PREDICTION OF HEALTH LITERACY SCORES FROM A LINEAR COMBINATION OF AGE, SEX, SMOKING STATUS, AND HEALTH INSURANCE FOR COLLEGE STUDENTS

by

Diane Mary Dolezel

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Philosophy

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ABSTRACT

The purpose of this quantitative correlational study is to examine how well the independent variables predict the health literacy levels of college-age students, to fill the gap in research in this area. This study is significant because research has shown that health literacy levels are low in the United States which leads to poor health outcomes and costly overuse of the healthcare system. College students have been underrepresented in health literacy studies. Results will inform educators' interventions to improve the health literacy abilities of college students, which could have future benefits for the students and the United States health care system. The population is a sample of university students at a state university (n = 184). Health literacy was assessed with the Short Test of Functional Health Literacy (STOFHLA). Numeracy was assessed with the Berlin Numeracy Test (BNT). Study data were analyzed with multiple regression. The dependent variables are the students' scores on health literacy and numeracy tests. The independent variables are age, sex, smoking status, and health insurance for college students. Results indicated age and gender were associated with numeracy scores, but no study predictors were related to STOFHLA scores. In conclusion, this study contributes to the understanding of factors associated with numeracy scores among college students, it did not contribute to the understanding of health literacy among college students. Future research should explore a larger random demographically diverse sample, interactions between predictors, and other predictors of health literacy such as race, class standing, and college major.

Keywords: health literacy, numeracy, STOFHLA, Berlin Numeracy Test, college students

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Dedication (Optional)

The dedication page is a page in which the candidate dedicates the manuscript. This page is optional.

Acknowledgments (Optional)

The acknowledgments page provides the opportunity for the candidate to acknowledge individuals who influenced the writing and completion of the dissertation. This page is optional.

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List of Abbreviations

Agency for Health Care Quality Research (AHRQ)

Berlin Numeracy Test (BNT)

Chronic Obstructive Pulmonary Disease (COPD)

Department of Health and Human Services (DHHS)

Health Literacy (HL)

Health Literacy Skills Framework (HLSF)

Health Literacy Questionnaire (HLQ)

Institutional Review Board (IRB)

Low health literacy (LHL)

National Assessment of Adult Literacy (NAAL)

National Center of Education Statistics (NCES)

Newest Vital Sign (NVS)

Patient Protection and Affordable Care Act (ACA)

Programme for the International Assessment of Adult Competencies (PIACC)

Rapid Estimate of Adult Literacy in Medicine (REALM)

Short Test of Functional Health Literacy (STOFHLA)

Single Item Literacy Screener (SILS)

Statistical Package for Social Sciences (SPSS)

Test of Functional Health Literacy (TOFHLA)

Variation Inflation Factor (VIF)

Wide Range Achievement Test-Revised (WRAT-R)

CHAPTER ONE: INTRODUCTION

Overview

The purpose of this quantitative correlational study is to examine how well the independent variables predict the health literacy levels of college-age students, to fill the gap in research in this area. Chapter One provides a background for the topics of health literacy and numeracy. The background includes an overview of the theoretical framework for this study. The problem statement examines the scope of the recent literature on this topic. The purpose of this study is followed by the significance of the current study. Lastly, the research questions are introduced, and definitions pertinent to this study are provided.

Background

According to the National Assessment of Adult Literacy (NAAL), less than 15 % of all adults in the United States have adequate health literacy (National Assessment of Adult Literacy, 2003). Low health literacy (LHL) has many adverse effects on individuals and the United States healthcare system (Fan et al., 2021; Yagi et al., 2021). Individuals with low health literacy may have problems with medication compliance, following diagnostic test preparation instructions, or making it to medical appointments (Adepoju et al., 2019; Lor et al., 2019). Low health literacy may affect an individual's ability to manage their medical insurance benefits, which can lead to missing routine medical appointments and not scheduling preventative diagnostic tests (e.g., mammograms) (Adepoju et al., 2019). Individuals with low health literacy may be challenged to make informed medical decisions involving the assessment of risks versus benefits (Garcia-Retamero & Cokely, 2013). This section presents a historical overview of health literacy, a discussion of health literacy in the context of society at large, and the theoretical framework for this study

Historical Overview

Health literacy is the ability of individuals to understand and utilize health information for healthcare decision-making, and numeracy, a subset of health literacy, is the capability to use numbers (Centers for Disease Control, 2019b). Specifically, numeracy is "the ability to access, use, interpret, and communicate mathematical information and ideas, to engage in and manage mathematical demands of a range of situations in adult life" (Centers for Disease Control, 2019b, para. 3). To effectively utilize health care information for decision making, individuals must "understand the risks and benefits of different medical treatments, screenings, and lifestyle choices" (Garcia-Retamero & Cokely, 2013, p. 392). Unfortunately, studies indicate that even well-educated individuals struggle to master basic numeric analysis concepts (Cokely et al., 2012; Lipkus et al., 2001; National Assessment of Adult Literacy, 2003).

A National Assessment of Adult Literacy (2003) report showed only 12 % of U.S. adults had sufficient health literacy skills to adequately comprehend and use health information. The National Center for Education Statistics (2021c) mentioned that only 37% of the United States participants ages 16 to 65 had high numeracy scores. Fortunately, the landmark DHHS National Action Plan to Improve Health Literacy, and Plain Writing Act of 2010 provided greater visibility to health literacy issues by associating health literacy with national goals (Department of Health and Human Services, 2010a). The Department of Health and Human Services (2021b) mentions the national Healthy People program which has collected evidence-based healthcare data since 1984 to generate national ten-year national health goals. Notably, the DHHS Healthy People 2021 program emphasizes health literacy and social determinants of health (Department of Health and Human Services, 2021c; Santana et al., 2021).

Society-at-Large

Low health literacy affects nine out of ten adults in the United States; it may be present in individuals of any age or race or educational level (National Coalition for Literacy, 2021). However, it is more prevalent among the elderly, and individuals with lower literacy levels lower incomes, or lower educational attainment (Ganguli et al., 2021). Non-native English speakers and those with public health insurance or no health insurance present higher than average LHL levels (U.S. Department of Education, 2019). LHL is concerning because it presents a significant barrier to communicating with patients to disseminate information on medications, compliance with preventative care, or appointments (Lor et al., 2019; Patil et al., 2021).

Another facet of health literacy is health insurance literacy which is defined as "the degree that a person has the knowledge, ability, and confidence to select and use health insurance plans" (James et al., 2020, p. 201). Research indicates that many college students do not have the skills to manage their health insurance policies (Adepoju et al., 2018, 2019). Additionally, research on literacy, numeracy, and problem-solving skills showed that over half of the U. S. adults tested scored in the two lowest levels for these skills (Centers for Disease Control, 2019b).

Theoretical Background

A theory is the "systematic organization of knowledge that predicts or explains behavior or events" (Layman & Walzlaf, 2009). A theoretical framework consists of the theoretical concepts and the relevant literature, it provides a rationale for undertaking the study of the research problem and sets the context for the research study (Lederman & Lederman, 2015). The theoretical framework that guided this study is the Health Literacy Skills Framework (HLSF). The HLSF "hypothesizes the relations between health literacy and health-related outcomes and depicts how health literacy functions at the level of the individual" (Squiers et al., 2012, p. 30y).

Paasche-Orlow and Wolf (2007) provided key constructs in the HLSF model development of the framework that established the pathway between health literacy and health outcome.

The HLSF framework includes independent variables of the development of health literacy skills such as demographics, knowledge of health care, and experiences with the health care system. It comprises print literacy, number literacy, the individual's ability to communicate with others, and their information-seeking behavior (Squiers et al., 2012). The HLSF framework considers how members of a given population use health literacy skills to decode health messages and how they decide to act upon those messages. This framework has been used to study information-seeking behaviors for colorectal screening (Jin et al., 2019). Sujin et al. (2018) adopted the HLSF framework to explore the knowledge of health care, healthcare system experiences, incentives to perform healthy behaviors, and other mediating factors as antecedents of the individual's health literacy.

Problem Statement

Low health literacy levels are problematic for college students and the national healthcare systems. Individuals with LHL have trouble understanding and following directions, they may not understand the importance of regular medical checkups, and they are challenged to correctly manage their medical insurance benefits (Adepoju et al., 2018, 2019; Yagi et al., 2021). Health literacy deficits have been associated with longer health stays (Cox et al., 2017), poor medication compliance (CHCS, 2011), and lower use of preventative care (Rafferty et al., 2022). CHCS (2013) noted that the adverse effects of LHL cost the United States healthcare systems billions of dollars each year in overuse of the healthcare systems.

Multiple regression has been utilized to examine low health literacy levels. Chew et al. (2004) found that "Characteristics significantly associated with a higher prevalence of LHL

included advanced age, low income, low education, unemployment, and cognitive impairment" (p. 251). Similarly, McLeod and Adepoju (2018) evaluated individuals with Medicare supplement insurance and determined that "Inadequate HL was associated with lower patient satisfaction, lower preventive service compliance, higher healthcare utilization, and expenditures" (p. 334). Cox et al. (2017) established the existence of relationships between health literacy levels, age, educational attainment, and unemployment (Cox et al., 2017).

These studies offer evidence of the negative impact of LHL on individuals and health systems. Across the nation, literacy and numeracy levels have been low for many years, presenting challenges to those seeking to reduce health literacy deficits (National Center for Education Statistics, 2021a). In the context of the college education system, assessments of college students' health literacy can provide important information for educators who aim to improve college students' health literacy. The interventions arising from these health literacy assessments could provide future benefits for college students on health literacy. College administrators could benefit from having a better understanding of what educators need to focus on to improve health literacy.

Prior evidence-based research on health literacy was focused on the elderly (Sedrak et al., 2020), children (Begum et al., 2021), or individuals with specific medical conditions (Cox et al., 2017; Wahl et al., 2021), with fewer than eight studies conducted on college-age adults (Nobles et al., 2019). Additionally, the previous literature on the health literacy of college students presents scant research on the topic of their numeracy. Nobles et al. (2019) stated, "College students have gone almost entirely unrepresented in the health literacy discussion: a limited number of studies have examined the health literacy of college students" (p. 469). The problem is that there is a gap in the current literature on health literacy and numeracy of college students.

Purpose Statement

The purpose of this quantitative correlational study is to examine how well the independent variables predict the health literacy levels of college-age students, to fill the gap in research in this area. The unit of analysis is the student at a large Southwestern university. The population is a convenience sample of university students at the study site who volunteered to be in the study (by responding to the study survey). Study data are analyzed with multiple regression. The dependent variable for RQ1 is the total score for the health literacy instrument. The independent variables are age, sex, smoking status, and health insurance. Age is the college student's age in years. Sex is the student's sex at birth reported as male or female. Smoking status is the status of smoker versus non-smoker, where a smoker is defined as having smoked 100 or more cigarettes in their life. Health insurance is reported as Yes (have insurance) or No (do not have health insurance).

Health literacy is the ability of individuals to understand and utilize health information for healthcare decision-making (Centers for Disease Control, 2020). Health numeracy is "the ability to access, use, interpret, and communicate mathematical information and ideas, to engage in and manage mathematical demands of a range of situations in adult life" (Centers for Disease Control, 2019b, para. 3). For this study, Health literacy is assessed with the Short Test of Functional Health Literacy (STOFHLA) (Baker et al., 1999), and numeracy is assessed with the Berlin Numeracy Test (BNT) (Cokely et al., 2012).

Significance of the Study

This study is significant because it examines health literacy for college students. Health literacy levels are low in the United States which leads to poor health outcomes and costly overuse of the healthcare system. Health literacy is important because individuals with low

health literacy levels have higher rates of hospitalization, higher utilization of emergency services, and lower usage of diagnostic and preventative services (Cox et al., 2017; McLeod & Adepoju, 2018). Low health literacy may be present at any age or educational level, it affects nine out of ten individuals in the United States (Department of Health and Human Services, 2010b; Health Resources and Services Association, 2019). It presents a significant barrier to communicating with patients to disseminate information on medications, preventative care, or appointments.

A Health Literacy Questionnaire (HLQ) analysis of students in a Texas college (n = 200) revealed that women and students with more educated parents had higher health literacy scores (Vamos et al., 2016). This study will extend the Ickes and Cottrell (2010) health literacy study on college students at a Midwestern university which utilized the TOFHLA (Ickes & Cottrell, 2010). The Ickes and Cottrell (2010) study was limited to college juniors and seniors, and assessed numeracy was assessed with "prescription labels, appointment slips, and glucose monitoring using actual hospital forms and labels for prescription vials" (Ickes & Cottrell, 2010, p. 491).

This study differs from the Ickes and Cottrell (2010) study because the STOFHLA is utilized instead of the STOFHLA, for health literacy assessment, and the BNT measures statistical literacy. Student status (full or part-time), present in the Ickes and Cottrell (2010), is not considered in this study. In contrast to the Ickes and Cottrell (2010) study, all levels of college classification (e.g., freshman, sophomore, etc.) are included, and the following new independent variables are examined: smoking status, and insurance type. Additionally, this study occurs 11 years later at a large Southwestern university which differs from the Ickes and Cottrell (2010) study at a Midwestern university, and it includes the BNT for numeracy. Guided by Chew

et al. (2004), the health literacy levels based on the STOFHLA score are inadequate health literacy (0-16), marginal health literacy (17-22), and adequate health literacy (23-26).

In summary, college students are underrepresented in health literacy studies. Nobles et al. (2019) stated, "College students have gone almost entirely unrepresented in the health literacy discussion: a limited number of studies have examined the health literacy of college students" (p. 469). Regarding numeracy, Cokely et al. (2012) stated, "Going forward, more research is needed to document the causal connections between numeracy, risk literacy, and risky decision-making" (p. 37). Research on college students' health literacy is needed to inform curriculum development and suggest educational interventions to remove health literacy barriers for college-age consumers. Improving the health literacy abilities of college students could have future benefits for the students and the United States health care system. College administrators could be informed on what teachers should focus on in the curriculum to improve college students' health literacy. The study will add to the body of research on health literacy and numeracy levels among college students.

Research Questions

The research questions for this study are:

RQ1: How accurately can health literacy scores be predicted from a linear combination of age, sex, smoking status, and health insurance for college students?

RQ2: How accurately can health numeracy scores be predicted from a linear combination of age, sex, smoking status, and health insurance for college students?

Definitions

1. *Age* – college students' age in years (Nobles et al., 2019).

2. *Berlin Numeracy Test (BNT)* - The BNT was developed in 2012 to assess statistical literacy among educated adults (Cokely et al., 2012). The test consists of four multiple-choice questions each having four answer choices.
3. *Health insurance*- reported as Yes (have insurance) or No (do not have insurance)
4. *Health literacy* - is the ability of individuals to understand and utilize health information for healthcare decision-making (Centers for Disease Control, 2020).
5. *Inadequate health literacy* - Short Test of Functional Health Literacy score of 0-1 Chew et al. (2004)
6. *Marginal health literacy* – Short Test of Functional Health Literacy score of 17-22 Chew et al. (2004)
7. *Numeracy* - the capability to use numbers for decision-making (Centers for Disease Control, 2019a). Numeracy is defined as "the ability to access, use, interpret, and communicate mathematical information and ideas, to engage in and manage mathematical demands of a range of situations in adult life" (Centers for Disease Control, 2019b, para. 3).
8. *Sex* – sex at birth reported as male or female.
9. *Short Test of Functional Health Literacy (STOFHLA)*. The STOFHLA measures health literacy. The S-TOHFLA has a total of forty questions comprised of 36 reading comprehension questions on sentence completion for the material in two text passages, and there are also four numeracy questions (Baker et al., 1999).
10. *Smoking status* – Status of smoker versus non-smoker; where smokers are defined as Yes or No, and those who self-reported having smoked 100 or more cigarettes in their

life respond with Yes, and those who have not smoked reported as No (Hoover et al., 2015).

CHAPTER TWO: LITERATURE REVIEW

Overview

The purpose of the literature review in this chapter is to present a context for the research and to demonstrate its importance based on the problem demonstrated via the literature as well as the gap in the literature. Chapter Two is comprised of a theoretical framework section, the related literature, and a summary, in that order. The theoretical framework section provides a general explanation of the framework for this study.

Theoretical Framework

The theoretical framework that guides this study is Squier's Health Literacy Skills Framework which examines the relationship between the individual's health literacy levels and their health outcomes (Squiers et al., 2012). The HLSF has four predominant components: "(a) factors that influence the development and use of health literacy skills; (b) health-related stimuli; (c) health literacy skills needed to comprehend the stimulus and perform the task; and (d) mediators between health literacy and health outcomes" (Squiers et al., 2012, p.30). The development of the framework was driven by the need to create a continuous cohesive model from previous models that addressed either the factors related to health literacy skills development (Baker, 2006; Mancuso, 2008) or the association between health literacy skills and health outcomes (Von Wagner et al., 2009).

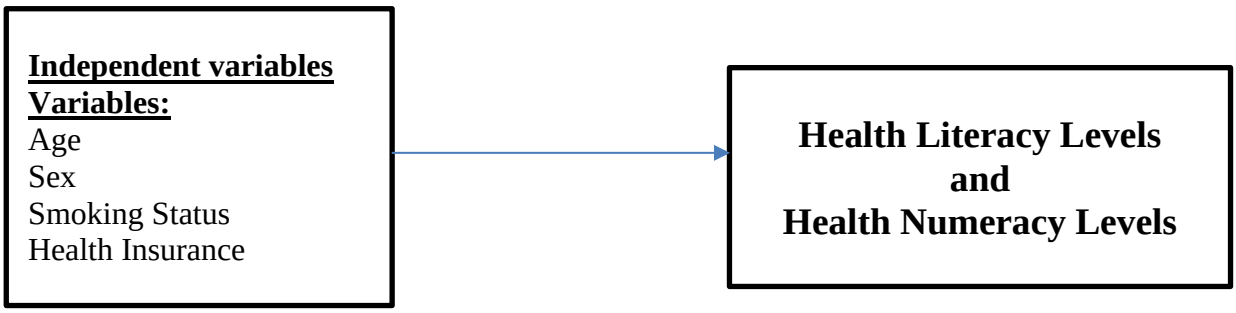
The HLSF framework was originally based on the prior work of several major theorists. Baker (2006) presented a conceptual model of health literacy including print and oral health literacy. For this model, the antecedents of print literacy were individual capacity (i.e. reading prose and quantitative ability), prior knowledge of health care, and healthcare vocabulary (Baker, 2006). Baker (2006) outlined their conceptual model but did not discuss interventions or model

implications. The Mancuso (2008) study, which was based on a literature review, considered the characteristics of health literacy to be communication, capacity, and comprehension (Mancuso, 2008). Specifically, the capacity to have adequate health literacy encompassed the individual's education, culture, and language skills. Communication of health literacy referred to the use of communication approaches for gathering and using health information for decision-making (Mancuso, 2008). Mancuso (2008) specified several literacy components: fundamental literacy, scientific literacy, civic literacy, and cultural literacy. They suggested that educators measure health literacy quantitatively, and consider language and culture when designing interventions to improve health literacy (Mancuso, 2008).

Paasche-Orlow and Wolf (2007) explored the causal pathways linking health literacy independent variables to health outcomes. Their independent variables of health literacy were race/ethnicity, education, age, employment, income, language, verbal ability, and reasoning, to name a few (Paasche-Orlow & Wolf, 2007). They posited that these independent variables affected the health outcome through the three intermediate outcomes of access and utilization of health care, provider-patient interaction, and self-care. Similarly, Von Wagner et al. (2009) used social cognition theory to describe how determinants of health literacy affect health actions (e.g., use of health care or patient-provider interaction) which are themselves associated with health outcomes. These effects occur through the intermediate social cognitive and psychological determinants, such as knowledge, understanding, health care costs, and accessibility to health information (Von Wagner et al., 2009). The Von Wagner et al. (2009) study was based on a literature review, it did suggest some interventions for improving health literacy. Based on the HLSF Framework independent variables, the proposed research model is shown in Figure 1.

Figure 1

Research Model



The proposed research relates to the HLSF framework because most of the independent variables of health literacy for this study are found in the Squiers et al. (2012) research as health literacy independent variables. In particular, the Health Literacy Skills Framework considered demographics, individual resources, capabilities, and prior knowledge as independent variables of the ability to attain health literacy skills (Squiers et al., 2012). Examples of demographics in the HLSF were age, race and ethnicity, income, and gender. In the Health Literacy Skills Framework, prior knowledge was operationalized as "conceptual knowledge of health and health care, and familiarity with health care vocabulary" (Squiers et al., 2012, p. 48). This definition of prior knowledge relates to the proposed research because the STOFHLA analyzes the individual's knowledge of medical terms such as those found on diagnostic exam instructions and in insurance policies. The HLSF definition of resources encompasses employment status, language, literacy, and educational level, which are all independent variables for the proposed study.

Moreover, the HLSF considers health literacy skills as print literacy (reading, writing, and numeracy), the individual's ability to communicate with others, and their information-seeking behavior (Squiers et al., 2012). This relates to the proposed research which will utilize the Berlin Numeracy Test to evaluate individuals' skill with using numbers for decision making.

In summary, this list of health literacy skills provides further support for the proposed study which examines how well the independent variables (e.g., age, race, gender, language, education, etc.) predict the health literacy and numeracy levels of college-age students. The proposed quantitative research could advance the concepts explored in the HLSF because it considers the underrepresented population of college students' health literacy and numeracy skills.

Related Literature

Health literacy is the ability of individuals to understand and utilize health information for healthcare decision-making (Centers for Disease Control, 2019b). Numeracy, a subcategory of health literacy, is the capability to use numbers for decision-making (Centers for Disease Control, 2019b). Specifically, numeracy is "the ability to access, use, interpret, and communicate mathematical information and ideas, to engage in and manage mathematical demands of a range of situations in adult life" (Centers for Disease Control, 2020, para. 3). In the United States, a precursor of adequate health literacy is the ability to read, write and understand the English language, which is called literacy (National Center for Education Statistics, 2017). Unfortunately, approximately forty-three million U. S. adults have low literacy skills (U.S. Department of Education, 2019).

Health Literacy

The Health Literacy Skills Framework considers factors that influence the development and use of health literacy (Squiers et al., 2012). Health literacy development is an important problem that has been evaluated by individuals and agencies for many years. In 1985, the (National Center for Education Statistics, 2021b) conducted its first national literacy survey of young adults to assess reading, writing, and quantitative abilities. Their results indicated a strong need for interventions to improve literacy. The National Assessment of Adult Literacy (2003)

survey of U.S. adults over 16 years of age, conducted in 1992, revealed literacy disparities. This provoked the 2003 NAAL population-based literacy study (National Assessment of Adult Literacy, 2003).

The NAAL 2003 report showed only 12% of U.S. adults had sufficient health literacy skills to adequately understand and use health information (National Assessment of Adult Literacy, 2003). The lowest health literacy scores occurred among adults over 65 years, non-English speaking adults, Hispanics, individuals below the poverty level, Medicare and Medicaid recipients, uninsured people, and males (National Assessment of Adult Literacy, 2003). Average health literacy rose with each advance in the level of education (past high school) and with each higher level of self-reported general health status (National Center for Education Statistics, 2021a). In 2008, a different DHHS study reiterated the importance of providing accessible available health information for decision-making to remove literacy disparities (Department of Health and Human Services., 2008). In 2017, the Programme for the International Assessment of Adult Competencies (PIACC) noted that race, being born outside the United States, and having lower levels of self-reported personal health predicted low literacy (National Center for Education Statistics, 2017). The PIACC study revealed that only 37% of the United States participants ages 16 to 65 had high numeracy scores.

The Department of Health and Human Services (2021a) Healthy People program generates national ten-year national health goals and has compiled evidence-based healthcare data. Over time, the Healthy People goals evolved to emphasize health literacy and social determinants of health (e.g., age, race, gender) (Santana et al., 2021). Future goals for Healthy People 2030 are to “Eliminate health disparities, achieve health equity, and attain health literacy to improve the health and well-being of all” (Department of Health and Human Services, 2021a,

para. 1). Other 2030 goals are assessing patient understanding, improving communication, engaging patients in decision making, and facilitating online medical record comprehension (Santana et al., 2021). For example, a Healthy People 2030 objective is to “Increase the proportion of adults who report that their healthcare provider always asked them to describe how they will follow instructions” (Santana et al., 2021, p. 4).

Asking adults to explain to the healthcare providers how they will follow their instructions is one way to assess their health literacy. The Agency for Health Care Quality Research (AHRQ), a federal agency that works to improve the safety and quality of America's healthcare system, recommends this “teach-back” method for ensuring that patients understand the directions given to them by healthcare professionals (Agency for Health Research and Quality, 2020). Using the teach-back method, the healthcare provider asks the healthcare consumer to describe in their own words how they will follow the provider’s instructions. Thus, teach-back “is a way to confirm that you have explained things in a manner your patients understand” (AHRQ, 2020, para. 1). Additionally, the AHRQ uses the “show-me” method where the healthcare consumer demonstrates their ability to follow directions for their care (e.g., proper handwashing or preparing an insulin injection). The teach-back and show-me methods can be incorporated into the interactions with individuals with low literacy levels. They can be used for training healthcare professionals on how to communicate effectively with LHL individuals.

According to the HHS (2017), the Patient Protection and Affordable Care Act (ACA) of 2010 increased the complexity of insurance policies presenting new challenges for those with LHL. Rand Corporation (2021) noted the goal of the ACA was to provide healthcare insurance for all uninsured Americans, estimated to be approximately 47 million individuals in 2010 (Rand Corporation, 2021). Demographically, many of the uninsured were low-income individuals at or

below the poverty line (Garfield et al., 2019). The ACA aimed to make healthcare accessible to these populations by loosening the requirements for Medicaid. Enacting the ACA also generated modifications to existing insurance policies. Unfortunately, their system for administering the benefits was complex and dynamic which created many problems related to system utilization. Thus, the ACA put a greater focus on health literacy deficits as LHL individuals struggled to understand the rules for obtaining the mandatory ACA health insurance coverage, or for utilizing their revised health insurance policies (Center for Health Care Strategies, 2011).

The reviews on the ACA goal achievements are mixed. Rand Corporation (2021) mentions that critics noted that by 2015 over five million previously insured Americas had lost their health insurance coverage. Garfield et al. (2019) noted, "the number of uninsured rose for the first time since implementation of the ACA to 27.4 million" (para. 3). On a positive note, provisions of the ACA required data for consumer decision-making, such as prescription drug labels, and insurance benefits, to be accessible to individuals at all levels of health literacy (Center for Health Care Strategies, 2011). Additionally, the ACA enactment resulted in directing the AHRQ to make their research "available to the public through multiple media and appropriate formats to reflect the varying needs of healthcare providers and consumers and diverse levels of health literacy" (Century Foundation, 2016). Similarly, the ACA directed the Public Health Service Act system to "update patient decision aids to assist healthcare providers and patients" (Century Foundation, 2016). For example, visual decision aids (e.g., graphs) are especially useful for communicating literacy and numeric topics (Ancker & Begg, 2017).

The Department of Health and Human Services (2010b) landmark National Action Plan to Improve Health Literacy, and Plain Writing Act associated health literacy with national goals. The National Action Plan encompasses print literacy, oral literacy, and numeracy. This plan

advocated plain language for drug labels and medication instructions as one way to reduce medication errors. Specifically, according to DHHS (2010) educators should “Incorporate Accurate, Standards-Based, and Developmentally Appropriate Health and Science Information and Curricula in Educational Settings from Childcare through University Levels” (p.32). According to the DHHS National Action Plan, health information and health services should be accessible to all demographics (Koh et al., 2012). The National Action Plan suggests increasing research on this topic to provide evidence-based knowledge for interventions by educators, policymakers, and healthcare providers.

Health Literacy Independent variables

The Health Literacy Skills Framework references independent variables of health literacy such as demographics, individual resources, capabilities, and prior knowledge as independent variables of the ability to attain health literacy skills (Squiers et al., 2012). Thus, the determinants of health literacy prevalence would include biological, demographic, and socio-economic status factors (Department of Health and Human Services, 2010b; Health Resources and Services Association, 2019). LHL affects nine out of 10 adults in the United States (Department of Health and Human Services, 2010b; Health Resources and Services Association, 2019). LHL may be present in individuals of any age (Nobles et al., 2019), race (Williams et al., 2021), gender (Rafferty et al., 2022), or ethnicity (Rafferty et al., 2022). It varies by educational level (Fleary & Ettienne, 2019), primary language (National Assessment of Adult Literacy, 2003), income status (Fleary & Ettienne, 2019), and insurance versus uninsured status (Rafferty et al., 2022).

For college students, Rababah et al. (2019) found that health literacy differed by college major and college classification. Among college students, LHL is associated with self-reported

health status (Hoover et al., 2015; National Assessment of Adult Literacy, 2003). Health literacy is also correlated with self-reported mental health status (Wahl et al., 2021). Other determinants of LHL among college students are smoking status (Rababah et al., 2019), and health insurance type (National Assessment of Adult Literacy, 2003).

The prevalence of LHL by determinant should be considered. In general, LHL is more widespread among individuals who are elderly, uninsured, and non-native speakers living in poverty with low education levels (Office of Disease Prevention and Promotion, 2019). It is also more common among those with lower overall literacy levels (Department of Health and Human Services, 2010b; Health Resources and Services Association, 2019). Race presents a significant barrier to health literacy, Hispanics and then African Americans have the lowest health literacy ratings. A related statistic is that Hispanics are twice as likely as native-English speakers to self-report a low health status (National Center for Education Statistics, 2017). People over 65 years of age and those in lower socio-economic income groups are more likely to display low literacy (Centers for Disease Control, 2019a). In particular, LHL is more prevalent in persons below the poverty level, who often lack health insurance, and those on Medicare or Medicaid (Office of Disease Prevention and Promotion, 2019).

Fleary and Ettienne (2019) explored the social determinants of health literacy for adults. The data they analyzed was from the 2013 U. S. Health Information National Trends Survey which is administered by the National Cancer Institute. This survey has four questions on health literacy that were derived from the Newest Vital Sign test. The highest health literacy levels were reported for White females ages 18 to 34 with high educational attainment and incomes greater than or equal to two hundred thousand dollars (Fleary & Ettienne, 2019). The most significant independent variables of health literacy were income and educational level. According to Fleary

and Ettienne (2019), “People who have lower income/education rates are more likely to have public health insurance, poorer access to health resources, and stressors that make practicing HL difficult” (p. e51).

Populations lacking adequate access to healthcare and those with poor English language skills are likely to have literacy deficits (Health Resources and Services Association, 2019; National Library of Medicine, 2021). This presents challenges because the United States has a large immigrant population, and only 53% of all immigrants have adequate English language skills (ProLiteracy, 2019b). Lower educational attainment is associated with health literacy shortfalls (National Library of Medicine, 2021). ProLiteracy (2019b) reported that in 2017 there were 23 million U.S. adults without a high school degree, and over 43 million adults had math, reading, and writing skills at or below the third-grade level. Of course, these conditions may occur together. Thus, older adults with poor English language skills, limited education, or income below the poverty level are at higher risk for poor health outcomes due to their health literacy deficits (Office of Disease Prevention and Promotion, 2019).

Rafferty et al. (2021) examined health literacy levels among individuals with multiple chronic conditions. The study data was from the Center for Disease Control’s Behavioral Risk Factor Surveillance System, the main self-reported health-related telephone survey in the United States (Rafferty et al., 2022). There were three health-related survey questions on obtaining information about health topics, understanding information from health professionals, and understanding information found in print or web sources. Participants had a variety of chronic conditions including heart disease, stroke, diabetes, kidney disease, and chronic obstructive pulmonary disease. Low health literacy levels were more prevalent for males, Hispanics, and adults without health insurance. Low health literacy was negatively correlated with education

and income. The occurrence of LHL increased with the increase in the number of chronic conditions (Rafferty et al., 2022).

Prior knowledge is a predictor of health literacy levels. Heine et al. (2021) conducted a systematic review and meta-analysis to assess the effectiveness of health education interventions designed to improve health literacy in adults with non-communicable diseases. Their definition of non-communicable diseases included cancer, cardiovascular disease, diabetes, and chronic respiratory disease (Heine et al., 2021). The inclusion criteria were studies (n = 53) that focused on measuring health literacy components (e.g., knowledge, attitude, behavior). The standardized mean difference of 1.27 indicates a significant positive effect of the health education intervention on health literacy across all studies, and for all of the disease group strata (Heine et al., 2021). Results suggest that health education to scaffold prior knowledge on health topics can improve health literacy on disease knowledge, attitude, and behavior for individuals with cancer, cardiovascular disease, diabetes, and chronic respiratory disease.

Health Literacy and Health Outcomes

The HLSF encompasses the connection between health literacy independent variables and health outcomes through the intermediate outcomes of provider-patient interaction, and self-care. Low health literacy has many adverse health outcomes. ProLiteracy (2019a) reported that many LHL individuals are uninsured which makes them less likely to seek (low-cost) regular care and more likely to use hospital emergency rooms or similar high-cost walk-in medical treatment centers. As an illustration, it is estimated that reducing the overuse of emergency rooms for non-emergent conditions could save $106 to $238 billion annually (ProLiteracy, 2019a). Similarly, health literacy was positively associated with low healthcare utilization (Call et al., 2021), low self-care for chronic conditions (Rafferty et al., 2021), and lower levels of

medication compliance (Lor et al., 2019). Additionally, individuals with LHL have higher risks of mortality (Fan et al., 2021).

Rafferty et al. (2021) examined a related topic which is the individual's ability to manage their medical conditions. Their study examined the associations between the health literacy levels of diabetic patients and their self-care and obtaining medical care behaviors. Rafferty et al. (2021) data were extracted from the 2016 Behavioral Risk Factor Surveillance System optional health literacy module. Health literacy data for 4 states (Alabama, Louisiana, Mississippi, and Virginia) and the Washington District of Columbia were analyzed. The health literacy questions encompassed obtaining health information, comprehending oral health information, and understanding written health information. As an illustration, diabetic care was operationalized as monitoring blood glucose, foot care, obtaining flu vaccinations, getting eye exams, going in for dental visits, and diabetic education, to name a few items. Results indicated that diabetics who had difficulty obtaining health information had (44-56%) lower odds of going to the dentist or doing foot examinations. Similarly, trouble understanding oral and written health information was correlated with not having taken a diabetic self-management class (Rafferty et al., 2021).

Ganguli et al. (2021) conducted a cross-sectional epidemiologic study of older adults (n = 1066) from a disadvantaged area revealing that male gender, older age, and lower reading literacy were predictive of lower STOFHLA scores. For this study, the Wechsler Test of Adult Reading, the Mini-Mental State Examination, and Instrumental Activities of Daily Living were insignificant. In a related study, the Rapid Estimate of Adult Literacy in Medicine (REALM) test assessed a cross-section of diabetic patients (n = 2543) on health literacy differences by gender (Ganguli et al., 2021). Logistic regression analyzed the sex-stratified diabetic data. For women, and not for men, lower health literacy levels predicted greater odds of poor diabetic outcomes.

The association between health literacy and medication protocol was examined by Lor et al. (2019). The medication protocol assessed was compliance with prescription directions for taking high blood pressure medicine among Hispanics located in New York who self-reported their hypertensive condition (Lor et al., 2019). A convenience sample (n = 1,355) was recruited from households and ambulatory care clinics associated with the New York Presbyterian Hospital. The Newest Vital sign measure was utilized to establish health literacy levels, and the Morisky Medication Adherence Scale measured medication compliance. Study results indicated that having adequate health literacy was associated with higher medication adherence (b = 0.378, p = 0.043). Additionally, medication adherence decreased with age, and males had higher adherence scores when compared to females (Lor et al., 2019). Lor et al. (2019) suggested that mental decline may account for the decrease in medication compliance with increasing age.

Warsame et al. (2019) explored the health literacy levels of adults who were waiting for a kidney transplant at the Johns Hopkins Hospital, in Baltimore, Maryland. Specifically, they considered the associations of the kidney transplant candidates' health literacy labels, getting on the kidney transplant waitlist, and mortality while wait listed for a kidney transplant (Warsame et al., 2019). The Brief Health Literacy Screen assessed the transplant candidates' health literacy levels. Among this sample, risk factors for low health literacy encompassed, not having a college degree, physical infirmity, coexisting diseases, and cognitive impairment. Low health literacy was associated with a lower likelihood of getting themselves on the kidney transplant waitlist and higher waitlist mortality.

Heart failure is a condition that requires chronic disease management by the patient related to managing their medications, weight, diet, and fluid intake. Cox et al. (2017) discovered that when heart failure patients were tested for literacy, as part of their hospital discharge

protocols, results showed lower health literacy levels were correlated with significantly higher rates of 30-day readmissions for heart failure-related issues. This result indicates a potential problem with post-hospital management of the heart failure condition related to provider and patient communication. Providers should consider a post-discharge follow-up to ensure the patients understand how to manage their chronic heart failure conditions.

Sterling et al. (2018) considered numeracy, health literacy, and cognition in 30-day readmissions of adult patients with acute heart failure. Participants were from the longitudinal Vanderbilt Inpatient Cohort Study at Vanderbilt University Medical Center (Sterling et al., 2018). The dependent variable was 30-day readmission for heart failure to any acute care hospital. The initial baseline data was obtained when the participants were hospitalized, and subsequent data were collected upon the 30-day readmission. Numeracy was assessed with the three-item Subjective Numeracy Scale.

There were 833 patients in the Sterling et al. (2018) initial baseline assessment, and 210 of those patients were readmitted within 30 days (Sterling et al., 2018). This study revealed that low health literacy was present in approximately 33% of the participants, and low numeracy was found in about 25% percent of the study group. However, results indicated that numeracy, health literacy, and cognition were not associated with 30-day readmissions of adult patients with acute heart failure. Sterling et al. (2018) suggested that the numeracy measures were not specific to objective numeracy for heart failure patients (e.g., blood pressure management, and salt intake management).

Wahl et al. (2021) explored demographic, clinical, and psychological determinants of health literacy of Chronic Obstructive Pulmonary Disease (COPD) patients. Psychological wellbeing and higher education levels were significant independent variables of health literacy

(Wahl et al., 2021). For their study, the measures for the health literacy of COPD patients were all domains of the Health Literacy Questionnaire and one domain from the eHealth Literacy Questionnaire. The psychological wellbeing of COPD patients was assessed by the World Health Organization's WHO-5 index (Wahl et al., 2021). Results showed the most significant independent variables of health literacy were psychological wellbeing and higher education levels. These results can enlighten educators who rarely consider psychological wellbeing when preparing lesson content.

Hildenbrand et al. (2020) evaluated the health literacy of first-year medical students on health literacy with a pre-test and post-test design. As an intervention, training with one lecture and an interactive activity was provided to the medical students on health literacy and clear patient-provider communication using plain language. Hildenbrand et al. (2020) conducted a post-test, and medical students' patient interactions were recorded for analysis. The AHRQ's Health Literacy Toolkit quiz was utilized to assess health literacy knowledge. Post-study analysis indicated improvement in the medical students' patient-provider interactions when compared to a previous cohort who did not receive the training intervention (Hildenbrand et al., 2020). This study indicates the benefits of providing health literacy training for medical students.

Nantsupawat et al. (2020) examined patient and provider communication, which is an important part of the HLSF. They evaluated nurses in 104 community hospitals on their knowledge of health literacy and awareness of patients' low health literacy. Health literacy knowledge was assessed with the Nursing Professional Health Literacy test which has forty-seven questions on health literacy knowledge. Over half of the nurses knew what health literacy was and over half self-rated their health literacy knowledge as moderate. Study participants stated they communicated with patients about their disease and had the repeat the instructions

back to them. Approximately 75% reported they used the “teach back” method” for checking health knowledge. Nantsupawat et al. (2020) participants noted their hospitals did not give patients health education materials and had no special aids for patients with low health literacy (e.g. classes or a specialist) (Nantsupawat et al., 2020). This study indicates a need for health literacy training for clinical staff and the possible addition of a health literacy specialist at the organizational level.

Wittenberg et al. (2018) explored oncology nurse communications (n = 70) with low health literacy patients in hospital and outpatient settings. Nurses were assessed with an open-ended survey developed by the researchers. Survey results indicated that nurses had the most difficulty with patients who had English as a second language, those without a high school degree, and ethnic minorities (Wittenberg et al., 2018). Nurses also reported having trouble detecting and assessing the literacy levels of their patients. Wittenberg et al. (2018) recommend continued education on health literacy skills to promote better patient outcomes.

Fan et al. (2021) conducted a systematic review that indicated that low health literacy was correlated with higher risks of mortality s (Fan et al., 2021). Fan et al. (2021) explored the association between low health literacy and mortality from 2006 to 2020 with articles in the Web of Science and PubMed databases. There were nineteen articles reviewed that involved over forty-one thousand participants, mostly located in the United States. Studies in the systematic review utilized a variety of instruments to assess participants' health literacy, the STOFHLA, and the Brief Health Literacy Scale were the most utilized instruments.

Conversely, Ferri-Guerra et al. (2020) conducted a study to determine if health literacy, was correlated with hospitalizations or mortality among veterans. The Ferri-Guerra et al. (2020) retrospective cohort study examined veterans in 2012 and again in 2018 on health literacy,

numeracy, and graph literacy. The multivariate analysis determined there was no association between health literacy and all-cause hospitalization or mortality. Notably, for those participants with a history of hospitalization, higher graph literacy was associated with lower mortality rates. They recommend further studies to evaluate the associations of health literacy, health utilization, and clinical outcomes.

These studies indicate a need for clinical professionals, and those training to work as clinical professionals, to have hands-on training in administering health literacy assessments. Accurately addressing health literacy requires detection because people with limited abilities to read and write may present high levels of oral literacy (Office of Disease Prevention and Promotion, 2019). This may be a reflexive reaction designed to conceal their low literacy levels. Conversely, people with high literacy skills (e.g., college students or health professionals) may have health literacy shortfalls. Clinical professionals should consider the use of talk-back and teach-back or similar methods as an intervention (Office of Disease Prevention and Promotion, 2019).

Health Literacy Skills

According to the HLSF, health literacy skills are print literacy (reading and writing), and information-seeking behavior (Squiers et al., 2012). This section discusses evidence-based research that assessed these abilities and behaviors. First, several studies examined adult literacy. Parker et al. (1995) developed the Test of Functional Health Literacy (TOFHLA) to measure the operational health literacy of patients. A panel of experts developed the TOFHLA question after reviewing hospital materials for diagnostic tests, prescriptions, patient registration, and patient instructions. The TOFHLA takes approximately 22 minutes to administer. It contains 50 questions on reading comprehension (using the Cloze method) and seventeen questions on

numeric literacy. The reading paragraphs are on preparation “for an upper gastrointestinal series, the patient rights and responsibilities section of a Medicaid application form, and a standard hospital informed consent form” (Parker et al., 1995, p. 538). The numeracy sections explore directions for drug administration, medical appointments, monitoring blood glucose, and getting financial aid for medical costs.

For the TOFHLA test, Parker et al. (1995) participants were recruited from two teaching hospitals, one in California and one in Atlanta, Georgi. There were 200 English-speaking participants and 203 Spanish-speaking participants. Construct validity was established by agreement between TOFHLA results and the REALM and Wide Range Achievement Test-Revised (WRAT-R) results. Results indicated that half of the English-speaking participants were challenged to read and comprehend the health material. This research suggests that health literacy is “an important nonfinancial barrier to receiving high-quality care” (Parker et al., 1995, p. 542).

Healthcare providers at a large university mobile clinic, that serves primarily lower socioeconomic groups, were part of a health literacy pre-test and post-test study on the utilization of the teach-back method (Drye, 2019). The multidisciplinary providers included family nurse practitioners, pharmacists, physicians, and social workers. Providers all completed a training module and a pre-test survey on the training material (Drye, 2019). After the survey, providers utilized the teach-back method on their patients for approximately two weeks. At the end of two weeks, they complete the post-test survey. Results indicated providers' self-confidence in utilizing these methods to foster patient-provider care collaboration was high (Drye, 2019).

Mock and Sethares (2019) tested the internal reliability of three health literacy measures on heart failure patients (Mock & Sethares, 2019). As background, congestive heart failure refers

to the failure of the heart as a pump. Heart failure affects over six million people in the US. Heart failure can be caused by the hardening of the arteries or high blood pressure. The progression of heart failure can include heart transplants or pacemakers (Mayo Clinic, 2022). Mitigating the progression of heart failure depends on vigilant self-management by the patients concerning a healthy diet, exercise, smoking cessation, stress management, and management of other comorbidities such as diabetes and obesity. Heart failure patients have complex medication schedules and detailed treatment plans. Heart failure patients go to the ER more frequently due to the difficulty of maintaining their self-management regimes, and they have more costly hospital readmissions (Mock & Sethares, 2019).

Mock and Sethares (2019) assessed the reliability of the Single Item Literacy Screener, STOFHLA, and the Newest Vital Sign in a cross-sectional study on adults (n = 85) hospitalized with heart failure. Patients were recruited from three community hospitals. The Single Item Literacy Screener asks, “How often do you need to have someone help you when you read instructions, pamphlets, or other written material from your doctor or pharmacist?” (Mock & Sethares, 2019, p.52). The Newest Vital Sign and the STOFHLA were reliable, with alpha levels at or above 0.70. Thus, they are appropriate measures for predicting low health literacy for hospitalized congestive heart patients.

Leech and Onwuegbuzie (2011) conducted a cross-sectional study to evaluate online health literacy and health information-seeking behaviors. Data were collected from adults (n = 614) at the Minnesota State Fair by researchers from the University of Minnesota (Lee et al., 2021). The binary outcome variable was the use or non-use of the Internet for health information seeking. Next, participants were asked twelve questions yes or no questions from the U. S. Health Information National Trends Survey on their use of the Internet for finding health

information. Health literacy was measured with three questions from the Behavioral Risk Factor Surveillance System Questionnaire developed by the Center for Disease Control. Participants also answered questions on their access to technology (e.g., smart phone, laptop, etc.). Results indicated that higher health literacy levels were associated with higher technology access and higher levels of internet use for finding health information (Lee et al., 2021).

Sedrak et al. (2020) explored the online health information-seeking behavior of older women with chronic illnesses. For this survey study, participants were a sample of women, age 65 or older, from the Women's Health Initiative program conducted by the National Heart, Lung, and Blood Institute which is part of the U. S. Department of Health and Human Services. Sedrak et al. (2020) data use of technology and use of the Internet were extracted from the 2014 Women's Health Initiative survey for analysis (Sedrak et al., 2020). Demographics associated with lower Internet use for health information were older age, less than high school education, income below fifty thousand, and nonwhite race. With one exception, findings indicate that women with a disease (e.g., stroke, cardiovascular disease, depression) were less likely to use the Internet to find health information when compared to women without a disease. The exception was that women with a cancer diagnosis in the last two years were more likely to search for information online. These findings indicate that providing health information via the Internet may not have the desired result of increasing their health literacy.

Yamashita et al. (2018b) explored the health information-seeking behaviors of approximately three thousand U.S. adults, ages 45 to 74. They extracted from the 2012-2014 Program for International Assessment of Adult Literacy. For the Yamashita et al. (2018b) study, examples of information sources are health professionals, friends, family, books, television, or Internet web searches. The independent variables were the ordinal variables from the PIAAC

literacy and numeracy questions (Yamashita et al., 2018a). Results indicated information sources most frequently accessed for health information included health professionals, the internet, and television, in that order. The information sources most frequently accessed for health information varied significantly by race, age, and gender (Yamashita et al., 2018a). This information can guide curriculum development and patient teaching by informing the selection and dissemination of health literacy and numeracy content 74 (Yamashita et al., 2018a).

Assessing Health Literacy

Campbell et al. (2020). explored the self-confidence of student teachers in teaching health literacy topics. Their study examined student teachers' confidence in teaching literacy, numeracy, and health and wellbeing (Campbell et al., 2020). The lens for the study was the theoretical background of Bandura's Teacher Self-Efficacy. Overall, respondents were not confident of their abilities to teach literacy and numeracy. The student teachers indicated they were more comfortable teaching health and wellbeing classes than teaching literacy and numeracy (Campbell et al., 2020). This presents an opportunity to scaffold student teachers on teaching literacy and numeracy.

Kushalnagar et al. (2018) assessed the health literacy levels of college students who were deaf and who used sign language. The Short Test of Functional Health Literacy in Adults was utilized to measure the student's abilities to read and understand health information (Kushalnagar et al., 2018). Interactive health literacy was assessed with the questions "How often do you discuss family medical history with your family?" and "How often do you discuss health issues with your friends?" (Kushalnagar et al., 2018, p. 829). Critical health literacy was explored with students' responses to questions on a video of a deaf woman who discovers a breast lump. Results indicate that most students had adequate health literacy, but most discussed health with

their friends, and health discussions with friends were moderately associated with critical health literacy scores (Kushalnagar et al., 2018).

Juvinya-Canal et al. (2020) conducted a cross-sectional study of nursing, social work, and education students (n = 209) on their health literacy levels. The health literacy levels were assessed with the European Health Literacy Survey Questionnaire (HLS-EU-Q16) (Juvinya-Canal et al., 2020). This instrument has sixteen questions on health care, disease prevention, and health promotion which were worth one point each. HLS-EU-Q16 between thirteen and sixteen were considered sufficient. Health literacy levels were the highest among Nursing and Social work students, followed by Education students. Participants who had previously earned a college degree also scored higher on health literacy. Juvinya-Canal et al. (2020) suggested that college curricula include training on "health care, disease prevention, and health promotion" (p. 8).

According to Ozen et al. (2019), healthcare professionals need to be aware of health literacy issues because "individuals primarily consult health personnel to access health-related information, and secondarily via the television and internet" (p. 397). Thus, their study aimed to assess the health literacy of nursing students (n = 283) at a vocational school. A semi-structured interview and the European health literacy scale were used to measure the health literacy of these future nurses. Results revealed significant differences in health literacy scores for second and fourth-year students, and scores rose for students from families with higher incomes (Ozen et al., 2019).

Rababah et al. (2019) utilized the Health Literacy Questionnaire for a cross-sectional study of college students (n = 520). For this study, there were 308 students in health-related fields and 212 in non-health-related fields who completed the HLQ. All nine constructs of the Health Literacy Questionnaire were used in this study, giving a total of 44 health literacy

questions. Study results indicated several demographics were determinants of literacy levels; college major was the most significant predictor of high literacy ratings. Rababah et al. (2019) found that gender and self-identifying as non-smoking were significantly associated with higher health literacy levels. The HLQ scale with the highest average score was “Social Support for health care”. Regarding this construct, according to Rababah et al. (2019), the highest level of Social Support for Health care would indicate that “A person’s social system provides them with all the support they want or need” (p. 213).

The Health Literacy Questionnaire assessed college students (n = 221) in Texas (Vamos et al., 2016). Studying the health literacy of college students in Texas is especially important because Texas has the highest rate of uninsured individuals in the United States (Kaiser Family Foundation, 2021). The HLQ constructs “Appraisal of health information” and “Understanding health information” were chosen for the analysis. For the HLQ domain “Understanding health information”, a high level of the construct would be, “Is able to understand all written information (including numerical information) concerning their health and able to write appropriately on forms where required. They can resolve conflicting information by themselves or with help from others” (Vamos et al., 2016, p. 213).

For the HLQ domain “Appraisal of health information”, a high level of appraisal would be “Able to identify good information and reliable sources of information. They can resolve conflicting information by themselves or with help from others” (Vamos et al., 2016, p. 213). The Vamos et al. (2016) results revealed that college women scored higher on both constructs. Additionally, students with more highly educated parents had higher health self-reported health literacy scores (Vamos et al., 2016). Students self-reported socioeconomic status as below average, average, or above average. The highest scores for both health literacy constructs

occurred among those who indicated they had above-average socioeconomic status (Vamos et al., 2016).

Avci et al. (2019) evaluated college students (n = 230) enrolled in an ethnically diverse public urban university in Texas on health literacy and racial, and ethnic inequalities associated with health literacy. Health literacy was assessed with the Newest Vital Sign Scale and the Rapid Estimate of Adult Literacy in Medicine. The first was the Newest Vital Sign Scale, a six-question instrument based on reading and understanding the contents of an ice cream label (Avci et al., 2019). The second scale was the Rapid Estimate of Adult Literacy in Medicine which evaluates the student's ability to understand and correctly speak about medical terms (Avci et al., 2019). Results revealed that Hispanic and foreign students presented lower numeracy scores.

Patil et al. (2021) conducted a Qualtrics online survey of United States college students on health literacy and digital health literacy in relationship to COVID-19-related information seeking, and COVID-19 preventative behaviors. Less than half of the students surveyed had adequate health literacy as measured by the Single-Item Health Literacy Screener (Patil et al., 2021). This measure asks the respondent one question, "How often do you need help to read instructions, pamphlets, or other written material from your doctor or pharmacy?" (Patil et al., 2021, p. 4). The Digital Health Literacy Instrument served as the measure for digital health literacy, and COVID-19 attitudes and behaviors were operationalized as self-rated statements on getting a COVID-19 vaccination, following public health guidelines (e.g., social distance, handwashing, masks), their opinion of their chances of getting the disease, and their thoughts on how getting COVID-19 would affect their lifestyle. Results indicate that female students were more likely to have adequate health literacy, while ethnic differences in LHL prevalence were not noted. Only seventeen percent of those with LHL indicated they followed all COVID-19

compliance protocols, while thirty-one percent of those with adequate health literacy stated they had followed all COVID-19 compliance public health behaviors (Patil et al., 2021).

Similarly, the Chesser et al. (2020) survey study assessed the health literacy of college students (n = 1,136) in the Midwestern United States. Participants answered questions on demographics, health literacy, and information-seeking behaviors for COVID-19 information (Chesser et al., 2020). Chesser et al. (2020) three questions on health literacy were derived from the 2016 Centers for Disease Control and Prevention Behavioral Risk Factor Survey health literacy questions. Only forty-five percent of the students had high health literacy levels, which is lower than the national average for college students (Chesser et al., 2020). Regarding demographics, most respondents were fourth-year students and females, and the majority were from engineering, nursing, or teaching majors. The majority accessed the Internet and social media for their COVID-19 information. Only eighteen percent of all the students correctly identified fever, cough, and shortness of breath as the three signs/symptoms of COVID-19 (Chesser et al., 2020).

Health Insurance Literacy

The HLSF has as an intermediate outcome the access and utilization of health. Thus, we consider the ability to understand and utilize health insurance concerning access and utilization to health care, and health literacy skills levels (Paasche-Orlow & Wolf, 2007; Squiers et al., 2012). Health insurance literacy, a subset of health literacy, is defined as “the degree that a person has the knowledge, ability, and confidence to select and use health insurance plans” (James et al., 2020, p. 201). Low levels of insurance literacy can be a barrier to accessing and utilizing health care.

A systematic review conducted by Yagi et al. (2021) explored the association of health literacy with healthcare utilization. There were twenty-one research studies in their systematic review with over sixty-two thousand respondents total (Yagi et al., 2021). Study methods included interventional, mix-methods, and cross-sectional studies. Ten of the meta-synthesis studies associated high scores on health insurance literacy with increased utilization of primary care and other medical services. Eight studies correlated low health insurance literacy with potential delays in seeking care or with avoidance of medical care (Yagi et al., 2021).

Community health centers perform an important function in providing health care to medically underserved communities. Williams et al. (2021) conducted an interesting cross-sectional study that examined the health insurance literacy levels of staff at three community health centers from 2018 to 2019. Data were collected with a Qualtrics survey that utilized health insurance questions from the Kaiser Family Foundation and the Health Insurance Literacy Measure (Williams et al., 2021). Respondents (n = 152) average health insurance literacy score was 6.31 out of 10. Independent variables associated with LHL were race, lower pay, and lower self-reported health status. The average scores for clinical staff were lower than the average scores for non-clinical positions (e.g., administrative) Williams et al. (2021) stated, “there is a patient-centric need to implement a health insurance education program across health centers, targeting those who work directly with patients” (p. 1264).

Feinberg et al. (2019) noted that most insurance is employer-based and written in complex language. They assessed full-time low-wage earners on health literacy, all participants were employees of an urban university in the United States (Feinberg et al., 2019). The Wide Range Aptitude Test-4 was used to correlate low literacy and low health literacy skills. Health insurance literacy was assessed with the Kaiser Family Foundation Health Insurance Literacy

Test. Results indicated moderate associations with reading, number, and digital literacy scores, education level, and health literacy levels. Multiple regression analysis determined that only reading levels were significantly associated with LHL (Feinberg et al., 2019).

Similarly, Call et al. (2021) explored the relationship between health insurance literacy and access the healthcare services among adults. Data were from the 2017 Minnesota Health Access cell and landline telephone survey. Participants were included if they were adults, and they had answered the survey questions related to health insurance, health insurance literacy, access, and affordability of health care. Call et al. (2021) respondents were randomly assigned to take either a four-item test derived from the Health Insurance Literacy Measure, or a four-item test derived from the Health Reform Monitoring Survey. The Call et al. (2021) Health Reform Monitoring Survey assessed confidence in the utilization of health insurance, and the Health Insurance Literacy Measure examined confidence in choosing, using, and managing a health insurance plan proactively. Results indicated that individuals who report higher confidence in performing insurance tasks were less likely to go without necessary healthcare.

Edward et al. (2018) considered access to health care concerning health insurance literacy. Their study explored health and health insurance literacy and access to care in their survey study of Hispanics and Latinos in Massachusetts. Health literacy was measured with the Short Assessment of Health Literacy scale in Spanish and with health insurance knowledge questions developed by the researchers. Data were analyzed with logistic regression analysis and chi-square tests. Over 50% of the respondents had LHL and over 90% had a low level of health insurance literacy (Edward et al., 2018). Participants with LHL and low levels of health insurance literacy were likely to have never sought medical care in the United States. Results

indicated associations between health literacy and health insurance literacy and having insurance and having access to medical care in the United States (Edward et al., 2018).

For college students, there are several constructs related to health insurance literacy. One consideration is that most college students are still listed on their parent's health insurance policies. Thus, they are not informed about the terms and conditions of use of their health insurance, because they have not been handling the insurance communications and paperwork. They do not understand terms like copay, deductible, documentation, or referral letter (Adepoju et al., 2019). As an illustration, college students need more education on when to use emergency services (very costly) and when to see a primary care provider (much lower cost).

Upadhyay et al. (2022) evaluated college students' health insurance literacy was evaluated with a survey study. Participants were students from a mid-Atlantic university in the United States who were enrolled in an undergraduate class on global health care which included instruction on health insurance. The control group of students was from the Psychology department where they did not receive any instruction on health insurance. There were three hundred and sixty-four students who completed the survey (Upadhyay et al., 2022). The Kaiser Family Foundation ten-item multiple choice quiz measured health insurance literacy, and the Health Insurance Literacy Measure measured insurance health self-efficacy. Most of the respondents were insured, and the predominant demographic was White females. Scores for health insurance knowledge and health insurance self-efficacy were higher for the group of students who received instruction on health insurance literacy. Overall, females and students with parents who had higher educational attainments presented lower health insurance self-efficacy scores (Upadhyay et al., 2022). This study gives evidence that classroom instruction on health insurance could improve college students' health insurance literacy.

James et al. (2020) assessed a random sample (*n* = 1450) of graduate and undergraduate students on health literacy and insurance self-efficacy. The Kaiser Family Foundation insurance quiz assessed health insurance knowledge, the Health Insurance Literacy Measure measured health insurance self-efficacy, and questions from the Behavioral Risk Factor Surveillance System were adapted to reflect the university student health center utilization (James et al., 2020). Their results established that participants had difficulty calculating out-of-pocket insurance costs, and many did not understand the term hospital formulary (James et al., 2020). Although most students were seen by a physician in the last year, respondents reporting lower levels of health insurance self-efficacy had fewer physician visits (James et al., 2020).

Nobles et al. (2019) provided insight into college students' health insurance literacy. The standard measure for health insurance literacy is the Health Insurance Literacy Measurement (HILM). However, they noted that "The HILM asks individuals to self-report their ability to select appropriate coverage levels and, therefore, is a measurement of an individual's self-efficacy rather than their ability to provide definitions of core terms" (p. 470). Consequently, these researchers created a measure of the ability to apply health insurance knowledge (Nobles et al., 2019). Study findings were significant, with 88% of the students scoring low on cost-sharing questions, and 50% reporting plan confusion (NLM, 2011; Nobles et al., 2019). This indicates that college educators should add content on this topic to help reduce the student's health insurance literacy deficits.

McLeod and Adepoju (2018) surveyed college students (*n* = 210) in the College of Health Professions at a university in the Southern United States on their knowledge of health literacy. Respondent's knowledge of health insurance literacy was assessed with the Health Insurance Literacy Measure (HILM). According to Mcleod (2018), HILM assesses "knowledge

and skills in choosing, comparing, managing, and using health insurance" (p. 2). The HILM question encompasses selecting the best insurance plan, expected out-of-pocket costs for medicines, visits to specialists, and emergency room visits, and understanding insurance coverage and healthcare utilization. A Partial Least Squares Path Modeling analysis revealed that the self-rated ability to compare ($\beta = 0.41$, $p < .01$) and manage ($\beta = 0.48$, $p < .01$) insurance plans were both significant (McLeod & Adepoju, 2018).

In a similar study, Adepoju et al. (2018) measured health insurance literacy constructs with the Health Insurance Literacy Measure which assesses an individual's abilities to evaluate, select and use health insurance benefits. Adepoju et al. (2018) revealed gender diversity in health insurance literacy levels among college students when comparing and using health insurance literacy. In a related study, Adepoju et al. (2019) explored health literacy for approximately 1,500 adults in the United States who were recruited with Amazon Turk survey tool (Adepoju et al., 2019). Respondents of the Amazon Turk survey, approximately 14 % were college students, results showed college students scored lower than other groups on all measures related to health insurance literacy (Adepoju et al., 2019).

Mbanda et al. (2021) evaluated a synthesis of forty-seven studies on the use of visual aids for low-literacy individuals and showed significant improvement in medication compliance and understanding of medical topics for this intervention. Visual aids were operationalized as pictograms (symbols to represent concepts) and videos. As an illustration, the food pyramid is a visualization. This research indicated a need for more studies focused on visual aids for low-literacy individuals in low to middle-income populations (Mbanda et al., 2021).

The studies in this section indicate a need for researchers to explore how the ability to understand and utilize health insurance is related to health literacy skills levels. One facet of this

problem is the math abilities of adults, which have historically been inadequate. Another consideration is the diverse set of skills needed for adequate health literacy. This skill set includes the ability to communicate health and compliance concerns, and the ability to understand graphs and work with numbers. Research on literacy, numeracy, and problem-solving skills among U. S. adults indicated over half of those tested scored in the two lowest levels of literacy and numeracy (Centers for Disease Control, 2019b).

Health Numeracy

The HLSF lists numeracy as a health literacy skill that is needed for individuals to comprehend health literacy stimuli (Squiers et al., 2012). Indeed, healthcare consumers often need to understand information about the risks related to diseases, the directions for medication prescriptions, diagnostic test preparation instructions, and the benefits of the different treatment options (Wahl et al., 2021). They need statistical numeracy skills for risk assessment to facilitate medical decision-making. Using the prevalent model of shared decision-making in health care, they will need to evaluate risk versus benefit information to make informed decisions. For example, these decisions may require determining probabilities from frequencies: assume Medicine A had a 1 in 4 chance of serious side effects, and Medicine B has a 25 in 100 chance of serious side effects. Which drug has the greatest probability of serious side effects? Individuals with low numeracy levels would likely have difficulty answering this question correctly (Traczyk et al., 2020).

Thus, perceptions of healthcare risk levels are relative to the consumer's statistical literacy levels. Moreover, prior evidence indicates that many people do not work well with numbers (Department of Health and Human Services, 2021c; National Center for Education Statistics, 2021a; National Coalition for Literacy, 2021). At the lowest level, working with

numbers comprises understanding the number line, understanding time, and correctly using measurements. At a higher level, the emphasis is on statistical tasks (ratios, proportions, percentages, probability) which are fundamental to risk analysis.

Cokely et al. (2012) established that variations in statistical literacy were strongly correlated with the decisions making with information involving statistics or probability. They developed the Berlin Numeracy Test for evaluating statistical numeracy and risk literacy levels in educated samples. The Berlin Numeracy Test, which takes three minutes to administer, has been validated in over 20 studies in 15 countries. The 28 questions for the test were derived from a pool consisting of the Schwartz et al. (1997) and the Lipkus et al. (2001) questions, this number was later reduced to four questions. Cokely et al. (2012) researchers have tested the BNT extensively.

The initial BNT test was evaluated with a general population sample (n = 300) from individuals living in Berlin, Germany. Most participants were undergraduate or graduate students (current or former) from a local university. In a second BNT test, Cokely et al. (2012) performed an online administration of a multiple-choice version of the BNT at Michigan Technological University. Students for the second test were predominantly undergraduates and graduates. However, only approximately 55% of the students' BNT responses were correct. Conversely, a different BNT study administered the pen and paper version of the BNT to college students studying to be physician assistants. This test was conducted at a university in Oklahoma, and it produced many high scores. Consistent with expectations, this indicates that physician assistant students are less likely to have low statistical literacy (Cokely et al., 2012).

Friederichs et al. (2020) utilized the BNT in an interesting study. They examined the association between the years of clinical experience and statistical literacy levels for risk literacy

as measured by the Berlin Numeracy Test score. Participants were from two groups, general practice medical doctors (n = 84) with years of clinical experience, and third-year medical students (n = 92). The general practitioners had an additional pre-assessment practice on evaluating mammography screening results. The students did not have this extra practice session because this material was covered (and assessed) in their coursework. Next, both groups of participants completed the BNT test. Friederichs et al. (2020) results indicated no statistically significant difference in risk literacy levels between the two groups.

After that, respondents evaluated several case studies on mammography screening. Some of these studies presented probabilities in relative number form (approximately 5% of these women will have breast cancer) and some had probabilities in Bayesian form with absolute numbers (Friederichs et al., 2020). An example of the latter is, you are given that breast cancer can be detected 95% of the time, and a false positive may occur 10% of the time. Calculate the probability of having breast cancer if a woman has a false positive. While the general practitioners scored higher than the medical students on the BNT test, they did not outperform the medical students in terms of applying their statistical literacy skills to the probabilities associated with hypothetical case scenarios related to mammography screenings (Friederichs et al., 2020). The results indicate that physicians need more education on risk literacy.

Fulawka et al. (2019) evaluated the associations between case fatality rates and fear of neoplasms and circulatory diseases among college students. They hypothesized that the higher case fatality rate statistics would be associated with higher self-reported levels of fear of neoplasms and circulatory diseases (Fulawka et al., 2019). Participants were undergraduates at one university who completed stimuli for affective evaluations and rate evaluations. For the affective evaluations, participants indicated their fear intensity rating, disgust rating, and

perceptions of how typical the disease was for its category (Fulawka et al., 2019). For the rate evaluations, they evaluated the number of patients with the disease and the number of deaths from the disease, given a population of 38 million people. Following the rate evaluations, all participants completed the Berlin Numeracy Test to assess their numeracy and risk levels (Fulawka et al., 2019). Fulawka et al. (2019) results indicate that case fatality rates were moderately associated with self-reported fear ratings ($r = 0.42$). This result was present on the individual level even when controlling for other ratings (including numeracy) (Fulawka et al., 2019).

Petrova et al. (2014) assessed over 170 physicians in training on risk literacy with the Berlin Numeracy Test-Schwartz. This test combined questions from the BNT test with the three questions in the Schwartz et al. (1997) test. Other independent variables for the Petrova et al. (2019) study were prior beliefs in the effectiveness of screening, understanding of screening statistics, physicians' specialties, and their prior statistical education. Results of Petrova et al. (2019) indicated that previous beliefs that cancer screening (in general) was not effective, lower levels of statistical literacy and lower numeracy still were significantly associated with lower comprehension of cancer screening results (Petrova et al., 2019). This study signals a need for more statistical literacy training for physicians during their medical residency.

Yamashita et al. (2020)assessed numeracy and health service utilization among adults forty-five years and older living in the United States. Data for participants ($n = 2,989$) were selected from the Programme International Assessment of Adult Competencies, an international survey on adult cognitive and workplace skills. The International Assessment of Adult Competencies has data for numeracy skills, literacy skills, and numeracy skill use at home. The

PIACC also provided data on the demographic independent variables: sex, race/ethnicity, education, employment status, and the number of household members.

The binary dichotomous dependent variables for health care utilization were dental checkups, vision screening, influenza vaccination, and osteoporosis screening. Results revealed that numeracy predicted seeing the dentist in the last year, but was not predictive of visual exams, flu vaccinations, or screening for osteoporosis. Yamashita et al. (2020) noted that these results may be related to the PIACC numeracy measures which are focused on numeracy context, responses, math context, and representations, and not specifically on health literacy.

Durand et al. (2020) utilized the Chew one-item scale for health literacy, the Subjective Numeracy Scale, and the Short Graph Literacy Scale all were utilized to examine the associations between graph literacy, health literacy, and numeracy literacy respectively. Participants in the cross-sectional literacy survey (n = 436) self-reported that they were in the Medicaid program, a government healthcare insurance program for lower-income individuals. Graph literacy was the only significant predictor of health literacy levels. To assess graph literacy, respondents had to interpret several graphs. Graphing score cutoffs were then assigned so that data could be grouped into high (above median graphing score) and low (below median graphing scores) scores. Durand et al. (2020) showed higher levels of graph literacy were associated with higher levels of health information comprehension; tables were the most understandable graphs. This is useful information because it indicates best practices for presenting data to LHL individuals.

Summary

In summary, low health literacy LHL affects nine out of 10 adults in the United States (Department of Health and Human Services, 2010b; Health Resources and Services Association,

2019). The determinants of health literacy, which include biological, demographic, and socio-economic factors, have been established by evidence-based research. There are many negative outcomes of low health literacy. LHL presents a significant barrier to provider-to-patient communications on health-related topics such as medications, preventative care, or appointments (Adepoju et al., 2018; Lor et al., 2019). As a group low health literacy individuals have above-average hospitalization rates, lower use of preventative services, higher utilization of high-cost healthcare services, and poor disease management skills (Call et al., 2021; Edward et al., 2018).

Previous research on health literacy focused on older adults (Yamashita et al., 2020), young children (Begum et al., 2021), or individuals with specific medical conditions (Cox et al., 2017; Wahl et al., 2021). There are few studies conducted on college-age adults (Nobles et al., 2019), and the existing literature does not adequately address their numeracy skills. Moreover, there is scarce literature that suggests college curricula for reducing health literacy disparities (Hildenbrand et al., 2020; Ickes & Cottrell, 2010). Nobles et al. (2019) stated, "College students have gone almost entirely unrepresented in the health literacy discussion: a limited number of studies have examined the health literacy of college students" (p. 469). Cokely et al. (2012) declared, "Going forward, more research is needed to document the causal connections between numeracy, risk literacy, and risky decision-making" (p. 37).

This study will extend the Ickes and Cottrell (2010) health literacy study of college students (n = 400) conducted at a Midwestern university (Ickes & Cottrell, 2010). Their study utilized the longer Test of Functional Health Literacy (TOFHLA) to assess reading and numeracy comprehension (Ickes & Cottrell, 2010). Their numeracy test materials included prescription labels, hospital forms, and appointment directions. The students in the Ickes and Cottrell (2010) study had acceptable health literacy levels, but item analysis revealed significant

variance on some TOFHLA questions (Ickes & Cottrell, 2010). Ickes and Cottrell (2010) evaluated only college juniors and seniors, and they assessed numeracy with "prescription labels, appointment slips, and glucose monitoring using actual hospital forms and labels for prescription vials" (Ickes & Cottrell, 2010, p. 491). Ickes and Cottrell (2010) reading comprehension materials included upper gastrointestinal exam, Medicaid patient rights and responsibilities, and hospital informed consent (Ickes & Cottrell, 2010).

This study differs from the Ickes and Cottrell (2010) study because it will use the STOFHLA and the Berlin Numeracy test for health literacy and numeracy assessments, respectively. Student status (full or part-time), present in the Ickes and Cottrell (2010), is not considered in this study. Distinct from the Ickes and Cottrell (2010) study, all levels of college classification are included in this study. Additionally, the following independent variables are explored in the proposed study: age, sex, smoking status, and health insurance. Furthermore, this current study occurs 11 years later at a large state university in the Southwest, in contrast to the Ickes and Cottrell (2010) study which was conducted at a midwestern university.

The theoretical framework that guides this study is the Health Literacy Skills Framework. The HLSF recognizes that health literacy skills are predictive of health outcomes. An effective starting point for HLSF utilization would be assessing the health literacy of college students to inform curricular interventions. Improving the health literacy abilities of college students could have future benefits for the students and the United States health care system. College administrators could gain knowledge on what teachers should focus on in the curriculum to improve college students' health literacy. Teachers could design educational interventions to reduce health literacy disparities. Students could reduce their health literacy deficits and may be able to better manage their medical care. Research on college students' health literacy is needed

to examine how well the independent variables predict the health literacy levels of college-age students, to fill the gap in research in this area.

CHAPTER THREE: METHODS

Overview

The purpose of this quantitative correlational study is to examine how well the independent variables predict the health literacy levels of college-age students, to fill the gap in research in this area. Chapter Three introduces the design of the study, including full definitions of all variables. Next, the research questions and null hypotheses are presented. Chapter Three includes the participants, setting, instrumentation, procedures, and data analysis plans.

Design

This study will utilize a nonexperimental quantitative correlational research design to examine how well the independent variables predict the health literacy levels of college-age students. Health literacy (HL) is the ability of individuals to understand and utilize health information for healthcare decision-making (Centers for Disease Control, 2020). Health numeracy is the capability to use numbers for decision-making (Centers for Disease Control, 2019a). Low health literacy (LHL) is a problem that affects individuals as well as the nation's healthcare system(Centers for Disease Control, 2020).

A quantitative design was selected because the goal of the study is to examine samples that are representative of the population by collecting numeric data, analyzing that numeric data with statistical inference methods, and generalizing study findings to the study population (Gall et al., 2021). A predictive correlational design is appropriate because the aim is to examine the relationship between two or more independent variables on one dependent variable. The dependent variable for this study is health literacy as measured by health literacy and health numeracy test scores (Baker et al., 1999; Cokely et al., 2012). The independent variables are age, sex, smoking status, and health insurance for college students. The independent and dependent

variables are appropriate as other researchers have used these variables in multiple regression studies to find relationships between the proposed independent variables and health literacy (Chew et al., 2004; Cokely et al., 2012). For college students, health literacy has been determined to vary by smoking status (Hoover et al., 2015; Rababah et al., 2019), and health insurance type (National Assessment of Adult Literacy, 2003).

Research Questions

The research questions for this study are:

RQ1: How accurately can health literacy scores be predicted from a linear combination of age, sex, smoking status, and health insurance for college students?

RQ2: How accurately can health numeracy scores be predicted from a linear combination of age, sex, smoking status, and health insurance for college students?

Hypotheses

The null hypotheses for this study are:

$H_0$1: There will be no significant predictive relationship between the dependent variable (health literacy score) and the linear combination of independent variables (age, sex, smoking status, and health insurance) for college students.

$H_0$2: There will be no significant predictive relationship between the dependent variable (numeracy score) and the linear combination of independent variables (age, sex, smoking status, and health insurance) for college students.

Participants and Setting

This section presents a description of the population, the participants, the sampling technique, and the sample size. The section ends with a description of the setting. The target population is all students (graduate and undergraduate) at a state university in the Southwest.

After obtaining Institutional Review Board (IRB) approval, student emails were extracted from an administrative system at the study site. The four thousand students on the extracted email list all received invitations to participate in the survey. Fourteen emails were undeliverable, and there were 224 initial responses for a response rate of 17.8%. The inclusion criteria for the study are that all respondents are over 18 years of age (so they can give consent) and that they completed all the health literacy survey questions. Application of the inclusion criteria produced a final sample that included 187 respondents.

The participants are a convenience sample of all university students at the study site who volunteered to be in the study by responding to the study survey during the Spring semester of 2023. According to Gall et al. (2021), 66 students are the minimum required for a correlation test for a medium effect size with a statistical power of 0.7 at the 0.05 alpha level. Gall indicates the sample size should be increased by “15 individuals for each variable” in the multiple regression analysis to balance the sample size and the number of independent variables (Gall et al., 2021, p. 361). Thus, a sample of 111 (66 + 3*15) individuals are needed for this multiple regression analysis which has 3 independent variables with a statistical power of 0.7 at the 0.05 alpha level.

Table 1 presents the potential demographics of the participants. The participants of the study were drawn from a convenience sample of all university students at the study site who volunteered to be in the study by responding to the study survey during the Spring semester of 2023. The sample consisted of 57 males and 127 females with ages ranging from 18 to 49 years. There were 13.0 % who reported having no insurance and less than 13% of the respondents who reported smoking, where Hoover et al. (2015) defined smokers as those who self-reported having smoked 100 or more cigarettes in their life.

Most respondents were White (50%) with household incomes over $50,000 annually

(44.6%). The primary language was English (83.7%), and approximately half of the respondents were juniors (21.7%) or seniors (28.8%). Most students were in the College of Liberal Arts (18.5%) followed by the College of Science and Engineering (17.4%).

Table 1

Demographics of Participants (n = 184)

Characteristic	*n*	*%*
Sex		
Male	57	31.0
Female	127	69.0
Age (reported in years)	*M* = 22.63	
Smoking Status		
Yes	23	12.5
No	161	87.5
Health Insurance		
Yes	160	87.0
No	24	13.0
Race		
White	92	50.0
Black or African American	13	7.1
Hispanic or Latino	55	29.9
Asian	17	9.2
American Indian or Alaskan Native	2	1.1
Other	5	2.7
Income		
Less than 10,000	27	14.7
10,000 - 25,000	26	14.1
26000 - 50,000	32	17.4
More than 50,000	82	44.6
Do not wish to answer	17	9.2
Primary Language		
English	154	83.7
Spanish	17	9.2
Other	13	7.1
Class Standing		
Freshman	31	16.8
Sophomore	27	14.7
Junior	40	21.7
Senior	53	28.8
Graduate student	33	17.9
College		
College of Applied Arts	17	9.2

College of Business Administration	18	9.8
College of Education	25	13.6
College of Fine Arts and Communication	20	10.9
College of Health Professions	27	14.7
College of Liberal Arts	34	18.5
College of Science and Engineering	32	17.4
Graduate College	11	6.0

The study site is a large university in the Southwest. The institution offers approximately two hundred degree programs at the bachelor's, master's, and doctoral levels. The study site has a strong commitment to involving graduate and undergraduate students in research. The predominant race is White, non-Hispanic (43.4%), and most students are 18-24 years old. Approximately 60% of the university's students are males (59.8 %), and forty percent are females.

Instrumentation

This section presents the instruments used for this study. Data will be collected from a self-administered web-based survey designed by the study researcher and composed of all reading comprehension questions from the validated STOFHLA health literacy test and the numeracy questions from the BNT test. The study survey also collects data on the independent variable age, sex, smoking status, and health insurance. A cross-sectional survey method is appropriate for a quantitative study because the aim is to rapidly collect data at one point in time (Gall et al., 2021). The survey method of data collection provides a quick, low-cost way to collect the study data. It allows the researcher to identify study characteristics from small groups of individuals that can be generalized to the larger population. Chesser et al. (2013) indicated that web-based STOFHLA scores are equivalent to paper-based scores for adults. Similarly, the Cokely et al. (2012) BNT computer-based format has the same convergent validity (i.e.,

correlates with other numeracy tests) and divergent validity (i.e., does correlate with unrelated concepts) as the pencil and paper form of the test.

Short Test of Functional Health Literacy

The purpose of this instrument was to measure health literacy levels. Regarding instrument development, the original Test of Functional Health Literacy (TOFHLA), which utilized clinical patient informational materials, was comprised of multiple choice questions on 3 reading comprehension passages (with 50 questions) and one set of 17 numeracy questions (Parker et al., 1995). The TOFHLA took over 20 minutes to administer, making it challenging for administration in clinical settings due to the time required. Baker et al. (1999) developed the Short Test of Functional Health Literacy (STOFHLA) which is a shortened version of the TOFHLA. The STOFHLA has 36 reading comprehension questions, and four numeracy questions (Baker et al., 1999). The administration time for the STOFHLA was 12 minutes on average, down from 22 minutes for the TOFHLA. Thus, the shorter STOFHLA was easier for healthcare personnel to utilize in clinical settings.

Peer-reviewed studies. The STOFHLA has been used in several studies (Ganguli et al., 2021; Mock & Sethares, 2019; Sterling et al., 2018). Ganguli et al. (2021) conducted a cross-sectional study of older adults (n = 1066) from a disadvantaged area. STOFHLA results revealed that the male gender, older ages, and lower reading literacy scores were predictive of lower STOFHLA scores (Ganguli et al., 2021). Similarly, Mock and Sethares (2019) assessed the reliability of the STOFHLA, Single Item Literacy Screener, and the Newest Vital Sign in a cross-sectional study on adults (n = 85) hospitalized with heart failure. The Newest Vital Sign and the STOFHLA were reliable, with alpha levels at or above 0.70. Thus, Mock and Sethares (2019) considered the STOFHLA and the Newest Vital Sign as appropriate measures for

predicting low health literacy for hospitalized congestive heart patients. Correspondingly, Sterling et al. (2018) considered numeracy, health literacy, and cognition in 30-day readmissions of adult patients with acute heart failure. Subjective health literacy was evaluated with the STOFHLA and the Brief Health Literacy Scale and the (Sterling et al., 2018). Sterling et al. (2018) indicated that low health literacy was present in approximately over thirty percent of the study participants.

The STOFHLA is a shorter version of the TOFHLA which assessed the domains of reading comprehension and numeracy. The STOFHLA was created by removing questions from the TOFHLA. The STOFHLA is an objective assessment of health literacy as it relates to the patient's reading ability on materials that may be found in healthcare settings. The STOFHLA has two passages, Passage A assesses reading comprehension of diagnostic tests, and Passage B evaluates reading comprehension of patient insurance and patient's rights.

Baker et al. (1999) reported internal consistency with Cronbach's $\alpha = 0.68$ for numeracy and $r = 0.97$ for the reading comprehension questions. Mock and Sethares (2019) assessed the health literacy of heart failure inpatients ($n = 85$) by comparing the STOFHLA, the Single Item Literacy Screener (SILS), and the Newest Vital Sign (NVS). Reliability levels were similar for the STOFHLA ($\alpha = 0.88$) and the NVS ($\alpha = 0.70$). The STOFHLA was strongly associated with the SILS ($r = -0.308$) (Mock & Sethares, 2019). Additionally, the TOFHLA was validated by Baker et al. (1999). They found convergent validity with a Spearman's correlation of 0.80 between the STOFHLA and the REALM, which was comparable to the correlation between the longer TOFHLA and the REALM. Paola et al. (2017) assessed the construct validity of the STOFHLA with Spearman correlations between NVS and STOFHLA, and among STOFHLA

sections. Their STOFHLA was positively correlated with the NVS (r = 0.58) demonstrating construct validity (Paola et al., 2017).

Number of questions. The STOHFLA has a total of 36 reading comprehension questions (on two passages), and four numeracy questions (Baker et al., 1999). As an illustration, in Baker et al. (1999) the Cloze questions assessed understanding of upper gastrointestinal diagnostic exam directions and they assessed understanding of the patient rights and responsibilities material. Only the reading comprehension questions are used for this study. The numeracy questions were not utilized because some researchers debate the validity of the numeracy measures.

The STOFHLA instrument is a reading test with thirty-six multiple-choice questions having nominal text answer choices labeled a, b, c, and d. The STOFHLA uses the Cloze method where words in the sentences are omitted. The participant reads a sentence (on a healthcare topic) and then they fill in the blanks in sentences by selecting one item from the list of the four multiple choices responses labeled a-d (Baker et al., 1999). For example, in Passage B the question “Medicaid I must report any _____ in my circumstances” has answer choices a) changes, b) hormones, c) antacids, and d) charges.

The STOFHLA will be scored by the Qualtrics survey software with one point for each correct answer for the 36 reading comprehension questions, resulting in a STOFHLA score range of 0 to 36 (Baker et al., 1999). In agreement with Chew et al. (2004), the health literacy levels, based on the STOFHLA scores, are inadequate health literacy (0-16), marginal health literacy (17-22), and adequate health literacy (23-36). As mentioned, the numeracy scores will be assessed by the second study instrument.

The test will be self-administered with an online Qualtrics software survey having multiple choices selection responses. The test is expected to take approximately seven minutes to complete (Baker et al., 1999)**.** The test will be scored by the primary author**.** The STOFHLA is not copyrighted. More information can be obtained from the website https://healthliteracy.bu.edu/s-tofhla. Permission to use the STOFHLA and to publish the STOFHLA questions was obtained from the instrument author. See Appendix A for STOFHLA questions. See Appendix B for documentation of permission for public use and publication of the STOFHLA.

Berlin Numeracy Test

The purpose of the Berlin Numeracy Test was to measure statistical numeracy and risk literacy in highly educated adult samples. The BNT was built on the earlier work on numeracy testing by Lipkus et al. (2001). Although the Lipkus et al. assessments were widely used, they displayed a negative skewing of the numeracy scores. Cokely et al. (2012) had the goal of developing the BNT which they envisioned as "a brief, valid, and easy-to-use instrument, with improved discriminability" (p. 28).

Cokely et al. (2012) developed the BNT to assess statistical literacy among educated adults, thus it is appropriate for college students. According to Risk Literacy (2021), the Berlin Numeracy Test has been used in several studies to assess statistical numeracy levels. Traczyk et al. (2020) explored the effect of individual differences in numeracy levels on experience-based presentations of probability. They used the BNT to assess the numeracy of undergraduates on experience based versus description-based stimuli. Traczyk et al. (2020) reported that adequate numeracy is an essential skill because "People with low statistical numeracy have difficulties understanding numerical information" (p. 273).

Similarly, a related cross-sectional study by Friederichs et al. (2020) of medical students revealed an average BNT score of 2.03 out of four points, with male participants scoring higher than females (Friederichs et al., 2020). In a related study, Petrova et al. (2019) assessed over one hundred physicians in training on risk literacy with the Berlin Numeracy Test-Schwartz (Petrova et al., 2019). Results of Petrova et al. (2019) indicated that prior beliefs that cancer screening was not effective, lower levels of statistical literacy, and lower numeracy still were associated with lower comprehension of cancer screening results which may indicate a need for more statistical literacy training for medical residents (Petrova et al., 2019).

This instrument was validated in many studies, it is used in 21 countries for risk assessment (Friederichs et al., 2020; Traczyk et al., 2020). The seminal study by Cokely et al. (2012) found convergent and divergent validity (i.e., no correlation with dissimilar concepts). For this study, the BNT was sent to 300 participants in Berlin, Germany. The survey consisted of 28 items and Cronbach's Alpha for this pen and pencil survey was $\alpha = .59$. In the Cokely et al. (2012) study, the BNT had twenty-eight questions. However, the number of questions was reduced to four because analysis revealed this reduction "did not affect test classification performance or validity yet reduced test-taking time" (p. 28). Thus, all subsequent BNT tests are based on four questions.

The BNT has no subscales or factors; all questions are multiple-choice questions with answer choices ranging from A to D. Similarly, later research on the association of numeracy of surgeons ($n = 292$) from different countries on interactions with their patient interactions determined that the surgeon's numeracy affected their willingness to communicate with patients Reliability for the Garcia-Retamero et al. (2014) study was high, with a Cronbach's alpha of 0.84.

The simplest form of the BNT is a four-item test having four multiple-choice case study questions where participants complete math case study problems that assess their numeracy knowledge.(Friederichs et al., 2014). Each question is worth one point, resulting in a total possible BNT test score of 0-4 points. The BNT developers did not assign meaning to the test scores, however, a score of 0 indicates no evident health numeracy abilities and a score of 4 indicates the maximum health numeracy ability. According to Cokely et al. (2012), the mean score for this test was 1.6 points. Thus, for this research, a BNT score less than 1.6 will be considered as below-average health numeracy, and a BNT score greater than or equal to 1.6 points will be reported as above-average health numeracy.

The BNT test is scored by the Qualtrics software by assigning one point to each correct answer resulting in a score range of 0 to 4. The BNT will be administered online by the Qualtrics survey software. The BNT takes approximately four minutes to complete. Permission to use the BNT questions for research was obtained from the instrument author. Permission to publish the questions was requested but not obtained. See Appendix C for BNT questions. See Appendix D for permission to use this instrument. See www.riskliteracy.org for more information.

Procedures

First, permission will be obtained from the IRB at Liberty to conduct the study. Second, permission will be obtained from the IRB at the study site to conduct the study. The IRB approval includes a request for permission to access a system that allows the researcher to generate a list of 4,000 student emails. The number 4,000 was chosen for email extraction because it is the maximum sample size allowed by the study university for student email recruitment. See Appendix E for IRB approval.

After IRB approval is obtained, all students on the list will be emailed and invited to

participate in the survey. The invitation email contains an explanation of the study purpose, a description of the survey, the IRB approval number, and contact information. See Appendix F for the recruitment email. The survey's main page contains a message indicating that taking the survey implies consent. The main page has a button that must be selected to indicate respondents are over 18, and a second button they must click to take the survey. See Appendix G for the informed consent on the main survey page. For anonymity, Qualtrics survey options are set so that participants' Internet addresses are not recorded. See Appendix A and C for survey questions.

Survey demographics are collected on separate pages of the Qualtrics survey. Qualtrics software will score literacy and numeracy questions. The scored survey data are exported from Qualtrics into an Excel spreadsheet and uploaded into IBM Statistical Package for Social Sciences (SPSS) statistics software for analysis. Regarding data security, during all data collection, all identifiable information is protected. Data are stored on a password-protected cloud storage area accessible only to the study researcher. Data will be retained in a secure area for five years after the completion of this research study.

Data Analysis

A multiple linear regression design will be utilized for the statistical analysis in this study. This design is appropriate because the goal of this study is to examine the relationship between two or more independent variables on one dependent variable (Gall et al., 2021). Multiple linear regression statistics will be conducted to determine the degree of correlation between a continuous dependent variable and a linear combination of the independent variables since these correlations are hypothesized to be linear. Multiple regression can determine “the magnitude and statistical significance of the relationships between variables” (Gall et al., 2021,

p. 353). Multiple regression can also determine how much each independent variable contributes to the variance in the dependent variable. Referencing peer-reviewed studies, multivariate regression was utilized to explore the relationship between health literacy and unplanned post-discharge healthcare visits for heart failure patients (Cox et al., 2017). Hierarchical linear regression (a type of multivariate regression) analysis determined health literacy was correlated with medication adherence among older individuals with chronic diseases (Cox et al., 2017).

Regarding data preparation, survey data will be exported as an Excel comma-separated value file which will be imported into SPSS for analysis. The overall analysis plan is that all independent variables are entered into the regression model at the same time, and the regression results are examined to determine how much the variance of each independent variable explains the dependent variable. Age in years will be a numeric variable. Within SPSS, binary dummy variables (0 and 1) are created for sex (at birth), smoking status, and health insurance. Numeric data are visually inspected for missing data points, inaccuracies, skewness, kurtosis, or unusual variance. Missing numeric data are imputed with the median of the variable having the missing data.

The significance level for the statistical test will be $\alpha = 0.05$. This value is commonly used in statistical studies (Gall et al., 2021). Data are analyzed with multivariate regression. Additionally, the descriptive statistics of the sample demographics are analyzed for frequency and percentages. The multiple regression analysis plan is that all independent variables are entered into the regression model at the same time, and the regression results are examined to determine how much the variance of each independent variable explains the dependent variable. The SPSS settings will include Estimates, Model fit, Collinearity diagnostics, Durbin-Watson (Residuals), and a Normal probability plot (Green & Salkind, 2021).

There are several assumptions of multiple regression that must be met to determine if your model will produce valid results. The multiple linear regression assumptions of the level of measurement are met because the dependent variable is the continuous total literacy score, and the independent variables are all numeric. However, these multiple regression assumptions must be tested: linearity, independence of residuals, normality, no bivariate outliers, multivariate normal distribution, homoscedasticity, and no multicollinearity among the independent variables.

The residuals of any two observations must be uncorrelated (i.e., independent). Within SPSS independence of the residuals is assessed with a Durbin-Watson test which checks for correlation between adjacent residuals (i.e., a test of serial correlation. The Durbin-Watson test ranges from 0-4. In general, values of less than 1 or greater than 3 are cause for concern. However, the Durbin-Watson statistic varies with the number of independent variables and the sample size, see the Watson and Durbin tables for more specific calculations of this test statistic.

Assumptions of multivariate normal distribution must be met. Each pair of variables will be assessed for a linear relationship. If the variables are not linearly related, the power of the test may be reduced. This assumption will be tested by plotting a scatter plot for each pair of independent variables (x, x) and between the independent variables (x) and the dependent variable (y). A classic “cigar shape” indicates a violation of this assumption.

There should be no extreme bivariate outliers. Extreme bivariate outliers are assessed with scatterplots and boxplots of all numeric independent variables. Extreme bivariate outliers are excluded from the data analysis. Multivariate normal distribution should be assessed by looking for a linear relationship on scatterplots between each pair of numeric independent variables, and between the numeric independent variables and the dependent variable. Normal distributions of categorical data can be assessed with bar plots, for numeric data histogram plots

are useful for assessing normality.

With homoscedasticity, the residuals are equally distributed along the regression model line of best fit. Homoscedasticity is checked by visually examining a scatterplot of the model's standardized residuals against the model's standardized predicted values (Green & Salkind, 2021). Optimally, the residual plot will not display any apparent pattern. As an illustration, a fan or cone-shaped pattern indicates the residuals are not equally distributed, while a random pattern of data on the residual plot indicates the data are equally distributed.

An independent variable that is highly correlated with another independent variable provides the same information about the dependent variable and it should be excluded from the model (Gall et al., 2021). Multicollinearity is assessed by conducting an SPSS linear regression test with Collinearity Diagnostics selected and examining the Collinearity Statistics Variance Inflation Factor (*VIF*) column in the Coefficients table. Acceptable VIF values are between 1 and 5 and values greater than 10 indicate a violation of the assumption of collinearity which would result in that variable being excluded from the model (Gall et al., 2021).

Next, the model and independent significance are assessed. If the SPSS ANOVA table *F*-value is less than the alpha level the overall model is a good fit for the data. With a good model fit, the combination of independent variables reliably predicts the dependent variable. If the overall model is significant, the Coefficients table *p*-values for each independent variable are examined to determine if the relationship between the independent variables and the dependent is significant (Green & Salkind, 2021). Independent variables with a *p*-value less than alpha are statistically significant and should be included in the final regression model.

The multiple regression Adjusted R^2 of the model is reported to explain the variance of the dependent. The Adjusted R^2 is preferred because it considers the number of independent

variables analyzed. For example, an Adjusted R^2 squared value of 0.70 indicates that 70% of the variance in the dependent variable is explained by the variance in the linear combination of independent variables. In addition, a comparison of the magnitude of the standardized coefficients indicates the effect size of each independent variable on the dependent variable (Green & Salkind, 2021). Specifically, standardized coefficients with larger beta coefficients will also have larger *t* values and they will have larger effects on the variance of the dependent. Interactions among the independent variables will not be assessed. Model equations will be reported for each research question.

CHAPTER FOUR: FINDINGS

Overview

The purpose of this quantitative correlational study was to examine how well the independent variables predicted the health literacy levels of college-age students, to fill the gap in research in this area. The predictor variables were age, sex, smoking status, and health insurance. The criterion variables were the STOFHLA and the BNT exam scores. Multiple linear regression was used to test the hypotheses. This section includes the research question, null hypothesis, data cleaning, descriptive statistics, assumption testing, and results.

Research Questions

RQ1: How accurately can health literacy scores be predicted from a linear combination of age, sex, smoking status, and health insurance for college students?

RQ2: How accurately can health numeracy scores be predicted from a linear combination of age, sex, smoking status, and health insurance for college students?

Null Hypotheses

$H_0$1: There will be no significant predictive relationship between the dependent variable (health literacy score) and the linear combination of independent variables (age, sex, smoking status, and health insurance) for college students.

$H_0$2: There will be no significant predictive relationship between the dependent variable (numeracy score) and the linear combination of independent variables (age, sex, smoking status, and health insurance) for college students.

Descriptive Statistics

The sample consists of 184 participants. There was no missing data in the data set. Table 2 displays descriptive statistics for age. Ages ranged from 18 to 49 with a mean of 22.6. The

skewness for age was 2.86 which is greater than 1.0 indicating a strong positive skew. The kurtosis value of 8.65 is greater than 3 indicating that age data may have long tails.

Table 2

Descriptive Statistics of Numeric Criterion Variables (n = 184)

Variable	Minimum	Maximum	Mean	Standard Deviation	Variance	Skewness	Kurtosis
Age	18	49	22.6	5.8	33.54	2.86	8.65

Table 3 provides descriptive statistics for STOFHLA and the BNT test scores. The STOFHLA measures health literacy with reading comprehension questions. The STOFHLA was scored with one point for each correct answer, resulting in a STOFHLA score range of 0 to 36. The BNT measures statistical numeracy and risk literacy in highly educated adult samples. The BNT has four questions with one point for each correct answer resulting in a BNT score range of 0 to 4. The mean of the STOFHLA was 33.6, the scores ranged from 6 to 36 with a standard deviation of 3.5. The mean of the BNT was 1.5, and the scores ranged from 0 to 4 with a standard deviation of 1.0.

Table 3

Descriptive Statistics of Predictor Variables (n=184)

Variables	*n*	Minimum	Maximum	Mean	Standard Deviation
STOFHLA	184	6	36	33.6	3.5
BNT	184	0	4	1.5	1.0

The bar charts below display the frequencies for gender (Figure 2), insurance (Figure 3), and smoking (Figure 4). Given the unequal group response size displayed in these bar charts, the regression reference levels are set to females, non-smokers, and having health insurance because these are the largest response categories.

Figure 2

Bar Chart of Gender

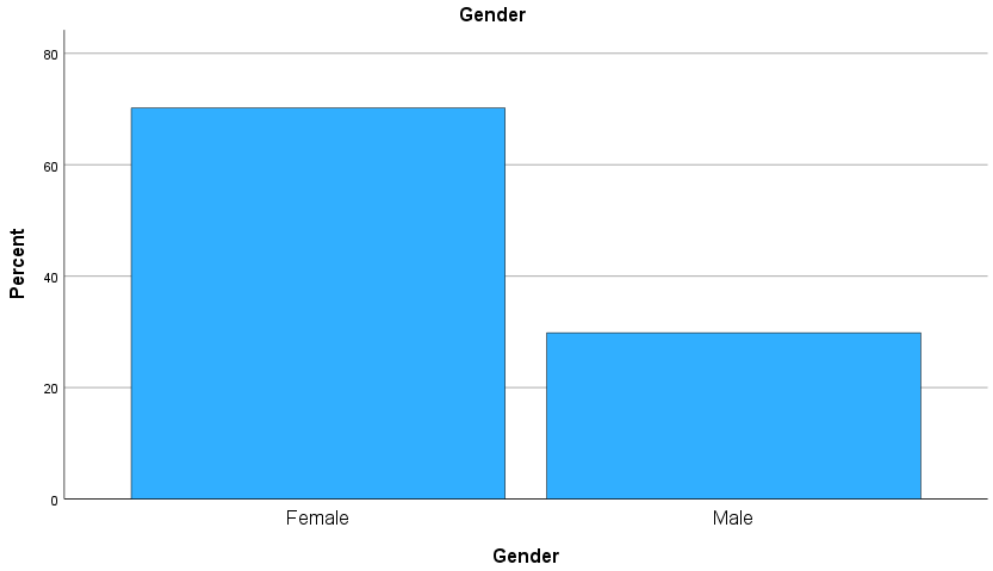


Figure 3

Bar Chart of Insurance

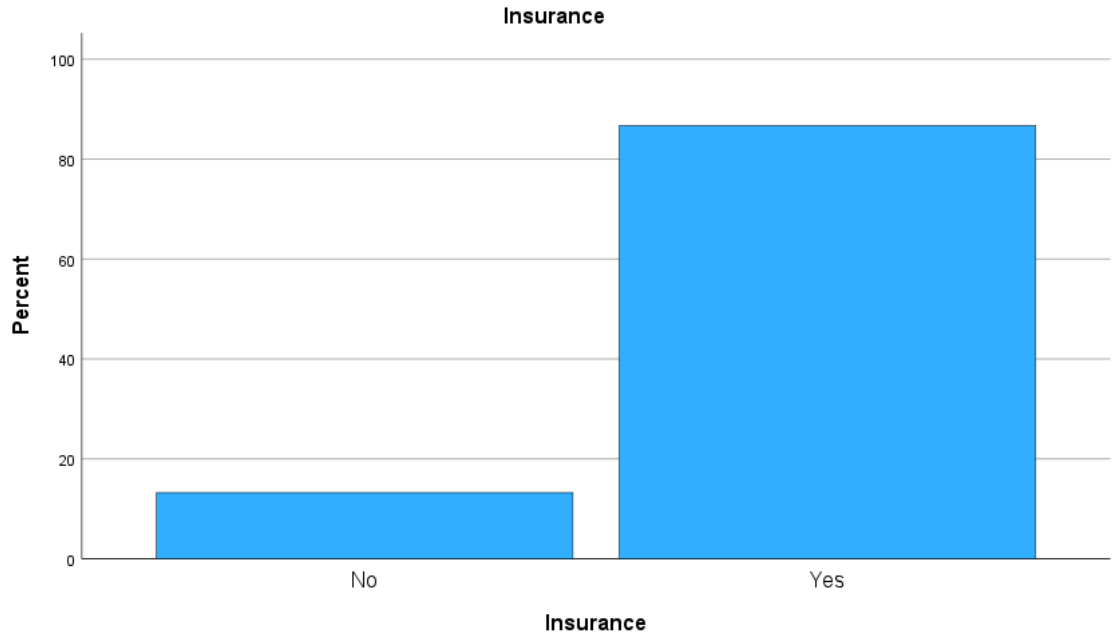
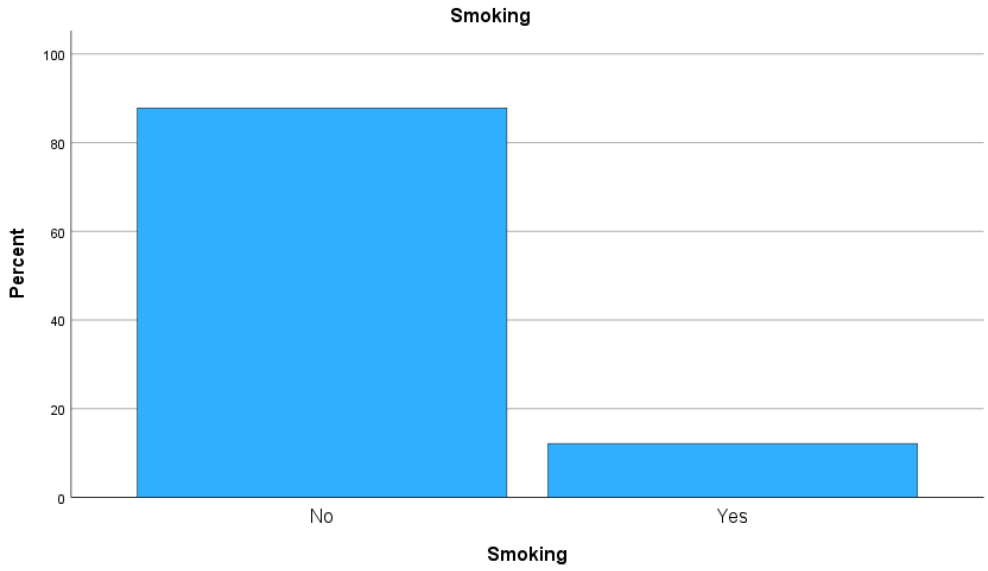


Figure 4

Bar Chart of Smoking



Assumption Testing

Both hypotheses used multiple linear regression models thus the same assumption tests were utilized for each hypothesis. The criterion STOFHLA and BNT scores were numeric. There was one numeric predictor, age in years, and the remaining predictors (gender, smoking, and insurance) were dichotomous variables coded 0 or 1. The assumptions tested before the regression were the assumptions of bivariate outliers and multivariate normal distribution for the numeric variables age, STOFHLA, and BNT scores. The assumptions tested with the regression residuals were the assumption of normal distributions, homoscedasticity, and linearity of the residuals.

Histograms of the predictor and criterion were generated to assess multivariate normal distributions. The histograms of the numeric variable age (Figure 5) and BNT (Figure 6)

revealed no extreme outliers. The histogram of the STOFHLA score (Figure 7) revealed three observations that were potential outliers.

The SPSS Regression method Casewise Diagnostics table confirmed these points were outside the 3 standard deviation cutoffs for outliers, and they were excluded from the data. For reference, two of the excluded observations had STOFHLA scores of 6, and one had a score of 13 (see Figure 8). The histograms of age, STOFHLA (with outliers excluded), and BNT scores support the assumption of normal distributions (Figure 8).

Figure 5

Histogram of Age

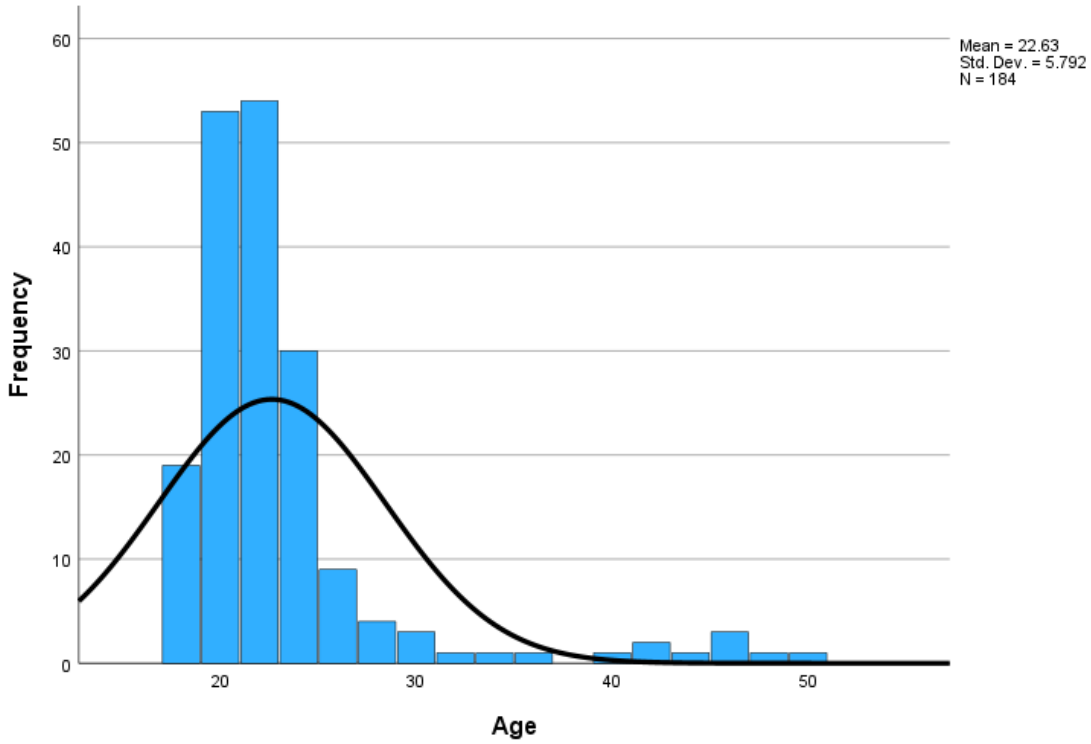


Figure 6

Histogram of BNT score

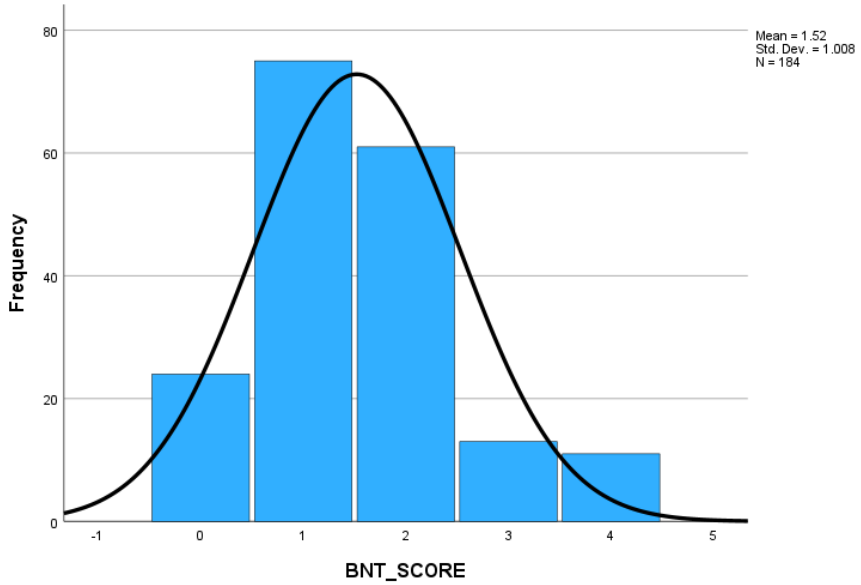


Figure 7

Histogram of STOFHLA score

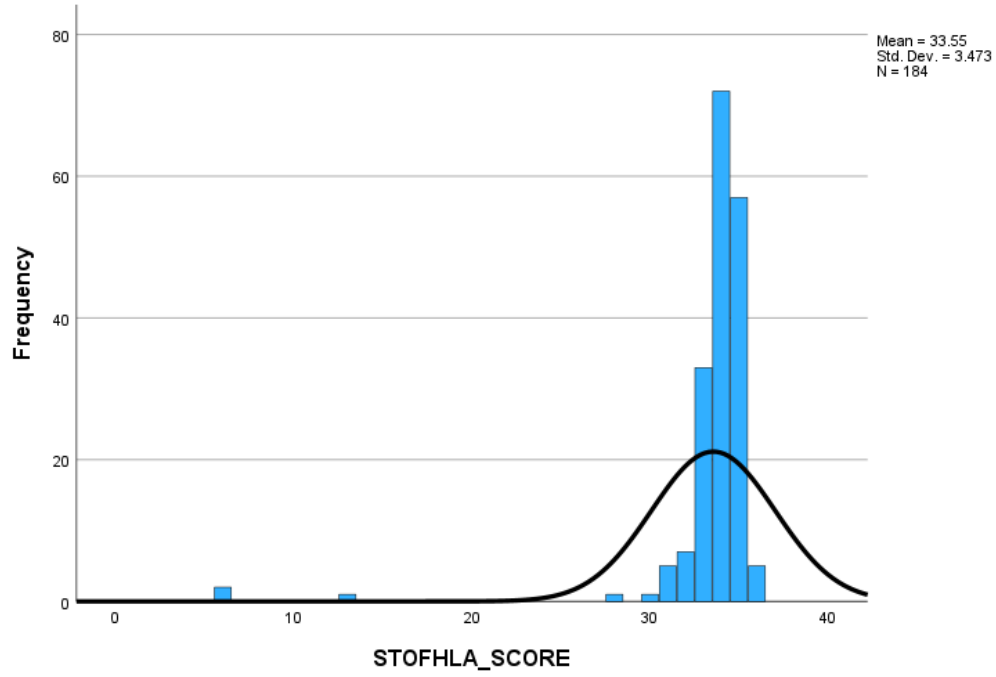
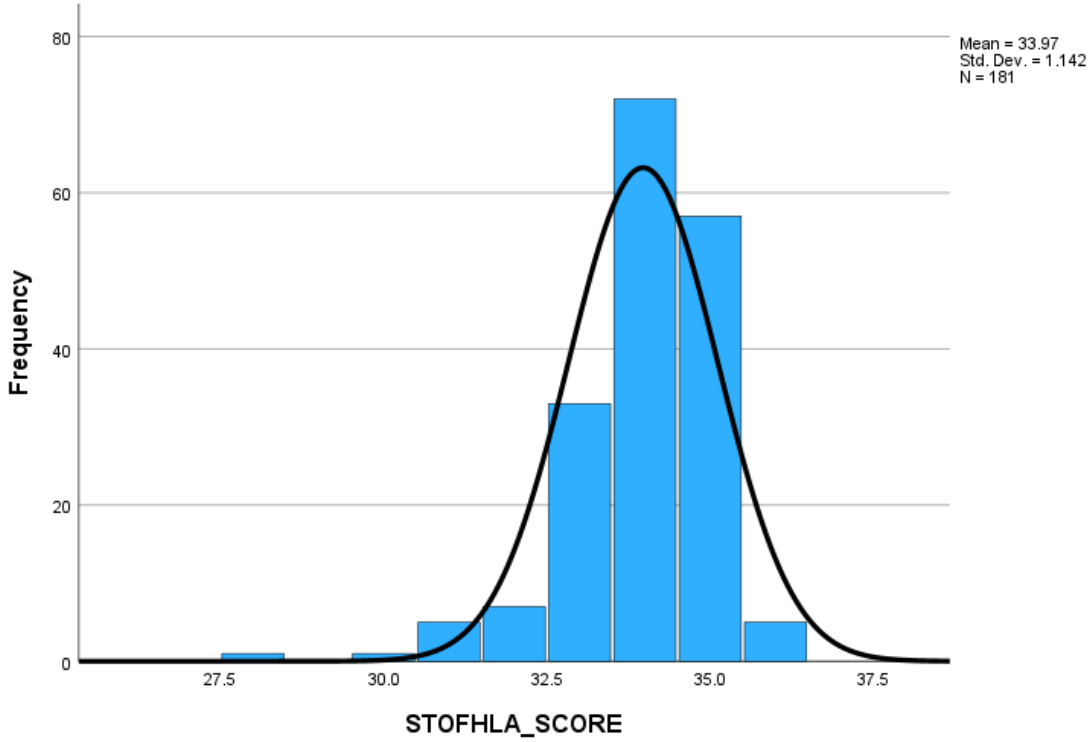


Figure 8

Histogram of STOFHLA score after outliers removed.



The assumption of bivariate outliers between the numeric predictor age and the criterion variable was assessed with scatterplots of age and STOFHLA scores, and a scatterplot of age and BNT scores. A visual examination of the scatterplots of age and STOFHLA exam scores (Figure 9) and age and BNT (Figure 10) exam scores indicate the assumption of no bivariate outliers is met.

Figure 9

Scatterplot of age and STOFHLA

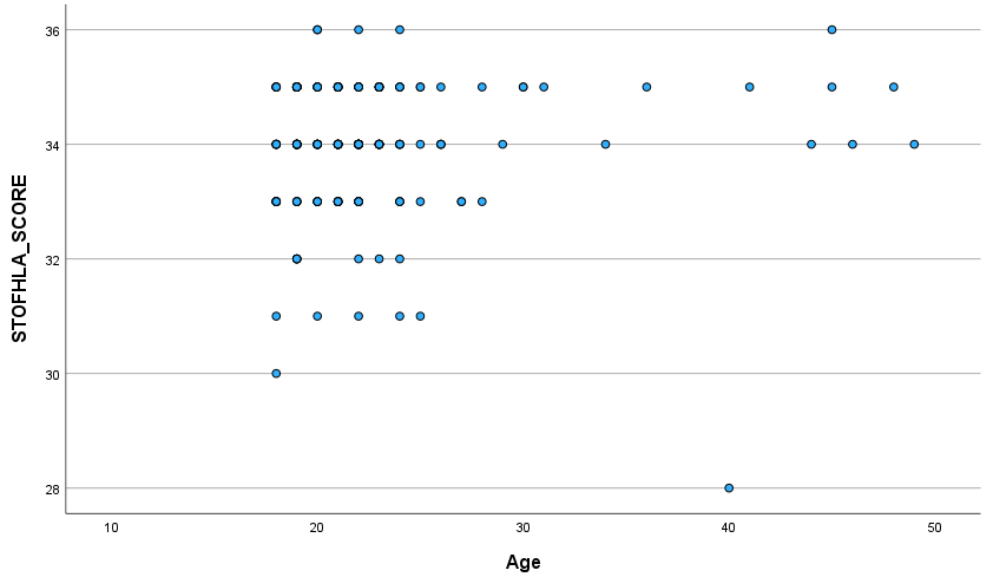
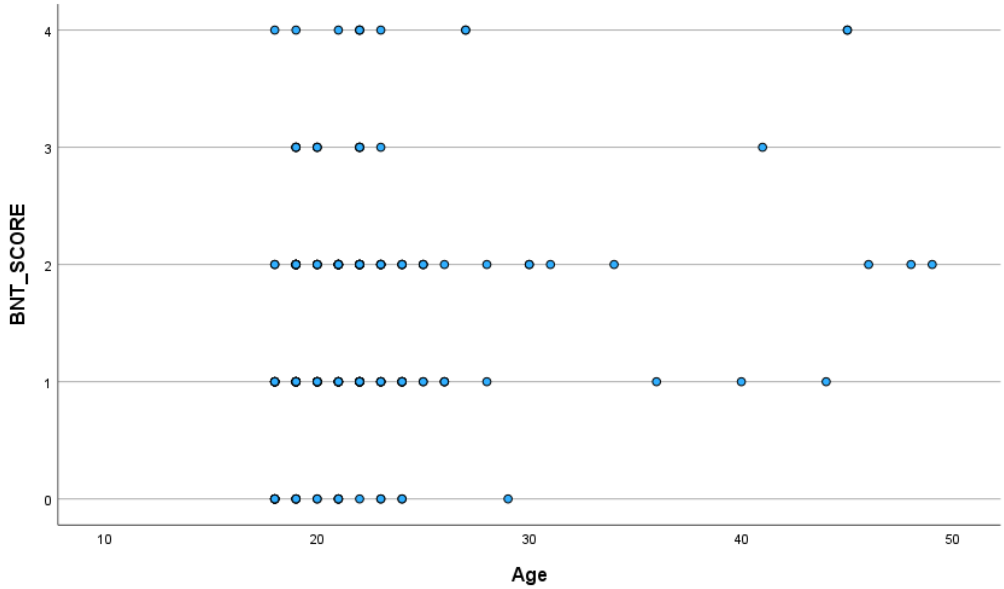


Figure 10

Scatterplot of age and BNT



The assumption of normal distributions of the residuals was assessed with a normal probability *p-p* plot of the regression standardized residuals for STOFHLA (Figures 11) and BNT (Figure 12) scores, and by noting the mean of the residuals for each of those regression models. The *p-p* plot is appropriate because these assumptions refer to the normality of the residuals from the whole regression model; they do not consider the individual predictor normality (i.e., numeric, or dichotomous). The data points approximately followed the diagonal in the *p-p* plot, and the residual means were close to zero confirming residual normality.

The assumption of homoscedasticity was assessed with a scatterplot of the regression standardized predicted value versus the regression standardized residuals (Figures 13 and 14). Equal variance means the residuals do not increase when the independent variable increases. The residuals were uniformly distributed with a mean near zero and equal variance across all levels of predictor variables indicating the assumption of homoscedasticity was met.

The assumption of linearity of the residuals was also assessed with the scatterplots of the regression standardized predicted value versus the regression standardized residuals (Figures 13 and 14). This assumption was met because the patterns for both regression models were random regardless of the predicted values. Regarding the coded dichotomous variables, without interaction terms, the dichotomous variables will only potentially change the *y*-intercept of the regression equation, it will not change the slope of the line. As an illustration, the variables coded zero will drop out of the regression equation, and those coded as one will have the additive effect of shifting the *y*-intercept by a value of the beta coefficient associated with the dummy variable (coded as 1). Thus, each level of a dichotomous variable coded will have a linear relationship with the dependent variable.

Figure 11

Normal probability p-p plot for STOFHLA

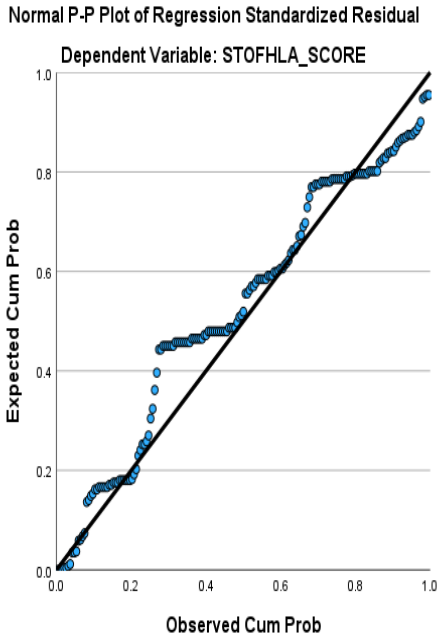


Figure 12

Normal probability p-p plot for BNT

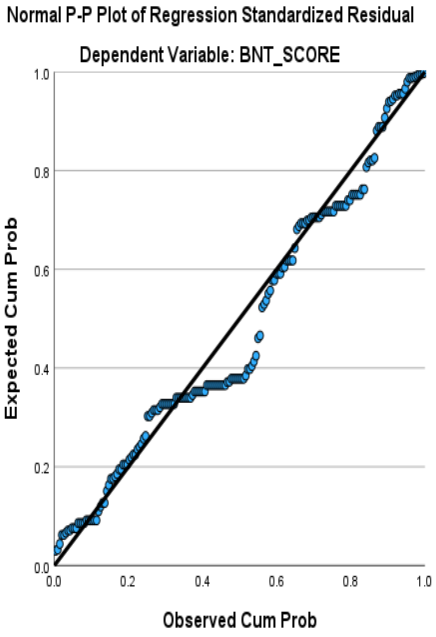


Figure 13

Residuals versus predicted standardized residuals for regression on STOFHLA.

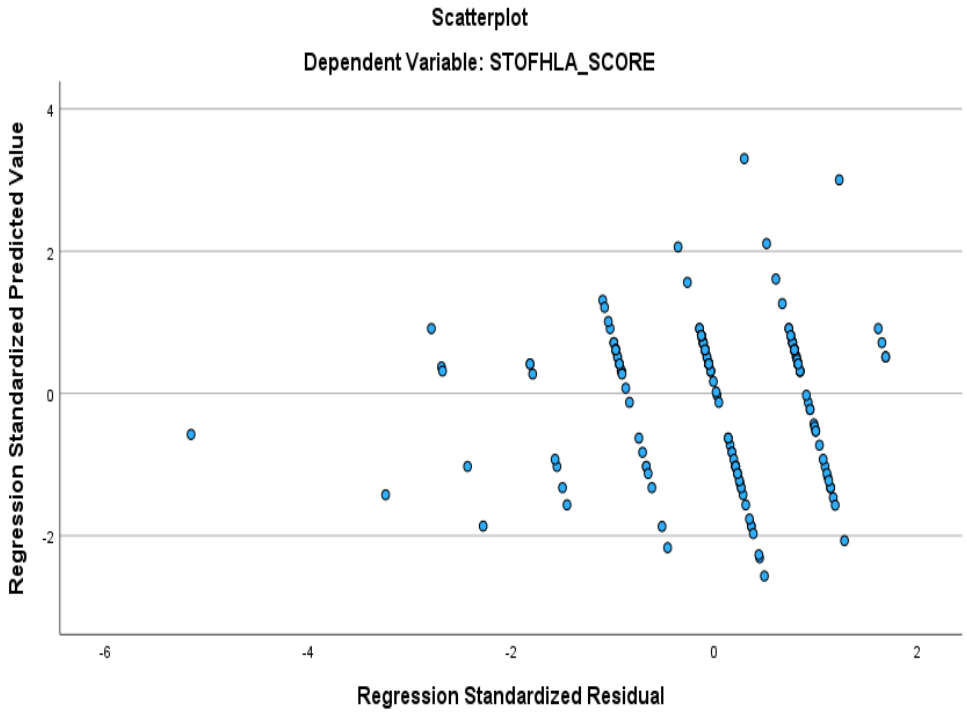


Figure 14

Standardized residuals versus predicted standardized residuals for regression on BNT

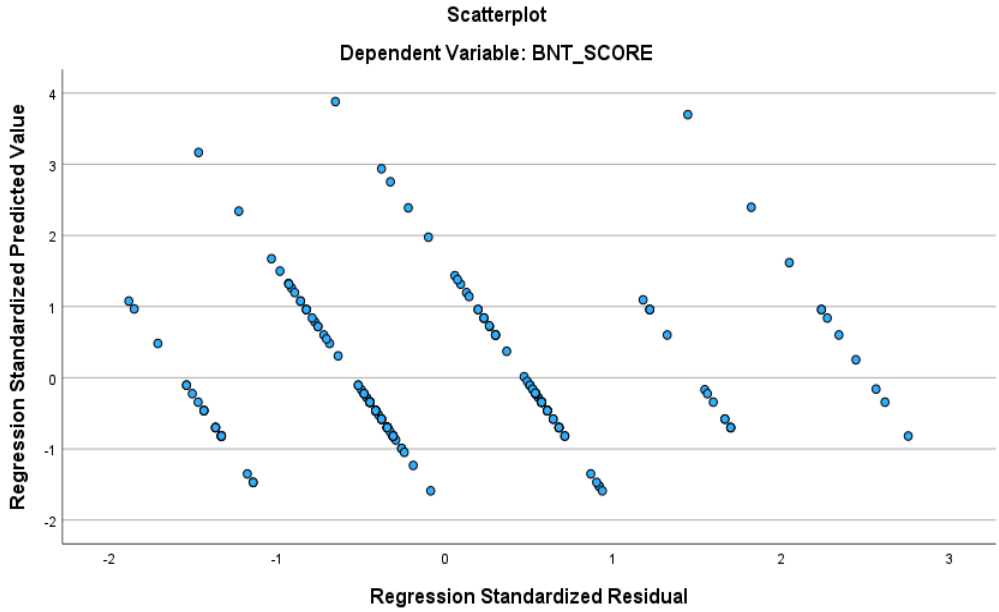


Table 4 displays the tolerance, *VIF*, and Durbin-Watson tests. The assumption of multicollinearity was met for the numeric variable age because the VIF, from the regression Coefficients table, was less than ten for both regression models. To avoid perfect multicollinearity among categorical data, all categorical variables were dichotomously coded into one categorical variable. Moreover, we know that if a dichotomous variable is added to the model and the Sig values for the unstandardized beta coefficients change significantly likely multicollinearity is present. For this reason, the models were developed with forward stepwise regression which removes predictors at each step if they are not significant.

Independence of the residuals was confirmed for the model of BNT score for the numeric variable (age) with the Durbin-Watson test value of autocorrelation of 1.88 for the Hypothesis 1 BNT regression model, which is greater than 1 and less than 3. The Durbin-Watson test value for Hypothesis 1 STOFHLA regression model was 0.11 which violated the assumption of residual independence. This is non-intuitive because the BNT data has no time elements. However, a visual examination of the standardized versus predicted residuals plots showed no patterns related to autocorrelations so the regression analysis will proceed.

Table 4
Collinearity and Durbin Watson test for age

Models	Tolerance	*VIF*	Durbin-Watson
Hypothesis 1 STOFHLA	0.844	1.19	0.11
Hypothesis 2 BNT	0.844	1.19	1.88

Results

Multivariate linear regression tests were conducted to examine how well the independent variables predict the health literacy levels of college-age students. The criteria were the STOFHLA and BNT exam scores. The predictors were age (numeric), and the dichotomous categorical variables (coded 0 and 1) were gender, insurance, and smoking. For this analysis, the reference level was set to 'Female', insurance = 'Yes', and smoking = 'No' because these categories had the highest number of responses. The significance level was alpha = 0.05.

Null Hypothesis One

$H_0$1: There will be no significant predictive relationship between the dependent variable (health literacy score) and the linear combination of independent variables (age, sex, smoking status, and health insurance) for college students.

Multiple linear regression was conducted to predict STOFHLA scores from age, sex, smoking, and health insurance. The overall model was not significant (F (4,176) = 1.520, p = .198), and none of the predictor variables were significant predictors of the STOFHLA score (Table 5). It is noted that the predictor gender had a p-value of 0.053 which is close to the significant cutoff level of alpha = 0.05 (Table 6).

These regression results do not support rejecting the null hypothesis, so no significant regression equation was derived from this analysis. However, it is worthwhile to explore the regression results, the model effect size was small with an adjusted R^2 = 0.011 which indicates only 1.1% of the variance in STOFHLA score could have been explained by the linear combination of predictor variables. See Table 7 for the Model Summary.

Table 5

Regression Model ANOVA Results for STOFHLA

Variable	Sum of Squares	*df*	Mean Square	*F*	*Sig.*
Regression	7.844	4	1.96	1.52	.198
Residual	227.018	176	1.29		
Total	234.862	180			

Table 6

STOFHLA Regression Coefficients

Variable	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	*B*	*t*	*Sig.*
(Constant)	32.24	0.82		39.19	0.000
Gender	0.36	0.19	0.146	1.95	0.053
Insurance	0.07	0.13	0.040	0.53	0.597
Smoking	0.28	0.29	0.080	0.98	0.326
Age	0.02	0.02	0.103	1.27	0.204

Table 7

Model Summary

Variable	*R*	*R* Square	Adjusted *R* Square	Std. Error of the Estimate	Durbin-Watson
Age	.183	0.03	0.01	1.14	0.11

Null Hypothesis Two

$H_0$2: There will be no significant predictive relationship between the dependent variable (numeracy score) and the linear combination of independent variables (age, sex, smoking status, and health insurance) for college students.

Multiple linear regression was conducted to predict BNT scores from age, gender, sex, smoking, and health insurance. The overall model was significant ($F(4,176) = 3.80$, $p = .005$), but only two variables (age and gender) were significant predictors of BNT score (Table 8). The individual *t*-test results (Table 9) were age $t(176) = 2.41$, $p = 0.017$, and gender $t(176) = -2.30$, $p = 0.023$.

Age was the most significant predictor of BNT ($\beta = 0.190$) when compared to gender ($\beta = -0.168$) because it had the largest absolute value of the standardized beta coefficient. The model effect size was small, the adjusted R^2 for the model was 0.059 indicating only 5.9% of the variance in the BNT score could be explained by the linear combination of the predictor variables age and gender (Table 10).

These regression results support rejecting the null hypothesis. The significant regression equation for predicting BNT is:

BNT score = 1.217 + 0.03 age -0.37 gender

Referencing the Table 9 regression output, the reference group is female and the average BNT score for females is 1.217. Males have a lower estimated average BNT score of 1.217 - 0.37 = 0.847, holding the age constant. The coefficient for the age indicates that each one-year increase in age is associated with a 0.03 increase in the BNT score while holding gender constant.

Table 8

Regression Model ANOVA Results for BNT

Variable	Sum of Squares	*df*	Mean Square	*F*	*Sig.*
Regression	14.54	4	3.64	3.80	.005
Residual	168.48	176	0.96		
Total	183.02	180			

Table 9

BNT Regression Coefficients

Variable	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	*B*	*t*	*Sig.*
(Constant)	1.217	0.71		1.72	0.088
Gender	-0.37	0.16	-0.168	-2.30	0.023
Insurance	0.13	0.11	0.085	1.16	0.246
Smoking	-0.02	0.25	-0.006	-0.07	0.941
Age	0.03	0.01	0.190	2.41	0.017

Table 10

BNT Model Summary

Variable	*R*	*R* Square	Adjusted *R* Square	Std. Error of the Estimate	Durbin-Watson
Age	.282[a]	0.079	0.059	0.98	1.88

CHAPTER FIVE: CONCLUSIONS

Overview

This section begins with a discussion of the findings of this quantitative correlational study on the health literacy of college students. Each research question is examined, and the results are compared with relevant research literature to determine if the current study's result supports or contradicts other similar research. The implications of this study on health literacy are explored in the context of what this study adds to the body of knowledge on the health literacy of college students. The chapter concludes with study limitations, in the context of internal and external validity, and recommendations for future research.

Discussion

The purpose of this quantitative correlational study was to examine how well the independent variables predicted the health literacy levels of college-age students, to fill the gap in research in this area. The predictor variables were age, sex, smoking status, and health insurance. Two multivariate linear regression tests were conducted to examine how well the independent variables predicted the health literacy levels of college-age students as measured by the STOFHLA and BNT exam scores. The alpha level for significance for all analyses was 0.05.

Research Question One

The first research question was:

RQ1: How accurately can health literacy scores be predicted from a linear combination of age, sex, smoking status, and health insurance for college students?

The null hypothesis for the first research question was:

$H_0$1: There will be no significant predictive relationship between the dependent variable (health literacy score) and the linear combination of independent variables (age, sex, smoking status, and health insurance) for college students.

The overall regression results for the first research question revealed that no statistically significant predictive relationship existed between age, sex, smoking status, health insurance, and the STOFHLA exam scores among college students. The overall model was not statistically significant (p = .198, Adjusted R^2 = 0.011) and none of the predictor variables were significant predictors of the STOFHLA scores. Specifically, sex (β = 0.363, p = .053), insurance age (β = .067, p = .597), smoking (β = .280, p = .326), and age (β = .021, p = .204) did not significantly predict STOFHLA exam scores at the alpha level of 0.05. These regression results did not support rejecting the null hypothesis and no significant regression equation was derived from this analysis. It was noted that gender had a p-value of 0.053 which is close to the alpha level of 0.05.

The current study aimed to extend the Ickes and Cottrell (2010) study of health literacy at a Midwestern university which examined college juniors and seniors with the TOFHLA. However, this study also considered enrolled college students at all college classification levels (freshman to graduate) and explored sex, smoking, and health insurance in addition to age. The findings from the current study support Ickes and Cottrell (2010) and Durand et al. (2020) who found no statistically significant difference in health literacy levels among gender groups.

The findings from the current study contradict several other research studies that found significance for age, gender, smoking status, and insurance on health literacy levels. Nobles et al. (2019) reported lower literacy scores for college students who were males and not on the student health plan. Hoover et al. (2015) found lower health literacy levels were associated with younger college students, males, smokers, and those who did not have health insurance during the last 12 months. For example, among those with low health literacy, 26.9% were male, 32.6% were smokers, and 25.7% did not have health insurance in the last twelve months.

These findings also contradict Rababah et al. (2019) who surveyed college students, their analysis revealed that age, gender, and smoking status had statistically significant effects on health literacy scores. Similarly, Rafferty et al. (2022) conducted a cross-sectional study of college students which revealed that low health literacy was more prevalent among males, and adults without insurance, or those without a personal doctor. Additionally, Rafferty et al. (2022) noted that female nonsmokers in health-related areas of study had higher health literacy levels.

Research Question Two

The second research question tested was:

RQ2: How accurately can health numeracy scores be predicted from a linear combination of age, sex, smoking status, and health insurance for college students?

The null hypothesis for the second research question is:

$H_0$2: There will be no significant predictive relationship between the dependent variable (numeracy score) and the linear combination of independent variables (age, sex, smoking status, and health insurance) for college students.

The multiple linear regression results for the second research question revealed that a statistically significant predictive relationship existed between two of the predictors and the BNT numeracy exam scores. The fitted regression model was:

BNT score = 1.217+ 0.03 age -0.37 gender

The overall regression model was statistically significant (p = .005, Adjusted R^2 = 0.059), and age (β = 0.03, p = < .017) and gender (β = -.37, p < .023) did significantly predict 5.9% of the variance in BNT scores among college students. Age was the most significant predictor of BNT (β = 0.19) when compared to gender (β = -0.17). It was determined that smoking status (β = -0.018, p < .941), and health insurance (β = .126, p = 0.246) did not significantly predict BNT

exam scores. These regression results supported rejecting the null hypothesis. The regression results indicate that males had lower BNT scores when compared to females and that increases in age in years resulted in an increase in BNT exam scores.

First, it was noted that most BNT studies considered numeracy scores at the group level for medical students (Friederichs et al., 2020), physicians (Petrova et al., 2019), or college students (Cokely et al., 2012), and a few BNT studies were found that considered demographics as predictors of BNT scores for college students. The results of this study indicate that male college students had lower estimated average BNT scores than females. In contrast, Friederichs et al. (2014) assessed German medical students with the BNT to establish that males had significantly higher numeracy scores than females. Durand et al. (2020) also found that females had higher odds of having lower numeracy scores among a Medicaid-eligible population. In the middle ground, Friederichs et al. (2020) found no statistical differences in BNT scores for males versus females among General Practitioner physicians when compared to the BNT scores for medical students.

Although the current study appears inconsistent with these studies on gender, there is a disparity in sample demographics and study settings between these three studies (i.e., German medical students (51% female), German practitioners (60% female), Medicaid eligible group (82% female), and making it problematic to establish external validity by comparing their results to the study sample of United States college students from various academic disciplines (69% female). The disparities are that one study had significantly fewer females and one had significantly more females than this study. Additionally, two studies were set in Germany and involved medical students and doctors, and one study sampled individuals in lower socio-

economic groups (i.e., Medicaid eligible), whereas this study sampled United States college students from various colleges with 44.6% having household incomes over 50000 dollars.

Regarding age, the current study determined that an increase in age was associated with higher BNT scores. In contrast, Bergner and Filzen (2022) examined C-suite risk numeracy among business executives and professionals with the BNT and they determined that age was negatively associated with numeracy indicating the older participants had lower BNT scores. However, the Bergner and Filzen (2022) study had a much higher average age (M = 54) than this study (M = 22.63), and a limitation of the Bergner and Filzen (2022) study was their small sample size (n = 77) when compared to this study (n = 184).

This study utilized Squier's Health Literacy Skills Framework which considers demographic factors and prior knowledge of healthcare concepts as factors that influence health literacy levels (Squiers et al., 2012). Guided by Squier's HLSF, this study measured the knowledge of healthcare concepts with the STOFHLA and the BNT test scores and considered a linear combination of age, sex, smoking status, and health insurance as predictors of the STOFHLA and BNT scores. Results for this study indicate that males had lower BNT scores when compared to females and that increases in the age in years resulted in an increase in BNT exam scores which provides information for interventions to improve health numeracy.

The current study contributes to the body of knowledge on numeracy by assessing demographic factors related to numeracy among college students using the BNT exam. This study revealed that age and gender are associated with numeracy scores, it indicated that smoking and having health insurance were not related to numeracy scores. The current study did not contribute to the understanding of factors associated with STOFHLA scores among college students. This sparsity of similar BNT evidence-based studies considering demographic

predictors indicates a need for more research on United States college students to provide more evidence-based conclusions for this underrepresented demographic.

Implications

Health literacy is the ability of individuals to understand and use health information for their healthcare decision-making (Centers for Disease Control, 2020). Numeracy is "the ability to access, use, interpret, and communicate mathematical information and ideas, to engage in and manage mathematical demands of a range of situations in adult life" (Centers for Disease Control, 2019b, para. 3). Low health literacy creates healthcare barriers for individuals who may not understand how to fill out an insurance form, prepare for a diagnostic test, utilize preventative services, or manage their medications. Low health numeracy levels may affect the ability to understand information about disease risks, medication directions, or the advantages of different treatment options which can result in poor medical decision-making.

This study aimed to examine the factors among college-age students that may present barriers to their ability to access, use, and interpret health information effectively to manage their healthcare needs. Understanding these health literacy barriers provides valuable information for designing interventions to improve health outcomes. Using Squier's Health Literacy Skills Framework, the factors that influence health literacy levels were explored (Squiers et al., 2012). Guided by Squiers et al. (2012) HLSF this study considered demographic factors that affect health literacy levels.

The BNT regression results support the conclusion that there is a statistically significant predictive relationship between age, sex, and BNT exam scores among college students. These results indicated that females and older college students had higher BNT exam scores. The STOFHLA regression results in this study support the conclusion that there is no statistically

significant predictive relationship between age, sex, smoking status, health insurance, and STOFHLA exam scores among college students.

Although the STOFHLA results did not find significant predictors of STOFHLA for this sample with a cross-sectional survey study, this does not indicate that these predictors are not associated with health literacy levels, and it does not indicate that all college students have adequate health literacy. Indeed, many researchers have found significance for smoking, age, and gender as well as other demographic predictors (Hoover et al., 2015; Ickes & Cottrell, 2010; Nobles et al., 2019; Vamos et al., 2016). Thus, it may be that this cross-sectional point in time sample does not accurately represent the study sites college students' health literacy causal pathways, a known potential limitation of cross-sectional studies.

The study adds to the body of knowledge on the health literacy levels of college-age students in several areas. Nobles et al. (2019) noted that college students' health literacy has not been adequately explored in research studies. Indeed, most health literacy research has focused on older individuals, individuals with specific conditions, chronic illnesses, or special groups (e.g., nursing homes, Medicare, or Medicaid recipients). While some of the BNT numeracy studies have explored college students or other educated populations, few have explored the same demographic factors (age, gender, smoking, insurance) examined in this study.

This study provides valuable information that can be used to develop targeted interventions to improve the health outcomes of college students by encouraging regular checkups and routine care designed to manage acute or chronic conditions. Study results inform healthcare providers that younger students may need more help understanding medical terms and procedure preparation. The results indicated that males may need more help managing their care. Assuredly the first step would be to assess the students' health literacy level with the STOFHLA

and the BNT tests. As the literature review indicates, talk-back and teach-back methods may be helpful for patient provider communication for college students with low health literacy. Curriculum content could be added to teach risk literacy for numeracy related to health topics.

Limitations

As with most research, this study has some limitations. This study was a non-experimental quantitative correlational survey study to determine how accurately health literacy scores could be predicted from a linear combination of age, sex, smoking status, and health insurance for college students. Survey studies may have limitations in internal or external validity.

Internal Validity

For this study, internal validity refers to how confident we can be that the variance in the regression predictors is responsible for the variance in the STOFHLA or BNT scores. Internal validity can be increased by controlling sample size, recruiting methods, and sampling methods. Although the sample size was adequate for the study at a statistical power of .8 and an alpha level of 0.05, the effect size, measured by the adjusted R^2, was small. A larger effect size would have been better because it indicates a stronger relationship between the model variables. A larger sample size could have produced a larger effect size and it might also have increased the significance level of gender ($p = 0.053$) and other predictors in the study.

A second consideration for internal validity is sample selection. For this study participants were recruited by emailing all students on one mailing list. Randomly selecting students from the student population could have possibly eliminated the potential selection bias inherent in non-random sampling which may mitigate the effect of extraneous variables. However, to ensure an adequate number of responses that adequately represented the population

could be collected within a short period, convenience sampling was used by requesting 4,000 students from the available list and emailing all those students.

Survey data collection has inherent limitations to internal validity. Survey respondents may exhibit survey fatigue and begin to randomly mark answers. Or they may not understand the questions and may just pick a selection from the drop-down choices. They may under report their lifetime use of tobacco or their age either inadvertently or on purpose.

External Validity

External validity refers to whether the study results can be generalized from the study sample to similar colleges, students, and academic settings. To ensure external validity the study population was defined as currently enrolled students at the study site. The inclusion criteria for the sample of students were set to those over the age of 18 years and have answered all the health literacy and numeracy survey questions.

Another threat to external validity is that this study was a quantitative correlational study to examine how well the independent variables predicted the health literacy levels of college-age students. A non-experimental correlational study can show the associations between the predictors and criterion, but it cannot prove the cause and effect between the predictors and the criterion. Proving cause and effect requires an experimental study.

The study site setting is a known limitation of external validity. The study site was a state research university in the Southwest. Thus, the study results may be different in different settings. For example, a different university (i.e., private, or religious), a university with a different culture (more liberal or more social), a university with a different ethnic mix, or one in a different geographic region of the United States may have different outcomes.

External validity can be assessed by comparing study results to the results obtained from similar populations in similar studies. However, as noted earlier, there are few recent studies on college students in the United States that have used the BNT or the STOFHLA test for health literacy assessment.

Recommendations for Future Research

It is important to raise awareness of college students' health literacy with further research because many college students are at risk for poor mental and physical health outcomes. For example, attending college exposes students to potential stressors from hectic schedules, moving away from friends and family, changes in sleeping patterns and diets, challenges to getting regular exercise, and course work related deadlines. Many will need to learn how to self-manage their healthcare for the first time (e.g., make doctor's appointments, understand health insurance benefits, get annual exams, buy medicines, and schedule flu shots).

Below are some suggestions for further exploration of health literacy and numeracy.

1. A different larger more demographically diverse sample might produce more significance among predictors when compared to this mostly female White English-speaking sample.
2. Respondents should be randomly selected for the sample which increases study validity.
3. Other demographics could be explored as predictors, such as race, class standing, college major, income, and parents' educational levels.
4. Interactions between predictors should be considered as interaction terms may have a larger effect size than single predictors.

5. Consideration should be given to using other health literacy instruments. For example, the Health Literacy Questionnaire explores nine constructs related to health literacy levels and thus provides a more complete picture of the association of demographics to health literacy levels.
6. Use an experimental model to prove cause and effect. For example, conduct pre- and post-tests with talk-back interventions, or with teach-back interventions.

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APPENDIX A: Short Test of Functional Health Literacy

Passage A

Your doctor has sent you to have a _____X-ray.

a. stomach
b. diabetes
c. stitches
d. germs

You must have an _____ stomach when you come for _____.

a. asthma	a. is
b. empty	b. am
c. incest	c. if
d. anemia	d. it

The X-ray will _____ from 1 to 3 _____ to do.

a. take	a. beds
b. view	b. brains
c. talk	c. hours
d. look	d. diets

THE DAY BEFORE THE X-RAY

For supper have only a _____snack of fruit, _____ and jelly, with coffee or tea.

a. little	a. toes
b. broth	b. throat
c. attack	c. toast
d. nausea	d. thigh

After _____, you must not _____ or drink

a. minute,	a. easy
b. midnight,	b. ate
c. during,	c. drank
d. before,	d. eat

anything at _____ until after you have _____ the X-ray.

a. ill	a. are
b. all	b. has
c. each	c. had
d. any	d. was

THE DAY OF THE X-RAY

Do not eat _____.

a. appointment
b. walk-in
c. breakfast
d. clinic

Do not _____, even _____.

a. drive	a. heart
b. drink	b. breath
c. dress	c. water
d. dose	d. cancer

If you have any _____, call the X-ray _____ at 616-4500.

a. answers,	a. Department
b. exercises,	b. Sprain
c. tracts,	c. Pharmacy
d. questions,	d. Toothache

PASSAGE B

I agree to give correct information to _____ if I can receive Medicaid.

a. hair
b. salt
c. see
d. ache

I _____ to provide the county information to _____ any

a. agree	a. hide
b. probe	b. risk
c. send	c. discharge
d. gain	d. prove

statements given in this _____ and hereby give permission to

a. emphysema
b. application
c. gallbladder
d. relationship

the _____ to get such proof. I _____ that for

a. inflammation	a. investigate
b. religion	b. entertain
c. iron	c. understand
d. county	d. establish

Medicaid I must report any _____ in my circumstances

a. changes
b. hormones
c. antacids
d. charges

within _____ (10) days of becoming _____ of the change.

a. three
b. one
c. five
d. ten

a. award
b. aware
c. away
d. await

I understand _____ if I DO NOT like the _____ made on my

a. thus
b. this
c. that
d. than

a. marital
b. occupation
c. adult
d. decision

case, I have the _____ to a fair hearing. I can _____ a

a. bright
b. left
c. wrong
d. right

a. request
b. refuse
c. fail
d. mend

hearing by writing or _____ the county where I applied.

a. counting
b. reading
c. calling
d. smelling

If you _____ AFDC for any family _____, you will have to

a. wash
b. want
c. cover
d. tape

a. member
b. history
c. weight
d. seatbelt

_____ a different application form. _____, we will use

a. relax
b. break
c. inhale
d. sign

a. Since
b. Whether
c. However
d. Because

the _____ on this form to determine your _____.

a. lung
b. date
c. meal
d. pelvic

a. hypoglycemia
b. eligibility
c. osteoporosis
d. schizophrenia

APPENDIX B: Short Test of Functional Health Literacy Permission

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Diane,
This is no longer under copyright, so you are welcome to use and publish in your dissertation. Best of luck!

David W. Baker, MD, MPH, FACP
Executive Vice President, Healthcare Quality Evaluation
Editor-in Chief, Joint Commission Journal on Quality and Patient Safety
Asst: Judy Azzarello
jazzarello@jointcommission.org

www.jointcommission.org
We support all the healthcare workers fighting COVID-19
Resources available at: https://www.jointcommission.org/covid-19/

APPENDIX C: Berlin Numeracy Test

Instructions: Please answer the questions below. Do not use a calculator but feel free to use scratch paper.

1. Imagine we are throwing a five-sided die 50 times. On average, out of these 50 throws how many times would this five-sided die show an odd number (1, 3 or 5)
    a. 5 out of 50 throws
    b. 25 out of 50 throws
    c. 30 out of 50 throws
    d. None of the above

2. Out of 1,000 people in a small town 500 are members of a choir. Out of these 500 members in the choir 100 are men. Out of the 500 inhabitants that are not in the choir 300 are men. What is the probability that a randomly drawn man is a member of the choir? Please indicate the probability in percent
    a. 10%
    b. 25%
    c. 40%
    d. None of the above

3. Imagine we are throwing a loaded die (6 sides). The probability that the die shows a 6 is twice as high as the probability of each of the other numbers. On average, out of these 70 throws, about how many times would the die show the number 6?
    a. 20 out of 70 throws
    b. 23 out of 70 throws
    c. 35 out of 70throws
    d. None of the above

4. In a forest 20% of mushrooms are red, 50% brown and 30% white. A red mushroom is poisonous with a probability of 20%. A mushroom that is not red is poisonous with a probability of 5%. What is the probability that a poisonous mushroom in the forest is red?
    a. 4%
    b. 20 %
    c. 50 %
    d. None of the above

APPENDIX D: Berlin Numeracy Test Permissions

Cokely, Edward T. <cokely@ou.edu>¶

You are welcome to use the questions for research (use just the 4 items if college sample or 7 items if general population sample). Regarding printing in your dissertation, is that a requirement?¶

¶

Best Wishes,¶

Ed¶

¶

Edward T. Cokely, Ph.D.¶
Presidential Research Professor & Professor of Psychology¶
Department of Psychology | University of Oklahoma¶
www.decisionanalyticslab.org¶

¶

Do you understand risk?↵

www.RiskLiteracy.org¶

¶

APPENDIX E: IRB Approval

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

April 6, 2023

Diane Dolezel
Eric Lovik

Re: IRB Exemption - IRB-FY22-23-769 PREDICTION OF HEALTH LITERACY SCORES FROM A LINEAR COMBINATION OF AGE, SEX, SMOKING STATUS, AND HEALTH INSURANCE FOR COLLEGE STUDENTS

Dear Diane Dolezel, Eric Lovik,

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study to be exempt from further IRB review. This means you may begin your research with the data safeguarding methods mentioned in your approved application, and no further IRB oversight is required.

Your study falls under the following exemption category, which identifies specific situations in which human participants research is exempt from the policy set forth in 45 CFR 46:104(d):

Category 2.(i). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording). The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects.

Your stamped consent form(s) and final versions of your study documents can be found under the Attachments tab within the Submission Details section of your study on Cayuse IRB. Your stamped consent form(s) should be copied and used to gain the consent of your research participants. If you plan to provide your consent information electronically, the contents of the attached consent document(s) should be made available without alteration.

Please note that this exemption only applies to your current research application, and any modifications to your protocol must be reported to the Liberty University IRB for verification of continued exemption status. You may report these changes by completing a modification submission through your Cayuse IRB account.

If you have any questions about this exemption or need assistance in determining whether possible modifications to your protocol would change your exemption status, please email us at irb@liberty.edu.

Sincerely,
G. Michele Baker, PhD, CIP
Administrative Chair
Research Ethics Office

APPENDIX F: Recruitment Email

Recruitment Template: Email

12/18/2022

Dear student:

As a graduate student in the School of Education at Liberty University, I am conducting research as part of the requirements for a PhD. The purpose of my research is to predict health literacy scores from a linear combination of age, sex, smoking status, and health insurance for college students. I am writing to invite eligible participants to join my study.

Participants must be 18 years of age or older and be a student at Texas State University. Participants, if willing, will be asked to complete a survey on health literacy. It should take approximately 10 minutes to complete the survey listed. Participation will be completely anonymous, and no personal, identifying information will be collected.

After completing the survey, you may choose to enter a drawing for a $50 Amazon gift card.

To participate, please [click here (include hyperlink to online survey)]

A consent document is provided as the first page of the survey. The consent document contains additional information about my research. After you have read the consent form, please click the button to proceed to the survey. Doing so will indicate that you have read the consent information and would like to take part in the survey.

Sincerely,

Diane Dolezel
Associate Professor
Texas State University
[redacted]

APPENDIX G: Informed Consent

Consent

Title of the Project: PREDICTION OF HEALTH LITERACY SCORES FROM A LINEAR COMBINATION OF AGE, SEX, SMOKING STATUS, AND HEALTH INSURANCE FOR COLLEGE STUDENTS

Principal Investigator: Diane Dolezel, Doctoral Candidate, School of Education, Liberty University

Invitation to be Part of a Research Study

You are invited to participate in a research study. To participate, you must be 18 years of age and older, a college student at Texas State University. Taking part in this research project is voluntary.

Please take time to read this entire form and ask questions before deciding whether to take part in this research.

What is the study about and why is it being done?

The purpose of the study is to examine how well the independent variables predict the health literacy levels of college age students, to fill the gap in research in this area.

What will happen if you take part in this study?

If you agree to be in this study, I will ask you to do the following:

1. Participate in a survey that will take 10 minutes.

How could you or others benefit from this study?

Participants should not expect to receive a direct benefit from taking part in this study.

Benefits to society include understanding how individuals find, understand, and use health information, and how they manage their health and interact with doctors and other healthcare providers. This knowledge could help to reduce missed medical appointments and costly overuse of emergency rooms for non-emergent care.

What risks might you experience from being in this study?

The expected risks from participating in this study are minimal, which means they are equal to the risks you would encounter in everyday life.

How will personal information be protected?

The records of this study will be kept private. Research records will be stored securely, and only the researcher will have access to the records.

- Participant responses to the online survey will be anonymous. Participants may volunteer their email for the drawing and that data will remain confidential.
- Data will be stored on a password-locked computer. After three years, all electronic records will be deleted.

How will you be compensated for being part of the study?

Participants will be compensated for participating in this study. At the conclusion of the survey participants will be eligible to enter a drawing to receive a $50 Amazon gift card. Email addresses will be requested for compensation purposes; however, they are entered voluntarily by the respondent and are separated from your responses because they will be collected through a separate survey from the study survey.

Is the researcher in a position of authority over participants, or does the researcher have a financial conflict of interest?

The researcher serves as a teacher at school. To limit potential or perceived conflicts, data collection will be anonymous. This disclosure is made so that you can decide if this relationship will affect your willingness to participate in this study. No action will be taken against an individual based on his or her decision to participate or not participate in this study.

Is study participation voluntary?

Participation in this study is voluntary. Your decision on whether to participate will not affect your current or future relations with Texas State University. If you decide to participate, you are free to not answer any question or withdraw at any time prior to submitting the survey without affecting those relationships.

What should you do if you decide to withdraw from the study?

If you choose to withdraw from the study, please retain the following statement if the survey will be online. Your responses will not be recorded or included in the study.

Whom do you contact if you have questions or concerns about the study?

The researcher conducting this study is Dr. Diane Dolezel. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at [redacted].

Whom do you contact if you have questions about your rights as a research participant?

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the IRB. Our physical address is

Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA, 24515; our phone number is 434-592-5530, and our email address is irb@liberty.edu.

Disclaimer: The Institutional Review Board (IRB) is tasked with ensuring that human subjects research will be conducted in an ethical manner as defined and required by federal regulations. The topics covered and viewpoints expressed or alluded to by student and faculty researchers are those of the researchers and do not necessarily reflect the official policies or positions of Liberty University.

Your Consent

Before agreeing to be part of the research, please be sure that you understand what the study is about. If you have any questions about the study later, you can contact the researcher using the information provided above.