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Effect of Socioeconomic and Neighborhood Factors on Stroke Hospitalization Rate in Virginia

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Abstract

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MPH, East Carolina University, 2012

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

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Abstract

The stroke rate in Virginia is above the national rate. Stroke results in poor quality health, morbidity, and mortality. This quantitative epidemiological study was conducted to investigate whether a significant association exists between stroke and (a) socioeconomic and (b) neighborhood factors among people who were admitted to Virginia hospitals between 2010 and 2015. An ecological design, including ecosocial theory, was used to examine associations between environmental factors and stroke. Data were acquired using patients' billing zip codes from the Virginia Health Information System in combination with socioeconomic and neighborhood data by Zip Code Tabulation Area from the U.S. Census Bureau and the U.S. Food and Drug Administration. Results of linear regression analysis showed a significant association between stroke hospitalization rate and educational attainment, per capita income, and Gini coefficient for income distribution. Also, a significant association emerged between stroke and neighborhood risk factors such as food access, Walkability Index, and population density. Findings from a one-way ANOVA showed a significant geographic difference in stroke hospitalization rate with the highest stroke rate in eastern Virginia and the lowest stroke rate in northern Virginia. Results may help stakeholders, policymakers, and public health agencies design, prioritize, and implement community-based prevention programs to reduce stroke rates in Virginia.

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Dedication

This dissertation is dedicated to my lovely husband, Duane. Thank you for your unwavering love and for sharing this journey with me. Without your support and understanding, this dream would not have come to reality. Importantly, you made sure I never forgot to take a break from writing when I needed to have some fun. To my daughter Imani, you have been my source of strength and joy as I finish this journey. To my mother Kaday Sanpha-Seisay, thank you for your encouragement, prayers and inspiring me to aim high in life. For that I continually will be grateful, without interruption. Finally, dedicated to the memory of my Father, John Santigie Sanpha-Seisay (1946-2017) who valued education above all.

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Chapter 1: Introduction to the Study

Stroke is the third leading cause of death and morbidity in the United States (Heron, 2016; Murphy, Xu, & Kochanek, 2012). Every year, approximately 130,000 of the 2,596,993 deaths in the United States are due to stroke (Xu, 2015). In 2013, about one in four deaths in the United States was due to a stroke and approximately 7 million Americans have experienced a stroke (Fang, Shaw, & George, 2012; Mozaffarian et al., 2016). Nearly $18 billion was spent in direct medical care for stroke in 2008; most of the cost was for hospitalization (Boan et al., 2014; Wang et al., 2014). Stroke patients spend an average of $15,000 for the first 90 days after a stroke episode (Boan et al., 2014). In Virginia, 3,394 of the 62,309 deaths were due to stroke in 2013 (National Center for Health Statistics, 2015). Despite the implementation of preventative stroke programs in Virginia, stroke rates have remained consistently above the national average (Virginia Department of Health [VDH], 2010, 2011). Limited research has been conducted on strokes in Virginia. Multiple studies have addressed the southeastern United States, known as the stroke belt, but few studies have targeted the State of Virginia. One study that targeted Virginia included only a small sample: the population of Richmond, Virginia (Williams, Sheppard, Marrufo, Galbis-Reig, & Gaskill, 2003). Limited data described the neighborhood effect on stroke and stroke outcomes in Virginia.

Through examination of risk factors for stroke in Virginia, preventive tactics and effective programs could be developed to target populations and communities in need. These approaches could increase perceptions of the seriousness of stroke in Virginia and could create awareness of direct susceptibility to stroke in different communities. Prevention programs could be effective in the United States (Kozub, 2010; Lackland et al., 2014) and other countries (Agyemang et al., 2012; Kim & Kim, 2013; Lowres et al., 2014). Therefore, promoting preventive measures at the community level and targeting key risk factors in Virginia may be more effective in improving stroke outcomes than currently implemented programs.

This chapter provides the background of stroke and an introduction to the problem. I then discuss the study purpose and identify the research questions (RQs) and hypotheses. The chapter includes an overview of the theoretical foundation of the study as well as the nature of the study. In addition, I provide working definitions of key concepts and assumptions, limitations, scope, and delimitations of the study. Finally, I discuss the significance of the study.

Background

A stroke is caused by a sudden blockage of blood into the brain (Carolei, Sacco, Santis, & Marini, 2002; Sudlow & Warlow, 1997). According to the American Stroke Association (ASA, 2016), the three main stroke types are (a) ischemic stroke, (b) hemorrhagic stroke, and (c) transient ischemic attack (TIA). Ischemic stroke occurs as a result of a blockage in the blood vessel supplying blood to the brain (American Heart Association [AHA], 2016). This type of stroke accounts for 85% of all stroke types, and the ASA (2016) described it as the most common stroke type. Hemorrhagic strokes occur when an artery in the brain breaks open or leaks, thereby causing damage to brain cells (AHA, 2016). The two types of hemorrhagic strokes of intracerebral hemorrhage and subarachnoid hemorrhage. A burst of arteries in the brain causes intracerebral hemorrhage, which leads to bleeding into surrounding tissues and is the most common type of hemorrhagic stroke (AHA, 2016). Subarachnoid hemorrhage occurs when bleeding occurs between the brain and the tissues that cover it and is the least common type of stroke (AHA, 2016). TIA is also known as a ministroke and is often viewed as a warning sign for a future stroke (AHA, 2016). A TIA occurs when there is a blockage of blood flow to the brain for less than 5 minutes (AHA, 2016).

Between 1995 and 2005, the stroke death rate decreased by approximately 30% in the United States, and the total number of stroke deaths declined by approximately 14% in that time period (Fang et al., 2012). The stroke mortality rate continued to decrease by 3.7% between 2007 and 2008 (Go et al., 2014). Despite the significant declines in stroke mortality in recent decades, the occurrence of stroke remains high. Over 700,000 people suffer a stroke each year; about 610,000 of these are first attacks, and 185,000 are recurrent attacks (Go et al., 2013). The stroke death rate remains higher than the 34.8% target set by Healthy People 2020 (U.S. Department of Health and Human Services, 2012). The rates of stroke also remain high in Virginia. Between 2008 and 2010, Virginia stroke death rates have consistently remained higher than the national stroke death rate (see Figure 1). Despite a decrease in stroke rates, National Vital Statistics reported in 2012 that Virginia ranked 17 among stroke cases in the United States. The rate of strokes in Virginia is remarkably higher in an area known as the Hampton Roads and cities and counties along the northern border of North Carolina (Hoyert & Xu, 2012).

Problem Statement

Studies have shown significant geographic differences in stroke rates in the United States. Of the southeastern states, 11 (Virginia, North Carolina, Georgia, Alabama, Indiana, Kentucky, Louisiana, Mississippi, South Carolina, Arkansas, and Tennessee) have higher stroke mortality rates, dubbed the stroke belt (Wetmore et al., 2013). Also, living in socioeconomically disadvantaged neighborhoods aligns with having a higher risk of stroke deaths (Balamurugan, Delongchamp, Bates, & Mehta, 2013; Brown et al., 2013, 2011; Clark et al., 2011; Gerber et al., 2011). Stroke is the third leading cause of death in Virginia, and stroke caused up to 7% of total Virginia deaths in 2010 (Stepanova, Venkatesan, Altaweel, Mishra, & Younossi, 2013). The percentage of adults who had been told they had a stroke was 3.2% in Virginia compared to 2.9% in the United States (Stepanova et al., 2013). In addition, neighborhood characteristics have a strong influence on an individual's stroke risk (Morgenstern et al., 2009; Sergeev, 2011; Wetmore et al., 2013), which may explain the gap seen in stroke incidence and mortality rates among different socioeconomic groups.

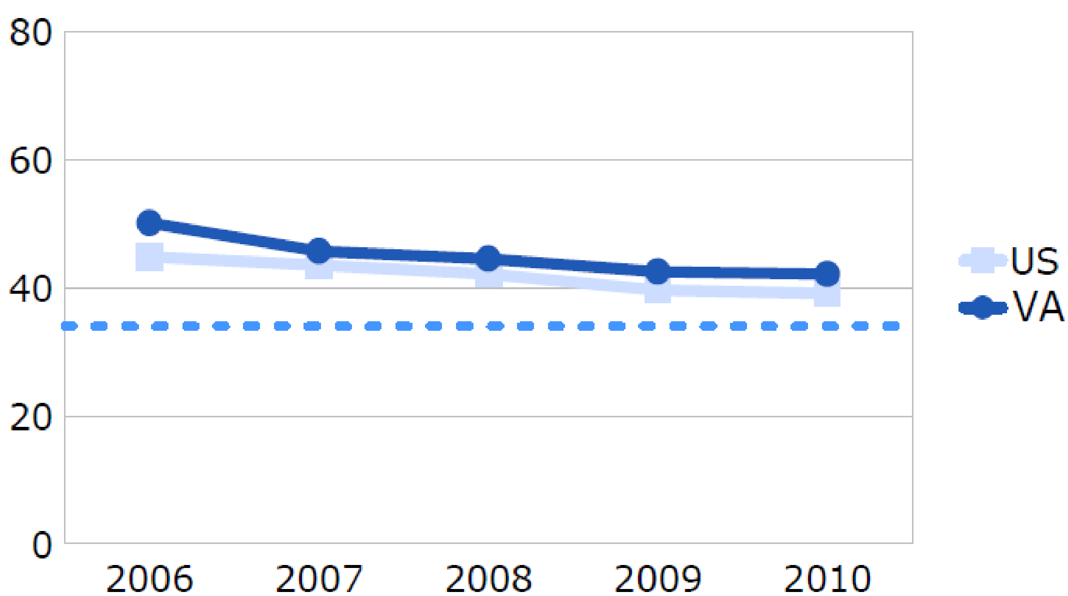

Figure 1. Age-adjusted (per 100,000 populations) stroke death rate for Virginia and the United States, 2006–2010.

Adapted from Centers for Disease Control and Prevention. Prevention Status Reports 2013: Heart Disease and Stroke— Virginia. Atlanta, GA: US Department of Health and Human Services; 2014, retrieved from file:///H:/Stroke%20articles/Virginia%20Prevention%20Status%20Report-2013.pdf

Furthermore, demographic groups experience stroke incidence, prevalence, premature death, and disability differently (Mensah, Mokdad, Ford, Greenlund, & Croft, 2005). Studies on stroke and socioeconomic status such as education and income have indicated independent associations between stroke hospitalization rates and socioeconomic risk factors (Addo et al., 2012; Arrich, Lalouschek, & Müllner, 2005; Boan et al., 2014; Mensah et al., 2005). Nationally, about 1,000,000 stroke hospitalizations occurred in 2009, and 5% of these stroke patients died in the hospital (Hall, Levant, & DeFrances, 2012). The average length of stay for a stroke patient was about 5 days in 2010 (Fang et al., 2012; see Figure 2) and many stroke patients, upon discharge, required additional outpatient or in-home services such as rehabilitation to restore function (Demaerschalk, Hwang, & Leung, 2010). Describing the stroke rates at the neighborhood level may help in understanding the role of neighborhood characteristics such as population density, population mobility, and access to exercise facilities in hospitalizations. However, little research has been done on the impact of neighborhood factors and socioeconomic status at the spatial level on stroke hospitalization rates in Virginia.

Purpose

This study adds to the limited research on neighborhood and socioeconomic factors and their effects on stroke hospitalization rates at the spatial level. This quantitative study addressed the issue of stroke hospitalizations in Virginia in the context of sociodemographic and neighborhood risk factors. The aim was to improve understanding of why disparities exist among people with low socioeconomic status and to identify risk factors at the spatial level that contribute to the trajectory of stroke hospitalizations. The study also addressed whether geographic differences exist in stroke hospitalization rates in Virginia. Analysis of neighborhood and socioeconomic variables identified factors with a greater impact on stroke hospitalization rates at the zip-code level in Virginia.

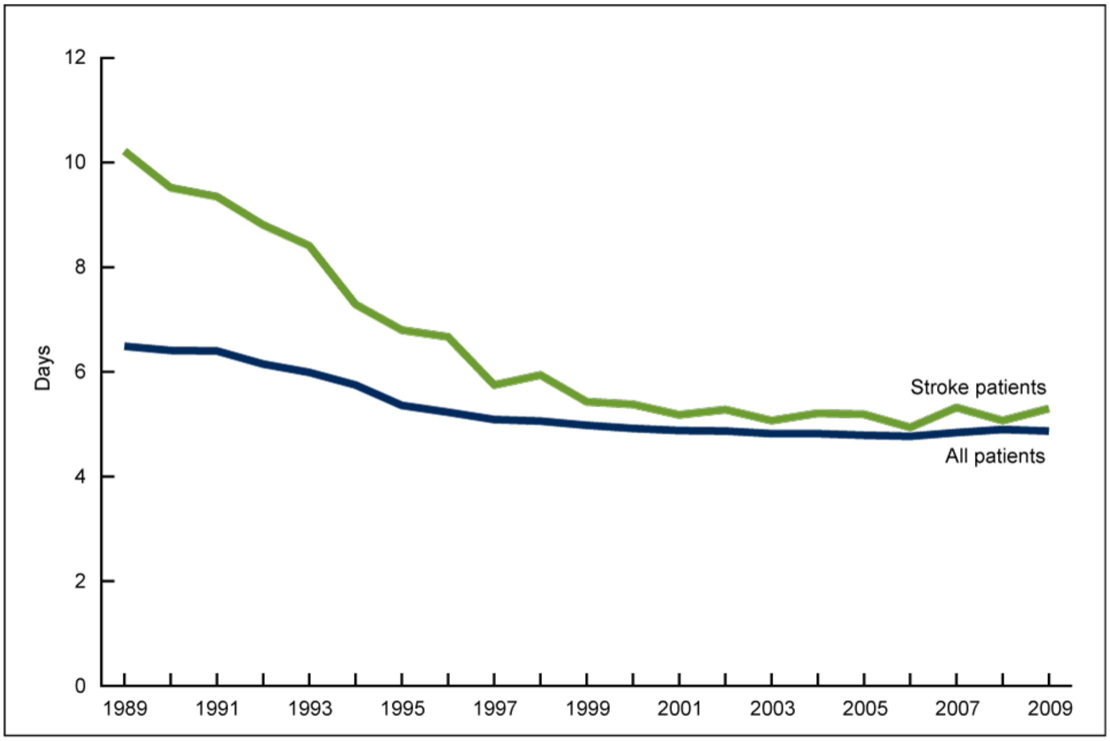

Figure 2. Average length of stay for stroke hospitalizations in the United States, 1989–2009.
Adapted from “Hospitalization for Stroke in U.S. Hospitals, 1989–2009,” by M. J. Hall, S. Levant, & C. J. DeFrances, 2012, NCHS Data Brief No. 95, Hyattsville, MD: National Center for Health Statistics, retrieved from http://www.cdc.gov/nchs/products/databriefs /db95.htm

Research Questions and Hypotheses

RQ1: What is the association between stroke hospitalization rates and socioeconomic status such as educational attainment, income, per capita income, Gini coefficient, and job participation?

*H_0*1: No association exists between socioeconomic status and stroke hospitalization rates.

*H_a*1: An association exists between socioeconomic status and stroke hospitalization rates.

RQ2: Does an association exist between stroke hospitalization rates and neighborhood factors such as food access and walkability?

*H_0*2: No association exists between neighborhood factors and stroke hospitalization rates.

*H_a*2: An association exists between neighborhood factors and stroke hospitalization rates.

RQ3: Do geographic differences exist in stroke hospitalization rates by region in Virginia?

*H_0*3: No significant geographic differences exists in stroke hospitalization rates by region in Virginia

*H_a*3: A significant geographic differences exists in stroke hospitalization rates by region in Virginia.

Theoretical Framework

Researchers use ecosocial theory to determine the impact of social determinants of health on stroke outcome. This theory, first described by Krieger in 2001, brought new perspectives to social inequalities in health and elements of population disease distributions through a multilevel framework by combining social, biological, historical, and ecological perspectives. Researchers now use ecosocial theory to gain insight into the relationship between chronic diseases and external factors such as social status and racial disparities, helping to shape new modes of thinking (Bharmal, Derose, Felician, & Weden, 2015; Lukachko, Hatzenbuehler, & Keyes, 2014; McCartney, Collins, & Mackenzie, 2013; Nadimpalli et al., 2016). For example, Nadimpalli et al. (2016) used ecosocial theory to explore discrimination and health status. The authors showed that self-reported discrimination was a significant (B = -.16, p = .04) predictor of poorer physical health (Nadimpalli et al., 2016).

Ecosocial theory may provide insight into how discrimination and neighborhood and social conditions may impact population health. Health care providers recognize that social determinants of health can have a noticeable impact on an individual’s well-being, changing the paradigms of research. Ecosocial theory considers not only ecological factors but also biological and political factors that influence health outcomes. This theory was appropriate to study the impact of socioeconomic and neighborhood factors and stroke rates.

Nature of the Study

For this retrospective epidemiological study, I use secondary stroke data from the Virginia Health Information (VHI) system to evaluate risk factors associated with strokes in Virginia between 2010 and 2015. This cohort study included secondary data from the VHI system and the U.S. Census Bureau to examine how neighborhood factors and socioeconomic conditions may align with stroke hospitalization rates. I compared the stroke occurrence between groups that have different levels of exposure. The dependent variable for this study was stroke (ischemic stroke, hemorrhagic stroke, and TIA). The nine independent variables were (a) education attainment, (b) per capita income (c) the Gini coefficient, d) job participation, (e) the federal poverty level, (f) the Food Access

Index, (g) the Walkability Index, (h) population density, and (i) the dependency ratio for the old population.

I used descriptive and inferential statistics to analyze the data. I used descriptive statistics to describe the sample, and inferential statistics to examine the association between variables in the sample to make inferences about the general population. I present details of the study-sample, data-collection, and data-analysis methods in Chapter 3.

Definitions of Terms

This section includes the key independent variables and other important terms not previously or thoroughly defined. The associated codes and the processes for analyzing coded data appear in Chapter 3.

Dependency ratio for old population: This ratio is derived by dividing the population 65 years and older by the population between 18 and 64 years and multiplying by 100 (U.S. Census Bureau, 2012).

Educational attainment: The highest level of education a person has completed (U.S. Census Bureau, n.d.).

Federal poverty rate: “The share of the tract population living with income at or below the federal poverty threshold by family size” (U.S. Department of Agriculture, 2017, para 31).

Food-access index: An index of equally weighted factors that contribute to a healthy food environment, including limited access to healthy foods and food insecurity. Low access means living far from a supermarket and high access means living close to a supermarket. In rural areas, 10-mile radius was used, and in urban areas, 1-mile radius to define those who are far from a supermarket (U.S. Department of Agriculture, 2017, para 1).

Gini Index: Also known as the Gini coefficient, this measures the inequality of income across the entire income distribution. The Gini coefficient ranges from 0 to 1. Zero indicates equal share (perfect equality), and 1 indicates unequal share (perfect inequality).

Hospitalization for stroke: The International Classification of Diseases, Ninth Revision, Clinical Modification codes 430–438 defined admission with a stroke as hospitalizations for acute stroke, TIA, and late effects of stroke. This definition includes all stroke types as the primary cause or reason for the admission, listed as the principal or primary diagnosis.

Labor-force participation: The percentage of individuals between the ages of 16 and 64 in the active labor force (U.S. Census Bureau, n.d.).

Per capita income: The average income computed per person in a given area (city, region, country, etc.) per year, calculated by dividing the aggregate income of the area by its total population (U.S. Census Bureau, n.d.).

Population density: Density indicates whether a census tract is in an urban or rural area. The area is defined as urban if the region has more than 2,500 people and rural if the region has fewer than 2,500 people (U.S. Census Bureau, 2010).

Socioeconomic status: The social standing or hierarchy of an individual or group is commonly measured as a combination of income, education, and occupation (U.S. Department of Health and Human Services, 2012).

Walkability Index: The characteristics of the built environment that influence the likelihood of walking as a mode of travel. The Walkability Index is based on the U.S. Environmental Protection Agency's (2017) previous data product, the Smart Location Database.

Zip code: A patients' 5-digit zip code of residence was described by the U.S. Postal Service. Records with a missing or known invalid value were assigned a default value of blanks.

ZIP Code Tabulation Areas (ZCTAs): Computer-delineated codes based on the location of addresses at the time of the study rather than manually delineated before the census. If more than one health planning region relates to a ZCTA, each region is listed (U.S. Census Bureau, 2015).

Assumptions and Limitations

I made two critical assumptions while planning this study. First, I assumed the VHI data system was of high quality. Although data collected for the registry came from hospital-discharge records and could be biased, I had no way to confirm this. Assuming the accuracy of the hospital data from VHI was a limitation because inaccurate data could lead to misleading results and lead to programs with little or no potential to reduce rates of stroke in Virginia. Potential errors in the data are admission date, discharge date, patient status at discharge, date of birth, principal diagnosis, and primary procedure.

This retrospective cohort was subjected to selection bias if ZCTA areas were more likely to be selected if they had an episode of stroke. Also, some information on socioeconomic status may have been missing for some ZCTA populations.

Environmental factors such as Walkability Index and food access are not recorded in the

VHI system; therefore, this information was triangulated using the U.S. Department of Agriculture Food Atlas and U.S. Census Bureau data. When calculating environmental variables, data can be combined into one database. This integration includes the transformation of different coordinate systems to a single system. I considered how this might influence the observed effects and checked for possible confounders such as other medical conditions that might impact the results. Also, ecological bias may have resulted if I failed to consider ecologic-effect estimates to reflect the biological effects of an individual.

In addition, sampling data has a potential to be erroneous; however, using proper techniques can narrow the error and render data reliable for the study. Use of appropriate data-analysis techniques can enhance the study’s internal validity (Frankfort-Nachmias & Nachmias, 2008). Some independent variables cannot be manipulated. Therefore, the study included logical inferences from the results (Frankfort-Nachmias & Nachmias, 2008).

Second, I assumed the study sample was representative of the entire Virginia population who had strokes between 2010 and 2015. I made this assumption because the study sample did not include Virginia residents who were admitted for stroke outside of the hospital setting between 2010 and 2015. Also, I made this assumption because information on Virginia residents who were hospitalized for stroke outside of Virginia between 2010 and 2015 was unavailable in the capacity needed for this study. This assumption was a limitation because the results may not represent the entire population of Virginia residents who had a stroke between 2010 and 2015, and some contributing factors for stroke in Virginia residents may have been disregarded or underestimated, especially if certain populations were not represented in the sample data.

Scope and Delimitations

The current study was limited to nine factors that may relate to the rate of stroke among Virginia residents. Stroke was the dependent variable. Specifically, I explored the association between stroke using 2010–2015 data and (a) education attainment (bachelor's degree and below), (b) per capital income, (c) the Gini coefficient, (d) job participation, (e) food access, (f) the Walkability Index, (g) the federal poverty level, (h) population density, and (i) the dependency ratio for the old population. Although stroke comprises TIA, ischemic, and hemorrhage types, for this study I did not distinguish between them.

I chose these factors for four reasons: (a) acknowledging the issues that may contribute to stroke rates in Virginia may be useful in developing stroke-prevention programs targeting characteristics among populations; (b) several factors were not addressed in the literature on stroke in Virginia, even though they were prevalent as contributors to stroke in the literature I reviewed for this study; (c) the nine factors were manageable for this study; and (d) results were likely to be useful for state or local agencies in the development of population-specific stroke-prevention programs. For example, if study results indicated that Virginia residents with access to exercise opportunities experienced stroke events less often than Virginia residents without access to exercise opportunities, that information could be used to develop programs targeted at helping Virginians have exercise opportunities.

Although I did not dismiss other theories or concepts that may have helped me understand study results or provide recommendations for action and future research, I focused my primary theoretical framework on ecosocial theory. I used ecosocial theory as a framework for this study because it provided a means to understand social and neighborhood factors and thereby facilitated an understanding of community impact on the health of Virginia residents. Such an understanding is vital for the development of population-specific stroke-prevention programs in Virginia.

Because the study included existing data from the VHI, I may not have been aware of potential errors in the data-collection process that may have impacted the interpretation of specific variables in the data sets used (see Cheng & Phillips, 2014). However, I scrutinized all pertinent documents and obtained concise documentation of relevant information about the validity of the data from the VHI. However, the information provided may not have been sufficient for the study to gain full value. Therefore, I used census data to obtain information on patients' neighborhoods.

Significance

Stroke continues to be one of the leading causes of death in Virginia, and sociodemographic and geographic disparities persist. With particular focus on the neighborhood-effect perspective—looking at factors in specific ZCTAs—this study provided substantial information on how socioeconomic and environmental factors influence the stroke rate in Virginia. This research helps narrow the gap in understanding how place matters and that where people live affects their health and well-being in complex ways. This study provides a better understanding of which features of disadvantaged neighborhoods strongly influence stroke incidence and how specific neighborhood characteristics contribute to stroke hospitalization in Virginia. Findings may be used to promote collaboration among members of different professions to incorporate community-level interventions and policy changes to reduce stroke risk in diverse, low-income, and underserved communities.

Summary

Despite evidence in the literature that stroke-prevention programs have been successful in decreasing rates of stroke in Virginia, the rates have remained high compared to the national average and are indicative of lowered quality of health and well-being in a population. Though researchers explored this problem more than 10 years ago, no researchers examined factors contributing to the current state of stroke in Virginia. For that reason, I conducted a quantitative epidemiological study to explore risk factors associated with stroke among Virginia residents who were admitted to Virginia hospitals between 2010 and 2015. Specifically, I examined the association between strokes and (a) education attainment (bachelor’s degree and below), (b) per capital income, (c) the Gini coefficient, (d) job participation, (e) food access, (f) the Walkability Index, (g) the federal poverty level, (h) population density, and (i) the dependency ratio for the older population. Because many of the risk factors associated with stroke relate to individual behavior and environmental conditions, I used ecosocial theory to guide (a) study development, (b) interpretations of the study analysis, and (c) suggestions for action and future research.

Results from this study may be used to develop programs that target groups and communities that have high risk of stroke. These programs may be more successful at reducing rates of stroke than current programs and may improve the quality of life for thousands of people in Virginia. In Chapter 2, I review the literature on factors that contribute to stroke, consequences of stroke, and strategies for decreasing rates of stroke. Chapter 3 will provide the methodology of the study, the sample size, and the instrumentation to be used, including detail about how the study will be conducted, the population of study, and how the study design was derived. Finally, Chapters 4 and 5 will provide the outcome of the quantitative data analysis, which includes descriptive statistical information and chi-square tests, along with discussion, recommendations, implications for social change, and a conclusion.

Chapter 2: Literature Review

In this section, I review the literature on the risk factors associated with stroke, its health consequences including cost and disability, and its impact on society. When conducting this review, I identified stroke as a significant measure in determining geographic health status in regions and between different states in the United States (Boan et al., 2014; Casper et al., 2003; Kulshreshtha et al., 2013). In Virginia, Hampton Roads' 15 localities are out of proportion because the number of strokes remains higher than other regions of the state (VDH, 2012). In this literature-review section, I show that significant socioeconomic and neighborhood risk factors contribute to the stroke rate in Virginia (VDH, 2012). In 2012, Virginia ranked 17th in the number of stroke deaths in the United States (Fang et al., 2012). Despite a decrease in the stroke rate between 2008 and 2010, Virginia's stroke rate has consistently remained higher than the national rate (Go et al., 2014). Because researchers showed that identifying risk factors associated with stroke will decrease its occurrence, the purpose of this study was to evaluate the factors that contribute to stroke in Virginia.

Literature Review Method

To conduct this literature review on risk factors associated with stroke, I searched the following databases: PubMed, Medline, CINAHL, Cochrane Database of Systematic Reviews, and ClinicalKey for Nursing. I also used the Google Scholar search engine. In addition, I conducted searches on the following websites: Virginia Department of Health, American Heart Association, American Stroke Association, Centers for Disease Control and Prevention, World Health Organization, and the National Institutes of Health. I used the following key terms: *stroke*, *stroke + risk factors*, *stroke + socioeconomic factors*, *stroke + education*, *stroke + income*, *stroke + neighborhood effect*, *stroke + geographic area*, and *stroke + Virginia*. The initial search identified 147 articles. I reviewed each article and found 74 articles that reported socioeconomic and neighborhood risk factors for stroke. The identified articles and the article reference lists supplied additional articles through the use of key terms directly relevant to socioeconomic and neighborhood risk factors for stroke. This literature review highlights the risk factors associated with stroke, the neighborhood impact on stroke, and the best strategies for prevention of stroke.

The purpose of this literature review is to highlight the importance of socioeconomic status in relation to stroke and its risk factors: (a) race/ethnicity, (b) gender, (c) age, (d) socioeconomic status, and (e) neighborhood factors. These risk factors help in monitoring the decline of stroke among the groups and communities in Virginia and the United States. Studies on stroke incidence and socioeconomic neighborhood characteristics by Grimaud et al. (2011), Kapral et al. (2012), and Roberson, Dutton, and Macdonald (2016) suggested the need for more research on stroke to help find more clues to the several factors that influence stroke. The limited research studies on stroke in Virginia are insufficient to counteract the high rate of stroke and provide a clear understanding of this issue's unanswered questions.

Theoretical Framework

Ecosocial theory recognizes the significance of economic, political, and social developments in shaping epidemiological profiles (Krieger, 2011). This theory explains the associations between exposure and disease with an explicit focus on inequalities in health status among subjugated groups by incorporating biological explanations, a life-course perspective, and a multilevel perspective of space and time (Krieger, 2000, 2011).

Ecosocial theory considers the interrelationships between diverse forms of social inequality such as class, gender, and racism (Krieger, 2001).

Four constructs of ecosocial theory describe and explain causal relationships in disease distribution between social factors and disease development in public health research (Krieger, 2005, 2014). The first is that of embodiment, referencing how natural and lived experiences interrelate in societal and ecological concepts (Krieger, 2005). The second, pathways of embodiment, refers to intermingling of channels such as chemical, biological, physical, and social exposure to create outcomes. Examples of these results include opposing exposure to social and economic deficit, social trauma, or degrading health care (Krieger, 2005). A third factor is the collective interaction of exposure, susceptibility, and resistance across the life course. This factor addresses not only the gene expression and frequency of an individual but also the entire timeframe and accumulation of exposures. Last, the fourth construct considers accountability and agencies that play a role in social disparities and health inequalities (Krieger, 2005), shown in Figure 3.

Introduction to Stroke

Stroke is the leading cause of death in the United States and accounts for one in every 19 deaths (Fang et al., 2012). Every year, about 795,000 stroke cases are recorded, of which 610,000 are new cases and 185,000 are recurrent (Fang et al., 2012). In Virginia, the proportion of stroke deaths remained higher than that of the United States (VDH, 2016). Because Virginia’s stroke hospitalization and mortality data remain underanalyzed at the subjurisdictional level, for example by zip code, it has been difficult for public health officials to target areas of high need. About 3.2% of the Virginia population is living with stroke, and the age-adjusted mortality (42.1 per 100,000) and hospitalization (265 per 100,000) rates are above the national average (VDH, 2013). Also, a huge disparity exists in stroke incidence, mortality, and hospitalization rates between Blacks and Whites in the United States and Virginia. The racial-disparity ratio for stroke hospitalization is higher in Blacks than Whites (Boan et al., 2014).

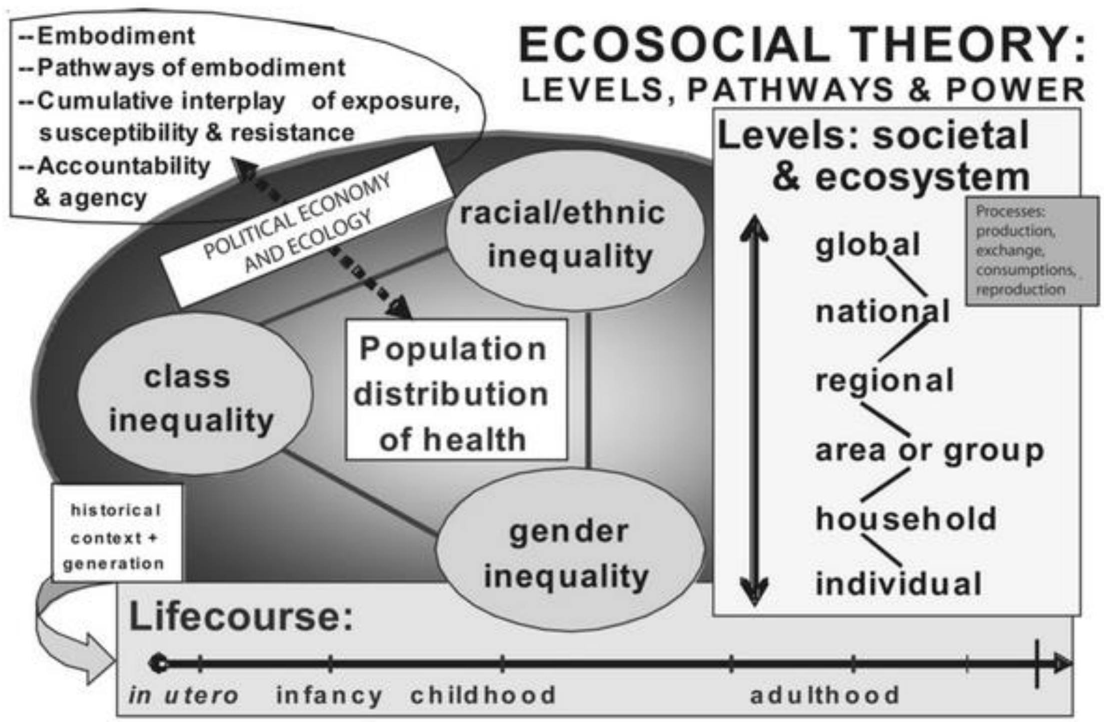

Figure 3. Ecosocial theory.
From "Proximal, distal, and the politics of causation: what's level got to do with it?" N. Krieger, 2008, *American Journal of Public Health*, *98*, 221–230, para 21. doi:10.2105 /AJPH.2007.111278. Copyright 2017 by the American Public Health Association/Sheridan. Adapted with permission of the Sheridan Press. See Appendix A.

Several researchers published articles on stroke incidence and mortality rate in the United States, but only a few examined stroke inpatient hospitalization (Fang et al., 2012; Heidenreich et al., 2011; Howard, Labarthe, Hu, Yoon, & Howard, 2007; Kochanek, Murphy, Xu, & Arias, 2014; Kunitz et al., 1984; Lloyd-Jones et al., 2010; Jacobs, Boden-

Albala, Lin, & Sacco, 2002). Even the few published articles failed to narrow the study of stroke to the small area-unit analysis to help public health officials and policymakers target areas of high need for intervention strategies. Most publications on stroke highlighted incidence rate (Jacobs et al., 2002; Moon et al., 2012) but few addressed inpatient stroke hospitalization (Boan et al., 2014; George, Tong, Kuklina, & Labarthe, 2011) and its relationship to social determinants of health.

Failing to model stroke hospitalization or mortality rates with social determinants of health at the smaller units makes targeting areas for proper intervention difficult. A research study at the state level is helpful but does not tell the whole story because it masks some pockets of areas that needed special attention. Using social determinants of health in a model of stroke may help highlight the racial disparity between Blacks and Whites.

Risk Factors Associated With Stroke

Numerous factors link to stroke risk. Managing treatable risk factors that contribute to stroke is paramount. Essential but unmodifiable risk factors for stroke include race/ethnicity (Sealy-Jefferson et al., 2012), age (Kissela et al., 2012), and gender (Lisabeth & Bushnell, 2012; Tian et al., 2012; Wilson, 2013). The major modifiable risk factors for stroke are hypertension (Howard et al., 2013), diabetes mellitus (Berry et al., 2012), smoking, and dyslipidemia. In addition, higher rates of stroke indicate public health problems due to socioeconomic status (Ahacic, Trygged, & Kåreholt, 2012; Dubowitz et al., 2012), and neighborhood conditions (Honjo et al., 2015; Kapral et al., 2012).

Individual's Race/Ethnicity

Extensive racial and ethnic diversity accompanies stroke prevalence and stroke mortality. Race/ethnicity is a risk factor for stroke, especially among the Black population in that Black people are disproportionately affected by stroke (Boan et al., 2014; Cruz-Flores et al., 2011; Kissela et al., 2004). In 2014, Boan et al. used hospital-discharge records from January 1, 2001, to December 31, 2010, to examine race and age-specific trends in stroke hospitalization rates in South Carolina. Using the Mantel–Haenszel method, researchers measured racial disparity using hospitalization-rate ratios and 95% confidence intervals by dividing the 10-year average rate for Blacks (e.g., rate of acute ischemic strokes among Blacks age ≥ 85 years) by the corresponding rate for Whites. Despite a noticeable decrease in stroke, the study showed an increase in stroke hospitalization rate in young Blacks only, resulting in a severe and persistent racial disparity. The racial-disparity-rate ratio for stroke hospitalization was consistently higher in Blacks for all stroke subtypes, with a decreasing trend as age increases (Boan et al., 2014). Racial and ethnic disparities in stroke risk factors appear to have a substantial relationship that also impacts stroke outcome.

Another study showed that hypertension, diabetes mellitus, and smoking are the greatest contributing factors to excess strokes in the Black population (Howard et al., 2013). Results from a 2011 study by Howard et al. indicated that use of antihypertensive medication, prevalence of diabetes mellitus, and smoking were higher among Blacks than Whites. When categorized by age, stroke incident risk was almost three times more likely in Blacks than in Whites at the age of 45 and nearly two times at the age of 65. Howard et al. (2013) concluded that racial differences in risk factors contribute to a greater incidence of stroke among Blacks.

Gender

Significant gender differences emerged in research on the incidence, severity, and recovery from stroke. Nationwide data showed that 60,000 more women than men have a stroke each year in the United States (Rosamond et al., 2007). In addition, 60% of all stroke events are in women (Reeves et al., 2008). Researchers have attributed hormonal differences between genders to the increase in stroke among women. Even though men have a higher risk of stroke compared to women, this disparity changes following menopause when stroke outcomes in women increase compared to men of the same age. In addition, sex hormone-related factors align with stroke risk in women and men (Sealy-Jefferson et al., 2012; Tian et al., 2012). The risk of stroke in women doubles after menopause (Lisabeth & Bushnell, 2012; Sealy-Jefferson et al., 2012). Women are significantly older at the first-ever stroke with an average age of 75 years, compared to 71 years in men (Haast, Gustafson, & Kiliaan, 2012). Premenopausal women have protection from ischemic stroke compared to their male counterparts of the same age (Palm et al., 2011). However, no difference emerges in stroke risk between men and women after 79 years old (Palm et al., 2011).

According to Lisabeth and Bushnell (2012), exposure to endogenous estrogen is a protective factor for stroke in premenopausal women. Changes in cardiovascular risk factors with menopause may also contribute to this increase in stroke risk (Sealy-Jefferson et al., 2012). Women experience stroke later in life than men, possibly due to loss of protection from estrogen after menopause (Tian et al., 2012). Although these differences are not fully understood, recognizing gender differences could lead to stroke treatment and improve outcomes.

In 2012, a population-based study identified age-specific sex differences that may independently influence stroke (Sealy-Jefferson et al., 2012). Characteristics of the study population included 2,421 stroke cases between January 2000 and May 2007 in individuals 45 years of age and older. Trained abstractors ascertained participants' genders from medical records. The Sealy-Jefferson et al. (2012) results showed a significant interaction between age and stroke risk. Over the life course, women have a lower age-adjusted stroke risk compared to men. That result is consistence with a 2012 study by Tian et al., which showed that the age-adjusted stroke rate is most prevalent in men than women, with a female to male ratio of 41:1 (Tian et al., 2012).

In addition, the outcome of stroke is more adverse in women than in men (Khare, 2016; Wilson, 2013). Women who have a stroke are more likely to be more severely impacted than men and more likely to die (Wilson, 2013). Wilson's (2013) study showed that, compared to male stroke survivors; female stroke survivors experience more severe outcomes with less chance of full recovery. Women are more likely to suffer more physical losses, lower quality of life, limited activities, and depression after a stroke (Wilson, 2013). Part of this outcome can be explained by differences in life expectancy for men and women after 85 years of 5.9 years versus 6.8 years, respectively (Palm et al., 2011). The increase in stroke among women in the older age group may be due to the longer life expectancy compared to men (Khare, 2016).

Age

Researchers indicated that age plays a vital role in stroke outcome. The incidence of stroke increases significantly with age (CDC, 2014; Fang et al., 2012; Rapsomaniki et al., 2014). More than two thirds of stroke hospitalizations occur in people 65 years and older (Fang et al., 2012; Roger et al., 2012). In men and women, the stroke rate doubles every 10 years after the age of 55 (Fang et al., 2012). Another study indicated that people over 75 years of age experience half of all strokes, and people above 85 years make up one third of the stroke population (Sealy-Jefferson et al., 2012). Other studies regarding stroke in younger groups indicated increasing trends of stroke in the young, with incidence rates increasing from 3 to 23 per 100,000 over the past 30 years (Jacobs et al., 2002; Kissela et al., 2012; Putaala et al., 2009). This increase in stroke rate among the younger group may be due to an increase in risk factors for stroke such as obesity and diabetes, which are increasing among people younger than 55 years (Blackwell, Lucas, & Clarke, 2014; U.S. Department of Health and Human Services, 2012, 2016). Advances in medical technology, such as the use of magnetic resonance imaging, may have led to the higher detection of stroke among the younger group (Lackland et al., 2014; Putaala et al., 2009).

Modifiable Risk Factors

Modification of risk factors such as hypertension, smoking, and diabetes may contribute to reducing stroke incidence over the years. People may modify risk factors pharmacologically through the use of drugs such as statins, antihypertensive agents, lipid-lowering medications, and anticoagulants, or through behavioral changes such as increasing physical activity and healthy eating.

Hypertension

Hypertension is the single most important treatable risk factor for stroke. Hypertension aligns with an increased likelihood of subclinical or silent stroke, which in turn links to an elevated risk of vascular dementia and recurrent stroke (Jackson, Lawes, Bennett, Milne, & Rodgers, 2005; Lisabeth, Smith, Sánchez, & Brown, 2008; Qureshi, Suri, Kirmani, Divani, & Mohammad, 2005; Rapsomaniki et al., 2014). Epidemiologic studies revealed that as blood pressure rises above 110/75 mmHg, a gradually increasing incidence of cardiovascular mortality emerges in treated and untreated patients (Howard et al., 2013). In addition to diastolic and systolic blood pressure, stroke risk may align with other blood-pressure variables such as mean pulse pressure, blood-pressure variability, blood-pressure instability, and lack of nocturnal blood-pressure dips (Kshirsagar, Carpenter, Bang, Wyatt, & Colindres, 2006; van den Hoogen et al., 2000; Vasan et al., 2001).

Howard et al. (2013) acknowledged the differences in hypertension rate among racial and ethnic groups in the United States. To determine the significant gap in stroke risk, Howard et al. opted to use a subset of the Reasons for Geographic and Racial Differences in Stroke study with more than 27,000 Black and White participants between 2003 and 2007. The researchers used proportion hazards to assess dissimilarities in the impact of systolic blood pressure as stroke-risk characteristics of Blacks and Whites in the southeastern states, known as the stroke belt (Alabama, Arkansas, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee; Howard et al., 2013). This study showed Whites have a lower prevalence of hypertension, diabetes, and obesity, as well as other stroke risk factors. The effect of blood-pressure level was three times less for Whites than for Blacks, for the same 10–mm Hg difference in systolic blood pressure. Whites only have an 8% increase in stroke risk compared to a 24% increase in stroke risk for Blacks. Also, differences emerged in control of blood pressure among Whites compared to Blacks. Black people are disproportionately affected by stroke with two- to three-times greater incidence than Whites in the same age group (Howard et al., 2013). This result demonstrates a significant relationship between racial differences in the impact of elevated blood pressure on stroke risk.

The limitations of the Howard et al. (2013) study included that researchers measured only a single measure of exposures at baseline and therefore could not adjust for changes in risk factors or measurement errors affecting results (i.e., regression dilution bias). Furthermore, the authors relied on significant stroke risk from previous research to guide the selection of risk factors. Thus, Howard et al. may have underestimated the level of racial differences not considered in the models. Howard et al. acknowledged inadequacy in the exploration of stroke disparities in the United States among Blacks and Whites. However, observations alone do not prove a causal relationship because increased blood pressure could be a marker for other risk factors such as increased body weight, dyslipidemia, glucose intolerance, and metabolic syndrome. The best evidence supporting a causal role of increasing blood pressure in stroke complications comes from studies that show outcome reduction in the risk of recurrent stroke with antihypertensive therapy. I review this evidence elsewhere.

Smoking

Cigarette smoking aligns with an increased risk for stroke and has a strong, dose-response relationship with subarachnoid hemorrhage and ischemic stroke (Goldstein et al., 2011; Kawachi et al., 1993; Kurth et al., 2003; Peters, Huxley, & Woodward, 2013; Xu et al., 2013). A meta-analysis of 18 population-based cohort studies with more than 3,980,000 participants showed a gender-independent relationship between stroke in men and women and smoking (Peters et al., 2013). The systematic review of articles published in 2013 evaluated sex-specific relative-risk ratios (RRRs) of stroke comparing smokers and nonsmokers and examined associated variability with stroke. The results showed an associated risk of stroke among male and female smokers with an RRR of 1.06 (95% confidence interval, 0.99–1.13). When compared with nonsmokers, current smokers were associated with 67% (95% CI, 1.49–1.88) increased risk in men and 83% (95% CI, 1.58–2.12) increased risk in women. The daily dose of cigarettes smoked among subgroups of less than 10, 10 to 20, and greater than 20 cigarettes per day versus nonsmokers were 0.94, 0.91, and 1.31 respectively (Peters et al., 2013).

Furthermore, researchers examined the association between smoking and stroke subtypes in 60 cohorts of 92,859 individuals showing 4,894 ischemic strokes and 1,990 hemorrhagic strokes (Peters et al., 2013). Current smokers aligned with an increased risk of ischemic stroke of 54% and 53% women and men respectively. For hemorrhagic stroke, current smokers aligned with an increased risk of 63% (95% CI, 1.21–2.19) in women and 22% in men, compared to nonsmokers. This meta-analysis showed that cigarette smoking is a major modifiable risk factor for stroke in men and women (Peters et al., 2013). This study’s results may have diminished the relationship between smoking and stroke risk due to underreporting of cigarette dose and misclassification of some current smokers as nonsmokers.

Diabetes Mellitus

The influence of diabetes on stroke outcome cannot be underestimated. The American Diabetes Association (2016) defined prediabetes as impaired glucose tolerance or a combination of impaired fasting glucose and impaired glucose tolerance. Prediabetes and diabetes may align with an increased risk of stroke (American Diabetes Association, 2016). The CDC (2011) reported that 16% of diabetes-related death among people 65 years and older in 2004 related to stroke. Population-based studies showed a high proportion of stroke risk factors in patients with prediabetes compared to those without diabetes mellitus (Banerjee et al., 2012; Khoury et al., 2013; Lee et al., 2012). Patients with diabetes mellitus are twice as likely to develop ischemic stroke compared to nondiabetic patients (Khoury et al., 2013). In addition, a higher risk of stroke aligns with diabetes in women compared to men (Peters, Huxley, & Woodward, 2014).

Among the several studies conducted on diabetes, Banerjee et al. (2012) examined the effect of diabetes duration on ischemic stroke risk. Banerjee et al. explained that diabetes duration independently predicts ischemic stroke. This study included more than 3,000 participants from the Northern Manhattan Study, a prospective population-based cohort study that examined stroke-risk factors, incidence, and prognosis, with special consideration for participants with diabetes as a time-dependent covariate. Study results showed baseline diabetes aligned with risk of stroke with a hazard ratio (HR) of 2.6, whereas the association between diabetes and stroke stayed the same (adjusted HR, 2.5; 95% CI, 1.9–3.3) even after adjusting for the effects of demographic and other cardiovascular risk factors including tobacco use, alcohol consumption, blood pressure, history of cardiac disease, and physical activity (Banerjee et al., 2012).

Researchers reported that the risk of ischemic stroke increases with longer duration of diabetes with a 3% increase each year, and triples in 10 years or more with diabetes (Banerjee et al., 2012). Those with diabetes for 0 to 5 years and 5 to 10 years were at increased risk with an HR of 1.7 and 1.8 respectively. After 10 years of diabetes history, the HR increased to 3.2 compared to nondiabetic participants. Diabetes also aligned with risk of ischemic stroke with an adjusted HR of 2.4, even after new-onset diabetes was considered a time-varying covariate, which supported the linkage between diabetes and stroke (Banerjee et al., 2012).

In addition to the 2012 population-based study by Banerjee et al., other researchers examined the effects of diabetes and prediabetes on future risk of stroke through systematic reviews of prospective studies (Lee et al., 2012; Peters et al., 2013). Lee et al. (2012) analyzed 15 prospective cohort studies published between 1947 and July 16, 2011, and a total of 760,925 participants with baseline prediabetes and any stroke as endpoints. The study evaluated the relationship between prediabetes and future stroke risk in the general population, older population, and in people with previous stroke or TIA. The study defined impaired glucose tolerance as nonfasting venous plasma glucose 140 to 199 mg/dL and used nonfasting glucose below 140 mg/dL as a reference. Lee et al. compared fasting glucose between 110 and 125 mg/dL to impaired glucose tolerance or a combination of impaired fasting glucose and impaired glucose tolerance. Peters et al. (2013) analyzed 12 articles from 1961 to 2002 that included 775,385 individuals with baseline diabetes. Peters et al. (2013) aimed to determine the association between diabetes and the risk of stroke and identified the ratio among those with diabetes and those without diabetes. Lee et al. and Peters et al. (2013) indicated heterogeneity across studies, as some studies only measured fasting glucose at baseline and some patients with nonfasting glucose of 200mg/dl or higher might have been included.

Results from the Lee et al. (2012) and Peters et al. (2013) studies indicated the possibility of reducing the risk of future stroke by controlling prediabetes and diabetes rates. Study outcomes of the systematic reviews revealed a significant relationship between diabetes and stroke. Similarly, the Lee et al. study supported the Peters et al. (2013) findings, suggesting hyperglycemia may be a constant risk factor for stroke. For example, the Peters et al. (2013) analysis showed higher stroke incidence in men and women with diabetes than in those without. Lee et al. observed an increase of stroke risk across the spectrum of insulin resistance from impaired fasting glucose to diabetes. After adjustment for established cardiovascular risk factors, an increased risk of stroke emerged among people with impaired glucose tolerance or impaired fasting glucose (RRR 1.26, 1.10 to 1.43; $p < .001$). In addition, fasting glucose between 110 and 125 mg/dL increased the risk of stroke after adjustment for established cardiovascular risk factors (RRR 1.21, 1.02 to 1.44; $p = .03$; Lee et al., 2012). When compared by gender, women with diabetes had a 27% greater RRR for stroke than men after controlling for major cardiovascular risk factors. The Lee et al. findings suggested that insulin resistance not only stimulates atherogenesis and inflammation but also may lead to or heighten other conditions that contribute to the effect of stroke. In contrast, the Peters et al. (2013) findings suggested that women may have a higher adverse impact in markers of blood pressure, lipids, and blood-pressure diabetes than men.

Socioeconomic Status

A growing body of research has assessed the influence of socioeconomic status on stroke risk in the United States and other countries (Addo et al., 2012; Ahacic et al., 2012; Arrich et al., 2005; Honjo et al., 2015). People in lower socioeconomic groups have a higher risk for stroke and are less likely to survive their stroke (Kapral et al., 2012). In a 2012 study, researchers investigated the degree to which income and education play a role in the Swedish population in predicting stroke mortality after hospital discharge from a first stroke (Ahacic et al., 2012). Of the 11,687 people aged 40–59 who were hospitalized for stroke for the first time between 1996 and 2000, 10,487 survived stroke. The researchers analyzed mortality after hospital discharge using Cox regressions for relative risk after controlling for sex, age, stroke category, and days of inpatient care. The researchers excluded people from the study if they had previous ischemic heart disease to avoid comorbidity and TIA. Ahacic et al. categorized education level as elementary, upper secondary, and university, whereas they grouped income into four quartiles.

Results indicated that the people with a university education had a lower risk of dying from stroke after their first stroke episode than those with an elementary education (Ahacic et al., 2012). The relative risk of dying from stroke was lower for people in the highest income quantile (RRR = 0.20) than those in the lowest income quantile. When combining income and education, results showed that people with little education and low income had higher risk for stroke-specific mortality. Study limitations included the use of stroke-mortality data. The researchers did not examine the effects of socioeconomic status on the risk of a first-time stroke and also had no record of stroke severity and risk factors such as smoking or obesity that may have impacted the rate (Ahacic et al., 2012).

Neighborhood Condition

Broader community environment strongly affects the capacity to be healthy. Broadly defined, environment includes not only physical factors such as safe housing, availability of nutritious foods, and a medical home with coordinated services, but also social and economic factors such as racism and the poverty status of families and communities. The neighborhood in which a person lives can play a significant role in controlling some of the preventable risk factors connected with stroke (Eum, Song, Kim, Leem, & Kim, 2015; Morgenstern et al., 2009). Examples of environmental factors include indoor and outdoor air pollution, Walkability Index, and the food desert. In a study conducted in 2013, the authors examined demographic factors in the State of Arkansas and explained its relationship to stroke-mortality data (Balamurugan et al., 2013). Using the state mortality data from 2005 to 2009, Balamurugan et al. (2013) analyzed the risk of stroke at the smallest geographical unit possible: census block groups (BGs). In the 2,134 BGs in Arkansas, a total of 8,930 stroke deaths were recorded between 2005 and 2009. Census BGs were used as alternatives for neighborhoods based on the American Community Survey tabulated data. The researchers selected the following for each BG: population by age and sex, household with income below the federal poverty level, the number of people greater than 25 years old with less than a high school diploma, and the population of non-Hispanic Blacks. The authors selected these variables to rank BGs by education, income, racial/ethnicity, population density, and mobility. Balamurugan et al. used a linear regression model to investigate associations among poverty, education, population density, population mobility, and adjusted RRRs for spatial trends. Results indicated that approximately 4 to 9% of stroke deaths between 2005 and 2009 in Arkansas could be explained by education attainment, population density, mobility, and poverty.

Another study conducted in Japan investigated the relationship between neighborhood deprivation and the incidence of stroke and mortality. The objectives of this study were to examine ischemic stroke and neighborhood socioeconomic status and also consider potential associations between the two (Honjo et al., 2015). This study used data from the Japan Public Health Center-Based Prospective Study. To examine the impact of neighborhood deprivation on stroke incidence and mortality, researchers used area deprivation data at the level of the chocho-aza unit, comparable to the U.S. BG. Honjo et al. (2015) used the Cox proportional-hazard regression model and individuals were nested in neighborhoods. Of the 90,843 who participated in the Japan Public Health Center-based Prospective Study, 1,147 died of stroke and 4,410 had stroke incidents for a follow-up period of 16.4 years and 15.4 years respectively. Results showed that living in a deprived neighborhood highly impacted stroke risk in Japan. Residents of areas with a lower perceived availability of healthy foods, safety, exercise facilities, and social relationships were more likely to have a stroke (Honjo et al., 2015). After adjusting for individual sociodemographic factors, HR for developing stroke in the least deprived area was 1.16 (95% CI, 1.04– 1.29). The HR increased to 1.19 (95% CI, 1.01–1.41) for developing stroke in the most deprived area. However, the researchers found no relationship between neighborhood deprivation level and stroke mortality (Honjo et al., 2015).

Consequences of Stroke

Stroke has severe effects (Feigin et al., 2014; Mukherjee & Patil, 2011; Murray et al., 2013). About half of all stroke survivors end up with disability (McKevitt et al., 2011) and several experiences short- and severe long-term health consequences (Scherbakov & Doehner, 2011; Wolfe et al., 2011). This literature review limited the scope of financial and physical disability.

Financial Consequences

The burden of stroke weighs heavily not only on individuals but also financially on the family (Wang et al., 2014). Healthcare institutions and governmental agencies are also affected (Demaerschalk et al., 2010). Based on the cost of medication to treat stroke, health care services, and the number of missed days of work, Mozaffarian and colleagues (2015) estimated that a total of $34 billion was spent each year on stroke in the United States. The length of hospital stay and stroke severity appeared to be the primary predictors of cost. For example, Wang et al. (2014) determined the cost of hospitalization for stroke patients 18 to 64 years old based on stroke type and diagnosis type according to the value of a dollar in 2008. Researchers obtained data from the 2006–2008 MarketScan Commercial Claims and Encounter including information on health insurance plan. The data from Commercial Claims and Encounters included approximately 97,374 hospitalizations with a diagnosis of stroke from about 100 health insurance companies among 40 large employers in the United States. The average per-admission costs for stroke diagnosis were $20,396. When analyzed by stroke type, the per-admission costs for ischemic stroke was $18,963, for a hemorrhagic stroke was $32,035, and other stroke types were $19,248 (Wang et al., 2014). One limitation in the Wang et al. study was that the researchers excluded the older population and those with government insurance or those who were uninsured, which are those with the highest prevalence of stroke. Therefore, the study may not apply to the broad U.S. population. Another limitation is that the study failed to distinguish initial stroke hospitalizations from readmission from stroke. These limitations prevented the ability to discern a certain understanding of the full economic burden of stroke.

In 2012, Australian researchers conducted a population-based study to describe the determinants of economic hardship in younger stroke survivors and explained the patterns of income and financial hardship before and after stroke (Essue et al., 2012). Researchers used data from the Psychosocial Outcomes in Stroke study, a 3-year prospective multicenter observational study. Researchers interviewed participants by telephone within 28 days of stroke from the Stroke Services New South Wales network in Australia to determine their household economic hardship. Characteristics of the study population included a total of 414 participants between the ages of 18 and 65 years. Study outcomes showed that 254 (61%) reported having hardship in the 12 months after stroke. Over time, a significant increase ensued in the proportion reporting financial difficulty and dissaving behaviors, most of which continued to increase significantly by 12 months (Essue et al., 2012).

Physical Disability

Stroke is a leading cause of severe long-term disability. More than 60% of stroke patients retain some degree of physical or cognitive impairment (Scherbakov & Doehner, 2011). A stroke may result in paralysis or weakness, sensory loss, and visual field loss. In a needs-assessment study among stroke survivors in the UK, 52% of participants reported reduction in or loss of work activities after a stroke, 18% reported a decline in income, and 31% reported increased expenses (Wolfe et al., 2011). Evidence from three studies in particular about cognitive impairment after stroke demonstrated a connection that individuals with stroke tend to have lower IQs (Douiri, Rudd, & Wolfe, 2013; Makin, Turpin, Dennis, & Wardlaw, 2013; Murray & Lopez, 2013; Schaapsmeerders et al., 2013). Douiri et al. (2013) examined changes in intellectual disability after first stroke incidence, stratified by sociodemographic and stroke subtypes, up to 15 years after stroke from the South London Stroke Register. Second, Schaapsmeerders et al. (2013) examined long-term cognitive performance after an incidence of ischemic stroke. Third, Makin et al. (2013) conducted a systematic literature review of the incidence and prevalence of cognitive impairment after lacunar stroke and its impact compared to cortical stroke. Despite the differences in study populations (older vs. younger people), researchers noticed a decrease in participants' cognitive skills in stroke patients (Douiri et al., 2013). Results from the Douiri et al. (2013) study signified high cognitive impairment strongly aligned with age and increased gradually after 5 years of stroke for patients older than 65 years. When analyzed by sociodemographic factors, cognitive impairment was significantly lower among the people in the higher socioeconomic group (20%) compared to those in the lower socioeconomic group (24%). The study also showed racial differences in cognitive impairment with 26% prevalence in Blacks compared to 17% in Whites, 3 months after stroke. Schaapsmeerders et al. (2013), in agreement with Makin et al. (2013), acknowledged the association of stroke with cognitive impairment due to stroke.

Strategies for Stroke Prevention

Stroke is mostly preventable; some modifiable behavioral and social changes could increase the possibilities of not having stroke. Avoiding tobacco and lowering blood pressure would dramatically reduce the risk of stroke (Goldstein et al., 2011). Researchers have suggested several approaches to fight the stroke rate in the United States (CDC, 2014; Kim & Kim, 2013; Pearson et al., 2013). Goldstein et al. (2011), for example, found that health education, availability of health care services, improved neighborhood conditions, and screening procedures could result in reducing stroke rate and enhancing stroke outcomes. These findings suggested that individuals and communities require a complete lifespan approach to identify behavior and environmental and medical issues prone to cause future stroke episodes that can be managed in the early stages of life (Frieden & Berwick, 2011; Leys et al., 2003). A classic example of stroke prevention was the study by Qureshi and colleagues (2005), which evaluated the referral pattern of patients to a stroke-prevention program and sought to determine the impact of managed modifiable risk factors such as diabetes, hypertension, and therapies to reduce cardiovascular disease and stroke. In addition to the outcome from previous stoke studies, several health agencies have proposed and sponsored prevention programs to reduce the incidence of stroke.

Numerous organizations supported the need to provide programs that would prevent stroke at the community levels, the national level, and around the world. The World Health Organization (WHO, 2012) described the challenges in poor neighborhoods and sponsored prevention programs to combat stroke. In 2005, WHO itemized the requirements to address huge public health challenges around the world with specific strategies to promote optimal cardiovascular health, including stroke, inaugurated by governing bodies. In support of WHO’s prevention campaign for stroke, the AHA also identified and recommended a provision of care for stroke prevention, management, and intervention to improve the quality of countries’ health (Goldstein et al., 2011). The CDC also ascribed and itemized basic fundamental strategies to decrease the rate of stroke, such as promoting a life-span approach to healthcare programs, increasing the availability of healthy food to all communities, emphasizing the importance of reducing hypertension and diabetes, encouraging additional research to identify solutions to stroke, and focusing efforts on social, demographic, and environmental risk factors that influence stroke (Fang et al., 2012).

Lifestyle Approach to Stroke Prevention

According to health organizations such as the CDC, researchers have linked some lifestyle approaches to a higher incidence of stroke, especially considering the population that is disproportionately affected by risk factors associated with stroke (Fang et al., 2012). Eating habits, physical activity, smoking, and drinking alcohol are examples of lifestyle stroke-risk factors. People can directly mitigate some medical risk factors by improving lifestyle risk factors. The Division of Heart Disease and Stroke Prevention has especially considered the effects of changed lifestyle behaviors (Fang et al., 2012). In addition to a CDC report about lifestyle approach, the CDC launched the Sodium Reduction in Communities Program in 2010, reporting the necessity to reduce the availability and accessibility of higher sodium foods for consumers and decrease sodium intake (CDC, 2015).

Concentrate Efforts on Demographic, Social, and Environmental Risk Factors That Influence Stroke Outcome

Generational influences perpetuate stroke (Aycock et al., 2015). A 2012 study by Bevan and colleagues showed that individuals with a family history of stroke are more likely to report a history of stroke risk factors such as hypertension than those with no family history of stroke. This highlights the importance of creating a better understanding of this problem and preventing this generational experience (Bevan et al., 2012). Also, the environment where a person lives affects their chances of having a stroke. This varies by location such as state, city, county, and even zip code (Lisabeth, Roux, Escobar, Smith, & Morgenstern, 2007). People who live in high-poverty environments are highly prone to experience stroke, which suggests a relationship between stroke, genetics, and environmental factors (Balamurugan et al., 2013; Brown et al., 2011).

Summary

The reviewed literature included research studies that focused on various risk factors associated with stroke. This review provides a basis for the evaluation of the risk factors affecting stroke outcome among people living in the Commonwealth of Virginia. Research studies described in the literature-review section used similar methodologies, but with different research questions. The reviewed literature helped identify possible problems that are relevant to the present study. It also identified the gap this study intends to fill. More than a decade ago, Williams et al. (2003) examined stroke characteristics among patients seen at a large urban hospital in Richmond, Virginia. Similar to the current study, Williams et al. explored substantial racial-difference outcomes at every education level after adjusting for the effects of age, marital status, state of residence, and gender of offspring, but the relationship was not monotonic. The authors recommended further research exploring a more extensive stroke database including information from other regions of the state, which may allow for differentiation of the population that contribute to increased stroke prevalence in Virginia.

The present study aimed to undertake these challenges using a more recent sample of data from 2010 to 2015. This study used a larger sample than the sample used by Williams et al. to evaluate the following variables: (a) poverty level (b) per capita income (c) population density (d) level of education, (e) the Walkability Index (f) the Food-Environment Index, and (g) workforce participation. The goal was to identify means to prevent or mitigate the effects of stroke. This study fills the gap in the literature by addressing risk factors associated with stroke in the Commonwealth of Virginia. The earlier work by Williams et al. provided descriptive knowledge about occurrences of stroke but did not provide detailed evidence of how to resolve these issues among a wide range of communities in Virginia. Williams et al. did not use the trend analysis adequately in the study of stroke.

The present study estimated past events and predict future events, such as the cause of risk factors for stroke in Virginia. The inconsistency of information about stroke found in the course of the literature review may create incorrect impressions as to what needs to be done to reduce the rate of stroke. Since Williams and colleagues conducted their study in 2003, the population in Virginia has increased significantly (VDH, 2015). Therefore, it is essential to identify the risk factors associated with stroke in present-day Virginia. Such knowledge will provide understanding of whether any changes have ensued in communities and if the stroke rate has increased or decreased since 2003.

Chapter 3 addresses the study design, considering the methodology, sample size, and instrumentation.

Chapter 3: Methodology

This study addressed stroke and risk factors among Virginia residents admitted to hospitals between 2010 and 2015. In particular, I examined the association between stroke and nine potential risk factors in two groups: socioeconomic status and neighborhood conditions. I also examined a possible geographic difference in stroke rate among the five regions in Virginia. In this chapter, I describe the study's methodology including the procedures for sampling, recruiting, data collection, and data analysis of the population; the research design and rationale; threats to validity; and ethical issues.

Research Design and Rationale

I conducted this study using an ecological-study design. In a case-control study, researchers identify participants by outcome status at the outset of the investigation and retrospectively obtain information on exposure to a risk factor. Retrospective studies provide researchers with an inexpensive means of quickly generating results (Woodward, 2013). Retrospective studies work well when the outcome being investigated is rare and has extended latency periods (Woodward, 2013). Specifically, researchers use case-control studies to generate detailed analyses of disease risk factors or other outcomes of interest, even when the conditions being studied are uncommon (Woodward, 2013). Because stroke is thought to have multifactorial causes, a case-control study design allowed me to examine multiple exposure and risk factors. Because I used retrospective data (VDH, 2010, 2011, 2012, 2013, 2014, 2015) to determine risk factors associated with an outcome of interest (stroke), to generate hypotheses, and to study nine risk factors simultaneously, a case-control study design was appropriate for my study. Using this study design allowed me to gather data quickly and with minimal resources.

To conduct this study, I used secondary data to analyze the risk factors associated with stroke among people admitted to Virginia hospitals during the years 2010 to 2015. The dependent variable, stroke, comprised all stroke types (TIA, hemorrhagic stroke, and ischemic stroke). The nine independent variables were (a) education attainment (bachelor's degree and below). (b) per capital income, (c) the Gini coefficient, (d) job participation, (e) food access, (f) the Walkability Index, (g) the federal poverty level, (h) population density, and (i) the dependency ratio for the older population. The covariates in the model included factors that may have influenced development or the recognition of stroke incidence. I also assessed geographic and socioeconomic factors using data from the U.S. Census Bureau. These data, combined with ZCTA-level U.S. Food and Drug Administration (FDA) neighborhood data, allowed me to determine whether geographic differences existed in stroke rate by performing an ANOVA and adjusting for socioeconomic and neighborhood risk factors.

Study Population and Sample

The study population included people in Virginia with a hospital-discharge record in the VHI between 2010 and 2015. Statistical information showed the population of Virginia was 8,260,405 in 2012 and 8,326,289 in 2014 (VDH, 2015) and was expected to increase 0.9% in each subsequent year. Hospital data in Virginia indicated a total of 18,608 hospitalizations (11,394 acute ischemic; 2,793 hemorrhagic; and 4,418 TIA) and inpatient discharges for stroke in 2011 (VDH, 2012).

Sampling and Sampling Procedures

The specific sample for this study included inpatient data at Virginia hospitals for stroke between 2010 and 2015, recorded by the VHI (N = 84,000). However, I did not use all of the number of patients and reconstructive procedures identified in the population . This created the need to have a sample size in place. The sample size refers to the number of participants from whom the researcher collect data. Because this study involved secondary data, I did not directly interact with respondents. Thus, the sample represented patients whose information was used as part of the correlational study. The sample included all stroke types. I used a nonprobability sampling procedure that did not involve randomization. The sampling method that best fit this study was purposive sampling. This meant that all patients, including elective and acute, who were admitted for stroke in Virginia during the 6-year period were purposively sought out and sampled with the recognition that this sample would not be a direct representation of the national population.

Even though statistical information was unavailable for all stroke hospitalizations for the entire 6 years, I estimated the total number to be more than 80,000. The study included patients recorded in VHI, including their diagnosis code and billing zip code. I excluded patients whose records did not include recorded age or zip-code information. I used a *t* test to determine whether a significant association existed between two variables (stroke and neighborhood conditions). Because the sample contained data for approximately 80,000 participants, this sample had sufficient data to determine significance in the study.

Data Collection

After I received Walden University’s Institutional Review Board approval (02-20-17-0494774) to gain access to the data, VHI mailed me a CD of the secondary data in an Excel file . The VHI stroke data were arranged by patients’ age, race, county, zip code, years, stroke code, and comorbidity data. I formatted the data to ensure consistency and accuracy, and coded the variables as numerical values. The U.S. Census Bureau provided information on (a) education attainment, (b) per capital income, (c) the Gini coefficient, (d) job participation, (e) the federal poverty level, (f) population density, and (g) the dependency ratio for the old population for all ZCTAs in Virginia through the fact finder website. I obtained information on food access, access to care, and the Walkability Index from the EPA website.

Procedures for Data Collection, Recruitment, and Participation

The study did not involve recruitment of any participants because it was conducted through a secondary data-collection procedure. However, it was essential to explain how data were obtained for further correlational analysis. I undertook the secondary data collection from VHI data, which are configured into a data-collection database form from all inpatient stays in Virginia. In addition, I collected distinctions concerning baseline comorbidities and socioeconomic status, subject to thorough analysis to help establish the research findings. Clinical outcomes that were measured from the data collected included primary diagnosis and patients' comorbidity at the time of inpatient stay, which included diabetes, hypertension, and renal disease. Social outcome, in contrast, included demographic variables such as zip code of the patient, age, sex, and race. Since its inception in 1993, the VHI system has collected inpatient hospital discharges for the entire State of Virginia. Collected quarterly, these data contain hospital-submitted billing claims with information on diagnosis, procedure, and demographic characteristics for each patient, with a unique identification number for each patient record (VDH, 2016).

Stroke Data

I obtained all stroke diagnoses (International Classification of Diseases, Ninth Revision, Clinical Modification codes: 430–438) data at the zip-code level for the period 2010 to 2015 from the VHI system in an Excel format. Using primary and secondary diagnosis codes and all stroke types ensured virtually complete identification of stroke patients admitted to hospitals. Patients aged 18 years and older at the time of hospital admission were included, regardless of whether they were alive or dead at the time of discharge. Age-adjusted rate was calculated for each ZCTA. Rate adjustment is a technique for removing the effects of age from crude rates, to allow meaningful comparisons across populations of different ages. The current study included only Virginia patients from 2010 to 2015.

The United States was not used as a standard population to obtain a standardized rate for each ZCTA. The calculated stroke rate was the number of cases in the study population compared to the expected Virginia population. I calculated standardized stroke rates by dividing the observed count by the expected value. Because stroke data from the VHI database are not available to the public, I obtained permission to use these data (see appendix B). I submitted a letter of request along with my provisional institutional review board approval from Walden University. Finally, I signed the VHI data-release agreement required by the state.

Socioeconomic and Neighborhood Data

For the study, I obtained socioeconomic and neighborhood data from the U.S. Census Bureau fact-finder website. I excluded population counts when the data met the criteria for confidentiality. I deleted ZCTAs with populations of less than 100 from the analysis or when information was based on only 1 or 2 years of data. I excluded all ZCTAs with unreliable data in calculating standardized rates and conducting correlational analysis and modeling. The number of ZCTAs in the study area was 860. Because 200 ZCTAs had unreliable or suppressed disease data, the number of data points (ZCTAs) for the statistical modeling was 746. Data on food access and the Walkability Index were extracted from the period 2010 to 2015 from the FDA online database. I linked stroke rate with socioeconomic and neighborhood rates for VHI recorded patients' addresses using billing zip code. I converted these zip codes into ZCTA codes according to the U.S. Census Bureau. I first matched patients' zip-code information with U.S. Census ZCTA codes so individual observations included original values.

Operationalization of Constructs

The dependent variable in this study was stroke. The nine independent variables were (a) education attainment (bachelor's degree and below), (b) per capital income, (c) the Gini coefficient, (d) job participation, (e) food access, (f) the Walkability Index, (g) the federal poverty level, (h) population density, and (i) the dependency ratio for the older population. I grouped the independent variables into socioeconomic and neighborhood factors. The socioeconomic status indicators included (a) education attainment, (b) per capital income, (c) the Gini coefficient, (d) job participation, (e) the federal poverty level, and (f) the dependency ratio for the older population. I measured education as the percentage of people in the ZCTA with a bachelor's degree and below. The neighborhood indicators included (a) food access, (b) the Walkability Index, and (c) population density.

Data Analysis

The model included relevant covariates such as age, whether a patient had any stroke event, and whether the patient was admitted at an inpatient hospital in Virginia, all collected in the VHI database. Because stroke data did not follow a normal distribution, they were transformed by natural logarithm before analysis. I used descriptive statistics to describe the sample data and explain the independent and dependent variables for the population of Virginia admitted for stroke. I examined the association between stroke rate and six socioeconomic variables and three neighborhood variables. I report the mean, range, and standard deviation for the continuous variables and used a linear regression model to determine whether a significant association exists between stroke and socioeconomic factors and neighborhood variables.

I constructed linear regression models with stroke rate as the dependent variable and socioeconomic and neighborhood factors as the independent variables. I identified the choice of socioeconomic indicators by comparing the sum of ranks of correlation coefficients between stroke and each independent variable, and higher correlation coefficients linked to lower ranking. Linear regression modeling presented avenues to regulate the impact of other independent variables on undertaking stroke and the associated outcomes. I used a one-way ANOVA to examine differences in stroke rate among the five regions, based on billing address in the hospital-discharge record. I set the significance level at $p < .05$ (2-tailed) and used SPSS software version 24 for the statistical analysis. The data analysis helped me answer the research questions for this study:

RQ1: What is the association between stroke hospitalization rates and socioeconomic status such as educational attainment, income, per capita income, Gini coefficient, and job participation?

$H_0$1: No association exists between socioeconomic status and stroke hospitalization rates.

H_a1: An association exists between socioeconomic status and stroke hospitalization rates.

RQ2: Does an association exist between stroke hospitalization rates and neighborhood factors such as food access and walkability?

$H_0$2: No association exists between neighborhood factors and stroke hospitalization rates.

H_a2: An association exists between neighborhood factors and stroke hospitalization rates.

RQ3: Do geographic differences exist in stroke hospitalization rates by region in Virginia?

$H_0$3*:* No significant geographic differences exists in stroke hospitalization rates by region in Virginia

H_a3*:* A significant geographic differences exists in stroke hospitalization rates by region in Virginia.

Threats to Validity

The potential overlap of similar variables in this study posed a threat to internal validity. For example, dormant confounders may have influenced the relationship between the independent variables, causing an increase in probability error during analysis. Because I used archival data, there is no threat to the internal validity of my analysis. Also, there is no treats to the external validity because it is appropriate to assume that a result found in the Virginia population will generalize to other populations.

Ethical Procedures

I maintained standards for ethical research at all times during this study. I obtained the appropriate permissions to conduct the study and accessed the VHI database before starting the data-collection process. Although the VHI data set did not contain any identifying information about participants, the data were stored electronically on a password-protected computer, and all related hard-copy documents will be kept in a locked file cabinet. The computer and the file cabinet were secured in my locked home office at all times. I will destroy the data 5 years following the study conclusion.

Summary

In this ecological study, I used secondary hospital data from the VHI system to determine whether socioeconomic and neighborhood risk factors aligned with stroke among Virginia residents who were admitted to hospitals between 2010 and 2015. I also examined possible geographic differences in stroke hospitalization rate by region in Virginia, after controlling for diabetes, hypertension, age, and gender.

I used descriptive statistic and a linear regression model to analyze the data. I used descriptive statistics on all independent variables for the stroke population in Virginia. I conducted inferential statistics to answer the research questions. Specifically, I used regression tests to determine whether significant associations exist between the independent and dependent variables. In Chapter 4, I present the results of the data analyses.

Chapter 4: Results

Chapter 4 includes the results of this quantitative ecological study. The purpose of this study was to examine stroke hospitalization rates in the State of Virginia in the context of socioeconomic and neighborhood risk factors. Three research questions and hypotheses guided the study. I designed this study to determine whether a significant association exists between stroke hospitalization rates and at least one of the nine risk factors: (a) education attainment (bachelor’s degree and below), (b) per capital income, (c) the Gini coefficient, (d) job participation, (e) food access, (f) the Walkability Index, (g) the federal poverty level, (h) population density, and (i) the dependency ratio for the old population. In this chapter, I describe the data-collection process and explain how I gained access to the secondary data. I also present the results, which include descriptive and inferential statistics for the variables evaluated in this study.

I answered the research questions using a quantitative method through linear regression models. I sought to improve on studies conducted more than a decade ago, and to generate new findings that identified current risk factors associated with stroke hospitalization in Virginia. According to the statistical data, the rates of stroke in Virginia remain high compared with the national average, despite the stroke alleviation programs in place. This study’s results provided the information necessary to comprehend current risk factors associated with stroke in Virginia.

Results

I assembled 6 years of stroke hospitalization data by ZCTA code, yielding a total of 756 ZCTA codes in Virginia. I used descriptive statistics and ANOVA tests to compare the frequency according to nine selected categorical variables (see Table 1).

Hospital discharge information comprised 6 years of data for patients 35 years of age and older. I included 746 ZCTAs in the analysis, categorized into five geographic health-planning regions. Using criteria from the operational definitions of the variables and the VHI data dictionary, I obtained records only for ZCTAs that included complete information and excluded those with missing, invalid, out-of-range, or unknown data. This culling dropped the final sample to 746 ZCTAs (a 99.6% retention rate). I used descriptive statistics to compare the frequency according to nine selected categorical variables for the state of Virginia (see Table 1).

Table 1

Summary Statistics for Selected Socioeconomic Factors and Neighborhood Indicators in Virginia 2010–2015

Variables	*N**	Mean	*SD*
Bachelor's and below[a]	746	15.8	9.2
Per capita income[b]	746	$29.821	$13.323
Gini Index	746	0.4	0.1
Labor-force participation[c]	744	61.2	10.8
Food Access Index[d]	746	0.2	0.3
Walkability Index	745	0.1	9.5
Federal poverty level	746	26.9	13.6
Population density[e]	393	18.246	31.382
Dependency ratio for old population	741	3.3	0.6

Note. (*) *N* is the number of ZCTAs used for the analysis, *SD* = standard deviation, [a]Bachelor and below: percentage of people in Virginia with a bachelor's degree or below, [b]Per capita income: aggregate income in dollars rounded to the nearest whole dollar, [c]Labor force participation: percentage of people in Virginia in the labor force, [d]Food access: distance to a store or by the number of stores in an area, and [e]Population density: excluding ZCTAs with less than 100 people living in the area.

Research Question 1 asked the following: What is the association between stroke hospitalization rates and socioeconomic status such as education attainment, income, per capital income, Gini coefficient, and job participation? I conducted a linear regression analysis to evaluate the prediction of stroke from the socioeconomic variables. . The results of the multiple linear regression analysis revealed a statistically significant association between the stroke rate and the six socioeconomic variables combined (f (5, 740) = 42.79, $p < .001$) with an R^2 of .224. The results of the linear regression analysis revealed job participation was not a statistically significant predictor ($p = .433$). However, the results revealed a statistically significant ($p < .001$) association between stroke and education attainment, and the Gini coefficient,

I examined the socioeconomic variables further to assess the association with stroke hospitalization rate. Results of the Pearson correlation indicated a significant negative association between stroke hospitalization rate and education attainment ($r(746) = -0.447$, $p = .00$) and between stroke hospitalization rate and per capital income ($r(746) = -0.369$, $p = .00$). The regression coefficient [$B = 0.94$, 95% C.I. (0.48, 1.40) $p < .001$] associated with the Gini Index suggested that with each increase in the Gini Index, the stroke hospitalization rate decreased by approximately 0.94. The R^2 value of .224 associated with this regression model suggested that socioeconomic status accounted for 22.4% of the variation in stroke hospitalization rate, which meant that about 78% of the difference in the stroke rate could not be explained by socioeconomic variables alone. The confidence interval associated with the regression analysis did not contain 0, which meant the null hypothesis (no association exists between socioeconomic status and stroke hospitalization rates such as educational attainment, per capital income, the Gini coefficient, job participation, and the federal poverty level with the stroke hospitalization rate) could be rejected. Table 2 presents a summary of the linear regression analysis.

Table 2

Summary of Linear Regression Analysis for SES Variables Predicting Stroke in Virginia (N = 743)

Variables	β	*t*	Sig. (*p*)
Bachelor's and below	-.42	-7.98	.00
Per capita income	-.17	-3.18	.00
Gini Index	.09	2.52	.01
Labor-force participation	-.02	-.45	.65
Federal poverty level	-.15	-2.72	.01

Note. R^2 = .229.

Table 3 displays the Pearson product correlations between five socioeconomic variables with stroke rate to measure the strength of linear dependence between the two variables. The per capita income (r = -0 .37, $p < .001$) negatively correlated with the stroke rate while and the federal poverty level (r = 0.27, $p < .001$) positively correlated with the stroke rate.

Table 3

Pearson Product Correlation for Socioeconomic Factors With Stroke Rate

Variables	Stroke rate	Sig (p)
Bachelor's and below	-.447	.000
Per capita income	-.369	.000
Gini coefficient	.104	.002
Labor-force participation	-.204	.000
Federal poverty level	.268	.000

Research Question 2 asked the following: Does an association exist between stroke hospitalization rates and neighborhood factors such as food access and the Walkability Index? I conducted a linear regression analysis to evaluate the prediction of stroke from neighborhood factors. The results of the multiple linear regression analysis revealed a statistically significant association between the stroke rate and the four neighborhood factors (f (3, 745) = 25.49, p < .001) with an R^2 of .142. The results also revealed a statistically significant (p < .001) association between stroke hospitalization rate and food access, the Walkability Index, and population density.

Controlling for the Walkability Index and population density, the regression coefficient [B = -0.057, 95% C.I. (-187, 0.072) p < .001] associated with food access suggested that with each decrease in food access, the stroke rate increased by approximately 0.057. The R^2 value of .001 associated with this regression model indicated that food access accounted for 1% of the variation in stroke hospitalization rate, which meant that 99% of the variation in stroke could not be explained by the Walkability Index and population density alone. The confidence interval associated with the regression analysis contained 0, which meant the null hypothesis (no association exists between neighborhood factors and stroke hospitalization rates.) could not be rejected.

Controlling for food access and population density, the regression coefficient [B = -0.005, 95% C.I. (-0.008, -0.002) p < .005] associated with walkability suggested that with each increase in the Walkability Index, the stroke rate decreased by approximately 0.005. The R^2 value of .012 associated with this regression model indicated that the walkability index accounted for 1.2% of the variation in stroke, which meant that 98.1% of the variation in stroke could not be explained by food access and population density alone. The confidence interval associated with the regression analysis did not contain 0, which meant the null hypothesis (no association exists between neighborhood factors and stroke hospitalization rates.) could be rejected. Table 4 presents a summary of the linear regression analysis for neighborhood variables.

Table 4

Summary of Linear Regression Analysis for Neighborhood Variables Predicting Stroke in Virginia (N = 388)

Variables	β	*t*	Sig. (*p*)
Food access	.36	7.53	.00
Walkability	.28	4.24	.00
Population density	-.39	-5.10	.00
Dependency ratio for old population	.46	9.47	.00

Note. R^2 = .326, *p* value is < .05 for all effects.

Table 5 displays the Pearson product correlations between four neighborhood factors with stroke rate to measure the strength of linear dependence between the two variables. Only the dependency ratio for the old population positively correlated with stroke rate ($r = 0.29$, $p < .001$).

Table 5

Pearson Product Correlation for Neighborhood Factors With Stroke Rate

Variables	Stroke rate	Sig (p)
Food access	-.031	.20
Walkability	-.110	.00
Population density	-.245	.00
Dependency ratio for old population	.285	.00

I conducted an ANOVA to determine whether a geographic difference exists in stroke hospitalization rates by zip code in Virginia. The analysis resulted in a statistically significant difference between regions in Virginia, determined by the one-way ANOVA [$F(4, 741) = 95.423$, $p < .005$]. A Levene post hoc revealed that the mean stroke rate was statistically significant between the central region and the northern region of Virginia [0.849, 95% CI 0.732, -0.965), $p < .005$] and between the eastern region and the southwestern region [0.245, 95% CI (0.122, 0.368), $p < .005$]. No statistical significance emerged in the mean stroke hospitalization rate between the central and eastern Virginia regions ($p = .988$) and between the northwestern and southwestern Virginia regions ($p = .131$).

A statistically significant difference ($p = .00$) in the mean stroke rate emerged between the five regions in Virginia. The eastern Virginia health-planning region has a higher mean stroke rate (6.85) than any other region in Virginia. The northern Virginia region has the lowest mean stroke rate (5.98) in Virginia. The mean stroke rate among the five health-planning regions ranged from 6.83 in the central Virginia region to 5.98 in the northern Virginia region. The mean stroke rate from 2010 to 2015 was 6.64 among the 743 ZCTAs in Virginia. Table 6 presents a comparison of stroke hospitalization rate by region. Table 7 presents a summary of the ANOVA findings.

Table 3 shows that per capita income, job participation, and education level were inversely aligned with stroke rate. Table 4 shows that food access and the Walkability Index both significantly and negatively correlated with stroke. As shown in Table 5 food access, Walkability Index, population density, and age group significantly aligned with the stroke hospitalization rate in Virginia.

Table 6

Comparison of Stroke Hospitalization Rate by Virginia Health Planning Region (N = 746)

Virginia regions	*N**	Mean[a]	*SD*
Central	139	6.8	.34
Eastern	153	6.9	.42
Northern	90	6.0	.30
Northwestern	176	6.7	.34
Southwestern	188	6.6	.40
Total	746	6.6	.45

Note.(*) *N* is the total number of zip code tabulation areas in the region, [a]is the mean age-adjusted stroke rate for each region. The rate of stroke was examined using the total number of Virginia population as the denominator while calculating the proportion of stroke hospitalizations.

Table 7

ANOVA Comparisons of Stroke Hospitalization Rate by Virginia Health Planning Region

	Sum of squares	*df*	Mean square	*F*	Sig.
Between groups	51.7	4.0	12.9	95.4	0
Within groups	100.4	741.0	0.1		
Total	152.1	745.0			

Summary of Findings

Chapter 4 began with descriptive statistics characterizing the study sample. The linear regression model showed significant associations between stroke and all nine risk factor variables. By adjusting for other risk factors, I found that people with lower income are more likely to have a higher stroke rate than people with higher income. People with lower educational attainment are more likely to have a stroke when compared to people with higher education attainment. The ANOVA also showed that those with a bachelor's degree and below (see Table 2) was the most significant risk factor associated with stroke among Virginia residents who were hospitalized for stroke between 2010 and 2015. In Chapter 5, I interpret the results by comparing and contrasting the observed results with findings reported in the literature. I also present the study limitations, implications, recommendations for future studies, and a conclusion.

Chapter 5: Discussion, Conclusions, and Recommendations

Stroke is a major issue affecting the residents of the State of Virginia for several decades, as well as in the United States as a whole. The rate of stroke death in Virginia remained higher than the 34.8% target set by Healthy People 2020 (U.S. Department of Health and Human Services, 2012). Stroke is a critical determinant of a nation's health. Socioeconomic status and neighborhood factors might influence an individual's risk of stroke (Yan et al., 2017). Studies by Honjo et al. (2015) and Howard et al. (2013) suggested that to decrease the rate of stroke, risk factors associated with stroke needed to be identified. The purpose of this study was to examine the association between risk factors and stroke among Virginia residents who were admitted to Virginia hospitals between 2010 and 2015, and to identify the most significant risk factors correlated with stroke. The results may help public health professionals develop population-specific prevention programs that prioritize communities at high risk of stroke, thereby lowering the rates of stroke.

Ecosocial Theory

Ecosocial theory was the underlying theory guiding this study. The results of this study confirmed its veracity. The application of the ecosocial theory to the research findings revealed that understanding the risk factors of populations' socioeconomic and neighborhood conditions can encourage participation in preventive health care programs. In the course of this study, I found that education attainment more closely correlated (r = -0.447) with stroke than any other risk factor among Virginia residents who were admitted for stroke in between 2010 and 2015. Per capital income was the most significant risk factor associated with stroke. How the environment can impact a person's health can be identified using the ecosocial theory. Grimaud et al. (2011) confirmed this concept, finding that neighborhood characteristics can be used to help communities lower the threat of stroke.

Interpretation of Findings

This quantitative study was conducted to examine the association between neighborhood and socioeconomic factors and stroke hospitalization in Virginia. The descriptive and linear regression models showed a significant association between each of the nine risk factors and stroke. I proposed several mechanisms to explain the association between socioeconomic status and stroke: per capital income, the Gini Index, the federal poverty level, and education attainment were used as socioeconomic indicators due to their significant association with stroke rate. Per capital income and the Gini coefficient inversely associated with stroke rate for the study period in Virginia. The direction of the association between socioeconomic status and stroke rate was opposite for low and high education levels: The association was positive for ZCTAs with a high percentage of people with less than a bachelor's degree, but was negative for regions with a low percentage of people with a bachelor's degree or below. Lower education level also significantly aligned with stroke rate in Virginia.

The current study findings showed a significant association between stroke hospitalization rates and areas with high neighborhood deprivation. The results of this study indicated that the Walkability Index among ZCTA codes in Virginia between 2010 and 2015 significantly aligned with stroke rate. "Walkability depends upon characteristics of the built environment that influence the likelihood of walking being used as a mode of travel" (U.S. Environmental Protection Agency, 2017, para 1). Also a linear association emerged between food access and stroke rate. Food access refers to travel time to shopping, availability of healthy foods, and food prices. Consumer choices about food spending and diet are likely to be influenced by the accessibility and affordability of food retailers. People, especially those with low income, may face greater barriers in accessing healthy and affordable food, which may negatively affect diet and food security. This result did not support a previous finding by Jiao, Moudon, Kim, Hurvitz, and Drewnowski (2015) who examined the relationship between having fast food or a quick-service restaurant near home and frequent eating at such restaurants. Jiao et al. found no relationship between living close to fast food and negative health outcomes. Also, the current study indicated a geographic difference in stroke rate by regions in Virginia. High-stroke hospitalization rates arose in areas of southeastern Virginia area and low stroke rates emerged in northern Virginia.

The impact of a significant interaction term indicates that the effect of one predictor variable on another variable is not the same at different values of the second predictor variable. Adding an interaction term to a model changes the interpretation of all coefficients. For example, Model 1 includes all socioeconomic predictors of stroke (education attainment + per capita income + Gini coefficient + job participation + poverty level) having an R^2 of .23. This shows that the predictors in Model 1 explain 23% of the variability in stroke, leaving some unexplained variability. In simple terms, some other factors are responsible for predicting stroke outcomes that I did not consider in this study. This study showed that education attainment significantly aligns with stroke: The lower the education level, the higher the stroke rate. Also, a significant positive correlation emerged between the Gini Index and stroke, showing that income inequality strongly aligns with stroke hospitalization rate.

Model 2 of the interaction term includes all neighborhood predictors of stroke (food access + walkability index + population density + dependency ration for old population) having an R^2 of .326. This shows that neighborhood predictors in Model 2 explain 32.6% of the variability in stroke. This outcome indicates that there is still some unexplained variability. In simple terms, some other factors are responsible for predicting stroke outcomes that were not considered in this study. The comparison of Model 1 and Model 2 shows that the confidence interval for Model 1 and Model 2 does not include zero, so both models are better in predicting stroke than random guessing. Overall neighborhood indicators in Model 2 are better than socioeconomic factors in Model 1 because Model 2 was better able to correctly identify stroke.

Limitations of the Study

There were limitations in the study. Given the nature of the ecological-study design, results could be biased by the ecological fallacy. I could not completely rule out the possibility of residual confounding due to unmeasured or inadequately measured covariates. The results at the population level could not be directly applied to individual patients. Socioeconomic status was a comprehensive state-level index estimated with comparable information; therefore, the bias in socioeconomic-status measurement was limited. In this study, the data included all stroke hospitalizations recorded in the VHI systems for a 6-year period. Reporting errors due to improper or insufficient medical coding as well as data-entry errors at the clinic may have occurred in each hospital. The accuracy and consistency over time and between hospitals and regions in the diagnosis may have affected the comparison of stroke rate at different time periods among regions. However, concerns about diagnostic accuracy were minimized by inclusion of all stroke types in this study, which improved comparability across regions and time.

Data from the VHI system were collected for registry purposes. I had no logical or feasible way to confirm the accuracy of this information. The accuracy of the stroke data from VHI was a limitation in this study because using inaccurate data could result in inaccurate findings. Also, because data were archival, I could not change this information.

Another limitation to this study was that the study sample, taken from the VHI hospital data, did not include Virginia residents who were hospitalized for stroke outside of Virginia between 2010 and 2015; these data were unavailable in the capacity needed for this study. This was a limitation because results may not reflect the entire population of Virginia residents who had a stroke between 2010 and 2015. Also, some factors that contribute to stroke among Virginia residents may have been overlooked or underestimated, particularly for certain populations who may not be recorded in the VHI system.

Recommendations for Action

Because this study supports some findings from previous studies and also indicates some new factors for stroke, results should be shared with community members, medical professionals, researchers, public health officials, and policymakers to combat the higher rates of unexplained stroke. It is of utmost importance to continue conducting studies on low-income areas that have a higher rate of stroke. Study results suggested the need to establish new legislation prioritizing changes in funding health care programs, according to their importance. Policies that address stroke should focus on creating awareness about the importance of educational programs, evaluating existing programs, and introducing and implementing competent programs that will target high-risk populations and address ethnic health disparities. These programs should include medical health care professionals and policymakers because both groups participate in the care of patients and in environmental changes. Finally, study findings suggested the need to examine health problems of Virginia families from a holistic point of view. Current study findings may be used to support current stroke statistics in Virginia and to emphasize the importance of overall well-being, including societal, neighborhood, household, and governmental components (see Krieger, 2011).

Recommendations for Future Research

The aim of this study was to identify potential risk factors that align with stroke hospitalization in Virginia and generate hypotheses for future studies. The results of this study should be of interest to researchers because several topics emerged after completion of the study that may compel further examination. First, additional study is necessary to examine individuals' socioeconomic status because the current study indicated a higher risk of stroke at the population level. The Virginia stroke rate ranks 17th in the United States (National Center for Health Statistics, 2015). Even though some states have higher rates than Virginia, another area for further study is to examine interregional problems related to stroke in other states. As a result of identified risk factors in this study, effort should be made to begin decreasing the rate of stroke in Virginia by researching the impact of individuals' income as a social determinant of health and neighborhood effect caused by level of economic disadvantage. Because stroke is a critical determinant in a nation's overall health, combating stroke is important in the State of Virginia. The current study's methodology is applicable to other states and around the world. This research represents a step toward progress that will reduce the rate of stroke and provide substantial savings in cost and resources for the government that could be used for other disease programs.

Implications for Social Change

The present study contributed to the literature and promoted positive social change. The study outcome can be used to develop population-specific prevention programs to lower the stroke rate in Virginia. Results may also be used to improve the quality of life in neighborhoods where inhabitants are prone to risks related to stroke.

In this study, I examined risk factors associated with stroke among Virginia residents who were hospitalized for stroke from 2010 to 2015. The findings provided Virginia residents with information on identified risk factors associated with stroke including education attainment, income, food access, population density, the Walkability Index, and the Gini coefficient. The combination of all variables showed a significant association with stroke. Krieger (2014) acknowledged that assessment of a structured approach for risk factors associated with health problems can be helpful to solve more comprehensive problems. I concentrated on health care and social-policy programs, focusing on population-specific stroke prevention through identification of risk factors such as education, income, job participation, and food access, to decrease the rate of stroke in Virginia.

This study contributed to positive social change by using current data to establish a benchmark approach to assess the challenges of stroke in Virginia. The results will be shared with policymakers in Virginia to create more awareness about what, how, and when to improve programs associated with stroke. Specifically, this study indicated which areas of the state are most affected by stroke and why. Stroke is a critical determinant in a nation's overall health, leading to increased cost of care (Wang et al., 2014). Ecosocial theory describes levels, pathways of class inequality, population distribution of health, and political and economic factors that influence individuals' likelihood of living healthy lives (Krieger, 2008). This framework assists in using a referent population to understand the human elements involved in factors that contribute to stroke risk.

Conclusion

Socioeconomic status and neighborhood conditions are important population indicators of stroke risk. For ZCTA populations with low- to low-middle income, stroke hospitalization rate significantly aligned with socioeconomic status. From middle- to high-income ZCTA populations, stroke hospitalization decreased with advancing socioeconomic status. This information allows health policymakers to organize appropriate resources and identify target populations for more efficient health protection and better health care services. This study showed that education attainment, per capital income, the Gini coefficient, poverty level, food access, and the Walkability Index have a significant impact on the risk of having a stroke. Though this study provides valuable information to public health workers, policymakers, and expecting parents, additional studies are needed to assess these associations, perhaps by including primary data sources.

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Appendix A: Ecosocial Theory Reprinted Permission

Sheridan
Ideas. Delivered.

October 31, 2017

Esther Stephens
393 Tyler Avenue
Newport News, VA 23601

Dear Esther Stephens,

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Proximal, Distal, and the Politics of Causation: What's Level Got to Do With it?
Nancy Krieger
American Journal of Public Health
February 2008; 98(2): 221 to 230
Figure 1

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Appendix B: Data Agreement from VHI

RECEIVED
MAY 18 2017
By__________

PLD AND RATS ORDERING INFORMATION

LICENSE AGREEMENT

Virginia Health Information
Application for and Agreement to License Patient Level Data
(Public Use File - PUF1)
Revised as of November 22, 2011

I. Name: ESTHER M. SEISAY
Company: Walden University, PhD Student (the "Contractor")
Address: 393 Tyler Avenue Newport News VA 23601
Telephone: (919)559 6417
email: estmusseymail.com
Check as Applicable: Business nonprofit (per IRS): ______ Business other: ______
University: _____ Government: _____ Other: ✓

II. State the reason the data is requested. Dissertation analysis on the effect of socio economic status on stroke hospitalization rate in Virginia

III. Will reports be created for sale to third parties using this data? If yes, please note target volume of expected reports using this data or extracts from this data and the file format of any such report. NO

IV. Will computer readable files be created for sale to third parties? If yes, please note the target volume and format of the files to be created. NO

V. Applicant desires the following license: (Please check only one)

A. Individual License: ✓ Allows Contractor to use data on a single computer belonging to the Contractor or the Contractor's designated subcontractor.

B. Site License: _____ Allows Contractor to make multiple copies of the data for use by individuals within the same organization of the Contractor or a single copy accessible by Contractor's computer network by more than one individual within the same organization.

C. Commercial License: _____ Allows Contractor to make multiple copies of the data for incorporation into computer software for subsequent resale and/or distribution of such computer software to third parties, subject to the condition that with respect to the data the third party is able only to access the data by queries that produce aggregated data reports. This license also allows Contractor to sell reports created from the database. Notwithstanding the forgoing, any subsequent resale and/or distribution by such third parties is expressly prohibited, and any distribution of data to third parties that enables third party access to data other than by aggregated reports is expressly prohibited.

VI. Virginia Health Information (VHI) hereby grants the Contractor indicated in Section I a non-exclusive, non-transferable, and perpetual license to use the Data Base described in Appendix A (or "data") under the terms and subject to the restrictions of this Agreement, and the Contractor hereby accepts, subject to the terms and conditions set forth in this Agreement, the nonexclusive and nontransferable right to use the Data Base pursuant to the terms of this Agreement. VHI reserves all rights, title, and interest in and to the Data Base (including ownership of all copyrights and other intellectual property rights pertaining thereto), subject only to the license expressly granted to Contractor herein.

In accepting the usage granted by VHI, the Contractor agrees that it shall:

A. Except as permitted under Section VI, Part F below, not license, rent, lease, distribute, or permanently transfer the Contractor's rights to use the Data Base.

B. Use the Data Base only for the expressed purpose stated by the Contractor in this application.

C. Make no attempt, by commission or omission, to identify, disclose, discuss, release, or provide access to information on specific individual patients.

D. Contractor agrees to include the following statement in any reports, publications, or secondary files created using the Data Base whether for internal use or for sale, presentation, or distribution to third parties:
"Virginia Health Information (VHI) has provided non-confidential patient level information used in this file, report, publication, or database which it has compiled in accordance with Virginia law but which it has no authority to independently verify. By using this file, report, publication, or database, the user agrees to assume all risks that may be associated with or arise from the use of inaccurate data. VHI cannot and does not represent that the use of VHI's data was appropriate for this file, report, publication, or database or endorse or support any conclusions of inferences that may be drawn from the use of VHI's data."

For any reports, publications, or secondary files created using the Data Base for sale, presentation, or distribution to third parties under Section V., Part C., Contractor also agrees to include the following statement:
"The patient level information used in this file, report, publication, or database is provided for your sole, internal use only, and is non-transferable, and shall not be distributed to any third parties whatsoever."

E. Not resell or externally distribute to third parties the Data Base unless Contractor obtains a commercial license from Virginia Health Information as defined in Section V., Part C above and incorporates the Data Base into a computer program that manipulates and analyzes or enables the user to manipulate and analyze the data as permitted under this License Agreement (the "Software".) Any such resale or external distribution shall be expressly limited to the internal use of such third party; Contractor shall not make any representation or attempt to authorize third parties to further resell or distribute the Data Base or patient level information therein. Contractor agrees to take all reasonable steps to limit such third party use to the sole use of making queries and generating reports of aggregated data, and as a condition of this license such third parties shall be expressly prohibited from accessing or exporting data or individual patient records.

F. Notwithstanding the restrictions set forth above if a multi-site license or commercial license as described in Section V., Parts B, or C is issued, Contractor shall be permitted to distribute the Data Base to entities or individuals that are directly or indirectly owned or controlled by Contractor or that are directly or indirectly owned or controlled by the same entity or individual that owns or controls Contractor, with any such distribution remaining subject to the terms and conditions herein.

G. Pay such additional licensing fees to VHI as may reasonably be demanded by VHI in the event that Contractor's use of the Data Base exceeds the scope of this agreement.

Contractor further agrees that VHI shall be entitled to terminate all of Contractor's rights to use the Data Base and Contractor shall return all copies of the Data Base to VHI, in the event Contractor violates the terms of this Agreement and fails to cure such violation within seven (7) days of the receipt of such notice. Notwithstanding the preceding sentence, if Contractor violates the terms of Section C above regarding patient identity, this license shall immediately terminate and Contractor shall immediately return all copies of the Data Base to VHI. The rights and remedies of VHI set forth herein with respect to Contractor's failure to comply with the terms of this Agreement (including, without limitation, the right to terminate this Agreement) are not exclusive, the exercise thereof shall not constitute an election of remedies, and VHI shall be entitled to seek whatever additional remedies may be available in law or in equity.

Upon receipt of this application and Agreement, executed by the Contractor acceptance by VHI hereof, and receipt of the license fee, VHI shall execute the Agreement and furnish the Contractor the Data Base in computer-readable form, subject to the terms of this agreement.

All fees payable by Contractor under this Agreement are net of applicable taxes. Contractor is solely responsible for any taxes or assessed fees which are, or may become, due by reason of this Agreement.

Contractor does hereby indemnify and shall hold harmless VHI, and its directors, officers, and any employees and agents from and against all liability (including punitive damages) and costs (including reasonable attorneys' fees) arising out of a claim or claims of third parties arising from the use by Contractor, in any manner, of the Data Base, including (but not limited to) the violation of any third party's privacy rights.

CONTRACTOR AGREES THAT THE DATA BASE IS BEING PROVIDED AS IS AND ALL WARRANTIES, WHETHER BY COMMON LAW, STATUTE, OR EQUITY, ARE EXCLUDED, INCLUDING THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE (WHETHER OR NOT VHI KNOWS, HAS REASON TO KNOW, HAS BEEN ADVISED, OR IS OTHERWISE IN FACT AWARE OF ANY SUCH PURPOSE). CONTRACTOR ACKNOWLEDGES THAT VHI ONLY COMPILES THE INFORMATION CONTAINED IN THE DATA BASE, AND DOES NOT INDEPENDENTLY VERIFY OR

WARRANT THE ACCURACY OF SUCH INFORMATION.

CONTRACTOR AGREES THAT VHI SHALL NOT BE LIABLE FOR SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES EVEN IF IT HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. THE ABOVE INDEMNIFICATION, DISCLAIMER OF WARRANTIES, AND LIMITATATION OF LIABILITY SHALL SURVIVE TERMINATION OF THIS AGREEMENT.

Contractor has read and agrees to abide by all terms and restrictions described regarding the use of Virginia Health Information (VHI) patient level data. Any change or waiver of any provision of this Agreement shall be only by signed writing of the parties to be effective.

VIRGINIA HEALTH INFORMATION

By: [signature]
Name: Michael T. Lundberg
Title: Executive Director
Date: May 25, 2017

CONTRACTOR

By: E. Seisay
Name: ESTHER SEISAY
Title: Phd Student, Walden University
Date: May 16th 2017

VHI License No. I 1070
November 2011

Description of the Data Base

Public Use File-PUF1

The Public Use File-PUF1 is a data file of all hospital discharges in the Commonwealth of Virginia for the identified quarter. Claims data elements are included for patient demographics, diagnoses and procedures, charges, and revenue groupings. Co-morbid conditions have also been added to aid in determining variations in patient outcomes.