Summer 2018

# Hypertension Prevalence Trends Among Mexican-Americans: NHANES 1999-2016

Sandra S. Valencia
*Central Washington University*, valencisan@cwu.edu

# HYPERTENSION PREVALENCE TRENDS AMONG MEXICAN AMERICANS: NHANES 1999-2016

---

A Thesis

Presented to

The Graduate Faculty

Central Washington University

---

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Nutrition

---

by

Sandra S. Valencia

July 2018

CENTRAL WASHINGTON UNIVERSITY

Graduate Studies

We hereby approve the thesis of

Sandra S. Valencia

Candidate for the degree of Master of Science

APPROVED FOR THE GRADUATE FACULTY

______________ ______________________________
Dr. David Gee, Committee Chair

______________ ______________________________
Dr. Nicole Stendell-Hollis

______________ ______________________________
Dr. Dominic Klyve

______________ ______________________________
Dean of Graduate Studies

# ABSTRACT

## HYPERTENSION PREVALENCE TRENDS AMONG MEXICAN AMERICANS: NHANES 1999-2016

by

Sandra S. Valencia

July 2018

Hypertension is a grave health issue affecting millions of adults in the United States (US). Uncontrolled hypertension can lead to cardiovascular disease, including stroke, heart attack, and heart failure. Current National Health and Nutrition Examination Survey (NHANES) 2015-2016 data reports that 29% of US adults above the age of 18 have hypertension. The objective of this project was to determine current and past hypertension prevalence trends among Mexican Americans (MAs) and non-Hispanic whites (NH-Whites) using NHANES data from 1999 to 2016, as well as the current American Heart Association (AHA) and American College of Cardiology (ACC) blood pressure guidelines of 2017. This project included 28,000 NHANES adult participants above the age of 20. Results showed the age-adjusted hypertension prevalence trend increased significantly among MAs, but not for NH-Whites despite increase in hypertension risk factors over time in both ethnic groups.

TABLE OF CONTENTS

LIST OF TABLES

## LIST OF FIGURES

# CHAPTER I

# INTRODUCTION

Hypertension (HTN) is a serious health issue affecting millions of adults in the United States (US). Within the past 10 years there has been a steady rise in the number of HTN related deaths. Uncontrolled HTN can lead to cardiovascular disease (CVD), including stroke, heart attack, and heart failure.[1] Until 2017, HTN was defined by the American Heart Association (AHA) and the American College of Cardiologists (ACC) as a systolic blood pressure (SBP) of ≥140mmHg or a diastolic blood pressure (DBP) of ≥ 90mmHg.[2] However, the AHA/ACC recently redefined HTN as a SBP of ≥130mmHg or a DBP ≥80mmHg. The critical thresholds for diagnosing HTN were lowered because the risk of heart disease was found to double at a SBP of ≥130mmHg, compared to a SBP <120mmHg, with the lowest risk of heart disease at a SBP of <120mmHg and a DBP of <80mmHg.[3] Research analyzing the most recent National Health and Nutrition Examination Survey (NHANES) data from 2015-2016 showed that 29% of US adults over the age of 18 have HTN and this number increased with age.[4] A number of risk factors have been associated with HTN. Research supports that obesity and particularly abdominal obesity increases the risk of diabetes, dyslipidemia, and CVD.[5,6] Both increasing age and male gender are also risk factors for HTN.[7]

Mexican Americans (MAs) are the largest subpopulation of the Hispanic population, making up about 36 million (63.3%) of the US population.[8] The most common health risk disparities among MAs include the increasing prevalence of obesity and obesity-related diseases, such as HTN, CVD, and type II diabetes.[9,10] Obesity among

MAs has been on the rise and increased from 37% to 46% between 2003 and 2014.[11,12] According to the US Department of Health and Human Services' Office of Minority Health (OMH), 77% of Mexican American (MA) females were overweight or obese compared to 64% of NH-White females using data from NHANES 2011-2014.[13] When adjusted for age, the OMH reported that MA females had a higher prevalence of HTN (29.3%) than NH-White females (27.5%). Compared to NH-White males (29.6%), MA males had a lower prevalence of HTN (27.3%), using NHANES 2009-2012.[14] As of 2016, HTN prevalence is higher in Mexico; 31.5% of Mexicans within the ages of 20 and 69 (34.2% males with HTN and 26.3% females) have HTN. These percentages were determined using the cut off measurements for blood pressure as the 2003 Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (2003 JNC7).[15]

Acculturation is the process in which people adopt behaviors and practices from the culture in which they live. The resulting behavioral changes may affect their health. Research has shown that being highly acculturated to the American culture increases weight by worsening food choices and reducing physical activity; leading to an increase weight and therefore an increased risk for obesity-related diseases, including HTN.[16,17] There is limited research on acculturation in the MA population and HTN prevalence. A study done in 1993 found that there was no linear result of acculturation on HTN after controlling for age, education, marital status, employment, smoking, alcohol consumption, and body mass index. However, Markides et al. found that middle-aged MA males with higher acculturation status had higher HTN rates than those lower on the acculturation scale, though these differences were not significant.[18] Due to the rapid increase in the MA population, rising health disparities within this group, and the population becoming more acculturated to the American lifestyle, the purpose of this study was to observe the HTN prevalence trends and HTN risk factors including acculturation between MAs and NH-Whites using the continuous NHANES data from 1999-2016 and using the current 2017 AHA/ACC HTN guidelines.

# CHAPTER II

# LITERATURE REVIEW

## Hypertension

### *Blood Pressure*

Blood pressure is the force of blood pushing against the walls of our blood vessels, mainly our arteries. When this pressure is consistently too high, it is referred to as high blood pressure or HTN. High blood pressure increases risk of heart attack, stroke, kidney failure, and other health threats. Blood pressure has many contributing factors that increase the risk of developing HTN, including stress, drinking alcohol, smoking, being overweight or obese, high cholesterol, and family history, among others. Prevalence of HTN is high, affecting about 80 million American adults in the US.[19]

According to NHANES data from 2011-2014, 29% of adults above 20 years old have HTN and the prevalence increases with age,[20] this percentage was based off the previous blood pressure guideline established in the JNC7 of 2003, where HTN was classified as a SBP reading greater than 140 mmHg over a DBP reading greater than 90 mmHg.[21] Results of a recent study completed by the SPRINT Research Group suggest that the target SBP should be less than 130 mmHg and target DBP less than 80mmHg, as this blood pressure measurement was shown to lower the rates of fatal and nonfatal major cardiovascular events.[3] The American Heart Association has now adapted these recommendations and defines a normal SBP over DBP measurements to be below 120 / 80 mmHg, an elevated blood pressure between 120-129/<80 mmHg, HTN stage 1 at 130-139/80-89 mmHg, and HTN stage 2 at $\geq$140/90 mmHg.[22] When left untreated, HTN increases the risk of heart attack, stroke, and other health threats.[19,23] Research shows HTN is a more common risk factor of CVD than obesity, smoking, and diabetes mellitus.[9]

## Contributing Factors of Hypertension

### *Obesity*

A significant increasing trend in obesity has been observed since 1999 through 2016 in both youth and adults. The percentage of US residing adults with obesity in data collected by NHANES from 2015-2016 was 39.8%. The prevalence of obesity was highest among those within 40-59 years of age. The highest prevalence of obesity was observed in Hispanics and non-Hispanic blacks. Adult obesity increases the risk for many health conditions such as HTN, high cholesterol, CVD, stroke, diabetes, arthritis, and some cancers, also called obesity-related diseases.[24] Hales et al. completed a trends analysis using NHANES data observing obesity trends in US youth and adults from 2007-2008 to the most current NHANES data set of 2015-2016. They found that obesity prevalence increased significantly for adults over the age of 40, but did not change in either the 20-39 age group or in US youth (ages 8-19).[25]

Obesity starting at a young age, anywhere before 10 years old, can results in additional obesity-related diseases and could decrease life expectancy in the US. Obesity is an important risk factor in the development of HTN. Research states that about two thirds of HTN prevalence is due to obesity. Precise mechanisms as to how obesity causes HTN are not well known, but possible causes include factors from the adipose tissue such as inflammation, activation of the renin–angiotensin–aldosterone system, increasing insulin and leptin resistance, or increasing sympathetic nervous system activity.[26]

Body mass index (BMI) is a common method for measuring obesity in clinical health settings. BMI is currently used to predict weight status; it is calculated using weight in kilograms divided by height in meters squared. Categories for BMI, as set by the Centers for Disease Control and Prevention, include underweight ($<18.5$ kg/m$^2$), normal weight (18.5-24.9 kg/m$^2$), overweight (25.0-29.9 kg/m$^2$), and obese ($> 30.0$ kg/m$^2$).[27] BMI may be a suitable indicator for weight status because it is positively correlated with increased risk for metabolic diseases. However, BMI does not give any information about body fat distribution, which may be more strongly foretelling of chronic disease risk.[28,29]

### *Abdominal Obesity*

The National Heart, Lung, and Blood Institute define abdominal obesity as a large waistline; where there is an excess of fat around the stomach area. Having body fat around the stomach poses greater risk for CVD than fat in other body locations.[30] Abdominal obesity, also known as central obesity, is highly associated with CVD, cardiovascular death, and type II diabetes. Abdominal obesity is a strong marker of disease risk because it measures visceral fat located around abdominal organs, such as the liver. A larger waist equals higher risk for health problems.[31] Abdominal obesity, also known as central obesity, has been linked with increased HTN and CVD risk.[26] Abdominal obesity can be determined by waist circumference and waist-to-height ratio.

*Waist Circumference*

Waist circumference (WC) is measured with a measuring tape just above the hipbones.[27] A WC higher than 40 inches (101 cm) for men and 35 inches (88 cm) for women indicates increased risk for obesity-related diseases. WC starts losing its predictive power when used on clients with a BMI >35kg/m$^2$.[29] A larger WC is associated with increased risk for obesity-related diseases, such as CVD and type II diabetes.

A study completed by Zhu et al. combined BMI and WC to show its strong association with CVD risk factors (including HTN) in non-Hispanic whites (NH-Whites) from the Third National Health and Examination Survey (NHANES III) data. Zhu et al. found that WC is more highly correlated with blood pressure than BMI in both NH-White men and women, and women especially had a greater likelihood of CVD risk with increased WC. Researchers concluded that the addition of the WC measurement to BMI helps identify those with increased CVD risk better than BMI alone.[28] Janssen et al. compared WC and BMI from participants in the NHANES III data showing that WC determines obesity-related health risk better than BMI. Researchers had three BMI groups (normal, overweight, and obese BMI) and two WC groups (high and low WC) and assessed obesity-related health risk by observing blood pressure, cholesterol (HDL and LDL) concentrations, triacylglycerol concentration, and metabolic syndrome. Janssen et al. concluded that the addition of BMI to WC measurement does not predict an increase in obesity-related health risk.[32]

Dobbelsteyn et al. completed a comparative evaluation of WC, waist-to-hip ratio (WHR), and BMI as indicators of CVD risk factors. Subjects were Caucasian, gathered from the Canadian Heart Health Surveys. Dobbelsteyn et al. found that WC is the better indicator of CVD risk in the Caucasian population than WHR and BMI. There are many advantages for using WC, especially in a clinical setting. WC does not require much equipment: only a tape measure. The WC measurement is simple to understand because it only requires the reading of one measurement instead of two, like those need to calculate a ratio.[33]

Niskanen et al. completed a prospective study following 379 healthy men participants from the Kuopio Ischemic Heart Disease Risk Factor Study in Eastern Finland for 11 years. The subjects were between the ages of 40 to 60 years old. The researchers goal was to identify how many men developed HTN over time and to assess known cofactors of HTN such as abdominal obesity, smoking, and inflammation, using C-reactive protein (CRP) as a marker. Abdominal obesity has been shown to cause inflammation; therefore it is important to evaluate abdominal obesity as a predictor of HTN. Niskanen et al. showed that 124 (33%) men developed HTN and men with heavier weights and larger WC were twice as likely to develop HTN. Also, men with a higher CRP levels and greater amount of cigarettes smoked were more likely to develop HTN. These researchers used previous cut off definitions for HTN: a SBP over a DBP of 140/90 mmHg. These finding show that abdominal obesity can greatly increase risk of HTN in men. This study only looked at men due to other research indicating that HTN is more common in men than in women.[34]

*Waist-to-Height Ratio*

Waist-to-height ratio (WHtR) seems to be highly correlated with diabetes, dyslipidemia, and HTN and is better than BMI for screening these conditions.[35] WHtR takes WC and divides it by height, both in inches. The preferred value is <0.5 and indicates a decreased risk of metabolic disease.[35,36] WHtR accounts for the effect of larger and smaller heights on WC.[36] Research suggests that WHtR is a better anthropometric measurement than WC when assessing for CVD risk, which includes HTN.[6,35] A study conducted by Ashwell et al. examined WHtR and BMI and compared which measurement had the highest years of life lost (YLL). YLL was determined through a ten-year follow-up using the Health and Lifestyle Survey. Ashwell et al. found that males have more YLL than females when looking at both WHtR and BMI.[36] They also found that YLL increases with an obese category BMI and with a WHtR greater than 0.6. Ashwell et al. concluded that "keep[ing] your waist circumference to less than half of your height" is ideal to decrease mortality.[36]

WHtR is the anthropometric measure that is most highly predictive of HTN. [5,6-37] A systematic review and meta-analysis completed by Ashwell et al. compared BMI, WC, and WHtR to screen for CVD, HTN, and type II diabetes. Researchers found that WHtR had higher statistical significance than WC in screening for HTN in both men and women.[6] Another study found similar results. Sayeed et al. gathered a total of 4923 subjects and collected height, weight, blood pressure, waist and hip measurements, fasting blood glucose, total cholesterol, triglycerides, and HDL-C. These researchers found that BMI, WHR and WHtR were significantly correlated with DBP and SBP, but the level of significance was highest for WHtR for both men and women.[5] Both Ashwell et al. and Sayeed et al. conclude that WHtR should be considered an important screening tool for obesity and predicting HTN.[5,6]

Another study showed that abdominal adiposity measurements are better than BMI for predicting risk of chronic diseases. Fuchs et al. used comparative analysis between anthropometric measurements of obesity and incidence of HTN, they found that both WC and WHtR were better at predicting risk of HTN than BMI.[37] All these studies used the previous 2003 JNC7 blood pressure guidelines.

### *Gender and Age*

Statistics have shown that males are more likely to develop HTN. Data also shows that HTN also increases with advancing age. Ervin completed a National Health Statistic report on metabolic syndrome, which includes abdominal obesity and blood pressure. Ervin's subjects were participants of NHANES data from 2003-2006 including adults over the age of 20. Subjects were stratified by sex, age, race/ethnicity, and BMI. Ervin found that overall males had a higher age-adjusted prevalence of HTN than females, but females had higher age-adjusted prevalence of abdominal obesity based on WC. For both males and females HTN prevalence increased by each succeeding age group, the older the age the higher the prevalence of HTN. In addition, they found that as age and BMI increases, so does the risk for obesity-related diseases.[7]

## Health Status Disparities Among Mexican Americans

The Mexican American (MA) population is the largest sub-population of Hispanics living in the US, consisting of 36 million people (63.3%) of the US population, as of 2015.[8] In 2003-2004, 36.8% of Mexican Americans (MAs) were classified as obese[11] while in 2011-2014 about 46.4% of MAs were obese.[12] Research shows that when compared to NH-Whites, MAs have a higher likelihood of developing obesity-related diseases, such as CVD and type II diabetes, partly due to physical inactivity and unfavorable body fat accumulation in the abdomen. Sundquist and Winkleby stated that CVD is the leading cause of death among MAs. Some contributing factors for the greater incidence of CVD and myocardial infarctions among MAs include higher prevalence of lipid abnormalities, especially higher levels of low-density lipoprotein cholesterol (LDL-C), lower levels of high-density lipoprotein cholesterol (HDL-C), and higher levels of uncontrolled high blood pressure than NH-Whites.[10] Ford et al. explored the prevalence of metabolic syndrome using NHANES III data from 1988-1994 and found that MAs have highest prevalence of abdominal obesity, hypertriglyceridemia, and low HDL-C concentrations when compared to NH-Whites.[38] Ervin also found similar results; MA females, along with NH-Black females, had the highest prevalence of abdominal obesity and a high prevalence of low HDL-C concentrations.[7]

Berber et al. investigated the projection of type II diabetes, dyslipidemia, and HTN in employees of a general hospital in Mexico City where the overall population was Mexican. This study surveyed 2426 men (aged 38.99 ±7.11) and 5939 women (aged 39.11 ±14.25) from 1994-2004. Berber's et al. study shows that when compared to MAs from the NHANES III data the Mexican population had a higher prevalence of being in the overweight category and a lower prevalence of being in the obese category. These findings suggest that despite similar genetics and originating from the same geographic location/country, there is a difference in overweight and obesity prevalence between the two study populations due to their current living environment. These researchers also found that the following cut off values for WC may be better for predicting the obesity-related diseases: 90 cm for males, and 85 cm for females. It may not be appropriate to generalize these findings to the MA population or other Hispanic populations, as the subjects were from Mexico City, but it does suggest that lowering the cut off values for WC may be beneficial in identifying and reversing abdominal obesity.[39]

Howell et al. investigated associations between mortality, BMI at time of survey, and maximum lifetime BMI using self-reported maximum lifetime weight. Researchers studied a total of 6,242 adult MAs from the NHANES III and continuous NHANES 1999-2010 and found that those who remained stable in the overweight or obese category did not have significant increased odds of mortality. Mortality data was accessed through the National Death Index from the Centers for Disease Control and Prevention and matched with the continuous NHANES data to predict for all-cause mortality. Investigators concluded that MAs who reported a maximum lifetime BMI in the obese category had a minimal increase in risk of death than those who maintained a normal weight over time.[40] This study shows that BMI is not a strong predictor of all-cause mortality, as those considered to be in the obese category only had a slight increase risk of death than those who remained at normal weights.

## Mexican Americans and Hypertension

Berber et al. found that in the Mexican Population from Mexico, as the prevalence of HTN increased (using 2003 JNC7 blood pressure guideline), the WC, BMI, and WHtR ratio increased as well. Suggesting that being from Mexico or originating from Mexico combined with an increase in weight can increase risk of HTN. This may be due to lifestyle changes, including the environment in which they migrated to.[39] According to the US Department of Health and Human Services Office of Minority Health, from 2009-2012, 27.3% of MA men had HTN, which was lower when compared to NH-Whites at 29.6%. Concurrently, MA women had a higher prevalence of HTN (29.3%) than NH-White women (27.5%).[13]

Hardy et al. looked at age- and sex-specific transitions between blood pressure categories within African Americans (AA), NH-Whites, and MAs using NHANES data from 2007-2008 to 2011-2012. This study used the JNC7 2003 blood pressure guidelines to assess the transition of blood pressure categories. Previous guidelines were defined as SBP/DBP: normal = <120/80mmHg, prehypertension = 120-139/80-89mmHg, and HTN = ≥140/90mmHg; participants aged 8-19 years, blood pressure was classified as normal blood pressure at <90th percentile by age and sex, prehypertension as 90th-95th percentiles or SBP/DBP ≥ 120/80 mmHg, and HTN as >95th percentile. Researchers found that MA young women (8-30 years old) had the lowest increase in HTN prevalence from normal to prehypertension category. After age 40, the change stabilized for men but increased rapidly for women. After age 60, MA women had the largest increase from normal to prehypertension category when compared to NH-Whites and AAs from the same age group. The net increase probability over the life course of ages 8 to 80 from prehypertension to HTN category increased the most for NH-White women and MA women. MA men had the highest net increase from prehypertension to HTN when compared to NH-White and AA men.[41] These findings suggest that the upward change between blood pressure categories impacts MAs the most. It is of interest to examine the trends with NHANES most currently released data and using the 2017 AHA/ACC blood pressure guidelines.

## Acculturation Status

### *Language Spoken*

Acculturation, including language preference and place of birth, may increase risk for developing obesity.[10,42,43] Assessing language spoken among MAs can help measure acculturation status and determine if language has an effect on the prevalence of HTN, using 2017 AHA/ACC guidelines. Research conducted by Sundquist et al. shows that Spanish-speaking MAs who were born in the US have higher BMIs than Spanish speaking MAs born in Mexico. English speaking MAs born in the US had lower CVD risk than Spanish speaking US- born MAs.[10] Findings suggest that the spoken language may increase risk for chronic disease; in this case speaking Spanish and not English increases disease risk. Crespo et al. used data gathered from NHANES III and examined acculturation status and physical activity in MAs. They found that MAs who spoke mostly Spanish had a higher prevalence of physical inactivity compared to those who only spoke English or both languages equally. It was also found that physical inactivity can increase weight and obesity-related disease risk.[42]

*Country of Birth*

Place of birth can have an impact on health. Findings support that there is a relationship between the health of MAs and their level of connection to their Mexican culture.[10,43] Akresh's study indicated that MAs born in the US have a higher chance of becoming overweight and obese than those born in Mexico.[44] Sundquist et al. showed similar results: MAs born in Mexico have healthier cardiovascular systems than those born in US. Researchers concluded this was due to the positive social and cultural influences from their country of birth, including practices such as sitting together at mealtimes, as well as eating a diet rich in fruits and vegetables and low in fat, and low smoking rates.[10] Another study completed by Sundquist and Winkleby found that Mexican-born women and men had the smallest WC when compared to US-born English-speaking and US-born Spanish-speaking MAs. Mexican-born women and men had a WC of 90.4cm, 94.0 cm respectively while US-born English-speaking women and men had intermediate WC (93.6 cm, 97.3 cm respectively), and US-born Spanish-speaking women and men had the largest WC (96.9 cm, 97.7 cm).[17] Findings suggest that being born in the US is associated with excess weight around the waist. In MAs this is possibly due to a higher degree of acculturation, because this trend toward abdominal obesity is seen among all ethnic groups living in the US.

*Number of Years Residing in the US*

Studies have shown that when people migrate to another country, their BMI tends to increase, possibly due to change in diet, exercise, and stress.[17] Hill et al. state that the longer MAs reside in the US the higher likelihood of developing abdominal obesity.[43]

Barcenas et al. investigated birthplace and years of residence in self-identified MA adults from Harris County, Texas. Barcenas et al. found that spending more years residing in the US increases chances of obesity for both US-born MAs and Mexico-born MAs. Authors used an acculturation score based on the Bi-dimensional Acculturation Scale for Hispanics, which has different acculturation based measures. Barcenas et al. used a language-based measure of the scale, as they thought this was the most appropriate for assessing acculturation because it shows how integrated MAs are to the US culture. Four questions were used to determine proficiency in the English language: what language did they use to speak, watch television, listen to the radio, and to read. Points were averaged to get the acculturation score from 1 to 4, a score greater than 2.5 indicated preference of the English language and therefore more acculturated to the US culture. Researchers found that for men with low acculturation scores, their risk of obesity increases 2% for every year residing in the US. For men with high acculturation score, their risk increases 4% each additional year. For women with low acculturation scores, their risk of obesity increases 1% for every year and a high acculturation score increases their risk by 3% each additional year.[45] These findings support the theory that the longer MAs reside in the US, the more acculturated they become and increase risk of developing obesity, along with its complications.

### *Acculturation Score*

An acculturation score can be determined by taking into consideration a combination of the language spoken, place of birth, and years living in the US. O'Brien et al. used an acculturation score and completed the breakdown as follows: if only or mostly

Spanish was spoken at home 0 points were given and 1 point was assigned to those who spoke only or mostly English or both languages equally, if place of birth was outside the US 0 points were assigned, born in the US resulted in 1 point, if MA had lived in the US for less than 20 years 0 points were given, living in the US for more than 20 years resulted in 1 point. The acculturation score ranges from lowest (0 points) to highest (3 points) acculturation, the higher the score the higher the acculturation status.[16] Not many studies have been conducted looking at acculturation scores among MAs. A study completed by O'Brien et al. looked at the prevalence of diabetes and acculturation status by using this acculturation score and found that the more acculturated MAs were the more likely they were to develop diabetes.[16]

## National Health and Nutrition Examination Survey

The National Health and Nutrition Examination Survey (NHANES) is designed to assess the health of individuals from different ethnicities living in the US. NHANES is continuously gathering data through home interviews and physical exams completed in their Mobile Examination Centers (MEC).[46,47] Home interviews included questions related to demographics, socioeconomics, occupation, health insurance, medical history, food consumption, and health-related questions, such as tobacco consumption. [47] Physical exams in the MEC include blood pressure testing, height and weight measurements, oral health screening with a dentist, and laboratory testing on blood and urine.[47] NHANES represents the entire US nation and samples about 5,000 people each year. Fifteen different counties are visited each year to allocate such a large sample size.[48] Participants within the following subgroups Hispanics, non-Hispanic Asians, non-Hispanic blacks, and NH-Whites above the age of 80 years old are oversampled to increase the reliability and precision of estimates of health status indicators.[49] To account for oversampling, each participant is given a sample weight, which is representative of the US civilian non-institutionalized Census population.[50] The institutionalized Census population includes those not living in houses such as nursing homes, hospitals, military/army, jails, or correctional centers,[51] NHANES does not represent this population.

## REFERENCES (INTRODUCTION AND LITERATURE REVIEW)


1. American Heart Association News. More than 100 million Americans have high blood pressure, AHA says. News on Heart.org. https://news.heart.org/more-than-100-million-americans-have-high-blood-pressure-aha-says/. Published January 31, 2018. Accessed May 13, 2018.

2. Chobanian AV, Bakris GL, Black HR, et al. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertens Dallas Tex 1979*. 2003;42(6):1206-1252. doi:10.1161/01.HYP.0000107251.49515.c2

3. The SPRINT Research Group. A randomized trial of intensive versus standard blood-pressure control. *N Engl J Med*. 2015;373(22):2103-2116. doi:10.1056/NEJMoa1511939

4. Fryar CD, Ostchega Y, Hales CM, Zhang G, Kruszon-Moran D. *Products - Data Briefs - Number 289 - October 2017*.; 2017. https://www.cdc.gov/nchs/products/databriefs/db289.htm. Accessed May 13, 2018.

5. Sayeed MA, Mahtab H, Latif ZA, et al. Waist-to-height ratio is a better obesity index than body mass index and waist-to-hip ratio for predicting diabetes, Hypertension and Lipidemia. *Bangladesh Med Res Counc Bull*. 2003;29(1):1-10.

6. Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: Systematic review and meta-analysis. *Obes Rev Off J Int Assoc Study Obes*. 2012;13(3):275-286. doi:10.1111/j.1467-789X.2011.00952.x

7. Ervin B. Prevalence of metabolic syndrome among adults 20 years of age and over, by sex, age, race and ethnicity, and body mass index: United States, 2003–2006. *US Dep Health Hum Serv*. 2009;13:8.

8. Flores A. How the U.S. Hispanic population is changing. *Pew Res Cent*. September 2017. http://www.pewresearch.org/fact-tank/2017/09/18/how-the-u-s-hispanic-population-is-changing/. Accessed July 9, 2018.

9. Guzman NJ. Epidemiology and management of hypertension in the Hispanic population. *Am J Cardiovasc Drugs*. 2012;12(3):165-178. doi:10.2165/11631520-000000000-00000

10. Sundquist J, Winkleby MA. Cardiovascular risk factors in Mexican American adults: a transcultural analysis of NHANES III, 1988-1994. *Am J Public Health*. 1999;89(5):723-730.

11. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM.

Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA*. 2006;295(13):1549-1555. doi:10.1001/jama.295.13.1549

12. National Center for Health Statistics. Health, United States, 2016 - Individual Charts and Tables: Spreadsheet, PDF, and PowerPoint files. https://www.cdc.gov/nchs/hus/contents2016.htm. Published July 20, 2017. Accessed December 15, 2017.

13. Heart Disease - The Office of Minority Health. https://minorityhealth.hhs.gov/omh/browse.aspx?lvl=4&lvlid=64. Accessed April 18, 2018.

14. National Center for Health Statistics. Health, United States, 2014 (5/2015). :473.

15. Hipertensión arterial en México. *Fed Mex Diabetes*. May 2016. http://fmdiabetes.org/hipertension-arterial-mexico/. Accessed July 9, 2018.

16. O'Brien MJ, Alos VA, Davey A, Bueno A, Whitaker RC. Acculturation and the prevalence of diabetes in US Latino Adults, National Health and Nutrition Examination Survey 2007–2010. *Prev Chronic Dis*. 2014;11. doi:10.5888/pcd11.140142

17. Sundquist J, Winkleby M. Country of birth, acculturation status and abdominal obesity in a national sample of Mexican-American women and men. *Int J Epidemiol*. 2000;29(3):470-477.

18. Markides KS, Lee DJ, Ray LA. Acculturation and hypertension in Mexican Americans. *Ethn Dis*. 1993;3(1):70-74.

19. What is High Blood Pressure? http://www.heart.org/HEARTORG/Conditions/HighBloodPressure/AboutHighBloodPressure/What-is-High-Blood-Pressure_UCM_301759_Article.jsp#.WmJb4JM-fow. Accessed January 19, 2018.

20. Yoon SSS, Carroll MD, Fryar CD. Hypertension prevalence and control among adults: United States, 2011-2014. *NCHS Data Brief*. 2015;(220):1-8.

21. 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(19):2560-2572. doi:10.1001/jama.289.19.2560

22. American Heart Association. Understanding blood pressure readings. http://www.heart.org/HEARTORG/Conditions/HighBloodPressure/KnowYourNumbers/Understanding-Blood-Pressure-

Readings_UCM_301764_Article.jsp#.WjGzbVQ-fow. Accessed December 13, 2017.

23. Prevention JNC on, Pressure T of HB. *JNC 7 Express: The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure*. US Department of Health and Human Services; 2003.

24. About NCHS - NCHS Fact Sheets - National Health and Nutrition Examination Survey. https://www.cdc.gov/nchs/data/factsheets/factsheet_nhanes.htm. Published December 14, 2017. Accessed December 15, 2017.

25. Hales CM, Fryar CD, Carroll MD, Freedman DS, Ogden CL. Trends in obesity and severe obesity prevalence in US youth and adults by sex and age, 2007-2008 to 2015-2016. *JAMA*. 2018;319(16):1723-1725. doi:10.1001/jama.2018.3060

26. Narkiewicz K. Obesity and hypertension—the issue is more complex than we thought. *Nephrol Dial Transplant*. 2006;21(2):264-267. doi:10.1093/ndt/gfi290

27. Assessing Your Weight | Healthy Weight | CDC. https://www.cdc.gov/healthyweight/assessing/index.html. Accessed December 13, 2017.

28. Zhu S, Heshka S, Wang Z, et al. Combination of BMI and waist circumference for identifying cardiovascular risk factors in Whites. *Obes Res*. 2004;12(4):633-645. doi:10.1038/oby.2004.73

29. National Institutes of Health. Obesity Education Initiative. *Clin Guidel Identif Eval Treat Overweight Obes Adults*. 1998.

30. What Is Metabolic Syndrome? - NHLBI, NIH. https://www.nhlbi.nih.gov/health/health-topics/topics/ms. Accessed November 29, 2017.

31. Harvard T.H. Chan: School of Public Health. Waist size matters. Obesity Prevention Source. https://www.hsph.harvard.edu/obesity-prevention-source/obesity-definition/abdominal-obesity/. Published October 21, 2012. Accessed November 29, 2017.

32. Janssen I, Katzmarzyk PT, Ross R. Waist circumference and not body mass index explains obesity-related health risk. *Am J Clin Nutr*. 2004;79(3):379-384.

33. Dobbelsteyn CJ, Joffres MR, MacLean DR, Flowerdew G. A comparative evaluation of waist circumference, waist-to-hip ratio and body mass index as indicators of cardiovascular risk factors. The Canadian Heart Health Surveys. *Int J Obes Relat Metab Disord J Int Assoc Study Obes*. 2001;25(5):652-661. doi:10.1038/sj.ijo.0801582

34. Niskanen L, Laaksonen DE, Nyyssönen K, et al. Inflammation, abdominal obesity, and smoking as predictors of hypertension. *Hypertension*. 2004;44(6):859-865. doi:10.1161/01.HYP.0000146691.51307.84

35. Gwynn RC, Berger M, Garg RK, Waddell EN, Philburn R, Thorpe LE. Measures of adiposity and cardiovascular disease risk factors, New York City Health and Nutrition Examination Survey, 2004. *Prev Chronic Dis*. 2011;8(3):A56.

36. Ashwell M, Mayhew L, Richardson J, Rickayzen B. Waist-to-height ratio is more predictive of years of life lost than body mass index. *PLOS ONE*. 2014;9(9):e103483. doi:10.1371/journal.pone.0103483

37. Fuchs FD, Gus M, Moreira LB, et al. Anthropometric indices and the incidence of hypertension: A comparative analysis. *Obes Res*. 2005;13(9):1515-1517. doi:10.1038/oby.2005.184

38. Ford ES, Giles WH, Dietz WH. Prevalence of the metabolic syndrome among US adults: Findings from the Third National Health and Nutrition Examination Survey. *JAMA*. 2002;287(3):356-359. doi:10.1001/jama.287.3.356

39. Berber A, Gómez-Santos R, Fanghänel G, Sánchez-Reyes L. Anthropometric indexes in the prediction of type 2 diabetes mellitus, hypertension and dyslipidaemia in a Mexican population. *Int J Obes Relat Metab Disord J Int Assoc Study Obes*. 2001;25(12):1794-1799. doi:10.1038/sj.ijo.0801827

40. Howell CR, Fontaine K, Ejima K, Ness KK, Cherrington A, Mehta T. Maximum lifetime body mass index and mortality in Mexican American adults: the National Health and Nutrition Examination Survey III (1988-1994) and NHANES 1999-2010. *Prev Chronic Dis*. 2017;14:E67. doi:10.5888/pcd14.160588

41. Hardy ST, Holliday KM, Chakladar S, et al. Heterogeneity in blood pressure transitions over the life course: Age-specific emergence of racial/ethnic and sex disparities in the United States. *JAMA Cardiol*. 2017;2(6):653-661. doi:10.1001/jamacardio.2017.0652

42. Crespo CJ, Smit E, Carter-Pokras O, Andersen R. Acculturation and leisure-time physical inactivity in Mexican American adults: Results From NHANES III, 1988–1994. *Am J Public Health*. 2001;91(8):1254-1257. doi:10.2105/AJPH.91.8.1254

43. Hill SE, Bell C, Bowie JV, et al. Differences in obesity among men of diverse racial and ethnic background. *Am J Mens Health*. 2017;11(4):984-989. doi:10.1177/1557988315580348

44. Akresh IR. Overweight and obesity among foreign-born and U.S.-born Hispanics. *Biodemography Soc Biol*. 2008;54(2):183-199.

doi:10.1080/19485565.2008.9989141

45. Barcenas CH, Wilkinson AV, Strom SS, et al. Birthplace, years of residence in the United States, and obesity among Mexican-American adults. *Obesity*. 2007;15(4):1043-1052. doi:10.1038/oby.2007.537

46. Inside NCHS - January 2013 - NHANES MEC. https://www.cdc.gov/nchs/newsletter/2013_January/a2.htm. Accessed December 13, 2017.

47. NHANES - NHANES Participants - Eligible Participants. https://www.cdc.gov/nchs/nhanes/participant-eligibility.htm. Accessed December 13, 2017.

48. NHANES - About the National Health and Nutrition Examination Survey. https://www.cdc.gov/nchs/nhanes/about_nhanes.htm. Published September 15, 2017. Accessed November 29, 2017.

49. NHANES Web Tutorial Frequently Asked Questions (FAQs). https://www.cdc.gov/nchs/tutorials/nhanes/faqs.htm. Accessed December 13, 2017.

50. NHANES - Continuous NHANES Web Tutorial - Specifying Weighting Parameters. https://www.cdc.gov/nchs/tutorials/nhanes/SurveyDesign/Weighting/intro.htm. Accessed December 13, 2017.

51. Statistical Abstract of the United States: 2011. 2011:62.

# CHAPTER III

# JOURNAL ARTICLE

## Hypertension Prevalence Trends Among Mexican Americans: NHANES 1999-2016

### INTRODUCTION

Hypertension (HTN) is a serious health issue that affects about 103 million adults in the United States (US). From 2005 to 2015, there has been a 38% rise in the number of HTN related deaths.[1] Uncontrolled HTN can lead to cardiovascular disease (CVD), including stroke, heart attack, and heart failure. The American Heart Association (AHA) and the American College of Cardiologists (ACC) recently redefined HTN as a systolic blood pressure (SBP) of ≥130mmHg or a diastolic blood pressure (DBP) ≥80mmHg. Because the risk of heart disease was found to double at a SBP of ≥130mmHg, the definition for diagnosing HTN was lowered.[2] Research analyzing the most recent National Health and Nutrition Examination Survey (NHANES) data from 2015-2016 showed that 29% of US adults over the age of 18 have HTN using the 2003 Seventh Report of the Joint National Committee Report on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure guideline (2003 JNC7).[3] A number of risk factors have been associated with HTN. Research supports that obesity and particularly abdominal obesity increases the risk of HTN as well as diabetes, dyslipidemia, and CVD.[4,5] Increasing age and male gender are also risk factors.[6]

Mexican Americans (MAs) are the largest subpopulation of the Hispanic population, consisting of about 36 million people or 63.3% of the US population.[7] The most common health risk disparities among MAs include the higher prevalence of obesity and obesity-related diseases, such as HTN, CVD, and type II diabetes.[8,9] As recently as 2016, HTN prevalence was higher in Mexico; 31.5% of Mexicans within the ages of 20 and 69 had HTN (34.2% males and 26.3% females). These percentages were determined using the cut off measurements for blood pressure as the 2003 JNC7.[10] Acculturation is the process in which people adopt behaviors and practices from the culture in which they live. The resulting behavioral changes may affect their health. Research has shown that being highly acculturated to the American culture increases weight by worsening food choices and reducing physical activity; leading to an increase weight and therefore an increased risk for obesity-related diseases, including HTN.[11,12] Due to the rapid increase in the MA population, rising health disparities within this group, and the population becoming more acculturated to the American lifestyle, the purpose of this study was to observe the HTN prevalence trends and HTN risk factors including acculturation between MAs and NH-Whites using the continuous NHANES data from 1999-2016 and the current 2017 AHA/ACC HTN guidelines.

## METHODS

### Study Population

Data from the National Health and Nutrition Examination Survey (NHANES) was used for this study. The NHANES is conducted by the National Centers for Health Statistics and is designed to assess the health of individuals from different ethnicities living in the US. The NHANES is a cross-sectional health study continuously gathering data through home interviews and physical exams completed in their Mobile

Examination Centers.[13,14] This study utilized data from the continuous NHANES 1999-2016.

Subjects in this study included self-identified MAs and NH-Whites over the age of 20 years who participated in both home interviews and physical examinations from NHANES. Both male and female participants were included. Females who were pregnant or lactating were excluded from this study as well as those in the underweight body mass index (BMI) category (n=1033).

**Design and Procedures**

This study examined a total of nine NHANES data sets accounting for 18 years worth of data. Data was analyzed in 2-year increments to observe trends in the prevalence of HTN among MAs and NH-Whites. Associated risk factors of HTN were also compared between MAs and NH-Whites. Risk factors included age, sex, BMI, and abdominal obesity (assessed using waist-to-height ratio). Hypertension was defined at a SBP measurement of ≥ 130mmHg or a DBP measurement of ≥ 80 mmHg, [2,15] or participants that used anti-hypertensive medication.

Anthropometric measurements including height, weight, and waist circumference (WC) were taken following NHANES protocols.[16] From those measurements, BMI and waist-to-height ratio (WHtR) were calculated to evaluate weight status and abdominal obesity, respectively. As a measure of abdominal obesity, the WHtR has been shown in some studies to better predict risk of diabetes and CVD risk factors than WC alone.[4,5,17] This study determined the odds ratio or likelihood of HTN compared with a reference group for each HTN risk factor. Males were compared to females, age groups 40-59 years old and 60+ years old were compared to the youngest age group (20-39 years old), overweight and obese BMI categories were compared to normal BMI category, and those with abdominal obesity (WHtR > 0.5)[18] were compared to those without abdominal obesity between both ethnic groups.

The degree of acculturation was based on the subject's country of birth, number of years the subject had lived in the US, and language spoken.[11] Acculturation was only assessed among MAs, as the acculturation questions were generally not given to NH-Whites. Answers to these questions were assigned points as follows: if country of birth was within the US, one point was given, if born outside the US, zero points were given; if participants had lived in the US for greater than 20 years, one point was given, less than 20 years resulted in zero points; and participants who spoke only/mostly English or spoke both languages (English and Spanish) equally were given one point, and those who spoke only/mostly Spanish were given zero points. Addition of these points resulted in an acculturation score ranging from zero (lowest) to three (highest).[11] Acculturation score was analyzed to assess the likelihood of MAs developing HTN as acculturation status increased.

**Statistical Analysis**

Statistical Analysis Software (SAS System version 9.2, SAS Institute Inc., Cary, North Carolina, USA) was used to analyze data from NHANES. All data analyses including variance estimates used examination sample weights, stratification, and clustering to account for the NHANES complex sample design. Linear regression analyses were conducted on the prevalence of HTN and related risk factors over time to determine significant trends. Multivariate logistic regression analysis was used to examine likelihood of HTN and the associated risk factors of HTN: age, sex, BMI, and WHtR between MAs and NH-Whites. T-tests and chi-squared analyses were conducted to determine statistical significance for continuous and categorical variables, respectively. The significance level was set at <0.05. This study was deemed exempt from review by the Central Washington University Institutional Review Board.

## RESULTS

Descriptive statistics of the sampled population are shown in Table 1. A total of 28,462 non-pregnant and non-lactating adults with accurate blood pressure measurements were analyzed from the continuous NHANES 1999-2016 data. Included in this sample were 8,002 self-identified MAs and 20,460 NH-Whites. The MA population was younger and had a greater percentage of males in comparison to NH-Whites. The average SBP and DBP were higher among NH-Whites than MAs. The percentage of those taking HTN medication was greater among NH-Whites (23.1%) than MAs (11.8%). The average BMI for both ethnic groups were in the overweight category (25-29.9 kg/$m^2$) with the mean BMI was significantly greater in MAs (29.5kg/$m^2$) than NH-Whites (28.4kg/$m^2$). The average WHtR was significantly greater among MAs (0.60) than in NH-Whites (0.58).

**Table 1**. Weighted descriptive statistics of sampled population, NHANES 1999-2016

| | **Mexican Americans** | **Non-Hispanic Whites** | **P-value*** |
|---|---|---|---|
| N | 8,002 | 20,460 | |
| Percent Males | 54.3 | 49.2 | <0.0001 |
| Percent Females | 45.7 | 50.8 | |
| Age (years) | 40.3±0.34 | 49±0.22 | <0.0001 |
| Systolic Blood Pressure (mmHg) | 120.5±0.31 | 122.7±0.21 | <0.0001 |
| Diastolic Blood Pressure (mmHg) | 69.9±0.21 | 70.8±0.18 | 0.0005 |
| Percent on Hypertension Medication ^ | 11.8 | 23.1 | <0.0001 |
| Weight (kg) | 79.7±0.35 | 82.4±0.21 | <0.0001 |
| Height (cm) | 164.2±0.15 | 170±0.08 | <0.0001 |
| BMI (kg/m$^2$) | 29.5±0.13 | 28.4±0.08 | <0.0001 |
| Waist-to-Height Ratio | 0.60±0.0022 | 0.58±0.0012 | <0.0001 |

***** P-value determined by t-tests between Mexican Americans and Non-Hispanic Whites
^ Percent based off entire population within each ethnic group, not of those who are hypertensive

Overall, the actual prevalence of HTN from 1999-2016 was lower among MAs than in NH-Whites as shown in Figure 1. A linear regression analysis of the prevalence of HTN from 1999-2016 among NH-Whites (*P* = 0.81) and MAs (*P* = 0.09) showed no significant change. Conversely, from 2005 to 2016 the prevalence of HTN among MAs was significant (*P* = 0.005). Because the mean age of the MA population was much lower than in NH-Whites (40.3 vs. 49.0 years), the age-adjusted prevalence of HTN among MA was determined for each NHANES cycle years by using the NH-White NHANES sample population as the standard population. The age-specific prevalence of HTN in each 10-

year age group of the MA sample population was multiplied by the proportion of NH-White sample population in that age group resulting in the estimated age-adjusted prevalence of that MA age group. The age-adjusted HTN prevalence for MAs is shown in Figure 1 (dashed line) and was similar to the prevalence of HTN in NH-Whites. A linear regression analysis for the age-adjusted HTN prevalence showed that the HTN prevalence trend from 1999 to 2016 did not significantly increase ($P$ = 0.229). However, from 2005 to 2016 there was a significant increasing trend in the HTN prevalence for MAs ($P$ = 0.014) but no significant trend upwards for NH-Whites ($P$ = 0.84). In the most current NHANES cycle (2015-2016) the age-adjusted HTN prevalence was higher among MAs (51%) than in NH-Whites (48.6%). In addition, the age-adjusted HTN prevalence of male MAs (52.6%) was greater than in NH-White males (50.3%), MA females (49.7%) also had a higher age-adjusted HTN prevalence than NH-White females (47%).

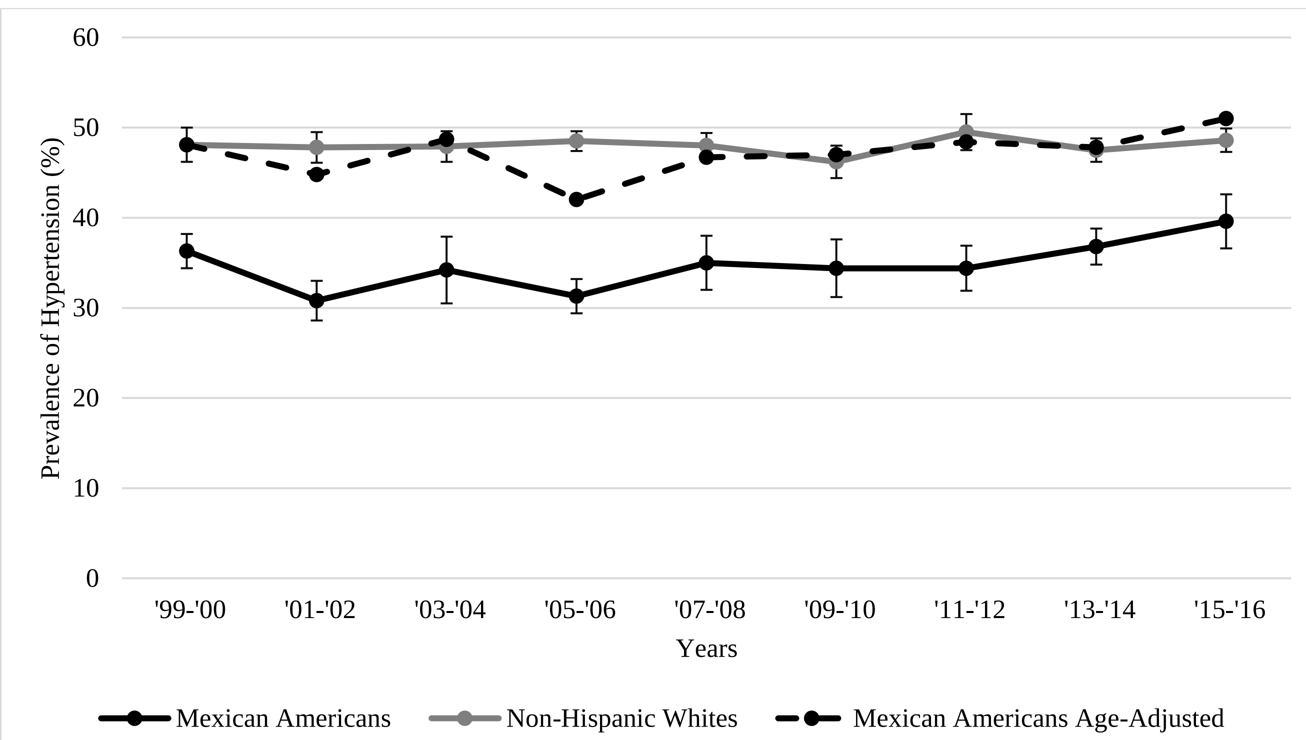


**Figure 1**. Prevalence of hypertension among adult Mexican Americans and Non-Hispanic Whites by years. Shows the prevalence of hypertension (± standard error bars) for non-Hispanic whites and Mexican Americans.

**Table 2.** Odds of hypertension prevalence among Mexican Americans and Non-Hispanic Whites, NHANES 1999-2016

| | **Mexican Americans** Odds Ratio (95% CI) | **Non-Hispanic Whites** Odds Ratio (95% CI) |
|---|---|---|
| **Gender** (ref = Females) | | |
| Male | 2 (1.8-2.3) | 1.4 (1.3- 1.5) |
| **Age Group** (ref = 20-39 years) | | |
| 40-59 years | 3.5 (2.9- 4.1) | 3.3 (3- 3.7) |
| 60+ years | 16.3 (13.7- 19.4) | 10.9 (9.8- 12.2) |
| **BMI** (ref= Normal (18.5-24.5 kg/m$^2$)) | | |
| Overweight (25-29.9 kg/m$^2$) | 1.6 (1.3- 2) | 1.4 (1.3- 1.5) |
| Obese (30+ kg/m$^2$) | 3.2 (2.6- 3.9) | 2.6 (2.4-2.9) |
| **Abdominal Obesity** (ref= Normal WHtR) | | |
| WHtR >0.5 | 1 (0.8- 1.3) | 1.4 (1.2- 1.5) |
| **Acculturation Score *** (ref= lowest (0)) | | |
| Low (1) | 1 (0.8- 1.2) | - |
| High (2) | 1.3 (1- 1.6) | - |
| Highest (3) | 1.5 (1.2- 1.7) | - |

***** Acculturation Score is the sum of the following questions ranging from lowest (0) to highest (3): country of birth (1 point if born in United States, 0 if born outside United States), years living in the United States (1 point if lived in United States >20 years, 0 points if lived <20 years in United States), and language spoken at home (1 point if only or mostly English or both Spanish and English equally were spoken at home, 0 points for Spanish).
**-** Acculturation score was not determined for NH-Whites due to limited answers to acculturation question

Using multivariate logistic regression analysis, Table 2 shows the odds or likelihood of having HTN stratified by risk factors associated with HTN. Overall, males were two times more likely than females to have HTN in MAs and 1.4 times more likely in NH-Whites. The likelihood of HTN substantially increased with increasing age. Those MAs in the > 60 year age group were over 16 times more likely to have HTN, while NH-Whites were about 11 times more likely to have HTN compared to younger adults. The likelihood of HTN was 3.2 and 2.6 times greater in obese compared to normal weight MAs and NH-Whites, respectively. NH-Whites who were abdominally obese had a 1.4 times higher risk of HTN than those without abdominal obesity. However, abdominal obesity was not associated with greater risk for HTN in MAs. A higher acculturation score resulted in a higher likelihood for MAs to have HTN with an odds ratio (OR) of 1.5 among the highest acculturation group compared to those in the lowest acculturation group.

Table 3 and 4 shows the prevalence of risk factors of HTN from 1999-2016. These tables were created to identify possible contributing causes for the increase in HTN prevalence in MAs. There was no significant change in the gender proportions in either MAs or NH-Whites. The prevalence within the young adult group was decreasing while the older adult age group was increasing in both ethnic groups. However, the prevalence within the middle-age adult group was increasing among MAs but not among NH-whites. The prevalence within the obese BMI category significantly increased over time for both ethnic groups, but the prevalence of obesity was higher among MAs (40%) than among NH-Whites (34%). The prevalence within the overweight BMI category did not significantly change for either MAs or NH-whites. For both MAs and NH-Whites, the prevalence of abdominal obesity increased over time, but the prevalence was higher in MAs. The percentages of those MAs in the lowest (0 score) acculturation score significantly decreased over time while those in the low (1), high (2), and highest (3) acculturation score increased, as shown in Table 3.

**Table 3**. Prevalence of risk factors of hypertension among Mexican Americans, NHANES 1999-2016

| | '99-'00 | '01-'02 | '03-'04 | '05-'06 | '07-'08 | '09-'10 | '11-'12 | '13-'14 | '15-'16 | Average | P-value* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** (% ± Std. Error) | | | | | | | | | | | |
| Males | 54±1.7 | 55.3±1.4 | 55.5±2 | 56.4±1.1 | 56±2.6 | 54.5±0.9 | 53.1±1.9 | 53.1±2 | 51.7±1.8 | 54.3±0.6 | 0.054 |
| Females | 46±1.7 | 44.7±1.4 | 44.5±2 | 43.6±1.1 | 44±2.6 | 45.5±0.9 | 46.9±1.9 | 46.9±2 | 48.3±1.8 | 45.7±0.6 | 0.054 |
| **Age** (% ± Std. Error) | | | | | | | | | | | |
| 20-39 years old | 57.7±3.1 | 62.8±2.3 | 58.8±4.5 | 56.2±2.6 | 55.8±2.9 | 50.5±2.6 | 55±2.4 | 50.1±3.2 | 48.4±3.1 | 54.4±1.1 | 0.002 |
| 40-59 years old | 31.8±2.3 | 27.8±1.3 | 30.8±2.3 | 32.5±2 | 32.6±1.8 | 35.6±1.3 | 35±2 | 35.9±2.5 | 35.8±1.6 | 33.4±0.7 | 0.003 |
| 60+ years old | 10.5±1.2 | 9.4±1.9 | 10.3±2.7 | 11.3±1.1 | 11.6±1.6 | 13.9±1.7 | 10±1.6 | 14±1.4 | 15.8±3.1 | 12.2±0.7 | 0.015 |
| **BMI** (% ± Std. Error) | | | | | | | | | | | |
| Normal (18-24.9 kg/m$^2$) | 28.7±2.4 | 31.8±2.4 | 25.8±3.2 | 26.1±1.9 | 22.3±2.3 | 20±1.7 | 20.6±2.9 | 17.4±1.4 | 16.8±1.7 | 22.5±0.8 | <0.001 |
| Overweight (25-29.9 kg/m$^2$) | 38.1±1.9 | 39.6±1.5 | 37.9±1.4 | 41.1±1.8 | 38.6±2.5 | 40.5±1.5 | 33.8±2.1 | 36.9±1.8 | 34.2±2 | 37.7±0.6 | 0.100 |
| Obese (30+ kg/m$^2$) | 33.2±2.6 | 28.7±2 | 36.3±2.6 | 32.7±1.2 | 39.1±3.9 | 39.5±1.9 | 45.6±2.4 | 45.6±2.4 | 49±1.7 | 39.8±0.7 | <0.001 |
| **Abdominal Obesity** (% ± Std. Error) | | | | | | | | | | | |
| Waist-to-Height Ratio >0.5 | 83.1±1.8 | 77.4±1.8 | 82.6±2.4 | 83.7±1.8 | 85±1.6 | 87.3±1.2 | 85.4±2.4 | 85.6±1.9 | 87.4±1.2 | 84.5±0.6 | 0.016 |
| **Acculturation Score (0-3)** | | | | | | | | | | | |
| Lowest (0) (%± Std. Error) | 34.5±3.3 | 44.5±4.2 | 36.5±6.4 | 41.4±4.3 | 35.6±4.5 | 31.6±4 | 34.5±3.6 | 25.3±4.7 | 25.6±3.4 | 33.7±1.6 | 0.016 |
| Low (1) (%± Std. Error) | 17.5±1.5 | 13.5±2 | 17±2 | 18±1.8 | 16.7±1.7 | 23.5±1.8 | 15.2±1.6 | 21.2±1.2 | 20.7±1.3 | 18.4±0.6 | 0.125 |
| High (2) (%± Std. Error) | 10.7±1.3 | 7.1±0.9 | 11.7±2 | 7.2±1.1 | 10.6±1.4 | 12.6±2.1 | 8.1±1.2 | 13.6±1.9 | 12.6±2.6 | 10.7±0.7 | 0.201 |

**Table 3**. Prevalence of risk factors of hypertension among Mexican Americans, NHANES 1999-2016 (Continued)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Acculturation Score (0-3)** | | | | | | | | | | | |
| Highest (3) (%± Std. Error) | 37.4±3.2 | 34.9±4.3 | 34.9±4.3 | 33.5±3 | 37.2±3 | 32.3±3 | 42.2±4.3 | 39.8±5.2 | 41.1±3.2 | 33.2±1.3 | 0.110 |

* P-value determined by linear regression analysis over the years

**Table 4.** Prevalence of risk factors of hypertension among Non-Hispanic Whites, NHANES 1999-2016

| | **'99-'00** | **'01-'02** | **'03-'04** | **'05-'06** | **'07-'08** | **'09-'10** | **'11-'12** | **'13-'14** | **'15-'16** | **Average** | **P-value*** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** (% ± Std. Error) | | | | | | | | | | | |
| Males | 49.5±1.1 | 49.9±0.6 | 48.8±1 | 49.7±0.7 | 48.4±0.7 | 49.1±0.6 | 49±1.2 | 49.1±0.9 | 49.2±0.9 | 49.2±0.3 | 0.317 |
| Females | 50.5±1.1 | 50.1±0.6 | 51.2±1 | 50.3±0.7 | 51.6±0.7 | 50.9±0.6 | 51±1.2 | 50.9±0.9 | 50.8±0.9 | 50.8±0.3 | 0.317 |
| **Age** (% ± Std. Error) | | | | | | | | | | | |
| 20-39 years old | 38.9±1 | 34.5±1.7 | 33.5±1.5 | 31.9±1.3 | 32.6±1.5 | 31.4±1.3 | 30.4±2.6 | 30.3±1.2 | 30.3±1.8 | 32.5±0.5 | 0.002 |
| 40-59 years old | 35.8±1 | 41.7±1.5 | 40.3±1.3 | 40.9±1.7 | 39.9±1.3 | 39.5±0.7 | 39.1±1.6 | 37.5±1.1 | 36.5±1.6 | 39.1±0.5 | 0.169 |
| 60+ years old | 25.3±1.4 | 23.8±1.2 | 26.2±1.2 | 27.2±2.3 | 27.5±1.2 | 29.1±1.2 | 30.5±1.4 | 32.2±1.3 | 33.1±2.1 | 28.4±0.5 | <0.001 |
| **BMI** (% ± Std. Error) | | | | | | | | | | | |
| Normal (18-24.9 kg/m$^2$) | 36.4±2.2 | 34.5±0.8 | 33.9±1.5 | 32.7±1.7 | 31.5±1.3 | 30.8±1.6 | 31.1±1.8 | 29±0.9 | 28±1.5 | 31.9±0.5 | <0.001 |
| Overweight (25-29.9 kg/m$^2$) | 34.4±1.3 | 35.1±1.3 | 34.7±1 | 33.6±1.2 | 35.3±1.1 | 33.8±1.5 | 35.5±1.6 | 33.6±1 | 33.4±0.4 | 34.4±0.4 | 0.316 |
| Obese (30+ kg/m$^2$) | 29.2±1.8 | 30.5±1.2 | 31.4±1.3 | 33.7±1.7 | 33.2±1.7 | 35.5±1.2 | 33.4±1.8 | 37.4±1.1 | 38.6±0.5 | 33.8±0.5 | <0.001 |
| **Abdominal Obesity** (% ± Std. Error) | | | | | | | | | | | |
| Waist-to-Height Ratio >0.5 | 70.7±1.6 | 70.5±0.9 | 74.7±1.2 | 73.7±1.5 | 73.7±1.2 | 75.6±2 | 77.1±1.8 | 78.3±1.2 | 79.8±1.3 | 75±0.5 | <0.001 |

* P-value determined by linear regression analysis over the years

## DISCUSSION

From 1999-2016, HTN prevalence has increased more rapidly among MAs than NH-Whites; with increased HTN, there was a simultaneous increase in HTN risk factors including age, weight, and abdominal obesity for both ethnic groups. Although HTN prevalence is higher among NH-Whites, the HTN prevalence did not significantly change from 1999-2016 despite the increase in all HTN risk factors. In contrast, the prevalence of HTN among MAs over this period of time tended to increase and significantly increased from 2005-2016. At the same time, all risk factors for HTN including age, BMI, and acculturation were increasing.

The age-adjusted HTN prevalence for MAs is slightly lower than NH-Whites from 1999-2007 and after 2008 that the prevalence seems to follow a similar pattern as NH-Whites (see Figure 1, dashed line). The increase of HTN prevalence was not significant despite increasing HTN risk factors for either ethnic group from 1999-2016. However, a significant upward age-adjusted HTN prevalence trend was observed among MAs from 2005-2016. The increased age-adjusted HTN prevalence trend among MAs can be explained by the increasing and higher prevalence of obesity (33% to 46% compared to 29% to 39% among NH-Whites), increasing and higher prevalence of abdominal obesity (84% to 87% compared to 74% to 80% among NH-Whites), decreasing prevalence of the younger (20-39 years old) age group (58% to 48% compared to 39% to 30% among NH-Whites), and a decline in MAs in the lowest acculturation level (41% to 26%) and an increase in the highest acculturation level (34% to 40%).

This study confirms earlier studies that obesity prevalence has been increasing among MAs in the US from 33% in 2003-2004 to 46% in 2011-2014.[19,20] The present study found that the prevalence of obesity among MAs increased from 33% in 1999-2000 to 49% in 2015-2016, 16 percentage point rise in obesity prevalence, while the prevalence of obesity among NH-Whites increased from 29% to 39%, a rise of 10 percentage points. These findings indicate that the prevalence of obesity is significantly rising at a greater rate among MAs than NH-Whites and this increase may be contributing to the greater increase in the total prevalence of HTN in this population.

The present study found that the odds for HTN compared to normal weight MAs was 1.6 times greater in overweight MAs and 3.2 times greater in obese MAs. These results are similar to those found in the study of Berber's et al., which found that as waist circumference, WHtR, and BMI increased among Mexicans from Mexico City, the prevalence of HTN also increased.[21] Conversely, the OR for the abdominal obesity measure of WHtR from the present study did not increase likelihood of HTN due to those being classified as abdominally obese were already accounted for in the overweight and obese BMIs, hence OR for increasing BMI proved to be significant in increasing likelihood of HTN. Both findings indicate the importance for MAs to maintain a healthy weight, as overweight and obese BMI increase the risk for obesity-related diseases, including HTN.

The present study and the OMH reported similar results. Both found that the age-adjusted prevalence of HTN was greater among MA females than NH-White females. However, for males, the OMH reported that MA had a lower age-adjusted HTN prevalence than NH-Whites[22] while the present study found MA to have a greater age-adjusted HTN prevalence than NH-Whites. The differences in results may be attributed to the different NHANES cycles used; OMH used data from 2009-2012 and used the 2003 JNC7 blood pressure guidelines. The present study found MAs have a lower percentage of people (11.8%) taking prescribed medication to lower blood pressure than NH-Whites (23.1%). This lower percentage among MAs could be due to, as the OMH reported in 2015, Hispanics and Latino Americans having the lowest health insurance rates compared to other US ethnic groups, with 19.5% of Hispanics not covered by health insurance, from this percentage, 21.5% of MAs were not covered.[23] Not having health insurance to help pay blood pressure medication can make it difficult for MAs to control their high blood pressure.

The results of the present study suggest that the odds of HTN prevalence substantially increased as age increases. These findings are consistent with what other researchers have found.[6,24] Hardy et al. found that older adult age groups (60+) exhibit the greatest increase from a prehypertensive state to HTN.[24] Similarly, Ervin found that HTN prevalence increases as age increases.[6] Other research has shown that MAs between the ages of 25 to 34 years are less likely to be aware of their HTN status compared to those aged 75 to 84 years[8] and with the new AHA/ACC blood pressure guideline in place, it is likely that younger populations will be at greater risk for HTN. The decline in the prevalence of young adult MAs is likely contributing to the increase in the prevalence of HTN among MAs. Overall, these findings emphasize that all age groups should monitor their blood pressure, especially MAs as they had a greater likelihood for HTN in all age groups than NH-Whites.

When compared to Mexicans from Mexico (HTN prevalence: 31.5%), MAs had a higher age-adjusted HTN prevalence (51%), using NHANES 2015-2016. Between males

(34.2%) and females (26.3%) from Mexico and MA males (52.6%) and females (49.7%) from present study (NHANES 2015-2016) the age-adjusted prevalence of HTN was higher among MAs. In both groups, males had a higher prevalence. Both findings coincide with previous research that males are at higher risk for HTN. HTN prevalence may be higher among MAs living in the US as they adapt behaviors of the American lifestyle.

The analysis of the effect of acculturation revealed that the more acculturated MAs were, the greater their likelihood of developing HTN. This may be due to their living environment changing over time and as MAs became more assimilated to the American culture and lifestyle. Research completed by Schulz and Chaudhari looked at the prevalence of type II diabetes among Arizona Pima Indians and Pima Indians from Mexico. They found that Arizona Pima Indians had a much greater prevalence of type II diabetes and obesity than Pima Indians from Mexico. This greater difference may be due to differences in lifestyle; Arizona Pima Indians were found to be less physically active and had a diet richer in fat, while Mexican Pima Indians were more physically active and had a lower-fat diet. Researchers concluded that Native Americans may have higher prevalence of diabetes and obesity due to their residing environmental conditions.[25] These findings support the notion that as MAs become more acculturated to an environment with decreased access to physical activity and a more typical American diet containing more fat and added sugar, they are at greater risk for chronic disease, as observed in Arizona Pima Indians.

### Strengths and Limitations

Strengths of this study include the large sample size and a large number of years to establish a trend. Another strength includes assessing current and past prevalence of HTN using the new AHA/ACC blood pressure guideline. As this study is an observational study, only associations can be established. Direct causation cannot be determined by this study.

## CONCLUSION AND APPLICATIONS

To our knowledge this study is the first to assess the current and past prevalence of HTN among MAs using the current AHA/ACC guidelines for assessing HTN. The current blood pressure guideline from the AHA/ACC not only increased the number of people now being diagnosed with HTN among MAs, but in NH-Whites as well. HTN is a particularly important risk factor for cardiovascular disease among MAs since their age-adjusted prevalence was greater than NH-Whites and that the prevalence of HTN and risk factors associated with HTN has been rising among MAs. It is important for clinicians to screen for HTN in MAs as well as assess modifiable risk factors of HTN, as controlling for these can prevent or treat HTN.

## REFERENCES

1. American Heart Association News. More than 100 million Americans have high blood pressure, AHA says. News on Heart.org. https://news.heart.org/more-than-100-million-americans-have-high-blood-pressure-aha-says/. Published January 31, 2018. Accessed May 13, 2018.

2. The SPRINT Research Group. A randomized trial of intensive versus standard blood-pressure control. *N Engl J Med*. 2015;373(22):2103-2116. doi:10.1056/NEJMoa1511939

3. Fryar CD, Ostchega Y, Hales CM, Zhang G, Kruszon-Moran D. *Products - Data Briefs - Number 289 - October 2017*.; 2017. https://www.cdc.gov/nchs/products/databriefs/db289.htm. Accessed May 13, 2018.

4. Sayeed MA, Mahtab H, Latif ZA, et al. Waist-to-height ratio is a better obesity index than body mass index and waist-to-hip ratio for predicting diabetes, Hypertension and Lipidemia. *Bangladesh Med Res Counc Bull*. 2003;29(1):1-10.

5. Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: Systematic review and meta-analysis. *Obes Rev Off J Int Assoc Study Obes*. 2012;13(3):275-286. doi:10.1111/j.1467-789X.2011.00952.x

6. Ervin B. Prevalence of metabolic syndrome among adults 20 years of age and over, by sex, age, race and ethnicity, and body mass index: United States, 2003–2006. *US Dep Health Hum Serv*. 2009;13:8.

7. Flores A. How the U.S. Hispanic population is changing. *Pew Res Cent*. September 2017. http://www.pewresearch.org/fact-tank/2017/09/18/how-the-u-s-hispanic-population-is-changing/. Accessed July 9, 2018.

8. Guzman NJ. Epidemiology and management of hypertension in the Hispanic population. *Am J Cardiovasc Drugs*. 2012;12(3):165-178. doi:10.2165/11631520-000000000-00000

9. Sundquist J, Winkleby MA. Cardiovascular risk factors in Mexican American adults: A transcultural analysis of NHANES III, 1988-1994. *Am J Public Health*. 1999;89(5):723-730.

10. Hipertensión arterial en México. *Fed Mex Diabetes*. May 2016. http://fmdiabetes.org/hipertension-arterial-mexico/. Accessed July 9, 2018.

11. O'Brien MJ, Alos VA, Davey A, Bueno A, Whitaker RC. Acculturation and the prevalence of diabetes in US Latino adults, National Health and Nutrition Examination Survey 2007–2010. *Prev Chronic Dis*. 2014;11.

doi:10.5888/pcd11.140142

12. Sundquist J, Winkleby M. Country of birth, acculturation status and abdominal obesity in a national sample of Mexican-American women and men. *Int J Epidemiol*. 2000;29(3):470-477.

13. Inside NCHS - January 2013 - NHANES MEC. https://www.cdc.gov/nchs/newsletter/2013_January/a2.htm. Accessed December 13, 2017.

14. NHANES - NHANES Participants - Eligible Participants. https://www.cdc.gov/nchs/nhanes/participant-eligibility.htm. Accessed December 13, 2017.

15. New ACC/AHA High Blood Pressure Guidelines Lower Definition of Hypertension. American College of Cardiology. http%3a%2f%2fwww.acc.org%2flatest-in-cardiology%2farticles%2f2017%2f11%2f08%2f11%2f47%2fmon-5pm-bp-guideline-aha-2017. Accessed May 29, 2018.

16. National Health and Nutrition Examination Survey. Anthropometry Procedures Manual. 2007. https://www.cdc.gov/nchs/data/nhanes/nhanes_07_08/manual_an.pdf.

17. Fuchs FD, Gus M, Moreira LB, et al. Anthropometric indices and the incidence of hypertension: A comparative analysis. *Obes Res*. 2005;13(9):1515-1517. doi:10.1038/oby.2005.184

18. Ashwell M, Mayhew L, Richardson J, Rickayzen B. Waist-to-height ratio is more predictive of years of life lost than body mass index. *PLOS ONE*. 2014;9(9):e103483. doi:10.1371/journal.pone.0103483

19. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA*. 2006;295(13):1549-1555. doi:10.1001/jama.295.13.1549

20. National Center for Health Statistics. Health, United States, 2016 - Individual Charts and Tables: Spreadsheet, PDF, and PowerPoint files. https://www.cdc.gov/nchs/hus/contents2016.htm. Published July 20, 2017. Accessed December 15, 2017.

21. Berber A, Gómez-Santos R, Fanghänel G, Sánchez-Reyes L. Anthropometric indexes in the prediction of type 2 diabetes mellitus, hypertension and dyslipidaemia in a Mexican population. *Int J Obes Relat Metab Disord J Int Assoc Study Obes*. 2001;25(12):1794-1799. doi:10.1038/sj.ijo.0801827

22. National Center for Health Statistics. Health, United States, 2014 (5/2015). :473.

23. Hispanic/Latino - The Office of Minority Health. https://www.minorityhealth.hhs.gov/omh/browse.aspx?lvl=3&lvlid=64. Accessed July 27, 2018.

24. Hardy ST, Holliday KM, Chakladar S, et al. Heterogeneity in blood pressure transitions over the life course: Age-specific emergence of racial/ethnic and sex disparities in the United States. *JAMA Cardiol*. 2017;2(6):653-661. doi:10.1001/jamacardio.2017.0652

25. Schulz LO, Chaudhari LS. High-risk populations: The Pimas of Arizona and Mexico. *Curr Obes Rep*. 2015;4(1):92-98. doi:10.1007/s13679-014-0132-9