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THE PREVALENCE OF MULTIMORBIDITY AMONG ADULTS AGED 65 YEARS AND OLDER IN THE UNITED STATES, DIFFERENCES BY RACE/ETHNICITY

BY

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DEPARTMENT OF EPIDEMIOLOGY

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BACHELOR OF SCIENCE

UNIVERISTY OF CALIFORNIA, DAVIS

2022

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An abstract of

A thesis submitted to the Faculty of the
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ABSTRACT

The Prevalence of Multimorbidity Among Adults Aged 65 Years and Older in the United States, Differences by Race/Ethnicity

Objective

The population of older adults in the U.S. is increasing, and the prevalence of multimorbidity has been consistently high across studies, where multimorbidity is defined as the coexistence of two or more chronic conditions in an individual. However, little is known about the prevalence of multimorbidity in older adults of different racial groups. This study aimed to assess the prevalence of multimorbidity involving seven chronic conditions among U.S. adults aged 65 years and older by race/ethnicity.

Methods

Data was analyzed on 8992 adults aged 65 years and older in the U.S. from the Health Retirement Study (HRS) in 2018, a nationally representative study of U.S. older adults. Seven self-reported chronic conditions were used to assess multimorbidity in this study: hypertension, diabetes, cancer, lung disease, heart problems, stroke, and arthritis. Descriptive analyses were used to show differences in multimorbidity prevalence across selected sociodemographic variables. Polytomous logistic regression models were performed to evaluate the association between multimorbidity with race/ethnicity and covariates (age, gender, education level, marital status, and total household income). All the analyses were adjusted by survey weights, aiming to generate nationally represented estimates.

Results

73.4% of older adults aged 65 years and over in the U.S. had multimorbidity. A higher prevalence of multimorbidity is associated with individuals with a non-Hispanic Black background, female, having a lower household income, attaining lower levels of education, or being divorced, unmarried, or widowed. Non-Hispanic Blacks had higher odds of having multimorbidity compared to non-Hispanic Whites; Hispanics were more likely to experience three or more chronic conditions compared to non-Hispanic Whites. Hypertension-arthritis was the most prevalent dyad across all racial groups; triads including hypertension were common across all racial/ethnic groups.

Conclusions

There was a significant association between non-Hispanic Blacks and multimorbidity. No significant association was found between Hispanic or non-Hispanic Others and multimorbidity. The chronic conditions patterns (dyads and triads) were similar across racial people, except non-Hispanic Whites.

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Table of Contents

I. INTRODUCTION

The rapidly aging population and the parallel increase in longevity have emerged as a pressing issue within the United States (U.S.). The U.S. Census Bureau indicates that approximately 54.1 million people,16% of the population, were aged 65 years and above in 2019, after an increase of 13.7 million since 2010 (40.4 million), and it is anticipated to reach 22% by 2040[31]. This demographic shift is accompanied by a rise in chronic diseases, a common correlate of aging; in 2020, 71.52% of the adult population aged 50 years and older were reported to have at least one chronic condition. Projections suggest an increase to 114.48% by 2035[4]. Furthermore, in 2020, 7.83% of adults were experiencing multimorbidity—defined as the coexistence of two or more chronic conditions in an individual—with expectations of an increase to 14.97% by 2035[4]. The gradual rise in chronic conditions amplifies the burden of multimorbidity on individuals and the pressure on healthcare systems, as those afflicted by chronic diseases often face adverse health outcomes, increased healthcare needs, and poor quality of healthcare.

In the U.S., evidence indicates that racial and ethnic minorities face a heightened risk of multimorbidity and mortality and encounter poorer healthcare quality compared to Whites [29]. Many studies have highlighted that African Americans are more likely to suffer from at least two chronic conditions compared to Whites, whereas Whites exhibit higher rates of such conditions compared to Asians[10],[42]. Additionally, current research among middle-aged adults shows that African Americans develop multimorbidity approximately four years earlier than Whites[42]. In terms of organ-related diseases, African Americans are most susceptible to experiencing multiple chronic conditions concurrently, followed by Whites and Native Americans[26]. Previous studies in the U.S. have predominantly focused on assessing the

accumulation of multimorbidity across races or analyzing trends and patterns of multimorbidity based on sociodemographic risk factors, utilizing data that is now decades old[5],[24],[25],[35],[38],[51]. Given the significant proportion of individuals from various racial and ethnic minority groups within the U.S. aging population and the existence of health disparities, there is a need to identify and have an updated understanding of the specific prevalence of multimorbidity and individual chronic conditions among different racial and ethnic groups, using recent data.

Objective and Research Question

This study aimed to estimate the prevalence of multimorbidity among U.S. adults aged 65 years and above. The study utilized data from the Health Retirement Study (HRS), with the sample participants representing approximately 20,000 American individuals. The primary research question was to estimate if multimorbidity prevalence differs by race/ethnicity among U.S. adults aged 65 years and older. Additionally, the study aims to identify the most common multimorbidity patterns among U.S. adults aged 65 and older and examine how these patterns vary across different racial and ethnic groups.

II. LITERATURE REVIEW

Multimorbidity Definitions

The concept of multimorbidity has yet to be concretely defined in any universally accepted manner[33]. In the majority of studies, multimorbidity is defined as the coexistence of two or more chronic conditions within an individual, aligning with the framework provided by the United States Department of Health and Human Services[10],[48],[50].In clinical practice and community settings, multimorbidity could be defined using 17 different measures. However, multimorbidity is typically measured using two approaches. The first is a simple count of diseases per individual, which can be collected through patient self-reports or clinical assessments; the second utilizes indices such as the Chronic Disease Score (CDS), the Charlson Comorbidity Index, and the Adjusted Clinical Groups (ACG) System. These indices assess the disease burden by applying varied weights to different conditions or diseases based on factors like mortality, condition severity, or anticipated healthcare resource utilization[23]. Although there is no uniform definition for multimorbidity in literature, this study will adopt the definition that most researchers have developed from the concurrent presence of several chronic conditions, which is the presence of two or more chronic conditions within an individual[1],[2],[7],[9],[10].

Multimorbidity Patterns

Two types of multimorbidity patterns are commonly identified in existing studies. The first describes the most frequent combinations of two of all listed chronic conditions (dyads) or three of the listed chronic conditions (triads)[46],[47],[50],[55]. Researchers frequently use these clusters in prevalence studies due to the high prevalence rates of chronic disease and shared risk factors. Based on the 2010 National Health Interview Survey (NHIS), the most common dyad across all age groups was arthritis and hypertension, followed by diabetes and hypertension identified in males across all age groups and females aged 45 years and older. The most prevalent

chronic conditions triad were arthritis, diabetes, and hypertension[55]. A cohort study measuring the incidence of multimorbidity in Minnesota showed the most common dyad of chronic conditions was hyperlipidemia and hypertension, especially in those aged 40 to 79 in both genders, with an exception of women aged between 40 and 49; and the most common triad being hyperlipidemia, hypertension, and diabetes in individuals aged between 40 and 79[50].

The second type of pattern estimates non-random associations between chronic diseases and underlying relationships between different chronic conditions in populations using analytical statistics such as factor analysis. The five most common patterns of chronic conditions found in a study using factor analysis were cardio-metabolic, psychiatric-substance abuse, mechanical-obesity-thyroidal, psychogeriatric, and depressive across all age groups[8].

Prevalence of Multimorbidity in the United States

Overall Prevalence of Multimorbidity in United States

Multimorbidity is an emerging issue in the field of public health due to its increasing prevalence. Most studies in the U.S. used a list of 20 chronic conditions classified by the Department of Health and Human Services[6],[38],[46],[50], even though the prevalence estimates of multimorbidity in the U.S. vary depending on the definition of multimorbidity, the chronic conditions, the number and types of the chronic conditions considered in the analysis, setting, and data sources[19],[32]. Based on the data from NHIS, the prevalence of having at least two chronic conditions has increased from 21.1% in 2010 to 27.2% in 2018 across all age groups[6],[53]. In addition, many studies mentioned that multimorbidity increased substantially with age. According to data sourced from the Medical Expenditure Panel Survey (MEPS), 2016-2019, the prevalence of having at least two chronic conditions was 7.9%, 35.5%, and 88.4% for adults aged 18-39, 40-64, 65 and older, respectively[47].

Prevalence of Multimorbidity by Demographic Groups

The estimates of the prevalence of multimorbidity have varied over the past 35 years due to differences in data sources and settings. However, several findings across existing studies used consistent definitions of multimorbidity. Most studies found that the prevalence of multimorbidity progresses with age and is mostly present in adults aged 65 and older[5],[9],[28],[35]. Recent estimates also showed that 81% or more of U.S. adults over age of 65 have multimorbidity[9]. Although the presence of multiple chronic health conditions is more commonly present in the elderly population, multimorbidity is also a concern in younger age groups. The incidence of people with multimorbidity younger than 65 years was more significant than in those aged 65 years and older[5]. All studies that found a substantial prevalence of multimorbidity in younger age groups included mental problems as one of the chronic conditions considered[5],[46]. In young age groups (0-19, 20-39, and 40-49), the multimorbidity patterns of dyads and triads that included one mental condition were more common than in older age groups (50+)[46],[50].

Many existing studies also examine the prevalence of multimorbidity concerning gender and race. Studies have shown that the prevalence of multimorbidity in women across all age groups was higher than in men[5],[28],[47],[55]. Studies have also shown that the prevalence of multimorbidity was higher in Black than White, and higher in White individuals than Asians[3],[10],[28],[38],[55]. In some studies, race was analyzed in conjunction with age, gender, or both. The approach often involves comparing the prevalence of multimorbidity among different racial and ethnic groups within the same sex category. For example, White males in younger age groups (18-44 years old) had a lower prevalence rate of having two or more multiple chronic conditions than White females. In contrast, White males were more likely to have at least four multiple chronic conditions compared to White females once they turned 65[55].

Risk Factors of Multimorbidity

Risk factors play a crucial role in understanding co-occurring chronic conditions' prevalence, progression, and management. In existing literature, various risk factors were assessed for multimorbidity, including behaviors, demographics, and socioeconomic factors. Two of the most common risk factors mentioned in studies are age and educational attainment[1],[2],[24],[25],[35],[38],[42],[43].[51]. The study by Van den Akker showed that compared to those aged 25-39, individuals aged 40-59 are 2.36 times more likely to have multimorbidity. This increases to 7.12 times for the 60-79 age group and 13.9 times for those aged 80 and older[54]. Educational attainment is commonly categorized into three levels: low (less than a high school degree), secondary (with a high school degree), and high (with at least a college degree)[25],[40],[54]. Some studies have categorized education levels in two ways: as a continuous variable based on years of schooling or as a categorical variable differentiated by those with less than a high school degree and those with a high school degree or higher[2],[24],[28],[38]. A systematic review of 24 cross-sectional studies indicated that low education is associated with 60% increased odds of multimorbidity after adjusting for age[40]. Other risk factors, such as smoking status, marital status, physical activity, and income, have also identified as essential contributors to multimorbidity [1],[7],[35],[38],[43],[51]. For example, current smokers in those aged 40-59 are 1.71 times more likely to have multimorbidity than non-smokers[51]. In addition, people who are married had a lower risk of having multimorbidity than people who are unmarried/widowed. The findings for income for multimorbidity are inconsistent. Some studies used the poverty ratios as income indicators. Some others used annual household income or total household wealth, especially in studies that assess multimorbidity in the elderly population, as they might get financial support from the public, outside the household, or pension[1],[8],[37],[40]. Some studies found an increasing risk of multimorbidity

with decreasing income in the U.S.[24],[51]. But studies from South Africa and India showed that people with low income have lower odds of having multimorbidity than people with high income[27],[40].

Multimorbidity in Elderly People

As mentioned earlier, the prevalence of developing at least two chronic conditions in people aged 65 and older is much higher than in other age groups. A nationally representative study by Ward and Schiller found that females were more likely to have two to three chronic conditions among adults 65 or older. In contrast, males have a higher rate of developing at least four chronic conditions among the same age group than females[55]. Based on the data from HRS 2014, the most common chronic conditions for both genders were hypertension and lipid disorders[9]. The most common multimorbidity patterns among U.S. adults aged 65 years and older in literature were arthritis and hypertension as a dyad and arthritis, hypertension, and diabetes as the most common triad[50],[55]. In addition, males aged 65 years and older were more likely to experience more dyads and triads, including cancer, than females. Whereas, based on two studies that recruited participants in Minnesota, women experienced more dyads or triads, including arthritis[43],[50].

Missing in Existing Literature

Despite extensive research on the prevalence of multimorbidity in the United States, there is a lack of data from more recent years that could capture the current prevalence of multimorbidity or associations with risk factors. Most literature relies on data from at least ten years ago, around 2014. A few papers used data sources from 2016 as part of longitudinal studies, but this is still outdated to some extent[7],[41],[46],[47]. Furthermore, the observed differences in multimorbidity among racial and ethnic groups highlight underlying health inequalities. These include limited access to healthcare, increased environmental risks, and chronic stress associated with social

disadvantages rather than inherent biological differences[20]. Evidence points to racial and ethnic minorities experiencing a higher prevalence of chronic conditions compared to White people[39]. African Americans tend to develop multimorbidity approximately four years earlier than Whites within a middle-aged adult cohort[7]. Hence, understanding the prevalence of multimorbidity among various races and ethnicities is crucial, underscoring the need to explore the social determinants behind these health disparities. These gaps motivate the need to evaluate the effect of race and ethnicity on multimorbidity patterns. To address the gaps in the existing literature, this research will focus on examining the prevalence of multimorbidity development in U.S. adults aged 65 and older by race and ethnicity, utilizing data from the HRS 2018 data sources.

Conceptual Framework

Study Significance

The U.S. population is aging, as evidenced by the consistent increase in the percentage of people over 65 over the last decade, mainly due to longer life expectancies[34]. In 2022, approximately 58 million adults aged 65 and older, representing 17% of the U.S. population[34]. As individuals age, they might develop new chronic conditions that combine existing chronic conditions, leading to various combinations of multimorbidity. Recent estimates indicate that about 81% of the older adult population experiences multimorbidity[9]. Despite the high prevalence of multimorbidity among U.S. older adults, data on their health remain inadequate. The existing literature on multimorbidity in the U.S. predominantly relies on data that is nearly a decade old, with data resources dating back to around 2014. In addition, differences in multimorbidity exist by race and ethnicity. Although many studies have shown racial and ethnic differences in multimorbidity across all ages, few focus on older adults. Given the dearth of current information on the prevalence of multimorbidity among U.S. older adults and racial

differences in multimorbidity among this population, this study aims to bridge this gap by assessing the prevalence of multimorbidity among U.S. adults aged 65 years and older by race and ethnicity, using data from HRS data 2018.

Factors Associated with Multimorbidity

To assess the prevalence of multimorbidity, it is crucial to identify and examine the factors that lead to multimorbidity in U.S. adults aged 65 years and older following chronic conditions. Existing literature has identified several critical sociodemographic factors significant to chronic disease prevalence[24],[25],[35],[38],[42],[43],[47]. Also, chronic conditions may develop through social determinants of health, such as access to healthy foods, smoking status, physical activity, stress, income, and education level[14].

Race/ethnicity has been identified in the literature as being associated with multimorbidity. The clustering and progression of chronic conditions vary among racial groups. For example, the risk of hypertension is often higher among non-Hispanic Blacks, and the risk of cancer is elevated among non-Hispanic Whites compared to other racial groups[15]. Research has consistently shown that minority racial and ethnic groups bear a higher burden and faster accumulation of multimorbidity, even after adjusting for income, education, and employment[7],[44].

The chronic condition development across different racial groups can be attributed mainly to differences in social determinants. Studies have shown that the level of food security and smoking status, employment, and stress level vary by race/ethnicity, which may explain the variations in the prevalence of chronic conditions by race/ethnicity. African Americans often

face food insecurity due to socioeconomic constraints, leading to a diet that is typically high in sodium, fats, and processed foods. Such dietary patterns are linked to high rates of hypertension and obesity[11]. Additionally, Black Americans disproportionately engaged in physically demanding jobs, which increased the risk of developing arthritis[18]. Racial minority groups had a higher level of chronic stress due to discrimination and poverty, which increased the risk of certain chronic conditions[49]. Furthermore, smoking status is also associated with multiple chronic conditions among racial groups. Existing research has shown that Hispanics had a lower smoking prevalence compared to people from other racial groups, contributing to lower risk of developing lung disease among Hispanics than non-Hispanic Whites[13],[45]. Other social determinants of health, such as education level and income, have also been identified in the literature as associated with chronic conditions. Individuals with low income and education levels had higher odds of multimorbidity than those with high income and education levels[40].

Age is a critical factor in the development of multimorbidity, as older adults experience progressive loss of homeostasis across multiple physiological systems and a decline in the ability to recover[17]. Gender is also an essential component in the development of multiple chronic conditions as the risk of chronic conditions in an individual often varies by gender[1],[6],[19],[21],[22]. Research consistently illustrates that both age and gender correlate with chronic disease, where the likelihood of multiple chronic conditions escalates with age and is typically more pronounced in women [1],[21],[22]. Marital status has also been shown in the literature to be associated with multimorbidity, where people who are married have lower odds of multimorbidity than people who are divorced, widowed, or unmarried[27].

The Transition from Chronic Condition to Multimorbidity

Most research often refers to multimorbidity as a count of chronic conditions. For an individual to transition from chronic conditions to multimorbidity, the number of chronic conditions and duration were considered when determining whether the person has multimorbidity or just the chronic condition[21],[32]. In addition, many chronic conditions are closely related, which means that one chronic condition could lead to the development of other chronic conditions, such as obesity leading to diabetes, which results in a transition from one chronic condition to multimorbidity in an individual[17],[21]. This study only considered the total number of co-occurring chronic conditions within each individual without considering the interrelatedness and duration of chronic conditions.

Study Variable Selection

This study adopts the definition of multimorbidity aligned with the U.S. Department of Health and Human Services framework, which recognizes it as the coexistence of two or more chronic conditions within an individual[48],[53]. Multimorbidity is a cumulative count of self-reported physical chronic conditions within the study population[21]. While the number of chronic conditions and their duration might influence the progression from a single chronic disease to multimorbidity in some research, this study concentrates solely on the concurrent number of physical chronic diseases, explicitly excluding emotional and sleep disorders.

This study aims to examine the prevalence of multimorbidity among U.S. adults aged 65 years and older, with a particular emphasis on race as the primary independent variable. The association of multimorbidity with sociodemographic factors, age and gender, educational attainment, income, and marital status will also be assessed in this study. The rationale for

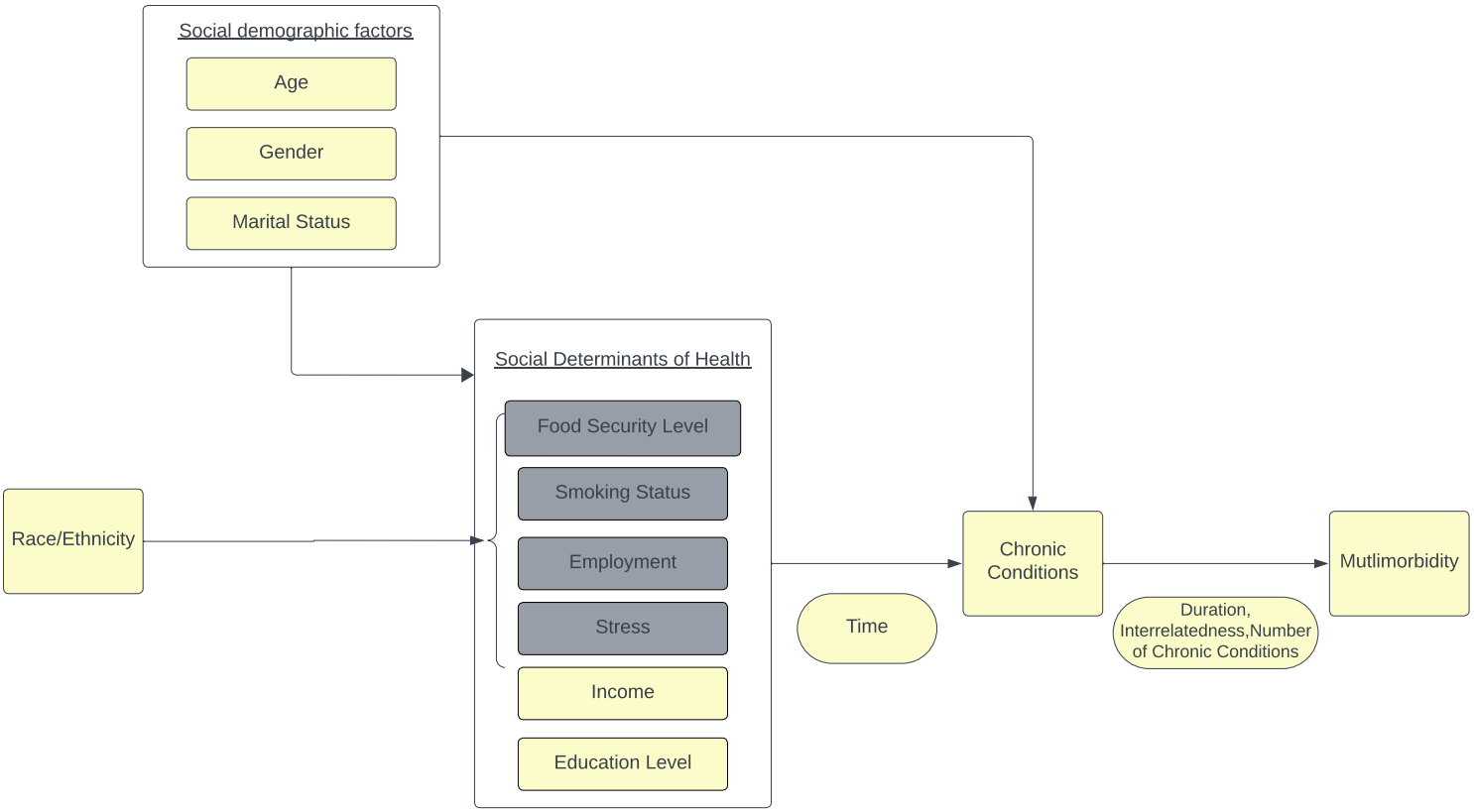
selecting race as the exposure is that multiple studies have demonstrated the significant disparities in the prevalence and patterns of multimorbidity among different racial and ethnic groups[10],[42], while limited research on the racial and ethnic differences in multimorbidity among adults aged 65 and older. Race/ethnicity was categorized as non-Hispanic White, non-Hispanic Black, non-Hispanic Other, and Hispanics, as previous studies using the HRS data used categories[42],[44].

Age is considered one of the covariates in this study as many studies have indicated the prevalence of multimorbidity was highest in adults aged 65 and older[6],[29],[38],[43]. Also, previous studies have shown that multimorbidity prevalence estimates are varied by gender, primarily aligned with race[1],[3],[24],[25],[42]. Therefore, gender would be analyzed as a dichotomous variable in this study. Other covariates in the study included income, marital status, and educational attainment. Total household income was used for this study as a continuous variable. The rationale of using total household income was considered a continuous variable in this study as it could provide a more comprehensive measure of income to older individuals. The total household income includes retirement benefits, pensions, and any financial support from the public. Marital status was dichotomized into "Married" and "Divorced/widowed/never married," as previous literature has shown the association between marital status and multimorbidity[28]. Education attainment was categorized into three groups in the study: "Less than High School," "High School Graduate," and "More than High School." Education level is an essential indicator for measuring an individual's socioeconomic status as it can be determined for all individuals, including people who do not have an occupation or income[25].

This study utilizes the 2018 Health and Retirement Study (HRS) dataset to analyze such conditions. In alignment with the U.S. Department of Health and Human Services Initiative's framework, the study includes the following conditions to quantify multimorbidity: (a) hypertension, (b) diabetes, (c) cancer, (d) lung disease, (e) heart problems (such as coronary heart disease, heart attack, angina, congestive heart problem or other heart problems), (f) stroke, (g) arthritis.

Representation of Conceptual Framework

This figure presents a conceptual framework outlining the factors associated with multimorbidity, as discussed previously. Variables highlighted in yellow are included in this study's analysis, while those in grey are excluded.



III. METHODS

Data Source

The data for this research were sourced from the Health and Retirement Study (HRS). The HRS is a nationally representative longitudinal cohort study focusing on non-institutionalized adults in their middle to later years (aged 50+). It employs a multi-stage area probability sampling design to select participants using in-person and telephone interviews and a computer-assisted interview program. The HRS examines the health transitions that typically occur as individuals move from their working years into retirement at both individual and population levels. The survey includes sociodemographic factors and patient-reported outcomes, making its findings applicable to the broader U.S. population of adults in their middle and older years. The National Institute on Aging, the Social Security Administration, Medicare, and the National Death Index support the HRS. Every two years, the survey evaluates participants and their partners from their initial inclusion until death. The first cohort of the HRS was recruited in 1992, with subsequent cohorts added in 1993 and 1998, and then every six years after that to maintain the survey's representativeness to the older population of U.S. adults. HRS data was grouped into public, sensitive, and restricted categories.

This study utilized public survey data from the 2018 and 2019 waves combined with the RAND HRS, a cleaned and streamlined version of the HRS. The 2018 wave of the HRS contained information on 17,146 respondents aged 50 to 104. The analytic sample for this study was a subset of those 65 years and older participating in the 2018 survey (n = 9012). All health information was self-reported.

Variables

Independent Variable of Interest

The primary independent variable of interest for this study was race/ethnicity. To determine this, HRS asked for participant's race and ethnicity separately, using the following questions: "What race do you consider yourself to be: White, Black or African American, American Indian, Alaska Native, Asian, Native Hawaiian, Pacific Islander, or something else?" and "Do you consider yourself Hispanic or Latino?" The RAND HRS dataset categorized the race variable into three groups: White/Caucasian, Black/African American, and Other. The ethnicity variable was combined into two groups: non-Hispanic and Hispanic. This analysis created a new variable that combined the original race and ethnicity variables and was categorized as non-Hispanic Black, non-Hispanic White, non-Hispanic Other, and Hispanic.

Other Independent Variables

Additional study variables used as covariates in the models were age, gender, education level, marital status, and income. Age was categorized into three groups: 65-74, 75-84, and 85 years and older. Age was categorized in this manner by previous studies, which used the same categories[24],[38]. The variable for gender was categorized into two groups: male and female. Participants were asked to respond: "What is the highest grade of school or year of college you completed?". RAND HRS grouped the education variable into five levels: High school, GED, high school graduate, some college, and above. For this analysis, education levels were recategorized into three groups: Less than high school, High school graduate, and more than high school. For marital status, RAND HRS is categorized into eight groups: Married, Married spouse absence, Partnered, Separated, Divorced, Separated/widowed, and Never married. For this analysis, marital status was categorized into two groups: Married and Divorced/widowed/never married. Total household income was left-skewed, as many data where the income values were

on the lower side, while a few data of the income were very large. Therefore, this variable was log-transformed to achieve a Normal distribution and reduce the range of the income variable.

Dependent Variables

The main outcome variable in the analysis was multimorbidity. The individual chronic conditions were used to assess the prevalence of multimorbidity based on the HRS questionnaire. Respondents were asked the question, "Has a doctor ever told you that you have…?" regarding any of the chronic conditions listed below: (a) high blood pressure/hypertension, (b) diabetes, (c) cancer, (d) lung disease, (e) heart problems (such as coronary heart disease, heart attack, angina, congestive heart problem or other heart problems), (f) stroke, (g) arthritis. For each chronic condition, a dichotomous variable was created in the RAND HRS dataset, representing the presence or absence of the condition. If an individual said they had been diagnosed with two or more of the seven chronic conditions listed above, they were considered multimorbidity. If individuals said they had not been diagnosed with any of the seven chronic conditions, they were considered as not having multimorbidity.

Data Preparation

Sample Creation

This study utilized respondents aged 65 years and older. The total sample size for the 2018 wave in RAND HRS was 42,406. Only 9,012 individuals were aged 65 years or older. Twenty observations that were missing data on race, ethnicity, and education level were excluded from the analysis. The final analytical sample was 8,992 older adults.

Data Filtering and Variable Selection

The data used for this study were extracted from the HRS Longitudinal File by the RAND center, which includes all cleaned data from 1992 to 2020. Only variables related to

respondents listed for the 2018 interview were selected for inclusion in this analysis. Variables were chosen based on their relevance to the conceptual framework described earlier. Selected variables included the exposure of interest, race/ethnicity (non-Hispanic White, non-Hispanic Black, non-Hispanic Other and Hispanic), and other sociodemographic covariates, such as age (65-74, 75-84, 85 and above), gender (Female, Male), education levels (Less than high school, High school graduate, and More than high school), marital status (Married, and Divorced/widowed/never married), and income (logarithm of income). Variables associated with the seven chronic conditions were also included to assess multimorbidity: high blood pressure/hypertension, heart problems, stroke, lung disease, diabetes, cancer, and arthritis (all yes/no). All selected variables had no missing values except race, ethnicity, and education level. Observations with missing values were excluded from the analysis (20 participants excluded).

Data Cleaning and Coding

After selecting data variables, this study recorded the data for analysis. A univariate analysis was initially conducted for all variables using the summary function in R. This step helped to understand the types of variables (continuous or categorical) and to check for missing data in the dataset, thereby confirming that there were no errors in data entry.

For categorical variables, the data were coded in the format "0" and "1". To facilitate better interpretation, some variables, such as gender, were recoded to 0 for "Male" and 1 for "Female." Categorical values with more levels were also recoded and recategorized as some categories contained a few observations. The education variable was coded as "Less than high school," "High school," and "More than high school" from five groups. The marital status was coded as "Married" and "Divorced/widowed/unmarried" from eight groups. All health variables (hypertension, cancer, lung disease, diabetes, heart problem, stroke, and arthritis) were coded as

1 or 0, where 1 indicated the presence of the chronic disease, and 0 indicated its absence. None of the health variables had missing values. The outcome variable, multimorbidity, was coded as a categorical variable with four categories, where 3 indicated the presence of three or more chronic conditions, 2 indicated the presence of two chronic conditions, 1 represented the presence of one chronic condition, and 0 indicated no chronic condition.

Creation of Chronic Diseases Combinations

To identify and quantify the prevalence of multimorbidity patterns among individuals with chronic conditions, focusing on dyads and triads of diseases, seven chronic diseases were selected: hypertension, cancer, lung disease, diabetes, heart problems, stroke, and arthritis. In total, 21 combinations were created for dyads and 35 for triads. Each combination was then designated as a variable named after the respective chronic conditions it comprised, and all such variables were categorized under the subset "CC."

Statistical Analyses

Descriptive Analyses

The descriptive analyses and statistical analyses were conducted using RStudio (Version 2022.07 "Spotted Wakerobin") and Stata (Version 18). All analyses accounted for stratum, person-level sampling weight, and standard error stratum, yielding results more accurately representing the U.S. adult population aged 65 years and older in 2018[31].

For descriptive analyses, the prevalence of multimorbidity in relation to race/ethnicity, age, gender, educational level, marital status, and income was estimated by using table1 package, as shown in Table 1. Percentages and frequencies were calculated for categorical variables, while median and standard deviations were calculated for continuous variables. For Tables 2 and 3, table functions in R were used to estimate the prevalence of the number of chronic conditions

and individual chronic conditions by race/ethnicity. Prevalent dyads and triads of conditions among people with two chronic conditions and people with three chronic conditions by race/ethnicity were identified using dtable in Stata18.

Modelling

A polytomous logistic regression model was fitted to estimate the association between the independent variable (race/ethnicity), the dependent variable (Multimorbidity), and covariates. A reference group was selected for all categorical variables. The outcome variable, Multimorbidity, was categorized into three groups: no chronic conditions (reference category = 0), one chronic condition (= 1), two chronic conditions (= 2), and three or more chronic conditions (>=3). The log of income was used in the logistic regression analysis. The unadjusted model only included race/ethnicity and Multimorbidity, with four categories of outcomes. In the adjusted model, polytomous logistic regression was performed while adjusting for age, gender, marital status, education level, and total household income.

IV. RESULTS

Descriptive Statistics Results

Univariate Analyses

Table 1 summarized the characteristics of the U.S. adult population aged 65 and older based on an analysis of the nationally representative sample from the 2018 Health and Retirement Study, stratified by multimorbidity status. The study's overall sample revealed that among the population of U.S. adults 65 years and older, 79.6% were non-Hispanic White, and 73.4% had at least two chronic conditions. Non-Hispanic Blacks indicated the highest percentage of having multimorbidity, followed by Hispanics. (non-Hispanic Blacks: 83.18%; Hispanics: 75.8%; non-Hispanic Others: 72.9%; non-Hispanic Whites: 72.1%).

The socio-demographic status indicators, including age, gender, educational attainment, household income, and marital status, correlated with the observed multimorbidity patterns. Over half of the U.S. older adults 65 years and older had completed more than a high school degree and were married. The median household income for the overall analytic sample was 45,600 U.S. dollars. The data revealed that a higher percentage of those without multimorbidity were in the younger senior age group, 65-74, had a higher education level, were more likely to be married, and had a higher average household income. Multimorbidity was more likely to be experienced among older individuals with lower educational attainment or a lower average household income. The prevalence of having at least two chronic conditions was the highest among people aged 85 years and older(84.2%), followed by people aged between 75 and 84 (81.5%). The gender distribution was similar between the two groups, with slightly more females than males. The prevalence of chronic conditions was higher in the multimorbidity group than in individuals with only one chronic condition. Specifically, 83.3% of those in the multimorbidity group had arthritis, compared to 34.4% of those with arthritis as their sole condition. Similarly,

82.7% of individuals with multimorbidity had hypertension, while in the no multimorbidity group, only 22.9% of people had hypertension.

Prevalence of Chronic Conditions

Table 2 provided an overview of chronic disease prevalence among U.S. older adults over 65, categorized by race/ethnicity. Overall, among American adults aged 65 years and older, 27.0% of the population had two chronic conditions, followed by three chronic conditions (25.8%).

The prevalence of the number of chronic conditions varied across racial groups. The number of individuals with chronic conditions continuously increases up to the point of having two chronic conditions among non-Hispanic Whites and non-Hispanic Others. Beyond this, the prevalence declines. Non-Hispanic Blacks and Hispanics had the prevalence of the number of chronic conditions increase up to three conditions then decrease. Non-Hispanic Whites had the highest percentage of individuals with no chronic condition (8.4%). Hispanics had a higher prevalence of no chronic condition than non-Hispanic Others (Hispanics: 7.1%; non-Hispanic Other: 6.4%). Non-Hispanic Blacks had the lowest percentage of individuals with no chronic conditions(4.0%). Hispanics had the highest prevalence of one chronic condition (20.0%), followed by non-Hispanic Whites (19.5%), non-Hispanic Others (17.8%), and non-Hispanic Blacks (12.8%). 28.3% of non-Hispanic Others had two chronic conditions, followed by non-Hispanic Whites(28.2%), non-Hispanic Blacks(26.9%), and then Hispanics (25.7%). Additionally, non-Hispanic Blacks overall had a higher number of three, four, and five or more chronic conditions compared to other racial groups (28.8%, 17.0%, and 10.6%, respectively). Conversely, the groups with the lowest prevalence vary by the number of conditions: Hispanics had the lowest prevalence of having four chronic conditions (11.6%), while non-Hispanic Whites

had the lowest prevalence of three and five or more chronic conditions (three conditions:23.8% five or more conditions:6.4%).

Prevalence of Individual Chronic Conditions

The prevalence of individual chronic conditions among U.S. adults aged 65 and over, categorized by race/ethnicity, was presented in Table 3. Hypertension was most prevalent among non-Hispanic Blacks (85.16%), followed by Hispanics (72.81%) and non-Hispanic Others (71.56%), all higher than that observed in non-Hispanic Whites (63.89%). In contrast, rates of arthritis were lower in non-Hispanic Others (65.25%), Hispanics (66.32%), and non-Hispanic Whites (70.52%) compared to non-Hispanic Blacks (73.56%). Diabetes affected 24.92% of non-Hispanic Whites, whereas the rates were substantially higher among non-Hispanic Blacks (40.53%), Hispanics (46.81%), and non-Hispanic Others (41.77%). Cancer prevalence was lower among non-Hispanic Others (12.62%), Hispanics (13.29%), and non-Hispanic Blacks (19.65%) compared to non-Hispanic Whites (21.59%). Non-Hispanic Blacks exhibited the highest prevalence of stroke at 13.38%. The rates of cancer among non-Hispanic Whites, Hispanics, and non-Hispanic Others were similar, at 9.91%, 9.86%, and 9.31% respectively. Lung disease prevalence was highest among non-Hispanic Blacks (14.50%), followed by non-Hispanic Others (12.48%), non-Hispanic Whites (12.22%), and Hispanics (11.05%). Higher rates of heart problems were observed in non-Hispanic Whites (32.60%), non-Hispanic Others (30.37%), and non-Hispanic Blacks (29.40%) compared to Hispanics (25.52%).

Chronic Conditions Combination: Dyads and Triads

Tables 4 and 5 presented the prevalence of dyads and triads of chronic conditions among U.S. adults aged 65 years and above, segmented by race and ethnicity. Among the two chronic conditions (dyad), the three most common combinations for non-Hispanic Whites were

hypertension-arthritis (44.8%), arthritis-heart problem (9.4%), and cancer-arthritis (8.5%). For non-Hispanic Blacks, the most prevalent dyads were hypertension-arthritis (62.8%), hypertension-diabetes (11.9%), and hypertension-cancer (4.6%). Non-Hispanic Others showed a high prevalence of hypertension-arthritis (41.3%), hypertension-diabetes (25.6%), and diabetes-arthritis (11.9%). Hispanics also predominantly experienced hypertension-arthritis (40.1%), hypertension-diabetes (23.7%), and diabetes-arthritis (10.4%).

Among three chronic conditions (triad), the three most common triads among non-Hispanic Blacks were hypertension-diabetes-arthritis (35.3%), hypertension-arthritis-heart problem (19.1%), and hypertension-cancer-arthritis (10.0%). Among non-Hispanic Whites, the three most common triads were the hypertension-arthritis-heart problem (25.0%), followed by hypertension-diabetes-arthritis (21.0%), and hypertension-cancer-arthritis (16.2%). Non-Hispanic Others had the highest prevalence of hypertension-diabetes-arthritis (40.7%), hypertension-arthritis-heart problem (22.3%), and hypertension-diabetes-heart problem (8.2%). Among Hispanics, the most common triads were hypertension-diabetes-arthritis (54.1%), followed by hypertension-arthritis-heart problem (15.5%), and hypertension-cancer-arthritis (5.4%).

Overall, there was a broader dispersion in the prevalence of chronic condition triads as compared to dyads among U.S. adults aged 65 years and older. Frequently, both dyads and triads that included hypertension were observed across all racial groups. The three most common dyads among individuals with two chronic conditions, as well as the three most prevalent triads among those with three chronic conditions, were stratified by race and ethnicity and are depicted in Figures 1 and 2.

Polytomous Logistic Regression

Table 6 displayed the results of the polytomous logistic regression analysis, examining the association between race/ethnicity and the prevalence of multimorbidity among U.S. older adults aged 65 and older. This table presented odds ratios for having one chronic condition, multimorbidity (two chronic conditions), and multimorbidity (three or more chronic conditions) and their respective 95% confidence interval. Model 1a-3a represented the unadjusted model, while model 1b-3b showed the full model adjusted by age, gender, education level, marital status, and household income.

<u>One Chronic Condition</u>

In unadjusted model 1a, none non-Hispanic Blacks, non-Hispanic Others, or Hispanics showed significantly different odds of having one chronic condition compared to non-Hispanic Whites. After controlling for all the covariates in model 1b, the association between race/ethnicity groups and one chronic condition remained insignificant. Age was significantly associated with one chronic condition compared to no chronic condition. Individuals between 75 and 84 years showed significantly higher odds of having one chronic condition than those aged 65-74 (75-84: 1.71, 95%CI:1.32-2.21). No significant association was found between having one chronic condition and gender, education level, marital status, and income.

<u>Multimorbidity: Two Chronic Conditions</u>

In models 2a and 2b, race was significantly associated with having two chronic conditions compared to no chronic condition. In the unadjusted model, non-Hispanic Blacks had significantly higher odds of having two chronic conditions compared to non-Hispanic Whites (OR: 1.98, 95% CI: 1.36-2.87). After adjusting age, gender, education level, marital status, and income, non-Hispanic Blacks still had significantly higher odds of having two chronic conditions

compared to non-Hispanic Whites (OR: 1.78 95% CI: 1.24-2.57). In comparison, all other racial groups showed no significant association with having two chronic conditions. The odds of multimorbidity (two chronic conditions) increased significantly with age compared to no chronic condition. The odds of having two chronic conditions were 2.48 times higher among people in the age group 75-84 years and 2.02 times higher among those aged 85 or older (age group 75-84: OR 2.48, 95% CI: 1.92-3.22; age group > 85: OR 2.02, 95% CI: 1.36-3.01). Similar to one chronic condition (Model 1a and 1b), other covariates remained insignificantly associated with two chronic conditions.

Multimorbidity: Three and More Chronic Conditions

In models 3a and 3b, there was a similar trend in the association between multimorbidity and race/ethnicity groups. The unadjusted model 3a indicated that non-Hispanic Blacks had 2.66 times the odds of having three or more chronic conditions than Non-Hispanic White individuals (95% CI: 1.79-3.95). After adjusting for age, gender, marital status, education level, and household income in model 3b, non-Hispanic Blacks had lower odds of three or more chronic conditions than non-Hispanic Whites in the unadjusted model. However, they remained significantly higher than non-Hispanic Whites (OR:2.16, 95% CI 1.45-3.24). There was no significant association found in non-Hispanic Others or Hispanics with three or more chronic conditions compared to non-Hispanic Whites.

The odds of multimorbidity (three or more chronic conditions) increased significantly with age (age group 75-84: OR 3.44, 95% CI: 2.52-4.42; age group > 85: OR 3.38, 95% CI: 2.29-5.01) compared to those with no chronic conditions. For education level, people who had more than a high school degree had 56% lower odds of having three or more chronic conditions than people aged 65-74 years (OR = 0.44, 95% CI: 0.27-0.71). Furthermore, income was

significantly inversely related to multimorbidity (3 or more chronic conditions) (OR=0.78, 95% CI: 0.68-0.90).

V.DISCUSSION

The study assessed the prevalence of multimorbidity among U.S. adults aged 65 years and older, stratified by race/ethnicity, using nationally representative data. It also identified the most common conditions, including dyads and triads, and compared the prevalence of these patterns among racial/ethnic groups. Findings indicated that multimorbidity was common, affecting 73.4% or 37.9 million older adults aged 65 years and over in the U.S. This is similar to a previous cross-sectional study, which reported a prevalence of 73.0% or 38.0 million[47]. The prevalence of having at least two chronic conditions increased with age, peaking at 84.2% among individuals aged 85 years and older. Additionally, certain demographic factors such as being non-Hispanic Black, female, having a lower household income, attaining lower levels of education, or being divorced, unmarried, or widowed were associated with a higher prevalence of multimorbidity.

The most common dyads of conditions varied with racial and ethnic groups, whereas the most common triads of chronic conditions were similar across four racial and ethnic groups, as shown in previous studies[3],[49]. Some of the most common dyads or triads observed in this study were hypertension-arthritis, hypertension-diabetes, and hypertension-diabetes-arthritis. These combinations were expected given the high frequency of the individual conditions and have been recognized in other studies[3],[16],[46]. Both hypertension and arthritis, as well as hypertension and diabetes, have been shown in previous studies to share common pathways in which one condition may develop after the other for the same individual[12],[30],[56]. Among the four racial and ethnic groups, non-Hispanic Blacks exhibited the highest prevalence of the hypertension-arthritis dyad. This may be attributed to adverse social determinants of health, including limited access to nutritious food and lower socioeconomic status[18]. Additionally,

occupational demands that involve bending, lifting, and repetitive movements—common in jobs frequently held by non-Hispanic Blacks—may also contribute to this prevalence[22]. Hypertension-diabetes was more frequently co-occurring among non-Hispanic Others than the other three racial and ethnic groups. This trend may be due to limited access to healthcare, which could be a lack of insurance or perceived discrimination, contributing to delays in the early detection of these conditions[36]. Hispanics had the highest prevalence of hypertension-diabetes-arthritis. This pattern could be associated with traditional dietary habits prevalent within Hispanic communities, where the consumption of calorie-dense foods contributes to disproportionately high obesity rates from a young age. Early-onset obesity increases the risk of developing diabetes later in life. Once diabetes is established, it can increase the likelihood of developing hypertension and arthritis through interconnected pathways[2],[52],[56]. Future research should investigate the association between multimorbidity and race/ethnicity with lifestyle factors, such as dietary patterns. Non-Hispanic Whites had a few distinct dyads among the most common dyads compared to the other three racial groups, which were arthritis-heart problem and cancer-arthritis. Behavior factors, such as smoking status, physical activity, as well as inflammatory forms of arthritis, lead to, which is the result of cancer or heart problems development[18].

Race/ethnicity was found to be associated with multimorbidity. Non-Hispanic Blacks showed greater odds of multimorbidity than non-Hispanic Whites, consistent with existing literature[25],[36]. Even after controlling for age, gender, marital status, education level, and household income, the association between non-Hispanic Blacks and multimorbidity persists. This suggests that factors such as stress from perceived discrimination, poorer mental health, and health behaviors influenced by cultural factors may contribute to racial/ethnic differences in

multimorbidity[57]. Future research should investigate these factors as potential mediators of the association between race/ethnicity and multimorbidity. However, Hispanics and non-Hispanic Others were not strongly associated with multimorbidity, which differs from previous studies[25],[44]. The possible reasons for the inconsistency may be due to the different numbers and types of chronic conditions involved in the study and the different measurements of multimorbidity.

Previous studies found that age, gender, education level, marital status, and income have been shown in the literature as predictors of health-related outcomes among U.S. adults[23],[42]. In this study, age, education level, and income were associated with multimorbidity; however, gender and marital status were not. Multimorbidity is significantly associated with increasing age, consistent with prior research[57]. Individuals with higher education levels were less likely to have multimorbidity than people with low education levels[42]. Previous studies have mentioned that people with higher education levels have more accurate health knowledge, thus better lifestyle choices and self-reported health outcomes[59]. In addition, education is closely related to income status, as generally, individuals with high education attainment tend to get more stable jobs that pay higher incomes[59]. Higher-income levels often give people better access to healthcare services and better nutrition, contributing to a lower likelihood of chronic conditions[36]. The findings from this study seem to support this, as higher income is linked to a decreased likelihood of having three or more chronic conditions.

Strength and Limitations

This study has several strengths. Firstly, the Health and Retirement Study (HRS) provides a nationally representative sample of older adults in the United States and contributes to the

generalizability of the findings. Secondly, the HRS collects comprehensive information on various health conditions and demographic factors, offering a rich dataset for studying multimorbidity differences by race/ethnicity. Thirdly, examining the prevalence of multimorbidity among U.S. older adults by race/ethnicity allows for the important identification of multimorbidity combinations within each racial group, serving as a platform for future research.

There are some limitations to this study. Firstly, given the nature of a cross-sectional study, this research cannot make causal inferences or assess changes in multimorbidity patterns over time within the same individuals. Secondly, this study only included seven chronic conditions to assess multimorbidity prevalence in American older adults. Most research has demonstrated that broader disease inclusion criteria yield higher prevalence estimates, suggesting that the limited disease count in this study might only partially reflect the burden of multimorbidity among older adults[1],[36]. Additionally, while the 2018 Health and Retirement Study (HRS) provided data on emotional problems and sleep disorders, these were not considered in the current analysis, aligning with the study's focus on physical health conditions. This exclusion likely contributes to an underestimation of multimorbidity prevalence as well. Furthermore, using total household income as a covariate among adults 65 years and older could potentially misrepresent socioeconomic status, as most were retirees. Since many older adults do not receive a regular income due to retirement, low-income levels might need to reflect their financial status accurately. Lastly, all health variables in this study were self-reported, which may lead to potential recall and misreporting biases. Participants aged 65 and older may forget whether they were diagnosed with a chronic condition, especially if it was a long time ago or if the condition was minor.

Future studies should consider including a broader array of chronic conditions beyond the seven assessed in the current study. Incorporating additional physical health conditions, as well as mental health and cognitive disorders, could provide a more comprehensive understanding of multimorbidity. Furthermore, future research should aim to include larger and more representative samples of racial minority groups. This enhancement would yield more data on multimorbidity for these populations and offer deeper insights into their specific health disparities.

Conclusion

The prevalence of multimorbidity among older adults aged 65 and older in the U.S. was found to be 73.4%. Non-Hispanic Blacks were more likely to have multimorbidity compared to non-Hispanic Whites. The dyads and triads pattern of chronic conditions involving hypertension, diabetes, and arthritis were shared across the non-Hispanic Whites, non-Hispanic Blacks, non-Hispanic Others, and Hispanics. The prevalence of multimorbidity and the prevalence of the three most common dyads and triads varied by race/ethnicity. These findings provide insights into the existence of racial and ethnic differences in the prevalence of multimorbidity among adults aged 65 years and older in the U.S. These differences underscore the urgent need for culturally sensitive and accessible healthcare interventions aimed at reducing the burden of chronic diseases and improving the overall health outcomes for these populations.

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VII.TABLES AND FIGURES

Table 1. Sample Characteristics of Adults aged 65+ in the US

	No Multimorbidity	Multimorbidity[a]	Overall
Sample Size	n=2,076	n=6,916	n=8,992
Age			
65-74	72.7%	54.2%	59.1%
75-84	20.6%	32.8%	29.5%
85+	6.7%	13.0%	11.3%
Gender			
Male	44.2%	44.7%	44.6%
Female	55.8%	55.3%	55.4%
Race/Ethnicity			
Non-Hispanic White	83.6%	78.1%	79.6%
Non-Hispanic Black	5.8%	10.5%	9.2%
Hispanic	7.6%	8.7%	8.4%
Non-Hispanic Other[b]	2.9%	2.8%	2.8%
Education Level			
Less than high school	10.5%	19.1%	16.8%
High school	24.7%	28.6%	27.6%
More than high school	64.8%	52.3%	55.6%
Marital Status			
Married	66.0%	57.3%	59.6%
Divorced/Widowed/Never Married	34.0%	42.7%	40.4%
Income[c]	58539 (163361.1)	41700 (208429.8)	45600 (197763.4)
Chronic Conditions			
Hypertension	22.9%	82.7%	66.8%
Diabetes	3.3%	37.8%	28.7%
Cancer	4.4%	26.3%	20.5%
Lung Disease	1.0%	16.5%	12.3%
Heart Problems	4.3%	41.5%	31.6%
Stroke	0.5%	13.7%	10.2%
Arthritis	34.4%	83.3%	70.3%

n=8992 N~ 51,683,086

a To assess multimorbidity, following chronic diseases were included in the analyses: hypertension, arthritis, diabetes, stroke, heart problem, chronic lung disease, cancer.

b Non-Hispanic Other includes American Indian, Alaskan Native, Asian, Native Hawaiian, and Pacific Islander

c Median (SD) of household income

Survey weighted; Source: Health Retirement Study, 2018

Table 2. Prevalence of Number of Chronic Diseases* Among U.S Adults aged 65+ by Race/Ethnicity Groups

	No Condition n=547	**1 Condition** n=1,529	**2 Conditions** n=2,429	**3 Conditions** n=2,323	**4 Conditions** n=1,422	**5+ Conditions** n=742
Non-Hispanic White	8.4%	19.5%	28.2%	23.8%	13.7%	6.4%
Non-Hispanic Black	4.0%	12.8%	26.9%	28.8%	17.0%	10.6%
Hispanic	7.1%	20.0%	25.7%	26.9%	11.6%	8.8%
Non-Hispanic Other[a]	6.4%	17.8%	28.3%	27.5%	13.0%	7.1%

n=8992 N~ 51,683,086
*Chronic diseases included in the analyses were hypertension, arthritis, diabetes, heart problem, chronic lung disease, cancer, and stroke
[a]Non-Hispanic Other includes American Indian, Alaskan Native, Asian, Native Hawaiian, and Pacific Islander
Row totals may not equal to 100, due to rounding
Survey weighted; Source: Health Retirement Study, 2018

Table 3. Prevalence of Chronic Disease by Race/Ethnicity among U.S Adults aged 65+

	Non-Hispanic White n=6051	Non-Hispanic Black n=1570	Hispanic n=1131	Non-Hispanic Other[a] n=240
Hypertension	63.89%	85.16%	72.81%	71.56%
Diabetes	24.92%	40.53%	46.81%	41.77%
Cancer	21.59%	19.65%	13.29%	12.62%
Stroke	9.91%	13.38%	9.31%	9.86%
Lung Disease	12.22%	14.50%	11.05%	12.48%
Heart Problem	32.60%	29.40%	25.52%	30.37%
Arthritis	70.52%	73.56%	66.32%	65.25%

n=8992 N~ 51,683,086
[a] Non-Hispanic Other includes American Indian, Alaskan Native, Asian, Native Hawaiian, and Pacific Islander
Survey weighted. Source: Health Retirement Study,2018

Table 4: Most Prevalent Dyads of Chronic Diseases among U.S Adults with Two Chronic Conditions, by Race and Ethnicity

Chronic Condition Dyads	Prevalence (%)
Overall (n=2429)	
Hypertension-Arthritis	45.9%
Hypertension-Diabetes	10.0%
Arthritis-Heart Problem	8.3%
Non-Hispanic White(n=1627)	
Hypertension-Arthritis	44.8%
Arthritis-Heart Problem	9.4%
Cancer-Arthritis	8.5%
Non-Hispanic Black (n=434)	
Hypertension-Arthritis	62.8%
Hypertension-Diabetes	11.9%
Hypertension-Cancer	4.6%
Non-Hispanic Other[a] (n=58)	
Hypertension-Arthritis	41.3%
Hypertension-Diabetes	25.6%
Diabetes-Arthritis	11.9%
Hispanic (n=310)	
Hypertension- Arthritis	40.1%
Hypertension-Diabetes	23.7%
Diabetes-Arthritis	10.4%

n=2429 N~ 14,466,792

[a]Non-Hispanic Other includes American Indian, Alaskan Native, Asian, Native Hawaiian, and Pacific Islander

*Prevalence estimates for each group does not add up to 100 as some dyads were not listed in the table due to low sample size

Survey weighted; Source: Health Retirement Study, 2018

Table 5. Most Prevalent Triads of Chronic Diseases among U.S Adults with Three Chronic Conditions, by Race and Ethnicity

Chronic Condition Triads	Prevalence (%)
Overall (n=2323)	
Hypertension-Diabetes-Arthritis	26.3%
Hypertension-Arthritis-Heart Problem	23.4%
Hypertension-Cancer-Arthritis	14.1%
Non-Hispanic White (n=1534)	
Hypertension-Arthritis-Heart Problem	25.0%
Hypertension-Diabetes-Arthritis	21.0%
Hypertension-Cancer-Arthritis	16.2%
Non-Hispanic Black (n=445)	
Hypertension-Diabetes-Arthritis	35.3%
Hypertension-Arthritis-Heart Problem	19.1%
Hypertension-Cancer-Arthritis	10.0%
Non-Hispanic Other[a] (n=55)	
Hypertension-Diabetes-Arthritis	40.7%
Hypertension-Arthritis-Heart Problem	22.3%
Hypertension-Diabetes-Heart Problem	8.2%
Hispanic (n=289)	
Hypertension-Diabetes-Arthritis	54.1%
Hypertension-Arthritis-Heart Problem	15.5%
Hypertension-Cancer-Arthritis	5.4%

n=2323 N~ 12,759,115.

[a]Non-Hispanic Other includes American Indian, Alaskan Native, Asian, Native Hawaiian, and Pacific Islander

*Prevalence estimates for each group does not add up to 100 as some dyads were not listed in the table due to low sample size

Survey weighted; Source: Health Retirement Study,2018

Table 6. Results of the Polytomous Logistic Regression Analysis

	One Chronic Condition[a]		**Multimorbidity (2 Chronic Conditions[a])**		**Multimorbidity (>=3 Chronic Conditions[a])**	
	Model 1a OR (95%CI)	Model 1b OR (95%CI)	Model 2a OR (95%CI)	Model 2b OR (95%CI)	Model 3a OR (95%CI)	Model 3b OR (95%CI)
Race (Non-Hispanic White)	1.36 (0.86-2.14)	1.27 (0.81-1.99)	1.98 (1.36-2.87) ***	1.78 (1.24-2.57) **	2.66 (1.79-3.95)***	2.16 (1.45-3.24)***
Non-Hispanic Black	1.21 (0.67-2.17)	1.18 (0.65-2.14)	1,07 (0.61-1.88)	1.05 (0.60-1.83)	1.27 (0.78-2.08)	1.19 (0.72-1.97)
Non-Hispanic Other[b]	1.20 (0.81-1.78)	1.04 (0.70-1.53)	1.32 (0.88-1.96)	1.03 (0.67-1.56)	1.42 (0.96-2.11)	0.83 (0.55-1.26)
Hispanic						
Age (65-74)						
75-84	--	1.71 (1.32-2.21) ***	--	2.48 (1.92-3.22) ***	--	3.34 (2.52-4.42)***
85+	--	1.37 (0.89-2.10)	--	2.02 (1.36-3.01) ***	--	3.38 (2.29-5.01)***
Gender (Male)						
Female	--	0.95 (0.73-1.25)	--	0.90 (0.69-1.16)	--	0.78 (0.60-1.01)
Educational Level (Less than high school)						
High school	--	1.03 (0.59-1.80)	--	0.86 (0.50-1.48)	--	0.69 (0.43-1.13)
More than high school	--	0.84 (0.51-1.38)	--	0.65 (0.39-1.10)	--	0.44 (0.27-0.71)***
Marital Status (Married)						
Divorced/Widowed/Never Married	--	1.07 (0.83-1.38)	--	1.19 (0.90-1.56)	--	1.15 (0.90-1.48)
Income	--	0.90 (0.77-1.05)	--	0.88 (0.77-1.02)	--	0.78 (0.68-0.90)***

[a]base outcome: no chronic condition.

[b]Non-Hispanic Other includes American Indian, Alaskan Native, Asian, Native Hawaiian, and Pacific Islander

Results from two regressions: Unadjusted model included race/ethnicity. Adjusted model included race/ethnicity and controlled covariates (age, fender, educational level, marital status, and income)

*<=.05 **<=.01 ***<=.001

Reference categories are shown in parenthesis.

Survey weighted; Source: Health Retirement Study,2018

Figure 1. Most Prevalent Dyads of Chronic Diseases among U.S Adults with Two Chronic Conditions, by Race and Ethnicity

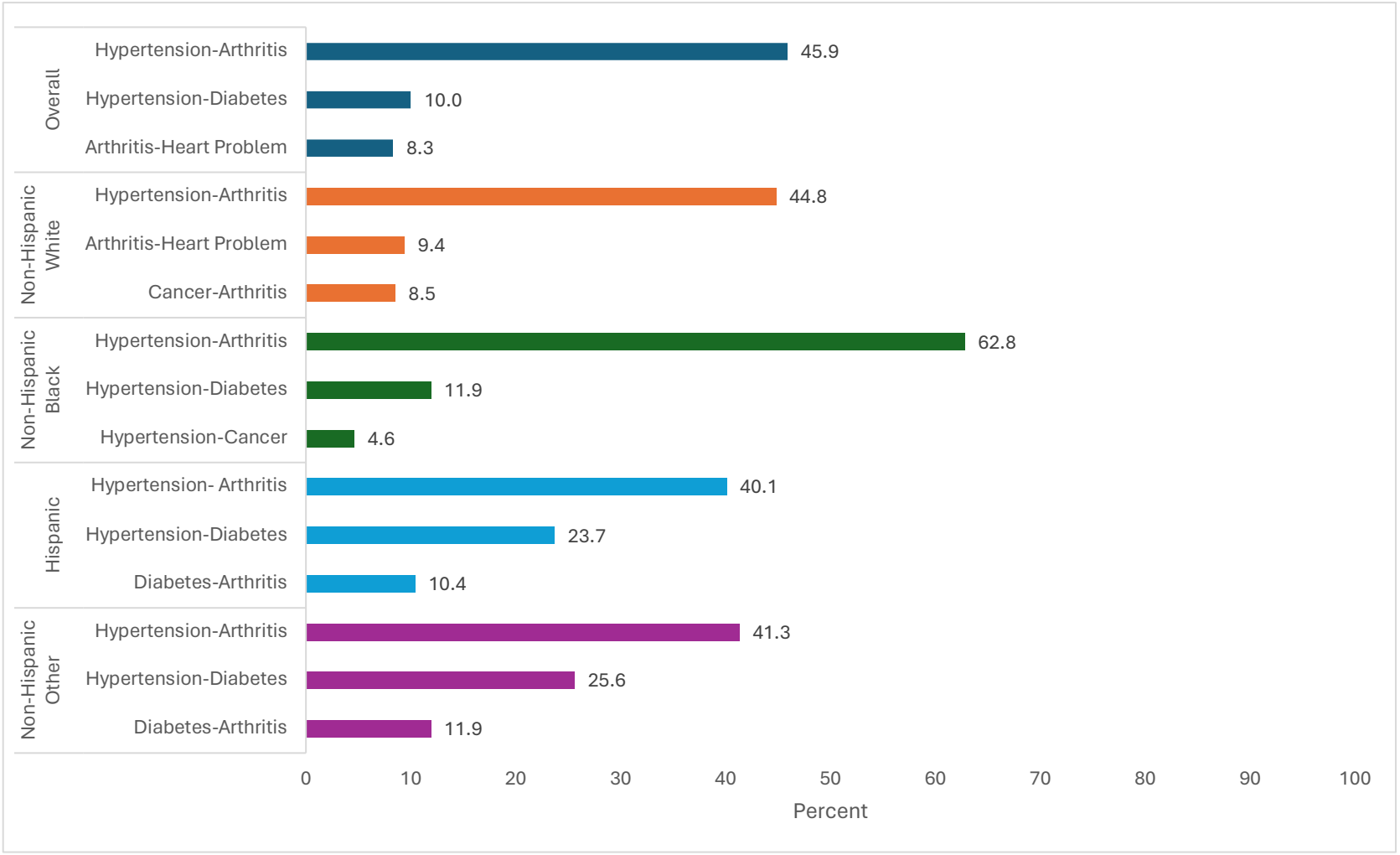
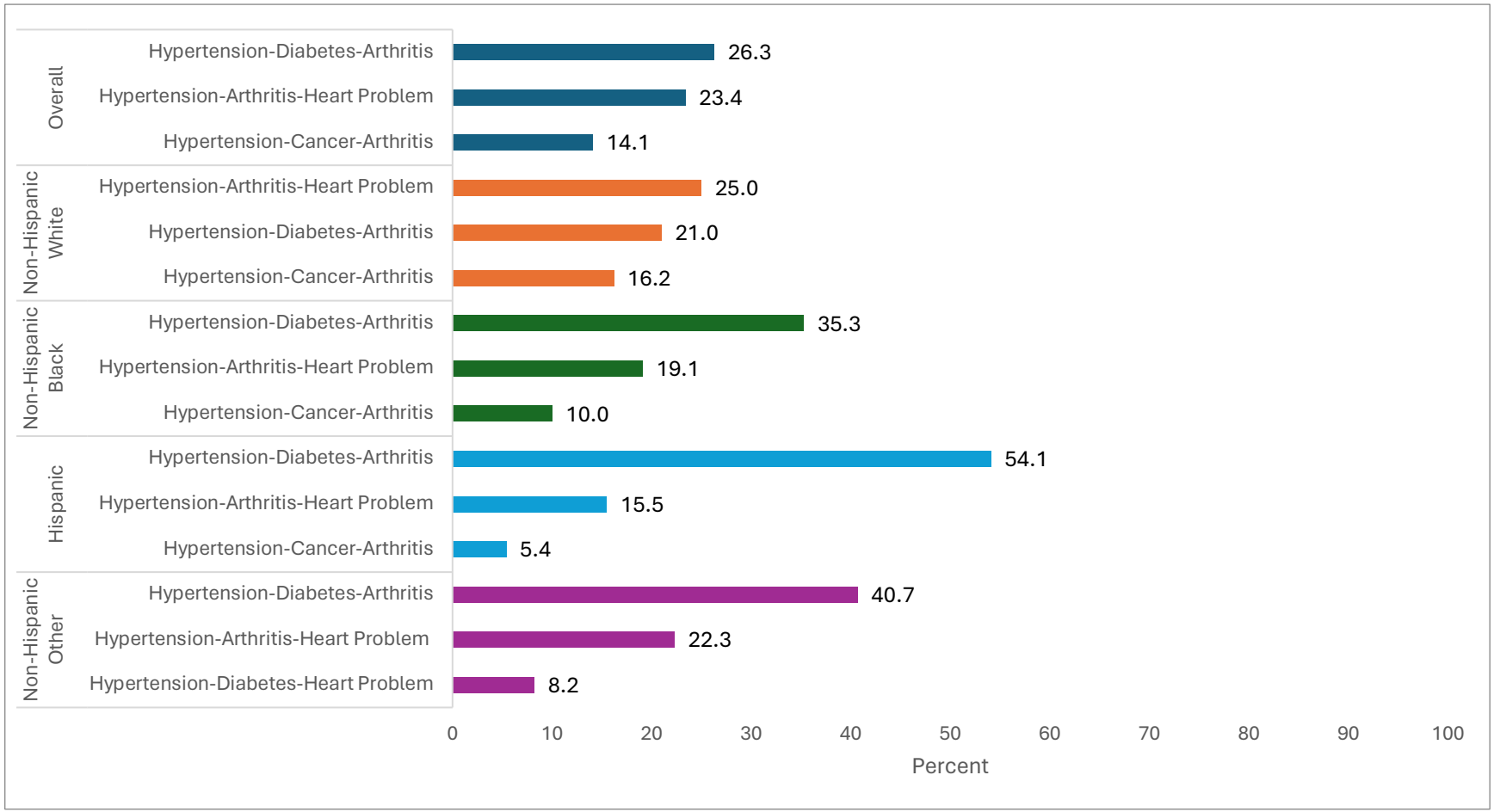


Figure 2. Most Prevalent Triads of Chronic Diseases among U.S Adults with Three Chronic Conditions, by Race and Ethnicity



VIII. APPENDICES

Table 1. Sample Characteristics of Adults aged 65+ in the U.S (n=8992)

	No Multimorbidity	Multimorbidity	Overall	Test
Sample Size	n=2,076	n=6,916	n=8,992	
Age, years				
65-74	1283 (61.8%)	2881 (41.7%)	4164 (46.3%)	<0.001***
75-84	603 (29.0%)	2898 (41.9%)	3501 (38.9%)	
85+	190 (9.2%)	1137 (16.4%)	1327 (14.8%)	
Gender				0.447
Male	862 (41.5%)	2807 (40.6%)	3669 (40.8%)	
Female	1214 (58.5%)	4109 (59.4%)	5323 (59.2%)	
Race/Ethnicity				
Non-Hispanic Black	259 (12.5%)	1311 (19.0%)	1570 (17.5%)	<0.001***
Non-Hispanic White	1458 (70.2%)	4593 (66.4%)	6051 (67.3%)	
Non-Hispanic Other[b]	71 (3.4%)	169 (2.4%)	240 (2.7%)	
Hispanic	288 (13.9%)	843 (12.2%)	1131 (12.6%)	
Education Level				
Less than high school	343 (16.5%)	1,679 (24.3%)	2022 (22.5%)	<0.001***
High school	548 (26.4%)	2,051 (29.7%)	2599 (28.9%)	
More than high school	1185 (57.1%)	3,186 (46.1%)	4371 (48.6%)	
Marital Status				
Married	1271 (61.2%)	3,585 (51.8%)	4856 (54.0%)	<0.001***
Divorced/Widowed/Never Married	805 (38.8%)	3,331 (48.2%)	4136 (46.0%)	
Income[c]	47004 (134,660)	34043 (163,283)	36564 (157,344)	<0.001***
Chronic Conditions				<0.001***
Hypertension	525 (25.3%)	5880 (85.0%)	6405 (71.2%)	
Diabetes	86 (4.1%)	2750 (39.8%)	2836 (31.5%)	
Cancer	94 (4.5%)	1775 (25.7%)	1869 (20.8%)	
Lung Disease	20 (1.0%)	1167 (16.9%)	1187 (13.2%)	
Heart Problems	85 (4.1%)	2930 (42.4%)	3015 (33.5%)	
Stroke	14 (0.7%)	1098 (15.9%)	1112 (12.4%)	
Arthritis	705 (34.0%)	5792 (83.7%)	6497 (72.3%)	

*** Significant at the .001 level

a To assess multimorbidity, following chronic diseases were included in the analyses: hypertension, arthritis, diabetes, stroke, heart problem, chronic lung disease, cancer.

b Non-Hispanic Other includes American Indian, Alaskan Native, Asian, Native Hawaiian, and Pacific Islander

c Median (SD)

Table 2. Prevalence of Chronic Condition Dyads Among U.S. Adults Aged 65+ with Two Chronic Conditions

	Non-Hispanic White	**Non-Hispanic Blac**	**Non-Hispanic Other**	**Hispanic**	**Total**
N	11,589,500 (80.1%)	1,281,029 (8.9%)	372,266 (2.6%)	1,223,997 (8.5%)	14,466,792 (100.0%)
Hypertension-Diabetes	914,292 (7.9%)	152,515 (11.9%)	95,364 (25.6%)	289,506 (23.7%)	1,451,677 (10.0%)
Hypertension-Cancer	506,119 (4.4%)	58,621 (4.6%)	16,355 (4.4%)	39,858 (3.3%)	620,953 (4.3%)
Hypertension-Lung	189,508 (1.6%)	16,570 (1.3%)	649 (0.2%)	0 (0.0%)	206,727 (1.4%)
Hypertension-Arthritis	5,193,318 (44.8%)	804,992 (62.8%)	153,725 (41.3%)	490,439 (40.1%)	6,642,474 (45.9%)
Hypertension-Heart	725,662 (6.3%)	49,289 (3.8%)	17,602 (4.7%)	66,738 (5.5%)	859,291 (5.9%)
Hypertension-Stroke	170,856 (1.5%)	29,955 (2.3%)	0 (0.0%)	7,651 (0.6%)	208,462 (1.4%)
Diabetes-Cancer	73,583 (0.6%)	0 (0.0%)	0 (0.0%)	10,495 (0.9%)	84,078 (0.6%)
Diabetes-Lung	13,078 (0.1%)	0 (0.0%)	0 (0.0%)	7,233 (0.6%)	20,311 (0.1%)
Diabetes-Arthritis	638,317 (5.5%)	46,152 (3.6%)	44,381 (11.9%)	127,660 (10.4%)	856,510 (5.9%)
Diabetes-Heart	49,953 (0.4%)	5,575 (0.4%)	0 (0.0%)	15,392 (1.3%)	70,920 (0.5%)
Diabetes-Stroke	5,443 (0.0%)	2,500 (0.2%)	0 (0.0%)	0 (0.0%)	7,943 (0.1%)
Cancer-Lung	30,110 (0.3%)	10,938 (0.9%)	0 (0.0%)	0 (0.0%)	41,048 (0.3%)
Cancer-Arthritis	985,652 (8.5%)	43,494 (3.4%)	6,351 (1.7%)	56,382 (4.6%)	1,091,879 (7.5%)
Cancer-Heart	136,677 (1.2%)	0 (0.0%)	5,603 (1.5%)	0 (0.0%)	142,280 (1.0%)
Cancer-Stroke	19,534 (0.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	19,534 (0.1%)
Lung-Arthritis	608,593 (5.3%)	14,329 (1.1%)	17,371 (4.7%)	29,259 (2.4%)	669,552 (4.6%)
Lung-Heart	24,656 (0.2%)	0 (0.0%)	0 (0.0%)	6,527 (0.5%)	31,183 (0.2%)
Lung-Stroke	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Arthritis-Heart	1,094,190 (9.4%)	29,683 (2.3%)	7,720 (2.1%)	63,257 (5.2%)	1,194,850 (8.3%)
Arthritis-Stroke	165,883 (1.4%)	15,503 (1.2%)	7,145 (1.9%)	5,481 (0.4%)	194,012 (1.3%)
Heart-Stroke	44,076 (0.4%)	913 (0.1%)	0 (0.0%)	8,119 (0.7%)	53,108 (0.4%)

Table 3. Prevalence of Chronic Condition Triads Among U.S. Adults Aged 65+ with Three Chronic Conditions

N	**Non-Hispanic White** 9,806,572 (76.9%)	**Non-Hispanic Black** 1,371,895 (10.8%)	**Non-Hispanic Other** 389,796 (3.1%)	**Hispanic** 1,190,852 (9.3%)	**Total** 12,759,115 (100.0%)
Hypertension-Diabetes-Cancer	161,371 (1.6%)	20,805 (1.5%)	9,692 (2.5%)	9,630 (0.8%)	201,498 (1.6%)
Hypertension-Diabetes-Lung	28,876 (0.3%)	13,195 (1.0%)	27,715 (7.1%)	16,294 (1.4%)	86,080 (0.7%)
Hypertension-Diabetes-Arthritis	2,063,431 (21.0%)	484,484 (35.3%)	158,642 (40.7%)	643,995 (54.1%)	3,350,552 (26.3%)
Hypertension-Diabetes-Heart	401,089 (4.1%)	104,750 (7.6%)	31,876 (8.2%)	30,838 (2.6%)	568,553 (4.5%)
Hypertension-Diabetes-Stroke	94,714 (1.0%)	25,523 (1.9%)	0 (0.0%)	48,222 (4.0%)	168,459 (1.3%)
Hypertension-Cancer-Lung	63,770 (0.7%)	29,677 (2.2%)	0 (0.0%)	0 (0.0%)	93,447 (0.7%)
Hypertension-Cancer-Arthritis	1,589,202 (16.2%)	137,160 (10.0%)	9,365 (2.4%)	64,604 (5.4%)	1,800,331 (14.1%)
Hypertension-Cancer-Heart	345,757 (3.5%)	22,320 (1.6%)	0 (0.0%)	7,444 (0.6%)	375,521 (2.9%)
Hypertension-Cancer-Stroke	49,911 (0.5%)	0 (0.0%)	0 (0.0%)	31,653 (2.7%)	81,564 (0.6%)
Hypertension-Lung-Arthritis	652,336 (6.7%)	97,512 (7.1%)	18,778 (4.8%)	44,645 (3.7%)	813,271 (6.4%)
Hypertension-Lung-Heart	57,108 (0.6%)	9,458 (0.7%)	0 (0.0%)	21,571 (1.8%)	88,137 (0.7%)
Hypertension-Lung-Stroke	14,517 (0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	14,517 (0.1%)
Hypertension-Arthritis-Heart	2,452,152 (25.0%)	262,248 (19.1%)	86,904 (22.3%)	184,242 (15.5%)	2,985,546 (23.4%)
Hypertension-Arthritis-Stroke	472,841 (4.8%)	82,235 (6.0%)	10,562 (2.7%)	8,062 (0.7%)	573,700 (4.5%)
Hypertension-Heart-Stroke	95,099 (1.0%)	7,810 (0.6%)	0 (0.0%)	13,268 (1.1%)	116,177 (0.9%)
Diabetes-Cancer-Lung	4,934 (0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	4,934 (0.1%)
Diabetes-Cancer-Arthritis	144,064 (1.5%)	21,019 (1.5%)	0 (0.0%)	15,458 (1.3%)	180,541 (1.4%)
Diabetes-Cancer-Heart	34,831 (0.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	34,831 (0.3%)
Diabetes-Cancer-Stroke	7,155 (0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	7,155 (0.1%)
Diabetes-Lung-Arthritis	57,576 (0.6%)	3,758 (0.3%)	0 (0.0%)	3,471 (0.3%)	64,805 (0.5%)
Diabetes-Lung-Heart	4,536 (0.0%)	7,465 (0.5%)	0 (0.0%)	0 (0.0%)	12,001 (0.1%)
Diabetes-Lung-Stroke	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Diabetes-Arthritis-Heart	218,396 (2.2%)	6,868 (0.5%)	21,621 (5.5%)	15,602 (1.3%)	262,487 (2.1%)
Diabetes-Arthritis-Stroke	31,142 (0.3%)	9,941 (0.7%)	0 (0.0%)	0 (0.0%)	41,083 (0.3%)
Diabetes-Heart-Stroke	13,053 (0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	13,053 (0.1%)
Cancer-Lung-Arthritis	74,649 (0.8%)	4,862 (0.4%)	2,389 (0.6%)	9,648 (0.8%)	91,548 (0.7%)
Cancer-Lung-Heart	11,804 (0.1%)	0 (0.0%)	7,021 (1.8%)	0 (0.0%)	18,825 (0.1%)
Cancer-Lung-Stroke	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Cancer-Arthritis-Heart	321,893 (3.3%)	0 (0.0%)	0 (0.0%)	4,649 (0.4%)	326,542 (2.6%)
Cancer-Arthritis-Stroke	22,949 (0.2%)	2,079 (0.2%)	0 (0.0%)	0 (0.0%)	25,028 (0.2%)
Cancer-Heart-Stroke	5,526 (0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	5,526 (0.1%)
Lung-Arthritis-Heart	127,950 (1.3%)	18,726 (1.4%)	0 (0.0%)	13,651 (1.1%)	160,327 (1.3%)
Lung-Arthritis-Stroke	25,117 (0.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	25,117 (0.2%)
Lung-Heart-Stroke	13,967 (0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	13,967 (0.1%)
Arthritis-Heart-Stroke	144,856 (1.5%)	0 (0.0%)	5,231 (1.3%)	3,905 (0.3%)	153,992 (1.2%)