ETHNIC VARIATIONS IN CARDIOVASCULAR DISEASE (CVD) RISK FACTORS- IMPLICATIONS ON PREVALENT CVD AND CVD MORTALITY

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Abstract

Cardiovascular disease (CVD) remains a prevalent global health concern, contributing significantly to morbidity and mortality rates. While ethnicity itself is not a direct cause of CVD, certain ethnic groups exhibit a higher prevalence and susceptibility to cardiovascular conditions, stemming from a blend of genetic, environmental, and socio-cultural determinants of health. Recognizing these disparities is pivotal for the development of targeted interventions and policies aimed at reducing health inequalities and fostering health equity. This study employed data from the National Health and Nutritional Examination Survey (NHANES) spanning from 2011 to 2020 to conduct a cross-sectional analysis of the ethnic differences in how CVD risk factors relate with prevalent CVD and CVD mortality. Exploring differences in CVD risk factors between diverse ethnic groups holds the potential to address disparities in healthcare, enhance risk assessment, and optimize treatment strategies through precisely targeted preventive interventions for ethnic minorities.

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Chapter 1.0 Introduction

Cardiovascular disease (CVD) remains a leading cause of worldwide morbidity and mortality, and its prevalence varies among different ethnic groups (1). The relationship between ethnicity, CVD risk and CVD mortality is complex, influenced by a multitude of factors. This study aims to explore the association between ethnicity and CVD risk factors, including physical inactivity, obesity, hypertension, type 2 diabetes (T2D), healthcare access and low family income. Understanding these relationships can shed light on the underlying mechanisms contributing to ethnic disparities in CVD risk and inform targeted prevention and intervention strategies. Numerous studies explore the impact of ethnicity on CVD risk factors, revealing variations in prevalence, risk factors, and health outcomes among diverse ethnic groups (2). Uncovering ethnic-specific patterns and disparities in relation to obesity, hypertension, diabetes, and lifestyle in CVD prevention, diagnosis, and management is paramount, and may enhance our understanding and facilitate tailored approaches to enhance cardiovascular health outcomes in ethnic minority groups. By investigating how ethnicity influences the prevalence, distribution, and impact of CVD risk factors, the study aims to provide valuable insights into the complex interplay between ethnicity, CVD risk factors and prevalent CVD and CVD mortality.

Chapter 2.0 Review of related literature

2.1 Ethnicity

Ethnicity refers to a social and cultural identity shared by a group of people who have common historical, cultural, linguistic, or ancestral traits that distinguish them from other groups (2). Ethnicity has been identified as a risk factor for CVD due to the complex interplay of genetic, environmental, and socio-cultural factors. While it is important to note that ethnicity itself does not directly cause CVD, certain ethnic groups have been found to have a higher prevalence and susceptibility to cardiovascular conditions such as hypertension, diabetes and coronary artery disease (2). Within the context of health disparities, ethnicity has been observed to have diverse impacts on the occurrence of heart disease. Black individuals not only have a higher incidence of hypertension and are more susceptible to developing heart diseases at an earlier age (3), but also bear a greater burden of traditional CVD risk factors such as obesity, diabetes, and sedentary lifestyles when compared to other ethnic groups (4). Research has indicated that Asians may also have a different risk profile for CVD compared to other ethnic groups. For example, Asians have a higher risk of CVD despite having a lower prevalence of traditional risk factors such as obesity as compared to those of White ethnicity (4). This suggests the relationship between certain risk factors may differ in how they relate with CVD risk in the Asian population. These ethnic differences may highlight the need for ethnic-specific approaches to CVD prevention and management. Excluding certain ethnic groups from research can introduce biases and limit the understanding of CVD risk and optimal management strategies in those populations. Thus, recognizing the influence of ethnicity as a risk factor for CVD, inclusive research becomes crucial in informing healthcare providers on delivering patient-centered care. By understanding the intricate interplay of genetic, environmental, and socio-cultural factors,

healthcare providers can ensure that their care is based on scientific evidence and tailored to the diverse ethnic backgrounds of the individuals they serve.

2.2 CVD

Cardiovascular disease (CVD) is a leading cause of morbidity and mortality in the United States (1), placing a significant burden on public health. Major risk factors include high blood cholesterol, hypertension, diabetes, cigarette smoking, binge drinking, obesity, and physical inactivity (1). CVD encompasses several conditions including coronary artery disease, heart failure, and stroke (1). The economic impact of CVD is considerable, encompassing both direct medical costs and indirect costs resulting from lost productivity (5). In 2016, the total cost of CVD to the U.S., including both direct and indirect expenses, amounts to $555 billion (5). This cost is projected to soar to $1.1 trillion by 2035 (5). The indirect costs of CVD, including lost productivity due to illness and premature death, are substantial. For example, the indirect cost of CVD alone currently is $237 billion, which amounts to 42.7% of total costs (5).

The high prevalence of CVD contributes to elevated mortality rates, with significant disparities observed among different ethnic groups; for instance, age-adjusted heart disease death rates per 100,000 are 168.1 for Whites compared to 82.0 for Asians (6). Conversely, Blacks have a higher prevalence of CVD than Whites (7). Research consistently shows that hypertension is notably more prevalent among Blacks, contributing to their elevated CVD risk (8). Additionally, Blacks experience higher rates of diabetes and obesity, which are critical risk factors for CVD (9). Hispanics present a mixed profile regarding CVD prevalence (10). While they have higher rates of diabetes and obesity, studies suggest that they have lower smoking rates compared to Whites and Blacks, (11). However, the higher prevalence of no leisure-time physical activity among Hispanics may contribute to their CVD

burden (12). Among Asians, the prevalence of CVD varies significantly by subgroup (6). For instance, South Asians have a higher risk of CVD compared to Whites, largely due to higher rates of diabetes, and central obesity (6). Conversely, East Asians tend to have a lower prevalence of CVD, likely due to lower obesity rates (6). Cultural and behavioral factors further influence CVD risk. For example, traditional western diets high in saturated fats and low in fruits and vegetables are common in some Black and Hispanic communities, contributing to higher rates of obesity and diabetes (7). Conversely, certain Asian subgroups maintain their traditional diets rich in vegetables and fish, which may offer protective benefits against CVD (7). Genetic predispositions also play a role; South Asians, for instance, have a higher genetic susceptibility to central obesity, increasing their CVD risk even at lower BMI levels compared to other ethnic groups (7). Addressing CVD disparities is vital for several reasons. First, reducing these disparities is essential for achieving health equity, as minority populations often experience a disproportionate burden of CVD due to a combination of socioeconomic, cultural, and genetic factors. Addressing these disparities can lead to more equitable health outcomes. CVD mortality rates vary significantly across ethnic groups, with distinct patterns observed among Asians, Blacks, and Hispanics. South Asians have a statistically significant increased risk of CVD-related mortality, with a 32% higher risk compared to Whites (13). This elevated risk persists even after adjusting for sociodemographic, lifestyle, environmental, and clinical factors (13). In contrast, studies on CVD mortality among Blacks present mixed results (13). While some research indicates higher CVD mortality rates among Blacks, particularly in the United States, other studies suggest lower rates in certain contexts (13). For instance, studies identified that Blacks had the highest cardiovascular death rate (6.1%) compared to other ethnic groups (3.9%; P=0.01) (13). Regarding Hispanics, literature on CVD mortality suggest lower mortality rates compared to Whites, a phenomenon often referred to as the "Hispanic paradox" (14). This

paradox indicates that despite higher rates of diabetes and obesity among Hispanics, their CVD mortality remains lower, potentially due to stronger social support networks, healthier behaviors, and genetic factors (15). Asian populations generally exhibit lower CVD mortality rates compared to other ethnic groups, with studies reporting significantly lower cardiovascular death rates in all three Asian ethnic groups (overall, 2.1%) compared to other groups (4.5%; P<.001) (13). However, it's important to acknowledge the heterogeneity within Asian populations. Additionally, cultural and behavioral factors, including dietary habits and physical activity levels influenced by cultural norms, can impact CVD mortality rates across different ethnic groups.

2.3 Physical Activity

Physical activity (PA) has been extensively studied and shown to have numerous positive effects on reducing the risk and management of CVD (16). PA contributes to lower blood pressure, healthy body weight, improved heart function, reduced risk of recurrent cardiac events, enhanced blood circulation, optimized lipid profile, reduced inflammation, decreased oxidative stress, enhanced insulin sensitivity and lowered risk of type 2 diabetes (16). Moreover, it is crucial to recognize that physical inactivity is comparable to tobacco use and high cholesterol as an independent risk factor for CVD (16). The American Heart Association (AHA) recommends adults engage in at least 150 minutes of moderate-intensity aerobic activity or 75 minutes of vigorous-intensity aerobic activity per week to achieve cardiovascular benefits (16). This guideline encompasses multiple domains of physical activity, which include leisure-time physical activity (LTPA), occupational physical activity (OPA), transport-related physical activity and household physical activity (16). LTPA refers to exercise or recreational activities that individuals engage in during their free time (16). It is frequently emphasized in physical activity guidelines and public health recommendations. LTPA shows considerable variation across different ethnic groups due to SES. Generally,

Whites report higher levels of LTPA compared to other ethnic groups (12)(17)(18). Asians also exhibit varying patterns of LTPA, with significant differences between subgroups (17). East Asian populations often report higher levels of LTPA compared to South Asian populations (18).

OPA encompasses the physical activities performed as part of one's job. This domain is especially relevant for individuals working in manual labour or physically demanding occupations (19). When it comes to OPA, Hispanic individuals often report higher levels of OPA compared to other ethnic groups (12). This higher OPA may partially compensate for their lower LTPA levels in terms of overall physical activity (12). Black individuals, especially those from lower socioeconomic status (SES) groups, may also have higher levels of OPA due to their occupational patterns (12,19). However, higher OPA does not necessarily translate to better health outcomes, as it may also be associated with increased stress and physical strain (20). Asians show diverse OPA levels depending on socioeconomic factors and occupation types, with some studies suggesting that recent Asian immigrants may have higher OPA compared to more established Asian American populations (18).

Transportation-related PA includes walking or cycling for purposes such as commuting to work or running errands (16). In urban areas with good infrastructure, transportation-related PA can be a significant daily activity source (21). Some studies indicate that recent immigrants, especially those from Asian and Hispanic backgrounds, may engage in more transportation-related PA due to lower car ownership rates (18).

Household PA encompasses activities like cleaning, gardening, and other domestic chores (16). Women across all ethnic groups generally report higher levels of household PA compared to men, with Hispanic and Black women potentially engaging in more household PA than White women due to cultural and socioeconomic factors (21).

A comprehensive assessment of PA levels should consider all domains—to understand their impact on CVD risk. Relying solely on LTPA might offer an incomplete view of an individual's total PA. For example, individuals with high OPA but low LTPA might still reach sufficient overall PA levels for cardiovascular benefits (14). Different ethnic groups often display varying PA patterns across these domains. Hispanic individuals might show lower LTPA but higher OPA, while Asian populations might engage more in transportation-related PA (21). From a physiological standpoint, PA regardless of domain should have health benefits. By including all domains, guidelines can be more inclusive and allow for different types of PA that may be more relevant to diverse populations.

2.4 Metabolic Risk Factors

Obesity is a medical condition marked by excessive body fat accumulation, posing significant health risks (22). It is typically measured using the Body Mass Index (BMI), calculated as weight in kilograms divided by the square of height in meters (kg/m^2) (22). Obesity is strongly linked to various health complications, with CVD being a major concern (23). Specifically, obesity elevates the risk of coronary artery disease, stroke, and heart failure (22). Additionally, it contributes to the onset of other CVD risk factors, including hypertension, dyslipidemia, and insulin resistance (11). Ethnicity plays a significant role in the relationship between body mass index (BMI) and its health implications (23). Asians have lower BMI cut-offs for obesity compared to other ethnic groups, because of their higher risk for obesity comorbidities at lower BMIs (24). This is, in part, due to differences in body composition and fat distribution (23). According to NHANES data, Asian adults exhibit the lowest prevalence of obesity (17.4%) even when the lower ethnic-specific BMI cut-offs are used, while White adults have a prevalence of 42.2% and Black adults have the highest prevalence of obesity at 49.6% (23). Further, CVD risk may be higher for Black and Asian

individuals at lower BMI levels compared to White individuals (25). This may be attributed to genetic and metabolic differences that affect fat distribution and metabolism, contributing to CVD risk (25). Conversely, Blacks and Hispanics generally experience a higher prevalence of obesity-related CVD risk factors such as hypertension and diabetes (11). Whites, while generally exhibiting lower obesity prevalence and associated CVD risks compared to Blacks and Hispanics, still face higher rates than Asians (11). Health risks linked to obesity and CVD are extensive across all ethnic groups. Additionally, South Asian populations face an elevated risk of metabolic syndrome, and Asian populations may experience higher body fat percentages at lower BMIs, potentially leading to increased cardiovascular risks even at lower weight levels (24). Ethnic differences in obesity and CVD risks are influenced by a combination of factors including genetic predispositions, environmental elements such as diet and physical activity, socioeconomic conditions, and cultural norms related to body weight and health behaviors. In conclusion, the impact of obesity on CVD risk is significant across all ethnic groups, but the prevalence and specific health risks differ markedly. Asian populations may encounter heightened CVD risks at lower BMI levels compared to other ethnic groups, emphasizing the need for ethnicity-specific strategies in obesity prevention and CVD risk reduction (24). Therefore, understanding these ethnic differences in CVD risk and BMI status is crucial for developing targeted BMI cut-offs and policies to address the unique cardiovascular health profiles among different ethnic groups (26).

Additionally, hypertension and Type 2 Diabetes (T2D) exhibit notable disparities across ethnicities. Hypertension is more prevalent among Blacks, affecting 39-43% of this group compared to 27-30% of Whites, 26-28% of Hispanics, and 25% of Asians in the U.S (27). Control of blood pressure is less effective among Hispanic (40%), Black (39%), and Asian (38%) individuals compared to White individuals (49%), and these disparities persist even after accounting for SES factors (8). Black individuals are diagnosed with hypertension

at an earlier age and face greater morbidity and mortality, including a 30% higher risk of fatal stroke, a 50% higher risk of CVD mortality compared to Whites (8). For hypertension, an increase of 20 mm Hg in systolic blood pressure and 10 mm Hg in diastolic blood pressure from a baseline of 115/75 mm Hg doubles the risk of a cardiovascular event, whereas a reduction of 5 mm Hg in systolic BP lowers the risk of major heart problems by about 9% among individuals without prior CVD (28).

Similarly, T2D is 2-4 times more common in ethnic minority communities than in White populations, with Hispanics being more than twice as likely to have diabetes compared to their White counterparts (29). People with T2D are twice as likely to suffer a heart attack or stroke compared to those without, and diabetes can damage blood vessels in the heart, brain, and kidneys, leading to higher levels of triglycerides and LDL cholesterol (28). Thus, the prevalence of traditional CVD risk factors varies among ethnic groups and may contribute to ethnic differences in CVD.

2.5 Socioeconomic (SES) Risk Factors

Socioeconomic status (SES) has consistently been shown to significantly impact health outcomes, particularly CVD risk and mortality, across various ethnic groups (30). Overall disparities among ethnic communities often reflect significant differences in economic development, health conditions, and educational attainment. Black and Hispanic populations generally experience poorer outcomes compared to White individuals across various measures of social determinants of health (31). Ethnic minorities are more likely to face poverty and have lower incomes than Whites, with Blacks and Hispanics showing higher poverty rates (7). Educational attainment also reveals disparities, with some minority groups exhibiting lower rates of high school and college completion (28). Specifically, Black and Hispanics are less likely to hold a bachelor’s degree or higher compared to their White

counterparts (28). In terms of employment, unemployment rates are higher among ethnic minorities compared to White individuals (7). Housing disparities are evident as well, with ethnic minorities more frequently residing in disadvantaged neighborhoods with limited resources and having lower homeownership rates. Health insurance coverage also varies significantly, with Hispanics less likely to have health insurance compared to Whites, Blacks and Asians, particularly in pre-retirement years (31). Studies reveal an inverse relationship between SES and CVD risk across ethnic groups, with lower SES being associated with higher risks of CVD incidence and mortality in both high-income families and low- and middle-income (31). Studies have highlighted that while the association between low SES and CVD is evident across ethnicities, its strength varies among different groups (32). Ethnic minorities, particularly Black and Hispanic populations in the United States, face a disproportionate burden of CVD risk related to low SES (32). Blacks experience higher rates of CVD mortality compared to Whites, with a significant portion of this disparity attributed to SES factors (32). This disparity is particularly pronounced among individuals younger than 65 years, indicating the impact of early-life socioeconomic disadvantages (32). The relationship between SES and CVD risk in Asians is complex and varies among subgroups; for example, South Asians have been found to have higher CVD mortality risk compared to Whites, partially attributable to SES factors (33). Addressing SES-related ethnic disparities in CVD risk is crucial for several reasons. First, it is essential for achieving health equity and social justice across populations. CVD imposes a significant economic burden on healthcare systems and society. By reducing CVD prevalence among high-risk ethnic groups, substantial cost savings can be achieved through decreased medical interventions and improved productivity. Lastly, improving CVD outcomes in disadvantaged populations can enhance overall population health metrics. Several factors contribute to these ethnic disparities in CVD mortality. SES plays a crucial role, with lower SES being associated with higher CVD

mortality across all ethnic groups, but often having a more pronounced impact on minority populations due to historical and systemic inequalities (33). Access to healthcare also significantly influences CVD mortality differences, as minority groups frequently encounter barriers to quality healthcare, leading to delayed diagnosis and treatment of CVD risk factors (33). Two critical SES factors affecting ethnic minorities are low family income and lack of healthcare access (31). Low family income is associated with higher CVD risk across ethnic groups, with the impact often more pronounced in certain minorities (33). For instance, low-income Black and Hispanics frequently encounter compounded disadvantages, such as living in food deserts and areas with limited physical activity opportunities (28). Additionally, lack of access to quality healthcare, including financial barriers like lack of insurance and non-financial barriers such as language and cultural issues, further exacerbates CVD outcomes for these populations (28). Limited access to preventive care and early interventions contributes to worse health outcomes (34). Addressing SES-related ethnic disparities in CVD risk requires multifaceted interventions. Policy-level actions should focus on reducing income inequality, improving education, and enhancing healthcare access for disadvantaged populations. Community-based programs must develop culturally tailored interventions to promote healthy lifestyles and CVD prevention in low-SES communities. Healthcare system improvements should aim to enhance cultural competence and access to quality care for ethnic minorities. Furthermore, ongoing research is needed to better understand the complex interactions between SES, ethnicity, and CVD risk and to evaluate the effectiveness of interventions in reducing disparities. In conclusion, the impact of SES factors on CVD risk varies significantly across ethnic groups, with certain minorities facing disproportionate burdens. Addressing these disparities, especially those related to low family income and healthcare access, is essential for achieving health equity and improving overall population

health. Future efforts should focus on understanding and mitigating the complex interplay between SES, ethnicity, and CVD risk.

Chapter 3.0 Manuscript

3.1 Introduction

CVD remains a leading cause of morbidity and mortality worldwide, with significant public health implications. In the United States, CVD burden varies significantly across ethnic groups, leading to pronounced disparities in prevalence and mortality rates (10). Understanding the risk factors contributing to these disparities is essential for developing targeted interventions and policies to address CVD's impact on diverse populations. Ethnic differences in risk factors such as physical inactivity, T2D, hypertension, low family income, obesity, and healthcare access are well-documented (10). However, how these risk factors may differ by ethnicity in their association with CVD prevalence and mortality is less explored. This manuscript aims to address this gap by examining ethnic differences in these risk factors and their associations with CVD outcomes. Ethnic minorities often face unique barriers to physical activity due to socioeconomic and environmental constraints. Similarly, the prevalence of T2D and hypertension varies by ethnicity, and is influenced by lifestyle, and healthcare access. SES is a critical health determinant, often associated with limited access to nutritious foods, and quality healthcare. Obesity, a major CVD risk factor, is more prevalent in certain ethnic groups, exacerbated by socioeconomic and cultural factors. Disparities in healthcare access further increase CVD risk, especially in underserved populations. This study investigates how ethnic variations in CVD risk factors, adjusted for sex and age, contribute to disparities in CVD prevalence and mortality. By analyzing data from White, Black, Hispanic, and Asian populations, we aim to help clarify the complex

interplay between these risk factors and their impact on cardiovascular health. Our findings will offer insights for public health strategies to reduce CVD disparities and improve cardiovascular health equity across ethnic groups.

3.2 Materials and Methods

3.2.1 Study Design and Data Source

This study is a cross-sectional study using data from the National Health and Nutritional Examination Survey (NHANES) 2011-2020. The NHANES is a nationally representative survey conducted by the Centers for Disease Control and Prevention (CDC) in the United States (35)

3.2.2 Study Sample

The dataset initially included 39,156 individuals. Participants under the age of 40 and over the age of 80 were excluded to focus on those with a higher likelihood of experiencing lifestyle associated CVD risk (n=15,066). Participants with missing data for variables of interest or a BMI below 18.5 kg/m^2 were excluded from the analytical dataset (n=6735). Those in the "other" ethnic group category were also excluded (n=1996) due to low sample size, leaving 17,355 individuals.

3.2.3 Survey Methods

Age, sex, ethnicity, poverty-income ratio, physical activity status, access to health insurance were obtained during the interview portion of the survey by trained personnel (36). Metabolic variable data were collected through standardized procedures using regularly calibrated devices during physical examinations (37). The survey incorporated health assessments conducted at mobile examination units and home interviews (37). In this study, all analyses were performed in accordance with relevant guidelines and regulations. Public-use data files

were used and thus these analyses do not require further ethical review from York University's Research Ethics board.

3.3 Variables

3.3.1 Ethnicity

The RIDRETH3 variable in NHANES represents the respondent's self-reported ethnicity or race (38). During the interview, participants are asked to select the category that best represents their ethnicity or race from a predetermined list of options. The response options for the RIDRETH3 variable include Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian or Other – including multi-racial (39). For this study, the sample will be stratified into four categories: White, Black, Asian, and Hispanic (Mexican American and Other Hispanic).

3.3.2 Cardiovascular Disease (CVD)

Participants who answered, 'yes' to the question: "Has a doctor or other health professional ever told you that you had a myocardial infarction, coronary heart disease, or stroke?" were considered to have cardiovascular disease (40)

3.3.3 Physical Activity Status

Individuals were considered physically active if the sum of the reported durations for vigorous-intensity leisure activities, moderate-intensity leisure activities, vigorous-intensity activities at work, and moderate-intensity activities at work was equal to or exceeded 150 minutes per week (37). The questions asked are as follows: "How much time {do you/does SP} spend doing vigorous-intensity sports, fitness or recreational activities on a typical day?" "How much time {do you/does SP} spend doing moderate-intensity sports, fitness or

recreational activities on a typical day?" "How much time {do you/does SP} spend doing vigorous-intensity activities at work on a typical day?" "How much time {do you/does SP} spend doing moderate-intensity activities at work on a typical day?" (37)

3.3.4 Obesity

During the NHANES examination, participants' height and weight measurements were taken by trained health technicians (39). Height was measured using a stadiometer, while weight was measured using a digital scale (39). These measurements were then used to calculate BMI using the formula: BMI = weight (in kilograms) divided by height (in meters) squared. Individuals were classified as having obesity if their BMI category fell under the obesity category. According to the Centers for Disease Control and Prevention (CDC): normal weight (BMI 18.5-24.9 kg/m^2), overweight (BMI 25.0 kg/m^2-29.9 kg/m^2) and obesity (BMI 30.0 kg/m^2 and higher)(22). The Asian specific BMI categories as defined by the World Health Organization (WHO) are as follows: normal weight (BMI 18.5-22.9 kg/m^2), overweight (BMI 23.0-24.9 kg/m^2) and obesity (BMI 25.0 kg/m^2 and higher) (41)Individuals in the normal weight and overweight category were classified as not having obesity.

3.3.5 Family Income

Family income was defined as the Family Poverty Income Ratio (PIR), as outlined in the NHANES dictionary (36). The PIR data on NHANES is collected through a combination of interviews and household income information. During the NHANES interview, participants were asked questions related to their household income, including the total household income for the past 12 months and the number of individuals in the household (37). This information was used to calculate the PIR, which is a measure of income relative to the federal poverty guidelines. The PIR was calculated by dividing the reported household income by the poverty threshold specific to the household size and composition.

3.3.6 Health Insurance

Individuals were classified as having health insurance if they answered “yes” to the question: "Are you covered by health insurance or some other kind of health care plan?". This question encompassed various sources of health coverage, including employer-provided plans, direct purchases, and government programs like Medicare and Medicaid (37).

3.3.7 Stage II Hypertension

Individuals are classified as hypertensive if they were taking antihypertensive medication, had a systolic blood pressure >= 140 mm Hg, had a diastolic blood pressure >= 90 mm Hg, or had a physician diagnosis of hypertension (42). NHANES collects blood pressure through standardized procedures by trained health technicians (37).

3.3.8 Type 2 Diabetes (T2D)

Individuals were classified as having T2D if they had a fasting glucose >7 mmol/L or HbA1c >6.5%, or use of diabetes medication (43). In NHANES, levels of fasting glucose and HbA1c were obtained through blood samples taken during physical examinations (44). Fasting glucose data was obtained through blood samples collected during physical examinations, providing a measure of glucose levels after an overnight fast (44).

3.4 CVD Mortality Follow-up

The National Center for Health Statistics merged data from death certificates and NHANES records until December 31, 2019. They used the ICD-10 to identify causes of death, such as heart diseases, cancer, lung issues, accidents, strokes, Alzheimer's, diabetes, flu, kidney problems, and others (45). CVD death was defined as ICD-10 codes I00-I09, I11, I13, and I20-I51.

3.5 Statistical Analysis

Participant characteristics are reported as prevalence (SE) and means (SE). The study investigated the association between PA, hypertension, T2D and obesity with prevalent CVD and CVD mortality across four ethnic groups. The first analysis assessed ethnic differences in the odds of prevalent CVD associated with common CVD risk factors (physical inactivity, low family income, hypertension, obesity, lack of health insurance and type 2 diabetes) using logistic regression. The second analysis assessed ethnic differences in CVD mortality risk associated with the same CVD risk factors using Cox proportional hazard regressions. For CVD mortality, Fine and Gray's sub-distribution hazard model was used to analyze survival data. Instead of ignoring competing risks (all-other causes of mortality except CVD) or treating them as censored, the model adjusted for these risks (46). Both analyses examined ethnicity by CVD risk factor interactions and main effects adjusted for sex and age. All analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC) with statistical significance established at $p \leq 0.05$.

3.6 Results

Table 1. Baseline Characteristics of individuals across different Ethnic groups (NHANES 2011-2020)

	White	Black	Asian	Hispanics
N	7218	4229	2362	4378
Age, years	59.1 ±0.2	56.2 ±0.3*	55.7 ±0.4*	54.3 ±0.3
Male, %	48.6 ±0.5	44.4 ±0.6*	46.5 ±0.8	49.9 ±0.6*
Active, %	71.6 ±0.7	63.7 ±0.9*	61.2 ±1.4*	64.9 ±1.1*
Health Insurance, %	89.4 ±0.8	79.1 ±0.9*	87.3 ±1.0	64.2 ±1.4*
Low Income, %	42.9 ±1.7	68.4 ±1.8*	45.2 ±2.4	74.1 ±1.5*
Hypertensive, %	36.9 ±0.9	42.9 ±0.8*	28.5 ±1.1*	24.2 ±1.1*
Type 2 Diabetes, %	13.8 ±0.5	18.8 ±0.7*	16.2 ±1.0*	16.3 ±0.8
Obesity, %	38.6 ±0.9	48.9 ±1.0*	30.8 ±1.2*	45.7 ±1.0*
CVD, %	7.9 ±0.4	6.9 ±0.3*	3.4 ±0.4*	4.1 ±0.4*
All-cause mortality, %	3.9 ±0.2	3.2 ±0.3*	1.3 ±0.3*	1.6 ±0.2*
CVD Mortality, %	1.5 ±0.2	1.6 ±0.2	0.4 ±0.1*	0.7 ±0.1*
Follow up, years	4.9 ±0.1	4.8 ±0.2	4.8 ±0.2	4.9 ±0.2

Values presented as means ± standard error or prevalence.

Values were weighted to be nationally representative of U.S adults.

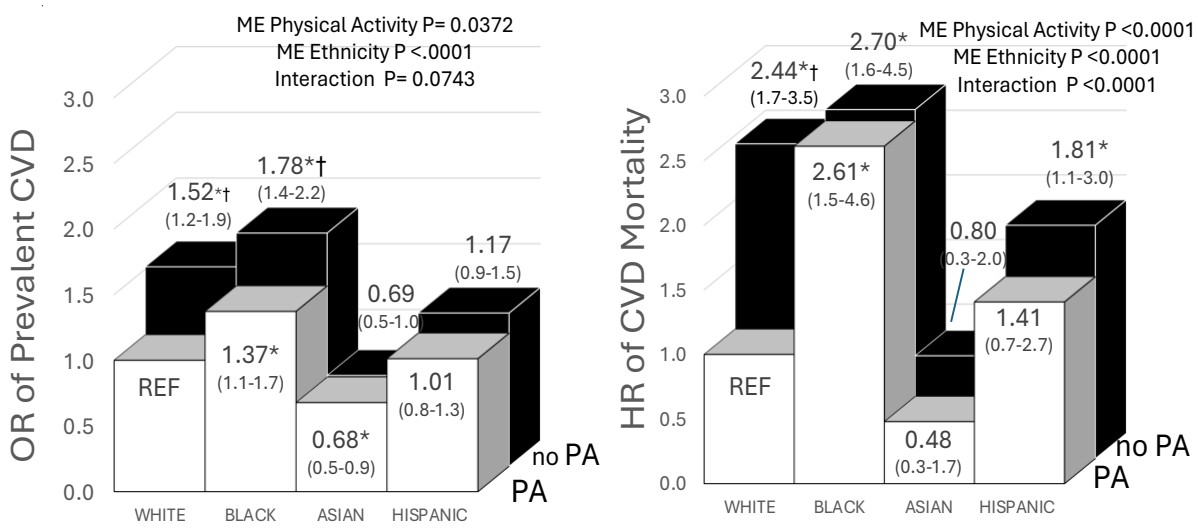
CVD = Cardiovascular Disease (Stroke, Myocardial Infarction, Coronary Heart Disease).

*Significant difference ($p<0.05$) compared to White.

Table 1 shows the characteristics among individuals stratified by ethnicity. Physical activity levels were significantly lower among individuals from all ethnic minority groups as

compared to White individuals (P<0.05). Access to health insurance and low-income rates were notably lower among Black and Hispanic individuals. Type 2 diabetes rates were significantly higher among Blacks and Asians (P<0.05). Rates of hypertension were higher among Blacks, and lower for Asian and Hispanics. Rates of obesity were higher among Black and Hispanics, and lower for Asians. Prevalent CVD and all-cause mortality were lower across all ethnic minorities, with CVD Mortality being lower only for Asian and Hispanics.

Figure 1: Association of Physical Activity (PA) and Ethnicity with Prevalent CVD and CVD Mortality



noPA= Physically Inactive (< 150 min/week)

ME = main effect

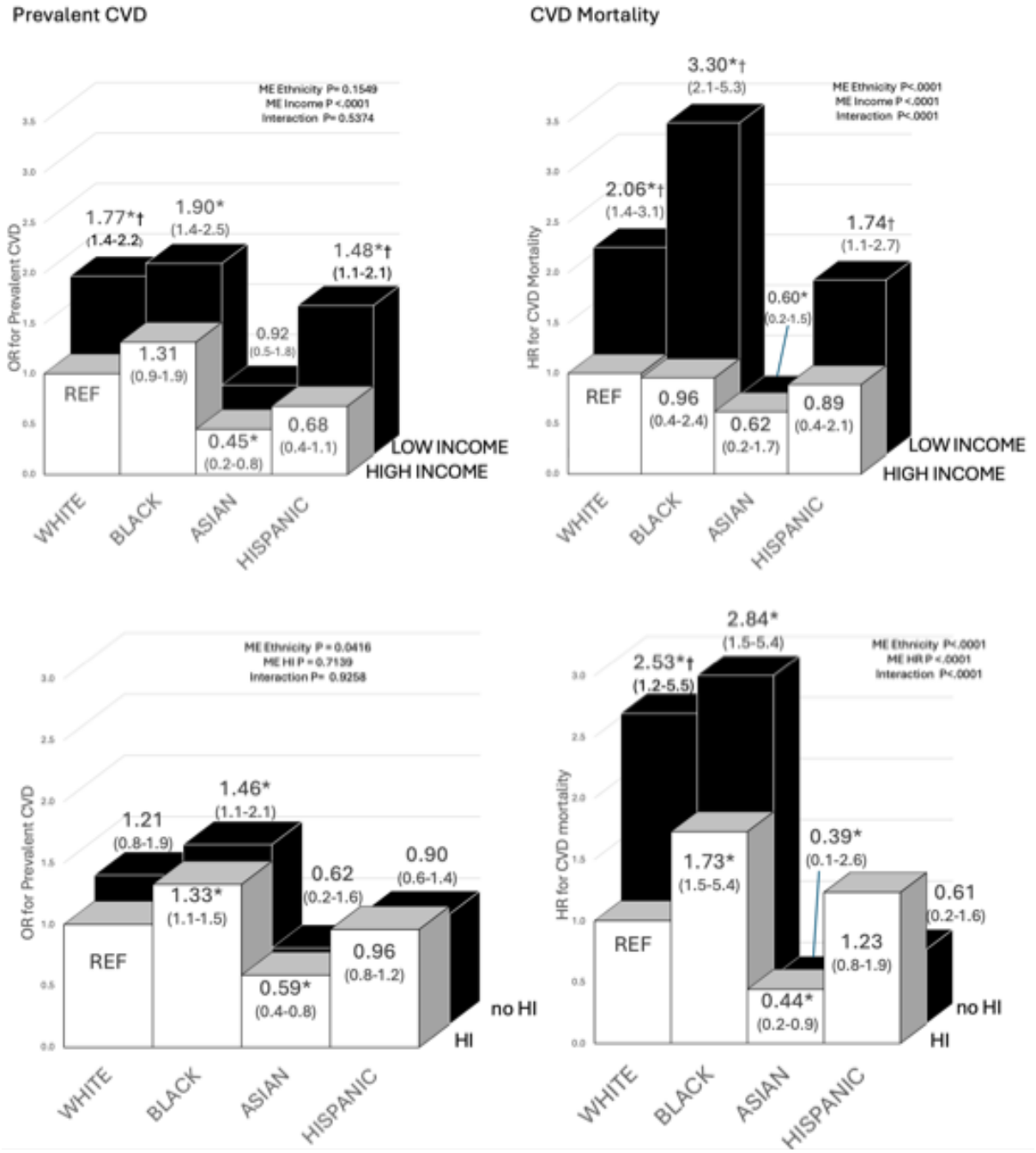
Models were adjusted for age and sex.

***** significant difference from White Physically Active (REF) (P < 0.05)

† significant difference within each ethnic group.

Our examination of prevalent CVD and physical activity revealed significant main effects of physical activity and ethnicity, with a potential ethnicity by physical activity interaction ($p=0.07$, **Figure 1**). Physical inactivity was associated with a greater odds of prevalent CVD for Black and White individuals, but not Hispanic and Asian individuals. Similarly, for CVD mortality, there was a significant ethnicity by physical activity interaction ($p<0.0001$, **Figure 1**), indicating a stronger association between physical activity and CVD mortality in White individuals, than Black, Hispanic and Asian individuals.

Figure 2: Association of Socioeconomic Risk Factors (Income & Health Insurance) and Ethnicity with Prevalent CVD and Mortality



Main Effect = ME

Low Income (Family PIR <3)

HI = Healthcare Insurance. ME = Main effect

Models were adjusted for age and sex

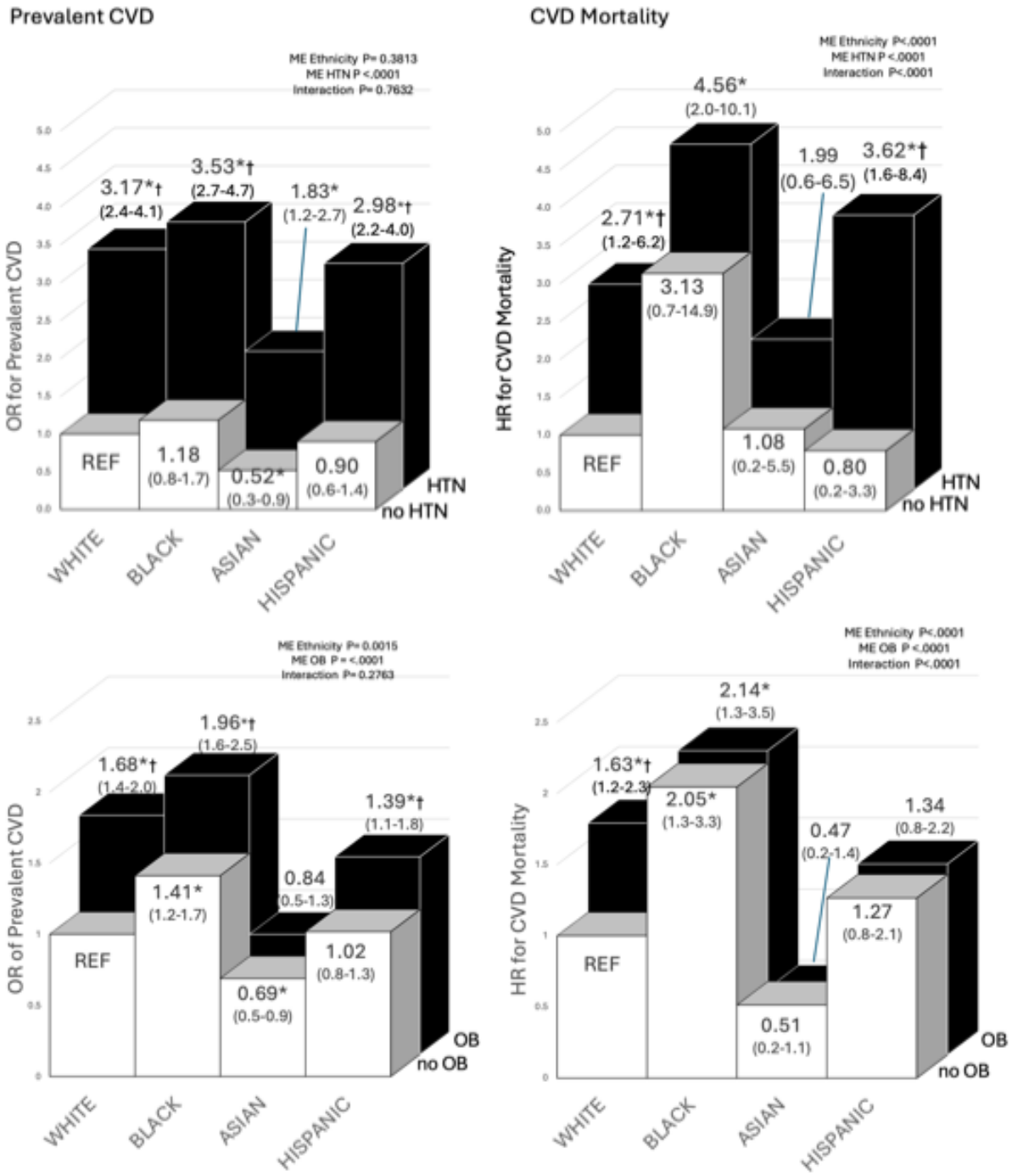
***** significant difference from White Affluent (REF) ($P < 0.05$)

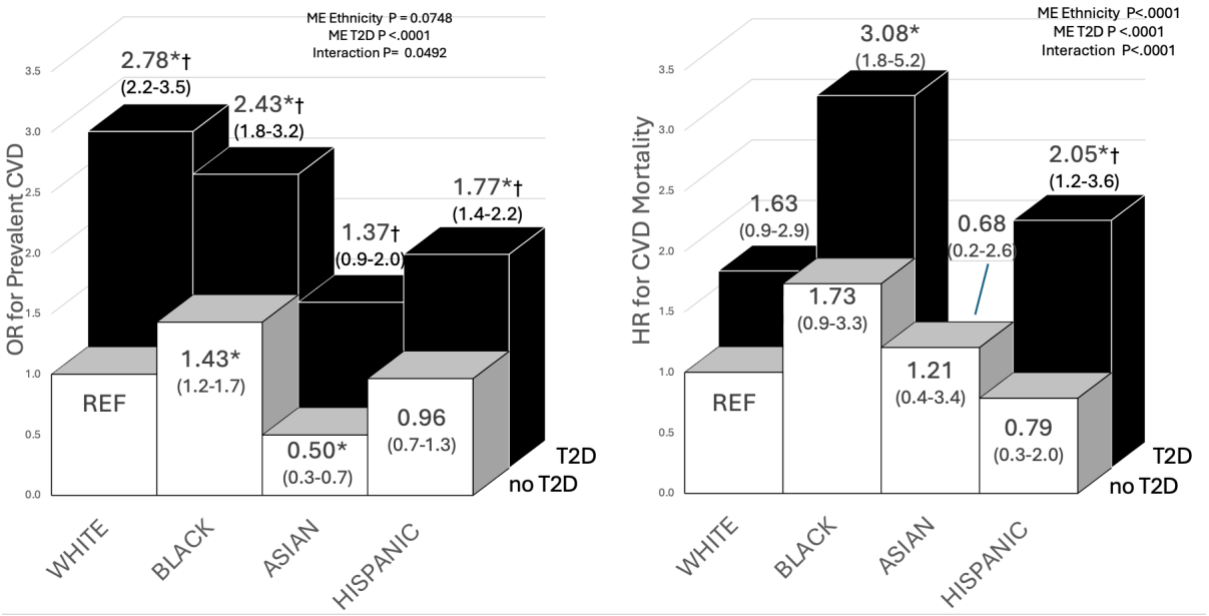
† significant difference within each ethnic group

For prevalent CVD, there was a significant positive main effect of low income, with no significant interaction effect for family income by ethnicity (p=0.54, **Figure 2**). For CVD mortality there was a significant interaction of ethnicity by family income (p<0.0001, **Figure 2**). Low income was positively associated with CVD mortality in White, Hispanic and Black individuals, but not in Asian individuals.

For prevalent CVD, a lack of health insurance was associated with a higher odds of prevalent CVD across all ethnic groups. For CVD mortality, there was a significant interaction of ethnicity by health insurance (p<0.0001 **Figure 2**). Lack of healthcare insurance was positively associated with CVD mortality in White individuals, but no association in Hispanic, Black and Asian individuals.

Figure 3: Association of Metabolic Risk Factors (Type 2 Diabetes, Obesity, Hypertension) and Ethnicity with Prevalent CVD and Mortality)





HTN = Stage II Hypertension (SBP >140, DBP>90 or currently on antihypertensive medication).

OB = Obesity (BMI>=30kg/m^2) Asian individuals (BMI>=27 kg/m^2).

T2D = Type II Diabetic (Glucose >=7mmol/L or HbA1C >=6.5% or OGTT >= 11.1mmol/Lor taking diabetes medication)

ME= Main Effect

Models were adjusted for age and sex.

***** significant difference from White Healthy (REF) (P < 0.05)

† significant difference within each ethnic group (P < 0.05)

For prevalent CVD, there was no interaction effect of hypertension by ethnicity (p=0.76, **Figure 3)**, but there was a positive main effect of hypertension across ethnic groups. Our analysis of CVD mortality and hypertension reveals a significant interaction between ethnicity and hypertension, and a significant main effect of hypertension (p < 0.0001, **Figure 3**). This indicates that hypertension is positively associated with CVD mortality, particularly in White and Hispanic individuals.

For prevalent CVD, there was no significant interaction between obesity and ethnicity (p=0.28, **Figure 3**). There was a positive main effect of obesity on the odds of prevalent CVD across ethnic groups. Our analysis of CVD mortality and BMI indicates a significant

interaction of ethnicity by obesity ($p<0.001$, **Figure 3).** Obesity was positively associated with CVD mortality, particularly in White individuals.

Our analysis of prevalent CVD and T2D indicates a significant positive main effect and interaction of ethnicity by T2D ($p=0.04$, **Figure 3)**, with T2D being positively associated with prevalent CVD among all ethnic groups. Our analysis of CVD mortality and T2D indicates a significant interaction of ethnicity by T2D ($p<0.0001$, **Figure 3**). T2D was positively associated with CVD mortality, particularly in Hispanic individuals.

3.7 Discussion

This study explores how factors such as T2D, physical inactivity, and low family income relate with CVD across four different ethnic groups—White, Black, Asian, and Hispanic. Compared to Whites, significant disparities were noted in several CVD risk factors in ethnic minorities, such as lower PA levels, SES, and increased metabolic risk factors. Despite lower prevalent CVD and all-cause mortality among ethnic minorities overall, Blacks and Hispanics have been consistently linked with increased CVD risk across SES and metabolic risk factors. Physical inactivity was strongly associated with prevalent CVD and CVD mortality among Whites and Blacks. Although family income did not correlate differently between ethnic groups with prevalent CVD, it contributed to elevated CVD mortality risks among Whites, Hispanics, and Blacks. This study reveals an inverse relationship where ethnic minorities, despite having the highest rates of CVD risk factors,

demonstrate the lowest prevalence of previous CVD and CVD mortality, whereas white individuals, with lower risk factor rates, show the highest prevalence and mortality from CVD. These disparities in CVD risk factors underscore the urgent need for targeted interventions to address CVD burdens across diverse populations.

While ethnicity itself does not directly cause CVD, certain groups exhibit higher susceptibility and prevalence rates for conditions like hypertension, diabetes, and coronary artery disease due to genetic, environmental, and SES factors (47). Our study, consistent with current literature (15), found that Black individuals carry a heavier burden of traditional CVD risk factors such as obesity, hypertension and diabetes (48). However, this did not translate to higher odds of prevalent CVD compared to Whites. Black and Hispanics also face greater socioeconomic barriers, including lower income and education levels, which limit access to healthcare and resources promoting healthy lifestyles, contributing to higher rates of CVD risk factors and potentially delayed diagnosis and treatment (49). Asians, despite having lower rates of obesity, may still face elevated CVD risk. Despite having lower rates of obesity, Asians exhibit higher visceral fat accumulation thus influencing the risk of T2D. This highlights ethnic-specific differences in how risk factors influence cardiovascular health (48). Part of these differences may be due to CVD risk factors not relating to hard outcomes such as heart attack, stroke, and coronary heart disease.

Studies reveal that individuals with T2D and hypertension exhibit significantly elevated prevalent and mortality rates of CVD compared to those without (50). Studies have shown that over time, CVD mortality rates have decreased at a slower pace among individuals with T2D compared to those without, suggesting continued higher risks despite overall improvements in treatment (51). We, and others in the literature, show that ethnic minorities have a higher prevalence of T2D and hypertension that contribute to a higher risk for CVD morbidity and mortality (52). Black adults under the age of 65 years are thought to

face heightened CVD mortality risks due to early onset of T2D, hypertension and lower socioeconomic status (53). Studies reveal that Asian individuals exhibit elevated rates of insulin resistance and diabetes compared to Whites, contributing to a 28% prevalent CVD risk even after adjusting for multiple factors (54). Other studies indicate that Black adults demonstrate a notably higher prevalence of hypertension compared to other ethnic groups (55). Moreover, hypertension control appears less effective among Black individuals than among White individuals, primarily attributed to challenges with medication affordability (56). In our study, we observed higher prevalent CVD rates among all ethnic groups with these metabolic syndromes. Our study found that Black individuals face heightened risks of CVD mortality, and Hispanics were found to have increased prevalent CVD and CVD mortality (Figure 3). Despite having the lowest rate of hypertension, Hispanics with hypertension had significantly higher CVD mortality rates. Even without hypertension or diabetes, Black individuals face an increased risk of prevalent CVD and CVD mortality compared to their counterparts with these comorbidities. In summary, while ethnic disparities in hypertension and T2D risk vary, these conditions collectively contribute to elevated prevalent CVD risk and CVD mortality among ethnic minorities.

Socioeconomic factors are well known to be associated with health and mortality outcomes (57). We observed that low income was associated with increased odds of prevalent CVD across all ethnic groups (Figure 2). Studies have revealed that lower family income is linked to a higher prevalence of major CVD risk factors, such as T2D, hypertension, and coronary artery disease (24). The increased burden of risk factors likely also contributes to the elevated CVD mortality risk observed across White, Black, and Hispanic populations with low family income. Low family income brings about several barriers detrimental to cardiovascular health, including limited access to healthy foods, increased stress and decreased access to preventive healthcare services (25). Additionally, Black and Hispanic

individuals encounter longer wait times and delays in medical care, systemic biases, and limited healthcare access that can be further compounded by low socioeconomic status (26). In contrast, we did not observe the association between low family income and prevalent CVD in Asians. This may be in part due to differences in cultural practices that might offset some of the risks associated with low income. In Asian cultures, living in a multigenerational home is more common and may allow for a more supportive arrangement, where chores such as meal preparation and financial burdens may be shared (58). The presence of caretakers at home alleviate may some financial and emotional burdens and ensures individuals with illness may be more likely to get health care (58). This contrasts with Western cultural norms where older generations often reside in caretaker homes or live independently, leading to a different dynamic in familial support and financial responsibilities (58). Our study revealed a lack of association between health insurance and ethnicity in predicting prevalent CVD may stem from various factors. If an individual experiences a CVD event, they would likely seek treatment at a hospital irrespective of their healthcare insurance coverage. However, our study reveals that Black and Hispanics without access to healthcare insurance had higher risk of CVD mortality. This emphasizes the influence of various socioeconomic factors on cardiovascular health outcomes across diverse ethnic groups. Blacks and Hispanics face substantial socioeconomic barriers that limit access to healthcare and preventive services, contributing to higher CVD prevalence and mortality. Addressing these disparities is essential for reducing CVD burden and improving health equity, particularly among populations such as Black and Hispanics.

Physical activity confers a range of health benefits, including enhanced cardiovascular health, weight management, and reduced risks of metabolic and chronic diseases such as CVD (27). While LTPA generally correlates positively with health outcomes, the relationship between OPA and health is more controversial (28). From a physiological standpoint,

physical activity, whether in leisure or occupational contexts, should confer health benefits. However, job-related stress, occupational hazards, or the low intensity of most occupational physical activity may explain why occupational activity is often associated with less positive or even negative health outcomes (29). Alternatively, it is plausible that the positive characteristics that enable individuals to be physically active in their leisure time (e.g., sufficient income, manageable stress, sufficient time, conducive environment, etc.) also contribute to the observed health benefits among those who are leisurely active (29). Among Blacks and Hispanics, 66% reported any form of participation in LTPA, which is lower compared to 78% of Whites (59) (18). Hispanics exhibited the highest prevalence of OPA among ethnic groups (29). In this study, our measure of physical activity included both domains of physical activity in accordance with current guidelines. We observed that Asians are the most inactive group, while Whites are the most active. Furthermore, physically inactive White and Black individuals showed increased risks of prevalent CVD compared to their active counterparts. However, despite engaging in physical activity, Black individuals still exhibit higher odds of prevalent CVD and CVD mortality compared to other active ethnic groups. In fact, there was no difference in mortality risk between active and inactive individuals in those of Black ethnicity. Our findings suggest that physical activity is particularly effective in reducing the risk of prevalent CVD and CVD mortality among Whites compared to other ethnic groups. For Black individuals, understanding why traditional physical activity measures may not provide similar cardiovascular benefits is crucial. In conclusion, while physical activity generally confers significant health benefits across various ethnic groups, our findings underscore the need for tailored strategies to enhance cardiovascular health outcomes, particularly among Black individuals, where traditional measures may not fully capture protective effects.

Culturally tailored dietary programs and community-based interventions can significantly enhance hypertension management and cardiovascular health among diverse ethnic groups (32). Developing dietary interventions that respect traditional eating patterns while promoting heart-healthy choices can help reduce salt intake, particularly in communities with higher hypertension prevalence. Community-based strategies, such as faith-based interventions and engaging community health workers to connect with Hispanic communities, have proven successful in improving blood pressure control (15). Programs like barbershop interventions, where healthcare providers offer hypertension management in frequently visited community settings, can also be effective. Additionally, language and communication strategies, including bilingual health services and culturally relevant educational materials, are crucial for improving understanding and adherence, especially among Hispanic populations. Targeted screening and early intervention, such as regular diabetes and CVD risk factor screening for Asian populations and adjusting BMI thresholds for Asian groups, can help identify and address conditions earlier (24). Medication strategies should consider ethnicity-specific responses to antihypertensive drugs, prioritizing calcium channel blockers and thiazide diuretics for Black patients (8). Addressing social determinants of health through interventions that improve access to healthy foods, safe physical activity spaces, and affordable healthcare is essential. Cultural competency training for healthcare providers can enhance patient-provider communication and trust, while technology-based interventions, such as culturally appropriate telehealth consultations, can improve accessibility for minority groups (13). Furthermore, genetic and pharmacogenomic approaches, including genetic testing to identify high-risk individuals and tailor prevention strategies, are valuable (13). Collaborative research should ensure that ethnic minority perspectives are incorporated into research design and implementation, with randomized

controlled trials including sufficient ethnic minority recruitment, particularly from underrepresented regions.

3.7.1 Strengths and Limitations

There are several strengths and limitations worth mentioning. This study utilized a large, representative NHANES dataset offering comprehensive insights into CVD risk factors, prevalent CVD, and mortality in the U.S. population (23). However, its cross-sectional design limits establishing causality, and reliance on self-reported data for physical activities and medications may introduce reporting biases. Combining all Asian subgroups into a single category may obscure potential differences in CVD risk factors and outcomes among distinct ethnicities, such as South Asians, East Asians, and others (60). South Asians generally exhibit elevated CVD risk due to higher rates of insulin resistance, diabetes, central obesity, and atherogenic dyslipidemia than White individuals, whereas East Asians have been demonstrated to have a lower likelihood of dying from a CVD event (54) (24). Future longitudinal studies are needed to validate these findings.

3.8 Conclusion

Our study identified significant associations between risk factors and CVD outcomes, highlighting how ethnicity influences cardiovascular health. Persistent disparities among all ethnic populations in CVD prevalence and mortality are shaped by socioeconomic and metabolic factors such as limited healthcare access and a higher burden of traditional CVD risk factors. To address these disparities effectively, targeted interventions are crucial. These interventions should focus on improving healthcare access, promoting healthier behaviors, and creating supportive environments. Additionally, they may inform the development of ethnicity-specific guidelines for managing and preventing CVD.

Chapter 4.0 General Discussion

To address ethnic disparities in CVD, several key steps should be taken. First, disaggregated data collection and analyses are essential for understanding unique risk factors and trends within specific ethnic subgroups. Improving SES, education, neighborhood environments, and access to healthcare significantly impacts CVD outcomes. Targeted interventions should be developed and implemented, with culturally appropriate strategies tailored to the unique risk factors and health behaviors of specific ethnic groups. Enhancing access to care is another critical step, particularly for underserved ethnic minority populations, by improving preventive care, early screening, and management of CVD risk factors. Research should investigate potential protective factors in certain ethnic groups, such as Asians, which may contribute to lower CVD mortality risk. Long-term monitoring systems should be established to track CVD trends in different ethnic groups, identify emerging patterns, and evaluate the effectiveness of interventions. Promoting cultural competency among healthcare providers will improve communication and care delivery to diverse populations. Targeted public health campaigns are necessary to raise awareness about CVD risk factors and prevention strategies within different ethnic communities. Finally, advocating for policy interventions that address systemic factors, such as safe spaces for physical activity, and quality healthcare in underserved areas, will contribute to reducing health disparities. By implementing these steps, we can work towards reducing ethnic disparities in CVD prevalence and mortality, ultimately enhancing cardiovascular health outcomes for all populations. This study's comprehensive approach offers a valuable perspective on how socioeconomic and lifestyle factors interact with ethnic background to influence CVD risk. By including a diverse range of ethnic groups, our research sheds light on varying risk profiles and highlights the need for culturally sensitive health strategies. The distinction between the effects of leisure-time versus occupational physical activity further underscores

the importance of considering different types of physical activity when assessing cardiovascular risk. Future research should delve deeper into the reasons behind the varying impacts of physical activity on CVD risk across different ethnic groups. Understanding these nuances, such as genetic variations and effectiveness of interventions can help in developing targeted public health strategies that address the specific needs of each population. Additionally, exploring how cultural and socioeconomic factors influence the effectiveness of health interventions could provide valuable insights for improving health outcomes in diverse communities. In summary, while the study highlights significant disparities in CVD risk factors across ethnic groups, it also points to the need for more tailored and culturally sensitive approaches to addressing these risks. By focusing on both common and unique factors contributing to cardiovascular health, future research and public health strategies can better target interventions to reduce the burden of CVD and promote health equity.

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