.07018 <.0001 3354	0.83309 <.0001 3354	0.02191 0.0822 3354	0.80466 <.0001 3345	1.00000 3354	-0.07275 <.0001 2049	0.05045 <.0001 3052
LBXTC Total Cholesterol(mg/dL)	-0.01263 0.4431 1689	0.04303 0.0094 1666	0.00649 0.6625 2048	0.07879 <.0001 2063	-0.02495 0.1027 2063	-0.00448 0.7817 2063	-0.03766 0.0112 2041	-0.07275 <.0001 2049	1.00000 2063	0.01795 0.2464 1900
INDFMPIR Ratio of family income to poverty	0.00487 0.7608 1796	0.03258 0.0428 1774	-0.02550 0.0366 3054	-0.01044 0.4334 3807	0.02061 0.0650 3807	0.10905 <.0001 3807	0.01721 0.1230 3622	0.05045 <.0001 3052	0.01795 0.2464 1900	1.00000 3807

Table 34:

Measures of Association: Hoeffding Dependence Coefficients

Hoeffding Dependence Coefficients Prob > D under H0: D=0 Number of Observations										
	mean_sbp	**mean_dbp**	**BMXBMI**	**RIAGENDR**	**RIDAGEYR**	**RIDRETH3**	**BMXWT**	**BMXHT**	**LBXTC**	**INDFMPIR**
mean_sbp	0.94717 <.0001 1973	0.02545 <.0001 1947	0.06232 <.0001 1961	0.00712 <.0001 1973	0.05897 <.0001 1973	0.00058 0.0325 1973	0.09577 <.0001 1954	0.07978 <.0001 1962	0.00008 0.2613 1689	-0.00009 0.5324 1796
mean_dbp	0.02545 <.0001 1947	0.95389 <.0001 1947	0.01117 <.0001 1935	0.00005 0.2841 1947	0.03003 <.0001 1947	0.00058 0.0328 1947	0.02608 <.0001 1928	0.02968 <.0001 1936	0.00147 0.0030 1666	0.00087 0.0153 1774
BMXBMI Body Mass Index (kg/m**2)	0.06232 <.0001 1961	0.01117 <.0001 1935	0.97889 <.0001 3356	-0.00014 0.9401 3356	0.15018 <.0001 3356	0.00179 <.0001 3356	0.35054 <.0001 3348	0.16142 <.0001 3353	-0.00010 0.6014 2048	0.00046 0.0193 3054
RIAGENDR Gender	0.00712 <.0001 1973	0.00005 0.2841 1947	-0.00014 0.9401 3356	0.11688 <.0001 4186	-0.00015 0.9998 4186	-0.00019 1.0000 4186	0.00034 0.0224 3977	0.00269 <.0001 3354	0.00122 0.0026 2063	-0.00020 1.0000 3807
RIDAGEYR Age in years at screening	0.05897 <.0001 1973	0.03003 <.0001 1947	0.15018 <.0001 3356	-0.00015 0.9998 4186	0.87417 <.0001 4186	0.00048 0.0063 4186	0.58097 <.0001 3977	0.61363 <.0001 3354	0.00085 0.0104 2063	0.00050 0.0078 3807

Hoeffding Dependence Coefficients Prob > D under H0: D=0 Number of Observations										
	mean_sbp	**mean_dbp**	**BMXBMI**	**RIAGENDR**	**RIDAGEYR**	**RIDRETH3**	**BMXWT**	**BMXHT**	**LBXTC**	**INDFMPIR**
RIDRETH3 Race/Hispanic origin w/ NH Asian	0.00058 0.0325 1973	0.00058 0.0328 1947	0.00179 <.0001 3356	-0.00019 1.0000 4186	0.00048 0.0063 4186	0.53746 <.0001 4186	0.00014 0.1035 3977	0.00041 0.0206 3354	-0.00012 0.6496 2063	0.00665 <.0001 3807
BMXWT Weight (kg)	0.09577 <.0001 1954	0.02608 <.0001 1928	0.35054 <.0001 3348	0.00034 0.0224 3977	0.58097 <.0001 3977	0.00014 0.1035 3977	0.99614 <.0001 3977	0.58627 <.0001 3345	0.00140 0.0014 2041	0.00019 0.0781 3622
BMXHT Standing Height (cm)	0.07978 <.0001 1962	0.02968 <.0001 1936	0.16142 <.0001 3353	0.00269 <.0001 3354	0.61363 <.0001 3354	0.00041 0.0206 3354	0.58627 <.0001 3345	0.99723 <.0001 3354	0.00378 <.0001 2049	0.00170 <.0001 3052
LBXTC Total Cholesterol(mg/dL)	0.00008 0.2613 1689	0.00147 0.0030 1666	-0.00010 0.6014 2048	0.00122 0.0026 2063	0.00085 0.0104 2063	-0.00012 0.6496 2063	0.00140 0.0014 2041	0.00378 <.0001 2049	0.96975 <.0001 2063	-0.00003 0.4250 1900
INDFMPIR Ratio of family income to poverty	-0.00009 0.5324 1796	0.00087 0.0153 1774	0.00046 0.0193 3054	-0.00020 1.0000 3807	0.00050 0.0078 3807	0.00665 <.0001 3807	0.00019 0.0781 3622	0.00170 <.0001 3052	-0.00003 0.4250 1900	0.98218 <.0001 3807

Table 35:

One-Sided Hypothesis Tests and Confidence Limits for the Correlations Using Fisher's Transformation

Pearson Correlation Statistics (Fisher's z Transformation)								
Variable	**With Variable**	**N**	**Sample Correlation**	**Fisher's z**	**Bias Adjustment**	**Correlation Estimate**	**Lower 95% CL**	**p Value for H0:Rho<=0**
mean_sbp	mean_dbp	1947	0.31892	0.33045	0.0000819	0.31885	0.284949	<.0001
mean_sbp	BMXBMI	1961	0.39701	0.42009	0.0001013	0.39692	0.365155	<.0001
mean_sbp	RIAGENDR	1973	-0.21019	-0.21337	-0.0000533	-0.21014	-0.245274	1.0000
mean_sbp	RIDAGEYR	1973	0.43509	0.46615	0.0001103	0.43500	0.404472	<.0001
mean_sbp	RIDRETH3	1973	0.02688	0.02689	6.81666E-6	0.02688	-0.010174	0.1163
mean_sbp	BMXWT	1954	0.51750	0.57292	0.0001325	0.51741	0.489614	<.0001
mean_sbp	BMXHT	1962	0.49137	0.53786	0.0001253	0.49127	0.462568	<.0001
mean_sbp	LBXTC	1689	-0.00760	-0.00760	-2.2518E-6	-0.00760	-0.047623	*0.6225
mean_sbp	INDFMPIR	1796	0.00146	0.00146	4.06752E-7	0.00146	-0.037368	0.4753
mean_dbp	BMXBMI	1935	0.19557	0.19813	0.0000506	0.19552	0.159285	<.0001
mean_dbp	RIAGENDR	1947	0.04434	0.04437	0.0000114	0.04432	0.007048	0.0252
mean_dbp	RIDAGEYR	1947	0.32471	0.33690	0.0000834	0.32463	0.290867	<.0001
mean_dbp	RIDRETH3	1947	0.05628	0.05634	0.0000145	0.05627	0.019019	0.0065
mean_dbp	BMXWT	1928	0.27950	0.28714	0.0000725	0.27943	0.244520	<.0001
mean_dbp	BMXHT	1936	0.32321	0.33523	0.0000835	0.32314	0.289238	<.0001
mean_dbp	LBXTC	1666	0.06044	0.06051	0.0000181	0.06042	0.020154	0.0068
mean_dbp	INDFMPIR	1774	0.07146	0.07159	0.0000202	0.07144	0.032468	0.0013

Pearson Correlation Statistics (Fisher's z Transformation)								
Variable	**With Variable**	**N**	**Sample Correlation**	**Fisher's z**	**Bias Adjustment**	**Correlation Estimate**	**Lower 95% CL**	**p Value for H0:Rho<=0**
BMXBMI	RIAGENDR	3356	0.00988	0.00988	1.47273E-6	0.00988	-0.018523	0.2836
BMXBMI	RIDAGEYR	3356	0.57350	0.65272	0.0000855	0.57344	0.554068	<.0001
BMXBMI	RIDRETH3	3356	-0.06045	-0.06052	-9.0091E-6	-0.06044	-0.088688	0.9998
BMXBMI	BMXWT	3348	0.88483	1.39761	0.0001322	0.88481	0.878473	<.0001
BMXBMI	BMXHT	3353	0.57849	0.66020	0.0000863	0.57844	0.559216	<.0001
BMXBMI	LBXTC	2048	0.02411	0.02411	5.88904E-6	0.02410	-0.012264	0.1377
BMXBMI	INDFMPIR	3054	-0.05986	-0.05994	-9.8042E-6	-0.05985	-0.089465	0.9995
RIAGENDR	RIDAGEYR	4186	-0.01364	-0.01364	-1.6293E-6	-0.01364	-0.039049	0.8111
RIAGENDR	RIDRETH3	4186	0.01310	0.01310	1.56464E-6	0.01309	-0.012336	0.1985
RIAGENDR	BMXWT	3977	-0.05697	-0.05703	-7.1641E-6	-0.05696	-0.082925	0.9998
RIAGENDR	BMXHT	3354	-0.07897	-0.07913	-0.0000118	-0.07896	-0.107122	1.0000
RIAGENDR	LBXTC	2063	0.09791	0.09823	0.0000237	0.09789	0.061884	<.0001
RIAGENDR	INDFMPIR	3807	-0.01011	-0.01011	-1.3282E-6	-0.01011	-0.036762	0.7336
RIDAGEYR	RIDRETH3	4186	0.04530	0.04533	5.41184E-6	0.04529	0.019888	0.0017
RIDAGEYR	BMXWT	3977	0.87484	1.35335	0.0001100	0.87481	0.868550	<.0001
RIDAGEYR	BMXHT	3354	0.93934	1.73241	0.0001401	0.93932	0.935889	<.0001
RIDAGEYR	LBXTC	2063	-0.02629	-0.02630	-6.3752E-6	-0.02629	-0.062450	0.8837
RIDAGEYR	INDFMPIR	3807	0.02306	0.02306	3.02898E-6	0.02305	-0.003611	0.0775
RIDRETH3	BMXWT	3977	0.01940	0.01941	2.44022E-6	0.01940	-0.006688	0.1106
RIDRETH3	BMXHT	3354	0.02241	0.02242	3.34213E-6	0.02241	-0.006002	0.0972

Pearson Correlation Statistics (Fisher's z Transformation)								
Variable	**With Variable**	**N**	**Sample Correlation**	**Fisher's z**	**Bias Adjustment**	**Correlation Estimate**	**Lower 95% CL**	**p Value for H0:Rho<=0**
RIDRETH3	LBXTC	2063	0.00512	0.00512	1.24178E-6	0.00512	-0.031111	0.4081
RIDRETH3	INDFMPIR	3807	0.21128	0.21451	0.0000278	0.21125	0.185634	<.0001
BMXWT	BMXHT	3345	0.86876	1.32801	0.0001299	0.86873	0.861576	<.0001
BMXWT	LBXTC	2041	-0.03284	-0.03285	-8.0496E-6	-0.03283	-0.069171	0.9310
BMXWT	INDFMPIR	3622	0.01738	0.01739	2.40057E-6	0.01738	-0.009958	0.1478
BMXHT	LBXTC	2049	-0.09809	-0.09841	-0.0000239	-0.09807	-0.133940	1.0000
BMXHT	INDFMPIR	3052	0.06842	0.06852	0.0000112	0.06841	0.038705	<.0001
LBXTC	INDFMPIR	1900	0.02002	0.02003	5.27229E-6	0.02002	-0.017742	0.1915

Yields from the Fisher's exact test were not significantly different from those suggested by the Pearson pared-wise results.

*The lack of significant associations between blood serum cholesterol levels and blood pressure is consistent with previous findings. [95-96]

4.11 Analysis of Variance

We compared averages of blood pressure levels in children and adolescents using analysis of variance (ANOVA). Since ANOVA assumes that sample sizes for all groups are equal, the general linear model was used to test whether blood pressure levels in children versus adolescents and boys versus girls were equal. The results suggest that there are significant differences in the means of blood pressure levels among the various groups. (See Table 23 on page 98). In children aged 2-11, the average weight for girls with stage 1 hypertension (51.08 kg) was higher than the average weight for boys (45.41 kg). Average standing height was also higher for girls (155.73 cm) than for boys (142.27 cm). However, boys had a higher body mass index (22.10 kg/m**2) than girls (20.63 kg/m**2). The average of blood serum total cholesterol was 155.32 (mg/dL) for boys with stage 1 hypertension and 135.97 (mg/dL) for girls. The ratio of poverty to family income for girls (3.87) with stage 1 hypertension was higher than that of boys (1.65). For stage 2 hypertension, there was no significant differences in the average for standing height. Mean standing height were 140.31 (kg) for boys and 140.59 (kg) for girls. Girls with stage 2 hypertension had body mass index average of 19.45 (kg/**2) compared to 17.02 (kg/m**2) for boys.

In adolescents, the average weight for boys with stage 1 hypertension was 71.48 kg compared to 68.35 (kg) for girls. Mean standing height in boys was 174.61 (cm) but 160.61 (cm) in girls. Mass index average for girls was 26.66 (kg/m**2) compared to 23.36 (kg/m**2) for boys. Girls had a higher total cholesterol average, 174.56 (mg/dL), than boys, 160.22 mg/dL. For stage 2 hypertension, the average of body weight for boys was 83.84 (kg) compared to 78.92 (kg) for girls. Mean of standing height for boys was

175.66 (cm) compared to 158.49 (cm) for girls. However, girls had higher body mass index (31.85 kg/m**2) average compared to boys (27.10 (kg/m**2) (Tables 24-28 were used to compile Table 23 on page 98).

4.12 Analysis of Covariance

Table 36:

Analysis of Covariance

The GLM Procedure

Dependent Variable: Systolic Blood Pressure (SBP)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	370.5113503	41.1679278	101741	<.0001
Error	1495	0.6049288	0.0004046		
Corrected Total	1504	371.1162791			

R-Square	Coeff Var	Root MSE	SBP Mean
0.998370	1.729936	0.020116	1.162791

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Body Weight (kg)	1	37.7921494	37.7921494	93398.2	<.0001
Standing Height (cm)	1	3.2126113	3.2126113	7939.54	<.0001
Blood Serum T. Cholesterol (mg/dL)	1	0.5418644	0.5418644	1339.14	<.0001
Ratio of Poverty to F. Income	1	0.1576936	0.1576936	389.72	<.0001
SBP*Body Mass Index (kg**m2)	1	306.7416868	306.7416868	758071	<.0001
SBP* Body Weight (kg)	1	0.4143446	0.4143446	1024.00	<.0001
SBP* Standing Height (cm)	1	21.6023410	21.6023410	53387.3	<.0001
SBP* Total Cholesterol (mg/dL)	1	0.0486507	0.0486507	120.23	<.0001
SBP*Ration of Poverty	1	0.0000085	0.0000085	0.02	0.8849

The model explains the variance of our response variable systolic blood pressure*

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Body Weight (kg)	1	0.00726330	0.00726330	17.95	<.0001
Standing Height (cm)	1	0.32851165	0.32851165	811.87	<.0001
Blood Serum T. Cholesterol (mg/dL)	1	0.04234069	0.04234069	104.64	<.0001
Ratio of Poverty to F. Income	1	0.00042409	0.00042409	1.05	0.3061
SBP*Body Mass Index (kg**m2)	1	0.58478038	0.58478038	1445.21	<.0001
SBP* Body Weight (kg)	1	0.84693673	0.84693673	2093.09	<.0001
SBP* Standing Height (cm)	1	8.28639897	8.28639897	20478.7	<.0001
SBP* Total Cholesterol (mg/dL)	1	0.04862451	0.04862451	120.17	<.0001
SBP*Ratio of Poverty to F. Income	1	0.00000849	0.00000849	0.02	0.8849

As show in Table 36, there were significant differences in the variations of elevated blood pressure in children except for ratio of poverty to family income which's critical value of (Pr F = 0.8849) was greater than F value (F Value = 0.02). This means that the model explains the variance of our response variable systolic blood pressure. From the table, there are three sources of variation for the response variable (SBP). These are: Model, Error and Corrected total. To see the variations accounted for by these sources, the sums of the squares must be compared.

Model = (the explained) Variance in the response accounted for by the model:

General Linear Model SAS Syntax for Generating Covariance Estimates

```
/*Linear equation of the dependent variable systolic blood pressure to
covariates*/

    model SBP=bmxwt bmxht lbxtc indfmpir SBP*bmxbmi SBP*bmxwt SBP*bmxht
    SBP*lbxtc SBP*indfmpir
```

Where: SBP = Systolic blood pressure, bmxwt = body weight (kg),
bmxht = standing height (cm), bmxbmi = Body mass index (kg/m**2) and
lbxtc = Blood serum total cholesterol

Error = (Unexplained) Variation not explained by the above Model.

Model + **Error** = **Corrected Total**

Parameterization of the general linear model constructs an intercept, regression effects and main effects. Since the corrected total is an adjusted sums of the squires, it includes information on the intercept. Each effect generates one or more columns in a matrix. By default, an intercept parameter (**DF**) which is also known as degrees of freedom is created. The general linear model uses an inverse $(\frac{1}{n} - 1)$ to obtain values of the estimates whenever parameters might not be estimable meaning estimates are zero. Where n = the sample size. Thus the degrees of freedom (DF) = Intercept (μ). From the table, the DF associated with the model plus DF associated with the error is equal to the **Corrected Source**. Regardless of the type of analysis conducted, all resulted models include a column of 1s. Linear dependencies exist among the parameter estimates. The next component of the parameterization is the regression effect or covariates. At this stage, values of the explanatory variables set in the model are copied directly into the matrix. Polynomial terms are then multiplied and outputted in the explanatory variables (covariates). The following SAS syntax was used to set the equation for the model:

```
/*Linear equation of the dependent variable systolic blood pressure to
covariates: body mass index, blood serum total cholesterol, body
weight, standing height and poverty ratio*/
ods graphics on;
      proc glm data=Selected;
      class BMI;
      model SBP=bmxwt bmxht lbxtc indfmpir SBP*bmxbmi SBP*bmxwt
      SBP*bmxht SBP*lbxtc SBP*indfmpir;
      label BMI = 'Body Mass Index';
      format SBP SBP. BMI BMI.;
      title 'Analysis of Covariance';
      run;
ods graphics off;
```

Also from Table 36, the column "**F Value"** shows a figure for testing how unlikely it is for variances to be the same if two or more variances were compared. It is derived by dividing the model by the error (9/1495) = 101741. The column "**Pr > F**" shows the critical value for determining the level of significance. The probability of observing an F Value as large as, or larger than 101741 under the null hypothesis is < 0.0001. If real variances were equal to each other, then probability will be 1. (p = 1). This means if variances were the same, then F-values would not be very different from 1. Given a 95% confidence by default in the general linear model in SAS, the critical value will be 0.05. This means we can accept a type 1 error as shown in the Type 1 SS analysis table. The overall joint effect of the distribution shows a value of 101741 with a critical value of P <.0001.

Since the critical value or F-statistic (p < .0001) is less than the F-value (101741), the null hypothesis must be rejected. We would reject the null hypothesis and conclude that our model statistically did not show significant proportion of the variance. Another way to interpret the result is to use the root of the mean square error (standard deviation). The standard deviation of the response observation about the predicted value given in the table as (Root MSE) was 0.020116. This figure is less than 0.05 making it significant. Mean of the response variable, SBP was given as 1.162791 with a coefficient variation of 1.729936 (which allows comparison of the variation of populations).

Table 37: Regression of Body Mass Index from Systolic Blood Pressure

(Optimization Technique: Fisher's Scoring)

Response Profile

Ordered Value	SBP	Total Frequency	Total Weight
1	Pre-hypertension (<=120 mmHg)	1738	42082209
2	Stage 1 Hypertension (<=124 mmHg)	89	2248429
3	Stage 2 Hypertension (Systolic >124 mmHg)	98	2648774

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
73510.6030	3	<.0001

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	355682.710	3	<.0001
Score	373947.348	3	<.0001
Wald	369614.928	3	<.0001

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	38166985	37811308
SC	38166996	37811336
-2 Log L	38166981	37811298

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq	Exp(Est)
Intercept	Pre-hypertension (<=120 mmHg)	1	1.9668	0.000657	8968094.25	<.0001	7.148

Intercept	Stage 1 Hypertension (<=124 mmHg)	1	2.6376	0.00074	11606842.7	<.0001	13.979
BMI	Normal Weight (85TH %)	1	0.4134	0.00081	260681.518	<.0001	1.512
BMI	Obese (100+)	1	-0.2298	0.00092	61567.3989	<.0001	0.795
BMI	Overweight (95TH %)	1	0.1045	0.00105	9933.1999	<.0001	1.110

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
BMI Normal Weight (85TH %) vs Underweight (5TH %)	2.017	2.008	2.025
BMI Obese (100+) vs Underweight (5TH %)	1.060	1.055	1.065
BMI Overweight (95TH %) vs Underweight (5TH %)	1.481	1.474	1.488

As shown in Table 37, body mass index is positively correlated with mean systolic blood pressure. The point estimate for stage 1 hypertension was 13.98 with a significant value of $p < 0.0001$.

Table 38: **Regression of Total Serum Cholesterol from Systolic Blood Pressure**

(Optimization Technique: Fisher's Scoring)

Response Profile

Ordered Value	SBP	Total Frequency	Total Weight
1	Pre-hypertension (<=120 mmHg)	749	15191719
2	Stage 1 Hypertension (<=124 mmHg)	21	423897
3	Stage 2 Hypertension (Systolic >124 mmHg)	10	326425

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
219187.148	2	<.0001

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	539479.372	2	<.0001
Score	584673.976	2	<.0001
Wald	464547.925	2	<.0001

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	7078520.5	6539045.1
SC	7078529.8	6539063.8
-2 Log L	7078516.5	6539037.1

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq	Exp(Est)
Intercept	Pre-hypertension (<=120 mmHg)	1	2.8916	0.00158	3355643.15	<.0001	18.023
Intercept	Stage 1 Hypertension (<=124 mmHg)	1	3.7738	0.00206	3362211.59	<.0001	43.547
TCL	Borderline (<= 129 Mg/dl)	1	-0.7970	0.00180	195296.407	<.0001	0.451

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq	Exp(Est)
TCL	Desirable (<=110 Mg/dl)	1	-0.2795	0.00273	10499.5255	<.0001	0.756

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
TCL Borderline (<= 129 Mg/dl) vs Very High (>130 Mg/dl)	0.154	0.153	0.154
TCL Desirable (<=110 Mg/dl) vs Very High (>130 Mg/dl)	0.258	0.255	0.260

Table 39: **Regression of the Age Variable from Systolic Blood Pressure**

(Optimization Technique: Fisher's Scoring)

Response Profile

Ordered Value	SBP	Total Frequency	Total Weight
1	Pre-hypertension (<=120 mmHg)	1758	42606283
2	Stage 1 Hypertension (<=124 mmHg)	90	2257891
3	Stage 2 Hypertension (Systolic >124 mmHg)	99	2656635

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
58662.1277	1	<.0001

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	1916493.67	1	<.0001
Score	1540564.63	1	<.0001
Wald	1180523.17	1	<.0001

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	38384759	36468267
SC	38384770	36468284
-2 Log L	38384755	36468261

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq	Exp(Est)
Intercept	Pre-hypertension (<=120 mmHg)	1	2.7564	0.000875	9916896.27	<.0001	15.744
Intercept	Stage 1 Hypertension (<=124 mmHg)	1	3.4396	0.000974	12471669.8	<.0001	31.175
Age	Adolescents(12 <= 19 Years)	1	-0.9509	0.000875	1180523.17	<.0001	0.386

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
Age Adolescents(12 <= 19 Years) vs Children(2 <= 11 Years)	0.149	0.149	0.150

Table 40: **Regression of the Sex Category from Systolic Blood Pressure (Optimization Technique: Fisher's Scoring)**

Response Profile

Ordered Value	SBP	Total Frequency	Total Weight
1	Pre-hypertension (<=120 mmHg)	1758	42606283
2	Stage 1 Hypertension (<=124 mmHg)	90	2257891
3	Stage 2 Hypertension (Systolic >124 mmHg)	99	2656635

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
358710.544	1	<.0001

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	1522858.61	1	<.0001
Score	1463068.79	1	<.0001
Wald	1319391.47	1	<.0001

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	38384759	36861902
SC	38384770	36861919
-2 Log L	38384755	36861896

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq	Exp(Est)
Intercept	Pre-hypertension (<=120 mmHg)	1	2.3029	0.000546	17810206.8	<.0001	10.003
Intercept	Stage 1 Hypertension (<=124 mmHg)	1	2.9856	0.000689	18798928.2	<.0001	19.798

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq	Exp(Est)
Gender	Boys	1	-0.6263	0.000545	1319391.47	<.0001	0.535

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
Gender Boys vs Girls	0.286	0.285	0.286

4.13 The Odds of Developing Sustained Blood Pressure Elevations in Children

Results from the regression coefficient given other predictors of a model in which blood pressure was equated to body weight, body mass index, standing height and blood serum total cholesterol did not show any regression coefficients of zero at 95% confidence limits. In other words, no zero values were observed between the Wald Confidence limits. True parameters for normal versus underweight was .50, obese versus underweight was .94 and overweight versus underweight was .67 with Wald Confidences of (.494-.498), (.939-.947) and (.672-.678) respectively. A test of the regression coefficient of body mass index (pr>chisq) was p<.0001, suggesting that it is unlikely for one to have an extreme blood pressure level as predicted by body mass index other than the values which have been observed and defined according to the significance level (p<.0001). Although score test for the proportional odds assumption of blood serum total cholesterol generally suggest high significance, the chi square difference for stage 1 hypertension is extremely large with an expected estimate value of (11.77). It is therefore likely for a predicted value to extremely deviate from the observed value using blood serum total cholesterol level as a predictor of systolic high blood pressure. Age as a predictor of elevated blood pressure showed higher significance with minimal standard errors. Given Wald Confidence limits of (.149-.150), a chi-square of p<.0001 and a true parameter estimate of 0.149, it is 15 times out of 100 more likely for an obese or overweight child to eventually develop either stage 1 or stage 2 hypertension if there is no intervention. Although similar calculations were made for diastolic blood pressure, diastolic blood pressure results were excluded from the results due to limited samples (missing data) of the analytic variables.

4.14 Risk Factor Estimates of Elevated Blood Pressure Levels

One of the specific objectives for this study was to determine the highest risk factor of elevated blood pressure levels in children and adolescents. A model was set for the dependent variable (Blood pressure readings) and its predictors, body mass index, body weight, standing height and total cholesterol levels. From the analysis, blood pressure levels was best predicted by body weight with a t-value of 7.88 and p-value of .0001. The least predictor of elevated blood pressure levels was blood serum total cholesterol levels which had a t-value of 1.41 and a p-value of 0.1573 (See Table 53). Although the t-value for body mass index was negative, by absolute significance was the second best predictor of elevated blood pressure with a p-value of .0001.

Table 41:

Least versus Highest Factor Predictors of Blood Pressure Levels in Children

(Dependent Variable: SBP)

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	5	50.81567	10.16313	47.63	<.0001
Error	1505	321.13403	0.21338		
Corrected Total	1510	371.94970			

Root MSE	0.46193	**R-Square**	0.1366
Dependent Mean	1.16281	**Adj R-Sq**	0.1338
Coeff Var	39.72534		

Parameter Estimates						
Variable	**Label**	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	Intercept	**1**	2.76353	0.44535	6.21	<.0001
BMXBMI	Body Mass Index (kg/m**2)	**1**	-0.07218	0.01070	-6.74	<.0001
BMXWT	Weight (kg)	**1**	0.03140	0.00405	7.75	<.0001
BMXHT	Standing Height (cm)	**1**	-0.01173	0.00277	-4.24	<.0001
LBXTC	Total Cholesterol(mg/dL)	**1**	0.00065216	0.00042130	1.55	0.1218
INDFMPIR	Ratio of family income to poverty	**1**	-0.01151	0.00779	-1.48	0.1395

From Table 41 above, the highest risk factor contributing to high blood pressure in the US children and adolescents was body weight which had a t-value of 7.75 and a significant value of ($p<.0001$). Total blood serum cholesterol and ratio of poverty to family income were the least predictors of hypertension in US children and adolescents both with t-values of less than 1.56 and significant values of more than .05.

CHAPTER V

DISCUSSIONS AND LIMITATIONS

5.1 Discussion of General Study Results

During the preliminary stage of this dissertation, several fundamental questions were raised to formulate specific conceptual underpinnings for the secondary data analysis. In this section, an attempt will be made to address these fundamental questions based on the study results. Results from this study will be compared with previous findings to evaluate effectiveness of methods, principles, concepts, definitions, and limitations used in our secondary data analysis and to examine how they might have impacted the present results.

The criteria for determining what is normal or abnormal blood pressure levels in children and adolescents is debatable to some extent in that the distributed guidelines for identifying normal or abnormal blood pressure levels in children were derived from percentile-based tables. For the most part, blood pressure break points are based on growth curves. Therefore, the renowned 2004 Task Force definitions may not perfectly fit all subgroups of the population. A linear trend analysis (Figure 7, Page 65) depicting the flow of stage 1 hypertension shows an upward movement towards the direction of stage 2 hypertension. This suggests that blood pressure reduction will likely benefit children and adolescents with stage 1 hypertension.

Researchers have investigated a variety of hypothesis regarding the link between childhood obesity and the risk of developing hypertension. At the center of massive evidence are findings on cardiovascular diseases and their associated risk factors useful

for better planning, development and implementation of interventions. As of now, most of the underlying questions on hypertension syndromes have cleared. However, the central premise of using the most appropriate methods for generating indicator estimates still lingers. While some researchers have tried to solve the issue by recommending cut-off points to define hypertension severity levels, others consider it from a genetic perspective and responses to environmental factors. Despite the obvious importance, there is still no best way of evaluating children at the highest risk of hypertension. Although blood pressure risk factors in children are well familiar, [15-16] variability exist in the assessments of hypertension in children.[17, 18] The problem becomes more complex when it comes to selecting methods for analyzing population-based public health data. The use of cross-sectional methods to generate parameter estimates for an outcome of interest implicitly assumes that characteristic measures of the general population are the same everywhere and remain constant during the selected period of analysis. This is practically not the case since population-based metrics vary across subgroups. Setting parameter estimation models based on this assumption compromises statistically valid inferences. To assume parameter stability across subgroups of a population with no formal test of this assumption is troubling.

Missing Data:

It was stated early on in this dissertation that approximately 30% of diastolic blood pressure data were missing. For this reason, analysis on diastolic blood pressure readings were limited to only frequencies, percentiles and means. The purpose for generating only frequencies, percentiles and means was to determine how much of the

missing data need imputation and whether it was necessary to impute values for missing data. Results of the descriptive data analyses have been shown in the appendix section of this report. According to Rubin (1993), [98] multiple imputation commonly known as MI can be used to determine data uncertainties for the purpose of sound analysis. MI is a Monte Carlo technique in which missing values are replaced by m>1 simulated versions, where m can only have 3-10 imputations. In this approach, complete simulated datasets are analyzed by standard methods. The results are then combined to produce estimates and confidence intervals. It is not uncommon for sample surveys such as the NHANES to be hindered by missing data. The MI although has produced reliable results in the past, has been criticized by some experts who argue that parametric models , and maximum likelihood estimates can be calculated directly from incomplete data using numerical methods such as estimation model (EM) algorithms. The problem is, probabilistic sampling methods of the NHANES include EM algorithms and is assumed to have already created estimation procedures by way of weighted factors. It was unclear which simulation methods were applied in creating the examination procedures. As good as it is, developing variable specific statistical procedures other than using MI to address issues of missing NHANES data is a great idea. During the preliminary data analytic phase, PROC MI, a SAS syntax was used to impute values for missing data. This was followed by PROC MINIANALYZE. Our results showed little advantages for imputing missing values. The original dataset yielded a selected sample of 4,196 of which approximately 30% of variables relating to diastolic blood pressure in children and adolescents were missing. After specifying 5 simulated imputations in the PROC MI statement, the sample size returned approximately 20,000 observations. While the effects were significantly

visible in the counts for nominal variables, the increase in the percentiles were insignificant from the pre-imputation dataset. Therefore, we concluded that it was irrelevant to impute values for the missing data. While this is true, the recommended approach for handling NHANES missing data is to code them with a period (.) to include non-responses and refused to answer all as missing. This approach in effect provides a good estimation of the non missing values which eventually are used in calculating values for subsequent measures of central tendencies in the analysis. The limitation of this approach is that frequencies generated in the tables exclude counts of missing values.

Effectiveness of Analytical Models

The study goal was to estimate current national hypertension prevalence in overweight and obese US children and adolescents for 2011-2012. Specifically, we sought to answer: whether with a nationally representative sample of young population (aged 2-19 years), the relationship between obesity and elevated blood pressure levels will be evident; whether high densities of lipoprotein cholesterol levels in children will correlate with elevated high blood pressure levels; whether there was an interplay between elevated blood pressure levels, age, gender and race/ethnicity; whether the analysis would help determine the highest risk factor/predictor for hypertension in children other than obesity; and whether sufficient evidence could be generated to test the effectiveness of previous concepts, theories, principles, definitions, and appropriate blood pressure measurement and data analysis techniques to further conceptualize the underlying framework of blood pressure modalities for further research. Finding answers

to these questions required the setting of statistical models based on validated concepts and approaches.

First, we will discuss the effectiveness of previous concepts applied in this analysis. By defining blood pressure per their levels of severity we were able to re-categorize the response variable (blood pressure levels) into three levels of severity to allow hypertension definitions to be translated into data. Likewise were the definitional thresholds for body mass index and blood serum total cholesterol. Class variables were derived and specified in statistical models. We tested the Mosaic concept which stipulated that, one risk factor may trigger elevations in blood pressure levels but it will take other risk factors to sustain it. As indicated by the study results, increased body weight was the highest trigger of high blood pressure levels in children and adolescents but other risk factors such as standing height and cholesterol can co-explain the variability. The McCullagh (1984), [99] linear model of unbalanced ANOVA happened to be extremely useful for testing this concept. In this analytic model, the dependent variable, blood pressure, was set as a function of other continuous variables. This was given as:

Linear Model → $Y = fn(X_1, X_2, X_3, X_4)$

Where:

Y = Mean Systolic Blood Pressure

X_1 = Body Weight (kg)

X_2 = Standing Height (cm)

X_3 = Blood serum Total Cholesterol

X_4 = Ratio of Poverty to Family Income

How much of the variability can be explained by the risk factors?

According to the **Mosaic Concept**, the highest predictor can trigger elevations but it will take nominal factors such as age, lack of physical activity, diet etc. to sustain the elevation.

The general linear model requires a response vector which in the above equation was given as "Y" of length n. It also requires a model matrix "X" of order n x p given a description of the conditions under which the observations were made. Finally, the model requires a p-dimensional parameter vector **β** for which estimates or confidence limits are required. If the model matrix is regarded as fixed and our primary objective is to investigate the relationship between "Y" and "X", then the measure of the population (parameter, **μ**) will be equal to the estimation of "Y" and "X".

Thus: **p = E(Y) and X**:

This relationship is assumed to be linear in the unknown called beta (**β**). That is, we can equally assume that: **μ= Xβ.** SAS syntax for the general linear model is the PROC GLM.

The linear model explained the variance of our response variable systolic blood pressure. From the Table 36 (Page 134), the "error" is the unexplained variability and the "corrected total" is the explained variability. An F Value was generated by the model by dividing the corrected total by the error (9/1495) = 101741, with a significance value of <.0001. Interpreting, the linear model used was appropriate since it explained the variability. Having known this, we determined the proportion of the explanation by each risk factor. From Table 41 (Pages 146-147), the highest risk factor contributing to high blood pressure in the US children and adolescents was body weight which had a t-value of 7.75 and a significant value of (p<.0001). Total blood serum cholesterol and ratio of poverty to family income were the least predictors of hypertension in US children and adolescents both with t-values of less than 1.56 and significant values of more than .05. Therefore by interpretation **using the Mosaic Theory, body weight was the highest trigger of blood pressure elevations in children** for the 2011-2012 analysis period.

Next, we tested this assumption by setting up another model that might explain variability in the response as predicted by the demographic and characteristic variables. This was the multiple logistic regression with the Fisher's Expansion Transformation. In SAS, it is known as the PROC LOGISTIC. / <fishers>. Table 35 (Page 130-132) is a return of the results of the logistic regression model. As shown in Table 35, the estimated value of the correlation between mean systolic blood pressure and gender was 0.21019 with p-value of 1. This means there was no significance and we can conclude that variability in the distribution of blood pressure levels in children were not explained by gender. The next characteristic variable was race. Estimated value of the correlations between mean systolic blood pressure and race was 0.02688 with a p-value of 0.1163 which means that race did not explain systolic blood pressure variations for the selected sample. The last characteristic variable was age which had a correlated value of 0.43509 with p-value of 0001. It can be concluded that **age explained variability in systolic blood pressure among the selected sample**.

Going by the Mosaic concept and with a critical value of 0.05, we are 95% confident that body weight triggered the highest elevations in systolic blood pressure among all children but it took age to sustain it. This also partly explains the 14% hypertension prevalence rate in adolescents compared to only 2.4% in children. Therefore, the mosaic concept makes sense.

The study results did not show significant associations between blood serum cholesterol and mean systolic blood pressure. This seems to be in agreement with some recent findings. According to Kit et al (2012), [100] adolescent lipid levels have decreased over the past 2 decades. Some analyst attribute the decline to the successful public health

efforts to reduce fats and cholesterol intake. Generally in children, higher levels of lipoproteins are needed for brain development and therefore not surprising to see less associations between mean systolic blood pressure and blood serum total cholesterol.

5.1.1 Discussion of Specific Preliminary Questions

Question 1:

Do mean differences in blood pressure levels in children and adolescents fall within normal range of blood pressure level fluctuations?

The evidence suggest that it is possible to have normal blood pressure in overweight or obese children. Likewise, an individual within healthy weight limits can stand the risk of having an elevated blood pressure level. Previous studies have linked high blood pressure to family history and concluded that it is more common in men than women. Several others have linked risk of hypertension to nutritional intake. More intake of added salt, fats and sugar increases one's risk of developing hypertension later on in life. The analysis did not include intake of added salts, fats and sugar which might explain why mean differences in blood pressure levels among children and adolescents may not fall within normal range of daily blood pressure level fluctuations. Still on nutritional intake, insufficient intake of potassium, calcium, magnesium and lack of physical activity might explain for the variations in blood pressure levels other than age, body weight, standing height and body mass index.

Question 2:

What is the implication of the mean of repeated blood pressure readings determined and used for all paired calculations?

Use of the four blood pressure readings ensured a precise measure of constant elevations of blood pressure readings. Placing the average of repeated blood pressure levels at or over the 95th percentile helps in avoiding over-diagnosis of hypertension. [65] Due to the large number of missing values for diastolic blood pressure readings it was more appropriate to use systolic blood pressure values for the analysis and national prevalence estimation. The weighted percentages associated with systolic blood pressure counts were not lower than for the general population. This was because, NHANES data was obtained through a multi-sample probability design which ensured that certain sub-groups which were under-represented were oversampled to account for the sampling biases.

Question 3:

What does the current evidence suggest and are there any consistencies or inconsistencies with what is known already?

The current evidence is sufficient to suggest 3% hypertension prevalence among US children under age 12 years and 14% hypertension prevalence in US adolescents aged between 12 and 19 years. These results are consistent with previous estimates. [37] Adolescents are more likely to develop hypertension than children. Out of a total of 1,149 adolescents, 171 (14%) either had stage 1 or 2 hypertension compared to 2.4% in children. 80 (46%) of 171 hypertensive adolescents were either overweight or obese. Adolescent blacks are twice more likely to develop hypertension than other adolescents. Trends exhibited in the results also suggest that body weight, age and sex are strong predictors of hypertension in US children and adolescents. The evidence of weaker

associations between household income and hypertension in children might suggest better health programs for all children in the US.

Question 4:

What are the highest and the least risk factor predictors of elevated blood levels in US children and adolescents?

The analysis results show that the highest risk factor contributing to high blood pressure in the US children and adolescents was body weight which had a t-value of 7.75 and a significant value of ($p<.0001$). (See Table 41 on pages 146-147). Total blood serum cholesterol and ratio of poverty to family income were the least predictors of hypertension in US children and adolescents both with t-values of less than 1.56 and significant values of more than .05.

5.2 Study Limitations

NAHANES data have been used to estimate prevalence and disease risk factors in several studies. Some studies have used NHANES data to estimate disease incidence and to develop population reference distribution of health parameters including growth and development. Others have used them to monitor secular changes in disease risk factors and their contribution to the understanding of disease etiology. Yet, the NHANES has several limitations. First, let's start with issues around the precautions on use and interpretation of study results. For the purpose of generating a sample for determining national estimates, the NHANES recommends the use a 2 year weighted factor. The central focus of secondary research has been to understand the factors for measuring indicators for which primary data were collected. This sometimes become challenging especially when there are not enough information given in the code book. It is important to understand the relationships between datasets and their nested variables, their structure, strategy for data collection, and shift in the paradigm of events. NHANES survey has a multi-stage cross sectional probabilistic sampling design and therefore assumes that model parameters across the population are stable throughout the survey.

The second limitation is BMI measurement as a measure of body fat. Although BMI is easy to calculate, and there is a lot of data that correlate with BMI numbers, BMI cannot differentiate between fat and muscle, and many individuals who are very fit and have very low body fat have high BMI numbers.

The next limitation is that, many of the design constructs used in the multi-stage probabilistic sampling do not address the issue of parameter varying overtime. Limitations can be corrected only during the next survey period. Whereas the 2007-2008

NHANES started addressing issues such as over/under representation of certain sub-populations, little attention has been given to the issue of parameter variability across age groups. For example, out of the 9, 756 total NHANES respondents for the 2011-2012 survey period, 4, 196 were 19 years or younger, for which more than 45% variable data were missing for diastolic blood pressure readings. The predominant reliance on population-based cross sectional analysis design for NHANES data also results to variability in significant methodological issues. During secondary analysis, failure to identify and account for variability issues can lead to biased parameter estimates and therefore inaccurate inferences. Alternate methods must be explored to possibly overcome most of these limitations and test for the variations in model parameters.

As mentioned previously, frequencies are underestimates due to item non-responses and unknowns. Although non responses were coded as missing values, these were excluded from the tables. The recommended weighted factors for the survey sample and examination were applied to the analytical models in this analysis. However, their application did not yield significant accuracies to the generated estimates. This problem impacted the percent concordance and disconcordance in the fit models. Regardless of the fact that certain variables were identified to have been associated with smaller sample sizes, the numbers were still not enough to run them against exact transformations such as poison regression which could have minimize inaccuracies in differential values. Therefore, interpretation of estimates provided by this study must be made only after a careful consideration of the methods used to make the estimations.

.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

6.1 Summary

The purpose of this dissertation was to estimate current national hypertension prevalence in children and adolescents in the United States using the most recent data from a nationally representative population-based survey to inform decisions around strategizing approaches to improve population health. Specific objectives were to: Identify and apply validated high blood pressure definitions, measurements and evaluation techniques and apply them to descriptive and comparative analysis; determine the distribution of elevated blood pressure in US children and adolescents for 2011 - 2012; and estimate the likelihood of BP occurrence in US children and adolescents based on their demographic characteristics.

To accomplish the study purpose, we employed the use of hypertension interrelated concepts to guide this research by determining which hypertension definitions were applicable; what the variables were; how variables were to be measured; and what type of statistical relationships must exist between the variables. We defined hypertension in children as the sustained elevation of either the systolic or diastolic blood pressure at or above the 95th percentile of blood pressure for a child's age, gender, and height percentile. [48] Per the normative values compiled from the 4th Report, three levels of hypertension were considered appropriate for our analysis. These were:

- Pre-hypertension: Systolic or diastolic BP is between the 90th percentile and the 95th percentile, or between 120/ 80 mmHg and the 95th percentile, if 120/80 mmHg

happens to be higher than the reported 90th percentile for the individual child based on his or her age, gender, and height percentile.

- Stage I HTN: Systolic or diastolic BP between the 95th percentile and the 99th percentile þ 5 mmHg.
- Stage II HTN: Systolic or diastolic BP above the 99th percentile þ 5 mmHg.

Then, we formulated a presumptive statement that, being an overweight or obese child or adolescent increases the risk of developing hypertension. The presumption was tested using, logistic regression models for categorical variables and the general linear model for continuous variables. We started with descriptive statistics to visualize normality and distribution of the 2011-2012 analytical data. This aid the determination of best fitted models to test the hypothesis. The descriptive data analysis also helped in the identification of extreme values which were to be excluded from the statistical analyses in order not to bias the measures of central tendencies. Next, the recommended NHANES sample weight factor along with the examination weight were multiplied to the selected sample (population aged 2-19 years). We then categorized age, body mass index, and blood serum total cholesterol as categorical variables to facilitate creation of 2X 2 tables and statistical analysis. Only then were, weighted frequencies of the distribution generated. Frequencies of nominal variables were expressed as counts and in their percentiles. Continuous variables were expressed by their means and standard deviations. Two analytic models were set to estimate variances. These were logistic regression for categorical variables and linear regression for continuous variables (Analysis of covariance). We also determined the highest risk factor for hypertension in the selected age group.

In summary, the 2011-2012 National Health and Nutrition Examination Survey reference data was used to evaluate blood pressure levels and body mass index in US children and adolescents. Higher hypertension prevalence were associated with being overweight or obese. The present analysis provides the most current estimates of hypertension prevalence in US children and adolescents. Among 4, 196 records analyzed for 2011-2012, the prevalence rate for hypertension in children as defined in this report is 3% compared to 14% in adolescents. This is in closer agreement to previous estimates. [37] Mean systolic blood pressure levels in children as determined in the analysis were substantially lower than the mean systolic blood pressure levels in adolescents. Generally, mean systolic blood pressure increased with age. Out of a total of 1,149 adolescents, 171 (14%) either had stage 1 or 2 hypertension compared to 2.4% in children. 80 (46%) of 171 hypertensive adolescents were either overweight or obese. Adolescents are more likely to develop hypertension than children with probability value of ($p<.0001$). (See Figure 4 on page 47). Particularly, adolescent boys were significantly more likely than adolescent girls to develop sustained high blood pressure elevations. The analysis, tables, statistical methods, and estimates of sample variability presented in this report were derived by replications adapted to suit sampling design of the NHANES.

Key findings:

- The current national hypertension prevalence in the United States for the 2011-2012 analysis period were 3% in children aged (2<=11 years), and 14% in adolescents aged (12<=19 years).
- 4 of every 10 US adolescents with stage 1 or stage 2 hypertension is either overweight or obese.
- Hypertension is more prevalent in adolescent boys than in adolescent girls. The rates in boys were (4%) for stage 1 and (7%) for stage 2 but (2%) for stage 1 hypertension and (0.86%) stage 2 in girls.
- Mean weight and height were generally lower in adolescent girls than in boys yet adolescent girls had higher BMI than boys.
- The highest risk factor contributing to high blood pressure in US children and adolescents for the 2011-2012 analysis period was body weight which had a t-value of 7.75 and a significant value of (p<.0001). Body weight triggered the highest elevations in systolic blood pressure among all children but it took age to sustain it.
- Additional data will be required if accurate estimation of national hypertension prevalence in children and adolescents is to be made using diastolic blood pressure readings. Approximately 30% of missing data for diastolic blood pressure values were observed.

6.2 Conclusions

6.2.1 Public Health Implications

4 out of 10 (46%) of US adolescents who had either hypertension stage 1 or 2 were also either overweight or obese. In 2011-2012, body weight was the highest risk factor to trigger blood pressure elevations in both children adolescents but age was the most likely risk factor to sustain the elevations. The underlying assumption of our conceptual framework was that an overweight or obese child or adolescent stands a higher risk of developing hypertension than a non-overweight or obese child or adolescent. The strongest evidence which was submitted by a previous study has been confirmed by other studies. The findings in this report suggest that being overweight or obese might have increased risk of hypertension. Therefore, interventions that decrease obesity in children such as healthy eating and good exercise and those that decrease elevated blood pressure levels in children and adolescents such as early screening and routine blood pressure checks at every pediatric visit must be broad based and focused on children and adolescents at the risk of high blood pressure.

6.2.2 Sufficiency and Accuracy of NHANES Data

As part of the objectives for conducting this study, we sought to determine whether the NHANES reference data would be sufficient to sample only children to estimate national hypertension prevalence in the US. The analysis and results suggest that while selected data for the 2011-2012 period of analysis had less than 15 missing data for systolic blood pressure, missing data percentage for diastolic blood pressure was more than 30%. Therefore, additional data will be required if accurate estimation of national hypertension prevalence in children and adolescents is to be made using diastolic blood

pressure readings. In terms of data accuracy and structure, the analysis yielded findings to also suggest that adolescent boys are taller and heavier than adolescent girls. By applying the Centers for Disease Control and Prevention metrics for calculating BMI, an individual's BMI is calculated by dividing body weight (kg) by standing height (cm) and squaring the yield. BMI is therefore measured in kilograms per meters square (kg/m**2). Per this approach, it would require further investigation to explain why mean of body mass index was higher in adolescent girls (31.85 kg/m**2) than in adolescent boys ((27.10 (kg/m**2) although adolescent boys were generally taller and heavier than their counterparts.

6.3 Recommendations

A growing body of evidence have been used to support hypertension intervention programs in children. The current results confirm hypertension risk in children with associated prevalence of obesity notably among children and adolescents. Although the variables and statistical measures differ, failure to embark on comprehensive hypertension intervention programs can have critical consequences on population health. Since the evidence suggest that obesity correlates with hypertension in children and adolescents, behavior targets [97] for obesity prevention must be embraced.

The NHANES is population-based and uses a multi-stage probabilistic sampling design. Therefore, it is recommended that a 2 year weighted factor be applied to selected samples before running statistical analysis on them. The weighted factor if applied will account for sampling biases, allow comparisons between samples and the population and infer study outcomes. When it comes to selecting the most appropriate statistical methods for analyzing public health data, the recommended 2 year sample, pseudo-stratum and

examination weights are not enough to account for variability in regression models. For instance, the most used models for variance analysis for NHANES reference data are the multiple logistic regression and analysis of variance (ANOVA). These regression models assume that variability is constant across the populations. ANOVA for example assumes that sample sizes are equal for all variables. The second assumption is that time is the constant factor between two different analysis periods. The odds estimates generated from multiple logistic regression models are used to determine likelihood of a phenomenon occurring in a time period other than the current period of analysis and thereby assuming that time will continue to remain constant (predicted odds assumption). In reality, time is not constant and variability is also not constant across populations. For instance, people of different races or gender may not respond to the same exposure under the same conditions. To explain further, segments of the same subpopulation (same racial and ethnic backgrounds) will show variability in an observed response. In this dissertation, our specific example is the recommended age range definition for "children" and "adolescents". It is a statistical misnomer to assume that one weighted factor will account for all variability in children and adolescents. Therefore, it makes sense recommend the development of group-specific weighted factors for measuring variability across subpopulations.

6.4 Future Studies

The current results confirm hypertension risk in children with associated prevalence of obesity notably among children and adolescents. A comprehensive hypertension intervention programs can positively improve population health. Future studies should focus on assessing the impact of intervention programs.

6.0 REFERENCES

1. Din-Dzietham R, Liu Y, Bielo MV, Shamsa F. High blood pressure trends in children and adolescents in national surveys, 1963 to 2002. Circulation 2007;1488-1496.
2. Bromfield S, Muntner P, High blood pressure: the leading global burden of disease risk factors and the need for worldwide prevention programs. Current Hypertension Reports 2013;15(3):134-136.
3. Ezzati M, Lopez AD, Rodgers A, Vander HS, Murray CJ. Selected major risk factors and global and regional burden of diseases. Lancet 2002;1347–1360.
4. Kearney_PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. Lancet 2005;15-21:365(9455):217-23.
5. Go AS, Mozaffarian D, Roger VL, Benjamin EJ, Berry JD, Borden WB. Heart disease and stroke statistics—2013 update: a report from the American Heart Association. Circulation 2013;127:e6–e245.
6. Portman RJ, Sorof JM, Injelfinger JR. Pediatric Hypertension. In Pediatric Hypaertension. Vol. 111 , Totowa NJ: Humanna Press, 2004;492.
7. Duncan GE, Li SM, Zhou XH. Prevalence and trends of a metabolic syndrome phenotype among U.S. adolescents, 1999–2000. Diabetes Care 2004;27(10):2438–2443.
8. Boyd GS, Koenigsberg J, Falkner B, Gidding S, Hassink S. Effect of obesity and high blood pressure on plasma lipid levels in children and adolescents. Pediatrics 2005;116(2):442–446.

9. Lawes CM, Vander HS, Law MR, Elliott P, MacMahon S, Rodgers A. Blood pressure and the global burden of disease 2000. Part 1: estimates of blood pressure levels. J Hypertens 2006;24:413–422.
10. Feber J, Ahmed M. Hypertension in children: new trends and challenges. Clin Sci (Lond) 2010;119:151-61.
11. Thompson M, Dana T, Bougatsos C, Blazina I, Norris SL. Screening for hypertension in children and adolescents to prevent cardiovascular disease. Pediatrics 2013;131:490-525.
12. McNiece KL, Poffenbarger TS, Turner JL, Franco KD, Sorof JM, Portman RJ. Prevalence of hypertension and pre-hypertension among adolescents. J Pediatr 2007;150:640-4.
13. Sorof JM, Poffenbarger T, Franco K, Bernard L, Portman RJ. Isolated systolic hypertension, obesity, and hyperkinetic hemodynamic states in children. J Pediatr 2002;140:660–666.
14. Sorof JM, Lai D, Turner J, Poffenbarger T, Portman RJ. Overweight, ethnicity, and the prevalence of hypertension in school-aged children. Pediatrics 2004;113:475–482
15. Tomson J, Lip GY. Blood pressure demographics: nature or nurture genes or environment? BMC Med 2005;3: 3.
16. Yusuf S, Reddy S, Ounpuu S, Anand S. Global burden of cardiovascular diseases. Part I: general considerations, the epidemiologic transition, risk factors, and impact of urbanisation. Circulation 2001;104: 2746–2753.

17. Hansen ML, Gunn PW, Kaelber DC. Underdiagnoses of hypertension in children and adolescents. JAMA 2007;298:874-9.
18. Brady TM, Fivush B, Flynn JT, Parekh R. Ability of blood pressure to predict left ventricular hypertrophy in children with primary hypertension. J Pediatr 2008;152: 73-8.
19. Thompson M, Dana T, Bougatsos C, Blazina I, Norris SL. Screening for hypertension in children and adolescents to prevent cardiovascular disease. Pediatrics 2013;131:490-525.
20. Moyer VA. Screening for primary hypertension in children and adolescents: U.S. Preventive Services Task Force recommendation statement. Pediatrics 2013;132: 907-14.
21. Flynn JT, Urbina EM. Pediatric ambulatory blood pressure monitoring: indications and interpretations. J Clin Hypertens (Greenwich) 2012;14:372-82.
22. Hammerness PG, Perrin JM, Shelley-Abrahamson R, Wilens TE. Cardiovascular risk of stimulant treatment in pediatric attention-deficit/hyperactivity disorder: update and clinical recommendations. J Am Acad Child Adolesc Psychiatry 2011;50: 978-90.
23. McNiece KL, Poffenbarger TS, Turner JL, Franco KD, Sorof JM, Portman RJ. Prevalence of hypertension and pre-hypertension among adolescents. J Pediatr 2007;150:640-4.
24. Lewington S, Clarke R, Qizilbash N, Peto R, Collins R; Prospective Studies Collaboration, Age-specifi c relevance of usual blood pressure to vascular

mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet 2002;360: 1903–13.

25. Frattola A, Parati G, Cuspidi C, Albini F, Mancia G. Prognostic value of 24-h blood pressure variability. J Hypertens 1993;11: 1133–1137.
26. Sander D, Kukla C, Klingelhofer J, Winbeck K, Conrad B. Relationship between circadian blood pressure patterns and progression of early carotid atherosclerosis: a 3-year follow-up study. Circulation 2000;102:1536–1541.
27. Barker DJP, Osmond C, Golding J et al. Growth in utero, blood pressure in childhood and adult life, and mortality from cardiovascular disease. Br Med J 1989;298:564-567.
28. 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. Lancet 2012;380: 2224-60.
29. The World Health Organization. A global brief on hypertension: World Health Day 2013. Geneva, Switzerland. WHO 2013 (Accessed at: http://apps.who.int/iris/bitstream/10665/79059/1/WHO_DCO_WHD_2013.2_eng.pdf.)
30. World Health Report, Mental Health: New Understanding, New Hope. Geneva, Switzerland. WHO 2001;144–9. (Accessed 2015) at http://www.who.int/whr/2001/en/whr01_en.pdf)
31. Bloom D, Cafiero ET, Jané-Llopis E. et al. The Global Economic Burden of Non-communicable Diseases. Geneva, Switzerland: World Economic Forum. 2011.

(Accessed at: http://www3.weforum.org/docs/WEF_Harvard_HE_GlobalEconomicBurdenNonCommunicableDiseases_2011.pdf).

32. Suhrcke M, Nugent R, Stuckler D, Rocco L. An Economic Perspective. Chronic Disease*:* The Oxford Health Alliance. 2006. (Accessed at http://archive.oxha.org/initiatives/economics/knowledge/publications/oxha-chronic-disease-an-economic-perspective.pdf)
33. Gaziano T, Bitton A, Anand S, Weinsten M. The global cost of non-optimal blood pressure. International Society of Hypertension. Journal of Hypertension 2009;27(7):1472-7.
34. Gaziano T, Bitton A, Anand S, Abrahams-Gessel S, Murphy A. Growing Epidemic of Coronary Heart Disease in Low- and Middle-Income Countries. Current problems in cardiology 2010;35(2):72-115.
35. Centers for Disease Control and Prevention (CDC), Vital signs: Prevalence, treatment, and control of hypertension—United States, 1999-2002 and 2005-2008. *MMWR*. 2011;60(4):103-8.
36. 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):e2–220.
37. Johnson WD, Kroon JM, Greenway FL, Bouchard C, Ryan D, Katzmarzyk PT. Prevalence of risk factors for metabolic syndrome in adolescents: National Health and Nutrition Examination Survey (NHANES), 2001–2006. Arch Pediatr Adolesc Med. 2009;163(4):371–377.

38. Lu X, Shi P, Lou C.et al. Prevalence of hypertension in overweight and obese children from a large school-based population in Shanghai, China. BMC Public Health 2013;13:24.
39. Heidenreich PA, Trogdon JG, Khavjou OA et al. Forecasting the future of cardiovascular disease in the United States: a policy statement from the American Heart Association. Circulation 2011;123:933-44.
40. Crim MT, Yoon SS, Ortiz E et al. National surveillance definitions for hypertension prevalence and control among adults. Circulation: Cardiovascular Quality and Outcomes. 2012;5:343-351.
41. Gerin W, Marion RM, Friedman R, James GD, Bovbjerg DH, Pickering TG. How should we measure blood pressure in the doctor's office? Blood Press Monit. 2001;6:257-262.
42. Giles TD, Berk BC, Black HR, et al. Expanding the definition and classification of hypertension. J Clin Hypertens (Greenwich). 2005;7:505–512.
43. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. JAMA. 2003;289:2560–2572.
44. Krakoff LR. New definitions of hypertension. Journal of Clinical Hypertension. 2006;8 (4):282-283.
45. Beckett NS, Peters R, Fletcher AE, et al: Treatment of hypertension in patients 80 years of age or older. *N Engl J Med* 2008;358(18):1887-1898.
46. Appel LJ, Wright JT Jr, Greene T, et al: Intensive blood-pressure control in hypertensive chronic kidney disease. N Engl J Med 2010;363(10):918-929.

47. The ACCORD Study Group: Effects of intensive blood-pressure control in type 2 diabetes mellitus. N Engl J Med 2010;362(17):1575-1585.
48. Julius S, Nesbitt SD, Egan BM, et al: Feasibility of treating prehypertension with an angiotensin-receptor blocker. N Engl J Med 2006;354(16):1685-1697.
49. National Heart, Lung, and Blood Institute, National Institutes of Health (NHLBINIH). Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents: Summary Report. Pediatrics. 2011;128(suppl 5): S213–S256.
50. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. Pediatrics 2004;114(2 Suppl 4th Report):555-76.
51. Whincup PH, Gilg JA, Donald AE et al. Arterial distensibility in adolescents: the influence of adiposity, the metabolic syndrome, and classic risk factors. Circulation 2005;112:1789-97.
52. Sandock BA, Whisnat JP. Hypertension and the brain: clinical aspects. In: Hypertension (eds.J.Genest, E. Koiw, O. Xuchell), pp. 716-729. New York: McGraw Hill 1977.
53. Day E, Stephens S, Rigden PA et al. Malignant hypertension secondary to renovascular disease during infancy—an unusual cause of failure to thrive. Nephrol.Dial. Transplant. 2011;26 (11): 3816-3819.
54. Sinha MD, Reid CJD. Systemic Hypertension. In: Anderson RH ed. Paediatric Cardiology. 3 edn. Amsterdam: Elsevier 2009; 1191.

55. Daniels SR, Loggie JM, McEnery PT et al. Clinical spectrum of intrinsic renovascular hypertension in children. Pediatrics 1987;80: 698–704.

56. Deal JE, Snell MF, Barratt TM et al. Renovascular disease in childhood. J Pediatr 1992;121: 378–384.

57. Ingelfinger JR. Renovascular disease in children. Kidney Int 1993; 43: 453–505

58. Krause I, Cleper R, Kovalski Y et al. Changes in behavior as an early symptom of renovascular hypertension in children. Pediatr Nephrol 2009;24: 2271–2274.

59. Ball AK, Clarke CE. Idiopathic intracranial hypertension. Lancet Neurol. 2006;(5):433-442.

60. Faz G, Butler IJ, Koenig MK. Incidence of papilledema and obesity in children diagnosed with idiopathic 'benign' intracranial hypertension: case series and review. J Child Neurol. 2010;(25):1389-1392.

61. Balcer LJ, Liu GT, Forman S, Pun K, Volpe NJ, Galetta MG. Idiopathic intracranial hypertension: relation of age and obesity in children. Neurology 1990 ;(52):870-872.

62. Brady TM. Hypertension. Pediatric in Review 2012;33:541. (Accessed at: http://pedsinreview.aappublications.org/content/33/12/541).

63. Lu X, Shi P, Lou C. Prevalence of hypertension in overweight and obese children from a large school-based population in Shanghai, China. BMC Public Health 2013;13:24.

64. Bibbins-Domingo K, Coxson P, Pletcher MJ et al. Adolecent overweight and future adolescent coronary heart disease. N Eng J Med. 2007;357: 2371-2379.

65. Prevalence of overweight among children and adolescents: United States, 2003-2004. Hyattsville, MD: National Center for Health Statistics.
66. Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999-2002. JAMA 2004;291:2847-50.
67. Ogden CL, Carroll MD, Curtin LR, McDowall MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. JAMA 2006;295: 1549-55.
68. Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and trends in overweight among US children and adolescents, 1999-2000. JAMA 2002;288:1728- 32.
69. Juonala M, Magnussen CG, Berenson GS et al. Childhood Adiposity, Adult Adiposity, and Cardiovascular Risk Factors. N Engl J Med 2011;365:1876-1885
70. Berenson GS, Srinivasan SR, Bao W, Newman WP III, Tracy RE, Wattigney WA. Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults: the Bogalusa Heart Study. N Engl J Med 1998;338:1650-6.
71. Freedman DS, Goodman A, Contreras OA et al. Secular trends in bmi and blood pressure among Children and Adolescents: The Bogalusa Heart Study. Pediatrics 2012;130:159 -166.
72. Davis PH, Dawson JD, Riley WA, Lauer RM. Carotid intimal-medial thickness is related to cardiovascular risk factors measured from childhood through middle age: the Muscatine Study. Circulation 2001;104:2815-9.

73. Magnussen CG, Raitakari OT, Thomson R, et al. Utility of currently recommended pediatric dyslipidemia classifications in predicting dyslipidemia in adulthood: evidence from the Childhood Determinants of Adult Health (CDAH) study, Cardiovascular Risk in Young Finns Study, and Bogalusa Heart Study. Circulation 2008;117:32-42.
74. Raitakari OT, Juonala M, K.h.nen M, et al. Cardiovascular risk factors in childhood and carotid artery intima-media thickness in adulthood: the Cardiovascular Risk in Young Finns Study. JAMA 2003;290:2277-83.
75. Khang YH, Lynch JW. Exploring determinants of secular decreases in childhood blood pressure and hypertension. Circulation 2011;124: 397–405.
76. Dong B, Wang HJ, Wang Z. et al. Trends in blood pressure and body mass index among Chinese children and adolescents from 2005 to 2010. Am J Hypertens. 2013;26 (8): 997-1004. doi: 10.1093/ajh/hpt050 First published online: April 18, 2013
77. Cook N, Gilman M, Rosner B, Taylor J, Hennekens C. Prediction of young adult blood pressure from childhood blood pressure, height and weight. J. Clin Epidemiol 1997;50(5):571-579.
78. Mahoney L, Clarke W, Burns T, Lauer R. Childhood predictors of high blood pressure. Am J. of Hypertension 1991;4(11):608S-610S.
79. Daniels S, Pratt C, Hayman L. Reduction of risk for cardiovascular diseases in children and adolescents. *Circulation* 2011;124(15):1673–1686.

80. Wen-Chieh Y, Lu-Lu Z, Chun-Yu C, Yung-Kang, W, Yu-Jun C, Han-Ping W. First-attack pediatric hypertensive crisis presenting to the pediatric emergency department. BMC Pediatr. 2012;12:200.
81. National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. National Heart, Lung, and Blood Institute, Bethesda, Maryland. Pediatrics. 2004;114:555–576.
82. Lurbe E, Cifkova R, Cruickshank JK, et al; European Society of Hypertension. Management of high blood pressure in children and adolescents: recommendations of the European Society of Hypertension. J Hypertens. 2009;27:1719–1742.
83. Chen X, Wang Y. Tracking of blood pressure from childhood to adulthood a systematic review and meta–regression analysis. Circulation 2008;117:3137–3180.
84. Bao W, Threefoot S, Srinivasan S, Berenson G, Essential hypertension predicted by tracking of elevated blood pressure from childhood to adulthood: The Bogalusa heart study. Am J. of Hypertension. 1995;8(7):657-665.
85. Update on the Task Force (1987) on High Blood Pressure in Children and Adolescents:a working group from the National High Blood Pressure Education Program. Pediatrics 1996;98:649-658.

86. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. Pediatrics 2004;114(2 Suppl 4th Report):555-76.
87. Stewart JN, McGillivray D, Sussman J, Foster B. The value of routine blood pressure measurement in children presenting to the emergency department with non-urgent problems Journal of Pediatrics.(2008);153(4):pp.478-483.
88. Friedman, A. Blood pressure screening in children: Do we have this right? The Journal of Pediatrics 2008;153(4):pp.452-453.
89. Lu, Q., Ma, C., Yin, F., Wang, R., Lou, D. Liu, X. Blood pressure-to-height ratio as a screening measure for identifying children with hypertension. European Journal of Pediatrics 2013;172(1):99-105.
90. Choy C, Chan W, Chen T, Shi C, Wu L, Liao C. Waist circumference and risk of elevated blood pressure in children: a cross-sectional study. Biomed Central 2011;1471-2458-11-613.
91. Centers for Disease Control and Prevention (CDC) Growth Charts; Washington, DC; National Center for Health Statistics; 2000.
92. Chobanian AV, Bakris GL, Black HR, et al. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure: the JNC 7 report. JAMA 2003;289:2560-72. [Erratum, JAMA 2003;290:197.].
93. American Academy of Pediatrics. National Cholesterol Education Program: report of the expert panel on blood cholesterol levels in children and adolescents. *Pediatrics.*1992;89(3 pt 2): 525–584.

94. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive summary of the third report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). *JAMA.* 2001;285(19):2486–2497.
95. Hickman TB, Briefel RR, Carroll MD, et al. Distributions and trends of serum lipid levels among United States children and adolescents ages 4–19 years: data from the Third National Health and Nutrition Examination Survey. *Prev Med.* 1998; 27(6):879–890
96. Ford ES, Mokdad AH, Ajani UA. Trends in risk factors for cardiovascular disease among children and adolescents in the United States. *Pediatrics.* 2004;114(6):1534–1544
97. Institute of Medicine. Bridging the Evidence Gap in Obesity Prevention: A Framework to Inform Decision Making. Washington, DC: National Academic Press; 2010.
98. Rubin DB. Multiple imputation after 18+ years. Journal of the American Statistical Association. (1993);473:489.
99. McCullagh P. Generalized linear models. North Holland. European Journal of Operations Research (1984);16:285-292.
100. Kit BK, Carroll MD, Lacher DA, et al. Trends in serum lipids among US youths aged 6 to 19 years, 1988–2010. JAMA. 2012;308:591–600.

APPENDIX:

Table 42

Blood Pressure Levels for Boys by Age and Height Percentile*

Age (Year)	BP Percentile ↓	Systolic BP (mmHg) ← Percentile of Height →							Diastolic BP (mmHg) ← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	50th	80	81	83	85	87	88	89	34	35	36	37	38	39	39
	90th	94	95	97	99	100	102	103	49	50	51	52	53	53	54
	95th	98	99	101	103	104	106	106	54	54	55	56	57	58	58
	99th	105	106	108	110	112	113	114	61	62	63	64	65	66	66
2	50th	84	85	87	88	90	92	92	39	40	41	42	43	44	44
	90th	97	99	100	102	104	105	106	54	55	56	57	58	58	59
	95th	101	102	104	106	108	109	110	59	59	60	61	62	63	63
	99th	109	110	111	113	115	117	117	66	67	68	69	70	71	71
3	50th	86	87	89	91	93	94	95	44	44	45	46	47	48	48
	90th	100	101	103	105	107	108	109	59	59	60	61	62	63	63
	95th	104	105	107	109	110	112	113	63	63	64	65	66	67	67
	99th	111	112	114	116	118	119	120	71	71	72	73	74	75	75
4	50th	88	89	91	93	95	96	97	47	48	49	50	51	51	52
	90th	102	103	105	107	109	110	111	62	63	64	65	66	66	67
	95th	106	107	109	111	112	114	115	66	67	68	69	70	71	71
	99th	113	114	116	118	120	121	122	74	75	76	77	78	78	79

5	50th	90	91	93	95	96	98	98	50	51	52	53	54	55	55
	90th	104	105	106	108	110	111	112	65	66	67	68	69	69	70
	95th	108	109	110	112	114	115	116	69	70	71	72	73	74	74
	99th	115	116	118	120	121	123	123	77	78	79	80	81	81	82
6	50th	91	92	94	96	98	99	100	53	53	54	55	56	57	57
	90th	105	106	108	110	111	113	113	68	68	69	70	71	72	72
	95th	109	110	112	114	115	117	117	72	72	73	74	75	76	76
	99th	116	117	119	121	123	124	125	80	80	81	82	83	84	84
7	50th	92	94	95	97	99	100	101	55	55	56	57	58	59	59
	90th	106	107	109	111	113	114	115	70	70	71	72	73	74	74
	95th	110	111	113	115	117	118	119	74	74	75	76	77	78	78
	99th	117	118	120	122	124	125	126	82	82	83	84	85	86	86
8	50th	94	95	97	99	100	102	102	56	57	58	59	60	60	61
	90th	107	109	110	112	114	115	116	71	72	72	73	74	75	76
	95th	111	112	114	116	118	119	120	75	76	77	78	79	79	80
	99th	119	120	122	123	125	127	127	83	84	85	86	87	87	88
9	50th	95	96	98	100	102	103	104	57	58	59	60	61	61	62
	90th	109	110	112	114	115	117	118	72	73	74	75	76	76	77
	95th	113	114	116	118	119	121	121	76	77	78	79	80	81	81
	99th	120	121	123	125	127	128	129	84	85	86	87	88	88	89

10	50th	97	98	100	102	103	105	106	58	59	60	61	61	62	63
	90th	111	112	114	115	117	119	119	73	73	74	75	76	77	78
	95th	115	116	117	119	121	122	123	77	78	79	80	81	81	82
	99th	122	123	125	127	128	130	130	85	86	86	88	88	89	90
11	50th	99	100	102	104	105	107	107	59	59	60	61	62	63	63
	90th	113	114	115	117	119	120	121	74	74	75	76	77	78	78
	95th	117	118	119	121	123	124	125	78	78	79	80	81	82	82
	99th	124	125	127	129	130	132	132	86	86	87	88	89	90	90
12	50th	101	102	104	106	108	109	110	59	60	61	62	63	63	64
	90th	115	116	118	120	121	123	123	74	75	75	76	77	78	79
	95th	119	120	122	123	125	127	127	78	79	80	81	82	82	83
	99th	126	127	129	131	133	134	135	86	87	88	89	90	90	91
13	50th	104	105	106	108	110	111	112	60	60	61	62	63	64	64
	90th	117	118	120	122	124	125	126	75	75	76	77	78	79	79
	95th	121	122	124	126	128	129	130	79	79	80	81	82	83	83
	99th	128	130	131	133	135	136	137	87	87	88	89	90	91	91
14	50th	106	107	109	111	113	114	115	60	61	62	63	64	65	65
	90th	120	121	123	125	126	128	128	75	76	77	78	79	79	80
	95th	124	125	127	128	130	132	132	80	80	81	82	83	84	84
	99th	131	132	134	136	138	139	140	87	88	89	90	91	92	92

15	50th	109	110	112	113	115	117	117	61	62	63	64	65	66	66
	90th	122	124	125	127	129	130	131	76	77	78	79	80	80	81
	95th	126	127	129	131	133	134	135	81	81	82	83	84	85	85
	99th	134	135	136	138	140	142	142	88	89	90	91	92	93	93
16	50th	111	112	114	116	118	119	120	63	63	64	65	66	67	67
	90th	125	126	128	130	131	133	134	78	78	79	80	81	82	82
	95th	129	130	132	134	135	137	137	82	83	83	84	85	86	87
	99th	136	137	139	141	143	144	145	90	90	91	92	93	94	94
17	50th	114	115	116	118	120	121	122	65	66	66	67	68	69	70
	90th	127	128	130	132	134	135	136	80	80	81	82	83	84	84
	95th	131	132	134	136	138	139	140	84	85	86	87	87	88	89
	99th	139	140	141	143	145	146	147	92	93	93	94	95	96	97

BP, blood pressure

* The 90th percentile is 1.28 SD, 95th percentile is 1.645 SD, and the 99th percentile is 2.326 SD over the mean. For research purposes, the standard deviations in appendix table B–1 allow one to compute BP Z-scores and percentiles for boys with height percentiles given in table 3 (i.e., the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles). These height percentiles must be converted to height Z-scores given by (5% = -1.645; 10% = -1.28; 25% = -0.68; 50% = 0; 75% = 0.68; 90% = 1.28; 95% = 1.645) and then computed according to the methodology in steps 2–4 described in appendix B. For children with height percentiles other than these, follow steps 1–4 as described in appendix B.

(Adapted from: The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents)

Table 43:

Blood Pressure Levels for Girls by Age and Height Percentile*

Age (Year)	BP Percentile ↓	Systolic BP (mmHg) ← Percentile of Height →							Diastolic BP (mmHg) ← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	50th	83	84	85	86	88	89	90	38	39	39	40	41	41	42
	90th	97	97	98	100	101	102	103	52	53	53	54	55	55	56
	95th	100	101	102	104	105	106	107	56	57	57	58	59	59	60
	99th	108	108	109	111	112	113	114	64	64	65	65	66	67	67
2	50th	85	85	87	88	89	91	91	43	44	44	45	46	46	47
	90th	98	99	100	101	103	104	105	57	58	58	59	60	61	61
	95th	102	103	104	105	107	108	109	61	62	62	63	64	65	65
	99th	109	110	111	112	114	115	116	69	69	70	70	71	72	72
3	50th	86	87	88	89	91	92	93	47	48	48	49	50	50	51
	90th	100	100	102	103	104	106	106	61	62	62	63	64	64	65
	95th	104	104	105	107	108	109	110	65	66	66	67	68	68	69
	99th	111	111	113	114	115	116	117	73	73	74	74	75	76	76
4	50th	88	88	90	91	92	94	94	50	50	51	52	52	53	54
	90th	101	102	103	104	106	107	108	64	64	65	66	67	67	68
	95th	105	106	107	108	110	111	112	68	68	69	70	71	71	72
	99th	112	113	114	115	117	118	119	76	76	76	77	78	79	79

5	50th	89	90	91	93	94	95	96	52	53	53	54	55	55	56
	90th	103	103	105	106	107	109	109	66	67	67	68	69	69	70
	95th	107	107	108	110	111	112	113	70	71	71	72	73	73	74
	99th	114	114	116	117	118	120	120	78	78	79	79	80	81	81
6	50th	91	92	93	94	96	97	98	54	54	55	56	56	57	58
	90th	104	105	106	108	109	110	111	68	68	69	70	70	71	72
	95th	108	109	110	111	113	114	115	72	72	73	74	74	75	76
	99th	115	116	117	119	120	121	122	80	80	80	81	82	83	83
7	50th	93	93	95	96	97	99	99	55	56	56	57	58	58	59
	90th	106	107	108	109	111	112	113	69	70	70	71	72	72	73
	95th	110	111	112	113	115	116	116	73	74	74	75	76	76	77
	99th	117	118	119	120	122	123	124	81	81	82	82	83	84	84
8	50th	95	95	96	98	99	100	101	57	57	57	58	59	60	60
	90th	108	109	110	111	113	114	114	71	71	71	72	73	74	74
	95th	112	112	114	115	116	118	118	75	75	75	76	77	78	78
	99th	119	120	121	122	123	125	125	82	82	83	83	84	85	86
9	50th	96	97	98	100	101	102	103	58	58	58	59	60	61	61
	90th	110	110	112	113	114	116	116	72	72	72	73	74	75	75
	95th	114	114	115	117	118	119	120	76	76	76	77	78	79	79
	99th	121	121	123	124	125	127	127	83	83	84	84	85	86	87

10	50th	98	99	100	102	103	104	105	59	59	59	60	61	62	62
	90th	112	112	114	115	116	118	118	73	73	73	74	75	76	76
	95th	116	116	117	119	120	121	122	77	77	77	78	79	80	80
	99th	123	123	125	126	127	129	129	84	84	85	86	86	87	88
11	50th	100	101	102	103	105	106	107	60	60	60	61	62	63	63
	90th	114	114	116	117	118	119	120	74	74	74	75	76	77	77
	95th	118	118	119	121	122	123	124	78	78	78	79	80	81	81
	99th	125	125	126	128	129	130	131	85	85	86	87	87	88	89
12	50th	102	103	104	105	107	108	109	61	61	61	62	63	64	64
	90th	116	116	117	119	120	121	122	75	75	75	76	77	78	78
	95th	119	120	121	123	124	125	126	79	79	79	80	81	82	82
	99th	127	127	128	130	131	132	133	86	86	87	88	88	89	90
13	50th	104	105	106	107	109	110	110	62	62	62	63	64	65	65
	90th	117	118	119	121	122	123	124	76	76	76	77	78	79	79
	95th	121	122	123	124	126	127	128	80	80	80	81	82	83	83
	99th	128	129	130	132	133	134	135	87	87	88	89	89	90	91
14	50th	106	106	107	109	110	111	112	63	63	63	64	65	66	66
	90th	119	120	121	122	124	125	125	77	77	77	78	79	80	80
	95th	123	123	125	126	127	129	129	81	81	81	82	83	84	84
	99th	130	131	132	133	135	136	136	88	88	89	90	90	91	92

15	50th	107	108	109	110	111	113	113	64	64	64	65	66	67	67
	90th	120	121	122	123	125	126	127	78	78	78	79	80	81	81
	95th	124	125	126	127	129	130	131	82	82	82	83	84	85	85
	99th	131	132	133	134	136	137	138	89	89	90	91	91	92	93
16	50th	108	108	110	111	112	114	114	64	64	65	66	66	67	68
	90th	121	122	123	124	126	127	128	78	78	79	80	81	81	82
	95th	125	126	127	128	130	131	132	82	82	83	84	85	85	86
	99th	132	133	134	135	137	138	139	90	90	90	91	92	93	93
17	50th	108	109	110	111	113	114	115	64	65	65	66	67	67	68
	90th	122	122	123	125	126	127	128	78	79	79	80	81	81	82
	95th	125	126	127	129	130	131	132	82	83	83	84	85	85	86
	99th	133	133	134	136	137	138	139	90	90	91	91	92	93	93

BP, blood pressure

* The 90th percentile is 1.28 SD, 95th percentile is 1.645 SD, and the 99th percentile is 2.326 SD over the mean. For research purposes, the standard deviations in appendix table B–1 allow one to compute BP Z-scores and percentiles for girls with height percentiles given in table 4 (i.e., the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles). These height percentiles must be converted to height Z-scores given by (5% = -1.645; 10% = -1.28; 25% = -0.68; 50% = 0; 75% = 0.68; 90% = 1.28; 95% = 1.645) and then computed according to the methodology in steps 2–4 described in appendix B. For children with height percentiles other than these, follow steps 1–4 as described in appendix B.

(Adapted from: The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents)