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The Association Between Dietary Flavonoid Intake and Cardiovascular Health Indicators in Women Aged 45 to 65

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2024

Abstract

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MPH, Benedictine University, 2020

BSHS, Purdue University, 2018

Dissertation Submitted in Partial Fulfillment

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Abstract

Cardiovascular disease is a leading cause of death in menopausal women in the United States. Aside from those with confounding comorbidities and risk factors, women have a protective factor against cardiovascular disease before menopause, but once menopause begins, their risk increases. Flavonoids have been associated with positive outcomes for overall cardiovascular health indicators without the side effects and risks of long term HRT use. The socio-ecological model was utilized as a framework to examine the association between dietary flavonoid intake on cardiovascular health indicators in women aged 45 to 65 in the United States. The 2017–2018 NHANES data set, containing 9,254 participants, was utilized for this study. Of the 9,254 participants, 4,697 were female, with 1,063 women within the target age range of 45–65. Controlling for covariates, complex samples multiple logistic regression resulted in no statistically significant findings for hypertension, hyperlipidemia, or hypertriglyceridemia and daily flavonoid intake. The results underscore the imperative for additional research to explore the impact of flavonoids on overall cardiovascular risk in this demographic through longitudinal studies and the inclusion of other factors, such as c-reactive protein values. This study's findings indicating the connections between overweight, obesity, and diabetes with cardiovascular risk in menopausal women could lead to positive social change by providing insight into the heightened cardiovascular risk this population faces and emphasizing the need for targeted interventions and public health initiatives to address the risk.

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Dedication

I dedicate this dissertation to my children and my grandchildren. My wish for you is that this serves as a lesson for each of you about the power of believing in your dreams and working hard to achieve them. If I can accomplish this, you can also accomplish anything you set your mind to accomplish and work hard to achieve.

Acknowledgments

I would like to thank my chair, Dr. James Rohrer, and committee member, Dr. Peter Anderson, for their expertise and guidance throughout this process. Dr. Rohrer helped me stay on track, answered my questions, reassured me when I struggled, and helped me to move through the dissertation process. Dr. Anderson's feedback was invaluable to the quality of my research and dissertation.

I would like to thank my family for their support and patience throughout this process. A special thank you to my friend and co-worker, LisaMaria Mariglia, for her continual encouragement and support throughout the dissertation process. She is one of the kindest, most caring, and encouraging people I have ever met.

I would like to thank God for His unwavering love and goodness. Without Him I would never have been able to manage working full time, completing my dissertation, and my doctoral internship with the Centers for Disease Control and Prevention. While there were many struggles, He was always with me giving me strength to continue.

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Chapter 1: Introduction to the Study

Cardiovascular disease (CVD) in menopausal women is a significant public health concern in the United States (El Khoudary et al., 2020). CVD is currently the leading cause of death in women in the United States, and the risk for CVD sharply rises in women as they enter menopause (El Khoudary et al., 2020). The changes in sex hormones at and during menopause are attributed to the increased risk of CVD in menopause, and these risks are measured using cardiovascular health indicators, which include blood pressure, lipid profiles, and resting heart rate (El Khoudary et al., 2020).

Healthy dietary patterns, including foods rich in flavonoids, may reduce the risk of increased cardiovascular risk in menopausal women (Wang et al., 2020). Flavonoids are a phytochemical found in fruits, vegetables, legumes (including soybeans), and leaves, possessing antioxidant and anti-inflammatory properties (Ulla et al., 2020). Flavonoids are a major group of phytoestrogens whose mechanism of action is not yet completely understood (Kiyama, 2023). There have been studies, albeit not large United States population-based studies, to examine the association between dietary flavonoid consumption and cardiovascular risk in menopause related to loss of estrogen that noted a positive association between flavonoid consumption and cardiovascular health (Ma et al., 2020; Prabakaran et al., 2021; Thangavel et al., 2019; Wolters et al., 2020). Phytoestrogens are structurally like endogen estradiol that bind to alpha and beta estrogen receptors and possess additional biological effects not associated with estrogen receptors (Desmawati, 2019). Phytoestrogens found in flavonoids have demonstrated an ability to suppress the symptoms of menopause, particularly the vasomotor symptoms, and decrease cardiovascular risk without the same risk of cancers of the breast and uterine lining as hormone replacement therapy (HRT; Desmawati, 2019). Phytoestrogens have been shown to provide protective effects on cardiovascular disease by improving heart function, lowering low density lipoprotein (LDL) cholesterol, increasing high density lipoprotein (HDL) cholesterol, reducing serum triglyceride levels, and lowering blood pressure via vasodilation effects (Desmawati, 2019; Ramdath et al., 2017). It was important to examine the association between dietary flavonoid consumption and cardiovascular health indicators in menopausal women through United States-based population studies because large United States population based studies are lacking.

This chapter includes descriptions of the key components of this study, including the background, research problem, study purpose, and research questions. I also discuss the design, theoretical framework, nature of the study, definitions, assumptions, scope, delimitations, and significance of the study.

Background

Before menopause, women have a lower risk of CVD than men of the same age, but this changes for women at menopause because during menopause, ovarian function begins to decrease and, over the transition, ceases (El Khoudary et al., 2020). As estrogen levels decrease, the risk of CVD increases and surpasses men (El Khoudary et al., 2020). Throughout the menopause transition, changes in endogenous sex hormones, particularly estrogen, play a significant role in body fat distribution, serum lipid levels, and overall measures of cardiovascular health (El Khoudary et al., 2020). In response to the symptoms and physiological changes of menopause, health care providers often prescribe

HRT, which can have serious risks with long-term use (Thangavel et al., 2019). Complications with long-term use of HRT include uterine hyperplasia; increased risk of cancer of the breast, ovary, and endometrium; coronary artery disease (CAD), gallbladder disease, heart attack, liver disease, thrombophlebitis, thromboembolism, and stroke (American College of Obstetrics and Gynecology, n.d.; Thangavel et al., 2019).

As an alternative to HRT, foods rich in flavonoids have been positively associated with lower and decreased cardiovascular health risk (Ma et al., 2020; Prabakaran et al., 2021; Thangavel et al., 2019; Wolters et al., 2020). Flavonoid-rich foods have been studied in women of menopausal age in other countries and within larger populations that do not include just women; however, large U.S. population studies of menopausal women are lacking despite the American College of Obstetrics and Gynecology (n.d.) having noted that plants, including soy, are an alternative to HRT.

Problem Statement

After menopause, which according to the National Institute of Health (n.d.), typically begin between 45 and 55 years of age, women have an increased risk of heart attack and heart disease and are often prescribed HRT, which is not without serious risk (Thankgavel et al., 2019). Phytoestrogens found in flavonoid-rich foods have been shown to help with the symptoms of menopause and potentially reduce cardiovascular risk, which cardiovascular health indicators would evidence (Khapre et al., 2022). However, there is an absence of studies on the effect of flavonoids on cardiovascular health indicators at a population level in the United States.

Purpose of the Study

In this quantitative study, I examined whether there was an association between regular dietary flavonoid consumption and cardiovascular health indicators for women of menopause age. The 2017–2018 National Health and Nutrition Examination Survey (NHANES) data set was utilized for this cross-sectional analysis of women aged 45–65. The U.S. Department of Agriculture (USDA) flavonoid data set provided the necessary values to operationalize the independent variable of daily flavonoid intake in the 24-hour dietary data within the NHANES data set. The results of this study may highlight the need for further study and consideration of dietary flavonoids to address cardiovascular risk in menopausal women.

Research Questions and Hypotheses

Research Question 1 (RQ1): What is the association between total daily flavonoid intake and hypertension in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity?

$H_0$1: There is no statistically significant association between total daily flavonoid intake and hypertension in U.S. women aged 45 to 65, controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

$H_1$1: There is a statistically significant association between total daily flavonoid intake and hypertension in U.S. women aged 45 to 65,

controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

RQ2: What is the association between total daily flavonoid intake and hyperlipidemia in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity?

$H_0 2$: There is no statistically significant association between total daily flavonoid intake and hyperlipidemia in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

$H_1 2$: There is a statistically significant association between total daily flavonoid intake and hyperlipidemia in U.S. women aged 45 to 65, controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

RQ3: What is the association between total daily flavonoid intake and hypertriglyceridemia in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity?

$H_0 3$: There is no statistically significant association between total daily flavonoid intake and hypertriglyceridemia in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

$H_1 3$: There is a statistically significant association between total daily flavonoid intake and hypertriglyceridemia in U.S. women aged 45 to 65, controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

RQ4: What is the association between total daily flavonoid intake and resting heart rate in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity?

$H_0 4$: There is no statistically significant association between total daily flavonoid intake and resting heart rate in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

$H_1 4$: There is a statistically significant association between total daily flavonoid intake and resting heart rate in U.S. women aged 45 to 65, controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

Theoretical Framework

The social-ecological model (SEM), which comprises the four levels of the individual, relationship, community, and societal, is an important framework for prevention (Centers for Disease Control and Prevention [CDC], 2022). The prevention lens used for this study was related to reducing the likelihood of cardiovascular risk with a diet rich in flavonoids found mainly in plant-based foods as an alternative to HRT, which carries significant risks with long-term use (see Thangavel et al., 2019). Utilizing the SEM as my theoretical framework, I examined the dietary intake of flavonoids and cardiovascular health indicators in women aged 45 to 65 (see Yang et al., 2022), which is related to a complex dynamic between individual, relationship, community, and societal factors (see CDC, 2022). Economic and societal development has led to changes in diet and lifestyle, particularly the consumption of food high in fat, salt, and sugar coupled with a sedentary lifestyle (Yang et al., 2022). These factors have increased the overall incidence of cardiovascular disease, resulting in increased mortality. In women, before menopause, estrogen has a protective effect on cardiovascular health, which lessens and continues to decline with menopause (Yang et al., 2022). Multiple factors influence health behavior (Rural Health Information Hub, n.d.), which is seen in the overall effects of the Western diet on cardiovascular risk and disease (Yang et al., 2022). At the individual level, the variables included in the current study were daily flavonoid intake, smoking, menopause (i.e., biology), obesity, blood pressure, resting heart rate, diabetes, race/ethnicity, serum triglyceride level, serum lipid level, and physical activity (see Yang et al., 2022) and HRT based on other level influences, such as provider recommendations and social influences. At the relationship level, marital status was included as a variable. At the community level, primary care provider recommendations for dietary change and HRT were included as variables, and at the societal level, years of living in the United States was a variable. While there was some measurement of certain levels in the study, I used the SEM used to interpret the results because the individual level factors are, and can be, influenced by higher levels including community and societal within the SEM.

Nature of the Study

To address the research questions in this quantitative study, I employed a cross-sectional, observational study design (see CDC, 2012). NHANES data were utilized for this study to analyze exposure (i.e., total daily flavonoid intake controlling for covariates) and health outcome (i.e., cardiovascular risk). NHANES data has been referred to as a good tool for descriptive epidemiology (CDC, 2012) and was appropriate to answer the research questions for this epidemiological study.

Definitions

Diabetes: Diabetes, as it relates to this study, refers to Type 2 diabetes, also known as adult-onset diabetes (CDC, 2022b). A person with Type 2 diabetes has trouble maintaining normal blood sugar levels because their bodies do not use insulin well (CDC, 2023).

Flavonoids: A significant group of polyphenol metabolites. They are a major group of phytoestrogens associated with decreased inflammation, reduced cardiovascular risk, and reduced symptoms of menopause, especially vasomotor symptoms (Kiyama, 2023; Ullah et al., 2020). Dietary sources of flavonoids include fruits, vegetables, and beverages, including tea leaves, nuts, and legumes, which include soy (Ullah et al., 2020).

Hyperlipidemia: Having a serum cholesterol of 200 mg/dL to 239 mg/dL is borderline high, and a serum lipid level of 240 mg/dL or higher is considered high (Cleveland Clinic, 2022a).

Hypertension: Also known as high blood pressure, blood pressure ≥ 130/80 mm/Hg, which is consistent with the definition of hypertension presented by the CDC

(2021) based on the 2017 guideline from the American College of Cardiology Heart Association.

Hypertriglyceridemia: Having a serum triglyceride level of 150 mg/dL or higher (Cleveland Clinic, 2022b)

HRT: Different combinations of female hormones that are used to treat the symptoms of menopause in women (Cleveland Clinic, 2021). HRT is not without serious side effects, as discussed earlier in this chapter; requires medical monitoring for side effects; and has contraindications previously discussed in this chapter.

Marital status: For this study, marital status was considered and coded as married or unmarried. Marriage is associated with a reduced risk of CVD and mortality from CVD; unmarried individuals have an increased association between not being married and cardiovascular risk/cardiovascular mortality (Wong et al., 2018).

Obesity: Having a body mass index (BMI) that is 30 or higher. BMI is calculated by dividing weight by height and is considered an indicator of overall body composition (CDC, 2022a).

Physical activity: Lack of physical activity is associated with an increased risk of cardiovascular risks and outcomes (National Heart, Lung, and Blood Institute, 2022). Regular moderate and vigorous physical activity lower overall cardiovascular risk (National Heart, Lung, and Blood Institute, 2022), making it an important covariate to control for in this study.

Race/ethnicity: Race and ethnicity were important to control in this study because disparities exist for specific racial and ethnic minorities (see Lopez-Neyman et al., 2022) apart from menopause. Within the 2017–2018 NHANES data set, race/ethnicity have the following categories: Mexican American; other Hispanic, non-Hispanic White; non-Hispanic Black; other race, which includes multiracial; and missing (CDC, 2023a).

Resting heart rate: Having a heart rate between 60–100 beats per minute, and an elevated resting heart rate will be defined as >100 beats per minute (Cleveland Clinic, 2022c).

Smoking: The use of tobacco products that contain nicotine, which directly affects cardiovascular health, increasing the risk for sudden cardiac death and overall cardiovascular mortality (American Heart Association, 2021).

Assumptions

I assumed the data came from a sample representative of women aged 45 to 65 in the United States, noting that the NHANES data set is secondary data. It was also assumed that the study data, including dietary data, demographic data, and cardiovascular health variables (i.e., lipid levels, triglyceride levels, blood pressure, and resting heart rate), were gathered using established guidelines without measurement error. Another assumption was that the average 24-hour dietary recall accurately represented the study participants' usual or typical daily dietary intake. It was not possible to rule out changes and alterations in the study participants' dietary habits and patterns in previous years; however, it should be noted that trained interviewers were used to carefully collect NHANES dietary recall data to lessen errors in the recall (see USDA, 2021). The 24-hour dietary recall process and protocols are detailed in Chapter 3.

Scope and Delimitations

The scope of this study involved information regarding the association between dietary flavonoid intake and cardiovascular health indicators in women aged 45–65 in the United States who are of menopause age. Data were extracted from the 2017-2018 NHANES data set for possible associations between dietary flavonoid intake and blood pressure, resting heart rate, hyperlipidemia, and hypertriglyceridemia. Confounders that were controlled for included race/ethnicity, smoking, obesity, physical activity, marital status, HRT, and years in the United States. I calculated a G*Power analysis a priori to determine the necessary sample size, and this process is reported in greater detail in Chapter 3. Identifying the appropriate statistical tests a priori was essential before beginning the study to remain within the intended scope of this study.

Limitations

For this study, I used an NHANES secondary data set, specifically the 2017–2018 NHANES data set. NHANES data, which are collected, stored, and made available by the CDC (2022), are protected through de-identification to ensure the confidentiality of its study participants, which means that there were considerations taken to avoid a breach of confidentiality of the participants of the original study and data collection. To protect and maintain the confidentiality of the participants, I had an expedited Walden University Institutional Review Board (IRB) review because the CDC did their due diligence in following human research subject protections during the original data collection and study. The IRB process reduces harm to study participants by assuring informed consent (Rudestam & Newton, 2007). Finally, it was important to ensure the security of the data and have a data storage plan that was in alignment with data security and maintaining the confidentiality of participants. In preparation for the IRB approval, I completed Collaborative Institutional Training Initiative (CITI) training.

Significance of the Study

This study may offer important information about associations found between lifestyle change through total daily flavonoid intake related to cardiovascular health indicators in postmenopausal women compared to the use of medication, specifically HRT. Many people think that taking a pill or simply taking an extra pill will be enough to compensate for poor lifestyle choices, and this belief if more widespread that was previously realized (Shmerling, 2020). Women who are of menopause age are at an increased risk of CVD (Prabakaran et al., 2021). There is a dearth of studies at the population level for women of postmenopausal age regarding daily dietary flavonoid consumption and its overall effect on cardiovascular health indicators. There are many studies on HRT; however, they include warnings about the risk of HRT, especially over time, and the Mayo Clinic (n.d.) noted that lifestyle change is an important consideration.

This study addressed the social determinants of health by highlighting the importance of access to nutritious foods and the benefits of foods rich in flavonoids for postmenopausal women (see Healthy People 2030, n.d.). Another aspect of the social determinants of health is access to health care that provides solutions and education related to the importance of lifestyle change and avoidance of medications and therapies that could be harmful over time when there is a plausible dietary alternative (Healthy People 2030, n.d.; Yang et al., 2022).

Implications of this study at the individual level include improved health outcomes for cardiovascular health indicators without the use of medications that can be harmful, adding quality of life, and empowering menopausal women to address the risk for CVD through lifestyle change (see Yang et al., 2022). At the peer level, women influence other women, which is spread through the community, and at the societal level, resulting in better overall cardiovascular outcomes as well as reducing mortality and morbidity from stroke and heart attacks in this population. The findings of this study highlight the fact that dietary and lifestyle choices are impacted at all levels suggesting that each level plays a role in a woman's choice to consume foods rich in flavonoids which are plant based foods.

At the policy level, this study aligned with prevention and making health care more affordable through lifestyle medicine and prevention. The Affordable Care Act is a watershed in the U.S. public health policy (Rosenbaum, 2011). Within the Affordable Care Act, there is an importance placed on lifestyle medicine, which is concerned with prevention and lifestyle change (Edington et al., 2020). The 2019 American College of Cardiologists (ACC) and American Heart Association (AHA) guidelines for the Primary Prevention of CVD recommended that adults over 40 years old be evaluated for the prevention of CVD before starting any medication (Edington et al., 2020). The current study could extend those recommendations to include recommendations for dietary soy intake before considering the use of HRT.

The findings could also impact physician practices, employers, and health campaigns in their recommendations for women of all ages, especially those nearing or in menopause. The findings could allow physicians to reconsider HRT for menopausal women as a primary option to address this population's increased risk of cardiovascular risk. The use of dietary management to reduce risk is preferable to medication that can have serious side effects.

Summary

Increased cardiovascular risk in menopausal women associated with loss of estrogen is a significant public health problem (El Khoudary et al., 2020). The literature indicated a positive association between dietary flavonoid intake and cardiovascular health indicators, but there is a lack of large population-based studies within the United States, so it was important to examine the association between dietary flavonoid consumption and cardiovascular health indicators in menopausal women aged 45–65 in the United States. The NHANES 2017–2018 data set provided a secondary data set containing the variables and covariates of interest. I utilized the USDA flavonoid database to operationalize the independent variable and correlate it directly with the 24-hour dietary recall in the NHANES data set.

This study will contribute to the literature on the topic despite the limitations and assumptions related to the research. The NHANES data collected were assumed to have come from a nationally representative sample population and were collected using appropriate and acceptable guidelines, which are free of error. The limitations of this study do not minimize the impact of the study or the ability to conclude any statistically significant associations between dietary flavonoid intake and cardiovascular health indicators in the target population. The results of this study could highlight the need for further large U.S. population-based studies.

In Chapter 2, I will provide a literature review for this study, including a discussion of the literature search strategy, theoretical framework, and literature relevant to dietary flavonoid intake and cardiovascular health indicators in women aged 45–65. In Chapter 3, I will present the methodology of this study, study variables, covariates, and the statistical analysis plan. Chapter 4 will include a detailed description of the data set preparation, statistical analysis, and statistical results, while Chapter 5 will contain a discussion of the study findings, implications for social change, and my recommendations for future research.

Chapter 2: Literature Review

When women begin menopause, typically between 45 and 55 years of age (National Institute of Health [NIH], n.d.), their risk of CVD increases (El Khoudary et al., 2020). The exact age of menopause transition will vary between women and is a progressive physiological process (Perry, 2019). Although the American Heart Association recognizes and reports CVD, especially heart attack, as the leading cause of death in women, their 2011 guidance did not address menopause as a risk for CVD despite a growing body of literature that supports menopause as a time of increasing and significant risk for CVD (El Khoudary et al., 2020). When a woman reaches menopause, there is a permanent cessation of ovarian function, causing hormonal changes and the cessation of menstruation, resulting in physiological and psychosocial symptoms (El Khoudary et al., 2020). The most important hormonal change related to cardiovascular risk is decreasing estradiol levels, the most potent estrogen, linked to the symptoms experienced in menopause and CVD risk (El Khoudary et al., 2020). Estrogen has been shown to improve overall vascular function related to better endothelial function, reduce atherosclerosis, and slow cardiac hypertrophy, which reduces overall CVD risk with the loss of estrogen, removing the protective factor (Murphy, 2011).

In response to menopause transition, women are often prescribed HRT to reduce the physiological effects of menopause (Thangavel et al., 2019). While HRT is often prescribed, it can produce serious and life-threatening side effects, especially with long-term use (Thangavel et al., 2019). Side effects of HRT include, but are not limited to, breast cancer, ovarian cancer, endometrial cancer, thromboembolism, and stroke (Perry, 2019). There are contraindications for HRT, including a history of thromboembolism or embolism, liver disease, undiagnosed vaginal bleeding, current or past diagnosis of either breast or endometrial cancer, CVD, gall bladder disease, uncontrolled hypertension, migraines, and uterine fibroids (Perry, 2019).

Phytoestrogens found in flavonoid-rich foods have been shown to help with the symptoms of menopause and potentially reduce cardiovascular risk, evidenced by positive cardiovascular health indicators without the use of HRT (Thankgavel et al., 2019). Although positive associations were found, particularly with phytoestrogens (Thankgavel et al., 2019), I did not find any studies that examined associations based on daily flavonoid consumption in menopausal women in the United States. In a meta-analysis of randomized controlled trials, Wolters et al. (2020) noted that flavonoid-rich foods had an association with modest improvement in cardiovascular risk profile. The authors stated that there was the need for rigorous studies to examine the association between phytoestrogens and cardiovascular risk in menopausal women. Despite several studies in other countries, there are limited studies on the effect of flavonoids on cardiovascular health indicators at a population level in the United States.

Menopause is a natural biological process that all women will experience and is medically defined as a time when a woman has not had a menstrual cycle in 12 months, which is unrelated to other causes or pathophysiology (El Khoudary et al., 2020). Before menopause, a woman will experience menstrual irregularity; however, the physiological movement toward menopause typically begins between 45 to 55 years of age, with 52 being the average age in the United States (NIH, n.d.). Menopause can be broken down into the following stages: premenopause, early and late menopause transition, and postmenopause (El Khoudary et al., 2020). Menopause typically lasts about 7 years but can take as long as 14 years, with symptoms of varying intensity, including hot flashes, changes in sleep, changes in bladder control, mood changes, weight gain, and vaginal changes (El Khoudary et al., 2020). Women are often most concerned with the typical symptoms of menopause, primarily hot flashes initially; however, CVD can be asymptomatic or present atypically in women, presenting an increased risk for morbidity and mortality (El Khoudary et al., 2020).

Literature Search Strategy

I gathered literature for this review using systematic searches for peer-reviewed literature in the PubMed, MEDLINE, Google Scholar, and CINAHL databases and search engines, accessed through the Walden University Library. The search terms included the following keywords: *flavonoids, flavonoid intake menopause, soy, menopause, postmenopausal women, plant-based diet, estrogen, women, CVD, cardiovascular risk indicators, menopause transition, blood pressure, cholesterol, LDL, HDL, triglycerides, heart attack, stroke, HRT,* and *resting heart rate*. Multiple searches were conducted using different keyword combinations for articles published in the English language between 2018 and 2023. From the articles reviewed, I identified additional articles by looking at the references for the original articles from the search.

Theoretical Framework

The SEM was developed by Urie Bronfenbrenner, a psychologist, in the 1970s to examine the complexity of how individuals are affected by social and environmental factors (University of Minnesota, 2015). The SEM comprises the four levels of the individual, relationship, community, and societal, making it an important prevention framework (CDC, 2022). The prevention lens for this research was related to reducing the risk of cardiovascular risk with a diet rich in flavonoids found mainly in plant-based foods as an alternative to HRT, which carries significant risks with long-term use. Utilizing the SEM as a theoretical framework, I examined the dietary intake of flavonoids and cardiovascular health indicators in women aged 45 to 65 (see Yang et al., 2022), which is related to a complex dynamic between individual, relationship, community, and societal factors (see CDC, 2022).

Economic and societal development has led to changes in diet and lifestyle, particularly the consumption of food high in fat, salt, and sugar coupled with a sedentary lifestyle (Yang et al., 2022). These factors have increased the overall incidence of CVD, resulting in increased mortality. In women, before menopause, estrogen has a protective effect on cardiovascular health, which lessens and continues to decline with menopause (Yang et al., 2022). Multiple factors influence health behavior (Rural Health Information Hub, n.d.), which is seen in the overall effects of the Western diet on cardiovascular risk and disease (Yang et al., 2022).

At the individual level, the variables included in the current study were daily flavonoid intake; smoking; menopause (i.e., biology); obesity; blood pressure; resting heart rate; diabetes; race/ethnicity; serum triglyceride level; serum lipid level; physical activity; and choice to use HRT based on other level influences, such as provider recommendations and social influences. Marital status was included as a variable at the relationship level. At the community level, primary care provider recommendations for dietary change and HRT were included as variables, and at the societal level, years of living in the United States was included. While there was some measurement of certain levels in the study, I used the SEM to interpret the results because the individual level factors are, and can be, influenced by higher levels, which are the community and societal levels, within the SEM. The SEM is used to consider the interplay between the person, their relationships, community, and societal factors (CDC, 2022). Individual dietary patterns are a significant risk for CVD (Chareonrungrueangchai et al., 2020) and are influenced by relationships, community, and societal factors.

Literature Review Related to Key Variables/Concepts

Menopause and Cardiovascular Risk

Li et al. (2021) studied the modification of lipid profiles in menopausal women and reported cardiovascular risk doubles in women aged 45 to 54 years of age and that cholesterol screening is an essential tool for the prevention of poor cardiovascular outcomes because it establishes the importance of examining hyperlipidemia and hypertriglyceridemia as cardiovascular health indicators. The study is noted as the first meta-analysis to find associations between serum lipids and menopause which is a strength; however, the study population was from Asia, which limits its application to global populations, particularly menopausal women in the United States (Li et al., 2021).

Early prevention is critical to averting and mitigating CVD risk in menopausal women (El Khoudary et al., 2020). El Khoudary et al. (2020) utilized NHANES data to study early interventions' importance in reducing CVD in menopausal women and found that a high percentage of women have high blood pressure related to hormone changes after menopause, which is a modifiable risk factor. Their use of NHANES data helped establish the usefulness and appropriateness of NHANES data in the current study. El Khoudary et al.'s study highlighted the importance of preventative care and preventative screenings for women in all stages of menopause.

Menopause physiology alone has been associated with increased CVD; however, certain comorbidities and factors can present confounding effects on the study outcomes (Nai et al., 2021). These variables include years in the United States, marital status, race/ethnicity, obesity, smoking, and physical activity (CDC, 2022a), and each were controlled for in the statistical analysis of the current study. El Khoudary et al. (2019) summarized the Study of Women's Health Across the Nation (SWAN) data available to inform both health care providers and women of the effect of menopause on their overall health, particularly their cardiovascular health. SWAN data were suggestive of significant differences in CVD risk for racial/ethnic minorities (El Khoudary et al., 2019), highlighting the need to control for race/ethnicity in the statistical analysis for the current study. The confounding variables were controlled for in many studies in the literature (Casas et al., 2018; Cheng et al., 2022; Dalgaard et al., 2019; Jackson, 2023; Kirichenko, et al., 2020).

Flavonoids

Flavonoids are polyphenolic compounds, meaning they are found in plants, such as fruits and vegetables, as well as in chocolate, wine, and tea (Linus Pauling Institute, 2014). Flavonoids have six major subclasses: anthocyanidins, flavan-3-ols, flavonoids, flavanones, flavones, and isoflavones (Linus Pauling Institute, 2014). Studies within the United States and Europe have examined the association between dietary flavonoid intake on CVD and CVD-related mortality (Linus Pauling Institute, 2014). A meta-analysis of studies between 1996 and 2012 reported a significant association between reduced risk of cardiovascular events and higher dietary intakes of flavonoids (Wang et al., 2014). Wang et al. (2014) stated that from the top versus the bottom quartiles of flavonoid subclasses, there was an association of an approximate reduction by 10% for CVD risk and flavonoid intake, highlighting the importance of further study. Specific functions of flavonoids related to mitigating menopause estrogen loss is their ability to down-regulate vascular cell adhesion molecules; increase the production of nitric oxide; inhibit angiotensin-converting enzyme, which will induce vascular relaxation; and inhibit platelet aggregation (Linus Pauling Institute, 2014). Each function improves cardiovascular health and reduces cardiovascular risk (Linus Pauling Institute, 2014).

I operationalized daily flavonoid intake, the independent variable, using the USDA flavonoid database, described below. Dalgaard et al. (2019) provided a benchmark for a statistically significant association between daily flavonoid intake and CVD when studying the association between flavonoid intake and hospital admissions for atherosclerotic CVD in an adult prospective cohort study. They found that a daily dietary intake of 1,000 mg of flavonoids was associated with a 14% lower risk of atherosclerotic CVD, a 9% lower risk of ischemic stroke, and a 32% lower risk of peripheral artery disease. Their findings are significant because they are correlated with lower risk at 1,000 mg of dietary flavonoids daily; however, their study was conducted in Denmark with 50–

65-year-old men and women participants, meaning the focus of the study was not menopausal women alone or was it a United States population-based study.

The findings of Dalgaard et al. (2019) were correlative with the findings of Wang et al. (2021) who studied soy intake and CVD risk in a large cohort study of more than 500,000 Chinese adults who did not have a previous history of CVD. Wang et al. found that individuals with the highest intake of soy products, 4 or more days per week, had a 25% lower risk of death from heart attacks. The importance and strength of the Wang et al.'s findings derives form the fact that it is a large population study in China that associated flavonoid intake from soy and decreased death rate from heart attacks in individuals with high soy intake. Despite the research findings and the study's size, it did not isolate menopausal women and was not a U.S. population study. It was important to establish risk reduction based on dietary flavonoid intake for menopausal women in the United States in the current study because the standard U.S. diet and lower overall activity levels in the United States play a role in CVD within all populations, including menopausal women (Casas et al., 2018). Population-based studies that explore the associations between dietary flavonoid intake and cardiovascular health indicators from other countries that do not have similar dietary patterns and activity levels cannot be widely applied to menopausal women in the United States.

During the literature search and review, I found more studies that examined the association between flavonoids and CVD risk in women throughout different stages of menopause in countries other than the United States. Gómez-Zorita et al. (2020) studied the many health benefits of isoflavones, a type of flavonoid, and notably the main flavonoid in soy and other plant foods, which exhibits important cardiovascular benefits. Gómez-Zorita et al. reported that flavonoids could be an alternative therapy for CVD. This finding helped establish the importance of the current study examining the effects of dietary daily flavonoid intake and cardiovascular risk indicators in menopausal women aged 45 to 65. Gómez-Zorita et al.'s study was conducted in Spain and was not a U.S. population-based study.

Flavonoid Intake and Menopause

Examining the effects of flavonoid intake and menopause in peer-reviewed literature was crucial to understanding the evidence available and the existing gap found in the literature. Ma et al. (2020) studied the association between isoflavone (a flavonoid) intake and the risk of heart disease in men and women in the United States, reporting a favorable association between tofu intake in women specifically and a decreased risk of cardiovascular risk without using HRT. Around the same time, Wolters et al. (2020) studied the effect of phytoestrogen (found in flavonoids) supplementation and reduced risk of cardiovascular health in menopausal women in their meta-analysis of randomized controlled trials. The authors found that flavonoid-rich foods were associated with a modest improvement in the cardiovascular risk profile in this population. They stated a need for additional rigorous studies to examine the role of phytoestrogens on the cardiovascular health of postmenopausal women. The main strength of their study was that it demonstrated the benefits of soy consumption on cardiovascular risk indicators and noted a need for rigorous studies to examine the role of phytoestrogens found in flavonoids and cardiovascular indicators.

In other non-U.S., population-based studies, Tang et al. (2020) had similar findings when they studied the effects of soy foods on health in Korea and reported health benefits related to decreased cardiovascular risk for menopausal women. Khapre et al. (2022) studied the association between supplementation of isoflavone (a type of flavonoid) and cardiovascular risk factors in postmenopausal women in a nursing home in Nagpur, India, and reported that women who consumed soy, which is rich in isoflavone, had lower blood pressure and a slower progression of atherosclerosis.

Examining the literature related to the importance and the effect of flavonoid consumption throughout all stages of menopause was an important aspect of the literature review to determine its relevance to all stages of menopause. Kirichenko et al. (2020) studied the effect of flavonoid-rich foods on cardiovascular risk in a randomized, double-blind, placebo-controlled clinical trial in Russia on premenopausal women to evaluate the progression of established atherosclerosis of the carotid arteries in premenopausal women. They reported that benefits were found not only in premenopausal women but also in late menopausal women. Sathyapalan et al. (2018) found similar results when they studied the intake of isoflavones (a flavonoid) and CVD risk markers. The authors found that isoflavone intake improved CVD markers in U.K. women during early menopause, noting a 24% reduction in 10-year coronary heart disease risk and a 42% reduction in CVD death risk (Sathyapalan et al., 2018).

Literature searches and reviews also focused on determining established findings regarding the mechanism of action of flavonoids on CVD risk to rule out possible synergistic effects and confounding variables. Lu et al. (2018) studied novel effects of phytoestrogen soy isoflavones, a type of flavonoid, in a double-blind trial of premenopausal women in and near Galveston, Texas. The authors examined daily phytoestrogen consumption as a potential alternative to risky HRT therapy. They found that isoflavones (flavonoids) impacted calcium, chloride, and albumin homeostasis, which improved cardiovascular risk, although the statistical association was more vital for calcium homeostasis (Lu et al., 2018). Calcium homeostasis is associated explicitly with either risk or protective factors in myocardial ischemia and reperfusion injury, which leads to higher mortality rates in those with negative alternations in calcium homeostasis (Wang et al., 2020). Another study found that, to the best of their knowledge, no other studies examine serum electrolytes, serum proteins, and flavonoid consumption. I could not locate any other studies examining these variables (Lu et al., 2018). A major strength of this study is that premenopausal women in the United States were the study subject. Still, the study was regionally restricted to Galveston, Texas (Lu et al., 2018), which leaves a gap in findings for women in all stages of menopause across the United States.

Cardiovascular Health Indicators

Cardiovascular symptoms often being in women aged 45 to 65 but are often not diagnosed in part because they can have an atypical presentation and are not monitored as well as they should be for prevention (Maas, 2019). Blood pressure, serum lipid levels, and resting heart rate are considered important indicators that are not typically elevated in premenopausal women unless other comorbidities are present (Maas, 2019). Maas (2019) noted that while progress has been made in recognizing ischemic health disease in women who are of menopause age, a more gender-specific approach is necessary, particularly for menopausal women.

Hypertension

Hypertension, also known as high blood pressure, is defined as having a blood pressure of 140/90 mm Hg by healthcare providers. However, some providers consider blood pressure readings consistently higher than 130/80 mm Hg hypertensive (CDC, 2021). Hypertension is linked to other health problems, including CVD, that can lead to heart attack and stroke (CDC, 2021). In a paper by Fuchs and Whelton (2020), the researchers found that hypertension presents the strongest evidence for the development of CVD and that the role blood pressure plays in CVD is greatly understated. Estrogen provides a positive effect on overall cardiovascular health in its mechanism of enhancing nitric oxide-mediated vasodilatation and modulating endothelin 1, a vasoconstrictor (Tasić et al., 2022), which are lost as estrogen levels decline throughout the menopause transition (El Khoudary et al., 2020).

Hyperlipidemia and Hypertriglyceridemia

Total cholesterol serum panels provide values for serum lipid levels and serum triglyceride levels (Dong et al., 2021). Dong et al. (2021) studied the risk between lipid profiles and CVD risk in a prospective cohort study of 4,128 patients between 2009 and 2020 and noted that dyslipidemia (high cholesterol) is a modifiable cardiovascular risk for CVD. Both elevated serum lipid and triglyceride levels are associated with CVD and a higher mortality risk (Dong et al., 2021). Hyperlipidemia has a serum lipid level greater than 200 mg/dL, and hypertriglyceridemia is a serum triglyceride level greater than 150 mg/dL (Dong et al., 2021).

Resting Heart Rate

Resting heart rate is the number of heart beats per minute in an individual at rest. Harvard Health Publishing (2022) reported that a resting heart rate higher than 76 beats per minute (bpm) was associated with a 26% higher risk of heart attack and mortality from heart attack in middle-aged women. Although a resting heart rate greater than 76 bpm was not as strongly associated with CVD as smoking, diabetes, and cholesterol level, it was still valuable as a predictor of heart attack risk (Harvard Health Publishing, 2022).

HRT Risks

HRT which is sometimes called postmenopausal hormone therapy, is prescribed by physicians to relieve the symptoms of menopause while also treating the long-term biological changes of the menopause transition, which includes CVD risk, vasomotor symptoms, and bone loss (National Cancer Institute, 2018). Both estrogen and progesterone are lost during the menopause transition, and HRT treatment can be estrogen therapy alone or estrogen and progestin (National Cancer Institute, 2018). Side effects of HRT include vaginal bleeding, urinary incontinence, dementia, stroke, blood clots, heart attack, breast cancer, and endometrial cancer (National Cancer Institute, 2018). Side effects or risks have different correlations based on whether a woman is prescribed estrogen or estrogen with progestin, and the risk increases with a longer duration of therapy (National Cancer Institute, 2018).

Thangavel et al. (2019) studied the risk of HRT. They found that the risk of long-term HRT included an increased risk of cancer, thromboembolism, and stroke while also finding that isoflavone (a type of flavonoid) improved overall heart and cardiovascular function, establishing the risks of long-term HRT use and the benefits of flavonoid intake. Prabakaran et al. (2021) studied mechanisms related to menopause and cardiovascular risk, noting HRT's dangers. They reported that estrogen loss after menopause increased the risk of cardiovascular risk but noted that the risk of HRT must be weighed, noting a positive association with flavonoid consumption (Prabakaran et al., 2021).

Measurement Tools

Sebastian et al. (2022) studied the intake of flavonoids to identify top dietary sources among children. To ensure the validity of their data, the authors utilized the USDA food codes for daily flavonoid intake, which is regarded as an accurate measure of flavonoid intake in foods in the United States when examining daily flavonoid intake in a U.S. population (Sebastian et al., 2021). The USDA flavonoid database was specifically designed for research studies that analyzed data from NHANES and What We Eat in America (WWEIA), which helps ensure the accuracy of the measure by providing flavonoid values per 100 grams of foods or beverages, including those discontinued (Sebastian et al., 2021). WWEIA is the dietary component of NHANES, with nutritional data being collected in partnership with the USDA (USDA, n.d.). The collaboration and partnership between the USDA and NHANES help establish the reliability and accuracy of nutritional measurements because the flavonoid database is based on the original collection tool (USDA, n.d.). Through initial in-person interviews and a secondary telephone interview no later than 10 days after the in-person interview, data is gathered about the individual's food intake identified using USDA food codes and total nutrient intake based on the data collected, which contains per day nutrient intake (USDA, n.d.). The sources identified reported flavonoid values to calculate the daily flavonoid intake as a continuous variable from the NHANES 2017-2018 dataset, demonstrating an effective way to operationalize daily flavonoid intake. USDA food codes provided flavonoid consumption profiles for 7.083 foods. They were then applied to items within the NHANES dataset, providing a daily flavonoid intake variable (Sebastian et al., 2022). The same method will be utilized to determine daily flavonoid intake for this study, thereby operationalizing the variable.

The USDA provides a food and nutrient database for dietary studies which contains a list of flavonoids and a release of the flavonoid content of foods with three releases (datasets) available for public use: 2007-2008, 2007-2010, and 2017-2018 (USDA, 2022). For this study the 2017 – 2018 release was used to correlate with the 2017 – 2018 NHANES dataset. The list of flavonoids includes six flavonoid classes which are anthocyanidins, flavan-3-ols, flavanones, flavones, flavonols, and isoflavones which are then further broken down into types of flavonoids in each category, providing one of the most complete sources of flavonoid content for food (USDA, 2022). Flavonoid intake from food and beverages is included in the dataset with foods and beverages (USDA, 2022), correlating with NHANES foods and beverages variables. To ensure quality reporting for flavonoid compounds, it is important to use data from good analytic procedures found in the USDA flavonoid database (USDA, 2022).

Population-Based Studies

Throughout the literature review, studies were found that utilized data from three major studies. These were NHANES, The Framingham Heart Study, and The Study of Women's Health Across the Nation (SWAN). Each will be discussed in greater detail below, and each study has provided a wealth of data. The study addressed the literature gap this study will address despite a wealth of reliable and valid datasets. Finally, the existing literature regarding general risk factors associated with the covariates of my study will be examined to highlight their inclusion.

NHANES

The NHANES is a U.S.-based study that assesses the health and nutrition of adults and children by collecting data on demographics, socioeconomic status, diet, medication use, and health running in 2-year cycles (CDC, 2022). NHANES is a CDC program under the National Center for Health Statistics beginning in the 1960s. It is still running (CDC, 2022). NHANES was utilized in a few of the studies found in the literature search and review, and again, despite the amount of data available, no studies were found using NHANES data that directly examined CVD risk in menopausal women and any associations with daily flavonoid intake.

Framingham Heart Study

The Framingham Heart Study began in 1948 and has been noted as one of the first long-term cohort studies about cardiovascular health (Framingham Heart Study, n.d.).

The study has shown that CVD is linked to modifiable lifestyle risk factors, which include hypertension, smoking, being inactive, elevated cholesterol, diet, and obesity (Framingham Heart Study, n.d.). Despite the comprehensive data compiled from The Framingham Heart Study, which has given much insight into CVD epidemiology and the modifiable risk factors, the data has not yielded any extensive population-based studies regarding menopausal women, cardiovascular risk, and flavonoid consumption.

SWAN Study

The SWAN is a three-phase multisite, multiracial/ethnic, longitudinal cohort epidemiological study that examines all aspects of mid-life and older women's health and well-being (SWAN Study, 2023). SWAN began in 1994, but enrollment started in 1996 and 1997, with 3,302 between 42 and 52 years of age enrolled (SWAN Study, 2023). Participants were required to have a uterus and at least one ovary, not pregnant or breastfeeding, had a menstrual cycle within the previous 90 days, and who were not on any form of HRT (El Khoudary et al., 2019). Once enrolled, women had a baseline visit and sixteen follow-up visits during the study enrollment period (El Khoudary et al., 2019). SWAN's website provides a download of all published articles (n = 640), in-press and provisionally accepted manuscripts (n = 4), and book chapters (n = 4) current as of May 2023 (SWAN Study, 2023). A title review of the articles, press and provisionally accepted manuscripts, and book chapters yielded no published studies using the SWAN Study data regarding associations between flavonoids and cardiovascular health indicators despite a SWAN Phytoestrogen database (Huang et al., 2012). There were about a handful of titles of published papers that focused on phytoestrogens found in flavonoids that produced statistically significant results for the association between flavonoid intake and CVD risk and cardiovascular events, but not concerning cardiovascular health indicators specifically in menopausal women (SWAN Study, 2023).

Covariates

Lifestyle plays a significant role in cardiovascular health outcomes. Poor dietary habits and patterns and lack of physical activity have increased the risk and prevalence of CVD in the United States and menopausal women (Yang et al., 2022). Before menopause, estrogen provided a protective mechanism for cardiovascular risk in women. Still, after menopause, women surpass men in their overall risk, highlighting the importance of maintaining good nutrition and being active before menopause (Yang et al., 2022). Increased acculturation for immigrants to the United States increased CVD risk and incidence (Osibogun et al., 2021), making years living in the United States a significant covariate. In a systematic review and meta-analysis, Wong et al. (2018) found a correlation between marital status and CVD. They noted that of the 34 included studies in their study, which included more than 2 million participants, for unmarried participants, there were increased odds of CVD (Wong et al., 2018). Lopez-Neyman et al. (2022), using NHANES data, reported that racial disparities were present for CVD risk in the United States after age adjustment. In a study by Zhang et al. (2020), the authors noted that being overweight or obese was associated with an increased CVD risk. However, overweight, and obese individuals who engaged in physical activity lessened their overall CVD risk (Zhang et al., 2020). Mahoney et al. (2022) noted that smoking had been associated with heart attack, stroke, and congestive heart failure using data from the Population Assessment of Tobacco and Health study. To control for confounding HRT, years in the United States, marital status, race/ethnicity, obesity, smoking, and physical activity are included as covariates.

Gap in the Literature

Despite several population-based studies that examined nutrition, including flavonoids, there remains a lack of population-based studies within the United States regarding cardiovascular risk in menopausal women at any stage of menopause and dietary intake of flavonoids. The gap found in the literature search and review cannot account for studies that are not yet published; instead, it notes the gap based on published literature.

Summary and Conclusions

Increased CVD risk in menopausal women is an established physiological progression for several reasons, including a progressive decline in estrogen over menopause transition, which plays a role in normal cardiovascular function, providing a protective mechanism before menopause onset (El Khoudary et al., 2020). This study was focus on the biological effects of dietary flavonoids and estrogen loss. Flavonoids have been shown to have a protective effect on CVD risk without using HRT within many different populations worldwide (Dalgaard et al., 2019; Gómez-Zorita et al., 2020; Khapre et al., 2022; Lu et al., 2018; Ma et al., 2020; Sathyapalan et al., 2018; Thangavel et al., 2019; Wang et al., 2021). Still, there is a dearth of studies on its impact at the population level within the United States. Specific measures of CVD risk include hypertension, hyperlipidemia, hypertriglyceridemia, and resting heart rate, which are established in the literature review as important indicators of CVD risk and overall cardiovascular health (Khapre et al., 2022; Wolters et al., 2020). HRT has serious side effects that include several types of cancer and are cautioned against long-term use (Lu et al., 2018; Thangavel et al.) Many women have conditions or health risks for which HRT is contraindicated (Thangavel et al., 2019). Other significant risk factors for CVD will be used as covariates to control for confounding and include years of living in the United States (Osibogun et al., 2021), marital status (Wong et al., 2018), race/ethnicity, obesity, smoking, and physical activity (Bays et al., 2021).

Using the 2017 – 2018 NHANES dataset and the 2017- 2018 release USDA flavonoid database best addressed the gap found in the literature. NHANES data allowed for an accurate assessment of the research problems by including the operationalized daily flavonoid intake using data from the USDA (Sebastian et al., 2022). This study examined the associations between daily flavonoid intake and cardiovascular health indicators in women aged 45 to 65 in the United States. My research methods and study design are described in Chapter 3.

Chapter 3: Research Method

This quantitative study was conducted to examine the association between dietary flavonoid intake and cardiovascular health indicators in women aged 45 to 65. In this chapter, I discuss the study design, the rationale for its use, and the methodology, including a description of the study population and the sampling procedures used with the 2017–2018 NHANES data set and the USDA flavonoid database. Additionally, the operationalization of the independent variable, daily flavonoid intake, is presented. Ethical considerations for this study are also discussed.

Research Design and Rationale

In this quantitative, epidemiological, cross-sectional study, I utilized the NHANES 2017–2018 data set because it contained the variables of interest. Data points included gender and age (used to filter out the target population), HRT, marital status, years in the United States, race/ethnicity, diabetes, smoking, obesity, physical activity, flavonoid intake, hypertension, hyperlipidemia, hypertriglyceridemia, and resting heart rate. For total daily flavonoid intake, the continuous variable of interest in NHANES is daily flavonoid intake and was calculated using the publicly available USDA database for flavonoid values for the dietary component of the NHANES data set (see Sebastian et al., 2022).

When deciding on the study design, I chose a cross-sectional design because it best aligned with the research questions that examined health outcomes rather than determining causation (see Szklo & Nieto, 2019). Cross-sectional studies are observational studies requiring data from one point in time to examine exposure and outcome association, aligning with the NHANES data used in the current study (see Szklo & Nieto, 2019). When using a cross-sectional study design, a researcher cannot identify temporal relationships, establish causation, or determine trends (Szklo & Nieto, 2019). I did not select cohort or case-control designs because each requires multiple measurements over a long period of time and significant resources (see Szklo & Nieto, 2019).

Methodology

Population

The population for this study were participants in the 2017–2018 NHANES. Data from the 2017–2018 study are publicly available (CDC, n.d.). The sample size for the 2017–2018 study was 15,560 participants: 7,721 participants are male, and 4,697 are female (CDC, n.d.). The sample population for NHANES represents the U.S. population that is not institutionalized and includes the population of interest, women aged 45 to 65 (CDC, n.d.). For this study, I included women from the 2017–2018 NHANES data set aged 45 to 65 to ensure the study participants were of menopausal age. This study did not include premenopausal women or women who surgically entered menopause much earlier than 45 years of age. The number of women aged 45 to 65 in the NHANES 2017–2018 dataset is 1,063 out of the 4,697 women in the data set.

Sampling Procedures

The 2017–2018 NHANES utilized complex probability sampling, which included multiple stages for study participant selection of individuals who were U.S. noninstitutionalized civilians (CDC, 2023). The NHANES utilized a four-stage sampling process beginning with primary sampling units with one or more household individuals selected for study participation (CDC, 2023). To ensure representation, NHANES oversampled specific demographics, including Hispanics, non-Hispanic Blacks, low-income Whites, and individuals 80 years or older (CDC, 2023). Every participant in the NHANES study was assigned a sample weight to ensure unbiased national estimates. This complex sampling procedure was utilized for the pre-COVID-19 pandemic 2017–2020 NHANES data sets (CDC, 2023).

Data Collection

The 2017–2018 NHANES data set was collected through interviews, medical examinations, and diagnostic testing. All interviews were conducted in the participants' homes by the same interviewer and the original individual interviewed. The interviewers were trained to administer the NHANES questionnaire, and the questionnaire that was utilized determined the household's eligibility to participate and established the relationship between participants within the household.

Sample Size

I conducted a power analysis for a binary logistic regression using daily flavonoid intake as the main continuous predictor variable to determine the minimum required sample size for this study. The results indicated a minimum of 691 cases were required to achieve a minimum power of .80. Raising the power to .95 would require a sample of 1,123. Based on the number of women aged 45 to 65 included in the data set and the calculated sample size range, there were enough study participants to have an appropriate sample size for the study.

To conduct the power analysis, I used G*Power 3.1 software (see Faul et al., 2009). For the test family, z tests were selected; for a statistical test, logistic regression was selected; and for the type of power analysis, and a priori compute the required sample size given α level and effect size was used. I selected two tails with an odds ratio of 1.5 and Pr(Y=1|X=1) set at 0.5 based on mean odds ratios found in the literature review. Next, I set Pr(Y=1|X=1) at 0.6 and transferred data. Power was initially set at 0.8 and later set at 0.95, R^2 was set at 0.7, with normal distribution, and x parm μ was set at 0, while x parm σ was set at 1.

Instrumentation

The data collection instruments used for this study consisted of diagnostic measures and survey questions from the 2017–2018 NHANES data set (see CDC, 2023). The variables of interest for this study were diagnostic labs, demographic statistics, and 24-hour food recall for each participant. The information gathered from participants came from interviews, medical examinations, and laboratory samples collected by trained technicians (CDC, 2023).

Interviewers conducted 24-hour food recollections from study participants at two separate points. The first food recall interview was an in-person interview, and the second interview was a phone interview conducted 3 to 10 days after the first food recall interview. The interviewers collected the food consumed and the portion sizes of those foods for the previous 24-hour period (USDA, 2022). To capture daily flavonoid intake accurately, the average of the dietary data from the two 24-hour food recalls after assigning flavonoid values utilizing the USDA flavonoid database were used. Trained dietary interviewers were guided by an automated interview program to help them execute the interview correctly, collect the data, and use multiple-pass methods to increase the accuracy of the food recall data (CDC, 2023).

The multiple-pass method is a computerized method used by interviewers to collect the 24-hour dietary recalls, initially in person and then over the phone 10 days later (USDA, 2021). The multiple-pass method was used for the NHANES WWEIA dietary portion of the NHANES study (USDA, 2021). The multiple-pass method uses research-based strategies to improve the overall dietary recall for accuracy. The method uses respondent-driven methods, probes for forgotten foods, reviews 24-hour days, associated foods with eating occasions, utilizes repetition, and uses the day's events for association (USDA, 2021). The five steps include a quick list of foods and beverages consumed in the prior day, a quick list to probe for foods that may have been forgotten, asking for time and eating occasions related to each food, gathering very detailed descriptions of each food are included, and then a final probe for any other foods or beverages that were consumed (USDA, 2021). For each food and beverage consumed, a description of the food; additions to the food, such as cream for coffee; amount of the food or beverage; the time food or beverage was consumed; and where the food and beverage were consumed were collected (USDA, 2021).

Operationalization of Study Variables

Independent Variable

Total daily flavonoid intake was the independent, continuous variable for this study. I calculated the daily flavonoid intake for those foods consumed that contain flavonoids by using the 2017–2018 release of the USDA flavonoid database for the 2 days of dietary intake for each participant, and the 2 days were averaged to provide a continuous variable for each participant.

The USDA flavonoid database contains six flavonoid classes, which are anthocyanidins, flavan-3-ols, flavanones, flavones, flavanols, and isoflavones, and 29 flavonoids total (USDA, 2022). The flavonoid intake data files applied values for flavonoids to the WWEIA portion of NHANES (USDA, 2022). The fact that the USDA (2022) database corresponds to WWEIA helps to increase the reliability of the measurements. This variable may not be normally distributed, which was known after running measures of central tendency, and if it was not, requires a log transformation or the creation of ordinal categories for analysis (Ma et al., 2020).

Dependent Variables

The dependent variables for this study were hypertension, hyperlipidemia, hypertriglyceridemia, and resting heart rate. Each of these variables are markers of cardiovascular health. Table 1 offers the variables with their respective level of measurement.

Table 1

Dependent Variables with Level of Measurement

Variable name	Level of measurement
Hypertension	Nominal, dichotomous
Hyperlipidemia	Nominal, dichotomous
Hypertriglyceridemia	Nominal, dichotomous

Resting heart rate	Nominal, dichotomous

Hypertension

Hypertension was dummy coded into a dichotomous variable with 1 for yes and 0 for no. I converted blood pressure in the NHANES data set to mean arterial pressure (MAP), and all three MAP readings were averaged. Hypertension is defined as a MAP ≥ 92, which is consistent with the definition of hypertension presented by the CDC (2021) based on the 2017 guideline from the American College of Cardiology/American Heart Association. When women begin the menopause transition, blood pressure can and often does increase, even for women who have had regular blood pressure readings consistently before menopause, which increases the risk of heart attack and stroke (El Choudhary et al., 2020).

Hyperlipidemia

A serum cholesterol of 200 mg/dL to 239 mg/dL is borderline high serum lipid levels, and a serum lipid level of 240 mg/dL or higher is considered high; this condition is known as hyperlipidemia (Cleveland Clinic, 2022a). At menopause, lipid levels rise, even for women who have had normal lipid levels before menopause, and this increases the risk of cardiovascular events, like heart attack and stroke, indicating cardiovascular risk (Li et al., 2021). For this study, I considered serum cholesterol ≥ 200 mg/dL as hyperlipidemia, and the variable was coded as 1 for yes and 0 for no.

Hypertriglyceridemia

A serum triglyceride level of ≥ 150 mg/dL or higher is considered hypertriglyceridemia (Cleveland Clinic, 2022b), and was coded as 1 for yes and 0 for no.

Hypertriglyceridemia is having too many triglycerides in the blood (i.e., serum), which happens when too much fat is consumed and then converted to triglycerides (Cleveland Clinic, 2022b). At menopause, women are predisposed to high triglycerides even if they have had normal triglyceride levels before menopause, which increases the risk of heart attack and strokes, making it an indicator of cardiovascular health (Li et al., 2021).

Resting Heart Rate

The Cleveland Clinic (2022c) defined normal resting heart rate as 60 to 100 beats per minute, noting that before menopause, women have better heart function than men of the same age; however, as estrogen declines, heart function is affected. One of the indicators is elevated resting heart rate (Cleveland Clinic, 2022c). I defined elevated resting heart rate as >100 beats per minute and was coded the variable as 1 for yes and 0 for no. Elevated heart rate is epidemiologically linked to cardiovascular risk and has been clinically used to predict cardiovascular events (American Heart Association, 2021; Arnold et al., 2008; CDC, 2020; Cleveland Clinic, 2022c).

Covariates

I discuss the covariates of HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity in the following subsections. Table 2 displays the covariates with their respective levels of measurement.

Table 2

Covariates with Level of Measurement

Covariate name	Level of measurement
HRT	Nominal, categorical

Years in the United States	Nominal, categorical
Marital status	Nominal, categorical
Race/ethnicity	Nominal, categorical
Diabetes	Nominal, categorical
Obesity	Nominal, categorical
Smoking	Nominal, categorical
Physical activity	Nominal, categorical

HRT

I included HRT as a covariate because it would be a confounder in examining the relationship between estrogen loss and its effects on cardiovascular health in menopause and dietary flavonoid intake. Controlling for HRT use assisted in avoiding confounding related to HRT medication. The variable for HRT was categorical with the following categories: yes, no, refused, don't know, and missing (see CDC, 2022).

Years in the United States

For migrants and immigrants to the United States, the risk for CVD increased over time based on the years they have lived in the country (Rosenthal et al., 2022). The overall risk is directly linked to the Western diet, which is high in fat and calories and decreased physical activity levels (Rosenthal et al., 2022). It was important to control for this variable, so I included it as a covariate to avoid confounding. Years in the United States was categorical with the following categories; less than 5 years, 5 years or more but less than 15 years, 15 years or more but less than 30 years, 30 years or more, refused, don't know, and missing. If there were large disparities between numbers within each category, this variable could have been operationalized to combine one or more categories.

Marital Status

Marriage is associated with a reduced risk of CVD and mortality from CVD. In contrast, unmarried individuals have an increased association between not being married and cardiovascular risk/cardiovascular mortality (Wong et al., 2018). Including marital status as a covariate is important to control for this association and avoid confounding. Marital status was a categorical variable with the following categories: married/living with a partner, widowed/divorced/separated, never married, refused, don't know, and missing (CDC, 2022).

Race and Ethnicity

Race and ethnicity play a role in cardiovascular risk, with racial and ethnic minorities experiencing disparities in overall cardiovascular risk independent of menopause onset (Jackson, 2023). To reduce confounding related to disparities in overall cardiovascular risk, race/ethnicity is included as a covariate. Race/ethnicity Race and ethnicity were coded in the following categories: Mexican American, other Hispanic, Non-Hispanic White, Non-Hispanic Black, Other Race – Including Multi Racial, and missing.

Diabetes

Diabetes is strongly associated with heart disease because high blood sugar over time damages blood vessels and nerves that go to the heart (CDC, 2022c). Additionally, individuals with diabetes often have high blood pressure, hyperlipidemia, and hypertriglyceridemia which are also risk factors for CVD (CDC, 2022). This variable was codes as 1 for yes and 0 for no.

Obesity

Obesity is strongly associated with an overall increased risk of CVD including CAD and heart attack related to hemodynamics, increased fats in the blood, and alteration of the heart structure, which can lead to heart attack and heart failure (Carbone et al., 2019). Controlling for obesity will control for confounding in participants who are obese. Within the NHANES dataset BMI was utilized to create a categorical variable with the following categories: underweight, normal weight, overweight, and obese (CDC, 2022a). These categories were based on current BMI tables from the CDC. According to the CDC a BMI of less than 18.5 is considered underweight, a BMI between 18.5 and 24.9 is considered normal, a BMI between 25 and 29.9 is considered overweight, and a BMI of 30 or more is considered obese (CDC, 2022a). BMI will be coded into the BMI categories listed.

Smoking

According to the American Heart Association (2021), smoking dramatically increases the risk for CVD, including heart attack and stroke. Based on new research, it is noted that the first cardiovascular symptom for smokers may be mortality (American Heart Association, 2021). It is important to control smoking as a covariate in this study. Within NHANES there is a variable for do you smoke now, which is categorical referring to tobacco products with the following categories: yes, no, refused, don’t know, and missing (CDC, 2022).

Physical Activity

Physical activity is a categorical variable in the 2017-2018 which is labeled days of moderate recreational activity and includes moderate intensity recreational activity, sports, and fitness in a day (CDC, n.d.). The categories were values from 1 to 7, refused, don't know, or missing. There was a second variable for moderate intensity work/physical activity that lists minutes of moderate-intensity work/activity with the following categories: range of values for minutes, refused, don't know, and missing (CDC, 2022). Tian and Meng (2019) studied exercise to prevent and relieve CVD and noted that the American Heart Association recommends at least 30 minutes of moderate exercise five times per week. Lack of physical activity has been correlated with increased cardiovascular risk (National Heart, Lung, and Blood Institute, 2022) and were be controlled for. Physical activity was operationalized and combined the two variables for number of days and number of minutes based on the American Heart Association guidelines of at least 30 minutes of moderate physical activity five times per week (National Heart Lung and Blood Institute, 2020; Tian & Meng, 2019). Ferraro et al. (2020) studied dietary and exercise recommendations for overall cardiovascular health and found the at least 150 minutes of moderate activity per week is best for reducing overall cardiovascular risk and their findings were published by the American College of Cardiology as the latest findings and recommendations for physical activity and overall cardiovascular health. Cardiology epidemiological studies have demonstrated that calculating the metabolic equivalent (MET) score is the best way to examine associations between physical activity and cardiovascular risk (Cheng et al., 2022; Jia et al., 2022,;

Wang et al., 2017). For this study, MET will be calculated operationalizing the physical activity variable and will be a categorical variable (Redd et al., 2016).

Data Analysis Plan

Software

The statistical analysis for this study was conducted with IBM statistical package for social sciences (SPSS) Version 28.

Data Preparation and Cleaning

NHANES datasets were downloaded in sections that contain different parts of the complete dataset. For example, demographic data, including gender, age, and race/ethnicity, are contained in the demographic section of the dataset (CDC, 2023). Each broad category of data from the 2017-2018 dataset was downloaded and merged into one dataset within SPSS. Next, only the variables of interest were kept, and the others deleted. Frequencies were run on the variables once variables that will not be used were removed. Next, the population of interest was chosen using the select cases option to include only women out of the gender variable aged 45-65. The dataset was analyzed for missing values, and the decision was made to either remove a participant based on too many missing values or to allow SPSS to insert values based on means. Based on the G*Power analysis, all 1,063 the women aged 45-65 in the dataset were an ample sample size even after cleaning the dataset in SPSS.

Research Questions and Hypotheses

Research Question 1 (RQ1): What is the association between total daily flavonoid intake and hypertension in U.S. women aged 45 – 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity? A

$H_0 1$: There is no statistically significant association between total daily flavonoid intake and hypertension in U.S. women aged 45 – 65, controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

$H_1 1$: There is a statistically significant association between total daily flavonoid intake and hypertension in U.S. women aged 45 – 65, controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

Research Question 2 (RQ2): What is the association between total daily flavonoid intake and hyperlipidemia in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity?

$H_0 2$: There is no statistically significant association between total daily flavonoid intake and hyperlipidemia in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

$H_1 2$: There is a statistically significant association between total daily flavonoid intake and hyperlipidemia in U.S. women aged 45 to 65, controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

Research Question 3 (RQ3): What is the association between total daily flavonoid intake and hypertriglyceridemia in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity?

$H_0$3: There is no statistically significant association between total daily flavonoid intake and hypertriglyceridemia in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

$H_1$3: There is a statistically significant association between total daily flavonoid intake and hypertriglyceridemia in U.S. women aged 45 to 65, controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

Research Question 4 (RQ4): What is the association between total daily flavonoid intake and resting heart rate in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity?

$H_0$4: There is no statistically significant association between total daily flavonoid intake and resting heart rate in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

$H_1$4: There is a statistically significant association between total daily flavonoid intake and resting heart rate in U.S. women aged 45 to 65,

controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

The data analysis plan for this study was first to conduct frequencies and measures of central tendency for all variables. Contingency tables (crosstabulation or two-way tables) were run in SPSS to examine and describe the relationship between variables. The complex sample module was utilized for this analysis in SPSS. The logistic regression assumptions were tested to ensure the analysis results are valid. A logistic regression analysis was be conducted to test the four null hypotheses controlling for all covariates. The p-values, and confidence intervals were interpreted to determine statistical significance. The confidence level was set at 0.95, with $\alpha 0.05$ based on the confidence level. Odds ratios were analyzed to examine the impact of each variable on the odds ratio of the event of interest, which will be cardiovascular health indicators that help to avoid confounding by analyzing the association of all variables together (Sperandei, 2014).

Threats to Validity

Threats to Internal Validity

The 24-hour dietary recall was important and significant threat to internal validity, which was controlled for by the second dietary recall and the averaging of the values for daily flavonoid intake to ensure a more consistent and accurate measurement (Cuncic & Goldman, 2022). This measure needed to be as accurate as possible to increase internal validity. Another threat to the internal validity was confounding, which was reduced by including potential confounding variables in the analysis as covariates to control for their effect on the analysis results. Good internal validity allows for confidence that the study results are accurate and not due to confounding or inaccurate measures (Cuncic & Goldman, 2022). Randomized sampling in this study was helpful in increasing internal validity (Cuncic & Goldman, 2022).

Threats to External Validity

Threats to external validity for this study were questions regarding whether the study results can be applied to the population of interest. The effect size was an essential indicator for external validity, indicating that the findings can be generalized and applied to the population outside of the study (Cuncic & Goldman, 2022). Ensuring that the study population is clearly defined and choosing the correct sample or population representation helped to ensure external validity (Cuncic & Goldman, 2022).

Threats to Construct or Statistical Conclusion Validity

Construct validity is how the statistical test accurately assesses or measures what it was meant to measure. Complex samples multiple regression analysis helped examine construct validity by determining whether the measure accurately predicts the outcome presented for the study (Bhandari, 2022).

Ethical Considerations

For my study, I utilized an NHANES secondary data dataset. I did not foresee ethical issues using this dataset or for this study. NHANES data, which are collected, stored, and made available by the CDC, is protected through deidentification to ensure the confidentiality of its study participants, which means that there were considerations taken to avoid a breach of confidentiality of the participants of the original study and data collection (CDC, 2022). As a researcher, I was still required to protect and maintain the confidentiality of the participants. An expedited IRB review was anticipated because the CDC did their due diligence in following human research subject protections during the original data collection and study. The IRB process will reduce harm to study participants by assuring informed consent (Rudestam & Newton, 2007). Finally, it is important to ensure the security of the data and have a data storage plan that is in alignment with data security and maintaining the confidentiality of participants. In preparation for the IRB approval, I completed the Collaborative Institutional Training Initiative (CITI) training and have the certificate saved.

Summary

To examine the association between dietary flavonoid intake and cardiovascular health indicators in women aged 45 - 65, a cross-sectional design is most appropriate, as well as using the 2017 - 2018 NHANES dataset for this cross-sectional study. I used socioeconomic, demographic, and dietary data from the 2017 - 2018 NHANES dataset and the 2017 – 2018 release USDA flavonoid database to assess the associations previously described in the study participants. The data collection instrument, the NHANES instrument, and the type of statistical analysis, logistic regression, minimize any potential threats to the validity of this study.

In Chapter 4, the study results are presented. The descriptive statistics of the study population are given first. In Chapter 4 I present the results of the statistical analyses that addressed the hypotheses of the four research questions and present the findings.

Chapter 4: Results

I utilized the 2017–2018 NHANES data set for a cross-sectional analysis of women aged 45–65 to examine if there was an association between dietary flavonoid intake and cardiovascular health indicators in this population of women of menopause age. The USDA flavonoid database provided the necessary values to operationalize the independent variable of daily flavonoid intake in the 24-hour dietary data within the NHANES data set. Statistically significant findings highlight the need for further study and consideration of dietary flavonoids to address cardiovascular risk in menopausal women. The following research questions and hypotheses guided this study:

RQ1: What is the association between total daily flavonoid intake and hypertension in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity?

$H_0$1: There is no statistically significant association between total daily flavonoid intake and hypertension in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

$H_1$1: There is a statistically significant association between total daily flavonoid intake and hypertension in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

RQ2: What is the association between total daily flavonoid intake and hyperlipidemia in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity?

$H_0$2: There is no statistically significant association between total daily flavonoid intake and hyperlipidemia in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

$H_1$2: There is a statistically significant association between total daily flavonoid intake and hyperlipidemia in U.S. women aged 45 to 65, controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

RQ3: What is the association between total daily flavonoid intake and hypertriglyceridemia in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity?

$H_0$3: There is no statistically significant association between total daily flavonoid intake and hypertriglyceridemia in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

$H_1$3: There is a statistically significant association between total daily flavonoid intake and hypertriglyceridemia in U.S. women aged 45 to 65

controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

RQ4: What is the association between total daily flavonoid intake and resting heart rate in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity?

$H_0$4: There is no statistically significant association between total daily flavonoid intake and resting heart rate in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

$H_1$4: There is a statistically significant association between total daily flavonoid intake and resting heart rate in U.S. women aged 45 to 65 controlling for HRT, years in the United States, marital status, race/ethnicity, diabetes, obesity, smoking, and physical activity.

In this chapter, I discuss the how the data set was prepared for analysis, adjustments that were made to the data set, descriptive characteristics, the analysis plan, and the results of the bivariate and multivariate analyses before concluding the chapter with a summary.

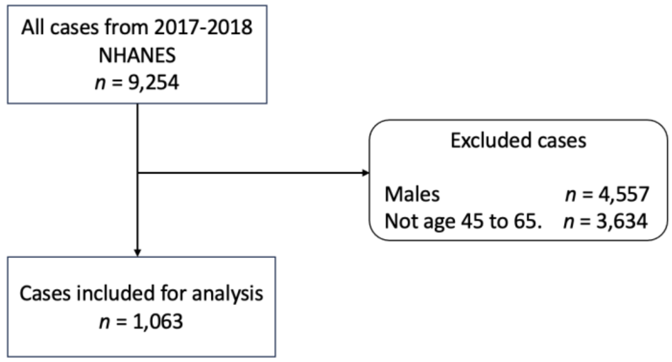
Data Collection

I received Walden University IRB approval for this study before any data were downloaded for analysis. The IRB approval number for this study is 08-02-23-1059628. The 2017–2018 NHANES data set, like all NHANES data sets, is compiled in different data sets. The 2017–2018 data sets that were downloaded from the CDC NHANES webpage and combined for this study included data on demographics, total cholesterol, dietary intake, smoking, diabetes, blood pressure, physical activity, LDL and triglycerides, and reproductive health. The downloaded data sets contained all variables of interest for the study except for the independent variable of daily flavonoid intake, which I obtained from the USDA flavonoid database. The USDA 2017–2018 release directly corresponds to the participants in the 2017–2018 NHANES data set, making it the appropriate choice for this study. Once downloaded, I merged the data sets in SPSS using the merge function. After merging, variables that were not of interest were deleted utilizing caution to not delete weight needed for the complex samples plan to weight the data set for complex samples analyses.

Within the NHANES 2017–2018 dataset, there were a total of 9,254 participants, of which 4,697 were female, and of those 4,697 females, 1,063 were aged 45 to 65 years old. Prior to analysis, I limited the data set to the population of interest, women aged 45 to 65, using the select cases function in SPSS. All 1,063 women aged 45 to 65 were included in this study. Figure 1 displays data set case availability for the study.

Figure 1

Cases Available for Analysis After Application of Exclusion Criteria



The data set was adjusted once I downloaded, merged, and reviewed it. The changes to the data set included operationalizing the independent variable of daily flavonoid intake, merging categories of the categorical covariates, and making the dependent variables dichotomous. The independent variable was operationalized by calculating a mean for both dietary intake days in the data set and then calculating one mean for daily flavonoid intake.

The continuous independent variable, daily flavonoid intake, was not normally distributed. To address the fact that the independent variable was not normally distributed, I transformed the variable under rank cases in SPSS with the SPSS rank command function, which is the option for setting categories, and set it to five, making daily flavonoid intake a categorical variable with five categories as described below in the descriptive statistics in Table 4. Tachycardia was excluded based on descriptive statistics and bivariate analysis from the study when I found that too much data were missing for it to be valid.

Descriptive Characteristics: Univariate Analysis

I conducted a univariate analysis for all variables in the study. Descriptive statistics for the independent variable, dependent variables, and the covariates were run in SPSS to assist with combining categories in the categorical variables based on percentages within each category and to analyze any missing data.

The study participants were females aged 45 to 65 (*n* = 1,063) from the 2017–2018 NHANES data set. The mean age was 55.8 ± 5.9.

I converted the independent variable to a new variable based on quintiles because it was not normally distributed, which created five categories: Table 3 displays the descriptive statistics for the five categories of the independent variable.

Table 3

*Descriptive Statistics: Independent Variable (*N = *1,063)*

Variable	*n* (%)
Daily flavonoid percent	
0% to 20%	140 (13.2)
21% to 40%	174 (16.4)
41% to 60%	179 (16.8)
61% to 80%	190 (17.9)
81% to 100%	248 (23.3)

I transformed each dependent variable from continuous to dichotomous in SPSS with 1 for yes and 0 for no. The calculations for the dependent variables are provided in Table 4.

Table 4

Descriptive Statistics: Dependent Variables (N = 1,063)

Variable	*n* (%)
Hypertension	
No	569 (53.5)
Yes	494 (46.5)
Hypertriglyceridemia	
No	965 (90.8)
Yes	98 (9.2)
Hyperlipidemia	
No	582 (54.8)
Yes	481 (45.2)

I examined each categorical covariate to determine which categories should be combined for analysis. For years in the United States, the original categories were in increments of 5 and 10 years but were combined into three categories because of uneven and low category counts. The marital status variable categories were combined to merge married with living together and widowed, divorced, and separated with each other because of uneven and low categories. Table 6 provides the descriptive statistics regarding the covariates.

Table 5

*Descriptive Statistics: Covariates (*N *= 1,063)*

Variable	*n* (%)
Years in the United States	
0 to 10 years	57 (5.4)
10 to 30 years	188 (17.7)
30 or more years	160 (15.1)
Missing	658 (61.9)
Marital status	
Married or living with partner	615 (57.9)
Widowed divorced or separated	333 (31.3)
Never married	113 (10.6)
Missing	2 (0.2)
Race	
Hispanic	265 (24.9)
White	290 (27.3)
Black	277 (26.1)
Other	231 (21.7)
Obesity	
Not overweight or obese	241 (22.7)
Overweight	297 (27.9)
Obese	478 (45)
Missing	47 (4.4)
Minutes of moderate exercise weekly	
Meets or exceeds 150 minutes per week	180 (16.9)
Does not meet 150 minutes per week	222 (20.9)
Missing	661 (62.2)
Smoking	
Yes	163 (15.3)
No	185 (17.4)
Missing	715 (67.3)
Diabetes	
Yes	183 (17.2)
No	840 (79)
Missing	40 (3.8)
HRT	
Yes	175 (16.5)
No	774 (72.8)
Missing	114 (10.7)

Bivariate Analysis

I ran crosstabs with chi-square analysis in SPSS Version 28 for each dependent variable and the covariates. Crosstabs were utilized to examine missing data and goodness of fit as well as better combine categories for categorical variables prior to multivariate analysis. The crosstabs and chi-square analysis for the dependent variable of hypertension and the covariates were run in SPSS Version 28 with the following results. Women using HRT and those not using HRT showed no statistically significant difference in hypertension, but the groups were not equal in number. The covariate of years in the United States showed no statistically significant difference for hypertension between any of the categories. Marital status was not statistically significant for hypertension between categories. Race was statistically significant for hypertension, and Black participants had higher rates of hypertension. Diabetes was not statistically significant for hypertension between those with and those without diabetes. Obesity was statistically significant for hypertension, while smoking was not found to be statistically significant for hypertension between those who smoke and those who do not smoke. One hundred fifty minutes of moderate exercise was not statistically significant for hypertension between the categories. In summary, based on bivariate analysis of the covariates and the dependent variable of hypertension, the only two covariates found to be statistically significant for hypertension were race and obesity (see Table 6).

Table 6

Hypertension and Potential Confounders

Variable	*n* (%)
HRT	*p* = .409
Using HRT has HTN	81(17.4)
No HRT has HTN	385(82.6)
Years in United States	*p* = .436
0–10 years has HTN	22(13.0)
10–30 years has HTN	74(43.8)
31 to 50 or more years has HTN	73(43.2)
Marital status	*p* = .337
Married/living with partner has HTN	281(56.9)
Widowed/divorced/separated has HTN	153(31.0)
Never married has HTN	60(12.1)
Race	*p* = <.001
Hispanic has HTN	117(23.7)
White has HTN	117(23.7)
Black has HTN	159(32.2)
Other has HTN	101(20.4)
Diabetes	*p* =.606
Diabetes has HTN	82(17.2)
No diabetes has HTN	394(82.8)
Obesity	*p* = .005
Not overweight/obese has HTN	99(20.2)
Overweight has HTN	137(27.9)
Obese has HTN	255(51.9)
Smoking	*p* = .809
Smokes has HTN	77(48.4)
Does not smoke has HTN	82(51.6)
150 minutes of moderate exercise per week	*p* = .259
Meets or exceeds has HTN	75(41.7)
Does not meet has HTN	105(58.3)

Note. HTN = hypertension.

I ran crosstabs and chi-square analysis for the dependent variable of hyperlipidemia and the covariates in SPSS Version 28 with the following results. Women using HRT and those not using HRT showed no statistically significant difference in hyperlipidemia. The covariate of years in the United States showed no statistically significant difference between categories for hyperlipidemia. Marital status and race were not statistically significant for hyperlipidemia between the categories. Diabetes was statistically significant for hyperlipidemia between those with and those without diabetes. Obesity was statistically significant for hyperlipidemia. Smoking was not found to be statistically significant for hyperlipidemia between those who smoke and those who do not smoke. One hundred fifty minutes of moderate exercise was not statistically significant for hyperlipidemia between any of the categories. In summary, based on bivariate analysis of the covariates and the dependent variable of hyperlipidemia, the only two covariates found to be statistically significant for hyperlipidemia were diabetes and obesity (see Table 7).

Table 7

Hyperlipidemia and Potential Confounding Variables

Variable	*n* (%)
HRT	$p = .360$
Using HRT has hyperlipidemia	89(19.6)
No HRT has hyperlipidemia	364(80.4)
Years in United States	$p = .777$
0–10 years has hyperlipidemia	27(14.5)
10–30 years has hyperlipidemia	89(47.9)
31 to 50 or more years has hyperlipidemia	70(37.6)
Marital status	$p = .340$
Married/living with partner has hyperlipidemia	279(58.2)
Widowed/divorced/separated has hyperlipidemia	156(32.6)
Never married has hyperlipidemia	44(9.2)
Race	$p = .112$
Hispanic has hyperlipidemia	120(24.9)
White has hyperlipidemia	139(28.9)
Black has hyperlipidemia	109(22.7)
Other has hyperlipidemia	113(23.5)
Diabetes	$p = <.001$
Diabetes has hyperlipidemia	60(12.9)
No diabetes has hyperlipidemia	406(87.1)
Obesity	$p = .003$
Not overweight/obese has hyperlipidemia	133(27.8)
Overweight has hyperlipidemia	144(30.1)
Obese has hyperlipidemia	201(42.1)
Smoking	$p = .101$
Smokes has hyperlipidemia	78(45.1)
Does not smoke has hyperlipidemia	95(54.9)
150 minutes of moderate exercise per week	$p = .339$
Meets or exceeds has hyperlipidemia	83(42.3)
Does not meet has hyperlipidemia	113(57.7)

Note. HRT = hormone replacement therapy.

Crosstabs and chi-square analysis for the dependent variable hypertriglyceridemia and the covariates was run in SPSS version 28 with the following results. Women using HRT and those not using HRT showed no statistically significant difference in the development of hypertriglyceridemia. Years in the United States showed no statistically significant difference for hypertriglyceridemia between the categories. Marital status is not statistically significant for hypertriglyceridemia between the categories. Race is statistically significant for hypertriglyceridemia noting that Hispanic participants had the higher rate of hypertriglyceridemia. Diabetes is statistically significant for hypertriglyceridemia between those with diabetes and those without diabetes. Obesity is not statistically significant for hypertriglyceridemia between the categories. Smoking was not found to be statistically significant for hypertriglyceridemia between those who smoke and those who do not smoke. One hundred and fifty minutes of moderate exercise was not statistically significant for hypertriglyceridemia between the categories. In summary, based on bivariate analysis of the covariates and the dependent variable hypertriglyceridemia, the only two covariates found to be statistically significant for hypertriglyceridemia were race and diabetes (Table 8).

Table 8

Hypertriglyceridemia and Potential Confounding Variables

Variable	*n* (%)
HRT	$p = .278$
Using HRT has hypertriglyceridemia	21(22.6)
Not using HRT has hypertriglyceridemia	72(77.4)
Years in United States	$p = .861$
0–10 years has hypertriglyceridemia	5(11.4)
10–30 years has hypertriglyceridemia	21(47.7)
31 to 50 or more years has hypertriglyceridemia	18(40.9)
Marital status	$p = .231$
Married/living with partner has hypertriglyceridemia	63(64.3)
Widowed/divorced/separated has hypertriglyceridemia	29(29.6)
Never married has hypertriglyceridemia	6(6.1)
Race	$p = <.001$
Hispanic has hypertriglyceridemia	38(38.8)
White has hypertriglyceridemia	31(31.6)
Black has hypertriglyceridemia	11(11.2)
Other has hypertriglyceridemia	18(18.4)
Diabetes	$p = <.001$
Diabetes has hypertriglyceridemia	33(34.7)
No diabetes has hypertriglyceridemia	62(65.3)
Obesity	$p = .018$
Not overweight/obese has hypertriglyceridemia	15(15.3)
Overweight has hypertriglyceridemia	24(24.5)
Obese has hypertriglyceridemia	59(60.2)
Smoking	$p = .284$
Smokes has hypertriglyceridemia	19(48.7)
Does not smoke has hypertriglyceridemia	20(51.3)
150 minutes of moderate exercise per week	$p = .185$
Meets or exceeds has hypertriglyceridemia	8(32.0)
Does not meet has hypertriglyceridemia	17(68.0)

Note. HRT= hormone replacement therapy.

Multivariate Analysis

A complex samples multiple logistic regression was conducted to test RQ1, RQ2, and RQ3 in SPSS. A CS plan was created using the 2-year Model Examination Center (MEC) sample weights in the 2017-2018 NHANES dataset. Following bivariate analyses, the Hosmer-Lemeshow modeling technique was utilized to determine which covariates should be included in the model (Statistics How To, 2023). For each dependent variable and covariates in the bivariate analysis, any covariate with $p < .15$ in the bivariate analysis was included in the model and the other covariates with $p \geq .15$ were excluded from the model (Statistics How To, 2023).

RQ1: A complex samples logistic regression analysis to investigate if there is a relationship between daily flavonoid intake and hypertension was conducted while controlling for race/ethnicity and obesity. The predictor variable, daily flavonoid intake, was tested a priori to verify that there was no violation of the assumption of the linearity logit. The model (p = .030) is statistically significant, the predictor variable daily flavonoid intake (p = .985) in the logistic regression analysis was not found to contribute to the model while race (p = .014) and obesity (p = <.001) were statistically significant in the model. The Nagelkerke pseudo-R^2 indicates that approximately 7% of the variance in the model was accounted for by daily flavonoid intake overall (see Table 9).

Daily Flavonoid Intake was not statistically significant (p = .985), OR = .839, 95% CI (.452, 1.558) for 21 to 40 % category vs. reference category 0 to 20 %. OR = .974, 95% CI (.591, 1.604) for 41 to 60 % category vs. reference category 0 to 20 %, OR = .842, 95% CI (.324, 2.185) for 61 to 80 % category vs. reference category 0 to 20 %, and OR = .874, 95% CI (.413, 1.852) for 81 to 100 % category vs. reference category 0 to 20 %. The OR results suggest that there is not increased risk for hypertension in any of the groups in comparison with the reference group of 0 to 20 % (see Table 9).

Race was statistically significant (p = .014), OR = .835, 95% CI (.549, 1.270) for White vs. reference category Hispanic suggesting Whites are less likely than Hispanics to have hypertension. OR = 1.815, 95% CI (1.004, 3.280) for Black vs. reference category Hispanic, and OR = .912, 95% CI (.500, 1.666) for Other vs. Hispanic suggesting Black races are more likely than Hispanics to have hypertension (see Table 9).

Obesity was statistically significant (p = <.001), OR = .1.294, 95% CI (.706, 2.372) for overweight vs. reference category not overweight/obese suggesting that overweight have a higher risk of hypertension than those who are not overweight/obese, and OR = 2.013, 95% CI (1.368, 2.962) for obese vs. reference category not overweight/obese suggests that obese have a higher risk for hypertension than those who are not overweight/obese (see Table 9).

Based on the results of the complex samples multiple logistic regression, the null hypothesis that there is no statistically significant association between total daily flavonoid intake and hypertension in U.S. women aged 45 – 65, controlling for race/ethnicity and obesity could not be rejected and the alternative hypothesis that there is a statistically significant association between daily flavonoid intake and hypertension in U.S. women aged 45 – 65, controlling for race/ethnicity and obesity is rejected.

Table 9

Complex Samples Multiple Logistic Regression: Daily Flavonoid Intake and Hypertension

Predictors	R^2	OR (95% CI)	*p* value
Model	.056		.030
Daily flavonoid intake			.985
21% to 40% vs. 0% to 20%		.839 (.452, 1.558)	
41% to 60% vs. 0% to 20%		.974 (.591, 1.604)	
61% to 80% vs. 0% to 20%		.842 (.324, 2.185)	
81% to 100% vs. 0% to 20%		.874 (.413, 1.852)	
Race			.014
White vs. Hispanic		.835 (.549, 1.270)	
Black vs. Hispanic		1.815 (1.004, 3.280)	
Other vs. Hispanic		.912 (.500, 1.666)	
Obesity			<.001
Overweight vs. not overweight/obese		1.294 (.706, 2.372)	
Obese vs. not overweight/obese		2.013 (1.368, 2.962)	

RQ2: A complex samples logistic regression analysis to investigate if there is a relationship between daily flavonoid intake and hyperlipidemia was conducted while controlling for smoking, race, diabetes, and obesity. The model (p = .647) was not statistically significant, the predictor variable daily flavonoid intake, was tested a priori to verify that there was no violation of the assumption of the linearity logit. The predictor variable, daily flavonoid intake in the logistic regression analysis was not found contribute to the model nor were any of the covariates found to contribute to the model. The Nagelkerke pseudo-R^2 indicates that approximately 3% of the variance in the model was accounted for by daily flavonoid intake overall (see Table 10).

Daily Flavonoid Intake was not statistically significant (*p* = .535), OR = 1.1811, 95% CI (.787, 4.170) for 21 to 40 % category vs. reference category 0 to 20 %. OR = 1.516, 95% CI (.658,3.491) for 41 to 60 % category vs. reference category 0 to 20 %, OR = 1.497, 95% CI (.586, 3.822) for 61 to 80 % category vs. reference category 0 to 20 %, and OR = 1.690, 95% CI (.847,3.374) for 81 to 100 % category vs. reference category 0 to 20 %. The OR results suggest that there is increased risk for hyperlipidemia the other four groups in comparison with the reference group of 0 to 20 % with higher risk in 21 – 40 % first, followed by the 81 to 100 % group, the 41 to 60 % group, and finally the 61 to 80 % group (see Table 10).

Smoking was not statistically significant (*p* = .520), OR = 1.098, 95% CI (.546, 2.210) for no smoking vs. reference category of smokes suggesting those who smoke have a higher risk than those who do not smoke of hyperlipidemia. OR = .825, 95% CI (.425, 1.637) for missing/refused vs. reference smokes suggesting that missing or refused have lower risk of hyperlipidemia than those who smoke (see Table 10).

Race was not statistically significant (*p* = .326), OR = .987, 95% CI (.650, 1.500) for White vs. reference category Hispanic suggesting Whites are less likely than Hispanics to have hyperlipidemia. OR = .736, 95% CI (.413, 1.313) for Black vs. reference category Hispanic suggesting that Blacks has a lower risk of hyperlipidemia than the reference category Hispanic, and OR = 1.422, 95% CI (.841, 2.404) for Other vs. Hispanic suggesting other races are more likely than Hispanics to have hyperlipidemia (see Table 10).

Diabetes was not statistically significant (*p* = .094), OR = 1.770, 95% CI (.897,3.493) for not having diabetes vs. reference category has diabetes suggesting those with no diabetes have a greater risk of hyperlipidemia than those with diabetes (see Table 10).

Obesity was not statistically significant (*p* = .908), OR = .1.011, 95% CI (.454, 2.252) for overweight vs. reference category not overweight/obese suggesting that overweight have a higher risk of hyperlipidemia than those who are not overweight/obese, and OR = .897, 95% CI (.454, .431) for obese vs. reference category not overweight/obese suggests that obese have a lower risk for hyperlipidemia than those who are not overweight/obese (see Table 10).

Based on the results of the complex samples multiple logistic regression, the null hypothesis that there is no statistically significant association between total daily flavonoid intake and hyperlipidemia in U.S. women aged 45 – 65, controlling for smoking, race/ethnicity, diabetes, and obesity could not be rejected and the alternative hypothesis that there is a statistically significant association between daily flavonoid intake and hypertension in U.S. women aged 45 – 65, controlling for smoking, race/ethnicity, diabetes, and obesity is rejected.

Table 10

Complex Samples Multiple Logistic Regression: Daily Flavonoid Intake and Hyperlipidemia

Predictors	R^2	OR (95% CI)	*p* value
Model	.034		.647
Daily flavonoid intake			.535
21% to 40% vs. 0% to 20%		1.811 (.787, 4.170)	
41% to 60% vs. 0% to 20%		1.516 (.658, 3.491)	
61% to 80% vs. 0% 20%		1.497 (.586, 3.822)	
81% to 100% vs. 0% to 20%		1.690 (.847, 3.374)	
Smoking			.520
No vs. yes		1.098 (.546, 2.210)	
Missing/refused vs. yes		.825 (.415, 1.637)	
Race			.326
White vs. Hispanic		.987 (.650, 1.500)	
Black vs. Hispanic		.736 (.413, 1.313)	
Other vs. Hispanic		1.422 (.841, 2.404)	
Diabetes			.094
No vs. yes		1.770 (.897, 3.493)	
Obesity			.908
Overweight vs. not overweight/obese		1.011 (.454, 2.252)	
Obese vs. not overweight/obese		.897 (.454, .431)	

RQ3: A complex samples logistic regression analysis to investigate if there is a relationship between daily flavonoid intake and hypertriglyceridemia was conducted while controlling for race, diabetes, and obesity. The model (p = .282) was not found to be statistically significant, the predictor variable daily flavonoid intake, was tested a priori to verify that there was no violation of the assumption of the linearity logit. The predictor variable, daily flavonoid intake in the logistic regression analysis was not found contribute to the model while diabetes (p = .006) was found to contribute to the model.

The Nagelkerke pseudo-R^2 indicates that approximately 14% of the variance in the model was accounted for by daily flavonoid intake overall (see Table 11).

Daily Flavonoid Intake was not statistically significant (*p* = .089), OR = .757, 95% CI (.148, 3.866) for 21 to 40 % category vs. reference category 0 to 20 %. OR = .635, 95% CI (.129, 3.120) for 41 to 60 % category vs. reference category 0 to 20 %, OR = .348, 95% CI (.087, 1.385) for 61 to 80 percent category vs. reference category 0 to 20 %, and OR = 1.157, 95% CI (.268, 4.991) for 81 to 100 % category vs. reference category 0 to 20 % (see Table 11).

Race was not statistically significant (*p* = .150), OR = .970, 95% CI (.492, 1.913) for White vs. reference category Hispanic suggesting Whites are less likely than Hispanics to have hypertriglyceridemia. OR = .256, 95% CI (.079, .834) for Black vs. reference category Hispanic suggesting that Blacks has a lower risk of hypertriglyceridemia than the reference category Hispanic, and OR = 1.444, 95% CI (.256, 8.149) for Other vs. the reference category Hispanic suggesting other races are more likely than Hispanics to have hypertriglyceridemia (see Table 11).

Diabetes was statistically significant (*p* = .006), OR = .222, 95% CI (.080, .613) for not having diabetes vs. reference category has diabetes suggesting those with no diabetes have a lower risk of hypertriglyceridemia than those with diabetes (see Table 11).

The results indicate that obesity, as the third variable, was not statistically significant (*p* = .187), OR = of 1.972 and a 95% CI (.756, 5.084). Furthermore, the results for the comparison of the overweight category to the reference category (not overweight/obese) suggest that individuals classified as overweight have a higher risk of hypertriglyceridemia compared to those who are not overweight/obese, OR = 2.794, 95% CI (.911, 8.569). Similarly, the comparison of the obese category to the reference category (not overweight/obese) indicates that individuals classified as obese have a higher risk of hypertriglyceridemia compared to those who are not overweight/obese. The odds ratio (OR) for this comparison is higher than that for the overweight category, emphasizing that individuals in the obese category face a greater risk. The data in Table 11 supports the conclusion that both overweight and obese individuals have a higher risk of hypertriglyceridemia compared to those who are not overweight/obese, with the obese category demonstrating a higher odds ratio than the overweight category.

Based on the results of the complex samples multiple logistic regression, the null hypothesis that there is no statistically significant association between total daily flavonoid intake and hypertriglyceridemia in U.S. women aged 45 – 65, controlling for smoking, race/ethnicity, diabetes, and obesity could not be rejected and the alternative hypothesis that there is a statistically significant association between daily flavonoid intake and hypertriglyceridemia in U.S. women aged 45 – 65, controlling for smoking, race/ethnicity, diabetes, and obesity is partially rejected.

Table 3

Complex Samples Multiple Logistic Regression: Daily Flavonoid Intake and Hypertriglyceridemia

Predictors	R^2	OR (95% CI)	*p* value
Model	.142		.282
Daily flavonoid intake			.089
21% to 40% vs. 0% to 20%		.757 (.148, 3.866)	
41% to 60% vs. 0% to 20%		.635 (.129, 3.120)	
61% to 80% vs. 0% to 20%		.348 (.087, 1.385)	
81% to 100% vs. 0% to 20%		1.157 (.268, 4.991)	
Race			.150
White vs. Hispanic		.970 (.492, 1.913)	
Black vs. Hispanic		.256 (.079, .834)	
Other vs. Hispanic		1.444 (.256, 8.149)	
Diabetes			.006
No vs. yes		.222 (.080, .613)	
Obesity			.187
Overweight vs. not overweight/obese		1.972 (.765, 5.084)	
Obese vs. not overweight/obese		2.794 (.911, 8.569)	

Summary

The results of the multivariate analyses addressing RQ1, RQ2, and RQ3 indicate that daily flavonoid intake was not a statistically significant predictor of cardiovascular risk in women aged 45 to 65 in the United States. Based on the results, for RQ1 and RQ2, the null hypothesis could not be rejected, and the alternative hypothesis is rejected. For RQ3, the null hypothesis could not be rejected, and the alternative hypothesis is only partially rejected because of the findings of some statistical significance.

In Chapter 5, I provide an interpretation of the findings for each research question and the theoretical framework, discuss the limitations of the study, make recommendations for future research, and discuss implications for positive social change.

Chapter 5: Discussion, Conclusions, and Recommendations

The purpose of this cross-sectional study using secondary data from the 2017–2018 NHANES data set was to examine the potential association between daily flavonoid intake and cardiovascular risk factors in women aged 45 to 65 in the United States. The statistical analysis indicated that daily flavonoid intake was not a significant predictor of cardiovascular risk factors in women aged 45 to 65 in the United States. Covariates to control for confounding were included in all three models.

For RQ1 regarding daily flavonoid intake and hypertension, the covariates race and BMI were included and were found to be statistically significant in the model. Regarding race, Black women had the highest odds ratio for hypertension compared to Hispanic women, *OR* = 1.815 with a 95% CI (1.004, 3.280). In terms of BMI, the obesity category had a significant association with hypertension, *OR* = 2.013 with a 95% CI (1.368, 2.962) compared to those not overweight or obese.

For RQ2 regarding daily flavonoid intake and hyperlipidemia, the covariates smoking, race, diabetes, and obesity were included, but none were found to be statistically significant in the model. The analysis for RQ2 did indicate that the odds of having hyperlipidemia for the daily flavonoid intake category of 21% to 40% are 1.811 times higher than those in the 0% to 20% category, 95% CI (0.787, 4.170).

For RQ3 regarding daily flavonoid intake and hypertriglyceridemia, the covariates race, diabetes, and obesity were included, and I found diabetes to be statistically significant in the model. Black women had lower odds ratio than Hispanic women for hypertriglyceridemia, *OR* = 0.256 with a 95% CI (0.079, 0.834).

In this chapter, I discuss my interpretation of the findings in greater detail and in relation to the theoretical framework. The limitations of the study, my recommendations for future research, and the implications for social change are also described.

Interpretation of Findings

Daily Flavonoid Intake and Hypertension

The relationship between daily flavonoid intake and hypertension among women aged 45 to 65 in the United States was not found to be statistically significant ($p = .985$). It is important to note that statistical significance, as determined by *p* value testing, does not define relevance of a study's findings by itself (Page, 2014). The overreliance on *p* values, as highlighted by Sharma (2021), emphasizes the importance of considering broader interpretations. The intent of this study was to examine the association between daily flavonoid intake and cardiovascular risk indicators that included hypertension.

Regarding RQ1, despite daily flavonoid intake not being statistically significant ($p = .985$), I found both race/ethnicity ($p = .014$) and obesity ($p = <.001$) to be statistically significant. Examining the odds ratios, Black ($OR = 1.815$) women had a higher risk of hypertension versus Hispanic women, which is consistent with published literature (see Maraboto et al., 2020). Both overweight ($OR = 1.294$) and obesity ($OR = 2.013$) suggest a higher risk for hypertension than those not overweight/obese, which is also consistent with published literature (see CDC, 2022a).

I observed the statistical insignificance of daily flavonoid intake in predicting hypertension, but caution should be used in simply overlooking potential clinical significance. Despite being an important part of hypothesis testing, *p* values cannot completely capture the nuances of population-based epidemiological studies (Greenland et al., 2016). The complexity of cardiovascular risk factors, such as hypertension, require a multifaceted understanding beyond binary statistical outcomes (Park, 2014).

The current study findings highlight the significance of considering other factors. Despite the nonsignificant association with daily flavonoid intake, the results highlight the roles of race and obesity in predicting hypertension. Black women demonstrated a higher odds ratio (*OR* = 1.815) for hypertension compared to Hispanic women, aligning with existing literature (see Maraboto et al., 2020). Additionally, both overweight (*OR* = 1.294) and obese (*OR* = 2.013) categories exhibited increased hypertension risks compared to those not overweight/obese, consistent with CDC (2022a) reports.

In summary, while daily flavonoid intake was not a statistically significant predictor of hypertension, these findings highlight the complexity of cardiovascular risk factors in agreement with El Khoudary et al.'s (2019) results. Additionally, the current study results emphasize the need for a comprehensive approach in clinical decision making that recognizes the influence of factors like race and obesity.

Daily Flavonoid Intake and Hyperlipidemia

When examining the association between daily flavonoid intake and hyperlipidemia, I found no statistical significance between daily flavonoid intake (p = .089) and hyperlipidemia. However, it is important to look beyond sole reliance on p values and to examine interpretation that considers a broader clinical context (Page, 2014).

While daily flavonoid intake did not exhibit statistical significance, there were covariates that played a role in predicting hyperlipidemia. Diabetes was a statistically significant factor (p = .006), aligning with existing literature that recognized diabetic dyslipidemia as a common morbidity associated with diabetes (see Hirano, 2018). Sharma (2021) emphasized that it is important to recognize the distinction between clinical-based study findings and population-based study findings. The complexity of human health, especially conditions like hyperlipidemia, require a more comprehensive understanding that encompasses various factors beyond the scope of one single predictor (Sharma, 2021).

Examining the odds ratios for daily flavonoid intake categories, I found that while there was not statistical significance, there were varying degrees of association observed. The nature of these associations highlights the potential influence of flavonoid intake on hyperlipidemia even if it does not reach conventional levels of statistical significance. Furthermore, the covariates of smoking, race, diabetes, and obesity each contributed to the model. For instance, the relationship between race and hyperlipidemia demonstrated interesting patterns, with Black women showing a lower odds ratio compared to the Hispanic women. These relationships underscore the importance of considering multiple factors in understanding the complexities of hyperlipidemia in this specific demographic (El Khoudary et al., 2019).

In summary, while daily flavonoid intake was not statistically significance in predicting hyperlipidemia, the interplay of various factors, including diabetes and race, emphasizes the multifaceted nature of cardiovascular risk (see El Khoudary et al., 2019).

This study encourages a holistic interpretation that goes beyond *p* values, providing a more comprehensive understanding of hyperlipidemia within the population of interest.

Daily Flavonoid Intake and Hypertriglyceridemia

Examining the association between daily flavonoid intake and hypertriglyceridemia, I found no statistical significance between daily flavonoid intake and hypertriglyceridemia (p = .089) or any of the included covariates. Like hypertension and hyperlipidemia, differences exist between clinical-based studies and population-based studies regarding statistical significance for *p* value testing (Sharma, 2021). Acknowledging this difference is important, particularly in the context of large-scale epidemiological investigations, such as this cross-sectional analysis of the 2017–2018 NHANES dataset. A cross-sectional population-based study was the appropriate study design for this epidemiological study examining secondary data (i.e., the 2017–2018 NHANES data set) despite not finding statistical significance. A thorough interpretation of these results goes beyond a mere reliance on *p* values and delves into the intricate dynamics inherent in population-based epidemiological studies (Page, 2014). The complex interplay of variables within a diverse population, captured by NHANES, requires a comprehensive approach that extends beyond statistical thresholds (Greenland et al., 2016). This study, although not finding a statistically significant association, contributes to an understanding of hypertriglyceridemia within the broader demographic context.

Examining the odds ratios associated with different daily flavonoid intake categories, despite not achieving statistical significance, suggests certain trends. The varying degrees of association suggest a relationship that may support further exploration. It is important to recognize that an absence of statistical significance does not negate the potential public health relevance of daily flavonoid intake in the context of hypertriglyceridemia (see Page, 2014).

The inclusion of covariates, such as race, diabetes, and obesity, provided additional insight. The lower odds ratio for hypertriglyceridemia among Black women compared to Hispanic women, for instance, adds complexity to the understanding of racial disparities in lipid metabolism. While statistical significance was not found in the examination of the association between daily flavonoid intake and hypertriglyceridemia, this study still contributes valuable insight into the landscape of cardiovascular health and risk. The interplay of variables, the appropriateness of the study design, and the broader context of population-based epidemiology collectively adds to the understanding of hypertriglyceridemia in women aged 45 to 65 in the United States.

Theoretical Framework

The theoretical framework for this study was the SEM. In this model, importance is placed on how an individual is affected by social and environmental factors with four main levels: individual, relationship, community, and societal (University of Minnesota, 2015). Dietary and lifestyle choices, such as consuming foods rich in flavonoids, are a complex dynamic between all four levels of the SEM (CDC, 2022). I chose the study variables, particularly the covariates, based on the SEM with additional consideration of the fact that individual dietary patterns in particular play a role in the overall risk of CVD (see Chareonrungrueangchai et al., 2020) and are further influenced by relationships, community influence, and societal factors (University of Minnesota, 2015). Regarding the variables in the current study, daily flavonoid intake, smoking, obesity, and physical activity are individual factors, while HRT is a community-level decision based on health care recommendations (see Yang et al., 2022), marital status is a relationship-level influence, and years living in the United States would be a societal influence. One of the difficulties in interpreting the results through the SEM was that several covariates were removed from the multivariate study, but the selection of variables was important based on the influence of each level on lifestyle decisions.

Limitations of the Study

Several limitations existed for this study. The main limitation was that there were only 2 days of dietary recall, which could not account for dietary patterns and flavonoid intake over time. The study was also limited in its ability to carefully control for confounding variables, with some of the validity arising from self-reporting of several confounding variables, such as activity level, smoking, HRT, and diabetes in addition to missing data for several covariates. The results should be interpreted considering these limitations with further research recommended to confirm or contradict these results.

The USDA flavonoid database was another limitation to this study. Researchers at the USDA (2018) did not determine values for every food in the database, rather they imputed flavonoid values for about a quarter of the database using foods that were similar. Some foods were also assigned a value of zero, particularly combination foods

(USDA, 2019), which suggests that the total daily flavonoid values may have been measured on the lower end rather than closer to the actual intake amount.

Recommendations for Further Research

One of my primary recommendations for further research is to examine the association between daily flavonoid intake and CRP values. CRP can be defined as the acute-phase reactant protein seen in inflammatory and infectious processes and is used to measure inflammation (Wu et al., 2023). Inflammation is not only associated with cardiovascular risk and disease but is also an independent risk factor for CVD (Wu et al., 2023). Flavonoids have demonstrated anti-inflammatory properties, inhibiting both the onset and the development of inflammation (Ginwala et al., 2019; Maleki et al., 2019). Further studies that would be helpful include longitudinal studies that examine the participants to detect changes over time and be beneficial in establishing a real sequence of events or patterns (see Thomas, 2020). Longitudinal studies could also be useful to capture a longer dietary history to more accurately measure and average daily flavonoid intake, which was a limitation in the current study.

Implications for Positive Social Change

Despite not having statistical significance, the results of this study can still impact positive social change by highlighting certain covariates, such as overweight, obesity, and diabetes, are largely lifestyle related, and flavonoid-rich foods represent the choice to eat more plant-based foods, which is positively correlated with improved health outcomes (see Clem & Barthel, 2021). Additionally, the positive correlation between flavonoids and inflammation highlights the fact that plant-based foods that are rich in flavonoids are important dietary choices (see Maleki et al., 2019).

Conclusions

I found no statistically significant association between daily flavonoid intake and cardiovascular risk indicators, but it is still important to report the results of this study. While a researcher wants their study results to be statistically significant, many times study results are simply not statistically significant and there is publication bias towards nonsignificant study findings (Visentin et al., 2019). While reporting the results despite their nonsignificance, it is still important to highlight the importance of lifestyle and dietary choices in CVD risk and the importance of further study (see Cheng et al., 2020; Ferraro et al, 2020).

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