MEDIATING EFFECT OF COGNITIVE FUNCTION ON HEALTH-RELATED QUALITY OF LIFE AMONG OLDER ADULTS WITH CARDIOVASCULAR DISEASE IN THE UNITED STATES

by

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DISSERTATION

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I dedicate this work to my family. I would not have completed this without your unconditional support. My husband, Dr. Richard Newman, has been my rock, my love, and my inspiration. After your cardiac arrest, your mental and physical strength has driven you to continue to run marathons and practice medicine. You are amazing. My parents have provided unwavering love and support my entire life. My dad, Gilbert Peterson, PhD, continues to be my role model with his depth of understanding and perseverance. My mom, Lorraine Peterson, continues to be my champion defender and supporter who ascends above and beyond to inspire…Chariots of...

Thank you! I love you!

ABSTRACT

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Cardiovascular diseases (CVDs) are related to disorders of the heart and blood vessels. They may become serious problems, especially in older adults. They could also negatively affect the health-related quality of life (HRQoL) of patients. Moreover, patients with CVDs may also experience cognitive issues, such as memory loss, that could be considered as a mediator in the association of CVD with HRQoL. The purpose of the study was to analyze the relationship among cognitive function, HRQoL, and CVD among older adults using a cross-sectional sample from a secondary database, including the 2019 Behavioral Risk Factor Surveillance System (BRFSS) representing the 2019 United States (U.S.) population. To study the association of these variables, the Wilson and Cleary Model for HRQoL was applied to the current study. The weighted survey logistic regression method was chosen to extract the data for analysis. The findings of the study showed the association between CVD and HRQoL, and cognitive function and HRQoL in patients with CVD. It has also shown the partial mediating effect of cognitive function on the relationship between CVD and HRQoL. These findings have implications for the nursing profession. Older adults with CVD should be thoughtfully evaluated by health care providers to identify cognitive deficits and assist in management of HRQoL. The management of CVD progression alone may not provide optimal clinical benefits. Identification of cognitive changes in older patients with a CVD condition should be considered in maintaining or improving HRQoL.

Keywords: mediator, cognition, CVD, HRQoL, cognitive function, quality of life

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CHAPTER ONE

INTRODUCTION

Cardiovascular diseases (CVDs), such as heart- and blood vessel-related problems, cause impairment of the cardiovascular system. CVDs include several conditions, including hypertension, coronary artery disease (CAD) or coronary heart disease, heart failure (HF), and stroke (National Association of Chronic Disease Directors, n.d.; Virani et al., 2021). CVDs are among the major health-related problems in the world as the prevalence of these diseases is on the rise (Mei et al., 2021b). The problem of CVD worsens with the increase in problems linked to health-related quality of life (HRQoL), which is considered as the self-perceived health-related condition of patients (Centers for Disease Control and Prevention: Measuring Healthy Days). The HRQoL is impaired in patients with heart-related disorders because of symptoms of those disorders, psychological problems, and functional limitations (Erceg et al., 2019). Cognitive function may be associated with HRQoL. These cognitive functions may include problems in immediate recall memory, delayed recall memory, and executive functions (Kim et al., 2019).

The purpose of the current study was to analyze the relationship among cognitive function, HRQoL, and CVD among older adults using a cross-sectional sample from a secondary database representing the 2019 United States (U.S.) population. Sociodemographic covariates were examined for correlations with the outcome variable, HRQoL.

In this chapter, a description of the background and significance of the research problem is presented. The theoretical framework on which the study was based is also discussed. The purpose of the study is presented, along with a description of the research questions and assumptions.

Background and Significance

In the U.S., in 2019, the number of adults who died due to coronary heart disease was 659,041 (Centers for Disease Control and Prevention, National Center for Health Statistics). The American Heart Association (AHA) lists seven cardiovascular health metrics (CVHM) as modifiable health risk factors for CVD. These metrics include physical activity, systolic blood pressure, smoking status, body mass index (BMI), dietary intake, fasting plasma glucose and total cholesterol (Lloyd-Jones et al., 2010). These seven CVHM risk factors for CVD are associated with HRQoL (Allen et al., 2015). Specifically, the number of physically and mentally healthy days has been linked to the CVHM for CVD (Allen et al., 2015), yielding a higher HRQoL (Odom et al., 2016). Gartside and Glueck (1995) also reported that diet and behavioral characteristics may be associated with CVD. These risk factors have also been linked to cognitive function (Adams et al., 2020). Adams and Grandpre (2016) found that six such risk factors, including current status of smoking, obesity, diabetes, depression, high blood pressure, and sedentary lifestyle, could negatively affect cognitive function and increase the risk of CVD. Although systolic blood pressure is associated with cognitive problems (Kivipelto et al. 2002), Cacciatore et al. (1997) reported that diastolic blood pressure in older people could also be a predictor of cognitive impairment. Barnes and Yaffe (2011) also reported that most of the risk factors associated with CVD, such as diabetes, obesity, hypertension, and physical inactivity, could contribute to dementia and cognitive decline. These risk factors may also be associated with several other chronic health-related conditions, such as arthritis, asthma, kidney disease, and chronic obstructive pulmonary disease (COPD) (Adams et al., 2019). Therefore, the relationship between CVD and cognitive function needs further examination.

CVD and Cognitive Function

Cognitive functions are mental processes that include memory, visuospatial ability, attention, and executive function (Cognitive function, n.d.). Cognitive impairment is characterized by frequent memory loss or confusion that has worsened over the past year (CDC, n.d.). Approximately 28% of U.S. adults diagnosed with CVD report cognitive impairment (CDC, n.d.). Patients with CVD have been found to be at increased odds of cognitive impairment (Haring et al., 2013) and have an increased risk of developing dementia (Chen et al., 2018). Cognitive decline is also associated with a greater number of CVHM health risks for CVD (Lutski et al., 2018).

CVD and the Primary Outcome, HRQoL

The primary outcome of CVD is HRQoL, which has been defined by the Centers for Disease Control and Prevention (CDC) as "an individual's or group's perceived physical and mental health over time" (CDC, 2021). Revicki et al. (2014) described HRQoL as a multidimensional concept linked to symptoms of health conditions and functional status across life domains of physical, mental, and social health that prominently includes patients' subjective experiences. The outcomes associated with HRQoL are also considered as patient-reported outcome (PRO) measures. Revicki et al. (2014) also elaborated PRO as a patient's report of their health-related status or other clinical outcomes without any interpretation from any clinician or health care provider (Revicki et al., 2014). Therefore, for this study, the definition presented by Revicki et al. (2014) was used, as it aligns with variables that were examined in the current study and with the concepts in the conceptual framework used to drive the research.

Association between Cognitive Function and HRQoL among CVD patients

Few and conflicting studies have analyzed the association between cognitive function and HRQoL among people with CVD. In one study, cognitive function was not found to be a predictor of HRQoL in CVD patients (Gathright et al., 2016). Contrarily, Warraich et al. (2018) reported that greater severity of CVD is linked to poor HRQoL and a greater likelihood of depression. Cascino et al. (2020) also reported the association of depression with poor HF-specific HRQoL. In a separate study, Adams et al. (2020) compared the HRQoL between CVD patients and patients with subjective cognitive impairment (SCI) and found that patients with SCI had poorer HRQoL than patients with CVD. In other words, it could be suggested that cognitive function may play a mediating role in the association between HRQoL and CVD.

Mediating Role of Cognitive Function in CVD and HRQoL

A mediator is a variable linking independent variables with dependent variables (Allen, 2017). Past studies have been few and conflicting regarding the mediating role of cognitive function. In one study, cognitive functions, except memory, did not mediate the relationship between HF and HRQoL (Pressler et al., 2010). Contrarily, Birch et al. (2016) connoted the mediating effect of cognitive function in associating depression with physical activity (which is one of the components of the CVHM). They found that physical activity could help protect against depression (Birch et al., 2016). Evers et al. (2001) also reported the involvement of cognition as a mediator. These results indicate that cognitive function might be a mediator in relating physical activity to depression, as depression has been associated with poor HRQoL (Judd et al., 1996).

To better understand the association between CVD and HRQoL, it was necessary to study the mediating role of cognitive function in the relationship of the independent variable, CVD, with the dependent variable, HRQoL, after adjustment of covariates. For the current study, it was hypothesized that the mediating variable, cognitive function, is influenced by the independent variable (CVD) and, in turn, influences the dependent variable (HRQoL). To study this hypothesis, a cross-sectional design with data retrieved from the 2019 Behavioral Risk Factor Surveillance System (BRFSS) was implemented.

Conceptual Framework

The effects of health, illness, and treatments all play a role in determining HRQoL (Ferrans et al., 2005). A theoretical framework that integrates key variables to measure health outcomes, such as HRQoL, is important to guide the scope of research in the CVD population. HRQoL is usually determined by the level of happiness and satisfaction a person may have in his or her life. In a seminal study, Campbell et al. (1976) described variances in life satisfaction with age, income, class, and education because of major social factors. Life satisfaction is described as the outcome of one's judgment regarding the current level of quality of life that matches one's self-imposed life standards (Pavot & Diener, 1993). Relationships between subjective assessments and objective conditions were evaluated (Campbell et al., 1976). Considering the operationalization of HRQoL presented by Campbell et al. (1976), Wilson and Cleary (1995) operationalized the concept of HRQoL with the development of an HRQoL model that combines biological and psychological characteristics to measure health outcomes. The model includes a causal linkage of factors at five levels, including biological factors, status of symptoms, functional health, general perceptions about health, and overall quality of life. From left to right, the model shows a progression from the cell to the individual, to the member of society. Concepts within each of the levels become progressively integrated and increasingly difficult for clinicians to define, measure, and control (Wilson & Cleary, 1995).

The first set of factors, *biological variables*, concentrate on the "function of cells, organs, and organ systems" and may be easily applied to the clinical environment (Wilson & Cleary, 1995). As the focus expands from biological and physiological variables within the human body to the whole person, the model broadens to the subjective concept of *symptom status*, the second factor, which includes a person's physical and psychological status to reveal the impact of symptoms on other domains. The relationship between symptom status and the first set of factors may be conflicting and complex (Wilson & Cleary, 1995), as biological variables lack direct correlation with symptom status due to each person's individual values and environmental factors (Ferrans et al., 2005). For example, depression may not result in biological or physiological changes, and an abnormal biological or physiological variable may not immediately present any symptoms. The third factor, *functional status*, broadens further to include a person's self-evaluation of their performance on tasks related to physical and psychological status (Wilson & Cleary, 1995). As an important effect on symptom status, Wilson and Cleary (1995) described functional status in terms of two patients with the same condition; one person with greater determination and self-reliance may have a higher level of function.

The fourth factor, *general perceptions about health*, encompasses biological as well as physiological variables, the status of symptoms, and functional status. General perceptions about health refer to one's subjective assessments of overall mental, physical, and emotional health, which may predict utilization of health care and mortality (Wilson & Cleary, 1995). General health perceptions may be reflected in Likert-type responses to health rating choices from poor to excellent (Ferrans et al., 2005). Functional status correlates with general health perceptions as, for example, we can determine how sick we are based on the level of limitation an illness causes to our usual activities (Barsky et al., 1992). The final factor, *overall quality of life*, is viewed as a culmination of the previous factors regarding one's overall happiness with life in general (Wilson & Cleary, 1995). For a better understanding of the association of the overall quality of life with the previous factors, general health perceptions are considered. Wilson and Cleary (1995) described the burden of some symptoms over others and the preference a person may have to take on new symptoms to relieve the burdensome symptoms. This example is also captured in the model's characteristics of the individual (Wilson & Cleary, 1995).

Under the concept of *characteristics of the environment*, Wilson and Cleary (1995) described the psychological health that would be required to respond to a stressful situation in one's environment, the level of functioning necessary to accomplish the task, and the psychological symptoms of anxiety presented within a person. They stress that there is a causal relationship between variables at each level of the model, regardless of how the factors are presented. A limitation of Wilson and Cleary's model is its vague descriptions of factors, which may cause overlap between factors when applied to populations. Another limitation of the model is its assumption that the linear relationship between factors is bidirectional, which is inferred but not explicitly stated (Wilson & Cleary, 1995). Despite these limitations, the model has been pervasive in the HRQoL literature, and will continue to be an important framework for future research and clinical findings (Höfer et al., 2005; Mathisen et al., 2007; Zubritsky et al., 2013).

Höfer et al. (2005) researched HRQoL in patients with CVD using Wilson and Cleary's HRQoL model to guide their research. They found that depression and anxiety symptoms were mediating factors in the relationship between CVD and HRQoL. Their results provided empirical evidence for the model. Each step between the symptoms status concept and the HRQoL of the model was significantly associated with their findings (Höfer et al., 2005).

Mathisen et al. (2007) studied HRQoL among patients after heart surgery, using Wilson and Cleary's HRQoL model to guide and synthesize related concepts. They investigated reciprocal causal relationships between overall QoL and general health perceptions pre and post cardiac surgery. They found the Wilson and Cleary model fit to be acceptable, which demonstrated that unidirectional models do not explain the impact of cardiac surgery on overall QoL (Mathisen et al., 2007).

To understand the relationship between interventions with the numerous aspects of the HRQoL concept, Zubritsky et al. (2013) modified the Wilson and Cleary HRQoL model to examine HRQoL among older adults receiving long-term services and supports (LTSS). They expanded the function concept to include cognition and added LTSS characteristics and behavior, which provided for enhanced process, structural, and outcome measures, adding to the knowledge demonstrated by the model (Zubritsky et al., 2013). Cognition could be operationalized by assessing the decline in ability to perform memory-related tasks during the past 12 months (Centers for Disease Control and Prevention, n.d.)

Ferrans et al. (2005) published an adaptation of the Wilson and Cleary model. The aim of the study was to provide a theoretical grounding to clarify factors and describe the related roles of each factor (Ferrans et al., 2005). Characteristics of the individual and characteristics of the environment were described in terms of associated variables, such as psychological factors or social influences, respectively (Ferrans et al., 2005). Unlike Wilson and Cleary's HRQoL model, Ferrans et al. (2005) emphasized the influence of individual and environmental characteristics on biological function. They deleted non-medical factors and labels on the arrows that could restrict the characteristics of the relationships (Ferrans et al., 2005).

Application to Current Study

The Wilson and Cleary Model for HRQoL (Wilson & Cleary, 1995) was applied to the current study to provide a pathway to understanding relationships between the study variables, CVD and cognitive function. The concepts associated with the model are presented in Figure 1. The model shows the progression of health outcome measures from symptoms to HRQoL for CVD. The CVD population is represented within the model, along with cognitive function (the independent/mediating variable) that mediates the relationship between CVD (the primary/independent variable) and HRQoL (the dependent/outcome variable). The biological-physiological status level is intentionally removed from the model because these variables are not captured in the current study. The overall model drove the hypothesis that cognitive function mediates the link between CVD and HRQoL (see Figure 1).

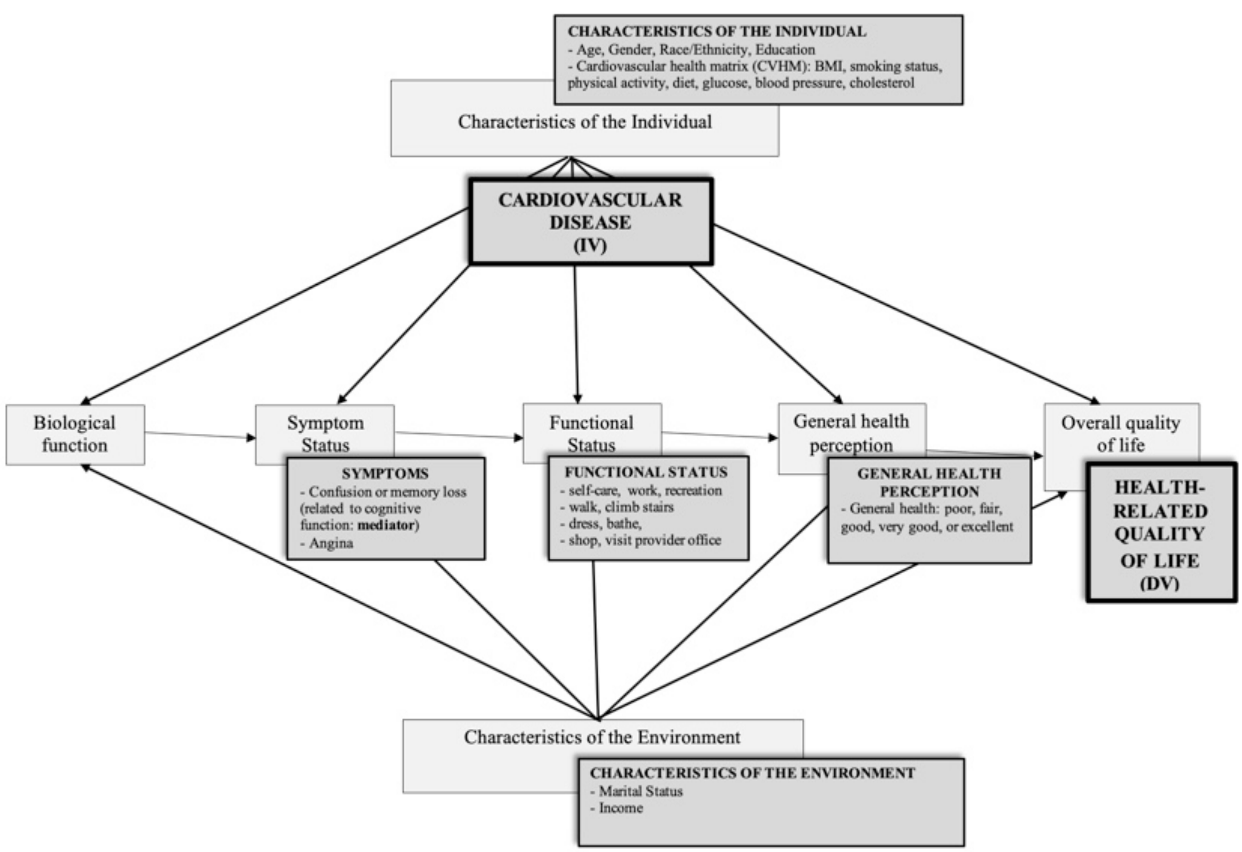

Figure 1. Wilson and Cleary Model for HRQoL with Cognitive Function as a Mediating Effect on the Relationship between CVD and HRQoL

The concepts presented in Figure 1 affect the overall HRQoL. The subjective nature of the concepts shows that the overall HRQoL is individualized and subjective in nature. It could also be considered as multidimensional and complex. Although the model in the figure shows a unidirectional flow of concepts affecting the quality of life, they only represent the typical causal pathway. They could also point in the opposite direction that could further add to the intricacy of the interactions between the concepts affecting HRQoL.

Propositions

As reflected in the conceptual framework and the review of literature, the following were the study propositions:

1. HRQoL is influenced by symptom status, general perceptions about health, functional status, characteristics of the environment, and characteristics of the individual, which include patients with CVD and cognitive function impairment.
2. Cognitive function mediates the relationship between CVD and HRQoL (see Figure 2).

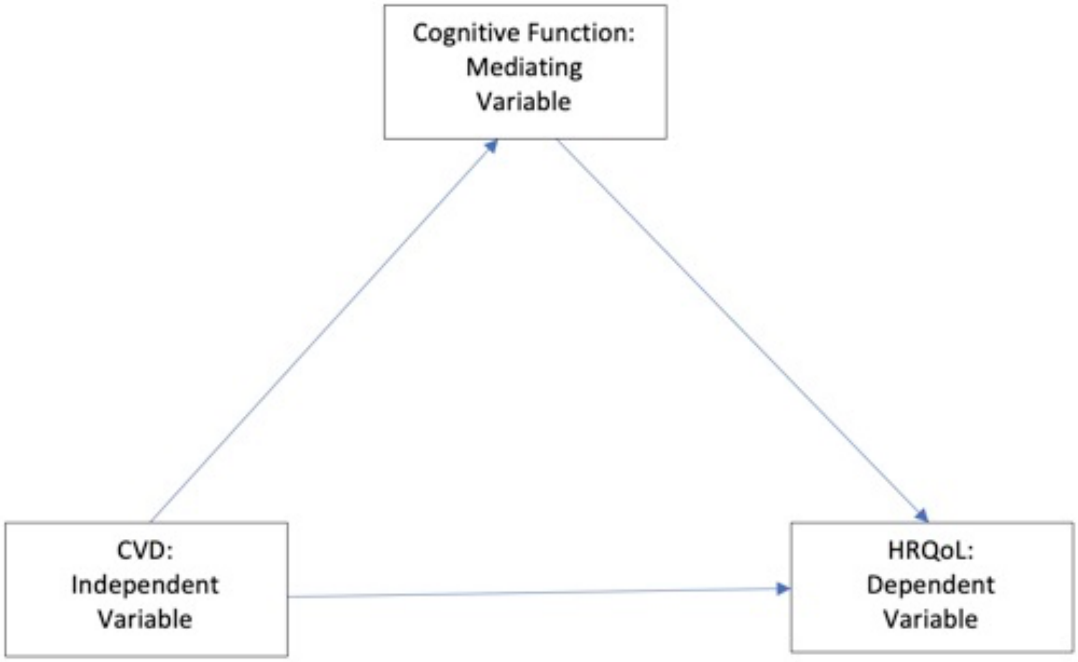

Figure 2. A conceptual model of cognitive function as a mediating variable related to the independent variable, CVD, and the dependent variable, HRQoL

Problem and Purposes

There is evidence to support the theoretical relationships among the factors in Wilson and Cleary HRQoL model (Höfer et al., 2005; Mathisen et al., 2007; Zubritsky et al., 2013), but little is known whether this model explains HRQoL in CVD with or without a mediating effect of cognitive function. Symptoms status has been characterized as a patient's perception of an abnormal physical, emotional, or cognitive state (Wilson & Cleary, 1995). Functional status is the ability to perform certain activities in several domains, including psychological function, physical function, social function, or role function (Wilson & Cleary, 1995). General health perception has been described as the subjective summation of an individual's health (Wilson & Cleary, 1995). However, researchers had not assessed the influence of confusion or memory loss, angina, self-care behaviors, or CVHM which includes BMI, smoking status, physical activity, diet, glucose, blood pressure, and cholesterol that contribute to HRQoL. Therefore, for the purposes of the proposed study were to assess the relationship among CVD, cognitive function, and HRQoL, and to determine if cognitive function mediated the relationship between CVD and HRQoL.

Study Questions

1. What is the relationship between CVD and HRQoL?
2. What is the relationship between cognitive function and HRQoL among CVD patients?
3. When controlling for individual characteristics (including age, gender, race/ethnicity, and education) and environmental characteristics (including marital status and income), is there a mediating effect of cognitive function associated with the relationship between CVD and HRQoL?

Definition of Variables

Cardiovascular Disease. A group of heart- and blood vessels-related disorders (CDC, n.d.).

Cognitive Function. Confusion or memory loss that is happening more often or is getting worse during the past 12 months." (CDC, n.d.).

Characteristics of the Individual. Demographic, developmental, psychological, and biological factors influencing health-related outcomes (Ferrans et al., 2005).

Characteristics of the Environment. Social: influences of family and society affecting an individual's behavior; Physical: attributes of a setting in society influencing health outcomes (Ferrans et al., 2005)

Overall Quality of Life. A multidimensional concept that includes symptoms of health conditions and functional status across life domains of physical, mental, and social health that prominently includes patient subjective experiences (Revicki et al., 2014)

Assumptions

1. CVD patients with cognitive impairment may experience poor HRQoL.
2. Cognitive function may explain worsening HRQoL in CVD patients.
3. Patients without CVD may experience good HRQoL.
4. Patients with CVD and without cognitive impairment may experience poor HRQoL.
5. HRQoL may decline in older adults with CVD.

Chapter Summary

Older adults with CVD experience changes in cognitive functioning and HRQoL. With Americans living longer, the incidence and prevalence of CVD are also increasing. Approximately ninety percent of U.S. adults over age 80 have CVD, including hypertension (Virani et al., 2021). Twenty-eight percent of U.S. adults diagnosed with CVD report cognitive decline (CDC, n.d.). Given these statistics, it is important to continue to study CVD. There were gaps in existing research, including an unknown association between cognitive function and HRQoL in the CVD population. The current study was guided by a modified structural framework from Wilson and Cleary's HRQoL model.

CHAPTER TWO

CRITICAL REVIEW OF RELEVENT LITERATURE

This paper includes a discussion of the significance of the problem of HRQoL changes in the CVD population, including its magnitude and impact, and a description of the CVD population. Background information is presented to support the need for a study of factors related to the CVD population. The discussion includes a description of HRQoL and cognitive functioning in the CVD population and factors associated with CVD in adults. This paper concludes with a discussion of 1) the association between cognitive function and HRQoL among CVD patients; and 2) whether cognitive function mediates the relationship between CVD and HRQoL, leading to the statement of a specific research problem and purpose for future study.

Data Sources and Search Strategy

Academic Search Complete, APA PsycInfo, CINAHL Plus with Full Text, and MEDLINE databases were searched for peer-reviewed research papers. The following key words were searched: CVD OR cardiovascular disease, HRQoL OR health-related quality of life, cognition OR cognitive function, and BRFSS OR Behavioral Risk Factor Surveillance System. Articles were included if they were published between 2000 and 2021, and in English. Articles were excluded if children (below 18 years of age) or pregnant women were studied.

Review of Relevant Literature

Globally, CVDs are the leading causes of death. According to the World Health Organization (WHO), 17.9 million people died from CVDs in 2019, accounting for 32% of all deaths in the world (WHO, 2021). In 2018, there were 126.9 million adults age 20 years or older (representing approximately 49.2%) in the United States (U.S.) who lived with CVD, consisting of a group of heart and blood vessel conditions including coronary heart disease (CHD), heart failure (HF), stroke, and hypertension. After exclusion of hypertension and considering only HF, CHD, and stroke, approximately 26.1 million people (representing approximately 9.3%) in 2018 were found to have CVD (Virani et al., 2021).

Underlying factors associated with heart-related disorders may include atherosclerosis, uncontrolled high blood pressure, and irregular heart rhythm. These factors may vary depending on the CVD disorder (Mendis et al., 2011). Considering all the factors associated with cardiac events, the American Heart Association (AHA) identified seven variables to improve overall cardiovascular health, including cholesterol, blood pressure, body mass index (BMI), blood glucose, smoking, physical activity, and diet. This list of variables is known as the comprehensive cardiovascular health index (CVHI) or CVHM (Lloyd-Jones et al., 2010). According to AHA, individuals with a controlled level of a minimum of five of these variables could have a 78% decreased risk of death caused by heart-related disorders in comparison to individuals with no control over any of these variables (AHA, 2021). In a study, Pilkerton et al. (2015) examined temporal changes in CVHI using BRFSS data from 2003 to 2011. They reported that total CVHI was reduced from 3.73 ± 0.01 in the year 2003 to 3.65 ± 0.01 in the year 2009. On a further note, ideal CVHI components decreased over time throughout the population, including greater incidences of high blood pressure and cholesterol. However, the prevalence of "ideal" diet has increased in several states. Pilkerton et al. (2015) suggested that an improvement in the "ideal" diet with a paradoxical decrease in "ideal" cholesterol could be attributed to an increase in overall consumption of food, including vegetables, fruits, and unhealthy foods. The prevalence of "poor" CVHI increased from 15.8% to 18.2% between 2003 and 2009, representing an additional seven million individuals at an increased risk of CVD as determined by the seven CVHI criteria (Pilkerton et al., 2015).

Individuals with CVD risk factors may experience cognitive function impairment that could be associated with a decline in HRQoL. Cognitive impairment in the CVD population include worsening memory, executive function, and attention, which can lead to poorer self-care and difficulty performing activities of daily living (ADL) (Leritz et al., 2011). However, few studies have been conducted on the relationship between cognitive function and HRQoL in CVD populations (Adams et al., 2020; Birch et al., 2016; Gathright et al., 2016; Pressler et al., 2010; Warraich et al., 2018). These studies have shown mixed findings. Furthermore, very few studies have directly addressed the mediating role of cognitive function in the HRQoL in patients with CVD. For example, studies, such as Mei et al. (2021b) and Lu et al. (2019), have often focused on depression and anxiety in addressing HRQoL in patients with CVD. Among these studies, there are also inconsistencies regarding the direct or indirect effect of cognitive issues on HRQoL in patients with CVD. Therefore, it seems imperative to conduct further research to clarify inconsistencies in the literature regarding cognitive function as a mediator of HRQoL in CVD populations. Nevertheless, before proceeding further, it is important to study the association of CVD with HRQoL, CVD with cognitive function, and HRQoL with cognitive function, as the study of these associations could help in developing foundations regarding the association of cognitive function with HRQoL in patients with CVD.

CVD and HRQoL as a Primary Outcome

In 1948, the World Health Organization (WHO) described the term *quality-of-life* as "a state of complete physical, mental, and social well-being – not merely the absence of disease or infirmity" (WHO, 2005). The Centers for Disease Control and Prevention (CDC) defined *health-related quality-of-life* (HRQoL) as "an individual's or group's perceived physical and mental health over time" (CDC, 2021). To provide the best description for the current study, Revicki et al. (2014) defined HRQoL as a multidimensional concept that includes symptoms of health conditions and functional status across life domains of physical, mental, and social health that prominently includes patients' subjective experiences.

In a qualitative study, Heo et al. (2009) investigated how 20 participants with HF perceived and defined HRQoL. Participants stated that factors such as physical symptoms, economic status, social and spiritual factors, self-care behaviors, and positive outlook influenced their HRQoL. Researchers have found that patients with similar HF diagnoses have varied perceptions about their health and its impact on the quality of their daily lives and levels of happiness. Participants who reflected an adapted perception of their changed clinical condition conveyed a positive outlook (Heo et al., 2009). Lewis et al. (2014) examined the impact of a second cardiovascular event on HRQoL in myocardial infarction (MI) survivors. They performed a prospective, longitudinal-study, a HRQoL sub-study of the VALIANT (Valsartan in acute myocardial infarction) trial, with 2,556 MI survivor participants over 24 months. A visual analog scale (VAS) was used to evaluate HRQoL scores on a questionnaire. They found the trajectory of the decrease in VAS scores was statistically significant (VAS 61.0 ± 19 vs 68.2 ± 18 [$p < 0.00$] after a second CVD event. Specifically, they found that a second non-fatal cardiovascular event led to participants experiencing worse HRQoL than was suggested by their previous trajectory, and worse HRQoL compared with participants who did not have a second cardiovascular event (Lewis et al., 2014).

Young et al. (2005) studied modifiable CVD risk factors to determine HRQoL in partnered versus single mothers (widowed, separated, divorced, never married, or married without spouse in household). The self-reported data was obtained from 1,446 respondents from the NHANES database. Single mothers reported lower levels of social support, poorer health, and less income; they were 70% more likely to have hypertension and diabetes and 3.3 times more likely to have a CVD than partnered mothers (95% CI 3.24 – 3.31) (Young et al., 2005). In another study, Tofighi et al. (2012) conducted post-treatment research regarding HRQoL in patients with coronary artery disease (CAD). They conducted their study on 49 patients with CAD utilizing the short form (36) health survey (SF-36). The SF-36 consists of eight subscales, including vitality, bodily pain, physical functioning, general health perceptions, emotional role functioning, physical role functioning, mental health, and social role functioning. They also conducted a path analysis to analyze the association. The researchers assessed HRQoL in the first year and third year after treatment. They found that HRQoL significantly changed in the third year after treatment than in the first year after treatment in patients with CAD. This showed that the heart-related disorder, CAD, was associated with HRQoL, and a decrease in the severity of this disorder could be negatively related to HRQoL. Considering the covariates, the significant change in the SF-36 scales was higher in the case of males than females. For example, in the case of males, significant changes were found in bodily pain ($p = 0.00$), general health perceptions ($p = 0.02$), social functioning ($p = 0.01$), and emotional role functioning ($p = 0.03$), whereas in the case of females, significant changes were found in social functioning ($p = 0.02$) and emotional role functioning ($p = 0.08$) (Tofighi et al., 2012).

Some researchers have studied associations between HRQoL and cardiovascular health using seven factors (Allen et al., 2015; Odom et al., 2016). As noted earlier, the AHA identified seven risk factors for poor cardiovascular health that can be improved through changes in lifestyle. These factors include systolic blood pressure, smoking status, physical activity, BMI, dietary intake, fasting plasma glucose and total cholesterol (Lloyd-Jones et al., 2010). Odom et al. (2016) studied HRQoL and CVHM with 347,073 respondents, using data from the 2013

BRFSS. The CVHM was measured based on participants' self-reported health in each of the seven categories, where higher values indicated a more ideal CVHM. HRQoL was measured according to participants' physically unhealthy days, mentally unhealthy days, and activity limitations within the past 30 days. Respondents who self-reported 3-5 or 6-7 ideal CVHM had lower aPR (adjusted prevalence ratio) for fair/poor health (aPR = 0.49, 95% CI 0.7 – 0.50; aPR = 0.21, 95% CI 0.19 – 0.23, respectively). Specifically, they found that (1) the prevalence of ≥ 14 physically unhealthy days decreased by 47% and 72%, respectively, for the 3-5 ideal CVHM group and the 6-7 ideal CVHM group (aPR = 0.53, 95% CI 0.51 – 0.55, aPR = 0.28, 95% CI 0.26 – 0.20, respectively); (2) the prevalence of mentally unhealthy days decreased by, respectively, 43% and 66% for both groups (aPR = 0.57, 95% CI 0.55 – 0.60, aPR = 0.34, 95% CI 0.31 – 0.37, respectively); and (3) the prevalence of ≥ 14 activity limited days decreased by, respectively, 50% and 74% (aPR = 0.50, 95% CI 0.48 – 0.53, aPR = 0.26, 95% CI 0.23 – 0.29, respectively) (Odom et al., 2016). These results indicated that a higher number of ideal CVHM could be associated with less HRQoL impairment (Odom et al., 2016). In a similar study, Allen et al (2015) examined HRQoL and CVHM with 7,115 participants between 2001-2010 using data from the National Health and Nutrition Examination Survey (NHANES) database. They found that a greater number of ideal CVHM was associated with improved overall health status and fewer mentally and physically unhealthy days as compared to individuals with fewer ideal CVHM. Specifically, participants with moderate and ideal levels of CVHM were less likely to report fair/poor health (44% and 71%, respectively) as compared to the participants with poor CVHM (Allen et al., 2015).

CVD and Cognitive Function

Cognitive function refers to mental processes, including thinking, perception, remembering, creation of imagery, judgment, and awareness (Cognitive function, n.d.). Subjective cognitive decline (SCD) or impairment (SCI) is the self-reported experience of worsening or more frequent confusion or memory loss within the previous 12 months (Alzheimer's Association, 2018). Taylor et al. (2018) studied SCI in 227,393 adults by analyzing BRFSS surveys from 2015 and 2016. The prevalence of SCI in respondents aged ≥ 45 was 11.2%, with 50.6% of those respondents reporting functional limitations related to SCI. Increases in the prevalence of SCI were found to correspond with advancing age (prevalence in individuals with the age range of 45 to 54 years is 10.4%; and prevalence in individuals with the age range of 75 years or older is 14.3%). Respondents who lived alone and those with chronic diseases, including CVD, had a higher prevalence of SCI (13.8% and 15.2%, respectively) than the overall respondent reports of SCI (Taylor et al., 2018).

Several studies have been conducted on the association of cognitive function with CVD, including the seven AHA CVD health metrics or risk factors (Bancks et al., 2019; Chen et al., 2018; Crichton et al., 2014; Gu et al., 2019; Haring et al., 2013; Loprinzi et al., 2017; Lutski et al., 2018; Tofighi et al., 2012; Tsai et al., 2018). Crichton et al. (2014) examined the association between cognitive function and the seven CVD risk factors, using secondary data from the Maine-Syracuse longitudinal study. In a cross-sectional study of 972 individuals, the seven CVD risk factors were studied to determine the cognitive performance of the participants. Cognitive function was measured through neuropsychological tests, including working memory, visual-spatial memory, scanning and tracking, verbal episodic memory, executive function, similarities test, and the Mini Mental State Exam (MMSE). The MMSE is beneficial in assessing certain domains of cognitive function, such as attention, calculation, recall, and registration. A significant linear association was found between cardiovascular health factors and cognitive performance ([0.001, 0.68], $p<0.05$). Tsai et al. (2018) took a new approach to assessing cognitive impairment. They described global-cognitive health (GCH) metrics as controllable and non-controllable cardiovascular health (CVH) risks of dementia to determine the risk of cognitive decline. The GCH metrics, originally proposed by Livingston et al. (2017), included nine factors: education, obesity, blood pressure, tobacco use, depression, physical activity, social integration, glycated hemoglobin (HbA1c), and hearing function (Tsai et al., 2018). Using data from the 1988-1994 NHANES III database, they investigated the cognitive functioning of 1,243 participants via symbol-digit substitution tests, simple reaction time tests, and serial digit learning tests. They found that individuals with significantly greater values of GCH metrics performed better on the cognitive tests (p for trend < 0.01). They also found a significantly positive association between the GCH metrics and CVH. Specifically, participants with 7 or more of the 9 ideal GCH metrics performed better on the cognitive tests than participants with less than 7 ideal GCH metrics ($p < 0.05$) (Tsai et al., 2018). Loprinzi et al. (2017) also studied data from the NHANES. Using the 1999-2002 NHANES database of 2,097 participants aged 60 and older, they found that an increase in CVD risk factors worsened cognitive function scores. Specifically, a non-linear inverse relationship was identified between cognitive function and the risk of CVD. Additionally, an increased risk of mortality was associated with poorer cognitive function, independent of CVD risk (low cognition, low CVD risk: HR 2.03, 95% CI 1.71 – 2.41, $p < 0.00$; low cognition, high CVD risk: HR 2.06, 95% CI 1.44 – 2.94, $p < 0.00$) (Loprinzi et al., 2017).

Using data from a prospective observational study to improve cardiovascular outcomes in high-risk older patients with acute coronary syndrome (ICON1 study), Gu et al. (2019) examined the prevalence of cognitive impairment in 271 older adults. They studied predictors of cognitive decline after invasive care related to non-ST-elevation acute coronary syndrome one year after the event. Using the Montreal Cognitive Assessment tool, they found a high prevalence of undiagnosed cognitive impairment (n = 130, 48.0%). They also found that patients with cognitive impairments were also more likely to have a major adverse CVD event (Kaplan-Meier analysis: p = 0.05). One year after the initial CVD event, 35.1% of the patients had experienced cognitive decline. An independent association was found between recurrent MI and cognitive decline (OR 3.19, 95% CI 1.18 – 8.63, p = 0.02) at 1 year (Gu et al., 2019).

Conversely, Bancks et al. (2019) did not find a significant association between cognitive performance and CVD risk factors. Using secondary data from the NHANES in 5,711 adults aged ≥60 years, Bancks et al. (2019) examined trends in cognitive performance with CVD risk factors from 1999-2000, 2001-2002, 2011-2012, and 2013-2014 using the Digit Symbol Substitution Test (DSST). They found that risk factors for CVD were not significantly associated with cognitive performance. In addition, they observed a minor attenuation (per annum: 0.40, 95% CI 0.28 – 0.51) after adjusting for blood pressure and smoking status (Bancks et al., 2019).

Cognitive Function and HRQoL

Many studies have been conducted to determine associations between cognitive function and HRQoL, without including the study variable CVD (Brody et al., 2019; Stites et al., 2018; Christianson et al., 2019). Brody et al. (2019) studied cognitive performance in 3,181 older adults using NHANES data from 2011 to 2014. Participants' cognitive abilities were assessed using word-list learning with immediate and delayed recall, an animal naming fluency test for verbal ability, and a digit symbol substitution test for speed, attention, and working memory. They found that SCD was significantly associated with low performance on objective cognitive measures. Specifically, a positive association was found between scoring in the lowest 25th percentile for the objective cognitive tests and responding yes to the subjective cognitive impairment (SCI) question (OR ranged from 1.8 [95% CI 1.3 – 2.6] for AF to 2.9 [95% CI 2.3 – 3.7] for CERAD-DR). They also found that fair/poor self-reported health was significantly associated with low performance on three out of four of the objective cognitive function tests, and that participants were more likely to score in the lowest 25th percentile (1.4, 95% CI 1.1 – 1.8 for the word list learning with recall test; 2.3, 95% CI 1.6 – 3.4 for the animal naming test; and 3.1, 95% CI 2.1 – 4.7 for the digit symbol substitution test) (Brody et al., 2019).

Stites et al. (2018) studied the relationship between SCI and QoL in 259 older subjects with varied degrees of cognitive impairment (normal cognition (NC), mild cognitive impairment (MCI), or mild stage Alzheimer's disease (AD) dementia. Three subjective cognitive complaints were examined: distress due to cognitive problems, cognitive difficulties, and the belief of experiencing more memory problems as compared to other people. Though significance was not found to explain HRQoL (EQ-5D) in participants with MCI (-0.02 for cognitive difficulties and cognitive symptom distress) or AD (-0.01 for cognitive difficulties and cognitive symptom distress), or for global health ratings (EQ-VAS) in participants with MCI (-0.29 for cognitive symptom distress) or AD (1.48 for cognitive symptom distress), associations were found with relatively lower HRQoL. Specifically, they found that MCI participants who described greater cognitive complaints than those with NC were significantly associated ($p < 0.05$) with experiences of relatively lower HRQoL (QoL-AD [satisfaction in daily life] (-1.87, -1.62, -1.02 for two of the three cognitive complaints: cognitive difficulties, cognitive symptom distress, and more memory problems than most (not significant), respectively) and DEM-QoL [difficulty in daily life]) (-6.42, -5.89, 4.54 for each cognitive complaint, respectively). Those with AD dementia also had greater cognitive complaints as compared to NC participants with satisfaction in daily life and difficulty in daily life. However, an independent association was found with relative domains of QoL (QoL-AD and DEM-QoL) for two of the three cognitive complaints (-2.16, -5.42 [cognitive difficulties] and -2.20, -5.51 [cognitive symptom distress], respectively). One's belief about the severity of their memory problems was not independently associated with relative domains of QoL (-1.13, 3.05) (Stites et al., 2018).

Christiansen et al. (2019) conducted a cross-sectional descriptive study of 247 participants aged 60 and older with existing cognitive impairments to determine their HRQoL. They found that three factors were associated with decreased mental and physical HRQoL: dependency during ADL, feelings of pain and loneliness, and receiving informal personal care (Christianson et al., 2019). Independence during the performance of ADL was associated with a statistically significantly higher HRQoL ($p = 0.03$) than dependence on performing ADL (8.3%). A weak correlation was found between dependency in functional ability and lower HRQoL ($r_s=0.31 – 0.33$, $p < 0.01$) (Christianson et al., 2019).

Association between Cognitive Function and HRQoL among CVD patients

Few studies have addressed the associations between CVD and both cognitive function and HRQoL. Adams et al. (2020) studied HRQoL similarities and differences between CVD and SCI by comparing measures of health care access, disability, quality of life, and the seven AHA risk factors in respondents with reported SCI or CVD. The outcomes were taken from 302,008 adult respondents aged 45 or older using data from the 2015-2017 BRFSS. The HRQoL measures included depression diagnosis, health status, mental distress, physical distress, and activity limitation. They found that respondents with SCI only reported poorer HRQoL than those with CVD only, even though the SCI-only group was younger on average than the CVD-only group (SCI only: 42.3, 95% CI 40.8 – 43.9 for frequent mental distress; 43.4, 95% CI 41.8-44.9 for frequent physical distress; 38.3, 95% CI 36.7 – 39.8 for frequent activity limitation; 29.2, 95% CI 27.9 – 30.6 for age ≥ 65 versus CVD only: 9.9, 95% CI 9.3 – 10.6 for frequent mental distress; 26.3, 95% CI 25.3 – 27.3 for frequent physical distress; 15.2, 95% CI 14.4 – 16.0 for frequent activity limitation; 63.3, 95% CI 62.2 – 64.5) (Adams et al., 2020).

In another study on HRQoL in CVD patients with cognitive impairments, Warraich et al. (2018) examined 202 acutely decompensated HF patients currently in hospital or rehabilitation. They compared ejection fraction (EF) in patients, comparing EF of 45% or greater (preserved EF or HFpEF) to EF of less than 45% (reduced EF or HFrEF). The impairments were found to be similar in each category of the physical function measures (physical performance battery, gait speed, frailty) and cognitive impairment (HFpEF=77%, HFrEF=81%; p=0.56). There were differences between the two groups related to depression and HRQoL impairments. Patients with HFpEF had worsened depression (HFpEF = 22%, HFrEF = 11%, p = 0.04) and QoL (General QoL, Short form-12 MCS: 95% CI 2 – 10; p = 0.00) versus HFrEF patients. Poor HRQoL was significantly correlated with the presence of depression (Kansas City Cardiomyopathy questionnaire, r = -0.58; SF-12 physical composite score, r = -0.63) (Warraich et al., 2018).

Associated with the findings of the studies conducted by Adams et al. (2020) and Warraich et al. (2018), Erceg et al. (2019) reported the involvement of depression in impaired HRQoL in patients with HF. The researchers conducted a prospective observational study on 200 elderly patients with HF with a median follow-up period of 28 months. They used the Minnesota Living with Heart Failure questionnaire (MLHFQ). The researchers also used the MMSE for the assessment of the cognitive status of the patients, and the five-item Geriatric Depression Scale (GDS) to assess possible depression in the patients. The primary outcomes in the study were heart-related mortality, all-cause mortality, and rehospitalization because of HF. The researchers found that poor HRQoL was associated with a significantly increased risk of heart-related mortality ($p = 0.03$) and rehospitalization because of HF ($p = 0.00$). They also reported that the mean overall MLHFQ score related to the participants was higher than most of the studies conducted on younger participants showing worse HRQoL in the participants. They suggested that this relationship between HF and HRQoL could be explained by the fact that the participants had symptoms of depression (Erceg et al., 2019). However, they have only suggested the possible involvement of depression in relating HF with HRQoL that could not be considered as empirical evidence of the cognitive mediator between HF and HRQoL.

The findings of another study conducted by Ojala et al. (2020) support the findings of the studies conducted by Warraich et al. (2018) and Erceg et al. (2019). Ojala et al. (2020) conducted their study on patients with stable CVD. The researchers assessed the association of different variables, including sleep, breathing, depression, vitality, and the variables associated with MMSE with HRQoL in home-dwelling patients with CVD ($n = 329$) having an age of ≥ 75 years. The researchers compared the findings of these patients with the general population after adjusting for covariates, including age and gender ($n = 103$). The researchers found that overall HRQoL was significantly impaired in patients with stable CVD than in the general population ($p = 0.00$). On a further note, the findings related to other variables, such as sleeping, breathing, discomfort, vitality, distress ($p < 0.00$ in all these cases), and depression ($p = 0.02$) were also statistically significantly different. The researchers also reported that MMSE points, which are beneficial in assessing cognitive functions, such as memory, attention, recall, and orientation, were significantly helpful in predicting the impairment of HRQoL ($p < 0.00$). Considering these findings, the researchers concluded that older people with CVD also exhibit impaired HRQoL because of impaired sleep and vitality, and an increase in depression and distress. The decline in MMSE scores shows the decline in cognitive performance, and it could also facilitate characterizing the worsening of HRQoL (Ojala et al, 2020).

In another study conducted by Mei et al. (2021b), HRQoL of patients with CHD was investigated. In the study, the researchers worked with 1,247 patients with CHD. The researchers conducted their study in China and utilized the Visual Analogue Scale (VAS) and the Chinese version of the European Quality of Life Five Dimension Five level scale (EQ-5D-5L) for the assessment of the HRQoL in patients suffering from CHD. The five dimensions in the EQ-5D-5L are mobility (MO), pain/discomfort (PD), usual activities (UA), self-care (SC), and anxiety/depression (AD). Researchers found that patients with CHD had higher rates of anxiety, poor sleep quality, stroke, and diabetes mellitus that were associated with a significant decrease in the scores related to EQ-5D and VAS. The researchers also found that hypertension, physical activity, and depression significantly affected several domain-specific EQ-5D scores in patients suffering from CHD ($p < 0.05$). Specifically, the researchers found that CHD patients with anxiety had more problems with AD (OR 3.00, 95% CI 1.63 – 5.51) and PD (OR 1.70, 95% CI 1 – 2.91). Furthermore, the CHD patients with depression had more problems with all dimensions of the questionnaire. The CHD patients with depression showed problems with SC (OR 3.58, 95% CI 1.69 – 7.59), PD (OR 2.12, 95% CI 1.28 – 3.52), MO (OR 2.38, 95% CI 1.36 – 4.18), UA (OR 4.38, 95% CI 2.31 – 8.3), and AD (OR 6.04, 95% CI 3.45 – 10.57). Considering the findings, the researchers reported that depression in patients with CHD could indirectly affect HRQoL of the patients as it has higher odds of negatively affecting the different dimensions of the questionnaire. Considering the confounders, the researchers reported that older age, gender, not having a spouse, education, high fat diet, and ever drinking alcohol could also affect several domain-specific EQ-5D scores in patients with CHD (Mei et al., 2021b).

The results obtained by Lu et al. (2019) supported the findings of the study conducted by Mei et al. (2021b) but are not consistent with those findings. Lu et al. (2019) conducted their study on patients with CAD. The purpose of the study was to analyze the association between HRQoL and depression and anxiety in CAD patients. The researchers conducted their study on 414 patients who had CAD. They assessed HRQoL, depression, and anxiety with the help of questionnaires, including SF-36, the Chinese version of the Zung Self-Rating Depression Scale (SDS), and the Zung Self-Rating Anxiety Scale (SAS), respectively. Considering the SF-36 subscales, the researchers found that all eight subscales were significantly negatively related to SAS scores (the value of r ranged from -0.40 to -0.20, $p < 0.00$), and SDS scores (the value of r ranged from -0.50 to -0.21, $p < 0.00$). The SF-26 total scores were -0.46 ($p < 0.00$) and -0.57 ($p < 0.00$) for SAS scores and SDS scores, respectively. Considering the confounders, the researchers reported that gender affected HRQoL both directly and indirectly, through anxiety and depression. The researchers found a significant direct effect of SDS scores on HRQoL ($B = -0.70$, $\beta = -0.47$) and a direct effect of SAS scores on HRQoL ($B = -0.26$, $\beta = -0.16$, $p < 0.00$) (Lu et al., 2019). It is this direct effect of depressive symptoms on HRQoL presented by Lu et al. (2019) that is inconsistent with the indirect effect of depressive symptoms on HRQoL presented by Mei et al. (2021b), even though both of the studies show the association of depressive symptoms with HRQoL in patients with heart-related disorders. Therefore, further studies need to be conducted to overcome the issues associated with the inconsistencies found in the literature.

Mediating Role of Cognitive Function in the Relationship between CVD and HRQoL

There was limited research addressing the relationship between CVD and HRQoL using cognitive function as a mediator. The mediating variable (cognitive function) is an intervening variable that may help explain the relationship between the independent variable (CVD) and the dependent variable (HRQoL). Here, cognitive mediators are considered as mental activities or processes taking place between the occurrence of a stimulus and the start of a closely linked response. These activities or processes can take place immediately after a stimulus as, for example, within seconds, or they could take place after some time as, for example, after some days or weeks.

Mediational models are used for better understanding of the cognitive processes associated with several health-related behaviors, experiences, and outcomes. Initially, research on behavioral medicine considered the influence of cognitive mediators on the perception of pain and health-related conditions of people with certain medical conditions. Now, it is also studied in research associated with health-promoting behaviors, such as enhancing physical activity, stopping smoking, improving dietary behavior, and other such activities or behaviors (Gellman & Turner, 2013). Nevertheless, cognitive functions that could work as mediators in associating HRQoL with CVD may include premorbid intellect, language, psychomotor speed, working memory, visuospatial ability, declarative verbal memory, and executive function. Pressler et al. (2010) studied these cognitive mediators in their study. In another study, Gathright et al. (2016) used attention, executive function, visuospatial ability, and memory as cognitive functions mediating the association of HRQoL with CVD. Depression could also be included in the studies conducted on cognitive mediators as some of the symptoms of depression are related to impairments in various domains of cognitive functions, such as executive functions, attention, processing speed, and memory (Perini et al., 2019).

As part of a larger exploratory study, Pressler et al. (2010) studied the HRQoL of 249 HF patients. The data was gathered via face-to-face interviewing. They examined the mediating effects of cognitive deficits on the association between the severity of HF and participants' HRQoL. They found that cognitive function did not mediate the relationship between HF and HRQoL. Psychomotor speed, executive function, and working memory were significantly negatively associated with HRQoL ($r = -0.28$, $p < 0.00$; $r = -0.14$, $p = 0.03$; $r = -0.15$, $p = 0.02$, respectively). Memory (total recall) was the sole cognitive function variable associated with HRQoL in the regression models ($r = 0.01$, $p = 0.02$). They also studied the confounders, and reported that gender, years of education, oxygen saturation, and medications that could affect cognitive functions had no association with HRQoL, though premorbid intellect was found to have some relation to HRQoL (Pressler et al., 2010).

Similarly, Gathright et al. (2016) studied the relationship between cognitive functioning and HRQoL in 302 HF adults with no history of neurologic diagnosis. They found that cognitive function did not significantly predict HRQoL in HF participants, except for executive function. Specifically, they discovered that one cognitive domain, executive function ($b = -0.17$, $p < 0.05$), was associated with HRQoL, which accounted for just 6% of HRQoL variance. Additionally, they found that more symptoms of depression and a higher New York Heart Association (NYHA) classification were associated with poorer HRQoL ($b = -0.49$, $p < 0.00$ and $b = -0.33$, $p < 0.00$, respectively). Among the other confounders, they reported that gender, highest level of education achieved, and estimated intelligence quotient (IQ) had no relation to HRQoL (Gathright et al., 2016).

Contrary to these findings by Pressler et al. (2010) and Gathright et al. (2016), Lee et al. (2014) reported the mediating effect of depression in association with HRQoL and CVD. Lee et al. (2014) conducted their study on a total of 209 patients with HF having an age range of 61 ± 11 years. The researchers used the MLHFQ instrument for the determination of HRQoL, Patient Health Questionnare-9 (PHQ-9) for the determination of depressive symptoms in the participants, and regular assessment for heart-related events. They followed the participants for a median of 357 days for the determination of heart-related event-free survival. After controlling for clinical and demographic variables, the researchers found that depressive symptoms (hazard ratio [HR] 1.08; 95% CI 1.03 – 1.13) and HRQoL (HR 1.01; 95% CI 1.00 – 1.03) were able to predict heart-related event-free survival separately. After simultaneous consideration of depressive symptoms and HRQoL in the model, only depressive symptoms separately predicted heart-related event-free survival (HR 1.07; 95% CI 1.00 – 1.14) showing a mediation effect associated with depressive symptoms. Based on these findings, the researchers concluded that depressive symptoms could become mediators in relating HRQoL with heart-related event-free survival (Lee et al., 2014).

Commensurate with the findings of the study conducted by Lee et al. (2014), Kim et al. (2019) reported that cognitive function and depressive symptoms could be associated with HRQoL in patients with HF. In this case, Kim et al. (2019) conducted their study with the objective of determining whether baseline cognitive domains of global cognition, executive function, and memory could help predict the baseline HRQoL and 15-month serious events in patients with HF. They conducted a prospective study in which 117 patients (with a mean age of 65.5 ± 9.42 years) were recruited. The participants of the study were asked to complete questionnaires related to depressive symptoms, cognitive function, HRQoL, and self-care.

Fifteen-month serious events were obtained from reviews of medical records. The researchers found that patients with serious events had statistically significantly worse memory (immediate recall memory, $p = 0.03$, and delayed recall memory, $p = 0.01$), and decreased executive function ($p = 0.03$). They also found that after controlling for confounders, including sex, age, and severity of HF, memory loss with symptoms of depression was related to impaired HRQoL. The risk of experiencing serious heart-related events also increased with a decrease in cognitive function (Kim et al., 2019).

The differences in the findings of the studies conducted by Pressler et al. (2010) and Gathright et al. (2016) from those of the findings of the studies conducted by Lee et al. (2014) and Kim et al. (2019) could be explained by the differences in the effects of impaired cognitive functions and depressive symptoms on HRQoL, as also noted by Morys et al. (2016). In the study, Morys et al. (2016) recruited 50 patients with stable, severe HF, and 50 patients with CHD without HF (control group). The researchers found that the cognitive function of the patients in the HF group was significantly impaired as compared to the cognitive function of the patients in the control group. Moreover, the HRQoL was also significantly lower in the group with HF in comparison to the group without HF. However, researchers reported that cognitive impairment had no influence on reducing HRQoL in patients with HF. The variable that significantly affected the HRQoL of the patients was the severity of the depressive symptoms. However, the findings of this study could not consider the clinical implications as one of the limitations of the study was a relatively small sample size. Moreover, the researchers conducted their study considering a small number of cognitive functions (Morys et al., 2016). Based on the above-mentioned findings, further study was required on the mediating role of cognitive function in association with HRQoL and CVD. These studies could be conducted from different dimensions, including the consideration of different forms of heart-related disorders and different forms of cognitive functions.

Confounders and cognitive function

Contrary to findings from Pressler et al. (2010) and Gathright et al. (2016), Birch et al. (2016) studied the mediating effect of cognitive function on the relationship between depression (dependent variable) and physical activity (independent variable) in 501 older adults. They found a protective effect of physical activity on depression (OR = 0.76, 95% CI 0.65 – 0.89, $p = 0.00$), a significant interaction between physical activity and cognitive function (OR = 0.991, 95% CI 0.99 – 0.99, $p = 0.01$), and a significant mediating effect of cognitive function on the relationship between physical activity and depression ($p = 0.04$) (Birch et al., 2016).

In a separate study, Vance et al. (2016) studied the association of physical activity and cognitive function, researching the mediating effect of depressive symptoms. They recruited 122 community-dwelling older adults. Among these adults, 62 participants suffered from mild cognitive impairment, whereas 60 adults were found to be neurocognitively normal controls. The participants in the study were asked to fill out the questionnaires related to physical activity, depression, and cognition. The researchers found that the duration of physical activity was significantly negatively correlated with geriatric depression ($r = -0.21$, $p < 0.05$). They also reported that depressive symptoms could be considered to have mediating effects on cognition in aging adults. They further noted that, in the aging population, physical activity had a direct effect on depressive symptomatology (standardized coefficient = -0.31) that, in turn, had a direct effect on cognition (standardized coefficient = 0.37). Specifically, the researchers noted that individuals with more physical activity showed a decreased level of depressive symptomatology, whereas individuals with a high level of depressive symptomatology showed poorer cognitive activity (Vance et al., 2016).

In another study conducted by Arrieta et al. (2018), researchers studied cognitive mediators in association with physical activity and the HRQoL of the participants. The researchers conducted a randomized controlled trial in which 114 people with a mean age of 84.9 years participated. The participants resided in nursing homes. The researchers adjusted the findings for confounding factors, such as age, level of education, gender, and strength of upper limb muscles. They found that an increase in the level of physical activity as shown by the number of steps taken in a day was negatively related to the risk of depression as noted by the Goldberg Depression Scale (EXP(B): 1.14, 95% CI 1.00 – 1.00). The researchers also found that upper limb muscle strength, in the participants who were not dependent on an assistive device for walking, was related to the Rey Auditory-Verbal Learning Test (EXP(B): 1.35, 95% CI 1.07 – 1.69). Furthermore, among those participants, the time spent on light physical activity was positively related to HRQoL test (EXP(B): 1.13, 95% CI 1.00 – 1.02), whereas the number of steps walked in a day was negatively related to risk of depression found through the Goldberg Depression Scale (EXP(B): 1.27, 95% CI 1.00 – 1.00). Based on these findings, the researchers concluded that physical activity and muscle strength are the variables that could be positively related to learning and HRQoL, and negatively related to depression in older people with mild to moderate levels of cognitive impairment. They also noted that physical performance is largely mediated by cognitive function (Arrieta et al., 2018).

These results indicate that cognitive mediators could be associated with physical activity and depression. Depression has been associated with poor HRQoL (Judd et al., 1996). Even though CVD was not addressed in the studies conducted by Birch et al. (2016), Vance et al.

(2016), and Arrieta et al. (2018), the independent variable, physical activity, has been studied that is a variable in the CVHM (Lloyd-Jones et al., 2010). To fully understand the explanatory effect of cognitive function on the relationship between CVD and HRQoL, further research was needed which would control for physical activity and depression covariates.

Chapter Summary

This literature review provides insight into what is currently known about factors associated with cognitive functioning and health-related quality of life in the CVD population. The largest gap in this body of knowledge concerns the mediating effect of cognitive function on the association between CVD and HRQoL, due to scarce and conflicting findings present in the existing literature. This leads to the research problem, which is that older adults with CVD experience changes in cognitive functioning and HRQoL.

The purposes of this study were (1) to describe the relationship between CVD and HRQoL, (2) to examine the associations between CVD and both cognitive function and HRQoL, and (3) to determine if cognitive impairment has a mediating effect on the relationship between HRQoL and CVD. The research questions were: 1) What is the relationship between CVD and HRQoL? 2) What is the relationship between cognitive function and HRQoL among CVD patients? 3) When controlling for individual characteristics (including age, gender, race/ethnicity, and education) and environmental characteristics (including marital status and income), is there a mediating effect of cognitive function associated with the relationship between CVD and HRQoL? This study used data from the BRFSS, which is the largest continuously administered health survey in the world (Moriarty et al., 2003). Results from this large dataset may help health professionals develop individual treatment options and guide future policy makers to improve HRQoL in the CVD population.

CHAPTER THREE

METHODS AND PROCEDURES

The research problem for the current study is described, along with methods and procedures used to determine if cognitive function is a mediating factor in HRQoL among older adults with CVD. The purposes of the study, research design, sample, setting, measurement methods, data collection and analysis, along with ethical considerations, are discussed.

Research Design

This cross-sectional designed study used the 2019 BRFSS data. The secondary analysis of the BRFSS was chosen because the data within it could be used to answer the study questions. The BRFSS is a database of health-related risk behaviors, chronic health conditions, and preventive services used by approximately 450,000 non-institutionalized adults with an age range of 18 years or older (CDC, n.d.). Each year since 1984, trained interviewers through random digit-dialed landlines or cellular phones have interviewed respondents. All 50 states, the District of Columbia, and U.S. territories are represented in the random calls as the U.S. civilian population. State health departments collect data through telephone surveys over landline and cellular telephones using standardized questions. The cohort size for each state varies depending on funding and the size of the regions in each state. Information collected in the survey is secure and confidential, and the privacy of the survey participants is protected as per public law (CDC, n.d.). Specifically, the National Center for Health Statistics (NCHS) reported that the Confidential Information Protection and Statistical Efficiency Act (CIPSEA, Title 5 of Public Law 107-347), Section308(d) of the Public Health Service Act (42 U.S.C.242m), and the Privacy Act of 1974 (5 U.S.C. 552a) are among the federal laws asking for the confidentiality and protection of information obtained from survey participants (CDC, n.d.).

Advantages of BRFSS

The BRFSS provides thorough information about the design, collection, and processing of data (Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System Survey Data, 2020). It was chosen due to the types of questions the respondents answered, which align with the research questions in the current study. For example, the survey questionnaire considered demographic information about the participants, current health behaviors of those respondents, and questions about a range of different health-related topics, such as healthy days/HRQoL. The large database includes de-identified data so that the public may have access to it easily. Other benefits of existing data include the size of the sample, low cost associated with a telephone survey, and the nationally representative study population. Pierannunzi et al. (2013) also reported that BRFSS could be compared to other national surveys. Therefore, it has been reliable for use in research.

Disadvantages of BRFSS

The results of the subpopulation obtained through the telephone surveys for each state could be biased due to lower telephone coverage for people in rural settings, low incomes, less than 12 years of education, and head-of-household age of less than 25 years (CDC, n.d.). Surveys based on self-reported data would be less accurate than objective measures (CDC, n.d.). In the current study, examples related to the study variables, CVD and cognitive function, do not provide measurement of vital signs, including blood pressure, or perform objective cognitive testing to assess cognitive functioning. Furthermore, non-responses that differ between subgroups, or *differential non-response*, may occur with data collected through telephonic interviewing (CDC, n.d.).

Another disadvantage may be the inability to account for variables that are not part of the BRFSS survey, such as the severity of a CVD condition (CDC, n.d.). The study of the variable severity of a CVD condition is important as studies have shown that with an increase in the severity of CVD, HRQoL could become worse. For example, patients with mild CVD may experience lower HRQoL but not significantly different from people without CVD, but patients with moderate and severe CVD, especially in the presence of a comorbid condition, may experience worse HRQoL (van de Poll-Franse et al., 2008; Vellattaz, 2019). Additionally, an increase in heart-related disorders, such as HF, could also be positively associated with cognitive issues, such as depression and anxiety (Angermann & Ertl, 2018).

To overcome disadvantages related to BRFSS, it should be emphasized that telephone non-coverage is negligible. For example, the 2018 American Community Survey (ACS) showed that approximately 98.5% of the occupied units in the U.S. had telephone service. The telephone non-coverage was in the range of 1% to 2.5% (CDC, 2020a). Also, with the use of weighted logistic regression statistics, many disadvantages of big data sets, such as BRFSS, can be overcome to yield findings with fewer biases or confounders. For example, a weight adjustment of the big data could help compensate loss of data associated with noncoverage and nonresponse. In this case, the weight adjustment is used to increase the weights of the sampled cases for which the data has been collected (Mohadjer & Choudhry, 2002). It is important to note that BRFSS collects data about U.S. residents from 50 states, the District of Columbia, and three different U.S. territories. The system completes over 400,000 adult interviews annually, making it the world's largest health survey system that operates in a continuous manner (CDC, 2020b).

Sample

The cohort was a cross-sectional sample from the BRFSS database and was composed of 264,208 non-pregnant, 50+ year old, non-institutionalized respondents with and without CVD who participated in a random digit dialing (RDD) national telephone survey in 2019. The BRFSS for the year 2020 had not yet been published when the current study was conducted. Each year, the BRFSS anticipates a cohort of approximately 450,000 respondents. In 2019, the BRFSS database captured 411,825 respondents for the current study. Power analysis was not indicated in the current study due to the large sample obtained for this secondary analysis of retrospective data.

Setting

The BRFSS is a yearly, state-based telephone survey that is funded by the Centers for Disease Control and Prevention (CDC). Non-institutionalized adults greater than or equal to 18 years are interviewed via RDD landlines or cellular phones. All 50 states, the District of Columbia, and the U.S. territories are represented as the U.S. civilian population. State health departments collected data through telephone surveys over landline and cellular telephones using standardized questions (see Appendix A). The information collected in the survey was secure and confidential, and the privacy of the survey participants was maintained (CDC, n.d.).

Measurement Methods

The BRFSS core questions captured health status, health risk, preventive behavior, and basic demographic information. Optional modules were offered for states to use, based on the needs of each state. A variety of health topics, including cognitive function, were included in the optional modules. No information in identifiable form (IIF), other than respondent phone numbers, was collected during telephone surveys (CDC, n.d.). To standardize data collection, trained telephone surveyors followed an algorithmic script to read to the respondents (see Appendix A). The survey was conducted for each of the 50 states, Washington D.C., and the U.S. territories with methodological and technical guidance from the CDC. Trained in-house interviewers through each state health department administered the BRFSS surveys using de-identified RDD on cell phones and landlines continuously throughout the year. Non-institutionalized adults aged 18 years, or more were asked to respond to the survey without monetary compensation. The data was an open data set that was provided through the CDC for analysis. It is considered public domain and is available to the public, including data files, design documents, codebooks, and methodology for each year, beginning in 1984 through the most recent results from 2019. The data and materials may be reproduced without permission (CDC, n.d.)

Research Variables

For this study, the variables that have been extracted from the 2019 BRFSS demographic data include the independent variable, CVD; covariates, such as age, sex, race/ethnicity, level of education, and income; mediating variable, cognitive function; and dependent variable, HRQoL (See appendix A). Effects of independent and the dependent variable, HRQoL, were studied to address the research questions, along with the demographic characteristics.

Demographic and other variables: Demographic variables included gender (male, female), age (50-59, 60-69, 70-79, 80+), race (white, black, Hispanic, other), education (<high school, high school, some college, postgraduate), BMI (underweight, normal, overweight, obese), health plan (yes, no), exercise (yes, no), smoking (yes, no), and drinking (yes, no).

Disability variables included memory loss, blindness, and deafness. Dietary variables included green, potato, veggie, and fries. Difficulty in physical functions variables included dressing, walking, and doing errands alone.

Independent variable: The CVD—which includes heart and vascular conditions, including hypertension, CHD or CAD, HF, and stroke—was reflected in the BRFSS self-report data: hypertension awareness ("Have you ever been told by a doctor, nurse, or other health professional that you have high blood pressure?") and chronic health conditions ("Has a doctor, nurse, or other health professional ever told you that you had any of the following? (Ever told) you that you had a heart attack also called a myocardial infarction, angina or coronary heart disease, stroke?") (See Table 1).

Dependent variable: The HRQoL was measured with the following self-report health status indicators: general health ("Would you say that in general your health is- Excellent, Very Good, Good, Fair, Poor?"), physical health ("Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?"), mental health ("Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?"), and physical/mental activity ("During the past 30 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self - care, work, or recreation?"). Fourteen or more unhealthy days are considered to decrease HRQoL (Chen et al., 2011) (See Table 1).

Mediating variable: Cognitive function was measured in the BRFSS data with the following indicator: cognitive decline ("During the past 12 months, have you experienced confusion or memory loss that is happening more often or is getting worse?"), ("During the past 12 months, as a result of confusion or memory loss, how often have you given up day -to -day household activities or chores you used to do, such as cooking, cleaning, taking medications, driving, or paying bills? Would you say it is…always, usually, sometimes, rarely, never?”), (“As a result of confusion or memory loss, how often do you need assistance with these day -to - day activities? Would you say it is… always, usually, sometimes, rarely, never?”), (“During the past 12 months, how often has confusion or memory loss interfered with your ability to work, volunteer, or engage in social activities outside the home? Would you say it is… always, usually, sometimes, rarely, never?”), (“Have you or anyone else discussed your confusion or memory loss with a health care professional?”) (See Table 1).

Table 1. Study Variables

Study Variable and Health Status Indicator	Operational Definition	Conceptual Definition	Level of Measurement
Independent Variable: CVD		Group of disorders of the heart and blood vessels	
1. Hypertension Awareness	high blood pressure: yes, no	“self-report of any prior diagnosis of hypertension by a health care professional among the population defined as having hypertension”	Nominal
2. Chronic Health Conditions	heart attack also called a myocardial infarction, angina or coronary heart disease, stroke: yes, no	“Conditions that last 1 year or more and require ongoing medical attention or limit activities of daily living or both”	Nominal
Dependent Variable: HRQoL		“An individual’s or group’s perceived	

			physical and mental health over time"	
1.	General Health	general health: Excellent, Very Good, Good, Fair, Poor	A global measure of overall health	Ordinal
2.	Physical Health	physical health not good: number of days in past 30 days (0-30)	Overall physical condition of a living organism at a given time	Ratio
3.	Mental Health	mental health not good: number of days in past 30 days (0-30)	"a state of well-being in which an individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to his or her community"	Ratio
4.	Physical/Mental Activity	unable to perform usual activities due to poor physical or mental health: number of days in past 30 days (0-30)	"a global indicator of perceived disability as well as an indicator of productivity and human capital"	Ratio
Mediating Variable: Cognitive Function			Processes in the brain that includes the ability to learn, remember, and make judgments	
	Cognitive Decline	Confusion or memory loss that is happening more often or is getting worse (past 12 months): yes, no	"Confusion or memory loss that is happening more often or is getting worse during the past 12 months."	Nominal

	Confusion or memory loss over past 12 months that caused decline in daily activities: always, usually, sometimes, rarely, never	Ordinal
	Confusion or memory loss that caused assistance needed with daily activities: always, usually, sometimes, rarely, never	Ordinal
	Confusion or memory loss over past 12 months interfered with work/social activities outside of home: always, usually, sometimes, rarely, never	Ordinal
	Confusion or memory loss discussed with health care professional: yes, no	Nominal

*Fourteen or more unhealthy days are considered to decrease HRQoL (Chen et al., 2011).

2019 BRFSS source: Centers for Disease Control and Prevention (CDC).

https://www.cdc.gov/BRFSS/Questionnaires/index.htm

Validity of BRFSS Measurement Method

Hsia et al. (2020) found BRFSS to be a valid tool for a wide range of health-related variables. Two national benchmark surveys, National Health and Nutrition Examination Survey (NHANES), and National Health Interview Survey (NHIS), were compared to the 2011-2016 BRFSS in 10 widely used health-related variables. The prevalence or means of most variables from BRFSS had similar trends to those from NHANES and NHIS. The average of absolute differences between BRFSS and NHIS across years were small for 8 of 10 variables, including for 'ever told have diabetes (1.06%) and hypertension' (1.77%) (Hsia et al., 2020). For this study, it was considered a valid tool as questions in the database fulfilled the purpose of this study.

Reliability of BRFSS Measurement Method

Andresen et al. (2003) found moderate to excellent reliability across measures of quality-of-life. There was a small amount of variation in categorical variables compared to continuous variables among measures of older adults. The measures of reliability of overall health are high ($k = 0.75$), along with measures of poor physical health days ($k = 0.57$), healthy days ($k = 0.75$), frequent physical distress ($k = 0.64$), and frequent mental distress ($k = 0.58$) (Andresen et al., 2003). Reliability was measured using 95% confidence intervals (CI). By estimating reliability using CI, the internal consistency of the respondents' values is evaluated on questionnaires (Chien et al., 2010).

Procedure

The BRFSS data is an open data set that is provided by the CDC for analysis. The researcher determines the variables to extract from the data set for examination to answer the research questions. The data is considered to be in the public domain, so permission or record of use is not required. The following steps were completed for data extraction:

1. Data management and analysis was conducted with SAS. The raw data was in the SAS XPT transport format as given on the CVD website: https://www.cdc.gov/brfss/annual_data/annual_2019.html.
2. The file combined both landline and cell phone data.
3. The XPT file was imported into the SAS library and converted to SAS data.

For this study, the variables, including demographics, condition, disability, diet, and difficulty with physical functions, were extracted from the 2019 BRFSS. The demographic data included gender, race, education, BMI, health plan, exercise, smoking, and drinking. The condition data included CVD, stroke, hypertension, diabetes, COPD, high cholesterol, and arthritis. The disability data included memory loss, blindness, and deafness. The dietary data included green leafy salads, potatoes, vegetables, and fried food. The difficulty with physical function data included dressing, walking, and doing errands alone.

Ethical Considerations

The BRFSS data was collected under the technical and methodological guidance of the CDC for each state that included research protocols for the collection, extraction, and maintenance of data. The CDC has determined that the BRFSS information collected is exempt from the requirements of 45 CFR 46. Therefore, IRB approval was not required. The 45 CFR 46 is a regulation set by the U.S. Department of Health and Human Services (DHHS) to protect human participants from risks in federal agency research studies. The CDC states that the Privacy Act of 1974 does not apply to BRFSS data because there was no collected information in identifiable form (IIF). There were no unique participant identifiers, such as names or social security numbers in the database. Samples were collected using list-assisted random digit dialing (RDD) on landline and cellular telephones. Even though it was considered that IRB approval was not required, this researcher submitted, all information to The University of Texas at Arlington Institutional Review Board (IRB) who approved the study as exempt from IRB review (see Appendix B).

Data Analyses

The following steps were completed for analysis:

1. The data was cleaned by removing categories "Don't know/Not Sure", "Refused" and blank categories from the variables of interest.
2. Variables were recoded into nominal and ordinal variables.

A normality test was not completed because there were no continuous variables. The BRFSS used a weighting methodology called raking or iterative proportional fitting. This process allows for statistical weighting of age, race and ethnicity, sex, geographic region, education level, marital status, and telephone ownership to reduce the potential for bias and improve the representativeness of estimates (CDC, n.d.).

The 411,825 respondents were identified from the 2019 BRFSS survey data set with or without CVD, of which 264,208 completed the sample after implementing exclusion criteria. Characteristics of the population sample were summarized using descriptive statistics, including frequencies and percentages, stratified by CVD (Yes and No). The associations between the outcome and independent variables were assessed using both the chi-square test and weighted logistic regression. The mediating effect, cognitive function, was assessed by fitting three weighted logistic regression models. The mediating effects were calculated using the method by Pham et al. (2019) by taking the product of the effect of memory loss and the effect of CVD. In this regard, the Sobel test was used, and the results of more than 1.96 z-score show the presence of mediating effect. Furthermore, bootstrap confidence intervals were used to show the significance of the indirect effect.

Table 2. Data Analysis of Study Variables

Study Variable	Level of Measurement	Data Analysis
Age	Ordinal	Chi Square
Gender	Nominal	Chi Square
Race/ethnicity	Nominal	Chi Square
Education	Ordinal	Chi Square
BMI	Ordinal	Chi Square
Smoking status	Nominal	Chi Square
Physical activity	Nominal	Chi Square
Diet	Nominal	Chi Square
Glucose	Nominal	Chi Square
Blood pressure	Nominal	Chi Square
Cholesterol	Nominal	Chi Square
Marital status	Nominal	Chi Square
Income	Ordinal	Chi Square
Major Study Variable		Survey Logistic
CVD	Nominal	Regression and
Cognitive Function	Nominal	Chi Square Test
HRQoL	Nominal	

Delimitations

To ensure that the research questions were answered, limitations were imposed on the study. First, a single-year sample and a retrospective quantitative design was chosen by the researcher to limit the complexity of the concepts. A second limitation to this study was related to the geographical location of respondents who may reside in any U.S. state or territory. Though the data was retrieved from interviewers for each state's residents, the researcher for the secondary analysis examined data that was combined nationally, representing the U.S. population. A third limitation of the current study was that the researcher collected only the data responses that were applicable to the research questions and theoretical framework.

Chapter Summary

This section presented the methodology and procedures for the study. It included in detail the research design, sample, setting, measurement methods, procedure, ethical considerations, data analysis, and delimitations using the 2019 BRFSS dataset. The survey logistic regression method was chosen to extract the data for analysis. A complete explanation of the research questions and the statistical analysis was given.

CHAPTER FOUR

FINDINGS

The purpose of this study was to determine the mediating effects of cognitive function on the relationship between CVD and HRQoL in older adults. This chapter describes the results of data analysis from the 2019 BRFSS data. Descriptive statistics, including the frequency and percentage, were calculated for each study variable stratified by CVD (Yes or No). The results obtained from the survey logistic regression included adjusted odds ratio and 95% confidence interval (CI) to compare the likelihood of three outcomes (general health, mental health, physical health) between respondents with and without CVD, after the adjustment of covariates. All three outcomes were binary (good vs poor). The reference category was chosen as ‘good’. In other words, if the odds ratio for a CVD is greater than 1, then this indicates that respondents with CVD had higher odds of poor health than respondents without CVD. Each of the study questions was addressed based on the survey logistic regression results.

Results

Descriptive Statistics

Sociodemographic Characteristics: The cohort included participants from the 2019 BRFSS data in the U.S. and the District of Columbia, of which 36735 were respondents having CVD and 264,208 were non-pregnant respondents having the age of ≥ 50 years. As reported in Table 3, of those respondents with CVD, 56.5% were male, 85.7% were aged ≥ 60, 80.4% were non-Hispanic White, 11.5% had < high school education, and 95% had a health plan. These percentages were higher than those for respondents without CVD (male: 44.5%; age ≥ 60: 71.7%; non-Hispanic White: 75.6%; < high school education: 6.7%; health plan: 91.1%).

Health-Related Measures: Respondents with CVD had a higher prevalence of cardiovascular risk factors than respondents without CVD (obesity: 39.1% vs 31.5%; no exercise: 38.9% vs 25.9%; current smoking: 17% vs 13.8%; hypertension: 75.3% vs 38.7%; diabetes: 33.8% vs 11.9%; high cholesterol: 65.3% vs 34.1%; inadequate fruit and vegetable consumption: 96.2% vs 96.8%), as shown in Table 3.

A relatively smaller percentage of respondents without CVD (9.7%) than those with CVD (20%) reported memory loss. Furthermore, the prevalence of comorbidities was higher in the group participants with CVD (stroke: 18% vs 3.11%; hypertension: 75.3% vs 38.7%; diabetes: 33.8% vs 11.9%; COPD: 25.8% vs 6.8%; high cholesterol: 65.3% vs 34.1%; arthritis: 58% vs 31.2%). Respondents with CVD showed more difficulty with physical functions than respondents without CVD (dressing: 3.8% vs 12.1%; walking: 15% vs 43.5%; doing errands alone: 6.8% vs 18.6%), as reported in Table 3.

Association of CVD with HRQoL: This section relates to the statistical evidence addressing the first Research Question: What is the relationship between CVD and HRQoL? Utilizing the 2019 BRFSS data and logistic regression for survey data, Table 4 presents the adjusted odds ratios and 95% CIs for HRQoL assessed through the subjective assessment of three components, including general, mental, and physical health. The data related to CVD showed the values of 2.11 (1.89, 2.36) for general health, 1.25 (1.06, 1.48) for mental health, and 1.48 (1.29, 1.69) for physical health ($p<0.05$). This means that respondents with CVD had, respectively, 2.11-, 1.25- and 1.48-times greater odds of poor general health, mental health, and physical health than respondents without CVD.

Association of cognitive function with HRQoL among patients with CVD: This section relates to the statistical evidence addressing the second Research Question: What is the relationship between cognitive function and HRQoL among CVD patients? Utilizing the 2019 BRFSS data and logistic regression for survey data, Table 5 presents the adjusted odds ratios and 95% CIs for cognitive function that was evaluated through the assessment of memory loss. The data related to memory loss showed the values of 1.60 (1.31, 1.95) for general health, 3.07 (2.39, 3.93) for mental health, and 1.42 (1.13, 1.80) for physical health ($p<0.05$). This means that respondents with CVD and memory loss had, respectively, 1.60, 3.07, and 1.42 times greater odds of poor general health, mental health, and physical health than respondents without CVD and memory loss.

Mediation test for cognitive function in HRQoL and CVD: This section relates to the statistical evidence addressing the third Research Question: When controlling for individual characteristics (including age, gender, race/ethnicity, and education) and environmental characteristics (including marital status and income), is there a mediating effect of cognitive function associated with the relationship between CVD and HRQoL? Previously, Table 4 shows the negative association of CVD with HRQoL after the adjustment covariates, including memory loss as an indicator of cognitive function. To assess the mediating effect, additional survey logistic regression analysis was conducted by excluding memory loss (Table 6) from the analysis for Table 4. The resulting adjusted odds ratios and 95% CIs for CVD were 2.15 (1.93, 2.41) for general health, 1.29 (1.10, 1.51) for mental health, and 1.43 (1.32, 1.56) for physical health. The mediating effects determined by taking the product of the effect of memory loss in Table 4 and the effect of CVD in Table 6 shows the values of 1.51 (1.35, 1.69) for general health, 1.19 (1.05, 1.36) for mental health and 1.15 (1.05, 1.26) for physical health. In bootstrapping, both the lower and upper values of CIs must be above or below 0. In the present case, the values of CIs for all values of health (including general health, mental health, and physical health) are above 0, so cognitive function can be said to have a partial mediating effect on the relationship between CVD and HRQoL.

In addition, unadjusted analysis was conducted to examine the mediation effects without adjusting for covariates (Table 7). For example, the unadjusted ORs for CVD were 5.20 (4.96, 5.44) for general health, 1.61 (1.52, 1.71) for mental health, and 4.25 (4.05, 4.47) for physical health, that were considerably greater than the aORs for CVD as shown in Table 4. Similarly, the ORs for memory loss adjusting for CVD only were 4.17 (3.85, 4.52) for general health, 5.59 (5.11, 6.12) for mental health, and 3.82 (3.52, 4.15) for physical health, considerably greater than the aORs for memory loss as shown in Table 6. Accordingly, the resulting unadjusted mediating effects of memory loss were calculated as 10.59 (11.78, 9.52) for general health, 2.28 (2.61, 1.99) for mental health, and 6.98 (7.83, 6.22) for physical health. The values of CIs for all values of health are above 0 showing the mediating effect on the relationship between CVD and HRQoL.

Table 3. Demographic characteristics and health-related measures of adults aged ≥ 50 reporting cardiovascular disease (CVD)=yes or CVD=no, Behavioral Risk Factor Surveillance System, 2019

	CVD=Yes		**CVD=No**	
	N	**%**	**N**	**%**
Characteristic				
Gender				
M	20740	56.46	166983	44.52
F	15995	43.54	208107	55.48
Age				
50-59	4827	14.29	65264	28.32
60-69	9692	28.69	79101	34.33
70-79	11692	34.61	58591	25.43

80+	7571	22.41	27470	11.92
Race				
White	28804	80.36	277842	75.63
Black	2522	7.04	28302	7.70
Hispanic	2098	5.85	34520	9.40
Other	2421	6.75	26698	7.27
Education				
<High school	4205	11.49	24945	6.68
High school	11405	31.17	98464	26.36
Some college	10501	28.70	104476	27.97
Postgraduate	10473	28.63	145655	38.99
Health-related measures, including CVD, HRQoL, Cognitive Function				
BMI				
Underweight	608	1.76	5863	1.71
Normal	7978	23.11	106894	31.09
Overweight	12443	36.04	122691	35.68
Obese	13493	39.09	108380	31.52
Health Plan				
Yes	34876	95.29	340006	91.09
No	1724	4.71	33260	8.91
Exercise				
Yes	21457	61.10	263241	74.13
No	13661	38.90	91876	25.87
Smoking				
Current	6004	16.99	49522	13.83
Former	15048	42.59	95094	26.57
Never	14279	40.41	213332	59.60
Drinking				
Yes	26368	71.87	242916	64.87
No	10318	28.13	131537	35.13
Comorbidities				
CVD				
Stroke	6569	18.01	11630	3.11
Hypertension	27506	75.28	143461	38.67
Diabetes	12355	33.84	43991	11.86
COPD	9287	25.75	25225	6.75
High cholesterol	23264	65.26	118660	34.10
Arthritis	21139	57.97	116343	31.18

Disability				
Memory Loss	2731	19.99	9335	9.71
Blind	4443	12.44	17319	4.77
Deaf	7767	21.73	29283	8.06
Dietary				
Green	30003	89.28	312573	91.90
Potato	28897	86.74	284182	84.28
Veggie	31902	96.18	325512	96.82
Fries	26170	77.74	278805	81.98
Difficulty in Physical functions				
Dressing	4325	12.15	13686	3.79
Walking	15462	43.48	54346	15.04
Doing errands alone	6610	18.64	24562	6.82

Table 4. Adjusted odds ratios for the outcomes of general health, mental health, and physical health among respondents aged ≥ 50 reporting cardiovascular disease, Behavioral Risk Factor Surveillance System, 2019

	Adjusted Odds Ratio (95% CI)		
Characteristic	**Model 1 General Health**	**Model 2 Mental Health**	**Model 3 Physical Health**
Gender			
F	1.00	1.00	1.00
M	1.17 (1.08, 1.28)	.62 (.55, .70)	1.02 (.92, 1.12)
Age			
50-59	1.00	1.00	1.00
60-69	.88 (.79, .98)	.68 (.60, .78)	.89 (.80, 1.00)
70-79	.77 (.68, .87)	.38 (.32, .46)	.75 (.66, .86)
80+	.66 (.57, .77)	.23 (.18, .29)	.55 (.47, .64)
Race			
White	1.00	1.00	1.00
Black	1.18 (1.04, 1.35)	.91 (.77, 1.07)	.82 (.70, .95)
Hispanic	2.29 (1.86, 2.83)	1.16 (.81, 1.64)	1.17 (.89, 1.53)
Other	1.44 (1.16, 2.83)	1.12 (.80, 1.56)	1.30 (1.00, 1.70)

Education			
Postgrad.	1.00	1.00	1.00
<HS	2.60 (2.20, 3.06)	1.21 (.97, 1.52)	1.16 (.96, 1.40)
HS	1.61 (1.46, 1.79)	1.24 (1.06, 1.46)	1.21 (1.08, 1.35)
Some college	1.32 (1.19, 1.46)	1.26 (1.10, 1.45)	1.11 (1.00, 1.24)
BMI			
Normal	1.00	1.00	1.00
Obese	.99 (.89, 1.11)	.89 (.76, 1.03)	.89 (.79, 1.01)
Overweight	.86 (.77, .96)	.92 (.78, 1.08)	.92 (.81, 1.04)
Underweight	1.50 (1.11, 2.03)	1.39 (.96, 2.01)	1.29 (.94, 1.76)
Smoker			
Never	1.00	1.00	1.00
Current	1.31 (1.16, 1.48)	1.60 (1.37, 1.88)	1.19 (1.04, 1.36)
Former	1.11 (1.01, 1.22)	1.29 (1.12, 1.50)	1.25 (1.12, 1.39)
Drink			
Yes	1.32 (1.20, 1.45)	1.15 (1.02, 1.29)	1.23 (1.11, 1.37)
Health Plan			
No	1.50 (1.23, 1.83)	1.34 (1.07, 1.68)	1.09 (.88, 1.35)
Exercise			
No	1.74 (1.58, 1.91)	1.37 (1.21, 1.55)	1.55 (1.41, 1.72)
Diabetes			
Yes	1.99 (1.80, 2.20)	1.13 (.98, 1.29)	1.29 (1.16, 1.45)
Hypertension			
Yes	1.48 (1.34, 1.63)	1.14 (1.00, 1.31)	1.11 (1.00, 1.24)
Stroke			
Yes	1.33 (1.34, 1.56)	1.02 (.86, 1.22)	1.15 (.98, 1.35)
Cholesterol			
Yes	1.18 (1.08, 1.29)	1.23 (1.10, 1.39)	1.13 (1.03, 1.25)
COPD			
Yes	2.23 (2.00, 2.49)	1.35 (1.18, 1.54)	1.76 (1.56, 1.98)
Arthritis			
Yes	1.43 (1.31, 1.56)	1.23 (1.10, 1.39)	1.67 (1.51, 1.84)
CVD			
Yes	2.11 (1.89, 2.36)	1.25 (1.06, 1.48)	1.48 (1.29, 1.69)
Memory Loss			
Yes	1.73 (1.54, 1.94)	3.00 (2.65, 3.40)	1.46 (1.28, 1.65)
Blind			
Yes	1.64 (1.40, 1.92)	1.53 (1.26, 1.86)	1.39 (1.14, 1.70)
Deaf			
Yes	1.05 (.93, 1.18)	1.30 (1.11, 1.53)	1.03 (.90, 1.17)

Diff. Dressing			
Yes	1.56 (1.27, 1.92)	1.37 (1.09, 1.71)	2.08 (1.75, 2.46)
Diff. Walking			
Yes	3.11 (2.81, 3.45)	1.68 (1.44, 1.95)	3.66 (3.25, 4.12)
Diff. Errands			
Yes	2.36 (2.02, 2.74)	1.98 (1.66, 2.36)	2.31 (1.98, 2.70)
Green Foods			
No	1.42 (1.24, 1.63)	1.34 (1.12, 1.61)	1.36 (1.16, 1.59)
Fried Foods			
No	1.11 (.99, 1.24)	1.13 (.95, 1.33)	1.13 (1.01, 1.28)
Vegetables			
No	1.04 (.77, 1.40)	1.30 (.83, 2.02)	1.06 (.77, 1.47)
Potato			
No	1.04 (.85, 1.11)	1.00 (.83, 1.21)	.85 (.74, .99)

Table 5. Adjusted odds ratio for the outcomes of general health, mental health, and physical health among respondents with CVD, including memory loss

	Adjusted Odds Ratio (95% CI)		
Characteristic	**General Health**	**Mental Health**	**Physical Health**
Gender			
F	1.00	1.00	1.00
M	1.18 (0.99, 1.41)	.73 (.58, .92)	1.07 (.88, 1.31)
Age			
50-59	1.00	1.00	1.00
60-69	.82 (.63, 1.06)	.65 (.47, .89)	1.02 (.77, 1.35)
70-79	.63 (.49, .83)	.29 (.21, .39)	.65 (.50, .84)
80+	.55 (.41, .74)	1.02 (.12, .25)	.51 (.37, .70)
Race			
White	1.00	1.00	1.00
Black	1.13 (.86, 1.48)	1.02 (.70, 1.47)	.83 (.61, 1.14)
Hispanic	2.81 (1.61, 4.89)	1.24 (.50, 3.10)	.84 (.40, 1.73)
Other	1.59 (1.02, 2.46)	.95 (.59, 1.53)	1.22 (.86, 1.74)
Education			
Postgrad.	1.00	1.00	1.00
<HS	2.07 (1.56, 2.74)	1.27 (.82, 1.99)	1.23 (.88, 1.71)
HS	1.6 (1.3, 2.0)	1.26 (.93, 1.71)	1.04 (.82, 1.32)

Some college	1.37 (1.12, 1.69)	1.39 (1.04, 1.85)	1.08 (.87, 1.33)
BMI			
Normal	1.00	1.00	1.00
Obese	.93 (.75, 1.15)	.98 (.75, 1.28)	.90 (.71, 1.14)
Overweight	.93 (.76, 1.15)	1.12 (.82, 1.54)	1.09 (.84, 1.40)
Underweight	.90 (.50, 1.65)	1.87 (1.04, 3.34)	.91 (.54, 1.53)
Smoker			
Never	1.00	1.00	1.00
Current	1.27 (.99, 1.64)	1.23 (.89, 1.68)	1.08 (.81, 1.43)
Former	1.32 (1.10, 1.59)	1.23 (.93, 1.64)	1.41 (1.15, 1.73)
Drink			
Yes	1.31 (1.09, 1.57)	1.14 (.87, 1.49)	1.47 (1.21, 1.78)
Health Plan			
No	1.19 (.74, 1.93)	1.03 (.60, 1.78)	1.09 (.67, 1.78)
Exercise			
No	1.49 (1.22, 1.71)	1.56 (1.22, 1.99)	1.51 (1.24, 1.83)
Diabetes			
Yes	1.64 (1.37, 1.96)	.94 (.71, 1.24)	1.22 (.99, 1.51)
Hypertension			
Yes	1.12 (.92, 1.37)	1.06 (.74, 1.52)	.89 (.69, 1.15)
Stroke			
Yes	1.27 (1.02, 1.59)	1.21 (.92, 1.59)	1.24 (.98, 1.57)
Cholesterol			
Yes	1.12 (.94, 1.33)	1.02 (.78, 1.34)	.95 (.78, 1.16)
COPD			
Yes	1.86 (1.53, 2.25)	1.23 (.97, 1.55)	1.81 (1.47, 1.22)
Arthritis			
Yes	1.09 (.92, 1.30)	1.02 (.79, 1.30)	1.27 (1.04, 1.56)
Memory Loss			
Yes	1.60 (1.31, 1.95)	3.07 (2.39, 3.93)	1.42 (1.13, 1.80)
Blind			
Yes	1.41(1.06, 1.88)	1.67 (1.11, 2.51)	.96 (.67, 1.39)
Deaf			
Yes	1.01 (.82, 1.24)	1.22 (.92, 1.61)	.98 (.80, 1.22)
Diff. Dressing			
Yes	1.39 (1.03, 1.87)	1.04 (.77, 1.40)	1.69 (1.25, 2.29)
Diff. Walking			
Yes	2.63 (2.17, 3.19)	1.37 (1.04, 1.81)	2.94 (2.41, 3.59)
Diff. Errands			
Yes	2.39 (1.83, 3.11)	2.46 (1.87, 3.23)	2.05 (1.61, 2.62)

Green Foods			
No	1.27 (.95, 1.69)	1.02 (.75, 1.40)	1.24 (.91, 1.68)
Fried Foods			
No	1.11 (.91, 1.37)	1.07 (.78, 1.47)	1.30 (1.03, 1.65)
Vegetables			
No	.96 (.58, 1.59)	.76 (.39, 1.47)	.50 (.26, .97)
Potato			
No	1.04 (.79, 1.37)	.97 (.59, 1.62)	.99 (.62, 1.44)

Table 6. Adjusted odds ratio for the outcomes of general health, mental health, and physical health among adults aged ≥ 50, excluding memory loss

	Adjusted Odds Ratio (95% CI)		
Characteristic	**General Health**	**Mental Health**	**Physical Health**
CVD			
Yes	2.15 (1.93, 2.41)	1.29 (1.10, 1.51)	1.43 (1.32, 1.56)
Gender			
F	1.00	1.00	1.00
M	1.16 (1.06, 1.27)	.63 (.56, .71)	1.04 (.98, 1.11)
Age			
50-59	1.00	1.00	1.00
60-69	.85 (.76, .95)	.66 (.58, .74)	.86 (.80, .93)
70-79	.75 (.66, .85)	.37 (.31, .44)	.72 (.66, .78)
80+	.64 (.55, .75)	.22 (.17, .27)	.53 (.47, .7059)
Race			
White	1.00	1.00	1.00
Black	1.15 (1.01, 1.31)	.90 (.76, 1.06)	.80 (.72, .89)
Hispanic	2.33 (1.88, 2.88)	1.16 (.83, 1.61)	1.17 (1.03, 1.32)
Other	1.44 (1.15, 1.79)	1.11 (.81, 1.53)	.88 (.74, 1.05)
Education			
Postgrad.	1.00	1.00	1.00
<HS	2.62 (2.21, 3.09)	1.22 (.98, 1.52)	1.21 (1.07, 1.36)
HS	1.59 (1.44, 1.76)	1.23 (1.05, 1.44)	1.15 (1.07, 1.24)
Some college	1.32 (1.19, 1.46)	1.25 (1.09, 1.43)	1.19 (1.11, 1.28)
BMI			
Normal	1.00	1.00	1.00

Obese	.98 (.88, 1.10)	.86 (.74, .99)	.87 (.80, .94)
Overweight	.86 (.77, .96)	.89 (.76, 1.04)	.91 (.84, .99)
Underweight	1.39 (1.03, 1.87)	1.38 (.94, 2.04)	1.39 (1.11, 1.73)
Smoker			
Never	1.00	1.00	1.00
Current	1.33 (1.17, 1.50)	1.68 (1.44, 1.95)	1.25 (1.14, 1.36)
Former	1.12 (1.02, 1.24)	1.31 (1.14, 1.51)	1.23 (1.15, 1.31)
Drink			
Yes	1.31 (1.19, 1.44)	1.15 (1.03, 1.29)	1.24 (1.16, 1.33)
Health Plan			
No	1.48 (1.21, 1.80)	1.36 (1.09, 1.68)	.98 (.85, 1.14)
Exercise			
No	1.75 (1.60, 1.93)	1.36 (1.21, 1.54)	1.55 (1.45, 1.65)
Diabetes			
Yes	2.00 (1.80, 2.21)	1.15 (1.01, 1.31)	1.25 (1.16, 1.34)
Hypertension			
Yes	1.47 (1.33, 1.63)	1.15 (1.00, 1.31)	1.16 (1.08, 1.24)
Stroke			
Yes	1.39 (1.19, 1.63)	1.10 (.94, 1.30)	1.24 (1.11, 1.39)
Cholesterol			
Yes	1.19 (1.09, 1.30)	1.27 (1.13, 1.42)	1.10 (1.04, 1.17)
COPD			
Yes	2.26 (2.02, 2.52)	1.39 (1.22, 1.58)	1.75 (1.61, 1.89)
Arthritis			
Yes	1.47 (1.35, 1.61)	1.30 (1.16, 1.46)	1.70 (1.60, 1.82)
Blind			
Yes	1.72(1.47, 2.01)	1.67 (1.39, 2.00)	1.35 (1.19, 1.54)
Deaf			
Yes	1.09 (.97, 1.23)	1.47 (1.26, 1.71)	1.06 (.97, 1.15)
Diff. Dressing			
Yes	1.67 (1.35, 2.08)	1.52 (1.23, 1.88)	2.18 (1.94, 2.45)
Diff. Walking			
Yes	3.20 (2.88, 3.55)	1.81 (1.57, 2.10)	3.76 (3.50, 4.05)
Diff. Errands			
Yes	2.51 (1.15, 2.92)	2.29 (1.93, 2.71)	2.36 (2.13, 2.61)
Green Foods			
No	1.11 (.99, 1.24)	1.33 (1.11, 1.58)	1.26 (1.13, 1.40)
Fried Foods			
No	1.11 (.99, 1.24)	1.12 (.95, 1.32)	1.15 (1.07, 1.24)
Vegetables			

No	1.04 (.77, 1.41)	1.28 (.84, 1.94)	1.16 (.96, 1.39)
Potato			
No	.98 (.86, 1.12)	1.00 (.83, 1.19)	.93 (.85, 1.03)

Table 7. Unadjusted odds ratios for the outcomes of general health, mental health, and physical health among respondents with CVD only and respondents with memory loss only, adjusting for CVD

	Unadjusted Odds Ratio (95% CI)		
Characteristic	**General Health**	**Mental Health**	**Physical Health**
CVD			
Yes	5.20 (4.96, 5.44)	1.61 (1.52, 1.71)	4.25 (4.05, 4.47),
Memory Loss			
Yes	4.17 (3.85, 4.52)	5.59 (5.11, 6.12)	3.82 (3.52, 4.15)
(Adjusting for CVD only: Yes)	(3.71 [3.44, 4.0])	(1.60 [1.43, 1.79])	(2.79 [2.56, 3.03])

Chapter Summary

The findings from this cross-sectional observational study provided evidence to support the relationship between CVD, cognitive function, and HRQoL from results of data analysis obtained from the 2019 BRFSS data. Differences were found in descriptive statistics for gender, race/ethnicity, and education, along with higher prevalence of CVD risk factors among respondents with CVD compared to respondents without CVD. Survey logistic regression results were analyzed to address each study question. An association was found between CVD and HRQoL. Also, a relationship was found between cognitive function and HRQoL among respondents with CVD. Specifically, respondents with CVD had greater odds of poor general health, mental health, and physical health than respondents without CVD. A mediating effect was found with cognitive function on HRQoL among respondents with CVD after performing additional survey logistic regression analysis. Additionally, unadjusted analysis was performed to examine the mediation effects of cognitive function without adjustment of covariates. The unadjusted effects were greater than the adjusted mediating effects, which indicates that unadjusted mediating effects were attenuated by the covariates.

CHAPTER FIVE

DISCUSSION

This chapter includes a discussion of the cross-sectional observational study findings regarding the effect of cognitive function as a mediator on the relationship between CVD and HRQoL in older adults. As noted earlier, a mediator is a variable linking independent variables with dependent variables. The existence of a mediator explains the association of one variable with the other variable (Allen, 2017). Interpretations of findings, study limitations, implications for nursing practice, and recommendations for additional nursing research are discussed.

Interpretation of Findings

This study showed that older adults with CVD have a relatively higher risk of having memory loss and problematic HRQoL. Considering the association of CVD with cognitive function, the association of HF with cognitive performance was also noted by Elias et al. (2003) and the association of blood pressure with cognitive performance was noted by Kilander et al. (1998) and Starr et al. (1993). Considering CVD and factors associated with HRQoL, Ko et al. (2015) reported that the percentage of people with the risk of CVD reporting depression increased in patients up to 53 years of age, but then the percentage of people with the risk of CVD reporting depression declined. The findings of the present study are supported by the findings of the study conducted by Ko et al. (2015) in that after a certain age, people may start reporting HRQoL at a better level.

The present study showed differences in HRQoL among demographic groups. Previously, Lam et al. (2015) and Vaccarino et al. (1999) found that sex differences could be found in the case of CVD-related issues. In the present study, it was found that men had 1.17 times greater odds of reporting poor general health than women, and 38% lower odds of reporting poor mental health than women, which are similar to findings from Saquib et al. (2019). For race and ethnicity, the Black, Hispanic and other race groups were, respectively, 1.18, 2.29 and 1.44 times more likely to report poor general health, than the White group. These results are similar to findings from several studies (Burns et al., 2019; Hayes et al., 2011; Levine et al., 2011; Odlum et al., 2020, and Thomas et al., 2011). The Hispanic and other race/ethnicity groups were also more likely to report poorer mental health than the White group. González et al. (2016) further reported that the reduction in CVHM could be associated with neurocognitive benefits among Hispanics/Latinos. For BMI, subjects who were underweight were more likely to report poor general health, and mental health. Findings from Park (2017) were similar to these results, especially in the case of men.

Association of CVD with HRQoL

The HRQoL was evaluated through the assessment of three variables, including general, mental, and physical health. It has been found that after controlling all other covariates, patients with CVD had 2.11 times increased risks of poorer general health as compared to individuals without CVD with the true population affect, or the true population mean, which falls within the range of the 95% confidence interval, ranging from 1.89 to 2.36 times. Moreover, patients with CVD had a 25% increased risk of having poor mental health as compared to individuals without CVD, with the true population affect ranging from 6% to 48%. Patients with CVD had a 48% increased chance of having poor physical health as compared to individuals without CVD, with the true population affect ranging from 29% to 69%. These findings show that CVD is negatively related to HRQoL. This result is supported by findings of the study by Ko et al. (2015). They reported that high-risk CVD individuals, represented by 10-year CVD risk ≥20.0%, had significantly higher odds of problems with mobility. High-risk CVD females were also found to have significantly higher odds of experiencing activity problems. They concluded that an increased risk of CVD could be considered as a significant independent predictor of impairment in HRQoL (Ko et al., 2015). Garster et al. (2009), Li et al. (2008), Opara and Jaracz (2010), Pool et al. (2019), and Vellettaz (2018) also reported that HRQoL was negatively affected in the patients with CVD. However, Konstam et al. (1996) also noted that HRQoL could be considered as a predictor of CVD-related hospitalizations.

The current study showed that older adults (80 years or more) had 36% lower odds of reporting poor general health and 77% lower odds of reporting poorer mental health than their younger counterparts (50 years to 59 years). This result was inconsistent with findings from Jackson et al. (2021). They studied the association of HRQoL with congenital heart disease over a period of three years. They found a significant decline in HRQoL, including physical functioning and emotional functioning, of the patients with the passage of time (Jackson et al., 2021). However, an important difference between this study and the study conducted by Jackson et al. (2021) is that they conducted their study on patients having an age range of 15 years to 39 years and not on older adults. The findings from Ko et al. (2015) support the current study in that, after a certain age, people may start reporting cognitive function at a better level.

Association of cognitive function with HRQoL among respondents with CVD

The findings of this study also suggest that cognitive function (memory loss) was negatively associated with HRQoL in patients with CVD. This finding was consistent with Adams et al. (2020), Moryś et al. (2016), and Warraich et al. (2018). Adams et al. (2020) reported that respondents with SCI-only reported poorer HRQoL and other disabilities as compared to the participants with CVD-only, even though the SCI-only group was younger on average than the CVD-only group. They noted that the participants with SCI include those who would find it difficult to concentrate, remember, and make appropriate decisions. These participants might also include participants with memory problems. They further reported that the outcomes could be worsened in the condition with both SCI and CVD. As seen in this study, CVD separately did not negatively affect HRQoL as much as SCI alone, indicating that CVD is less critical compared to SCI alone in affecting the HRQoL of patients. This could be due to the reason that patients with SCI could not appropriately access health care services and could experience other related disabilities negatively affecting HRQoL (Adams et al., 2020). Warraich et al. (2018) concluded that hospitalized patients aged 60 years or older with acute decompensated heart failure (ADHF) not only have considerable impairments in physical activities along with elevated rates of frailty, but also have impairments in cognition, showing the negative association between CVD and cognitive function. Specifically, poor HRQoL was significantly correlated with the presence of depression (Warraich et al., 2018).

The current study also found that, after controlling for all other covariates, patients with memory loss had 73% increased risks of problems in general health as compared to individuals without CVD, with the true population affect ranging from 54% to 94%. Patients with memory loss had three times greater odds of poor mental health and 1.46 times greater odds of poor physical health. These findings showed that the decline in cognitive function could be associated with poor HRQoL after controlling for all other covariates. Ezzati et al. (2019) reported an association between memory loss and HRQoL in an elderly cohort. They also reported that after controlling for covariates, including age, race, gender, and education, the association was maintained between the components of HRQoL and memory and other cognitive domains (Ezzati et al., 2019).

However, before controlling the covariates, patients with memory loss had 4.17 times greater odds of poor general health, 5.59 times greater odds of poor mental health, and 3.82 times greater odds of poor physical health. This shows that before controlling covariates, the negative association between cognitive issues, represented by memory loss, and HRQoL was worse. Moreover, the presence of all other variables could have a negative effect on the outcomes. The adjusted odds ratios and unadjusted odds ratios are usually different as the other variables could affect the outcomes in the odds ratio. This has also been found in other studies. For example, in a study on cognitive domains and HRQoL, Bosboom and Almeida (2016) also found that crude odds ratios for episodic memory were different from the adjusted odds ratios, in which they adjusted for anxiety, depression, and number of medications.

Nevertheless, the current study showed that HRQoL not only declined in the presence of CVD but also declined with memory loss. However, it is important to note that further studies are still required to assess the association of HRQoL with the cognitive domains, including memory, as the findings of this study are in contrast to the findings of the study conducted by Bosboom and Almeida (2016). They worked on several cognitive domains, including episodic memory, working memory, language comprehension, cognitive switching, psychomotor speed, word fluency, and naming. They found that none of the identified cognitive domains showed a negative association with HRQoL. However, it is important to note that a relatively large number of participants lost to follow-up affected the results of the study (Bosboom & Almeida, 2016), and this could be associated with the difference in the findings of this study from the findings of the study conducted by Bosboom and Almeida (2016).

The mediating effect of cognitive function on CVD and HRQoL

This study showed that HRQoL could be negatively affected even after controlling for memory loss. However, it has also been found that cognitive function mediated the association between CVD and HRQoL. Cognitive function has been found to have a partial mediating effect on the relationship between CVD and HRQoL. This is considered as a partial mediating effect as the lack of the mediator does not completely eliminate the association between CVD and HRQoL. The unadjusted mediating effects of cognitive function were considerably greater than the adjusted mediating effects. This suggests that the unadjusted mediating effects have been influenced by covariates.

This result was consistent with the findings from the studies by Hsu et al. (2014) and Mei et al. (2021a). Hsu et al. (2014) found that CVD and stroke could be negatively associated with the mental component score and physical component score through different pathways. They further reported that CVD and stroke could directly affect HRQoL and indirectly affect HRQoL through negative mental health, including anxiety and depression (Hsu et al., 2014). Mei et al. (2021a) studied the mediating role of depression and anxiety on HRQoL and life satisfaction in patients with CVD. They found that depression and anxiety have a mediating role between life satisfaction and HRQoL. They reported that a reduction in life satisfaction could be associated with an increase in the level of depression and anxiety that could eventually be related to poor HRQoL (Mei et al., 2021a). Although the current study did not assess life satisfaction, it was commensurate with the finding of the study by Mei et al. (2021a) about the mediating role of cognitive function.

Study Limitations

There were several limitations associated with this study. First, causal relationships are not determined by cross-sectionally designed studies, like the BRFSS. Second, the generalizability of cross-sectionally designed studies is limited to the sample population. Third, self-reported data was used in the current study, which limited the validity and reliability. Fourth, the BRFSS data included non-institutionalized adults and therefore could have excluded individuals who resided in extended care facilities, who could have been more likely to respond affirmatively to questions related to problems with cognitive functioning, HRQoL, and CVD conditions. Fifth, the BRFSS excluded adults within households who were mentally or physically unable to participate in the survey. If subgroups are not represented in the study, such as in the fourth and fifth limitations, problems could occur with generalizability of conclusions made without full understanding of individual correlations.

Implications for Nursing Practice

The current study has important clinical implications. Older adults with CVD need to be properly evaluated by health care providers to identify deficits and assist in management of HRQoL. The management of CVD progression alone may not provide the required clinical benefits. Identification of cognitive changes in older patients with a CVD condition should be considered in maintaining HRQoL. For example, in patients with stroke, there is a high prevalence of depression after stroke. Therefore, therapeutic interventions must not only consider functional recovery but also psychological support (Hsu et al., 2014) based on patient's ability to self-regulate and implement coping skills related to their medical condition (Leventhal et al., 1992). However, it is important to note that focusing only on cognitive improvements may not always help, as CVD could also directly affect the HRQoL of patients and concentrating completely on cognitive improvements may not improve HRQoL at a desired level.

Interventions should be individualized for patients. For example, the level of memory loss may be different between different patients who have the same CVD condition. Moreover, the levels of CVD and its progression are different among patients. Therefore, therapeutic strategies should be developed after thorough subjective and objective evaluation of the patient. In this regard, patients should be provided with appropriate education and therapeutic interventions, so that they will be better able to manage their health-related condition and potentially improve their HRQoL.

Conclusions

The older adult population may have a greater need for health care providers than younger adults because of several health problems faced by this population. For example, older adults may experience CVD, cognitive problems, and a decline in HRQoL. Using the BRFSS 2019 data and controlling for possible confounders, the results of this study showed that CVD is negatively associated with the three components of HRQoL. In addition, cognitive function, especially memory loss in patients, is also negatively associated with HRQoL in patients with CVD. These findings show that patients with CVD and memory loss problems have increased risks of poor general health, mental health, and physical health than people without CVD. The findings of the present study also showed that CVD could indirectly affect HRQoL through mediation of cognitive function, such as memory loss. These findings may be used to show that, in the future, the assessment of cognitive functioning in patients with CVD must be reflected in the clinical setting so patients may maintain optimum HRQoL.

Recommendations for Future Nursing Research

The current study was limited to associations made within the cross-sectional sample of respondents. In the future, longitudinal studies should be conducted to infer causal relationships between the major study variables. Qualitative studies would be fruitful in determining the themes of HRQoL within this population. HRQoL should be captured comprehensively to include subjective data from patients because quality may be influenced over time, by social determinants of health, and based on changes in health conditions like CVD and cognitive function. Furthermore, studies need to be conducted on the association of HRQoL with wide age ranges in patients with heart-related disorders, as mixed findings have been reported in this regard. For example, people may report a high level of cognitive problems up to a certain age, and after that time, they may not report cognitive problems.

Chapter Summary

This chapter included a description of the study findings. These findings showed that CVD was associated with reduced HRQoL. Specifically, CVD negatively affected HRQoL, even after controlling for memory loss. An indirect negative effect has also been found in which cognitive impairment, such as memory loss, may have a partial mediating effect on the relationship between CVD and HRQoL. Therefore, it could be considered that memory loss, as a partial mediator, could be associated with the decline of HRQoL in patients with CVD, though its exclusion may not completely eliminate the relationship between CVD and HRQoL. Research findings were compared to those in the literature. For example, the findings of this study have been supported by several of the findings of previously published studies conducted on the topic of the association of HRQoL with CVD, association of HRQoL with cognitive functions, or the association of all three variables. Based on the findings, implications for nursing practice and recommendations for future research were proposed. In particular, personalized interventions need to be developed considering the direct or indirect effect of CVD on HRQoL through mediating cognitive function. Recommendations for future research include studies on the association of age with reporting of cognitive functioning and qualitative studies to assess themes of HRQoL within a population with CVD.

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APPENDIX A

Measurement Instrument: 2019 BRFSS Questionnaire

OMB Header and Introductory Text

Read if necessary	Read	Interviewer instructions (not read)
Public reporting burden of this collection of information is estimated to average 27 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. An agency may not conduct or sponsor, and a person is not required to respond to a collection of information unless it displays a currently valid OMB control number. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to CDC/ATSDR Reports Clearance Officer; 1600 Clifton Road NE, MS D-74, Atlanta, Georgia 30333; ATTN: PRA (0920-1061).		Form Approved OMB No. 0920-1061 Exp. Date 3/31/2021 Interviewers do not need to read any part of the burden estimate nor provide the OMB number unless asked by the respondent for specific information. If a respondent asks for the length of time of the interview provide the most accurate information based on the version of the questionnaire that will be administered to that respondent. If the interviewer is not sure, provide the average time as indicated in the burden statement. If data collectors have questions concerning the BRFSS OMB process, please contact Carol Pierannunzi at ivk7@cdc.gov.
	HELLO, I am calling for the (health department). My name is (name). We are gathering information about the health of (state) residents. This project is conducted by the health department with assistance from the Centers for Disease Control and Prevention. Your telephone number has been chosen randomly, and I would like to ask some questions about health and health practices.	

Cell Phone Introduction

Question Number	Question text	Variable names	Responses (DO NOT READ UNLESS OTHERWISE NOTED)	SKIP INFO/ CATI Note	Interviewer Note (s)	Column(s)
CP01.	Is this a safe time to talk with you?	SAFETIME	1 Yes	Go to CP02		78
			2 No	([set appointmen t if possible]) TERMINATE]	Thank you very much. We will call you back at a more convenient time.	
CP02.	Is this [PHONE NUMBER]?	CTELNUM 1	1 Yes	Go to CP03		79
			2 No	TERMINATE		
CP03.	Is this a cell phone?	CELLFON5	1 Yes	Go to CADULT		80
			2 No	TERMINATE	If "no": thank you very much, but we are only interviewing persons on cell telephones at this time	
CP04.	Are you 18 years of age or older?	CADULT1	1 Yes			81
			2 No	TERMINATE	Read: Thank you very much but we are only interviewing persons aged 18 or older at this time.	
CP05.	Are you male or female?	CELLSEX	1 Male 2 Female			82
			7 Don't Know/ Not sure	TERMINATE	Thank you for your time, your	

Core Section 2: Healthy Days

Question Number	Question text	Variable names	Responses (DO NOT READ UNLESS OTHERWISE NOTED)	SKIP INFO/ CATI Note	Interviewer Note (s)	Column(s)
C02.01	Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?	PHYSHLTH	_ _ Number of days (01-30) 88 None 77 Don't know/not sure 99 Refused			102-103
C02.02	Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?	MENTHLTH	_ _ Number of days (01-30) 88 None 77 Don't know/not sure 99 Refused			104-105
C02.03	During the past 30 days, for about how many days did poor physical or	POORHLTH	_ _ Number of days (01-30) 88 None	Do not ask this question and skip to next section if C02.01, PHYSHLTH, is		106-107

Core Section 1: Health Status

Question Number	Question text	Variable names	Responses (DO NOT READ UNLESS OTHERWISE NOTED)	SKIP INFO/ CATI Note	Interviewer Note (s)	Column(s)
C01.01	Would you say that in general your health is—	GENHLTH	Read: 1 Excellent 2 Very Good 3 Good 4 Fair 5 Poor Do not read: 7 Don't know/Not sure 9 Refused			101
	mental health keep you from doing your usual activities, such as self-care, work, or recreation?		77 Don't know/not sure 99 Refused	88 and C02.02, MENTHLTH, is 88		

Core Section 4: Hypertension Awareness

Question Number	Question text	Variable names	Responses (DO NOT READ UNLESS OTHERWISE NOTED)	SKIP INFO/ CATI Note	Interviewer Note (s)	Column(s)
C04.01	Have you ever been told by a doctor, nurse, or other health professional that you have high blood pressure?	BPHIGH4	1 Yes		If "Yes" and respondent is female, ask: "Was this only when you were pregnant?" By other health professional we mean nurse practitioner, a physician assistant, or some other licensed health professional.	112
			2 Yes, but female told only during pregnancy 3 No 4 Told borderline high or pre-hypertensive 7 Don't know / Not sure 9 Refused	Go to next section		
C04.02	Are you currently taking prescription medicine for your high blood pressure?	BPMEDS	1 Yes 2 No 7 Don't know / Not sure 9 Refused			113

Core Section 6: Chronic Health Conditions

Question Number	Question text	Variable names	Responses (DO NOT READ UNLESS OTHERWISE NOTED)	SKIP INFO/ CATI Note	Interviewer Note (s)	Column(s)
C06.01	Has a doctor, nurse, or other health professional ever told you that you had any of the following? For each, tell me Yes, No, Or You're Not Sure. (Ever told) you that you had a heart attack also called a myocardial infarction?	CVDINFR4	1 Yes 2 No 7 Don't know / Not sure 9 Refused			117
C06.02	(Ever told) (you had) angina or coronary heart disease?	CVDCRHD4	1 Yes 2 No 7 Don't know / Not sure 9 Refused			118
C06.03	(Ever told) (you had) a stroke?	CVDSTRK3	1 Yes 2 No 7 Don't know / Not sure 9 Refused			119

	glasses?					
C08.22	Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions?	DECIDE	1 Yes 2 No 7 Don't know / Not sure 9 Refused			204
C08.23	Do you have serious difficulty walking or climbing stairs?	DIFFWALK	1 Yes 2 No 7 Don't know / Not sure 9 Refused			205
C08.24	Do you have difficulty dressing or bathing?	DIFFDRES	1 Yes 2 No 7 Don't know / Not sure 9 Refused			206
C08.25	Because of a physical, mental, or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping?	DIFFALON	1 Yes 2 No 7 Don't know / Not sure 9 Refused			207

Module 20: Cognitive Decline

Question Number	Question text	Variable names	Responses (DO NOT READ UNLESS OTHERWISE NOTED)	SKIP INFO/ CATI Note	Interviewer Note (s)	Column(s)
M20.01	The next few questions ask about difficulties in thinking or remembering that can make a big difference in everyday activities. This does not refer to occasionally forgetting your keys or the name of someone you recently met, which is normal. This refers to confusion or memory loss that is happening more often or getting worse, such as forgetting how to do things you've always done or forgetting things that you would normally know. We want to know how these	CIMEMLOS	1 Yes	If respondent is 45 years of age or older continue, else go to next module. Go to M20.02		377
			2 No	Go to next module		
			7 Don't know/ not sure	Go to M20.02		
			9 Refused	Go to next module		

	difficulties impact you. During the past 12 months, have you experienced confusion or memory loss that is happening more often or is getting worse?					
M20.02	During the past 12 months, as a result of confusion or memory loss, how often have you given up day-to-day household activities or chores you used to do, such as cooking, cleaning, taking medications, driving, or paying bills? Would you say it is…	CDHOUSE	Read: 1 Always 2 Usually 3 Sometimes 4 Rarely 5 Never Do not read: 7 Don't know/Not sure 9 Refused			378
M20.03	As a result of confusion or memory loss, how often do you need assistance with these day-to-day activities? Would you say it is…	CDASSIST	Read: 1 Always 2 Usually 3 Sometimes			379
			4 Rarely 5 Never Do not read: 7 Don't know/Not sure 9 Refused	Go to M20.05		

M20.04	When you need help with these day-to-day activities, how often are you able to get the help that you need? Would you say it is…	CDHELP	Read: 1 Always 2 Usually 3 Sometimes 4 Rarely 5 Never Do not read: 7 Don't know/Not sure 9 Refused			380
M20.05	During the past 12 months, how often has confusion or memory loss interfered with your ability to work, volunteer, or engage in social activities outside the home? Would you say it is…	CDSOCIAL	Read: 1 Always 2 Usually 3 Sometimes 4 Rarely 5 Never Do not read: 7 Don't know/Not sure 9 Refused			381
M20.06	Have you or anyone else discussed your confusion or memory loss with a health care professional?	CDDISCUS	1 Yes 2 No 7 Don't know/ not sure 9 Refused			382

APPENDIX B

IRB Document

From: Morris, Christina <christina.morris@uta.edu>
Sent: Tuesday, June 29, 2021 3:27 PM
To: Peterson-Newman, Julie Kathleen <julie.petersonnewman@mavs.uta.edu>
Cc: Wang, Jing <jing.wang@uta.edu>
Subject: RE: Request for Letter to Indicate IRB Review not Required

Hello Julie,

I can confirm that analysis of de-identified data sets does not require IRB review. Do you need a letter for a specific purpose? We're happy to write letters if a sponsor asks for it or a journal asks for it, for example, but we try to avoid writing them before they are formally asked for.

Thank you,

Christina Morris
IRB Specialist
Office of Regulatory Services
The University of Texas at Arlington
Center for Innovation, Suite 300
Open Office Hours: In-person office hours are temporarily suspended as UTA responds to health and safety concerns related to COVID-19. Request a "virtual" meeting or phone call instead! Email us: regulatoryservices@uta.edu