Spring 5-12-2023

Hypertension and Diabetes Comorbidity: Factors that are Associated with their Joint Occurrence

Oluwatoyosi Ogunmuyiwa

Hypertension and Diabetes Comorbidity: Factors that are associated with their Joint Occurrence

by

OLUWATOYOSI OGUNMUYIWA

Under the Direction of Ike Okosun, MS, MPH, Ph.D., FTOS, FACE

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

Master of Public Health

in the School of Public Health

Georgia State University

2023

Hypertension and Diabetes Comorbidity: Factors that are Associated with their Joint Occurrence

by

Oluwatoyosi Ogunmuyiwa

Committee Chair: Ike Okosun

Committee Member: Heartley Egwuogu

Electronic Version Approved:

School of Public Health

Georgia State University

May 2023

ACKNOWLEDGEMENTS

I am honored to have completed my thesis and I would like to express my sincerest gratitude to God Almighty and individuals whose support and guidance have been instrumental towards this achievement.

I am extremely grateful to my parents, Mr. Hakeem Ogunmuyiwa and the Late Mrs. Motunrayo Ogunmuyiwa for their support through my academic journey. I would also like to thank my siblings Toyin and Tope Ogunmuyiwa for their belief and words of encouragement which served as a constant motivation and inspiration.

I would like to express my deepest appreciation to my committee chair, Dr. Ike Okosun, whose wisdom, encouragement and unwavering support guided me through this journey. I also thank my committee member, Dr. Heartley Egwuogu, for his insightful feedback and suggestions. I am sincerely grateful to Dr. Emily Graybill and the entire CLD team for their contribution to my career development.

Finally, I thank the amazing community of family and friends that I have especially Oge Igbokwe, Adetomiwa Adekoya and Abolaji Adeyi for their emotional support and encouragement through this journey.

AUTHOR'S STATEMENT

In presenting this thesis as a partial fulfillment of the requirements for an advanced degree from Georgia State University, I agree that the Library of the University shall make it available for inspection and circulation under its regulations governing materials of this type. I agree that permission to quote from, copy from, or publish this thesis may be granted by the author or, in his/her absence, by the professor under whose direction it was written, or in his/her absence, by the Associate Dean, School of Public Health. Such quoting, copying, or publishing must be solely for scholarly purposes and will not involve potential financial gain. It is understood that any copying from or publication of this dissertation which involves potential financial gain will not be allowed without written permission of the author.

-Toyosi Ogunmuyiwa

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

- BMI- Body Mass Index
- Comorbid- Hypertension + Diabetes
- C.I- Confidence Interval
- DBP- Diastolic Blood Pressure
- SBP- Systolic Blood Pressure
- HTN- Hypertension
- HDC-Hypertension-Diabetes Comorbidity
- NHW- non-Hispanic Whites
- NHB- non-Hispanic Blacks
- OR- Odds Ratio
- aOR- Adjusted Odds Ratio

ABSTRACT

AIM: Hypertension and Diabetes are important metabolic disorders and risk factors for cardiovascular diseases. Although factors that are associated with hypertension and diabetes for cardiometabolic diseases are well established, little is known regarding factors that are associated with their joint occurrence. This study aims to determine factors that are associated with hypertension and diabetes comorbidity (HDC). This study also examines the risk factors that are independently associated with hypertension and diabetes and their joint occurrence.

METHODS: This study utilized data from a cross-sectional survey of the United States Nationwide National Health and Nutrition Examination Survey (NHANES) using the 2017-2020 pre-pandemic dataset. The aim was to investigate the potential links between various demographic, behavioral, and clinical factors, and the likelihood of developing both hypertension and diabetes. Univariate and multivariate logistic regression analyses were employed to examine these associations.

RESULTS: An increase in age and Body Mass Index (BMI) was associated with increased odds of diabetes, hypertension, and HDC. Race/ethnicity and educational level also was found to be positively associated with increased odds of hypertension, diabetes, and HDC with men having an increased odds compared to females. NHB and Hispanics were disproportionately affected by metabolic disorders.

CONCLUSION: The findings of this study suggest several factors, including age, BMI, race/ethnicity, and total cholesterol levels, were found to be closely linked to the occurrence of both diabetes and hypertension. Public health interventions should be implemented specifically for these high-risk population groups to decrease the burden of these conditions and also reduces the risk of cardiovascular disease in the United States.

CHAPTER I

INTRODUCTION

1.1 Background

Chronic metabolic diseases continue to be a leading cause of morbidity and mortality among adults in the United States. Diabetes and hypertension are common risk factors for developing severe cardiovascular disease and prevalent comorbidities. (Chi and Lee, 2022). The causal relationship between hypertension and diabetes is not clear as studies have shown a bidirectional relationship between these two metabolic diseases. Studies have not only shown an increased prevalence of diabetes among hypertensive populations but also shown a high hypertensive prevalence among diabetic populations. (Clime at al., 2019, Sun et al 2019, Abougalambou, et al., 2013). The coexistence of hypertension and diabetes is due to the shared pathophysiological mechanisms between the two conditions, particularly in relation to obesity and insulin resistance. (Wang et al., 2021; Tsimihodimos et al., 2019). There is also substantial overlap related primarily to microvascular and microvascular disease (Petrie et al., 2018, Long et al., 2011; Sabuncu et al., 2021). Several results have contributed to our understanding of this joint occurrence, but the whole pathogenic pathways remain poorly known.

1.2 Purpose of Study

The prevalence of hypertension and diabetes as comorbidity has often been discussed however little is known regarding factors that are associated with their joint occurrence. This thesis, therefore, aims to:

- Determine factors that are associated with hypertension and diabetes comorbidity (HDC)

- To examine if the factors that are associated with hypertension and diabetes independently differ from their joint occurrence
- To examine the differences in metabolic syndrome among different racial and ethnic groups in the United States.

1.3 Research Questions

- What are the factors associated with Hypertension-Diabetes Comorbidity (HDC)?
- Do the factors associated with HDC comorbidity differ from factors that affect hypertension and diabetes independently?
- Is there a difference in the proportion of metabolic disorders among ethnic groups?

CHAPTER II

LITERATURE REVIEW

2.1 Diabetes

Diabetes mellitus is a group of chronic metabolic conditions characterized by a set of long-term metabolic irregularities, which arise from either the body's resistance to the activity of insulin or its inability to produce the hormone. This inability results in elevated blood sugar levels. The chronic hyperglycemia associated with diabetes can cause damage, malfunction, and deterioration of several organs in the body, including the eyes, kidneys, nerves, heart, and blood vessels. (ADA, 2010).

According to the American Diabetes Association (ADA) in 2019, diabetes ranked as the seventh leading cause of death in the United States, with 282,801 death certificates citing diabetes as the cause of death. Diabetes is the primary cause of kidney failure, lower limb amputations, and adult blindness. (CDC, 2023) Additionally, diabetes is associated with a range of complications that affect multiple body tissues, including peripheral vascular disease, diabetic neuropathy, diabetic foot problems, diabetic retinopathy, and nephropathy. (Schmidt, 2018; Bailes, 2002). The economic burden of diabetes is also significant, with an estimated total cost of $327 billion in 2017, including $237 billion in direct medical costs and $90 billion in reduced productivity. People with diagnosed diabetes have medical expenditures that are on average 2.3 times higher than what would be expected in the absence of diabetes. (ADA, 2017). Ariza et al., 2010 reported that one in five healthcare dollars is spent on people with diabetes, while more than one in ten healthcare dollars is spent on conditions that can be attributed to diabetes.

The development of diabetes involves various pathogenic pathways, such as the autoimmune destruction of pancreatic β-cells, resulting in insulin deficiency, and abnormalities leading to insulin resistance. Inadequate insulin secretion and/or impaired tissue response to insulin along the complex hormonal pathways can lead to insufficient insulin levels. Often, insulin secretion and defects in insulin action coexist, making it challenging to identify the primary cause of hyperglycemia. (ADA, 2010)

Risk factors for diabetes are more diverse; some are modifiable, and others are not. Nonmodifiable risk factors for type 2 diabetes include age, race or ethnicity, family history (genetic predisposition), history of gestational diabetes, and low birth weight. (Deshpande et al., 2008)

2.2 Hypertension

Hypertension is a cardiovascular syndrome that arises from various complex and interconnected factors. (Giles et al., 2009). High blood pressure refers to the consistent elevation of the force of blood flowing through the blood vessels. (AHA, 2023). Hypertension is an established independent risk factor for cardiovascular disease (CVD) and contributes to 1 in 7 deaths. The cost associated with hypertension in the United States from 2014–2015 was approximately $56 billion (Commodore-Mensah et al., 2022; Gou et al., 2012). High blood pressure (BP) is the most critical risk factor for cardiovascular disease (CVD), ranking first in global disability-adjusted life-years and associated with approximately 1,000 deaths per day (Carey and Whelton, 2021). Effective blood pressure management has been shown to decrease the incidence of stroke, heart attack, and heart failure. Hypertension is a major risk factor for cardiovascular disease and a major modifiable risk factor for dementia (Ostchega et al., 2020; Carey and Whelton, 2021). Coronary heart disease is the primary complication of hypertension among middle-aged Europeans and Americans, while stroke is more common among Asians and older individuals. African American Populations tend to have higher blood pressure and experience more hypertension-related mortality than other racial or ethnic groups. (Staessen et al., 2003)

2.3 Hypertension and Diabetes Comorbidity (HDC)

Hypertension is a major risk factor for severe cardiovascular disease, particularly diabetes mellitus. As a result of its role as a major risk factor, there has been substantial basic and clinical research on the pathogenesis of hypertension, specifically clinical management, and treatment of hypertension in diabetes mellitus (Cryer et al., 2018). The causal relationship between hypertension and diabetes is not clear as studies have shown a bidirectional relationship between these two metabolic diseases. Clime at al., 2019, Sun et al., 2019, Abougalambou, et al., 2013). Some studies have shown that the prevalence of hypertension is high in diabetic patients (Zhou et al., 2019; Colosia et al., 2013, Malaguarnera et al., 2012) while others have shown an increased prevalence of diabetes in hypertensive populations. (Edmin et al., 2015; Petrie et al., 2018).

Hypertension and diabetes share common risk factors such as endothelial dysfunction, vascular inflammation, arterial remodeling, atherosclerosis, dyslipidemia, and obesity. Studies suggest that individuals with diabetes have a prevalence of hypertension that is approximately 1.5-2.0 times higher than those without diabetes, as reported by Nouh et al., (2017) and Berraho et al., (2012). Additionally, there is significant overlap in the cardiovascular complications associated with diabetes and hypertension, with microvascular and macrovascular diseases being the primary concerns. These complications include myocardial infarction, congestive heart failure, stroke, peripheral vascular disease, retinopathy, nephropathy, and neuropathy. (Petrie et al., 2018, Long et al., 2011; Sabuncu et al., 2021) . According to Ian et al., in 2017, epidemiological analyses have revealed that hypertension is linked to an increased incidence of atherosclerotic cardiovascular disease, heart failure, retinopathy, kidney disease, and mortality. This highlights the importance of blood pressure control in improving clinical outcomes for patients with diabetes.

Faiza et al., in 2017 reported that the occurrence of concurrent hypertension and diabetes differs among various social, ethnic, and racial groups. In particular, Lynch et al., in 2014 found that African Americans have a higher incidence of coexisting diabetes and hypertension compared to whites or Hispanics. This increased prevalence of comorbid conditions among African Americans can lead to a greater risk of complications associated with diabetes. (lynch et al., 2014). The incidence of hypertension in the diabetic population is influenced by factors such as the degree of obesity, advanced age, and the presence of extensive atherosclerosis. (Faiza et al., 2017)

The relationship between diabetes mellitus and hypertension is thought to be influenced by the adrenergic system, which includes mechanisms such as incretin-mediated regulation of the renin-angiotensin-aldosterone system. The calcium-calmodulin pathway has also been extensively studied in both disorders, with alterations in this system leading to elevated intracellular calcium levels that inhibit insulin gene transcription in pancreatic beta cells. These changes contribute to the development of diabetic nephropathy, extracellular fluid expansion, and increased arteriole stiffness. Interestingly, individuals with uncontrolled blood pressure, despite taking antihypertensive medication, are at an increased risk for developing diabetes mellitus. (Cryer et al., 2018).

Some prescription and over-the-counter medication can also interfere with medications used to decrease blood pressure. Insulin can increase blood pressure through several mechanisms: Increased renal sodium re-absorption, activation of the sympathetic nervous system, alteration of transmembrane ion transport, and hypertrophy of resistance vessels. (Faiza et al., 2017).

CHAPTER III

METHODS AND SAMPLING

3.1 Study Design

The data source used for this study is a combined dataset from the 2017-2020 pre-pandemic National Health and Nutrition Examination Survey (NHANES). This dataset includes cross-sectional data of individuals diagnosed with diabetes and hypertension. NHANES is a multistage, stratified, clustered probability sample of civilian noninstitutionalized individuals conducted by the National Center for Health Statistics (NCHS) under the Centers for Disease Control and Prevention (CDC). NHANES aims to obtain demographic, socioeconomic, dietary, and health-related information from a representative sample of the US population. Each NHANES Continuous survey release involves approximately 10,000 individuals assessed on various health factors at mobile examination units and through home interviews. The survey includes questions on health, dietary information, demographics, and socioeconomic status. Additionally, medical, dental, physiological, and laboratory tests are conducted in mobile examination centers by trained interviewers. Informed consent was obtained from participants before the examination and interview. The data used in this study were downloaded from the NHANES. (NHANES, 2023)

3.2 Study Variables

Demographic variables included in this study were gender (male/female) and age (in years), which were grouped into four categories (18-31, 32-45, 46-59, and 60+). Race/ethnicity was also grouped into four categories: Hispanics (Mexican Americans and other Hispanics), non-Hispanic White, non-Hispanic Black, and other races. Educational level was categorized into three groups (<11th grade, high school graduate, and some college graduate/college graduate), and health insurance and self-rated general health condition were also included. General health condition was grouped into two categories (good and poor).

Clinical variables included body mass index (BMI), systolic blood pressure (SBP), diastolic blood pressure (DBP), HbA1c levels, LDL, HDL, total cholesterol, and waist circumference. BMI was categorized based on existing standards (>24.9 as normal weight, 25.0-29.9 as overweight, and >30 as obese). Total cholesterol was categorized as normal (<200 mg/dL) or high. Triglyceride was categorized as normal (<150mg/dL) and high (>150mg/dL). High-density lipoprotein (HDL) was categorized as normal (at least 40 mg/DL and women with at least 50 mg/dL) and poor (less than least 40 mg/DL and women with at least 50 mg/dL). Low-density lipoprotein was classified as normal (<100mg/dL) and high (>100mg/dL)and Hypertension was defined as a DBP of 90 mm Hg, SBP of 140 mm Hg, or current treatment with prescribed anti-hypertension medication. Mean systolic blood pressure was computed as the mean of the 2nd and 3rd oscillometer readings.

Diabetes was defined as individuals who had fasting sugar levels greater than 120mg/dL, HbA1c values greater than 6.5%, and those who are currently taking prescription medication for diabetes. Comorbidity was defined as individuals who had both hypertension and diabetes. Diabetes is defined as having a) fasting blood glucose of 125mg/dL b) HbA1c level greater than 6.5% c) answering ‘yes’ to whether the doctor has ever told you that you have diabetes d) answering “yes” to whether you are currently taking insulin and e) answering “yes” to whether you are taking diabetic pills to lower your blood sugar. Hypertension was defined as a) mean systolic blood pressure (the mean of the 2nd and 3rd systolic blood pressure) greater than 140mg/dl; b) mean diastolic blood pressure (the mean of the 2nd and 3rd reading) greater than

90mg/dl; c) answering "yes" to whether you are currently taking medication for hypertension and d) answering "yes" to whether the doctor has ever told you that you have hypertension.

Other variables included in this study are general health conditions, smoking status, and alcohol use. Blood pressure status, which in NHANES is obtained with the use of a questionnaire, is defined as answering "yes" to whether the doctor has ever told you that you have high blood pressure. In the NHANES dataset, the survey question is "In the past 12 months, how often did you drink any alcoholic beverage?" Men who drank more than five drinks and women who drank more than four, on average, on drinking days would be classified as alcohol users. Lifetime smoking was defined as those who answered "yes" to whether they have smoked at least 100 cigarettes in their lifetime. Participants who answered negatively to "Are you covered by health insurance or other healthcare plans?" are classified as uninsured in this study, while those who respond positively would be classified as insured. Self-rated general health was categorized from NHANES data as "Good" (answering excellent, fair, very good) and "Poor" (answering fair or poor).

3.3 Statistical Analysis

The data from the NHANES was downloaded in the Statistical Analysis System (SAS) format and then imported into SPSS for analysis. Descriptive analysis was conducted to understand the characteristics of the study population and to compare the characteristics of the comorbid population to the general population. Bivariate analysis was conducted to determine the association between comorbidity and selected study variables and their respective 95% confidence intervals. The data was exported to SAS, and a multivariate logistic regression model was used to assess the association and adjust for selected variables. P-values less than 0.05 and 95% confidence intervals were considered statistically significant.

CHAPTER IV

RESULT

4.1 Characteristics of the Study Population

The study population had a mean age of 46.6±18.6, with a nearly equal gender distribution of 48.7% male and 51.3% female. The mean BMI for the population was 29.9±7.6, with 31% classified as obese. The racial and ethnic composition of the sample included 21.9% Hispanics, 34.8% Non-Hispanic Whites, 26.4% Non-Hispanic Blacks, and 17.0% of other races. More than half of the population (56.8%) had completed college or some college degree, while 19.1% had not completed high school and 24.1% were high school graduates. Of the study population, 43.3% reported being non-smokers, 42.2% reported alcohol use, and 46.6% reported physical activity. The mean systolic and diastolic blood pressure for the study population was 124.1mmHg and 74.1mmHg, respectively (*Table 1*, *Table 2*).

Table 1: Demographics of the Study Population (Continuous)

	n	**Mean**	**STD**
Age	9693	46.6	18.6
Body Mass Index (kg/m2)	8790	29.9	7.6
Total Cholesterol (mg/dL)	8298	184.4	40.9
Fasting Glucose (mg/dL)	4173	112.9	37.5
Waist Circumference	8449	100.4	17.3
Mean Systolic Blood Pressure (mmHg)	7993	124.1	19.3
Mean Diastolic Blood Pressure (mmHg)	7993	74.1	11.7
Triglyceride (mg/dL)	4100	108.3	93.4
LDL (mg/dL)	4068	107.8	35.5
HDL (mg/dL)	8298	53.5	15.9

Table 2: Demographics of the Study Population (Categorical)

	n	%
Age (9693)		
18-31	2119	21.9
32-45	2025	20.9
46-59	2129	14.2
60+	3422	22.8
Gender (9693)		
Male	4718	48.7
Female	4975	51.3
BMI (8790)		
Normal Weight	2335	26.6
Obese	2767	31.5
Overweight	3688	42.0
Educational Level (9217)		
≤11th grade	1760	19.1
High School Graduate	2225	24.1
Some College/College Graduate	5253	56.8
Race (9693)		
Hispanics	2122	21.9
NHW	3370	34.8
NHB	2555	26.4
Others	1646	17.0
Total Cholesterol (9693)		
Normal	5691	38.0
High	9295	62.0
Current Smoking Status (3889)		
Yes	1684	43.3
No	2205	56.7
Alcohol Use (5844)		
Yes	2463	42.1
No	3381	57.9
Physical Activity (9693)		
Yes	4518	46.6
No	5174	53.4
Health Insurance (9693)		
Yes	8112	83.9
No	1554	16.1
General Health Conditions (9683)		
Good	7321	75.6
Poor	2362	24.4

4.2 Characteristics of the Comorbid Population

Individuals with comorbid diabetes and hypertension were significantly older, with a mean age of 64.1 ± 11.4, compared to those without these conditions, who had a mean age of 47.4 ± 18.5. Of the comorbid population, 69.8% were aged 60 years and above. In terms of gender, 53.2% of the comorbid population were male, and 47.5% had completed some college degree. The mean BMI of the comorbid population was 33.3 ± 7.7, with 62.0% having a BMI greater than 30.0. Regarding race and ethnicity, 32.4% of the comorbid population were non-Hispanic Whites, 32.2% were non-Hispanic Blacks, 20.7% were Hispanics, and 14.6% belonged to other races. Among the comorbid population, 69.2%, 71.3%, and 38.4% were not currently smoking, not using alcohol, and not physically active, respectively. Furthermore, 92.3% of the comorbid population was covered by health insurance, compared to 82.7% of the non-comorbid population. In line with the study's definition of smoking, 49.3% of the comorbid population were categorized as smokers, while 38.8% of the non-comorbid population were categorized as smokers. Moreover, 61.6% of the comorbid population reported being physically active, and 53.3% of the sample population rated their health condition as good. On the other hand, 54.8% of the non-comorbid population reported physical inactivity, and 21.0% reported poor health conditions. *(Table 3 & Table 4*).

Table 3: Characteristics of the HDC Population (Continuous)

	Comorbid		Not-Comorbid		
	N	Mean	n	Mean	p-value
Age	1273	64.1 ± 11.4	8420	47.4 ± 18.5	<.001
BMI (kg/m)	1163	33.2 ± 7.7	7627	29.4 ± 7.5	<.001
Waist Circumference (cm)	1095	111.4 ± 15.9	7354	98.8 ± 16.9	<.001
Fasting Glucose (mg/dl)	664	115.7 ± 58.5	3509	104.8 ± 24.8	<.001
Mean SBP (mmHg)	1070	134.4 ± 21.6	6923	122.5 ± 18.4	<.001
Mean DBP (mmHg)	1070	74.1 ± 11.7	6923	73.9 ± 11.5	<.001
HDL (mg/dl)	1117	48.4 ± 13.6	7181	54.2 ± 16.0	<.001
LDL (mg/dl)	641	96.8 ± 39.2	3427	109.8 ± 34.4	<.001
Triglyceride (mg/dl)	652	134.40± 116.1	3448	102.9 ± 87.5	<.001
Total Cholesterol (mg/dl)	1117	171.7 ± 43.2	7181	186.39 ± 40.3	<.001

Table 4: Characteristics of the HDC Population (Categorical)

	Comorbid		Not Comorbid		P-Value
	N	%	n	%	
Age					<.001
18-31	5	0.4	2114	25.1	
32-45	88	6.9	1935	23.0	
46-59	291	22.9	1838	21.8	
60+	889	69.8	2533	30.1	
Gender					<.001
Male	677	53.2	4041	48.0	
Female	596	46.8	4379	52.0	
BMI					<.001
Normal Weight	113	9.7	2067	27.1	
Overweight	329	28.2	2438	32.0	
Obese	721	61.9	2967	38.9	
Educational Level					<.001
≤11th grade	333	26.2	1427	18.0	
High School Graduate	334	26.3	1891	23.8	
Some College/College Graduate	604	47.5	4628	58.2	
Race					<.001
Hispanics	264	20.7	1858	22.1	
NHW	412	32.4	2958	35.1	
NHB	411	32.2	2144	25.5	
Others	186	14.6	1460	17.3	
Total Cholesterol					<.001
Normal	878	69.0	4813	35.1	
High	395	31.0	8900	64.9	
Lifetime Smoking Status					<.001
Yes	627	49.3	3262	38.8	
No	644	50.6	5155	61.2	
Binge Alcohol Use					<.001
Yes	98	15.7	1027	19.6	
No	523	84.2	4215	80.4	
Physical Activity					<.001
Yes	784	61.6	6200	45.2	
No	489	38.4	7513	54.8	
Health Insurance					<.001
Yes	1174	92.3	6938	82.7	
No	98	7.7	1456	17.3	
General Health Condition					<.001
Good	678	53.3	6643	79.0	
Poor	595	46.7	1767	21.0	

4.3 Logistic Regression Analysis

The odds of reporting comorbidity among age groups 32-45, 46-59, and 60+ compared to those aged 18-31 were 19.23 (7.79-47.45), 66.93 (27.59-162.39), and 148.39 (61.49-358.07), respectively. The odds of reporting comorbidity among the male population were 1.23 (1.09-1.39) times higher than in females. About normal weight, overweight and obese individuals had odds of 2.65 (2.13-3.31) and 4.78 (3.89-5.87), respectively. Those who completed less than 11th-grade education had odds of 1.79 (1.55-2.07) compared to those who completed college/some college education, while those who completed just high school education had odds of 1.35 (1.17-1.56) times the risk of reporting diabetes-hypertension comorbidity. Among races, Hispanics had odds of 1.12 (0.9-1.36), NHB had odds of 1.51 (1.25-1.81), and other races had odds of 1.12 (0.91-1.33) of reporting comorbidity compared to NHW. There were odds of 1.24 (0.22-0.28) of comorbidity among those with high levels of cholesterol compared to those with normal cholesterol levels. Those who self-reported having HDC were at odds of 3.29 (2.92-3.73) of reporting it compared to those who reported having other blood health conditions (*Table 3*).

Table 5: Bivariate Logistic Regression

	OR	95% CI
Age		
18-31	1.00	1.00
32-45	19.23	7.79-47.45
46-59	66.93	27.59-162.39
60+	148.39	61.49-358.07
Gender		
Male	1.23	1.09-1.39
Female	1.00	1.00
BMI		
Normal Weight	1.00	1.00
Overweight	2.65	2.13-3.31
Obese	4.78	3.89-5.87
Educational Level		
≤11th grade	1.79	1.55-2.07
High School Graduate	1.35	1.17-1.56
Some College/College Graduate	1.00	1.00
Race		
Hispanics	1.02	0.87-1.20
NHW	1.00	1.00
NHB	1.38	1.19-1.59
Others	0.92	0.76-1.10
Total Cholesterol		
Normal	1.00	1.00
High	1.24	0.22-0.28
Lifetime Smoking Status		
Yes	0.53	0.44-0.63
No	1.00	1.00
Binge Alcohol Use		
Yes	0.71	0.55-0.93
No	1.00	1.00
Physical Activity		
Yes	1.94	1.73-2.19
No	1.00	1.00
Health Insurance		
Yes	1.00	1.00
No	0.39	0.32-0.49
General Health Condition		
Good	1.00	1.00
Poor	3.29	2.92-3.73

4.4 Multivariate Logistic Regression Analysis

After adjusting for Age, BMI, Gender, Race, Educational Level, Total Cholesterol, Lifetime Smoking Status, Alcohol Use Physical Activity, and Health Insurance and the multivariate logic regression in Table 4 shows the association between the dependent variables (Hypertension, Diabetes, and Hypertension-Diabetes Comorbidity) and explanatory variables within the sample population. After adjusting for the independent variable, the odds of comorbidity among overweight was 2.44 (1.75-3.40) and obese 5.16 (3.75-7.08) compared to those who have normal weight. The odds of diabetes among this group is overweight at 2.14 (1.64-2.82), and obese at 4.68 (3.61-6.07); while the odds of hypertension in this group were overweight at 1.73 (1.45-2.06) and obese 3.01(2.55-3.35) compared to those who had normal weight BMI. By gender, the male sample population, had 1.30(1.15-1.48) odds of hypertension, 1.38 (1.12-1.63) odds of diabetes, and 2.44 odds of HDC compared to females after adjusting other variables. Hispanics were at 0.68 (0.57-0.81), 1.45 (1.15-1.82) 1.16 (0.85-1.46) odds of reporting, Hypertension, Diabetes, and HDC compared with NHW groups. NHB were a 1.68 (1.44-1.96), 1.43 (1.16-1.75) 1.72 (1.37-2.18) odds of reporting, Hypertension, Diabetes, and HDC compared with NHW groups, while other races were at a 1.03(0.84-1.25), 2.49 (1.93-3.23) 2.06 (1.51-2.80) odds of reporting, Hypertension, Diabetes, and HDC compared with NHW groups. Participants who completed less than 11th-grade education were at a 1.27(1.05-1.54) 1.51(1.19-1.89) and 1.61 (1.24-2.09) odds of developing diabetes, hypertension, and comorbidity respectively while participants who completed just high school education were at a 1.27 (1.09-1.48), 1.18 (0.97-1.43) and 1.22(0.98-1.52) odds of developing diabetes, hypertension, and comorbidity respectively compared to those who completed college or some college education.

After adjusting for variables there was a 1.26 (1.05-1.52) increased odds of hypertension diabetes among those who were categorized as drinkers. Participants who reported physical inactivity had increased odds of 1.36 (1.14-1.62) and 1.27(1.04-1.56) of diabetes and HDC respectively. Those who smoked ad 1.12 (0.95-1.32) odds of diabetes and 1.16(0.96-1.40) odds of HDC. *(Table 6*)

Table 6:Multivarite Logistic Regression

	HTN		**Diabetes**		**Comorbid**	
Variable	**aOR**	**CI**	**aOR**	**CI**	**aOR**	**CI**
Age						
18-31	1.00	1.00	1.00	1.00	1.00	1.00
32-45	2.33	1.89-2.88	5.86	3.58-9.61	12.61	4.56-34.88
46-59	5.99	4.86-7.400	14.23	8.79-23.04	40.78	15.02-110.73
60+	13.81	11.15-17.11	26.39	16.34-42.63	86.26	31.87-233.48
Gender						
Male	1.30	1.15-1.48	1.38	1.17-1.63	1.45	1.19-1.75
Female	1.00	1.00	1.00	1.00	1.00	1.00
BMI						
Normal weight	1.00	1.00	1.00	1.00	1.00	1.00
Overweight	1.73	1.45-2.06	2.14	1.64-2.82	2.44	1.75-3.40
Obese	3.01	2.55-3.56	4.68	3.61-6.07	5.16	3.75-7.08
Race						
Hispanics	0.68	0.57-0.81	1.45	1.15-1.82	1.16	0.85-1.46
NHW	1.00	1.00	1.00	1.00	1.00	1.00
NHB	1.68	1.44-1.96	1.43	1.16-1.75	1.72	1.37-2.16
Others	1.03	0.84-1.25	2.49	1.93-3.23	2.06	1.51-2.80
Education Level						
>11th Grade	1.27	1.05-1.54	1.51	1.19-1.89	1.61	1.24-2.09
High School Graduate	1.27	1.09-1.48	1.18	0.97-1.43	1.22	0.98-1.52
Some College/College	1.00	1.00	1.00	1.00	1.00	1.00
Total Cholesterol						
Normal	1.00	1.00	1.00	1.00	1.00	1.00
High	0.97	0.86-1.10	0.52	0.44-0.62	0.51	0.41-0.62
Lifetime Smoking						
Yes	0.78	0.70-0.86	1.12	0.95-1.32	1.16	0.96-1.40
No	1.00	1.00	1.00	1.00	1.00	1.00
Binge Alcohol Use						
Yes	1.26	1.05-1.52	1.01	0.79-1.30	1.05	0.77-1.41
No	1.00	1.00	1.00	1.00	1.00	1.00
Physical Activity						
Yes	1.00	1.00	1.00	1.00	1.00	1.00
No	1.11	0.97-1.27	1.36	1.14-1.62	1.27	1.04-1.56
Health Insurance						
Yes	1.00	1.00	1.00	1.00	1.00	1.00
No	1.29	1.09-1.55	1.17	0.91-1.51	1.38	1.06-1.99

4.5 Metabolic Disorders

As seen in *Table 5* below; among the Races, NHB had a higher proportion of hypertension (53.5%) and obesity (50.5%) in this sample population. Hispanics had a higher proportion of Triglyceride (23.7%), HDL (35.3%), and LDL (12.1%) among this study population**.** *(Table 7).*

Table 7:Metabolic Disorders by Races

	Hispanics	**NHW**	**NHB**	**Others**
Hypertension	34.3%	45.5%	53.5%	35.2%
Diabetes	19.6%	16.4%	19.1%	17.1%
Obesity	45.3%	42.1%	50.5%	24.1%
LDL (mg/dL)	12.1%	11.7%	11.7%	13.0%
HDL (mg/dL)	35.3%	29.4%	24.4%	27.5%
Triglyceride (mg/dL)	23.7%	21.1%	6.2%	22.6%

CHAPTER V

DISCUSSION

5.1 Interpretation of Findings

Hypertension and Diabetes often co-exist in individuals who reported having comorbid conditions (Chi et al., 2022, De Boer et al., 2017; Ferranni et al., 2012). There is a need to control the prevalence of hypertension and diabetes to prevent further cardiovascular disease complications (Lu et al., 2019; Wang et al., 2021). This study aims to study Hypertension and Diabetes as comorbidity and access the association between variables and the development of comorbidity among the sample population (NHANES 2017-220 Pre-pandemic dataset).

The age of individuals who reported having (HDC) in this study was significantly higher (64.1 ± 11.4) than those who did not report HDC (47.4 ± 11.4), which is consistent with findings from a similar cross-sectional analysis of a nationwide survey in Bangladesh by Ali et al., (2019). Abougalambou et al., 2013; Lu et al., 2019, also reported similar findings. Furthermore, research has shown that elevated pulse pressure, rather than mean pressure, is associated with a poorer cardiovascular outlook in middle-aged and older individuals, regardless of gender, hypertension treatment status, or a history of myocardial infarction or renal failure (Staessen et al., 2003). HDC and diabetes are associated with cognitive decline among the older population. Individuals who have HDC are at a higher risk of having a decline in cognitive function compared to those who have diabetes alone. (Hassing et al., 2004). An increase in age has been linked with a higher incidence of diseases (Abdissa et al., 2020).

This study shows that men have a higher adjusted odds of 1.53 (1.23-1.83) of developing comorbidity, with a higher prevalence among the male population. This is consistent with a cross-sectional survey study using the Korean Nutrition Examination Survey, which showed that the prevalence of hypertension and diabetes comorbidity was higher in men than women (Chi et al., 2022). Conversely, men have a higher prevalence than their female counterparts for both hypertension (1.30(1.15-1.48)) and diabetes (1.38(1.17-1.63)) and are more likely to have comorbidity. This higher prevalence among women can be explained by various biological and environmental factors (Ali et al., 2019).

The mean BMI among the comorbid population is higher compared to those without HDC (33.2 ± 7.7 vs. 29.4 ± 7.5, respectively). Waist circumference was also higher among the comorbid population compared to the non-comorbid population (111.4 ± 15.9 vs. 98.8 ± 16.9). This present study observed a positive association between BMI and hypertension, diabetes, and HDC for both overweight and obese individuals compared to the reference group (normal weight). Previous studies have also shown this association (Ali et al., 2019; Abougalambou et al., 2013; Okosun et al., 2012, Lu S, et al., 2019; Wang et al., 2021). Obesity is the most powerful confounder of the association between blood glucose and blood pressure (Ferrannin & Cushman, 2012). Excessive weight gain is associated with an increased cardiovascular risk, endothelial dysfunction, inflammation, hemodynamic alternation, and atherosclerosis. Furthermore, when a person gains weight, they develop insulin resistance, too much bad cholesterol builds up in the blood vessels, narrowing them, and eventually developing HTN. (Abdissa and Kene, 2020)

In addition to clinical and demographic factors, behavioral lifestyle choices have been identified as significant determinants of health outcomes. The present study found that binge drinking alcohol was associated with an increased risk of hypertension, while physical inactivity was associated with an increased odds of diabetes and HDC. Although smoking was not associated with Hypertension it was associated with Diabetes and HDC although not statistically significant. This trend was also observed by Sabuncu et al., 2021 who also noted a negative association between smoking and hypertension. The author explained that the result might be attributed to the fact that smokers have a lower body weight than nonsmokers. This trend can however be misleading as the negative effect of smoking on health outcomes is widely known. (Sabuncu et al., 2021). Therefore, interventions and initiatives aimed at reducing the burden of these comorbid conditions should focus on educating individuals on the impact of their lifestyle choices on their health outcomes, particularly concerning diet and physical activity. By raising awareness and promoting healthy behaviors, it may be possible to reduce the incidence and severity of hypertension, diabetes, and HDC, and improve overall health outcomes.

Ninety-two percent of the comorbid population have health insurance, with a 2.66 (2.19-3.29) adjusted odds of reporting a poor general health condition compared to 82.7% of the non-comorbid population. This is supported by Casagrande & Cowie (2018), who reported significantly higher insurance coverage in the diabetic population compared to the non-diabetic population, and Fang et al., 2016 who reported a high insurance rate among those with diabetes.

Table 5 analyzes metabolic disorders across races including Hispanics, NHB, NHW, and other races. Racial and ethnic minorities are more likely than non-Hispanic whites to have diabetes and hypertension. (Britton et al., 2018; Long et al., 2016). In this present study, NHB had the highest proportion of hypertension and obesity, Several studies have proposed possible hypotheses, including genetic makeup, biological differences, and environmental factors. Although the role of complex genetic interactions and environmental determinants has yet to be adequately studied and identified, data from Zilbermint et al., (2019) has shown a relationship between inadequate control of high blood pressure and modifiable factors like racial segregation, environmental factors like high-stress environments, and lifestyle habits including smoking and physical activity. Therefore, a proper understanding of the factors affecting this population and health policies that promote health equity in reducing the burden within this population are required (Ferdinand & Ferdinand, 2008; Musemwa & Gadegbeku, 2017). Self-management as an intervention with a clear goal (diet and physical exercise) has been shown to improve these conditions, particularly diabetes. (Dugani et al., 2021; Katz, 2014) Therefore primary care providers can encourage patients with either of the condition to own measuring devices for both sugar levels and hypertension. Clinicians supporting lifestyle change is a key tactic to reduce the burden of chronic diseases. (Williams et al., 2021). Canedo et al., 2018 suggested that a lack of insurance might explain the disparities observed in diabetes complications. There is a need for a more all-encompassing strategy to manage obesity, with a focus on the diagnosis of particular subtypes of obesity that will guide future therapy of obese people. (Okosun et al., 2019). Hispanics were disproportionately affected by cholesterol levels, including HDL, LDL, and triglycerides. This is in line with Rodriguez et al. (2014), who observed a similar increase among Hispanic communities. These metabolic syndromes are risk factors for coronary heart disease and should thus be prioritized in the distribution and development of interventions within this population (Graff et al., 2017).

5.2 Strength, Limitations, and Future Research

One of the main strengths of this study is the use of the NHANES dataset, which is a nationally representative dataset, collected using a robust methodology and sampling. However, the cross-sectional design of the survey limits the ability to establish a causal relationship between hypertension and Diabetes. The data collection design used questionnaires and in-person interviews which subjects the data to self-reported bias. The high number of refused/don't know responses in the 2017-2020 pre-pandemic dataset, especially for social proclivity variables such as smoking, may introduce bias due to nonresponse and missing values. Also, this study did not distinguish between type 1 and type 2 diabetes Melius. To further understand the relationship between hypertension and diabetes longitudinal studies are needed. Moreover, a multidisciplinary approach should be employed to investigate the role of genetics in hypertension pathogenesis in NHB communities, along with exploring the relationships among hypertension, diabetes, and kidney diseases.

5.3 Conclusion

Several factors including Age, BMI, Race/ethnicity, education level, and physical activities are closely associated with increased odds of Hypertension and Diabetes Comorbidity. These factors ought to be considered as indicators of high-risk populations when creating public health interventions aimed at reducing the prevalence of hypertension and diabetes in the United States.

REFERENCES

Abdissa, D., & Kene, K. (2020). Prevalence and Determinants of Hypertension Among Diabetic Patients in Jimma University Medical Center, Southwest Ethiopia, 2019. Diabetes, metabolic syndrome, and obesity: targets and therapy, 13, 2317–2325. https://doi.org/10.2147/DMSO.S255695

Abougalambou, S. S. I., & Abougalambou, A. S. (2013). A study evaluating prevalence of hypertension and risk factors affecting on blood pressure control among type 2 diabetes patients attending teaching hospitals in Malaysia. Diabetes & Metabolic Syndrome: Clinical Research & Reviews, 7(2), 83-86.

Ali, N., Akram, R., Sheikh, N., Sarker, A. R., & Sultana, M. (2019). Sex-specific prevalence, inequality and associated predictors of hypertension, diabetes, and comorbidity among Bangladeshi adults: results from a nationwide cross-sectional demographic and health survey. BMJ open, 9(9), e029364.

American, D. A. (2006). Diagnosis and classification of diabetes mellitus. Diabetes Care, 29(1), S43-8. Retrieved from https://www.proquest.com/scholarly-journals/diagnosis-classification-diabetes-mellitus/docview/223032673/se-2

American Diabetes Association; Economic Costs of Diabetes in the U.S. in 2017. Diabetes Care 1 May 2018; 41 (5): 917–928. https://doi.org/10.2337/dci18-0007

American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2010 Jan;33 Suppl 1(Suppl 1):S62-9. doi: 10.2337/dc10-S062. Erratum in: Diabetes Care. 2010 Apr;33(4):e57. PMID: 20042775; PMCID: PMC2797383

Amerircan Heart Association: High blood pressure. Accessed May 23 2023, from https://www.heart.org/en/health-topics/high-blood-pressure/the-facts-about-high-blood-pressure/what-is-high-blood-pressure

Ariza MA, Vimalananda VG, Rosenzweig JL. The economic consequences of diabetes and cardiovascular disease in the United States. Rev Endocr Metab Disord. 2010 Mar;11(1):1-10. doi: 10.1007/s11154-010-9128-2. PMID: 20191325

Bailes BK. Diabetes mellitus and its chronic complications. AORN J. 2002 Aug;76(2):266-76, 278-82; quiz 283-6. doi: 10.1016/s0001-2092(06)61065-x. PMID: 12194653.

Berraho, M., El Achhab, Y., Benslimane, A., Rhazi, K. E., Chikri, M., & Nejjari, C. (2012). Hypertension and type 2 diabetes: a cross-sectional study in Morocco (EPIDIAM Study). Pan African Medical Journal, 11(1).

Britton LE, Berry DC, Hussey JM. Comorbid hypertension and diabetes among U.S. women of reproductive age: Prevalence and disparities. J Diabetes Complications. 2018 Dec;32(12):1148-1152. doi: 10.1016/j.jdiacomp.2018.09.014. Epub 2018 Sep 26. PMID: 30291018; PMCID: PMC6289742.

Canedo, J. R., Miller, S. T., Schlundt, D., Fadden, M. K., & Sanderson, M. (2018). Racial/Ethnic Disparities in Diabetes Quality of Care: the Role of Healthcare Access and Socioeconomic Status. Journal of racial and ethnic health disparities, 5(1), 7–14. https://doi.org/10.1007/s40615-016-0335-8

Carey RM, Whelton PK. New findings bearing on the prevention, detection and management of high blood pressure. Curr Opin Cardiol. 2021 Jul 1;36(4):429-435. doi: 10.1097/HCO.0000000000000864. PMID: 34059611; PMCID: PMC8175002.

Center for disease control and prevention. Retrieved May 12, 2023. https://www.cdc.gov/heartdisease/statistics_maps.htm

Centers for Disease Control and Prevention High blood pressure. Accessed April 23 2023 from https://www.cdc.gov/bloodpressure/facts.htm

Centers for Disease Control and Prevention. Diabetes. Accessed April 23 2023 from https://www.cdc.gov/diabetes/basics/quick-facts.html

Chi JH, Lee BJ (2022) Risk factors for hypertension and diabetes comorbidity in a Korean population: A cross-sectional study. PLoS ONE 17(1): e0262757. https://doi.org/10.1371/journal.pone.0262757

Climie, R. E., van Sloten, T. T., Bruno, R. M., Taddei, S., Empana, J. P., Stehouwer, C. D., ... & Laurent, S. (2019). Macrovasculature and microvasculature at the crossroads between type 2 diabetes mellitus and hypertension. Hypertension, 73(6), 1138-1149.

Colosia, A. D., Palencia, R., & Khan, S. (2013). Prevalence of hypertension and obesity in patients with type 2 diabetes mellitus in observational studies: a systematic literature review. Diabetes, metabolic syndrome and obesity: targets and therapy, 327-338.

Commodore-Mensah Y, Turkson-Ocran RA, Foti K, Cooper LA, Himmelfarb CD. Associations Between Social Determinants and Hypertension, Stage 2 Hypertension, and Controlled Blood Pressure Among Men and Women in the United States. Am J Hypertens. 2021 Aug 9;34(7):707-717. doi: 10.1093/ajh/hpab011. PMID: 33428705; PMCID: PMC8351505.

Cryer, M. J., Horani, T., & DiPette, D. J. (2016). Diabetes and Hypertension: A Comparative Review of Current Guidelines. Journal of clinical hypertension (Greenwich, Conn.), 18(2), 95–100. https://doi.org/10.1111/jch.12638

David L. Katz, Diet and Diabetes: Lines and Dots, The Journal of Nutrition, Volume 144, Issue 4, April 2014, Pages 567S–570S, https://doi.org/10.3945/jn.113.182923

De Boer, I. H., Bangalore, S., Benetos, A., Davis, A. M., Michos, E. D., Muntner, P., ... & Bakris, G. (2017). Diabetes and hypertension: a position statement by the American Diabetes Association. Diabetes care, 40(9), 1273-1284.

Deshpande AD, Harris-Hayes M, Schootman M. Epidemiology of diabetes and diabetes-related complications. Phys Ther. 2008 Nov;88(11):1254-64. doi: 10.2522/ptj.20080020. Epub 2008 Sep 18. PMID: 18801858; PMCID: PMC3870323.

Dugani SB, Mielke MM, Vella A. Burden and management of type 2 diabetes in rural United States. Diabetes Metab Res Rev. 2021 Jul;37(5):e3410. doi: 10.1002/dmrr.3410. Epub 2020 Oct 5. PMID: 33021052; PMCID: PMC7990742.

Emdin, C. A., Anderson, S. G., Woodward, M., & Rahimi, K. (2015). Usual Blood Pressure and Risk of New-Onset Diabetes: Evidence From 4.1 Million Adults and a Meta-Analysis of Prospective Studies. Journal of the American College of Cardiology, 66(14), 1552–1562. https://doi.org/10.1016/j.jacc.2015.07.059

Fang, J., Zhao, G., Wang, G., Ayala, C., & Loustalot, F. (2016). Insurance status among adults with hypertension—the impact of underinsurance. Journal of the American Heart Association, 5(12), e004313.

Ferdinand KC, Ferdinand DP. Race-based therapy for hypertension: possible benefits and potential pitfalls. Expert Rev Cardiovasc Ther. 2008;6(10):1357–66.

Ferrannini, E., & Cushman, W. C. (2012). Diabetes and hypertension: the bad companions. The Lancet, 380(9841), 601-610.

Giles, T. D., Materson, B. J., Cohn, J. N., & Kostis, J. B. (2009). Definition and classification of hypertension: an update. Journal of clinical hypertension (Greenwich, Conn.), 11(11), 611–614. https://doi.org/10.1111/j.1751-7176.2009.00179.x

Guo F, He D, Zhang W, Walton RG. Trends in prevalence, awareness, management, and control of hypertension among United States adults, 1999 to 2010. J Am Coll Cardiol. 2012 Aug 14;60(7):599-606. doi: 10.1016/j.jacc.2012.04.026. Epub 2012 Jul 11. PMID: 22796254.

Ian H. de Boer, Sripal Bangalore, Athanase Benetos, Andrew M. Davis, Erin D. Michos, Paul Muntner, Peter Rossing, Sophia Zoungas, George Bakris; Diabetes and Hypertension: A Position Statement by the American Diabetes Association. Diabetes Care 1 September 2017; 40 (9): 1273–1284. https://doi.org/10.2337/dci17-0026

Hirode, G., & Wong, R. J. (2020). Trends in the prevalence of metabolic syndrome in the United States, 2011-2016. Jama, 323(24), 2526-2528.

Hassing, L. B., Hofer, S. M., Nilsson, S. E., Berg, S., Pedersen, N. L., McClearn, G., & Johansson, B. (2004). Comorbid type 2 diabetes mellitus and hypertension exacerbates cognitive decline: evidence from a longitudinal study. Age and ageing, 33(4), 355–361. https://doi.org/10.1093/ageing/afh100

Lu S, Bao MY, Miao SM, Zhang X, Jia QQ, Jing SQ, Shan T, Wu XH, Liu Y. Prevalence of hypertension, diabetes, and dyslipidemia, and their additive effects on myocardial infarction and stroke: a cross-sectional study in Nanjing, China. Ann Transl Med. 2019 Sep;7(18):436. doi: 10.21037/atm.2019.09.04. PMID: 31700872; PMCID: PMC6803213.

Long, E., Ponder, M., & Bernard, S. (2017). Knowledge, attitudes, and beliefs related to hypertension and hyperlipidemia self-management among African-American men living in the southeastern United States. Patient education and counseling, 100(5), 1000-1006.

Lynch, E. B., Liebman, R., Ventrelle, J., Avery, E. F., & Richardson, D. (2014). A self-management intervention for African Americans with comorbid diabetes and hypertension: a pilot randomized controlled trial. Preventing chronic disease, 11, E90. https://doi.org/10.5888/pcd11.130349

Malaguarnera M, Vacante M, Frazzetto PM, Motta M. The role of diabetes and aging in the determinism of hypertension and the related cerebrovascular complications. Arch Gerontol Geriatr. 2012 Sep-Oct;55(2):221-5. doi: 10.1016/j.archger.2011.08.008. Epub 2011 Sep 13. PMID: 21920611.

Musemwa, N., Gadegbeku, C.A. Hypertension in African Americans. Curr Cardiol Rep 19, 129 (2017). https://doi.org/10.1007/s11886-017-0933-z

National Health and Nutrition Examination Survey. (NHANES). Accessed January 20, 2023. From https://wwwn.cdc.gov/nchs/nhanes/

Nouh, F., Omar, M., & Younis, M. (2017). Prevalence of hypertension among diabetic patients in Benghazi: a study of associated factors. Asian Journal of Medicine and Health, 6(4), 1-11.

Okosun, I. S., Chandra, K. D., Choi, S., Christman, J., Dever, G. A., & Prewitt, T. E. (2001). Hypertension and type 2 diabetes comorbidity in adults in the United States: risk of overall and regional adiposity. Obesity Research, 9(1), 1-9.

Okosun, I. S., Okosun, B., Lyn, R., & Henry, T. L. (2019). Chronic medical conditions-based obesity phenotypes: A two-step cluster analysis of a representative sample of obese American adults. Diabetes & Metabolic Syndrome: Clinical Research & Reviews, 13(5), 2897-2905

Ostchega Y, Fryar CD, Nwankwo T, Nguyen DT. Hypertension Prevalence Among Adults Aged 18 and Over: United States, 2017-2018. NCHS Data Brief. 2020 Apr;(364):1-8. PMID: 32487290.

Petrie JR, Guzik TJ, Touyz RM. Diabetes, Hypertension, and Cardiovascular Disease: Clinical Insights and Vascular Mechanisms. Can J Cardiol. 2018 May;34(5):575-584. DOI: 10.1016/j.cjca.2017.12.005. Epub 2017 Dec 11. PMID: 29459239; PMCID: PMC5953551.

Rodriguez, C. J., Daviglus, M. L., Swett, K., González, H. M., Gallo, L. C., Wassertheil-Smoller, S., Giachello, A. L., Teng, Y., Schneiderman, N., Talavera, G. A., & Kaplan, R. C. (2014). Dyslipidemia patterns among Hispanics/Latinos of diverse background in the United States. The American journal of medicine, 127(12), 1186–94.e1. https://doi.org/10.1016/j.amjmed.2014.07.026

Schmidt A. M. (2018). Highlighting Diabetes Mellitus: The Epidemic Continues. Arteriosclerosis, thrombosis, and vascular biology, 38(1), e1–e8. https://doi.org/10.1161/ATVBAHA.117.310221

Sabuncu, T., Sonmez, A., Eren, M. A., Sahin, I., Çorapçioğlu, D., Üçler, R., ... & Araz, M. (2021). Characteristics of patients with hypertension in a population with type 2 diabetes mellitus. Results from the Turkish Nationwide SurvEy of Glycemic and Other Metabolic Parameters of Patients with Diabetes Mellitus (TEMD Hypertension Study). Primary Care Diabetes, 15(2), 332-339.

Sun D, Zhou T, Heianza Y, Li X, Fan M, Fonseca VA, Qi L. Type 2 Diabetes and Hypertension. Circ Res. 2019 Mar 15;124(6):930-937. doi: 10.1161/CIRCRESAHA.118.314487. PMID: 30646822; PMCID: PMC6417940.

Tsimihodimos, V., Gonzalez-Villalpando, C., Meigs, J. B., & Ferrannini, E. (2018). Hypertension and Diabetes Mellitus: Coprediction and Time Trajectories. Hypertension (Dallas, Tex. : 1979), 71(3), 422–428. https://doi.org/10.1161/HYPERTENSIONAHA.117.10546

Wang Z, Yang T, Fu H. Prevalence of diabetes and hypertension and their interaction effects on cardio-cerebrovascular diseases: a cross-sectional study. BMC Public Health. 2021 Jun 25;21(1):1224. DOI: 10.1186/s12889-021-11122-y. PMID: 34172039; PMCID: PMC8229421.

Williams, A. R., Wilson-Genderson, M., & Thomson, M. D. (2021). A cross-sectional analysis of associations between lifestyle advice and behavior changes in patients with hypertension or diabetes: NHANES 2015–2018. Preventive Medicine, 145, 106426.

Zilbermint, M., Hannah-Shmouni, F., & Stratakis, C. A. (2019). Genetics of Hypertension in African Americans and Others of African Descent. International journal of molecular sciences, 20(5), 1081. https://doi.org/10.3390/ijms20051081