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Assessment of Vitamin D Levels and Depression Among Adults in the United States

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Abstract

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MPH, Walden University, 2011

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Dissertation Submitted in Partial Fulfillment

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Doctor of Philosophy

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Abstract

Vitamin D is essential to optimizing health; vitamin D deficiency (VDD) can increase risk of hypertension, cardiovascular disease, and insulin resistance. VDD occurs when individuals do not receive sufficient oral intake or obtain adequate sun exposure. Previous researchers indicated there is a relationship between VDD and depression, while others have indicated there is no relationship. The purpose of this study was to examine the relationship between vitamin D levels and depression, and how this relationship might be moderated by an individual's demographic characteristics (gender, age, smoking status, or marital status). This study was a quantitative data analysis of archival data from the 2005-2006 National Health and Nutrition Examination Survey. The Health Belief Model was the theoretical framework. An ex-post facto exploratory analysis was used to test 2,623 adults located throughout the United States. Employing moderated multiple regression, a significant relationship was found between vitamin D levels and depression ($p. < .001$); however, the relationship was not moderated by demographic characteristics (gender, age, smoking status, or marital status). This study supports prior researchers who affirmed a correlation between vitamin D levels and depression. Given the definitive findings, practitioners should continue to recommend intake of vitamin D to individuals not meeting recommended daily dosages, but recommendations should not be based on gender, age, smoking status, or marital status. Understanding the connection between VDD and depression provides a basis on which to foster positive social change at the individual, family, organizational, and societal level.

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Dedication

I dedicate this achievement to my wife and best friend, Dimar. I also wish to dedicate this dissertation to my daughters, Giselle and Isabelle. It is because of your unconditional love, encouragement, and patience that this doctorate of philosophy was attained. I am incredibly, indescribably fortunate and grateful to have each of you in my life.

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Chapter 1: Introduction to the Study

Background of the Study

Vitamin D deficiency (VDD) can affect individuals of any age, race, or gender (Lappe, 2011). Vitamin D receptors exist in almost all human tissue and cells, and sufficient levels are important for optimum operation of those tissues and cells (Lappe, 2011). VDD can lead to multiple health consequences, including a major mood disorder (e.g., depressed mood, abated interest, altered appetite, sleep disorder, exhaustion, psychomotor disorder, feelings of inadequacy, inability to make decisions, and suicidal speculation; Wilkins, Sheline, Roe, Birge, & Morris, 2006).

At-risk groups for VDD include the elderly, women, and those with a history of chronic illness (e.g., diabetes, heart attack, stroke, and/or cancer; Hoang et al., 2011). These same at risk groups are also at risk for depression (Dong, Zhang, Tong, & Qin, 2012; Gross, Gallo, & Eaton, 2010; Pan et al., 2011). Despite considerable research linking VDD with depression, the evidence remains controversial, because some researchers have concluded that there is no relationship between VDD and depression (Bertone-Johnson, 2009; Harris & Dawson-Hughes, 1993; Kwasky, & Groh, 2012; Schneider, Weber, Frensch, Stein, & Fritze, 2000). Results have been inconsistent and inconclusive (Bertone-Johnson, 2009). Additional investigation is warranted to better understand whether there is a relationship between these two conditions.

According Bertone-Johnson (2009), confounding variables often interfere in research focusing on vitamin D and depression due to multiple factors (e.g., aging, period of time living indoors, geographic coordinates, physical exercise, weight, and drug use)

that can alter 25(OH)D (a prehormone that is formed in the liver through hydroxylation of vitamin D_3; cholecalciferol) levels, many of which cannot be controlled. Further, the epidemiological evidence on whether hypovitaminosis D (i.e., deficiency of vitamin D) is associated with depression remains limited (McCann & Ames, 2008; Milaneschi et al., 2013). More investigations are needed to determine if preventive or treatment interventions for depression should be coupled with preventing hypovitaminosis D as a cost-effective form of treatment (Holick, 2004; Milaneschi et al., 2013).

Such investigation is necessary because both VDD and depression are two major public health concerns that have significant implications for those who suffer from either condition. Whether the two health conditions are associated with each other requires further research. Addressing VDD and depression via cost-effective, safe, and effective public health measures may be an appropriate means to lowering the rates of both adverse health conditions. This study was designed to contribute to the existing base of scholarship in this area. This chapter includes an introduction to the study, including the problem and purpose of the research, the guiding research questions, and the nature of the study. The theoretical framework is also presented, along with relevant definitions that will be used throughout the study.

Problem Statement

The direction and result of common chronic conditions (e.g., arthritis, asthma, cardiovascular disease, cancer, diabetes, and obesity) could be adversely impacted by depression (Centers for Disease Control and Prevention [CDC], 2012a). If depression is left untreated, job absence, low job performance, and diminished work productivity can

result (CDC, 2012a). Similarly, vitamin D levels are often examined during routine physical exams and VDD is linked to risk for multiple health issues (Grineva, Karonova, Micheeva, Belyaeva, & Nikitina, 2013). For instance, vitamin D deficiency is a relevant and significant risk factor implicated in many health conditions such as cardiovascular disease, type 2 diabetes, obesity, rickets, osteomalacia, and progressive renal function loss (de Borst et al., 2011; Grineva et al., 2013).

Given the significant health risks that are associated with VDD and depression, it is important to fully understand the potential correlation between the two. However, the association between VDD with depression remains limited (McCann & Ames, 2008; Milaneschi et al., 2013). There is a possibility that the inconsistencies in the prior research stem from a failure to identify any possible differences in this relationship by gender, age, smoking status, or marital status. Without such understanding, prevention and intervention strategies designed to address both conditions will be limited. The research problem addressed in this study is whether or not vitamin D levels effect depression, and if covariates (gender, age, smoking status, or marital status) have an impact.

Purpose

I examined the relationship between vitamin D levels and depression, and how this relationship might be moderated by an individual's demographic characteristics (gender, age, smoking status, or marital status). There is evidence that vitamin D is essential to optimizing health and preventing disease (Bertone-Johnson, 2009). There is a need to determine if VDD is physiologically related to the occurrence of depression

(Bertone-Johnson, 2009). The intent of this study was to explore whether there is a relationship between vitamin D levels and depression, and how this might be moderated by an individual's demographic characteristics such as gender, age, smoking status, or marital status.

Research Question

To guide this quantitative study, one research question was used. The variables of interest included vitamin D, depression, and demographic characteristics. The research question was:

Research Question 1: What is the relationship between vitamin D levels and depression and is it moderated by demographic characteristics (gender, age, smoking status, or marital status)?

H_0: There is no relationship between vitamin D levels and depression and it is not moderated by demographic characteristics (gender, age, smoking status, or marital status).

H_A: There is a relationship between vitamin D levels and depression and it is moderated by demographic characteristics (gender, age, smoking status, or marital status).

Nature of the Study

To answer the stated research question, a quantitative, ex post facto comparative research design was used. Data were extracted from the National Health and Nutrition Examination Survey (NHANES), which was administered in 2005-2006 (CDC, 2013). NHANES is a well-established program in the United States designed to monitor

a variety of health and nutrition measurements and status of adults and children (CDC, 2013). The study's sample consisted of adults who were at least 18 years old located in the U.S. To be included in the sample, adults must have taken part of the NHANES in 2005 – 2006. Approximately 4,773 individuals, aged 18 years and older, participated in the study (CDC, 2013b).

For the single research question, a moderated multiple regression (MMR) analysis was incorporated. Depression was the single criterion variable, while vitamin D levels were the predictor variable. A moderator was introduced to attempt altering the relationship between other variables. This can help gauge whether a relationship between the predictor variable and moderation variables occurs on the criterion variable (Keith, 2006). The moderation variables for the hypothesis are gender, age, smoking status, and marital status. As such, MMR determined if specific demographic characteristics have an impact on the relationship between depression and vitamin D levels. MMR allowed me to determine if a predictor variable is correlated to the criterion variable, followed by estimating the magnitude of any effect. MMR enabled me to determine the unknown value of a variable from the known value of two or more variables. However, the size of the sample was to be relatively large to determine statistical power. A relatively small sample could lead to failure of detecting a moderating effect (Aguinis 2004).

Assumptions

A number of assumptions were critical to the meaningfulness of this study and were implicit to the design of this study. I assumed that testing the relationship between VDD and depression among sociodemographic subgroups was necessary to the context

of this study, and could be discernible when using a large sample size. The health belief model (HBM), which provided the theoretical framework for this study, was assumed to be necessary because this model can explain behaviors.

There is an assumption that all research protocols, statistical processes and ethical protections outlined by the NHANES were followed, and that all participants in the NHANES survey answered fully, honestly, and to the best of their ability. Accurate instrumentation and feedback supported the validity of the national surveillance survey. It was assumed that the sampling methodology of collecting relevant data from NHANES documents was meaningful in order to analyze the material and address the research question and hypotheses.

Scope and Delimitations

The conceptual framework for this study applied the HBM deductively as a logical process in order to focus on the attitudes and beliefs of participants. The research question and hypothesis was verified by the HBM. NHANES datasets were examined according to adults ≥ 18 years with VDD and depression who volunteered information pertaining to the predictor variable and the criterion variables during a specific period (2005-2006).

This study was delimited to adults who are at least 18 years old, located in the United States, and who have taken part within a specified biannual (2005-2006) NHANES dataset(s). The extent of the research study focused solely on the hypotheses and did not surpass the theoretical foundation that the research study was established upon. Depression and VDD were measured using an instrument designed to monitor a

variety of health and nutrition measurements. The study's results were generalizable only to adults who take part in the NHANES.

Limitations

There were multiple limitations to the design of this study. The hydrophobic qualities of vitamin D and the tight binding that occurs to the vitamin D binding protein can inhibit accurate measurements (Romagnoli, Pepe, Piemonte, Cipriani, & Minisola, 2013). The pseudo-quantitative nature of the method (i.e., subjective data that are assigned numeric values without objective affirmation) served as a form of misreporting, which can constitute as a limitation. Concerning quality control purposes, only 5% of the interviews were recorded and reviewed (CDC, 2013). Not all interviews are reviewed, which may indicate a misrepresentation to the general audience.

While it may appear suitable to implement the conclusion to the population, it may not be a correct or proper assumption to all volunteers who resided in various areas of the U.S. Persons who were U.S. nationals living abroad, institutionalized, or residing in nursing homes, were excluded from this study and were not examined. The concern of generalization was described as a limitation to this present study. Criteria for participating required that volunteers who were at least 18 years old, located in the United States, were not institutionalized, and who were mentally able to respond to a questionnaire. These requirements reduced the ability to generalize results to the U.S. population as a whole. Lastly, Statistical Package for the Social Sciences (SPSS) was used to appropriately examine data; however, limitations existed due to examiners being

required to appropriately interpret information that may have required additional learning.

Theoretical Framework

The HBM, developed during the 1950s by psychologists Rosenstock, Hochbaum, and Kegels, is a psychological health behavior change model that is grounded in the sociopsychological theory of thought processes to health-related behaviors of an individual (Harrison, Mullen, & Green, 1992). It is hypothesized that for an action to be health-related, the individual must be dependent on three factors that occur simultaneously: (a) a health concern must exist for an issue to be considered relevant, (b) one must believe that they are vulnerable to a perceived health threat or condition, and (c) a belief that abiding by suggested health recommendation could be helpful to avoiding or lowering the possible threat at a cost (i.e., financial) that is relatively acceptable (Edberg, 2010; Janz & Becker, 1984; Rosenstock, 2005).

People often fail to take health-related action or comply with medical advice because they do not recognize the benefits of protecting their health (Rosenstock, 2005). Individuals who fail to take corrective action often believe they will not be impacted by an illness. They fail to believe that personal intervention can avoid or stabilize a condition that they are faced with (Edberg, 2010; Janz, & Becker, 1984; Rosenstock, 2005). HBM is a model that addresses behavioral change (Rosenstock, 2005).

The HBM is relevant to addressing VDD and depression because the conceptual framework provided by the HBM is effective in understanding health behavior and possible reasons for non-compliance (i.e., not engaging in behaviors to avoid VDD and

depression). The HBM consists of six concepts: (a) perceived susceptibility, (b) perceived severity, (c) perceived benefits, (d) perceived barriers, (e) cues to action, and (f) self-efficacy that represent perceived threat and net benefits (Akompab et al., 2013). These concepts facilitate health action and can be applied to address reasons an individual may be non-compliant (Rosenstock, 2005).

According to Carpenter (2010), the HBM was developed so that researchers could understand the beliefs that should be targeted to influence health behaviors. However, the HBM was not designed to determine if subjects would adhere to a treatment program for an existing condition. Rather, the HBM was developed so that researchers may understand the benefits and barriers to predicting behaviors directed toward preventing negative health outcomes (Janz & Becker, 1984). HBM was not designed to predict treatment for existing disorders, but was rather initiated to predict the compliance of preventative measures with those who are not suffering from an existing disabling disease (Rosenstock, 1974).

According to Janz and Becker (1984), a cue to action is necessary to generate health-promoting behavior. The HBM theory related to this study's approach and research question by examining predictors of depression in persons with VDD. This study will enhance the general public's understanding to predictors of depression in persons with VDD. This study will contribute to existing research involving any association between depression and VDD, which may help address an area that is in need of further research.

Significance

This study will have significance for both scholarship and practice in public health education. Understanding if a relationship between VDD and depression is impacted by demographics (gender, age, smoking status, and marital status) is important for preventive strategies when allocating resources and targeting education programs. This study can also assist in further research of distinguishing those groups at risk for VDD and depression as an implication for positive social change, which is consistent with and bounded by the scope of this study. Such potential contributions may advance practice by targeting solutions toward these stakeholders.

The correlation among vitamin D status, cognition, and mood has been documented in previous studies (McCann & Ames, 2008; Wilkins et al., 2006), where some conclude that treating VDD improves depression symptoms (Benton, Haller, & Fordy, 1995; Mozaffari-Khosravi, Nabizade, Yassini-Ardakani, Hadinedoushan, & Barzegar, 2013). VDD may be indicative to underlying biological vulnerability for depression, but further research is warranted (Milaneschi et al., 2013). According to Nemeroff and Vale (2005), there is a strong possibility that psychiatric illnesses result in increased vulnerability when coupled with environmental influences. In addition, some studies have found VDD to be associated with multiple chronic debilitating diseases (e.g., osteoarthritis, cardiovascular disease, and type 1 diabetes; Holick, 2004; Tamai et al., 2013).

Definitions

Age: Age is interpreted as the amount of time during which a person has lived (Merriam Webster, 2013a).

Depression: Depression is a serious medical condition in which a person feels very sad, hopeless, and unimportant and often is unable to live in a normal way (Merriam Webster, 2013a). Depression is defined as a person acknowledging of having thoughts of hurting oneself in some way or considering oneself as being better off dead, despite the timeframe (CDC, 2013b).

Income: Income is defined as a gain in money that derives from capital received in a period of time (Merriam-Webster, 2013b).

Marital status: Marital status is defined as married, widowed, divorced, separated, never married, and living with partner (CDC, 2013).

Sex: Sex is defined as the state of being male or female (Merriam Webster, 2013c).

Smoking: Smoking is defined as the act of smoking a cigarette, cigar, etc. (Merriam Webster, 2013d).

Socioeconomic status: Socioeconomic status is defined as a composite measure that typically incorporates economic, social, and work status (CDC, 2013).

Vitamin D: Vitamin D is defined as any or all of several fat-soluble vitamins chemically related to steroids, essential for normal bone and tooth structure, and found especially in fish-liver oils, egg yolk, and milk or produced by activation (as by ultraviolet irradiation) of sterols as calciferol orcholecalciferol (Merriam-Webster,

2013b).

Vitamin D deficiency (VDD): Vitamin D deficiency is defined as a serum 25-hydroxyvitamin D concentrations ≤20 ng/mL (50 nmol/L; Forrest & Stuhldreher, 2011).

Summary

Some researchers have indicated that there is an association between depression and vitamin D (Wilkins et al., 2006), while some researchers concluded that the data associating vitamin D to the development of depression is circumstantial due to inconsistencies in research findings (Bertone-Johnson, 2009; Harris & Dawson-Hughes, 1993; Kwasky, & Groh, 2012; Schneider et al., 2000). Determining whether a relationship exists between vitamin D levels and depression, and if it is moderated by demographic characteristics (gender, age, smoking status, or marital status) may help public health practitioners uncover preventive strategies and allocate resources that target education programs. Findings in this study, which focused on the general U.S. population, may contribute to the goal of Healthy People 2020 by gradually eliminating demographic disparities and improve mental health through prevention.

Previous researchers have studied vitamin D status, cognition, and mood (McCann & Ames, 2008; Wilkins et al., 2006). The use of NHANES enabled provisional diagnoses for depression and assisted with grading the severity of depressive symptoms (CDC, 2013b). However, what remained unknown is if variables served as important indicators for VDD and depression when coupled with gender, age, smoking status, or marital status. What was needed is an empirical understanding of how risk for VDD and depression function due to gender, age, smoking status, or marital status.

I intended to examine a representative sample of the U.S. population. Public data between 2005 and 2006 was obtained from the NHANES. The literature review described in Chapter 2 is an overview of the relationship between VDD and depression. A more detailed explanation of the HBM is provided in Chapter 2. Chapter 3 is the design and methodology. Chapter 4 is the results and analyses. Finally, Chapter 5 is an interpretation of these findings and concludes with a description of recommendations.

Chapter 2: Literature Review

Introduction

I evaluated the association between vitamin D and depression. There is a paucity of epidemiological research data regarding the association VDD with depression (Milaneschi et al., 2013). A better interpretation of the association between depression and vitamin D levels could possibly lead to greater self-efficacy. Kennel, Drake, and Hurley (2010) argued that VDD occurs when individuals do not receive sufficient oral intake or obtain adequate sun exposure. Demographic factors such as gender, age, and smoking status may contribute to individuals becoming deficient (Lange, Sparrow, Vokonas, & Litonjua, 2012; Nanri et al., 2011).

Given adequate support, individuals at risk for VDD can more easily address behaviors related to diet, lifestyle, screening, and convenient access to treatment (CDC, 2011). Bridging potential gaps in the literature may help support public health initiatives involving promotional efforts geared toward increasing awareness and providing reminders of health-related action (i.e., receiving adequate amounts of vitamin D). Achieving a greater understanding of demographic factors and their association between depression and vitamin D levels could possibly enhance public health education strategies involving a person's motivation to take positive health actions against VDD (CDC, 2011).

This review of the literature begins with an exploration of HBM, which provides the theoretical framework for this study. The limited body of available literature that has examined the connection between VDD and depression is synthesized in this chapter. I

provide background information on depression and on vitamin D and its biochemical mechanisms. The chapter concludes with an exploration of public health education efforts that have focused on both depression awareness and mental health as well as the promotion of vitamin D.

Literature Search Strategy

The primary objective of the literature search was to review the key concepts of depression and vitamin D. The secondary objective was to explore scholarly reviews pertaining to depression and vitamin D to address the stated research question of this study. The literature search consisted of scholarly peer reviewed literature to avoid circulating insignificant findings, baseless claims, unsuitable analyses, and bias. Literature for this study was gathered from scholarly journal articles, books, Walden University research databases, University of California San Diego research databases, Centers for Disease Control and Prevention databases, United States National Library of Medicine, National Institutes of Health, and Google Scholar dating from 1930 to May 2014, searching varying methodologies to review the progression, distribution, and risk factors of depression and vitamin D. Peer-reviewed articles contained in this study were reviewed to obtain influential data and information pertaining to the scope of my study. Secondary searches for scholarly, peer-reviewed journal articles available in print-only format were obtained from the University of California San Diego Library. The literature search encompassed the key words *depression, calcitriol, gender, age, smoking status, marital status, NHANES, treatment, recurrence, brain function, health risks, and education*.

Theoretical Framework

The theoretical framework for this study is the HBM. The HBM was developed during the 1950's by social psychologists Rosenstock, Hochbaum, and Kegeles (1974). This model is validated to function as a guiding theoretical framework in the scope of preventive health behavior and compliance (Rosenstock, 2005). The HBM is used to understand health behaviors and possible predictors of depression in persons with VDD. The central tenet of the HBM is that an individual will partake in health-related action in order to avoid an adverse outcome (Trifiletti, Gielen, Sleet, & Hopkins, 2005). In addition, the HBM postulates that if an individual is in favor of avoiding a negative outcome, he or she will take a recommended health action. Conversely, the HBM indicates that unhealthy behaviors can result if an individual perceives they are not at risk for a potentially negative outcome (Institute of Medicine, 2001). For example, an individual who may be at risk for depression and wishes to avoid that situation is more likely to take preventive recommendations such as seeking treatment than an individual who is unconcerned about their potential risk for depression.

The interaction between perceived risk and health behavior advanced by the HBM suggests that awareness and education about health issues can positively affect change through improvements in individual health behavior. The HBM relates to the present study and research question by examining predictors of depression in persons with VDD. The material collected in this study may have a significant impact on social change by providing efficient measures (e.g., screening and counseling) for patients with VDD to successfully respond to depression.

Association between Depression and Vitamin D Deficiency

Vitamin D receptors (VDR) and hydroxylases (i.e., enzymes that facilitate hydroxylation) in different areas of the brain confirm the existence of vitamin D in its bioactive form, known as calcitriol (Eyles, Smith, Kinobe, Hewison, & McGrath, 2005; Prüfer, Veenstra, Jirikowski, & Kumaret, 1999). VDR and hydroxylases are located central to the limbic system, which is where emotional and behavioral regulation occur (Walbert, Jirikowski, & Prüfer, 2001). Depressive symptoms and impaired cognition are associated with VDR gene polymorphisms (Kuningas et al., 2009).

Beyond VDR gene polymorphisms, depressive symptoms are associated with vitamin D status, and the neurobiological plausibility of this association is strengthened by data that indicates VDD influences inflammation (Capuron et al., 2003; McCann & Ames, 2008). Although inflammation may contribute to depression (Miller, Maletic, & Raison, 2009), vitamin D's immunomodulatory activity may partake by down-regulating inflammatory mediators (e.g., nuclear factor κB) that are connected to depression (Capuron et al., 2003; McCann & Ames, 2008). According to Miller et al. (2009), active inflammatory pathways in the brain are similar to neuropathologic findings (i.e., a junction of reduced neurotrophic aid and modified glutamate release and reuptake) that represent depressive disorders.

Consequences of Vitamin D Deficiency

People who feel depressed (i.e., sad or anxious) each year during the same season are often considered to have seasonal affective disorder (SAD) that is consequential to VDD (Gloth, Alam & Hollis, 1999). Gloth et al. (1999) studied 15 participants with

SAD in a prospective and randomized trial to measure the hypothesis that VDD is associated with SAD. According to Gloth et al., phototherapy was administered to seven participants and 1,000,000 international units (IU) of vitamin D were administered to eight participants. Gloth et al. discovered that there was an association in the progress between depression scale scores and concentrations of circulating vitamin D (p=0.05; r^2=0.26) based on all subjects who received vitamin D improved in all outcome measures. Although no significant changes were found in depression scale measures with those receiving phototherapy, significant changes were found with those receiving serum vitamin D.

Variables Impacting the Relationship between Depression and Vitamin D Deficiency

Age. A cross-sectional study involving 3,262 Chinese participants who were aged 50-70 years were measured according to depressive symptoms and concentrations of circulating 25(OH)D (Pan et al., 2009). Symptoms of depression were determined by a Center for Epidemiologic Studies Depression Scale (CESDS) score (Pan et al., 2009). Radioimmunoassay's were measured to determine circulating 25(OH)D concentrations (Pan et al., 2009). However, causal relations remained unknown. In addition, investigators concluded that symptoms of depression in adult Chinese had no association correlated with 25(OH)D concentrations (Pan et al., 2009).

Sex. A population-based cohort study involving 423 men and 531 women over the age of 64 years was performed to uncover the association between 25(OH)D and symptoms of depression (Milaneschi et al., 2010). Assessments of depressive symptoms using the CESDS were taken at baseline, 3-yr, and 6-yr follow-up. The CESDS consists

of a scale that is self-reported and has 20 items, which ranges from 0 to 60 points. A score higher than 15 is typically considered to signify clinically relevant symptoms of depression.

Women with 25(OH)D greater than 50 nmol/L distinguished from women having levels less than 50 nmol/L, had experienced CESDS results of 2.2 (P=0.04) and 2.1 (P=0.02) points, respectively (Milaneschi et al., 2010). The prevalence of depressed mood was 18% for males and 42% for females. Nearly 75% of females and 50.4% of males had serum 25(OH)D less than 50 nmol/liter ($P < 0.0001$), which suggests that the weight of the prospective relationship is greater among females compared with males (Milaneschi et al., 2010). Milaneschi et al. (2010) concluded that there is a stronger prospective association among women than men regarding VDD as a risk factor for development of depressed mood (i.e., depressed mood was determined by CESDS score of > 15).

Smoking. A double blind and randomized study investigated by Jorde, Sneve, Figenschau, Svartberg, and Waterloo (2008) examined 441 participants (159 men and 282 women) to investigate the relationship between serum 25(OH)D levels and depression. Jorde et al. determined that smokers compared with nonsmokers were more depressed. Participants measured their main outcome using the Beck Depression Inventory (BDI) score; smokers scored non-significantly higher as having clinically relevant symptoms of depression when compared to nonsmokers (Jorde et al., 2008).

Income. Ganji, Milone, Cody, McCarty, and Wang (2010) examined the relationship between vitamin D status and depression of the US general population at large. Those who were VDD (25(OH)D≤75 nmol/L) had a prevalence of approximately 50% (Ganji et al., 2010). The sample population consisted of 7970 participants, women comprised approximately 54% of this group, while 67% were African American and Mexican American (Ganji et al., 2010). Further, approximately, 27% lived below poverty, and approximately 4% noted that depression occurred during periods of taking the examination (Ganji et al., 2010). Participants living below poverty levels reported a higher prevalence of VDD compared with participants living above poverty levels (Ganji et al., 2010).

Vitamin D Deficiency. VDD is reported in areas with sufficient resources as often as it is reported in areas with limited resources, which places children and adults at risk of complications (e.g., rickets osteomalacia, and osteoporosis) (Handa, Ali Kalla, & Maalouf, 2008; Prentice, 2008; Robinson et al., 2006) regardless of place of origin (Prentice, 2008). In areas where resources are limited, contributors to VDD are often linked to insufficient dietary intake of vitamin D (Awumey, Mitra, Hollis, Kumar, & Bell, 1998). However, most vitamin D originates from determinants not contained in one's diet, rather from non-dietary sources (e.g., inadequate sun exposure, skin pigmentation, clothing, keeping infants indoors; Holick & Chen, 2008; Munns et al., 2006). The biochemical characteristics of vitamin D show strong potential in minimizing risk of depression and mitigating depressive symptoms.

In order to realize the benefits of this correlation, it is essential to recognize the biochemical factors that underlie depression, as well as the biochemical characteristics involved with vitamin D. It is also important to understand the health behavior considerations associated with vitamin D, including discernment that over 40% of Americans are vitamin D deficient (Forrest & Stuhldreher, 2011). Thus, it is critical that more Americans be educated about the benefits of vitamin D to mental health, and aware about how to achieve sufficient vitamin D levels.

Depression

Depression is a condition that reaches beyond feelings of sadness or consternation. Each year in the U.S., depression affects approximately 14.8 million adults, or 6.7% of those 18 years and older (Kessler, Chiu, Demier, & Walters, 2010). Globally, approximately 350 million people are subject to depression (World Health Organization, 2013). According to Kessler et al. (2010), depression can affect approximately one in six men and one in four women in their lifetimes. Depression can negatively impact a person's quality of life, such as increasing one's risk of mortality (Katz et al., 2010).

The American Psychiatric Association (2012b) described depression as a serious medical illness that adversely affects ones feelings, thoughts, and actions. The onset of depression can result into a range of symptoms (e.g., feelings of sadness, loss of enjoyment in activities that were previously enjoyable, insomnia, and difficulty thinking). Depression is often caused by biochemical abnormalities (i.e., an imbalance in serotonin and norepinephrine levels may regulate mood that may lead to depression), genetics,

personality traits, and environmental factors (vitamin deficiency, exposure to violence, abuse, or poverty) that can affect anyone (American Psychiatric Association, 2012b).

Depression affects men and women differently, and risk of depression varies over the course of an individual's lifetime. Gender has a direct correlation to depression, with females more likely to experience depression than males. Females are often twice as likely to encounter major depressive disorder (MDD) as males (Kessler, McGonagle, Swartz, Blazer, & Nelson, 1993; Weissman & Klerman, 1977; Weissman et al., 1993). This appearance of gender variation in depression may be regarded as biological factors (e.g., genetics, neurotransmitters, and hormones) and victimization (e.g., childhood trauma, restrictive gender roles; Ryba & Hopko, 2011).

The average age of onset for depression is 32 years (National Institute of Mental Health, 2013). However, persons 18 to 25 years are more likely to report suicidal thoughts and episodes of MDD (Substance Abuse and Mental Health Services Administration, 2013). Further, the highest rates for depression occur from ages 49 – 54 years (University of Maryland Medical Center, 2013).

Mental health disorders, such as major depressive disorder, are treatable through the use of psychotherapy and anti-depressant medications (American Psychiatric Association, 2012b). According to the National Institute of Health (2008), 13.4% of adults in 2008 received treatment for a mental health disorder. That same year, 71% of adults with major depression, mostly women over 50 years, were found to use mental health services and treatment (National Institute of Health, 2008).

Signs and Symptoms of Depression

Depression is a medical condition, which if left untreated, can interfere with person's daily activities and prevent them from conducting normal activities (CDC, 2011). Symptoms can include persistent sadness, anxiousness, or a feeling of emptiness, which can adversely impact daily activities by contributing to disturbances in sleep, reverting to physical inactivity, and increased risk for smoking (CDC, 2011). Symptoms of depression involve the combination of these symptoms, adversely interfering with daily activities; these symptoms may range in severity, frequency, and duration (National Institutes of Mental Health, 2104; New York State Office of Mental Health, 2012).

Causes of Depression

According to the National Institutes of Health (2014), depression can occur based on a variety of factors (e.g., genetic, biological, environmental, or psychological). However, there is a paucity of research involving neurobiological basis and pathophysiology related to depressive disorders. Correlations have been identified between genetics and depression, as indicated with researchers investigating adoptions and twins (Lohoff, 2010). Despite vast improvements genome-associated studies have developed to understand depression, researchers remain challenged with properly identifying a single genetic variation that can substantially increase the risk of depression (Lohoff, 2010). Recognizing that genetic variants are likely to exert just a limited influence to the total risk of depression, various genetic factors and environmental factors are reasonably causal to the progression of depression (Lohoff, 2010).

Health Risks Associated with Depression

Depression can exacerbate the course of common chronic diseases (e.g., cancer, Parkinson's disease, heart disease, and diabetes) by complicating the recovery phase and worsening the overall physical condition (CDC, 2012a). For instance, depression can increase development of coronary artery disease and myocardial infarctions (Rejai et al., 2012). Further, negative lifestyles (e.g., smoking or consuming excessive alcohol) can interfere with treatment (Kenney et al., 2009). Both physical health risks and mental health risks are associated with depression, which can negatively impact disease progression.

For example, Penninx et al. (1998) conducted a prospective study involving persons aged 71 years and older, and discovered that chronically depressed persons (i.e., those who are depressed for at least two years) were 88% more likely to develop cancer, compared with non-chronically depressed elderly persons. Further, when depression was present for more than five years, an increased risk of cancer (*e.g.*, stomach, rectum, liver, gallbladder, pancreas, lung, skin, uterus, prostate, bladder, kidney, and lymphatic) was present. An alternative hypothesis linking depression and cancer is due to a raised cortisol response to the adrenocorticotropic hormone and adrenal hypertrophy (Penninx et al., 1998). Depression that remains persistent over relatively long periods is an important factor that may link to future cancer developments (Penninx et al., 1998).

Depression and cancer commonly co-occur. For instance, evidence from a meta-analysis study conducted by Pinquart and Duberstein (2010) correlated depression with elevated mortality in cancer patients. Pinquart and Duberstein (2010) investigated 105

subjects derived from 76 prospective studies, who were an average of approximately 65 years. Further, 72% of the participants were women, and approximately 50% were married. Findings from Pinquart and Duberstein (2010) revealed that 91% of the bivariate associations between depression and mortality reported relative risks greater than 1.0, which indicates there is an association between depression and elevated mortality in cancer patients

The prevalence of depression among cancer patients increases with disease severity and symptoms, such as pain and fatigue. According to Gross et al. (2010), MDD can increase the hazard for cancer, markedly among females with breast cancer. Gross et al. conducted a study on a population-based sample of 3,177 cancer-free adults from the Baltimore Epidemiologic Catchment Area Study, which included 24 years (i.e., adults followed between 1981 and 2005) of follow-up data and 334 cancer cases. Gross et al. (2010) concluded that a history of major depression was associated with a higher risk of breast cancer. Mental health and physical well-being can impact biological processes and outcomes (Pinquart & Duberstein, 2010).

Treatment

Multiple variations of antidepressants exist (e.g., selective serotonin reuptake inhibitors (SSRIs), norepinephrine and dopamine reuptake inhibitors (NDRIs), and serotonin and norepinephrine reuptake inhibitors (SNRIs); American Psychiatric Association, 2012a). According to practice guidelines of the American Psychiatric Association (2012a), a change in dose or an augmentation of therapy is recommended for

patients with MDD who fail with responding to treatment or attain only limited response to treatment following 1 to 2 months of therapy while in the acute phase.

Though antidepressants are the prevailing treatment for depression, two-thirds of people who initiate treatment fail to achieve remission (Nelson, Pikalov, & Berman, 2008). An initial treatment for depression typically includes SSRIs or psychotherapy, or both may be used in combination (Gelenberg, 2010). However, investigators have found that approximately 70% of subjects with MDD who have previously encountered remission failure were often treated with only one antidepressant (Nelson et al., 2008). Considering that depression is a recurrent disease that is often inadequately treated (National Institute of Health, 2008), clinicians are often challenged to conform to treatment options to determine the most effective means by avoiding recurring episodes of depression in order for remission to occur.

Risk of Recurrence

Depression is often an episodic disease; recurring episodes of depression can affect nearly 50% of those who recover from their first episode (Kennedy & Giacobbe, 2007). The second recurrence often begins within five years from the initial episode (Burcusa & Iacono, 2007). In addition, 80% of those who have a second episode are likely to have more episodes (American Psychiatric Association, 2012a). Further, for those with a history of recurring episodes, they are likely to experience five to nine separate recurrent episodes over the course of their lifetime (Burcusa & Iacono, 2007).

The probability of recurrence escalates with each consecutive recurrent episode of depression (Solomon et al., 2000). In a study involving long-term treatment for MDD,

Solomon et al. (2000) found that cumulative probability was 25% for subjects who had one recurrence at 1-year post recovery, 42% probability for recurrence at 2-year post recovery, and 60% probability for recurrence following 5-year post recovery (Solomon et al., 2000). In addition, collective probability increased to 41% for subjects who had two recurrences at 1-year post recovery, 59% probability for recurrence at 2-year post recovery, and 74% probability for recurrence at 5-year post recovery (Solomon et al., 2000).

Vitamin D

According to the Institute of Medicine (2011), vitamin D, also known as calciferol, is a fat-soluble vitamin that is available as a dietary supplement and produced endogenously. Vitamin D was originally recognized as a vitamin at the beginning of the 20th century, but is now recognized as a prohormone that is made available in two forms of fat-soluble seco-sterols known as vitamin D_2 or *ergocalciferol,* and vitamin D_3 or *cholecalciferol* (Institute of Medicine, 2011). Both forms display equivalent reactions in the body, and effectiveness to alleviate VDD (Institute of Medicine, 2011).

Two forms of vitamin D (D representing D_2 or D_3) include vitamin D_3 that is produced in the skin, and vitamin D_2, which is made in yeast and mushrooms exposed to UVB radiation (Holick, 2011). Vitamin D_3 and vitamin D_2 are equally effective in maintaining vitamin D status in both children and adults (Holick et al., 2008). However, not all children and adults are capable of synthesizing sufficient vitamin D levels.

When rays strike the epidermis and dermis, 7-dehydrocholesterol absorbs ultraviolet B (UVB) rays from the sun, which convert to previtamin D_3. Previtamin D_3

then converts to vitamin D_3 due to temperature dependent process (*e.g.*, time of day, season during the year, latitude), aging, sunscreen use, and level of skin pigmentation (Holick, 2011). Vitamin D then travels to the liver and converts to 25-hydroxyvitamin D [25(OH)D], also known as calcidiol (Holick, 2011). The kidneys then convert 25(OH)D to 1,25-hydroxyvitamin D, or calcitriol, which is the active form of vitamin D (Holick, 2011). The active form of vitamin D, calcitriol ($1,25(OH)_2$-vitamin D) is then induced by binding to its specific ligand, the vitamin D receptor (VDR) gene (i.e., a nuclear receptor protein that recognizes calcitriol; Holick, 2011).

Endogenously, vitamin D synthesis occurs when ultraviolet sunrays penetrate the skin and activate synthesis via hydroxylation. Two hydroxylations occur involving activation for vitamin D when attained from diet, supplements, and sun exposure. First, calcidiol occurs when vitamin D is converted to 25-hydroxyvitamin D [25(OH)D] in the liver (Institute of Medicine, 2011). Then calcitriol occurs, which is hydroxylation formed by a physiologically active 1,25-dihydroxyvitamin D [$1,25(OH)_2D$] (Institute of Medicine, 2011).

Many people and healthcare clinicians believe that sufficient vitamin D intake is achievable solely through diet; this belief is inaccurate (Kennel et al., 2010). Aside from fatty fish, vitamin D content in most foods is relatively low (Kennel et al., 2010). Although both modes of vitamin D are located in dietary supplements or fortified in foods, only vitamin D_3 synthesizes in human skin and vitamin D_2 is synthetic and used as an additive to foods (Ross et al., 2011). Diet alone cannot be relied upon to supply sufficient vitamin D intake.

Vitamin D and Brain Function

Although various mechanisms for how vitamin D affect brain function have been proposed (Alexopoulos, 2005; Fernandes de Abreu, Eyles, & Feron, 2009; McCann & Ames, 2008), what remains controversial is how vitamin D protects against Parkinson disease. A high vitamin D status may serve as a safeguard from developing a brain disease such as Parkinson's disease (Knekt et al., 2010). According to Knekt et al. (2010), persons with Parkinson's are often found to have low serum levels of vitamin D, which is associated with the degeneration of dopamine neurons.

Orme, Bhangal, and Fricker (2013) explored the development of rat ventral midbrains and discovered that the degeneration of dopamine neurons is causal to polymorphisms that occur in the VDR. Findings from Orme et al. concluded that polymorphisms of the VDR permit susceptibility to Parkinson's disease (PD) and suggested that vitamin D3 and calcitriol may have a role with PD therapies involving neuroprotection.

Calcitriol increases the number of dopamine neurons (Knekt et al., 2013) and enables neuroprotection by regulating neuronal concentrations of both extra and intracellular calcium (McCann & Ames, 2008). Calcitriol is beneficial because it reduces toxicity levels due to excess calcium in neurons (Fernandes de Abreu et al., 2009; vinh quoc Luong & Nguyen, 2013). VDR and hydroxylases in different areas of the brain confirm the existence of calcitriol (Eyles et al., 2005; Prüfer et al., 1999). VDR and hydroxylases are located central to the limbic system, also known as amygdala, which is where emotional and behavioral regulation occur (Walbert et al., 2001). Recent studies

suggest depressive symptoms and impaired cognition are associated with VDR gene polymorphisms (Kuningas et al., 2009).

Although calcitriol increases the number of dopamine neurons through neuroprotection, habitual inadequate levels of vitamin D can result in a reduction of dopaminergic neurons, which raises the possibility of further progression to PD (Knekt et al., 2013). Evidence by Knekt et al. (2013) exhibit that vitamin D aids in neuroprotective effects via neuronal calcium regulation, immunomodulation, and enhanced nerve conduction (Knekt et al., 2010). Syntheses of calcium-binding proteins enables neuroprotection by way of inhibiting oxidation (Alexopoulos, 2005; Fernandes de Abreu et al., 2009; Kalueff, Eremin, & Tuohimaa, 2004; McCann & Ames, 2008).

As a tenable biological risk factor for neuropsychiatric disorders, vitamin D protects brain health and provides physiologic support in preventing depression (Alexopoulos, 2005; Fernandes de Abreu et al., 2009; McCann & Ames, 2008). Moreover, vitamin D provides neuroprotection because of its ability to induce the synthesis of calcium-binding proteins (Alexopoulos, 2005; Fernandes de Abreu et al., 2009; McCann & Ames, 2008). In addition, vital neurotrophic factors are regulated by vitamin D, which play a role in synaptic plasticity and neurotransmission (McCann & Ames, 2008). Neuroprotection from vitamin D occurs when neuronal concentrations of calcium extra- and intracellular are regulated. Neuroprotective effects that benefit brain health occur via neuronal calcium regulation, immunomodulation, and enhanced nerve conduction (Knekt et al., 2010).

Benefits of Vitamin D

Growing evidence suggests vitamin D is beneficial to a healthier brain, and can diminish the onset and development of depression (Hoang et al., 2011); however, the mechanism that connects vitamin D to mental health requires further investigation (Ganji et al., 2010). Vitamin D has been shown to protect brain health, and may provide physiologic support in preventing depression (Alexopoulos, 2005; Fernandes de Abreu et al., 2009; McCann & Ames, 2008). Vitamin D regulates vital neurotrophic factors that play a role in synaptic plasticity and neurotransmission (McCann & Ames, 2008).

For instance, vitamin D manifests a neuroprotective effect by causing neutrophin induction to the synthesis of calcium-binding proteins, which inhibits the brain from producing of nitric oxide. As a result, apoptosis of neural pathways that transmit dopamine is prevented (Alexopoulos, 2005; Fernandes de Abreu et al., 2009; Kalueff et al., 2004; McCann & Ames, 2008). Further, inflammation may contribute to depression as well. Vitamin D immunomodulatory activity can down-regulate inflammatory mediators (e.g., nuclear factor κB) that are connected to depression (Capuron et al., 2003; McCann & Ames, 2008). Given the role of vitamin D in neurological processes, the consequences of VDD are significant; both physical and mental health consequences have been noted in the literature.

Vitamin D Deficiency

VDD is prevalent among North Americans who may not receive adequate doses of vitamin D through either exposure to direct sunlight or through their diets. Forrest and Stuhldreher (2011), analyzed vitamin D levels in 4495 U.S. adults and determined that of

the 41.6% considered as vitamin D deficient, the majority were African American (82.1%), followed by Hispanic Americans (69.2%) (Forrest & Stuhldreher, 2011). Further, VDD was more common among persons with no college education, overweight, inadequate health status, and hypertension (all $p < .001$; Forrest & Stuhldreher, 2011). In North America, the majority of African Americans do not obtain optimal 25(OH)D concentrations. This deficit stems from skin pigmentation, which reduces vitamin D skin production (Harris, 2006).

It is therefore important to recognize that VDD risk differs by individual and differences from person to person must be considered when intervention and corrective action is considered. According to Vieth (1999), the onset of VDD indicates corrective action should occur in the event anatomic, physiological, or biochemical abnormalities exist. Corrective action entails properly administering nonpharmacological doses of vitamin D. Further, the preferred method to derive vitamin D condition is to measure a serum concentration of 25-OH D (Holick & Chen, 2008).

Serum 25 [OH] D is a preferred method when determining vitamin D status because it is an effective clinical index that is used to verify vitamin D levels that are stored (Milaneschi et al., 2010). Serum 25 [OH] D is an indicator for the amount of vitamin D retrieved through the skin and that from diet and additives (Institute of Medicine, 2011). In humans, vitamin D that is in circulation as a reported half-life of approximately 15 days (Jones, 2008) to 30 days (Clements et al., 1992). 25(OH)D serves as a biomarker to sunlight exposure. However, the effect to which 25(OH)D levels present as a biomarker is undetermined (Institute of Medicine, 2011).

Researchers lack consensus regarding what constitutes an appropriate serum 25(OH)D concentration cutoff (Bischoff-Ferrrari, Giovannucci, Willett, Dietrich & Dawson-Hughes, 2006; Dawson-Hughes et al., 2005; Ganji, Zhang, & Tangpricha, 2012). Individuals with serum 25-hydroxyvitamin D levels of 30.0 to 74.0 nanograms per milliliter (ng/mL) are found to have adequate amounts of serum 25-hydroxyvitamin D levels (Ganji et al., 2012). However, the Institute of Medicine (2011) found persons at risk of VDD to have serum 25(OH)D concentrations of 12 ng/mL, while sufficient serum 25(OH) vitamin D levels are found above 20 ng/mL (Institute of Medicine, 2011) and above 30 ng/mL (Holick & Chen, 2008).

Yet, just as VDD poses health risks, so too do excessively high levels of vitamin D, or hypervitaminosis D. Serum 25-OH D levels above 50 ng/mL are a concern for being too high of a level (Institute of Medicine, 2011). According to the National Institute of Health (2013), doses of vitamin D exceeding 4000 units per day over several days may cause hypercalcemia (i.e., abnormalities with contracting muscles, releasing hormones and brain functioning). Hypervitaminosis D can cause abnormally high levels of calcium in the blood (Kjærgaard et al., 2012). As a result, bones, soft tissues, and kidneys can be damaged when there is an excess of serum 25-OH D (Kjærgaard et al., 2012).

Health Risk and Treatment for Vitamin D Deficiency

In adults, VDD is linked to hypertension, cardiovascular disease, and insulin resistance (Saintonge, Bang, & Gerber, 2009). According to Malabanan, Veronikis, and Hollick (1998), treatment of VDD in the U.S. consists of attaining a serum 25-OH D of

75 nmol/L, which can be accomplished by administering 50 000 IU vitamin D3 or D2 each week for up to 8 weeks (Malabanan et al., 1998). Further, by administering 50,000 IU of vitamin D2 twice a month, Holick (2007) suggested subjects can maintain a sufficient level of serum 25-OH D of 75 nmol/L.

The Role of Public Health Education

Mental Health

Behavioral health, which encompasses depression, is one of five public health priorities of the U.S. Department of Health and Human Services (2013). According to Kessler et al. (2010), each year approximately 13 million American adults have a significant and debilitating mental health issue. A goal of Healthy People 2020 (i.e., 10 year public health objectives) is to improve mental health through prevention and by ensuring access to appropriate mental health services. Despite such stated efforts, persons diagnosed with psychological disorders often do not obtain adequate treatment (Kessler et al., 2005). In addition, many who do access initial treatment fail to complete treatment (Edlund et al., 2006; Wang, 2007).

However, the prevalence of mental health and the number of people who are successful at gaining access and completing mental health treatment remains inversely proportional. Depression is the third most common reason for people to visit a primary medical care clinic after hypertension and diabetes (U.S. Department of Health and Human Services, 2013). Also, there is a gap that often leads to attrition for those requiring care. Critical steps required to reduce unmet needs for mental health include receiving care that is identifiable, effective, and accessible (Pence, O'Donnell, & Gaynes,

2012). Gaps in care and intervention can have significant negative consequences for individuals in need of treatment.

Gaps in service may result in attrition for those requiring care, because critical steps to reducing unmet needs for mental health care are often unmet. For instance, Pence et al. (2012) suggested the following must occur for a clinical response to positively impact MDD: (a) the person must enter the health care system; (b) be recognized clinically; (c) initiate treatment; (d) receive adequate treatment; and (e) respond to treatment. According to Pence et al. (2012), the primary care practitioner (PC) setting plays a significant role, because PC healthcare providers manage approximately two thirds of adults with MDD who receive treatment, while the remaining one third are managed by mental health experts. However, despite the amount of people with MDD that PC providers treat, gaps in PC settings often remain due to failures to identify, initiate, and provide effective treatment (Pence et al., 2012).

According to Pence et al. (2012), patients with MDD comprise 12.5% of the PC population; further, 47% of this patient population with MDD are diagnosed, but of the 24% of those treated, 9% are adequately treated, and 6% obtain remission. However, the PC setting is crucial for elderly adults because patients are comfortable with discussing depression and treatment, which is closely monitored and coordinated by healthcare providers.

Public health education can promote health by positively supporting and influencing individuals and communities. Further, public health education raises awareness to audiences who require access and treatment to mental health services that

are often essential for achieving remission (Pence et al., 2012). Public health education may be a benefit if directed toward people with mental health disorders including depression, by incorporating multiple healthcare providers who specialize in mental disorders. One effective public health program, which was directed toward the PC setting and focused on adults > 59 years with major depression, is the Improving Mood–Promoting Access to Collaborative Treatment (IMPACT).

A multisite randomized controlled trial involving 1801 elderly patients with MDD (17%), dysthymic disorder (30%), or both (53%) was conducted to determine the effectiveness of the IMPACT program (Unutzer et al., 2002). The mean age was approximately 71 years; 23% were from ethnic minority groups (12% African American and 8% Latino), and 65% were women. Nine hundred six patients representing 18 primary care sites were randomly assigned to the IMPACT program, and 895 patients were assigned to usual care. The IMPACT intervention was comprised of an initial visit conducted by a depression clinical specialist (DCS; e.g., nurses or psychologists) that involved a clinical and psychosocial history, review of educational material, and a discussion related to patient preference of treatment (psychotherapy or anti-depressant medication; Unutzer et al., 2002).

Although final treatment choices were determined by patient and PCP, the DCS collaborated with PCs to review treatment plan based on a recommended algorithm (i.e., a choice of anti-depressant medication (serotonin-reuptake inhibitor) or a 6-8 session course on problem solving treatment in primary care (PST-PC). Partial responders who remained depressed and were previously taking anti-depressant medication were advised

to increase dose or include anti-depressant medication with PST-PC. For non-responders, they were recommended to either adjust their medication or PST-PC. Patients were followed up in person or over the phone at least every two weeks. After 12 months of follow up from baseline, 45% of the experimental group had 50% or more reductions in depressive symptoms when measured with approximately 20% from the control care group (OR 3.45, 95% CI -1.19 to -.064; $p < 0.01$). Unutzer et al. (2002) concluded that the IMPACT model is more advantageous and beneficial for depression than usual care. The U.S. Preventive Services Task Force (2013) recommends not screening for depression in PC settings unless there is sufficient staff-assisted care to provide proper diagnosis, efficient therapy, and follow through. Staff-assisted support as found with IMPACT can assist with identifying and treating depression (U.S. Preventive Services Task Force, 2011).

Vitamin D

Although depression can be identified and treated, the neurobiologic basis or cause for depression remains unknown (Nemeroff & Vale, 2005). Whether levels of vitamin D are causal to depression, affect the outcome of depression, or has any relationship on depression is ambiguous among scholar practitioners (Ganji et al., 2010; Kjaergaard et al., 2012). In a study conducted by Ganji et al. (2010), data was collected from the third NHANES to determine whether a relationship exists between serum vitamin D and depression. The study consisted of 7970 participants aged 15-39 years.

Participants from the third NHANES were evaluated through the use of the Diagnostic Interview Schedule. Higher prevalence of VDD was observed by Ganji et al.

(2010) in non-Hispanic African American women, persons living below poverty, and persons with current depression when comparing those with adequate vitamin D conditions. Ganji et al. determined that in participants with 25(OH)D ≤ 50 nmol/L the OR is significantly higher compared with 25(OH)D ≥ 75 nmol/L (OR = 1.85; $P = 0.021$). Ganji et al. concluded that persons with VDD are more likely to experience depression compared with those who are vitamin D sufficient. Yet, consensus of whether VDD is causal to depression was not determined and remains inconclusive.

Kjaergaard et al. (2012) examined the comparison of depressive symptoms in subjects, which were evaluated with the BDI, Hospital Anxiety and Depression Scale (HADS), Seasonal Pattern Assessment (SPA) scale and Montgomery Depression Rating (MDR) scale, and noted that in a healthy population, supplementation of high dosage vitamin D have no effect on depressive symptoms. In a randomized controlled trial, 114 participants in the control group reported high (>70nmol/l) serum 25(OH)D levels while 243 participants in the experimental group reported low (<55 nmol/l) serum 25(OH)D levels; Kjaergaard et al., 2012). After further investigation whether D3 supplementation would mitigate symptoms in persons with low serum levels of 25(OH)D, Kjaergaard et al. concluded that low levels of vitamin D are seen as an outcome, as opposed to a cause, of depressive symptoms.

However, results from Kjaergaard et al. (2012) are not universally recognized and accepted. Sanders et al. (2011) conducted a randomized and double-blinded trial of women aged ≥ 70 who were community-dwellers to examine whether supplementation of vitamin D can affect mood. Over the course of 3-5 years during autumn and winter,

subjects randomly received placebo or 500,000 IU of vitamin D (3). Sanders et al. concluded that when measuring outcomes of mental health there are no significant distinctions among the placebo and vitamin D groups detected.

Although Sanders et al. (2011) concluded vitamin D is not related as an outcome of depressive symptoms, a previous study by Lansdowne and Provost (1988) uncovered that vitamin D levels can impact mental health. Lansdowne and Provost (1988) examined whether vitamin D3 supplementation during winter improves mood in healthy subjects. Over a period of five days, 44 participants assigned to a double-blind study were randomly administered 400 IU, 800 IU, or no vitamin D3. Lansdowne and Provost (1988) determined that vitamin D3 significantly enhanced participants' mood, which resulted in a positive effect on serotonin levels, food preference, sleep, and circadian rhythms.

Some authors have found high-dose vitamin D supplementation has a distinctive effect on depressive symptoms (Jorde et al., 2008; Kjaergaard et al., 2012; Lansdowne & Provost, 1988). Jorde et al. (2008) obtained similar results noted by Lansdowne and Provost (1988). Jorde et al. (2008) conducted a randomized double-blind controlled trial to determine the relation between 25(OH)D levels and depression. Depression was measured using the BDI scores of 441 participants consisting of 159 men and 282 women. Subjects were provided a placebo versus 20,000 or 40,000 IU vitamin D weekly for 12 months. According to Jorde et al. (2008), participants with serum 25(OH)D levels less than 40 nmol/l had more depressive traits, in comparison to persons with serum 25(OH)D levels $\geq$ 40 nmol/l. The placebo group did not show an improvement in BDI

scores. However, the two groups administered vitamin D did show significant improvement in depressive traits. Jorde et al. (2008) concluded that elevated dose supplementation of vitamin D alleviates symptoms of depression suggesting that a causal relationship is possible.

Research remains inconclusive whether VDD is an indicator for depression or whether depression is an indicator for VDD (Kjaergaard et al., 2012). Additional research is essential to deduce the specific role, relationship, and indication of vitamin D in mental disorders (Kjaergaard et al., 2012). Further, persons at risk for depression and/or VDD should be identified and receive intervention, because both conditions can negatively impact long-term health (Kjaergaard et al., 2012). According to Kjaergaard et al. (2012), VDD results from depression, but is not causal. Further, supplementation of vitamin D should not be used to treat depression, but rather patients who are depressed may be at risk of VDD.

Summary

Various mechanisms for how vitamin D plausibly impacts brain function have been proposed (Alexopoulos, 2005; Fernandes de Abreu et al., 2009; McCann & Ames, 2008); but the findings have been inconsistent and not sufficiently comprehensive. Although recent epidemiological associations exist between vitamin D and depression (May et al., 2010), evidence is inclusive about whether VDD is linked to mental health disorders (Bertone-Johnson, 2009). There is a paucity of information whether VDD precedes depression, or if depression is sub sequential to malnutrition and/or behavioral modifications (Bertone-Johnson, 2009). Until further research is conducted to determine the association of low levels of vitamin D and the occurrence of depression, Bertone-Johnson (2009) argued that researchers should currently refrain from concluding that there is a relationship between vitamin D levels and depression.

The HBM, which postulates health action by way of preventative methods by engaging individuals to a healthier lifestyle, was the theoretical framework for this study and was incorporated to explain and predict health-related behaviors. The use of HBM can address why an individual may or may not adopt healthy behaviors (i.e., accept or reject preventative health services). In addition, the use of HBM may address and uncover behaviors involving individuals with VDD and depression.

It is well established that depression negatively impacts a person's quality of life. However, what is not certain is whether a relationship exists between vitamin D levels and depression, nor is it clear if an existing relationship is moderated by demographic characteristics (gender, age, smoking status, or marital status). The present study fills

gaps in the current literature because the association between depression and VDD remains unclear. Because research remains inconclusive, this present study extends knowledge and attempts to provide social change through the use of HBM by reviewing efficient measures (e.g., screening and counseling) for patients with VDD to successfully identify if there is a relationship between vitamin D levels and depression, and if it is moderated by demographic characteristics (gender, age, smoking status, or marital status). Chapter 3 is an explanation of the methodology used to gather and interpret the data.

Chapter 3: Methodology

Introduction

VDD is a complex concern to the U.S. population. Researchers consider VDD a pandemic that is largely caused by insufficient sun exposure, which is a large source of vitamin D for human beings (Holick & Chen, 2008). However, findings on whether the occurrence of depression is related to serum levels of vitamin D are inconsistent (Bertone-Johnson, 2009). I examined the relationship between vitamin D levels and depression, and how this might be moderated by an individual's demographic characteristics (gender, age, smoking status, or marital status).

Research Design and Rationale

I conducted a quantitative, ex-post facto comparative research design as a framework to assess the single hypothesis. Quantitative research incorporates causal paths and identifies collective strength of multiple variables (Frankfort-Nachmias & Nachmias, 2008). Comparative research studies evaluate the relationship of two variables (Crosby, DiClemente, & Salazar, 2006). Also, coefficient ranges measure correlation strength (Frankfort-Nachmias & Nachmias, 2008). The coefficient of correlation is considered as Pearson's product moment correlation coefficient, or Pearson's r demonstrates a linear relationship by measuring the relation between two interval or ratio level variables (Frankfort-Nachmias, & Nachmias, 2008). Three possible results of a comparison study could have occurred (e.g., positive correlation, a negative correlation, and no correlation).

When results indicate that variables increase or decrease simultaneously, suggesting a strong positive correlation exists when Pearson's r is near +1.00, this constitutes as a positive correlation. Further, a negative correlation indicates that variables increase or decrease non-simultaneously when Pearson's r is near -1.00, which suggests there is a strong negative correlation. However, when there is no association between the variables, then Pearson's r will equate to 0.

Comparison studies are performed to determine whether a relationship among variables exists. Ex-post facto indicates that there will be no manipulation to the predictor variable. In the case of this study, participants were not designated to any particular group considering that data was gathered and assembled by NHANES. Considering the purpose of this research is to obtain findings from a nationwide sample that represents individuals with VDD and depression throughout the U.S., I conducted a non-experimental study research design, as opposed to an experimental design, to advance knowledge in this discipline of study.

Experimental designs enable investigators to have control over variables that are intrinsic and extrinsic, which strengthens internal validity (i.e., the amount of change recorded that is attributable to the investigation; McKenzie, Neiger, & Thackeray, 2009). However, experimental designs have weak external validity because investigators are unable to replicate real-life social conditions. Non-experimental designs evaluate the status of a criterion variable by measuring pre and post the introduction of some treatment (Campbell & Stanley, 1963).

Research Questions

To guide this quantitative study, one research question was used. The variables of interest included vitamin D, depression, and demographic characteristics. The research question is:

Research Question (RQ) 1: What is the relationship between vitamin D levels and depression and is it moderated by demographic characteristics (gender, age, smoking status, or marital status)?

$H1_0$: There is no relationship between vitamin D levels and depression and it is not moderated by demographic characteristics (gender, age, smoking status, or marital status).

$H1_A$: There is a relationship between vitamin D levels and depression and it is moderated by demographic characteristics (gender, age, smoking status, or marital status).

Operational Model

A structured view of the variables for Hypothesis 1 is displayed in Figure 1. The predictor variable is vitamin D level, while the criterion variable is depression. Additionally, four moderators (age, gender, smoking status, and marital status) are stated as a condition. Effect measures are presented using the characters r, R^2, and $R^2\Delta$.

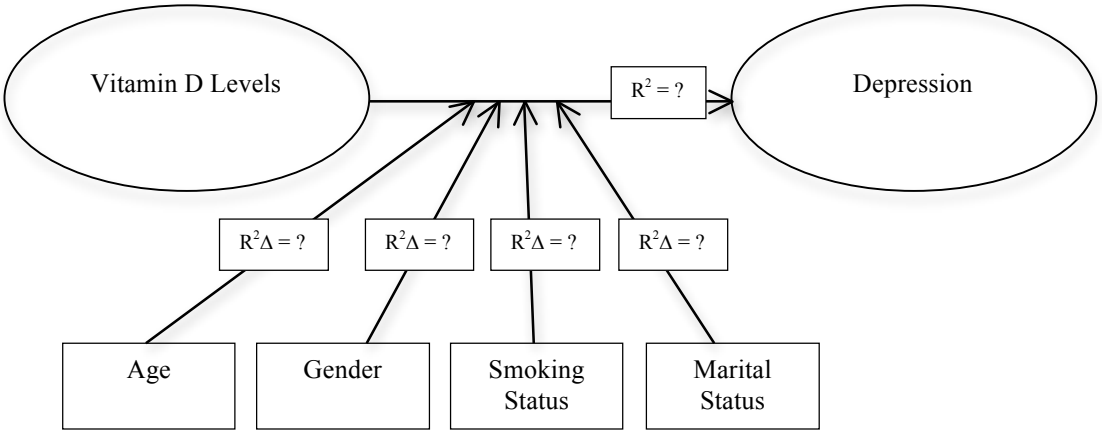

Figure 1. Operational model.

Population, Sample, and Sampling Methodology

Population

The study's population will focus on adults who are at least 18 years old located in the U.S. According to the U.S. Census Bureau (2013b), there are approximately 210,316,000 individuals throughout the U.S. that fit this criterion.

Sample

The study's sample consisted of adults who were at least 18 years old located in the United States. To be included in the sample, adults must have taken part in NHANES during 2005 – 2006. Approximately 4,773 individuals, aged 18 years and older, participated in the study (CDC, 2013b). In addition, the entire data set was used in the study.

Sampling Methodology

Archival data during 2005 – 2006 was extracted from the NHANES data set. The entire data set was used to answer the research question. That is, 4773 participants made up the sample. A complex, multistage probability technique was used to select participants for the NHANES project. The NHANES sample consisted of a representative sample of civilian, non-institutionalized US citizens. The sample did not include individuals living in nursing homes, members of the armed forces, institutionalized persons, or U.S. nationals living abroad.

Power Analysis

Minimum sample size was derived from the power table presented by Aguinis (2004). This power table offers multiple slope variations when using moderated multiple regression. To obtain a power ≥ 0.80, an approximate sample size of 200 is recommended. Further, Aguinis (2004) argued, in order to identify smaller regression slope differences, the sample size should be from 320 to 400. Preferably, group sample sizes ought to be similar. A minimum sample size of approximately 400 (i.e., 200 per group) was required to find a difference between regression slopes. Given the available sample consisted of over 4700 participants, the minimum sample size for the study was met.

Procedures

After receiving approval from Walden University's Institutional Review Board (IRB), data files were downloaded from the NHANES website. Research organizations (e.g., universities, health care providers, and educators) have access to NHANES's

information. NHANES' data (i.e., data involving serum 25[OH]D and depression) are available online for public use and do not require any formal permission to gain access. Disclaimers are indicated on the NHANES website to assure data is used solely for statistical analysis and health research purposes (CDC, 2013).

The National Center for Health Statistics (NCHS) provides downloadable public-use data files through the CDC's file transfer protocol (FTP). FTP supports file sharing by sending data electronically via Internet servers. Users of FTP can obtain questionnaires, data sets, and documentation when accessing the NHANES website. Instructions for obtaining these data files are available by accessing Readme files, which are files that contain information for users to obtain basic facts (e.g., directory, contact information, and software information) about the program.

Due to the extensive nature of NHANES and the amount of processing involved with post-data collection, data is reported to NCHS and made available biannually as opposed to a single point in time. NCHS Disclosure Review Board (DRB) reviews documentation, edits and approves data before releasing any information on an ad hoc basis. Data is often published within three months of receipt of the data.

Instrumentation

The NHANES program is directed by the NCHS, which is affiliated with the CDC (2013). NHANES is a well-established program in the U.S. designed to monitor a variety of health and nutrition measurements and status of adults and children (CDC, 2013). The program began during the 1960s and since its existence has surveyed over 140,000 participants in a reliable and valid format that assesses health and nutritional

status (CDC, 2013). Currently, health data are also collected through the use of interviews, medical examinations, and sophisticated laboratory tests.

The first three National Health Examination Surveys, (NHANES I, II and III) were performed periodically from 1960 to 1970 as a serial program, while between each portion of the survey, intervals were implemented. Doing so permitted adequate time to extrapolate data (CDC, 2013). From 1971 to 1975, a nutrition component was attached to a fourth series, which was included in the two prior periodic surveys performed during 1976-1980 and 1988-1994.

In 1999, the CDC introduced a continuous survey to increase the time required to release datasets and estimations concerning issues of public health interest every six months (CDC, 2013). The move away from a serial survey enabled annual estimates to contribute to small population groups and less prevalent conditions and diseases (CDC, 2013). Currently, NHANES is conducted annually. Doing so increases opportunities for public health practitioners to adjust survey contents to meet emerging needs (CDC, 2013).

The cross-sectional survey is conducted to annually examine 5,000 participants who make up a U.S. nationally representative sample of the non-institutionalized civilian population (CDC, 2013). Participants are located and selected through a statistical process using the most current U.S. Census information (CDC, 2013). Fifteen counties across the U.S., were randomly selected using a probability sampling technique that involved a complex, multistage design. According to WHO (2013), multi-stage sampling involves two or more stages, where people are chosen for interviewing from a large and diverse population.

To provide evidence that may guide practical decisions, NHANES sampling procedure consists of four phases to ensure statistical conclusion validity. Phase one involves selection of primary sampling units (PSUs), such as individual counties or a collection of adjoining counties that are comparable to a sizeable measure. The second phase involves PSUs being detached into divisions (e.g., city blocks or their equivalent). In the third phase, random selection occurs for each housing unit from each neighborhood. The fourth phase of the sampling procedure pertains to individuals being drawn within allocated screening subdomains (e.g., age-sex- ethnicity subdomains). In this final stage, approximately 1.6 persons are selected per household, and an introductory letter is sent to a specific household member (CDC, 2013).

All participants who consent and take part in the survey are reimbursed for time and travel expenses. The survey comprises of two main entities: the home interview and health examination. The interview, which takes approximately one hour, involves a NHANES interviewer asking questions about the participant's diet, disease history, and health in participant's home. The interview is also conducted to collect information regarding demographics, socioeconomic status, and any other health related questions. Following the interview, participants visit a local Mobile Exam Center (MEC) where lab tests, body measurements, dental, and physiological assessments are conducted (CDC, 2013).

To expedite, simplify, and strengthen participation, transportation is granted to and from the MEC. Confidentiality policies are established to prevent releasing inadvertent identification of individuals. The Health Insurance Portability and Accountability Act of 1996 (HIPAA) Privacy and Security Rules aids in granting federal

protection to personal health information of participants; in addition, HIPAA also protects public health authorities (e.g., NHANES interviewers and examiners) and their role surrounding essential public health services (U.S. Department of Health & Human Services, 2013). For the proposed study, the data collected in 2005-2006 will be used, which provides sufficiency of instrumentation to answer the research questions for the current study. Since this data was previously collected, I will not make any contact with the participants.

To generate reliable and valid statistics, the NHANES program overestimates financially challenged people, adolescents, adults ≥ 60 years, African Americans, and Hispanics (CDC, 2009a). Additionally, both reliability and validity are verified by pretest and pilot studies conducted prior to the implementation of survey (CDC, 2009a). The NHANES survey was tested and retested by the CDC to ensure reliability. Further, MEC interview data were recorded electronically using questionnaire forms to ensure reliability and validity of data (CDC, 2013). As part of the quality control process, check item variables were used to verify correct data was collected (CDC, 2013). Also, during data preparation, variable frequency counts were checked, patterns of skipping questions were verified, and responses to questions were reviewed to determine response reasonableness (CDC, 2013).

Operationalization of Variables

Six variables were discussed: including one predictor variable (vitamin D level), one criterion variable (depression), and four moderating variables (age, gender, smoking status, and marital status). The predictor and criterion variables were scaled at the interval level, while the moderating variables were scaled at the nominal level.

Vitamin D Levels

Vitamin D levels data for NHANES 2005-2006 were first published in June, 2008 and revised November, 2010. For the proposed study, this data will be collected from SAS transport files located on the NHANES Web site. A two-step procedure occurred for the laboratory assay of 25[OH]D. First, an extraction of 25[OH]D from serum with acetonitrile undergoes treatment. The treated sample is then assayed through the use of an equilibrium radioimmunoassay (RIA) procedure based on an antibody, which is specific to 25[OH]D. After 90 minutes, at 20-25 °C, the sample, antibody, and tracer are incubated. Following incubation at 20-25 °C for 20-minutes with a second antibody-precipitating complex, phase separation occurs. After incubation and prior to centrifugation, a NSB buffer is added to assist with the reduction of non-specific binding.

For the present study, categories for Vitamin D were defined as serum 25[OH]D concentrations ≤ 20 ng/mL, which were used for correlation analyses (CDC, 2013b). Two categories included VDD (serum 25[OH]D concentrations ≤20 ng/mL; code 0) and vitamin D sufficient (serum 25[OH]D concentrations >20 ng/mL; code 1).

Depression

The patient health questionnaire (PHQ) is a self-administered survey questionnaire that establishes provisional depressive disorder diagnoses and determines depressive symptom severity (Kroenke, Spitzer, & Williams, 2001). The PHQ was developed to assist primary healthcare providers make criteria-based diagnoses of DSM-IV disorders (e.g., mood, anxiety, somatoform, alcohol, and eating; CDC, 2013b). The PHQ-9 is a questionnaire designed to specifically focus on the nine diagnostic criteria for DSM-IV depressive disorders. Depression is diagnosed if a symptom answered on the

questionnaire is identified as depressed mood, and also if five or more of the nine diagnostic criteria are identified by the participant as occurring “more than half the days” in the previous two weeks (CDC, 2013b). Further, depression is diagnosed if a participant acknowledges “thoughts that [you] would be better off dead or of hurting [yourself] in some way,” has occurred, regardless of the timeframe (CDC, 2013b). The use of NHANES offers provisional diagnoses for depression and provides clinicians the ability to grade the severity of depressive symptoms (CDC, 2013b).

For the purpose of addressing this study’s research question, the PHQ-9 questionnaire was scored from "0" (*not at all*) to "3" (*nearly every day*). Considering that there are individual questions that can score from 0 to 3, a total score for a respondent can range from 0 to 27. The total score is based on cutpoints that correspond with thresholds (i.e., a cutpoint of 5 represents mild depression, a cutpoint of 10 represents moderate depression, a cutpoint of 15 represents moderately severe depression, and a cutpoint of 20 represents severe depression). However, for this study, a single screening of a cutpoint of 10 or greater was used to determine major depression. In any other study, a cutpoint less than 10 will indicate no depression. A cutpoint of 10 has a specificity of 88% and sensitivity of 88% for MDD (Kroenke & Spitzer, 2002; Kroenke, et al., 2001). Two categories for the depression variable were used, including positive diagnosis or depressed (code 1 for PHQ9 score >10) and negative diagnosis or not depressed (code 0 for PHQ9 score ≤ to 10).

Gender

NHANES interviewers asked all respondents whether they were male or female (CDC, 2013b). This variable is scaled at the nominal level. The two categories included: (a) male (code 0); and (b) female (code 1).

Age

A common and important confounding factor to health research is age. Age was evaluated as a categorical variable. The following five classifications of codes were used by the NHANES interviewer: (a) 20-29 (code 0); (b) 30-39 (code 1); (c) 40-49 (code 2); (d) 50-59 (code 3); and (e) > or = to 60 years (code 4) (CDC, 2013b).

Smoking Status

Cigarette smoking was measured on all examinees who were 18 years or older. However, history of alternative methods of inhaling tobacco (e.g., by way of pipe smoking, passive smoking, vaporizers, and cigars), were not included in the survey. Further, all questions pertaining to smoking were administered by interviewers via the Computer-Assisted Personal Interviewing-CAPI system. Within this present study, respondents were categorized as not a current smoker (do not smoke at all; code 0) or a current smoker (smoke daily or some days; code 1).

According to the CDC (2012a), an estimated 19% (i.e., 43.8 million) of the U.S. general adult population were considered as smokers in 2011. This study's findings may potentially strengthen public health through greater awareness regarding the distribution of cigarette smoking among individuals with VDD. The use of CAPI assures validity of the data collected due to built-in edit checks when respondents answer questions.

Interviewers are alerted when abnormal responses are entered and instructed to verify responses.

Marital Status

Participants 18 years and older were inquired by interviewers of their current status (e.g., married, widowed, divorced, separated, never married, or living with a partner). In the present study, single (e.g., unmarried, widowed, divorced, or separated; code 0) and married (code 1) will be used.

Data Analysis Plan

For the single research question, MMR analysis was incorporated. MMR was used when examining the association between a predictor variable and the criterion variable, followed by estimating the magnitude of any effect. MMR is a statistical method used for prediction and determining if there is a moderating effect (Stone & Hollenbeck, 1989). The purpose of MMR is to detect the unknown value of a variable from the known value of two or more variables (Stone & Hollenbeck, 1989). MMR was used to conduct data analysis when determining if there was a relationship between vitamin D levels and depression, and if the relationship was moderated by demographic characteristics (gender, age, smoking status, or marital status).

Depression was the single criterion-confounding variable, while vitamin D levels was the predictor-confounding variable. Further, a moderator was introduced to alter the relationship between other confounding variables. This can help gauge whether a relationship between the predictor variable and moderator variable occurs on the criterion variable (Keith, 2006). All regression models had a criterion available, predictor variable, and moderator(s). The moderation variables for Hypothesis 1 were gender, age,

smoking status, and marital status. As such, MMR determined if the demographic characteristics had an impact on the relationship between depression and vitamin D levels. Utilization of MMR allowed me to determine if the predictor variable was correlated to the criterion variable, followed by estimating the magnitude of any effect.

Chapter 4 contained results displayed in three discrete sections that consisted of the demographic, detail of analyses, and summary of results sections. The demographic section consisted of a profile of participants who were part of the initial survey by NHANES. The section for data analysis incorporated a thorough summary of the analysis conducted. The analysis contained applicable assumptions and concluding inferential results. The synopsis of results encompassed a summary of the study, study design, outcome and information detailed in Chapter 5.

This analysis of data comprised of descriptive statistics, means, standard deviation, and frequency where appropriate. Also, histograms, z-scores, and plots were displayed to support assumptions of normality. In addition, a regression table and supporting figures were presented on the conditions that a relationship or affect was identified. For this analysis, alpha was set at $p = .05$ on the condition that assumptions of normality were reached. In the event there were any violations to these assumptions, the investigator established suitable action steps.

Threats to Validity

Validity pertains to the amount and type of error that may occur. Construct validity is a combined critique assessment of the amount, or degree, to which empirical data and theoretical hypotheses defend the sufficiency and suitability of translations and operations based on test scores or other measures of evaluation (Messick, 1990).

Construct validity indicates an experiment measures the construct it sets out to measure (Messick, 1990). Validity can change as findings develop, making validity evidence serially incomplete (Grimm & Widaman, 2012).

According to Campbell and Stanley (1963), there are two forms of threats to validity: external and internal. External validity involves scientific and statistical generalization and internal validity involves results being affected by random and bias errors (Rothman, 2002). The NHANES was designed to minimize external and internal validity by conducting health examinations in MECs, which provide an ideal setting for the collection of high quality data in a standardized environment (CDC, 2013). All data files collected in MECs are merged using the common participant number (variable name: SEQN) to ensure information for each study participant is appropriately linked (CDC, 2013). Further, all questionnaires addressed by study participants are administered by trained household interviewers whose performance is evaluated and tested prior to assessing participants (CDC, 2013).

Methodological Limitation

To reduce the possibility of there being limitations with sample size, the NHANES administered in 2005-2006 included approximately 4,773 individuals, aged 18 years and older, in the study (CDC, 2013). Having a relatively large sample size strengthens the possibility of there being proper distribution of the population, to which results will be generalized. Also, interview (questionnaire) data are based on self-reported data, which is subject to non-sampling error. To mitigate self-reported data, personal health data of participants are protected by HIPAA (CDC, 2012b; CDC, 2013). Also, to protect the confidentiality of data obtained from sample persons, masked

variance units (MVUs; masked variables that distinguish single counties) are constructed for the purpose of variance estimation (CDC, 2013).

Further, there is a lack of prior research studies on the relationship between vitamin D levels and depression, and how this might be moderated by an individual's demographic characteristics (gender, age, smoking status, or marital status). This lack of research constitutes as a methodological limitation. Hence, there was an important opportunity and need to conduct this current quantitative study for further research.

Ethical Procedures

The NCHS Research Ethics Review Board (ERB) verifies that NHANES follows ethical procedures when conducting studies. To avoid any misunderstandings, participants were informed that the NHANES examination is not an alternative to routine primary care examinations. Potential participants provided voluntarily consent before taking part in any research. Twelve weeks after the NHANES exam, each participant was provided with a written report of findings. If any abnormalities to the survey were detected, then a letter was immediately mailed to all participants.

Federal law (i.e., HIPAA), and ethical obligations (i.e., the Public Health Service Act regarding provision 42 United States Code 242m) assures respondents strict confidentiality that any personal information collected by NCHS is protected (CDC, 2012b). To ensure that all personal information is collected and stored, restrictions were imposed and guidelines were implemented (CDC, 2012b). For instance, random inspections by the NCHS Confidentiality Officer aid with assuring confidentiality standards were maintained (CDC, 2012b).

Also, the NCHS Associate Director for Science (ADS) has responsibility to review and assure adherence to restrictions pertaining to confidentiality and disclosure remain within compliance (CDC, 2012b). For instance, the ADS reviewed public-use audio and video components (e.g., tapes, CDs, DVDs) to ensure confidentiality and conduct an editorial review (e.g., formatting and proper punctuation) of all products for efficiency (CDC, 2012b). Protecting confidentiality of individual identifiable information required maintaining restrictions on how information was collected.

To uphold such restrictions, the Public Health Service Act (Section 308 [d]) was passed to enforce statutorily based requirements on any data collected by the NCHS and CDC for the objective of obtaining analysis and reporting health statistical information (CDC, 2012b). Within Section 306 of the Public Health Service Act (42 USC 242k), the section indicates that NCHS is authorized to collect data via telephone surveys, mail surveys, and electronic technology (e.g. e-mail; CDC, 2012b). This law was passed to prohibit efforts of data users to determine the identity of data subjects (CDC, 2012b). Should any such discovery occur, notification must be communicated to NCHS (CDC, 2012b). Further, any identity linking data subjects from alternative NCHS or non-NCHS datasets is prohibited under the Public Health Service Act (CDC, 2012b). Finally, the collection of data involving any personal favors, gifts, or payment to respondents is prohibited under this law.

The NHANES program allows availability of downloading data in their website (CDC, 2013). NHANES data files are stored in a statistical analysis software (SAS) transport file format (.xpt; CDC, 2013). A SAS-accessible library is available for software users through the use of XPORT statements that communicate to SAS to extract

data from the transport file (CDC, 2013). The latter is accomplished by using the XPORT engine, which is conducted in an open SAS-accessible format. Having an open statistical software program available allows data collected by NCHS and CDC to remain vendor neutral and omit any endorsement or requirement that can be potentially solicited by any vendor (CDC, 2013). SAS allows data entry, report writing, statistical analysis, and development of project management and operations research to occur in a safe and controlled format (CDC, 2013).

Safeguarding data is of utmost importance to NCHS (CDC, 2013). To protect NHANES participants' confidentiality, the Confidential Information Protection and Statistical Efficiency Act (CIPSEA) was passed. At all times, records such as names, addresses, and social security numbers are kept secured and locked when not in use. Finally, confidential records must remain within NCHS, unless assurance of confidentiality is transferred to a receiving party with the same protection level of confidentiality. According to the CDC (2013a), measures of security (e.g., access control, user authentication, encryption, and access monitoring) are in place to protect statistical and analytical information. The PHSA upholds strict confidentiality and was passed into law in order to prohibit NCHS from using or sharing any personal information for any purpose aside from what was described and agreed by participants (CDC, 2013). Any violation of the PHSA can result in fines and imprisonment based on provisions set forth by the CIPSEA (CDC, 2013).

The CIPSEA has a unique responsibility to protecting information, as does the NCHS, which is responsible for outlining procedures of dissemination of NHANES data (CDC, 2013). NCHS disseminates public-use data files (e.g., results of epidemiologic,

demographic, and methodological research; CDC, 2009). The CDC disseminates community health assessments and information by way of print (e.g., publications in peer-review journals), electronic (e.g., Listserv and e-mail), audiovisual (e.g., audio and broadcast scripts), and oral (e.g., formal speeches and oral presentations; CDC, 2009).

Summary

This quantitative study was constructed to examine the association between vitamin D and depression status. The research methodology that was applied to achieve this purpose is specified in this chapter. Additionally, the population and sample, data collection procedures, and data analysis are specified in this chapter. Lastly, ethical considerations are identified to secure confidentiality and protection of those who are surveyed.

An analysis of the study, explanation of the results, significance, significance of the results, limitations of the study, and recommendations for prospective research are integrated into Chapter 4. Chapter 5 incorporates a summary of the data collected, the data analysis process, and the findings of the study, as they pertained to the hypotheses and research question.

Chapter 4: Results

Introduction

The purpose of this current quantitative study was to examine the relationship between vitamin D levels and depression, and how this relationship might be moderated by an individual's demographic characteristics (gender, age, smoking status, or marital status). The examination involved a nationwide sample of those aged 18 years and older, representing the U.S. population between 2005 and 2006. One research question was used to guide this quantitative study. The variables of interest included vitamin D, depression, and demographic characteristics.

This chapter begins with a summary of the applied statistical methods and the results consisting of a detailed summary of the evaluated participants. Next, this chapter presents a discussion of the descriptive statistics of the sample, and a review of the independent variable in relation to the criterion variable. The description of the sample is followed by a discussion of the data analyses, which made use of MMR analysis to determine if a significant relationship between depression and vitamin D levels was moderated by demographic characteristics (gender, age, smoking status, or marital status). Data were screened for univariate outliers, and tests for assumptions of normality, linearity, and homoscedasticity were conducted. Finally, this chapter concludes with a summary of my findings.

Data Collection

Data were collected from selected individuals, aged 18 years and higher, to examine the relationship between vitamin D levels and depression, and how this relationship might be moderated by an individual's demographic characteristics. Data

collection took place between January 2005 and December 2006. Data documenting vitamin D levels and depression, both with and without the covariates of gender, age, smoking status, or marital status were collected and analyzed using MMR. Data analyses were conducted on the entire data set using SPSS Statistics 22.0.

Population and Sample

The population of interest consisted of adults who are at least 18 years old located in the U.S.; approximately 210 million U.S. residents that fit this criterion. Complex, multistage probability technique was used to select participants for the NHANES project (CDC, 2013). The sampling procedure for the NHANES consisted of four phases to ensure statistical validity. Phase one involved selection of PSUs. The second phase involved PSUs being detached into divisions. In the third phase, random selection was performed for each housing unit from each neighborhood. The fourth phase of the sampling procedure pertained to individuals being drawn within allocated screening subdomains. The multi-stage procedure was established to ensure that the sample consisted of a representative sample of civilian, non-institutionalized US citizens (CDC, 2013).

Overestimating reduced the likelihood of biased estimates occurring in this current study, while increasing the reliability and validity of indicator estimates of health status. To reduce the occurrence of discrepancies during data collection, the NHANES program overestimated financially challenged people, adolescents, adults ≥ 60 years, African Americans, and Hispanics (CDC, 2009a). The sample did not include individuals living in nursing homes, members of the armed forces, institutionalized persons, or U.S. nationals living abroad.

Data Analysis Procedure

Inferential statistics were used to draw conclusions from the sample tested. SPSS 22.0 was used to code and tabulate scores collected from the survey and provide summarized values where applicable including the mean, central tendency, variance, and standard deviation. MMR analyses were used to evaluate the research question. The research question was:

RQ 1: What is the relationship between vitamin D levels and depression and is it moderated by demographic characteristics (gender, age, smoking status, or marital status)?

$H1_0$: There is no relationship between vitamin D levels and depression and it is not moderated by demographic characteristics (gender, age, smoking status, or marital status).

$H1_A$: There is a relationship between vitamin D levels and depression and it is moderated by demographic characteristics (gender, age, smoking status, or marital status).

Prior to analyzing the research question, data cleaning and data screening were undertaken to ensure the variables of interest met appropriate statistical assumptions. The following analysis was assessed using an analytic strategy in that the variables were first evaluated for missing data, univariate outliers, normality, linearity, and homoscedasticity. Subsequently, four MMR analyses were run to determine if any significant relationships existed between the variables of interest.

Analysis of Research Question 1

Research Question 1was evaluated using four MMR analyses to determine if a significant relationship existed between vitamin D levels and depression, and if the relationship was moderated by demographic characteristics (gender, age, smoking status, and marital status). The criterion variable for the four analyses was depression as measured by nine-items on the *Patient Health Questionnaire* (PHQ). Response parameters for the nine survey items were measured on a 3-point scale where 0 = *not at all* to 3 *nearly every day*. Composite scores were then calculated by summing case responses across the nine PHQ items, resulting in scores with a possible range between 0 and 27. That is, higher scores indicated higher levels of depression (i.e., 5 represents mild depression, 10 represents moderate depression, 15 represents moderately severe depression, and 20 represents severe depression).

The predictor variable for the four analyses was vitamin D levels as measured by the NHANES and defined in Chapter 3. The moderating variable for Analysis 1 was gender (male, female). The moderating variable for Analysis 2 was age groups (18-29 years old, 30-39 years old, 40-49 years old, 50-59 years old, 60 years and older). The moderating variable for Analysis 3 was smoking status (do not smoke at all, occasionally smoke). Lastly, the moderating variable for Analysis 4 was marital status (single, married).

This study's sample consisted of 4,773 adults who were at least 18 years old located in the United States and had taken part in NHANES during 2005 – 2006. The NHANES sample consisted of a representative sample of civilian, non-institutionalized US citizens, who were residing in the U.S. during the time of the study.

Data was collected from a valid sample of 2623 participants. Specifically, the majority of participants were female (56.5%, *n* = 1483) and the remaining 43.5% were male (*n* = 1140). Additionally, 16.7% of the participants were between 18 and 29 years old (*n* = 439), 17.9% were between 30 and 39 years old (*n* = 470), 19.1% were between 40 and 49 years old (*n* = 501), 16.3% were between 50 and 59 years old (*n* = 428), and 29.9% were 60 years and older (*n* = 785). Described in Table1 are frequency and percent statistics of participants' gender, marital status, and smoke status.

Table 1

Frequency and Percent Statistics of Participants' Gender and Age

Demographic	Frequency	Percent
Gender		
Male	1140	43.5
Female	1483	56.5
Age groups		
18 - 29 years old	439	16.7
30 - 39 years old	470	17.9
40 - 49 years old	501	19.1
50 - 59 years old	428	16.3
60 years and older	785	29.9

Note. Total *n* = 2623

Furthermore, the majority of participants were single (53.6%, *n* = 1217) and the remaining 46.4% were married (*n* = 1406). Lastly, there was a similar frequency of participants that smoked (50.4%, *n* = 1323) as compared to those that do not smoke (49.6%, *n* = 1300). Described in Table 2 are frequency and percent statistics of participants' gender, marital status, and smoke status.

Table 2

Frequency and Percent Statistics of Participants' Marital Status and Smoke Status

Demographic	Frequency	Percent
Smoke Status		
Do not smoke at all	1300	49.6
Smoke	1323	50.4
Marital Status		
Single	1406	53.6
Married	1217	46.4

Note. Total $n = 2623$

Data cleaning. Before the analyses were evaluated, the data were screened for missing data, univariate outliers, and multivariate outliers. Missing data were investigated using frequency counts. Upon review, it was found that 339 participants did not provide their smoke status. These participants were removed from the analysis. The data were screened for univariate outliers by transforming raw scores to z-scores and comparing z-scores to a critical range between -3.29 and +3.29, $p < .001$ (Tabachnick & Fidell, 2007). Z-scores that exceed this critical range are more than three standard deviations away from the mean and represent outliers. The distributions of Vitamin D and depression were evaluated, and 54 cases with univariate outliers were found and removed from the analysis. There were 3016 responses received from participants and 2623 were evaluated by the MMR analysis ($n = 2623$). Descriptive statistics for the criterion and predictor variables are displayed in Tables 3, 4, 5, 6, and 7.

Table 3 displays descriptive statistics for depression and vitamin D. The average depression score was 3.93 (SD = 3.42) while the average vitamin D score was 21.47 (SD = 21.47). Skewness for depression is 1.60 and skewness for vitamin D was 0.43.

Table 3

Descriptive Statistics of the Criterion and Predictor Variables

Variable	Min	Max	Mean	Std. Deviation	Skewness	Kurtosis
Depression	1.00	17.00	3.93	3.42	1.60	2.27
Vitamin D	3.00	52.00	21.47	8.87	0.43	-0.14

Note. n = 2623

Table 4 displays descriptive statistics for depression and vitamin D by gender (male, female). For males the average depression score was 3.75 (SD=3.42), while the average vitamin D score was 21.14 (SD = 8.32). Skewness for depression in males was 1.72 and skewness for vitamin D in males was 0.41. For females, skewness for depression was 1.52 and skewness for vitamin D was 0.43.

Table 4

Descriptive Statistics of the Criterion and Predictor Variables by Gender

Variable	*n*	Min	Max	Mean	Std. Deviation	Skewness	Kurtosis
Male							
Depression	1140	1.00	17.00	3.75	3.42	1.72	2.68
Vitamin D	1140	3.00	52.00	21.14	8.32	0.41	0.09
Female							
Depression	1483	1.00	17.00	4.07	3.42	1.52	2.02
Vitamin D	1483	3.00	52.00	21.73	9.26	0.43	-0.31

Table 5 displays descriptive statistics for depression and vitamin D by age (i.e., 18-29 years old, 30-39 years old, 40-49 years old, 50-59 years old, 60 years and older). For the age group 18-29 years old, the average depression score was 3.89 (SD = 3.38), while the average vitamin D score was 22.08 (SD= 9.35). Skewness for depression for

the age group 18-29 years old was 1.63 and skewness for vitamin D was 0.49. For the age group 30-39 years old, the average depression score was 3.67 (SD = 3.14), while the average vitamin D score was 21.94 (SD = 9.22). Skewness for depression for the age group 30-39 years old was 1.69 and skewness for vitamin D was 0.39. For the age group 40-49 years old, the average depression score was 4.39 (SD = 3.69), while the average vitamin D score was 20.66 (SD = 8.60). Skewness for depression for the age group 40-49 years old was 1.44 and skewness for vitamin D was 0.52. For the age group 50-59 years old, the average depression score was 4.24 (SD = 3.77), while the average vitamin D score was 21.40 (SD = 8.93). Skewness for depression for the age group 50-59 years old was 1.54 and skewness for vitamin D was 0.36. For the age group 60 years and older, the average depression score was 3.65, while the average vitamin D score was 21.42. Skewness for depression for the age group 60 years and older was 1.62 and skewness for vitamin D was 0.38. Descriptive statistics of the criterion and predictor variables by age group are displayed in Table 5.

Table 5

Descriptive Statistics of the Criterion and Predictor Variables by Age Groups

Variable	*n*	Min	Max	Mean	Std. Deviation	Skewness	Kurtosis
18-29 years old							
Depression	439	1.00	17.00	3.89	3.38	1.63	2.52
Vitamin D	439	3.00	52.00	22.08	9.35	0.49	-0.11
30-39 years old							
Depression	470	1.00	17.00	3.67	3.14	1.69	2.80
Vitamin D	470	5.00	51.00	21.94	9.22	0.39	-0.22
40-49 years old							
Depression	501	1.00	17.00	4.39	3.69	1.44	1.61
Vitamin D	501	4.00	50.00	20.66	8.60	0.52	0.07
50-59 years old							
Depression	428	1.00	17.00	4.24	3.77	1.54	1.81
Vitamin D	428	5.00	51.00	21.40	8.93	0.36	-0.39
60 years and older							
Depression	785	1.00	17.00	3.65	3.19	1.62	2.40
Vitamin D	785	3.00	52.00	21.42	8.48	0.38	-0.14

Table 6 displays descriptive statistics for depression and vitamin D by smoking status (do not smoke at all, smoke). For non-smokers, the average depression score was 4.26 (SD = 3.67), while the average vitamin D score was 21.87 (SD = 8.90). Skewness for depression in non-smokers was 1.45 and skewness for vitamin D in non-smokers was 0.39. For smokers, the average depression score was 3.61 (SD = 3.13), while the average vitamin D score was 21.09 (SD = 8.82). Skewness for depression in smokers was 1.75 and skewness for vitamin D in smokers was 0.47. Descriptive statistics of the criterion and predictor variables by smoking status are displayed in Table 6.

Table 6

Descriptive Statistics of the Criterion and Predictor Variables by Smoking Status

Variable	*n*	Min	Max	Mean	Std. Deviation	Skewness	Kurtosis
Do not smoke at all							
Depression	1300	1.00	17.00	4.26	3.67	1.45	1.48
Vitamin D	1300	3.00	52.00	21.87	8.90	0.39	-0.22
Smoke							
Depression	1323	1.00	17.00	3.61	3.13	1.75	3.29
Vitamin D	1323	3.00	51.00	21.09	8.82	0.47	-0.04

Table 7 displays descriptive statistics for depression and vitamin D by marital status (single, married). For single, the average depression score was 3.69 (SD = 3.23), while the average vitamin D score was 22.60 (SD = 8.66). Skewness for depression in single was 1.61 and skewness for vitamin D in single was 0.33. For married, the average depression score was 4.22 (SD = 3.61), while the average vitamin D score was 20.18 (SD = 8.93). Skewness for depression in married was 1.56 and skewness for vitamin D in married was 0.59. Descriptive statistics of the criterion and predictor variables by marital status are displayed in Table 7.

Table 7

Descriptive Statistics of the Criterion and Predictor Variables by Marital Status

Variable	*n*	Min	Max	Mean	Std. Deviation	Skewness	Kurtosis
Single							
Depression	1406	1.00	17.00	3.69	3.23	1.61	2.34
Vitamin D	1406	5.00	52.00	22.60	8.66	0.33	-0.16
Married							
Depression	1217	1.00	17.00	4.22	3.61	1.56	2.04
Vitamin D	1217	3.00	52.00	20.18	8.93	0.59	0.04

Test of normality. Before Analyses 1-4 were conducted, basic parametric assumptions were assessed. That is, for the criterion variable (depression) and predictor variable (vitamin D), assumptions of normality, linearity, and homoscedasticity were tested. Linearity and homoscedasticity were evaluated using scatterplots, and no violations were observed. To test if the distributions were significantly skewed, the skew coefficients were divided by the skew standard error, resulting in a z-skew coefficient. This technique was recommended by Tabachnick and Fidell (2007). Specifically, *z*-skew coefficients exceeding the critical range between -3.29 and +3.29 ($p < .001$) may indicate non-normality. Based on the evaluation of the z-skew coefficients, distributions for both the criterion and predictor variables exceeded the critical range (depression z-*skew* = 33.35 and vitamin D *z-skew* = 9.00).

Kurtosis was also evaluated using the same method, and the distribution of the criterion variable (depression) was found to be significantly kurtotic (*z-kurtosis* = 23.68). Although the distributions were significantly skewed and kurtotic, according to the central limit theorem, sample sizes of 30 or more approximates the mean of the population (Durrett, 2004). With this in mind, Tabachnick and Fidell (2007) posited that when a sample size exceeds 100, statistical tests that use the general linear model, such as regression and analysis of variance, are robust against violations of normality. The distributions were conditionally assumed to be normally distributed. Displayed in Table 8 are skewness and kurtosis statistics of the criterion and predictor variables.

Table 8

Skewness and Kurtosis Statistics of the Criterion and Predictor Variables

Variable	*n*	Skewness	Skew Std. Error	z-skew	Kurtosis	Kurtosis Std. Error	z-kurtosis
Depression	2623	1.60	0.05	33.35	2.27	0.10	23.68
Vitamin D	2623	0.43	0.05	9.00	-0.14	0.10	-1.44

Note. $n = 2623$

ANOVA Analyses

Two analyses of variance (ANOVA) were conducted to determine if there were significant differences in depression and vitamin D between gender, age, smoking status, and marital status. Specifically, analysis 1 evaluated differences in depression (dependent variable) and analysis 2 evaluated differences in vitamin D levels (dependent variable). The independent variables were gender (male, female), age (18-29 years old, 30-39 years old, 40-49 years old, 50-59 years old, 60 years and older), smoking status (do not smoke at all, occasionally smoke), and marital status (single, married).

ANOVA Analysis 1

Using SPSS 22, ANOVA was conducted to determine if a significant difference in depression existed between gender, age, smoking status, and marital status. Results indicated that a significant difference did exist between gender ($p < .001$), age ($p = .001$), smoking status ($p < .001$), and marital status ($p < .001$). That is, females had significantly higher depression scores ($M = 4.07$, $SD = 3.42$) than males ($M = 3.75$, $SD = 3.42$). For age, results from a Tukey post-hoc analysis indicated that there were several significant differences between age groups. Specifically, participants between 40 and 49 years old ($M = 4.39$, $SD = 3.69$) had significantly higher depression scores than participants between 30 and 39 years old ($M = 3.67$ $SD = 3.14$, $p = .008$) and participants

60 years and older (M = 3.65, SD = 3.19, p = .001)—see Table 15 in Appendix A for summary details of the post-hoc analysis. Additionally, participants between 50 and 59 years old (M = 4.24, SD = 3.77) had significantly higher depression scores than participants 60 years and older (p = .030). Furthermore, participants that did not smoke had significantly higher depression scores (M = 4.26, SD = 3.67) as compared to those that do not smoke (M = 3.61, SD = 3.13). Lastly, married participants had significantly higher depression scores (M = 4.22, SD = 3.61) than single participants (M = 3.69, SD = 3.23). A model summary of the ANOVA analysis is displayed in Table 9.

Table 9

Model Summary of ANOVA Analysis of Analysis 1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.(p)	Partial Eta Squared	Observed Power
Corrected Model	1216.092	39	31.182	2.731	< .001	.040	1.000
Intercept	35221.613	1	35221.613	3084.417	< .001	.544	1.000
Gender	141.868	1	141.868	12.424	< .001	.005	.941
Age	223.354	4	55.839	4.890	.001	.008	.960
Smoke Status	377.096	1	377.096	33.023	< .001	.013	1.000
Marital Status	156.137	1	156.137	13.673	< .001	.005	.959
Error	29495.828	2583	11.419				
Total	71268.000	2623					
Corrected Total	30711.921	2622					

Note. Dependent variable = depression

ANOVA Analysis 2

ANOVA was conducted to determine if a significant difference in vitamin D levels existed between gender, age, smoking status, and marital status. Results indicated that a significant difference did exist between gender (*sig.* = .004), smoking status (p = .001), and marital status (p < .001). That is, females had significantly higher vitamin D levels (M = 21.73, SD = 9.26) than males (M = 21.14, SD = 8.32). Furthermore, participants that did not smoke had significantly higher vitamin D levels (M = 21.87, SD

= 8.90) as compared to those that do not smoke (M = 21.09, SD = 8.82). Lastly, single participants had significantly higher vitamin D levels (M = 22.60, SD = 8.66) than married participants (M = 20.18, SD = 8.93). There were no significant differences in vitamin D levels between age groups (p = .313). A model summary of ANOVA Analysis of Analysis 2 is displayed in Table 10.

Table 10

Model Summary of ANOVA Analysis of Analysis 2

Source	Type III Sum of Squares	df	Mean Square	F	Sig.(p)	Partial Eta Squared	Observed Power
Corrected Model	10972.316	39	281.341	3.725	< .001	.053	1.000
Intercept	1029044.010	1	1029044.010	13624.755	< .001	.841	1.000
Gender	628.105	1	628.105	8.316	.004	.003	.822
Age	359.364	4	89.841	1.190	.313	.002	.377
Smoke Status	878.370	1	878.370	11.630	.001	.004	.926
Marital Status	3102.214	1	3102.214	41.074	< .001	.016	1.000
Error	195087.592	2583	75.528				
Total	1415555.000	2623					
Corrected Total	206059.909	2622					

Note. Dependent variable = vitamin D

Results Analysis 1

Using SPSS 22.0, Analysis 1was evaluated using regression and moderated multiple regression (MMR) analysis to determine if a significant relationship existed between depression and vitamin D levels, and if that relationship was moderated by gender. Regression analysis was used to determine if a significant relationship existed between depression and vitamin D. Results indicated that a significant, negative relationship did exist between participants' depression and vitamin D, R = .075, R^2 = .006, $F(1, 2621) = 14.703$, *sig. (p)* < .001. A model summary of the regression analysis is displayed in Table 11.

Table 11

Model Summary of Regression Analysis

Source	R	R^2	Standard Error	F	Sig. (p)
Omnibus Model	.075	.006	3.414	14.703	< .001

	Unstandardized Coefficients		Standardized Coefficients		
Source	B	Std. Error	Beta	t	Sig. (p)
(Constant)	4.551	0.175		26.053	< .001
Vitamin D	-0.029	0.008	-0.075	-3.835	< .001

Note. Dependent variable = depression

MMR was used to test if gender moderated the relationship between vitamin D and depression. MMR Results indicated that there was a significant relationship between depression and vitamin D levels, $R = .09$, $R^2 = .01$, $F(2, 2620) = 10.59$, $p < .001$; however, results indicated that the relationship between depression and vitamin D was not significantly moderated by gender, $\Delta R^2 = .001$, $\Delta F(1, 2619) = 2.60$, $\Delta sig.\ (p) = .11$ (two-tailed). A model summary of the MMR for Analysis 1 is displayed in Table 12.

Table 12

Model Summary Generated from Moderated Multiple Regression Analysis 1

Model	R	R^2	ΔR^2	ΔF	df1	df2	ΔF Sig. (p)
1	.09	.01	.01	10.59	2	2620	< .001
2	.10	.01	< .01	2.60	1	2619	.11

	Unstandardized		Standardized			
Variable	B	S.E.	Beta	t	Sig. (p)	Partial Correlation
Model 1						
(Constant)	4.03	0.27		14.97	< .001	
Vitamin D	-0.03	0.01	-0.08	-3.92	< .001	-0.08
Gender	0.34	0.13	0.05	2.54	0.01	0.05
Model 2						
(Constant)	3.17	0.60		5.32	< .001	
Vitamin D	0.01	0.03	0.03	0.42	0.68	0.01
Gender	0.87	0.36	0.13	2.45	0.01	0.05
Interaction 1	-0.03	0.02	-0.14	-1.61	0.11	-0.03

Note. Dependent variable = depression
Interaction 1 = vitamin D * gender

Results Analysis 2

Analysis 2 was evaluated using MMR analysis to determine if the significant relationship between depression and vitamin D levels was moderated by age groups (18-29 years old, 30-39 years old, 40-49 years old, 50-59 years old, 60 years and older). As found in Analysis 1, there was a significant relationship between depression and vitamin D levels, $R = .08$, $R^2 = .01$, $F(2, 2620) = 7.58$, $p < .01$; however, results indicated that the relationship between depression and vitamin D was not significantly moderated by age groups, $\Delta R^2 < .001$, $\Delta F(1, 2619) = 0.54$, $\Delta sig.(p) = .46$ (two-tailed). A model summary of the MMR for Analysis 2 is displayed in Table 13.

Table 13

Model Summary Generated from Moderated Multiple Regression Analysis 2

Model	R	R^2	ΔR^2	ΔF	df1	df2	ΔF Sig. *(p)*
1	.08	.01	.01	7.58	2	2620	< .01
2	.08	.01	< .001	0.54	1	2619	.46

	Unstandardized		Standardized			
Covariate	B	S.E.	Beta	t	Sig. (*p*)	Partial Correlation
Model 1						
(Constant)	4.65	0.23		20.10	< .001	
Vitamin D	-0.03	0.01	-0.08	-3.85	< .001	-0.08
Age groups	-0.03	0.05	-0.01	-0.68	0.50	-0.01
Model 2						
(Constant)	4.40	0.42		10.47	< .001	
Vitamin D	-0.02	0.02	-0.05	-0.97	0.33	-0.02
Age groups	0.05	0.12	0.02	0.42	0.67	0.01
Interaction 2	< 0.01	0.01	-0.05	-0.73	0.46	-0.01

Note. Dependent variable = depression
Interaction 2 = vitamin D * age groups

Results Analysis 3

Analysis 3 was evaluated using MMR analysis to determine if the significant relationship between depression and vitamin D levels was moderated by smoke status (do not smoke at all, occasionally smoke). As found in Analyses 1 and 2, there was a significant relationship between depression and vitamin D levels, $R = .12$, $R^2 = .02$, $F(2, 2620) = 20.59$, $p < .001$. However, results indicated that the relationship between depression and vitamin D was not significantly moderated by smoke status, $\Delta R^2 < .001$, $\Delta F(1, 2619) = 1.04$, $\Delta sig.(p) = .31$ (2-tailed). A model summary of the MMR for Analysis 3 is displayed in Table 14.

Table 14

Model Summary Generated from Moderated Multiple Regression Analysis 3

Model	R	R^2	ΔR^2	ΔF	df1	df2	ΔF Sig (p).
1	.12	.02	.02	20.59	2	2620	< .001
2	.13	.02	< .001	1.04	1	2619	.31

	Unstandardized		Standardized			
Covariate	B	S.E.	Beta	t	Sig. (p)	Partial Correlation
Model 1						
(Constant)	5.61	0.27		20.77	< .001	
Vitamin D	-0.03	0.01	-0.08	-4.08	< .001	-.08
Smoke Status	-0.68	0.13	-0.10	-5.13	< .001	-.10
Model 2						
(Constant)	6.11	0.56		10.99	< .001	
Vitamin D	-0.05	0.02	-0.14	-2.25	.02	-.04
Smoke Status	-1.01	0.35	-0.15	-2.90	< .01	-.06
Interaction 3	0.02	0.02	0.08	1.02	.31	.02

Note. Dependent variable = depression
Interaction 3 = vitamin D * smoke status

Results Analysis 4

Analysis 4 was evaluated using MMR analysis to determine if the significant relationship between depression and vitamin D levels was moderated by marital status (single, married). As found in Analyses 1-3, there was a significant relationship between depression and vitamin D levels, $R = .10$, $R^2 = .01$, $F(2, 2620) = 13.48$, $p < .001$. However, results indicated that the relationship between depression and vitamin D was not significantly moderated by marital status, $\Delta R^2 < .001$, $\Delta F(1, 2619) = 1.27$, $\Delta sig.(p) = .26$ (two-tailed). The null hypothesis was partially retained. That is, there was a significant relationship between vitamin D levels and depression, however the relationship was not moderated by demographic characteristics (gender, age, smoking status, or marital status). A model summary of the MMR for Analysis 4 is displayed in Table 15.

Table 15

Model Summary Generated from Moderated Multiple Regression Analysis 4

Model	R	R^2	ΔR^2	ΔF	df1	df2	ΔF Sig.(p)
1	.10	.01	.01	13.48	2	2620	< .001
2	.10	.01	< .001	1.27	1	2619	.26

	Unstandardized		Standardized			
Covariate	B	S.E.	Beta	t	Sig. (*p*)	Partial Correlation
Model 1						
(Constant)	3.79	0.28		13.52	< .001	
Vitamin D	-0.03	0.01	-0.07	-3.33	< .001	-.07
Marital Status	0.47	0.14	0.07	3.49	< .001	.07
Model 2						
(Constant)	4.34	0.56		7.71	< .001	
Vitamin D	-0.05	0.02	-0.13	-2.14	.03	-.04
Marital Status	0.11	0.35	0.02	0.30	.76	.01
Interaction 4	0.02	0.02	0.08	1.13	.26	.02

Note. Dependent variable = depression
Interaction 4 = vitamin D * marital status

A final model was generated to observe the association between vitamin D and depression after controlling for age, marital status, gender, and smoke status. Sequential regression was used to test the final model where block 1 contained the four covariates, and block 2 added vitamin D. Sequential regression is used to examine r-squared change to determine if an association exists between vitamin D and depression after controlling for the effects of the covariate. Based on findings, a significant relationship was found between vitamin D and depression after controlling for the effects of age, marital status, gender, and smoke status; $\Delta R^2 = .01$, $\Delta F(1, 2619) = 14.34$, $\Delta Sig.\ (p). < .001$ (two-tailed) A model summary of the final model is displayed in Table 16.

Table 16

Final Model Summary Generated from Sequential Multiple Regression Analysis

Model	R	R^2	ΔR^2	ΔF	df1	df2	ΔF Sig.(p)
1	0.14	0.02	0.02	12.96	4	2620	< .001
2	0.16	0.03	0.01	14.34	1	2619	< .001

	Unstandardized		Standardized			
Covariate	B	S.E.	Beta	t	Sig. (p)	Partial Correlation
Model 1						
(Constant)	3.79	0.44		8.65	< .001	
Gender	0.64	0.16	0.08	4.10	< .001	.08
Smoke Status	-0.80	0.15	-0.11	-5.37	< .001	-.10
Marital Status	0.72	0.15	0.09	4.77	< .001	.09
Age	-0.01	< .01	-0.05	-2.34	.02	-.05
Model 2						
(Constant)	4.72	0.49		9.73	< .001	
Gender	0.68	0.16	0.09	4.37	< .001	.08
Smoke Status	-0.84	0.15	-0.11	-5.66	< .001	-.11
Marital Status	0.63	0.15	0.08	4.12	< .001	.08
Age	-0.01	< .01	-0.05	-2.46	.01	-.05
Vitamin D	-0.04	0.01	-0.09	-4.40	< .001	-.09

Note: Dependent Variable = Depression

Summary

In summary, vitamin D is essential to optimizing health and preventing disease (Bertone-Johnson, 2009). Therefore, there is a need to determine whether VDD is physiologically correlated to the occurrence of depression (Bertone-Johnson, 2009). My intent for researching this current study was to explore whether there is a relationship between vitamin D levels and depression, and how this might be moderated by an individual's demographic characteristics such as gender, age, smoking status, or marital status.

The ex-post facto exploratory MMR analysis of this current study indicated that there was a significant relationship between vitamin D levels and depression; however

the relationship was not moderated by demographic characteristics (gender, age, smoking status, or marital status). Table 17 provides a summary of the results for all analyses. There were no statistically significant relationships between any of the predictor variables, concluding that the predictor variables and the interaction effects do not have a significant effect on the outcome variable. In Chapter 5, I provide a detailed discussion of these results. Additionally, I present study limitations, recommendations for future studies, and implications for social change. The final model, though did find a significant relationship between vitamin D and depression after controlling for the four covariates.

Table 17

Summary of Results for Analyses 1-4

Hypothesis	Criterion Variable	Predictor Variable	Moderator	Test	Δ Sig.(p)
1	Depression	Vitamin D Levels	Gender	Moderated Multiple Regression	.11
2	Depression	Vitamin D Levels	Age Groups	Moderated Multiple Regression	.46
3	Depression	Vitamin D Levels	Smoke Status	Moderated Multiple Regression	.31
4	Depression	Vitamin D Levels	Marital Status	Moderated Multiple Regression	.26
Final Model	Depression	Vitamin D Levels	Gender, Age, Smoke, and Marital Status	Sequential Regression	< .001

Chapter 5: Discussion

Introduction

The purpose of this current quantitative study was to examine the relationship between vitamin D levels and depression, and how this relationship might be moderated by an individual's demographic characteristics (gender, age, smoking status, or marital status). Results of the analyses indicate that vitamin D levels are associated with depression. Yet, following the adjustment of demographic characteristics, the relationship between vitamin D levels and depression was not moderated by demographic characteristics (gender, age, smoking status, or marital status). The findings of this study contribute to the existing body of literature that has explored the implications of VDD in relation to mental health by confirming the correlation with depression and indicating that this finding did not vary by the selected moderating variables of gender, age, smoking status, or marital status.

Many studies have researched the relationship of vitamin D status in persons with depression. However, to date, the results of these studies remain controversial (Bertone-Johnson, 2009; Harris & Dawson-Hughes, 1993; Kwasky, & Groh, 2012; Schneider, Weber, Frensch, Stein, & Fritze, 2000). Prior to the current study, no published research has explored the association between vitamin D levels and depression by determining if this relationship is moderated by demographic characteristics (gender, age, smoking status, or marital status). My purpose was to highlight original research by offering a new perspective to the field of public health.

This current study provides evidence-based research to support the implementation and achievement of the 10-year national objectives set forth by

HealthyPeople 2020, which is a strategic plan for improving the health of all Americans. As the federal government continues to enhance health reform legislation, this study can provide direction to persons with VDD and depression and their providers, including new screening opportunities and education services that empower individuals to make informed health decisions.

Bertone-Johnson (2009) conducted a meta-analysis that investigated primary research literature that suggested and refuted whether serum vitamin D and depression are associated. Bertone-Johnson completed the study without conclusion and recommended further research. Further, Bertone-Johnson cautioned that it was premature to relate the occurrence of depression to vitamin D status and that many cross-sectional studies have presented unadjusted results not taking into consideration confounders (e.g., age, time spent outdoors, latitude, physical activity, body mass index, smoking and alcohol use; Brot, Jorgensen, & Sorensen, 1999; Gerdhem, Ringsberg, Obrant, & Akesson, 2005; Holick, 2008; Santori et al., 2008). These same confounders are also associated with depression and vitamin D status (Jané-Llopis & Matytsina, 2006; Pasco et al., 2008; Roberts, Kaplan, Shema, & Strawbridge, 1997). Researchers have not been able to determine whether these associations occur from confounders (Michelson et al., 1996; Schneider et al., 2000; Wilkins, Sheline, Roe, Birge, & Morris, 2006).

Each year nearly 13 million adults in the U.S. experience depression, a serious and disabling mental health issue causing social distress and impaired quality of life (Kessler et al., 2010). According to the CDC (2011b), from 2001 to 2006, approximately 33% of the U.S. population was at risk of having low levels of vitamin D (serum 25OHD 30–49 nmol/L), while approximately 8% were at risk of VDD (serum 25OHD less than

30 nmol/L). Further, the prevalence was higher in persons who were adult, female, or minority (CDC, 2011b). This study was conducted to determine if statistical and theoretical support should be applied for the association of vitamin D levels and depression. Although there is evidence that Vitamin D is vital to enhancing health and reducing the risk of disease (Bertone-Johnson, 2009), there is a paucity of research whether VDD is physiologically related to the occurrence of depression (Bertone-Johnson, 2009). This study was conducted to explore whether there is a relationship between vitamin D levels and depression, and how this might be moderated by an individual's demographic characteristics such as gender, age, smoking status, or marital status.

This present study was developed according to a quantitative, ex-post facto comparative research design. Medical, mental, and laboratory results were derived from 2005-2006 NHANES data (CDC, 2013). The study's sample consisted of adults at least 18 years old, resided in the U.S., and had taken part of the NHANES in 2005 – 2006. The single research question for this present study integrated a MMR analysis to determine the effect of a predictor variable (VDD) on a criterion variable (depression), is dependent on the moderators (gender, age, smoking status, and marital status). Moderators were introduced to explore if the demographic characteristics impact the relationship between depression and vitamin D levels, which helped determine that the predictor variable was correlated to the criterion variable. Further, I would have been able to determine the magnitude of any effect if the moderating variables had exerted influence on the correlation.

Summary of Findings

In this study, a sample of 2623 adults located within the United States were evaluated. Data was entered into SPSS 22.0 and were then tested using MMR analysis to evaluate the research question. The research question was, *What is the relationship between vitamin D levels and depression and is it moderated by demographic characteristics (gender, age, smoking status, or marital status)?*

Results of Research Hypothesis 1

$H1_0$: There is no relationship between vitamin D levels and depression, and it is not moderated by demographic characteristics (gender, age, smoking status, or marital status).

$H1_A$: There is a relationship between vitamin D levels and depression, and it is moderated by demographic characteristics (gender, age, smoking status, or marital status).

Using SPSS 22.0, Hypothesis 1 was evaluated using four MMR analyses to determine if a significant relationship existed between vitamin D levels and depression, and if the relationship was moderated by demographic characteristics (gender, age, smoking status, and marital status). Results from Analyses 1-4 indicated that there was a significant relationship between depression and vitamin D levels ($p < .001$). However, the relationship between depression and vitamin D was not significantly moderated by gender ($\Delta p = .11$), age ($\Delta p = .46$), smoke status ($\Delta p = .31$), or marital status ($\Delta p = .26$). The null hypothesis for the Research Question was rejected in part and retained in part. Though a correlation was found between vitamin D and depression, the moderating variables did not exert influence.

This data represents new findings that contribute to the literature on addressing VDD and depression, which may further lead investigators to lower the rates of both adverse health conditions. Further, inconsistencies in the prior research stem from a failure to identify any possible significant differences in this relationship by gender, age, smoking status, or marital status. This current study has the potential to assist public health practitioners in promoting prevention strategies and developing appropriate intervention strategies designed to address at risk individuals with VDD and depression.

The findings of this study are significant for determining the relationship between vitamin D levels and depression, which can assist with distinguishing groups at risk of VDD and depression and measures to target solutions directed toward these particular individuals. The model in this study supports prior research that had also affirmed a correlation between vitamin D levels and depression **(**Jorde et al., 2008; Kjaergaard et al., 2012; Lansdowne & Provost, 1988).

Strengths of the Study

The current study obtained data from a nationally representative multistage, random sample of non-institutionalized individuals who reported being 18 years or older at the time of data collection. The survey set files were in SAS transport file format, which were used to account for complex probability and proper analysis of the data that specifically incorporated sample design complications such as weighting and clustering. Data for the study was obtained from NHANES 2005-2006. Analytic guidelines were followed to monitor weighting, variance estimation, and sample design to ensure recommended methodologies were compliant when obtaining survey estimates, computing sample variances, and recommending sample sizes for analysis. Further,

through the protection of public health laws, all data collected is private and strictly confidential.

Limitations of the Study

As with most research, the results of this study are constrained by a number of limitations that must be acknowledged. Though these limitations must be considered in relation to the study findings, the conclusions of the study make a valuable contribution to the existing body of literature on this subject. First, it must be noted that the causal relationship between VDD or vitamin D levels cannot be established based on the nature of the MMR analysis. Kjaergaard et al. (2012) indicated that the association between VDD and depression could be bidirectional, which suggests more research is needed to determine causality.

Generalizability

This study targeted only non-institutionalized adults over the age of 18 years; this may have impacted the generalizability of my results because of partial representation. The sample consisted of non-institutionalized civilian adults who were at least 18 years old, resided in the U.S and had taken part of the NHANES in 2005 – 2006. In addition, I cannot determine whether there are limitations to NHANES ability to estimate population trends that are pertinent. Therefore, these findings may not be generalizable to other populations.

Validity

This current study's assessment was conducted using the PHQ-9 questionnaire, a screening and diagnostic instrument, which measures depression. According to Kroenke et al. (2001), the PHQ enables provisional depressive disorder diagnoses and establishes

depressive symptom severity. Data from the PHQ-9 were collected to determine a respondents' major depression score according to the respondents' self-reported retrospective perception. Although the CDC (2013) considers the PHQ a reliable and valid tool for diagnosing depression, concerns with validity should be considered because perceptions of oneself may be different than reality, as seen by the interviewer or others. Although PHQ-9 is a useful screening instrument and is efficient for assessing a general population (Inoue et al., 2012), research validating the specificity of the PHQ-9 questionnaire remains unavailable (Kroenke et al., 2001).

Reliability

NHANES is a reliable reference that is dependable, accurate, and honest (CDC, 2013). Federal agencies (e.g., the National Institutes of Health, the Food and Drug Administration, and CDC) formulate and implement national health policy agendas and resource allocation activities. Such research centers depend on NHANES to develop and disseminate data necessary for planning and executing public health activities (Novick, Morrow, & Mays, 2008). As a reliable source of national-level prevalence and tends of selected diseases and risk factors, NHANES facilities community health planning and monitoring prevention effectiveness. To generate reliable statistics, over-sampling occurred to adjust the class distribution of the data set. As a means to control reliability, a U.S. national representation of those 18 years and older, (i.e., persons 60 and older, African American, and Hispanics) were over-sampled to ensure that there were enough respondents reporting for this group.

However, the use of secondary data increases the probability of measurement error and data variance. Error can occur due to constructs and content validity of the data

collected. Further, standard concept error could have presented errors to invalidate secondary data. For instance, the PHQ-9 questionnaire has limited control over reliability, because healthcare clinicians were not onsite to assess clinical findings for depression. Further, the PHQ-9 questionnaire has limited control over reliability because the instrument is not applicable for diagnosing current depressive episodes a participant may be experiencing while taking the questionnaire (Kroenke et al., 2001). Further, deception can occur to avoid embarrassment in answering questions truthfully when answering the PHQ-9 questionnaire. Participants may have been improperly classified as not having depression, which may impact this present study's reliability.

Also, my actions and attitude when collecting the data could have played a role in measurement error (i.e., deviating from the true value's outcome when measuring results). Finally, lag time may have played a role with increasing measurement error and data variance due to the time that primary data was collected is different that the time the data was published. For instance, in this study participants were examined for depression and vitamin D levels in 2005 and 2006; however, results were not published until 2008 and updated in 2010, respectively.

Further, to produce reliable statistics, the CDC tested and retested the NHANES data and the information collected during MEC interviews were electronically recorded. Also, quality control processes (*e.g.,* checking for variable frequency counts and patterns of skipping questions), were implemented to verify collection of correct data and ensure the survey produces stable and consistent results (CDC, 2013).

Recommendations

Recommendations for Future Research

The results of this current study provide a basis for multiple recommendations. Some recommendations for further research are grounded in the limitations of the current study, involving generalization, validity, and reliability. To test this current study's hypothesis, archival data during 2005 – 2006 was chosen from the NHANES data set. The entire data set was used to reflect the entire population and to answer the research question. To reduce the generalizability to the U.S. population as a whole, volunteers who participated in the NHANES were required to be at least 18 years, residing in the United States, were not institutionalized, and were mentally capable of responding to a questionnaire. However, persons living in long-term care facilities, members of the federal military forces of the United States, those who are institutionalized, and U.S. nationals living in a foreign country, were not included in this current study. A future study may consider including these populations as part of the larger group, or may examine these populations individually to gain insights into how they may be similar to or different from the participant who were eligible for inclusion under the NHANES parameters.

Additional recommendations for further research emerge from an examination of the results of this study in relation to the literature reviewed in Chapter Two. More research is needed to determine what role vitamin D supplementation may involve with preventing and treating depression (Penckofer, Kouba, Byrn, & Ferrans, 2010). Currently, public health initiatives are invested into raising awareness about the importance of physical exercise, consuming foods with adequate vitamin D or

supplementing a sufficient amount of vitamin D, to reduce the prevalence of VDD in the U.S. If by improving vitamin D levels could enhance mental health, then taking part in physical activity in the sun and consuming nutrients rich in vitamin D to improve VDD could be measures that are simple and cost-effective to potentially reduce risks for depression (Penckofer et al., 2010). Additional research is necessary to explore the potential of supplementation in addressing this issue.

The inclusion of ethnicity as a moderating variable was beyond the scope of this study, yet ethnicity may influence VDD on depression in adults. This current study had ample representation of Non-Hispanic White, Non-Hispanic Black, and Hispanic participants. However, the non-Hispanic Asian American population lacked sufficient representation of participants in the current study. The 2005-2006 NHANES could have oversampled non-Hispanic Asian Americans to disseminate whether there is an influence of VDD on depression and is it moderated by demographic characteristics (gender, age, smoking status, or marital status) on this population subgroup. Further, data analysis involving non-Hispanic Asian Americans may add to the knowledge of ethnic differences.

Recommendations for Practice

Most people in the United States do not recognize the severity of vitamin D status, largely because many who have VDD feel asymptomatic (Holick, 2008). Yet, scholar practitioners are aware that VDD can raise the risk for depression, type 1 diabetes, type 2 diabetes, cardiovascular disease, stroke, auto-immune diseases (*e.g.*, multiple sclerosis and rheumatoid arthritis; Thacher & Clarke, 2011). People often believe that they will know when the onset of VDD occurs. Signs and symptoms of

vitamin D deficiency frequently include pain in bones, joints, and muscles, which can lead to healthcare clinicians misdiagnosing as fibromyalgia, chronic fatigue syndrome, or depression (Holick, 2008). The connection between vitamin D status and symptoms revealed are often not identified by general routine examination (Thacher & Clarke, 2011).

However, prompt medical treatment and assertive vitamin D replacement are advised at the onset of VDD (Thacher & Clarke, 2011). Often medical practioners only provide a person who is vitamin D deficient with the required daily amount (i.e., 1000 IU/day) of vitamin D3 (Holick, 2008). This approach does not increase serum levels of 25(OH)D sufficiently (Kjærgaard et a., 2012). Although no international standard has been established for vitamin D sufficiency, clinicians should consider rectifying VDD by understanding that the total dose of vitamin D is more predictive of vitamin D sufficiency rather than the frequency of dosing (Ish-Shalom et al., 2008).

Pepper, Judd, Nanes, and Tangpricha (2009) performed a retrospective analysis to examine a suitable regimen that can be introduced to correct vitamin D insufficiency in healthy adults. Approximately 300 healthy adults were prescribed varying levels of vitamin D_2 to determine the most effective amount to achieve vitamin D sufficiency. The investigators concluded that at least 600,000 IU of vitamin D2 appeared to be the most effective in achieving vitamin D sufficiency in nearly 65% of cases, avoiding vitamin D toxicity. Pepper et al. (2009), also indicate that guidelines for treatment of vitamin D insufficiency be developed for clinical practice to standardize the management of vitamin D insufficiency in healthy adults.

Implications for Positive Social Change

This current study is a response to significant impacts that depression is having on the United States, which leads to economic strain, adversity, and dissatisfaction. In 2012, United States health care spending exceeded $2.8 trillion, or $8,915 per person (Martin, Hartman, Whittle, & Catlin, 2014). However, more than $25 billion was annually attributed to medical costs directed toward depression (Wade & Häring, 2010). People with depression and those who are providing care to those with depression can be emotionally impacted, which can lead to immense suffering and interfere with QOL.

These results reflect spending costs toward depression. However, the spending amount attributed to depression could be higher than $2.8 trillion; many people who have a depressive disorder do not pursue treatment (National Institute of Mental Health, 2013). Further, the results do not reflect psychological and emotional costs that can be attributed to families, organizations, and societies. There is a need for positive social change at all impacted levels (individual, family, organizational, and societal/policy).

The material collected in this study contribute to improving human and social conditions by recommending efficient measures (e.g., screening and counseling) for patients with VDD to successfully respond to depression. This study focused on exploring whether there is a relationship between vitamin D levels and depression, and how this might be moderated by an individual's demographic characteristics such as gender, age, smoking status, or marital status. Understanding the connection between VDD and depression provides a basis on which to foster positive social change at the individual level, family, organizational, and societal level.

The results of the current study support positive social change aimed at broadening the understanding of a relationship between vitamin D levels and depression. This increased knowledge can positively enhance the general public's understanding of predictors of depression in persons with VDD. In addition, the results of this study can contribute to preventive strategies related to both depression and VDD when allocating resources and targeting education programs. This study can also provide a basis for additional research focused on distinguishing groups at risk for VDD and depression, noting that the presence of one may be correlated with the presence of the second condition.

The connection between vitamin D levels and depression status suggests that there is a need to recognize VDD as part of screening for development or triggering of depression risk factors (persistent feeling of sadness and loss of interest; emotional and physical distress). The current study shows that VDD and depression are related, thereby extending the existing literature that improvements in QOL, physical health and mental health are correlated to the relationship between VDD and depression. Screening individuals with low levels of vitamin D may be a cost effective measure for determining potential depression.

Conclusion

The personal and public health consequences of depression and VDD are significant and evident. Depression is a significant and debilitating health illness that can impair an individual's quality of life and cause regular activities to become challenging. Further, some people may be challenged with depression while concomitantly managing an additional chronic disease, which can impact the individual and their surroundings

(e.g., emotional burdens on family members and financial impact on society). Failure to treat VDD or depression accordingly and effectively may cause further complications that may result in diminished quality of life to the individual and higher healthcare costs. Proper identification, analysis, and therapy may aid with early identification of at-risk patients. Also, efficient tools and evidence-based protocols that provide an aligned intervention that is patient centric can be valued as a holistic healthcare solution. By proactively adopting practices and focusing on solutions that target the needs of persons with depression and low vitamin D levels, public health practitioners can enable positive outcomes and enhance patient quality of life in a measure that is cost-effective and simple.

The results of this study provide a basis for constructive and effective social change in adults residing in the United States who are 18 years and older by implementing practices that acknowledge and address the connection between VDD and depression. This study reports ample statistical evidence to suggest an important role for vitamin D in the incidence of depression. However, demographic characteristics (gender, age, smoking status, and marital status) were reported not to have a significant role with the association between vitamin D levels and depression. Consideration of demographic characteristics (gender, age, smoking status, and marital status) does not statistically satisfy the criteria of being significantly associated. Therefore, until further investigations are conducted, determining demographic characteristics (gender, age, smoking status, and marital status) during screening should not be applied to populations who are at greater risk for VDD.

According to Penckofer et al. (2010), prompt detection and effective treatment when managing vitamin D levels in persons with depressive disorders may be a means to enhance an individual's prospective health outcomes and their quality of life. From an evidence based research perspective, this current study provides empirical understandings for practice when investigating depression rates stemmed from low levels of vitamin D. Further, this current study may provide positive social change by strengthening public health policies and services.

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Appendix A

Tables

Skewness and Kurtosis Statistics

Table 18

Skewness and Kurtosis Statistics of the Criterion and Predictor Variables by Gender

Variable	*n*	Skewness	Skew Std. Error	z-skew	Kurtosis	Kurtosis Std. Error	z-kurtosis
Male							
Depression	1140	1.72	0.07	23.86*	2.68	0.15	18.50*
Vitamin D	1140	0.41	0.07	5.74*	0.09	0.15	0.64
Female							
Depression	1483	1.52	0.06	23.78*	2.02	0.13	15.91*
Vitamin D	1483	0.43	0.06	6.64*	-0.31	0.13	-2.46

**Note*. Distribution was significantly skewed/kurtotic (*z-skew/kurtosis* > 3.29)

Table 19

Skewness and Kurtosis Statistics of the Criterion and Predictor Variables by Age Groups

Variable	*n*	Skewness	Skew Std. Error	z-skew	Kurtosis	Kurtosis Std. Error	z-kurtosis
18-29 years old							
Depression	439	1.63	0.12	13.89*	2.52	0.23	10.80*
Vitamin D	439	0.49	0.12	4.16*	-0.11	0.23	-0.45
30-39 years old							
Depression	470	1.69	0.11	14.99*	2.80	0.23	12.44*
Vitamin D	470	0.39	0.11	3.43*	-0.22	0.23	-0.96
40-49 years old							
Depression	501	1.44	0.11	13.25*	1.61	0.22	7.40*
Vitamin D	501	0.52	0.11	4.75*	0.07	0.22	0.34
50-59 years old							
Depression	428	1.54	0.12	13.03*	1.81	0.24	7.68*
Vitamin D	428	0.36	0.12	3.07	-0.39	0.24	-1.65
60 years and older							
Depression	785	1.62	0.09	18.66*	2.40	0.17	13.80*
Vitamin D	785	0.38	0.09	4.38*	-0.14	0.17	-0.78

**Note*. Distribution was significantly skewed/kurtotic (*z-skew/kurtosis* > 3.29)

Table 20

Skewness and Kurtosis Statistics of the Criterion and Predictor Variables by Smoking Status

Variable	*n*	Skewness	Skew Std. Error	z-skew	Kurtosis	Kurtosis Std. Error	z-kurtosis
Do not smoke							
Depression	1300	1.45	0.07	21.25*	1.48	0.14	10.85*
Vitamin D	1300	0.39	0.07	5.79*	-0.22	0.14	-1.63
Smoke							
Depression	1323	1.75	0.07	26.15*	3.29	0.13	24.53*
Vitamin D	1323	0.47	0.07	7.01*	-0.04	0.13	-0.30

**Note*. Distribution was significantly skewed/kurtotic (*z-skew/kurtosis* > 3.29)

Table 21

Skewness and Kurtosis Statistics of the Criterion and Predictor Variables by Marital Status

Variable	*n*	Skewness	Skew Std. Error	z-skew	Kurtosis	Kurtosis Std. Error	z-kurtosis
Single							
Depression	1406	1.61	0.07	24.78*	2.34	0.13	17.98*
Vitamin D	1406	0.33	0.07	5.09*	-0.16	0.13	-1.20
Married							
Depression	1217	1.56	0.07	22.26*	2.04	0.14	14.57*
Vitamin D	1217	0.59	0.07	8.43*	0.04	0.14	0.26

**Note*. Distribution was significantly skewed/kurtotic (*z-skew/kurtosis* > 3.29)

Appendix B

Data Use Agreement

Data User Agreement

Warning! Data Use Restrictions Read Carefully Before Using

The Public Health Service Act (Section 308 (d)) provides that the data collected by the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention (CDC), may be used only for the purpose of health statistical reporting and analysis.

Any effort to determine the identity of any reported case is prohibited by this law.

NCHS does all it can to assure that the identity of data subjects cannot be disclosed. All direct identifiers, as well as any characteristics that might lead to identification, are omitted from the dataset. Any intentional identification or disclosure of a person or establishment violates the assurances of confidentiality given to the providers of the information. Therefore, users will:

1. Use the data in this dataset for statistical reporting and analysis only.
2. Make no use of the identity of any person or establishment discovered inadvertently and advise the Director, NCHS, of any such discovery.
3. Not link this dataset with individually identifiable data from other NCHS or non- NCHS datasets.

By using these data you signify your agreement to comply with the above-stated statutorily based requirements.

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