

Manuscript

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Milestone A

Hypertension affects 37 million people in the United States; however, only about one in four people with hypertension have it under control¹. Hypertension is a cardiovascular disease that relates to a person's blood pressure². Optimal blood pressure is about 120/80 mmHg; however, hypertensive blood pressure levels are about 130-140/80-90 mmHg. The increasing prevalence and long-term health related problems associated with hypertension has made it into a major public health issue². In a study from 2010, high blood pressure trailed just behind cigarette smoking as the leading cause of deaths from cardiovascular disease in the United States³. Furthermore, a more recent study from 2018 showed that high blood pressure was the primary cause of death for over 494,873 people in the United States². In terms of interest groups for developing hypertension, men are at a higher risk of having high blood pressure than women². Although doctors are more likely to recommend medication for non-Hispanic white adults, non-Hispanic black adults have a 54% prevalence compared to white adults which is 46%².

In a study that looked at hypertension related deaths from 2000-2018, there were disproportionate issues regarding gender and race⁴. From 2000-2012, white men were the only group to increase in deaths per 100,000⁴. However, from 2012-2018, white women and black men increased⁴. The only group that decreased in deaths from hypertension for 2000-2018 is black women⁴. Black men experienced hypertensive related death at a 2.44 higher rate in 2000 and 1.76 higher rate in 2018 than white men⁴. A similar inequality was shown for black

women. These deaths could be correlated with the lack of medical attention and quality care people of color have in America compared to white people.

A study has showed that hypertension was more common among people who live in rural areas than those who live in urban areas⁵. The increase of prevalence was evident for all subgroups like gender, age, and race. Lack of access to healthcare, affordable healthy foods, physical activity, transportation, and smoking are all higher in rural areas which could be correlated to the increase of hypertension⁶. In a study about hypertension between white and black people, black people had a 1.11 higher rate of having hypertension than white when controlling for socio-economic status, demographics, racial discrimination, and health characteristics⁷. Looking at the race and gender variable in conjunction, a study showed that one of the primary leading causes of death among black women is heart disease from high blood pressure⁹. When analyzing data concerning the gender variable regardless of race, women were more likely to receive medication for hypertension even though their prevalence was less than men⁸.

In a study assessing the risk of hypertension in young girls from rural areas, their environment put them at higher risk for hypertension with the association of BMI affecting the risk as well. There is a greater risk of having a higher BMI in low socioeconomic rural areas, and a higher BMI is associated with greater risk of hypertension⁹. The article explained that living in a rural area is not the only factor affecting BMI and hypertension⁹. The association between rural areas and poverty, discrimination, and unequal access to healthcare also play a role⁹. Hypertension prevalence in a population varies by the level of social support available in the community⁸.

While rates of hypertension in rural areas are higher than in urban areas, the resources to treat this disease are not as readily available in rural areas. In addition, rural populations have higher rates of hypertension and may lack access to treatments to help lower the blood pressure. This is especially seen in the Appalachian population¹⁰. It is apparent that these regions need access to better healthcare, more resources, education, etc. in order to combat this growing trend. In a similar study, urban areas were compared with very rural areas and the disparity between hypertension rates were higher in the rural areas. The prevalence of hypertension was so different between the two regions that other factors such as age and sex did not have any notable impact on these statistics. Hypertension rates were the highest in Southeastern and Appalachian counties⁶.

While development of risks for hypertension are not completely known, it is important to research it further. One study used almost 15,000 participants to gather data on cumulative lifetime risk of hypertension and it was found that lifetime risk for hypertension was over 75% for African Americans and white men⁹. It shows that the prevalence of a blood pressure of 130/80 mm Hg and up as young adults is increasing and becoming a pressing issue. Another study went on to examine the trends of hypertension in the past two decades to see the association of obesity or increased BMI with hypertension. Using surveys, they collected data from 1999-2014 of BMI, medication use, and blood pressure readings. The article found that there was a positive correlation of $p=.006$ and that over the years the association has been becoming stronger¹¹. This can have major consequences as major diseases go along with prolonged hypertension¹¹.

In a study focusing on the rural south, there was a statistically significance in medical nonadherence in the African Americans who thought of themselves with high social standing

versus low social standing. However, there was no statistical significance in white people for medical adherence of hypertensive medication¹². The participants measured their own perceived social standing because they thought it would be significant to see the perception of people versus the socio-economic status. Of the people who reported nonadherence across race, 75% of the stated that they changed or altered their medication without consulting a doctor because the hypertensive medication made them feel worse¹².

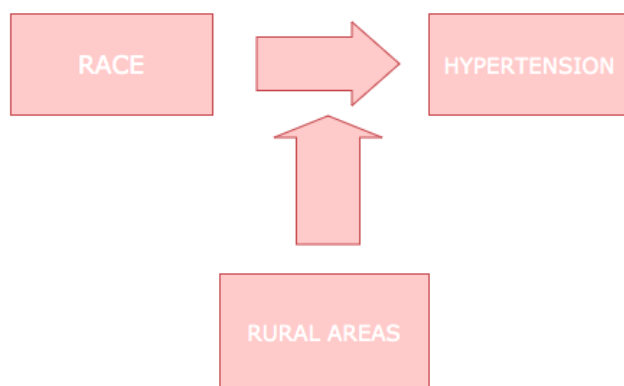


Figure 1: The figure above highlights the relationship in the study. There is a direct relationship between race, hypertension, and rural areas.

Hypertension has a high prevalence in the United States. Which indicates that people are having difficulty control it. There has been an increase in the rate of hypertension and a disproportionate affects between genders⁴. Hypertension is a silent, but deadly cause of death in the United States. Questions concerning hypertension amongst southern areas, gender, and ethnicity have not been addressed sufficiently due to the silent nature of this disease. There is a consistent worsening of national mortality rates for all hypertension-related mortalities, and

unacceptable racial disparities. This public health epidemic is disproportionately affecting those of low-income individuals, those who are less likely to take prescription medicine, those with little access to healthy food, and lastly those who have limited access to medical care. Furthermore, there was a significant, positive linear association between obesity and hypertension¹¹. A stringent public health effort is necessary for the detection, control, and prevention of complications from hypertension.

The current study asks three questions about the relationship between race/ethnicity and hypertension. First, what is the association between race/ethnicity and high blood pressure prevalence. Second, is the presence of high blood pressure affected by region. Third, does gender affect high blood pressure levels. The use of hypertensive medication may confound these relationships, and this will be addressed in the analysts.

Milestone B

The National Institute Health Interview Survey (NHIS) collects microdata using a household recruitment methodology to measure household member demographics, health behaviors, and survey reported health outcomes¹³. This data source is suitable to answer questions about how race, gender, and regional status as they relate to blood pressure in adults. The population of this study include African American/ black and white people between the ages of 40 and 70 years old. Additionally, there will be comparison between males and females and people who live in the south and people who do not live in the south. All data will come from the United States in 2017. Each of these groups of people will be analyzed with blood pressure ranges of normal and borderline to high.

This study is examining normal blood pressure versus borderline to high blood pressure in different races, genders, and regions. To reinforce the validity of the study, there will be one

criterion restricted for each computation. The study will restrict for age to only include individuals between 40 and 70 years old. The NHIS asked the participants when they last had their blood pressure checked if they were told if it was low, normal, borderline, or high¹³. According to the American Heart Association, elevated blood pressure is about a systolic pressure greater than 120 mmHg and diastolic pressure of greater than 80 mmHg is stage¹⁴. Combining borderline and high blood pressure helps include individuals who may develop hypertension in the future if an intervention does not occur. The study will compare blood pressure differences between genders, race, and regional area. Additionally, there will be restriction to include people only between the ages of 40-70. Race, gender, and regional status will be classified as dichotomous variables (female: 0, male:1, black: 0, white: 1, and south: 0, not south: 1).

The variable “RACEA”, which is the self-reported main racial background of the person, was selected. Using the variable “White” and “Black/African-American”. For the variable of regional area, the study will dichotomize the term “REGION” into “South” and “Not South”. The variable “HYPLEVEL” is the range of blood pressure at the most recent check-up. This variable was self-reported with seven possible options. This study focuses on normal and borderline to high. Adults with normal blood pressure will be reclassified as zero (the comparison) and people with borderline to high blood pressure will be operationalized as 1 to indicate a cardiovascular risk classification. The variable “SEX” will be in the study to dichotomize males and females. Additionally, “AGE” will be a variable to eliminate young people from the study because this could cause confounding as the study focuses on adults 40-70-year-old adults.

Some of the data used in this study was retained from self-reported surveys which in turn could produce bias. Confounding variables such as smoking status, prevalence of a chronic disease, socioeconomic status, genetics, access to healthcare, and pre-prescribed medications are all variables that could influence this study. The survey asked the question of blood pressure level by asking their level from the most recent check-up (low, normal, borderline, or high). A major confounding variable for the study is the use of medication. Although the study is not looking directly at the prevalence of hypertension, it is important to note that hypertensive medications can lower blood pressure which confounds the study of measuring high blood pressure across gender, race, and areas. This coincides with access to healthcare and socioeconomic status (SES) because people who have a higher SES could have more access to medication and the means to pay for it through insurance or out of pocket compared to people without insurance. It is also important to acknowledge that just because people have blood pressure medication does not mean that they will take it. Hypertension medication can be costly for people which could create confounding regarding the amount of people who are given hypertensive medication and the people who benefit from taking the medication.

The plan to assess for confounding is to stratify by a third variable. "HYPMEDNOW" was asked to participants who had been diagnosed with hypertension. There will be two additional tables for each question. For example, when looking at gender and blood pressure levels, there will be a table for the population who is not taking medication for hypertension and a table for people who are taking medication for hypertension.

In the first table, the comparison between blood pressure and gender. Males will be cell A, females will be cell B, normal blood pressure will be cell C, and borderline to high blood pressure will be cell D. Blood pressure will remain cell C and D for each table. In table two,

blood pressure will be compared to race which is either black (cell A) or white (cell B). Finally, the regional area table will show the south (cell A) and non-south (cell B) versus borderline to high blood pressure and normal blood pressure. To deal with confounding of medication use, there will be six more 2x2 tables using the variable hypertension medication (yes or no) versus gender, race, and geographic area.

Milestone C

We measured the prevalence of hypertension using data from participants of different race, sex, and region. The total population is 11727 participants. The mean age of the sample is about 56 years old, and we included data from people between the ages of 40 and 70. The ratio of men to women is 0.87, black to white is 0.14, and south to not the south is 0.62. Women make up 46.5% of the sample population while men make up 53.5%. Black/ African American people make up 12.6% of the population and white people make up 87.4%. People from the south make up 38.2% and people not from the south are 61.8% of the sample population. This study is generalizable to people in those two geographical areas as well as personal characters like age (40-70), race (white and black), and sex.

There is effect modification in the study when trying to look at the association of hypertensive medications. The study saw a protective third variable that influenced the crude measures of association when accounting for people who have taken hypertensive medication as not everyone in the survey answered this question. As a result, the computations for confounding have a smaller sample population. The study stratified based on the hypertension medication question where the participants either answered “yes” or “no” to currently taking medication. The subpopulation is for those who have no take hypertensive medication is 476 and the subpopulation for those who said they are taking hypertensive medication is 4102. The

proportions of people were like the larger population with gender about 50% for both males and females, black/ African Americans were about 15-17% and white people were 83-85%, people from the south were 43% and those not from the south were 57%.

Is sex associated with borderline to high blood pressure?

When looking at the relationship between sex and blood pressure between men and women ages 40-70 the following measures were observed. Twenty percent of men reported having borderline-to-high blood pressure (BH-BP), and the prevalence was 15% for women indicating BH-BP was 1.30 times higher for men compared to women. Men were 30% more likely to report BH-BP than women. This relationship was not confounded by participants not taking medication. When reporting medication for hypertension, 34% of men and 29% of females had BH-BP. The prevalence ratio indicated that men are 1.19 times more likely to report BH-BP.

Is race associated with borderline to high blood pressure?

When looking at the relationship between race and blood pressure the following measures were observed. Twenty-four percent of black/ African Americans reported borderline-to-high blood pressure (BH-BP), and 16% percent of women reported BH-BP. Black/ African Americans experienced BH-BP at 43% higher rate than white people. Black/ African Americans had a 1.43 times higher rate of BH-BP than white people. When looking at the subpopulation of people who not taking a medication, 43% of black/ African Americans had BH-BP and 36% of white people reported BH-BP. Black/ African Americans experienced BH-BP at a 1.2 higher rate than white people. Participants reporting that they do take medication, 33% of black/ African Americans and 31% of white people reported BH-BP. White people were 8% less likely to experience borderline to high blood pressure than black/ African Americans.

Is region associated with borderline to high blood pressure?

Lastly, this study addressed the relationship between region and blood pressure. In this association, 19% of participants from the south reported having borderline to high blood pressure. The sample population not from the south reported 16% BH-BP. These prevalence rates provide a prevalence ratio of 1.21. It is reported that people in the south are 21% more likely to experience high blood pressure. When computing for confounding, participants who do not take medication not from the south experienced BH-BP at a .89 higher rate. However, those who do take medication not from the south had a 11% lower chance of reporting BH-BP. In the population of people who did not report taking hypertension medication, thirty-four percent of people from the south reported BH-BP while thirty-nine percent of people not from the south reported BH-BP. For the population who reported they did take medication, 33% of people had BH-BP from the south while 30% of people not from the south had BH-BP.

Milestone D

Deaths attributed to hypertension have increased in recent years. Despite public health efforts, new diagnosis and the prevalence of hypertension control remain remarkably low. Our results support the existing literature that hypertension disproportionately affects those of low income, those less likely to take prescription medication, those with little access to healthy food, and those who have limited access to medical care. Analysis shows that treatment of hypertension amongst those in rural areas and of different ethnicities is not adequately addressed due to the silent nature of the disease. There is a consistent worsening of national mortality rates for all hypertension-related mortalities, and unacceptable racial disparities. This study evaluated race, gender, and regional status as they pertain to blood pressure. A stringent public health effort is necessary for the detection, control, and prevention of complications from hypertension.

The Current results showed constant trends of pre-hypertension and hypertension in rural men and women in 2017 proving that hypertension is an enormously prevalent disease in the United States with its associated risk factors being race, gender, and location. Urban areas have better detection and medication use which suggested a probability of prevalence disparities between rural and urban areas. Disparities in United States health care availability and outcomes are related to race/ethnicity which is seemingly tied to economic status in rural areas. More attention needs to be given to such disparities. Resources such as telehealth, patient portals, focus groups, and community intervention could dramatically reduce the prevalence of hypertension in these areas. Racial and social determinants of health disparities should be fully investigated to improve population-based health. Although the results of this study were comparable to urban adults, it can be noted that hypertension detection and medication use of rural adults was minimal. The differences attributed to confounding effects between urban and rural hypertension detection and medication use were even greater than that of hypertension prevalence based on the questionnaire that investigated medication use. This can suggest an unbalanced distribution of education resources, primary care providers, access to healthy grocery stores and even gyms which can explain a lack of awareness of hypertension.

Observed gender differences in hypertension can be due to both biological and behavioral factors. It was noted that men had a 30% higher rate of borderline to high blood pressure compared to women. Some of these biological factors that put men at a higher vulnerability can include sex hormones, chromosomal differences, and BMI. Behaviorally, it is scientifically proven that men are less likely to seek medical attention compared to women. This may be due partially to the fact that most women are under regular gynecological services where their blood pressure is often check and managed preventively, if needed. Men on the other hand, who choose

to not see a doctor frequently may not notice signs of hypertension until it is too late which in turn leads to the higher incidence rate seen in men. In order to lower hypertension in men, awareness of the disease needs to be heightened. Regular physicals and screenings are important to one's health and should be utilized by all. A way to promote more men seeking medical attention could be the implementation of a simple worksite health program that allows companies to intervene on their employees and ensure they are staying safe and healthy.

The research question over the other variable is the relationship between race and hypertension. This type of research is important to examine the differences in prevalence of high blood pressure in different races. This could lead to further research in the why there might be differences. Is it due to possible differences in lifestyle or socioeconomic status? It could be due to lack of access to healthcare or measures to keep blood pressure in check. Research over this could be valuable in providing more access and awareness to these groups to promote good health. Results show a difference in race for borderline to high blood pressure, and this could be due to the factors listed above. There could be measures put in place to make healthcare more accessible to the at-risk populations. One way is providing more doctors in different areas that take a multitude of insurances and self-pay options, thus allowing for more annuals and prevention strategies to the patients. Workplaces could start requiring annual checks ups or physicals once a year for the safety of their employees. Many places require blood pressure checks and blood work in order to continue qualifying for insurances. It helps promote the worker's health and well-being. Another idea could be providing resources like educational posters or tips at workplaces, grocery stores, and other common high traffic areas.

To aid in prevention of hypertension, there are different prevention methods that could be adopted for different circumstances. For primary prevention eliminating areas that are called

“food-deserts” which are common in the south specifically in rural areas and in predominately low-income neighborhoods which also commonly have a larger black population. By eradicating these fast-food chains from monopolizing on low-income neighborhoods and replace these establishments with affordable, heart-healthy grocery stores and restaurants to help manage blood pressure. In terms of secondary prevention, surveillance of developing hypertension could be helpful for these groups of people. For example, universal healthcare could help people detect borderline blood pressure levels and reduce their risk of developing hypertension. Additionally, adding more clinics and healthcare establishments in rural areas in the south could aid in the early detection of hypertension. For tertiary prevention, universal healthcare and medications with a lower cost can diminish the burden of the disease as well as information on how to manage hypertension and how to take the medication correctly to increase its efficacy.

The measures for the stratification analysis highlighted relationships between people who take hypertensive medication and those who do not. The study had effect modification when accounting for the use of hypertensive medication. As a result, that variable was only included when it was stratified by “yes” or “no” because it was protective of the relationship between all the variables and blood pressure. When measuring confounding for the south and not the south, people who live in the south had a decreased prevalence ratio when not taking medication compared to those who are not from the south compared to the crude. However, people who live in the south had a higher rate of prevalence compared to those not from the south when taking hypertensive medication. This indicates that people who are from the south are not managing their hypertension as well compared to those not from the south. Men and women increased in reporting compared to the crude of having borderline to high blood pressure when taking hypertensive medications and when not taking hypertensive medication. This could indicate that

their hypertensive medications are not working, they are not using them correctly, or they are reporting from before they started medication. Finally, for black/ African American people the prevalence ratio decreased for both medication use and not use compared to white people; however, the overall prevalence increased for both groups compared to the crude. For race and gender, the prevalence ratios decreased slightly when only looking at people who take hypertensive medications, but only by about 7% for males and 10% for black/ African Americans. It would be beneficial if the medication could decrease the prevalence rates of each group by a more substantial amount.

The crude measures of association are generalizable to the groups they represent which are male, female, white, black, south, and not in the south. These variables were comparable to the make-up of the United States. Even when controlling for hypertension medication, the participant composition is similar to the general population. The larger sample population helped indicate strong relationships between certain outcomes. However, the subpopulations were not as large which led to some effect modification. If the study was able to ask the larger population if they were diagnosed with hypertension or if they take hypertensive medication it could have showed different relationships when accounting for the confounding. By including these questions in the survey that was distributed there would have been a more comprehensive understanding of hypertension medication use and prevalence of diagnosis.

Additionally, the blood pressure question was self-reported based on memory from their last check-up. In an ideal world, taking a person's blood pressure at the time of the survey by a tool that is a standard use of measurement would be more accurate. However, this is not possible for this type of study and when wanting data on very large population sizes. To answer this question accurately the participant would have had to go to the doctor to have their blood

pressure read and many Americans are not insured or underinsured. Therefore, the study is measuring a group of people with access to health care and the reading of their blood pressure.

This study looked at the relationship between blood pressure versus gender, race, and regional status. The findings were congruent with previous studies in which males, black people, and those from the south experience borderline to high blood pressure at higher rates than females, white people, and those not from the south. Targeting these groups can help diminish the likelihood of developing hypertension. The most logical and impactful intervention for this condition that would help with primary, secondary, and tertiary prevention would be universal healthcare. The burden of cost and inability to locate a doctor within network who could prescribe the medication needed to treat hypertension would be gone if Americans had the ability to have healthcare for all. This helps with surveillance in detecting pre-hypertension and continuity of care for those with hypertension.

References:

1. Center for Disease Control. Facts About Hypertension. <https://www.cdc.gov/bloodpressure/facts.htm#:~:text=High%20blood%20pressure%20was%20a,the%20United%20States%20in%202018.&text=High%20blood%20pressure%20costs%20the,years%20from%202003%20to%202014>. Published 2020. Accessed.
2. Center for Disease Control. High Blood Pressure <https://www.cdc.gov/bloodpressure/facts.htm>. Published 2020. Accessed.
3. Reboussin DM, Allen NB, Griswold ME, et al. Systematic Review for the 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults; A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Journal of the American College of Cardiology*. 2018(19).
4. Rethy L, Shah NS, Paparello JJ, Lloyd-Jones DM, Khan SS. Trends in Hypertension-Related Cardiovascular Mortality in the United States, 2000 to 2018. *Hypertension (0194911X)*. 2020;76(3):e23-e25.
5. Ellis C, Grubaugh AL, Egede LE. The effect of minority status and rural residence on actions to control high blood pressure in the U.S. *Public Health Rep*. 2010;125(6):801-809.
6. Samanic CM, Barbour KE, Liu Y, et al. Prevalence of self-reported hypertension and antihypertensive medication use by county and rural-urban classification - United States, 2017. *Morbidity and Mortality Weekly Report*. 2020;69(18):533-539.
7. Gabriel AC, Bell CN, Bowie JV, LaVeist TA, Thorpe RJ, Jr. The Role of Social Support in Moderating the Relationship between Race and Hypertension in a Low-Income, Urban, Racially Integrated Community. *Journal of Urban Health*. 2020(2):250.
8. Bell CN, Thorpe RJ, LaVeist TA. Race/Ethnicity and Hypertension: The Role of Social Support. *American Journal of Hypertension*. 2010;23(5):534-540.
9. Webster EK, Logan SW, Gray WN, Robinson LE. A cross-sectional study on the relationship between the risk of hypertension and obesity status among pre-adolescent girls from rural areas of Southeastern region of the United States. *Preventive Medicine Reports*. 2018;12:135-139.
10. Mbabazi K, Eric S. Distribution of Cardiovascular Disease and Associated Risk Factors by County Type and Health Insurance Status: Results from the 2008 Ohio Family Health Survey. *Public Health Reports (1974-)*. 2015;130(1):87.
11. Ryu S, Frith E, Pedisic Z, Kang M, Loprinzi PD. Secular trends in the association between obesity and hypertension among adults in the United States, 1999–2014. *European Journal of Internal Medicine*. 2019;62:37-42.
12. Cummings DM, Wu J, Cene C, et al. Perceived social standing, medication nonadherence, and systolic blood pressure in the rural south. *Journal of Rural Health*. 2016;32(2):156-163.
13. IPUMS Health Surveys: National Health Interview Survey, Version 6.4 [dataset]. Minneapolis, MN: IPUMS; 2019. <https://nhis.ipums.org/nhis/citation.shtml>.

14. Heart. 2020. <https://www.heart.org/en/health-topics/high-blood-pressure/understanding-blood-pressure-readings>. Published Understanding Blood Pressure Readings. Accessed.