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An Analysis of the Association Between Cognitive Decline and Geographic Residence Among Women Over 65 in the Southeastern United States

Christine Invergo
christine.invergo@gmail.com

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Christine Invergo, Student

Keith Knapp, Committee Chair

Sarah Wackerbarth, Director of Graduate Studies

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CAPSTONE PROJECT PAPER

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Christine Invergo
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Capstone Committee:
Dr. Keith Knapp, PhD, MHA, CNHA, HSE, FACHCA (Chair)
Dr. Rachel Hogg-Graham, DrPH, MA
Dr. Dana Quesinberry, JD, DrPH

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Abstract

Introduction: The United States is an increasingly aging nation, and aging increases the risk of cognitive decline. Information on the relationship between cognitive decline and geographic residence in the U.S. is limited. Available evidence suggests that rural residents tend to suffer persistent disadvantages in cognitive functioning when compared to sociodemographically similar urban peers. This analysis focused on women over 65 years of age living in the southeastern U.S. The primary objective of this analysis was to determine if there was a significant association between geographic residence and cognitive decline. A secondary objective was to explore variables of interest that may contribute to the relationship between geographic residence and cognitive decline.

Methods: Data from the 2019 BRFSS survey were used for this research. To determine if there was a significant relationship between cognitive decline and geographic residence, the primary analysis was a Chi-square test between the geographic residence variable and the cognitive decline variable. Chi-square tests were also performed between cognitive decline/geographic residence and 5 variables of interest: education level, income level, social support, exercise, and healthcare access. An ANOVA was performed between education level/geographic residence and income level/geographic residence, to determine if the means of these variables differed between urban and rural areas. A subgroup analysis was performed including only women who reported experiencing cognitive decline.

Results: A significant association was not observed between cognitive decline and geographic residence ($p=0.75$). Education, income, and exercise were shown to have significant associations with geographic residence. Significant associations were also observed between cognitive decline and education, income, exercise, and social support. Mean education level and mean income level were shown to significantly differ between urban and rural areas.

Conclusions: Despite the null results of the primary research question, previous research indicating rural cognitive health deficits and known rural health disadvantages make this an area worthy of further study. Understanding the social determinants of health, and particularly of cognitive health, and how these factors affect urban and rural populations differently, is an important step in improving health outcomes and promoting healthier aging.

Keywords: cognitive decline, geographic residence

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Acronyms and Abbreviations

ANOVA – Analysis of Variance

BRFSS – Behavioral Risk Factor Surveillance System

CD – Cognitive Decline

REGARDS – Reasons for Geographic and Racial Differences in Stroke

Introduction

Background

The U.S. population is aging at an unprecedented rate. In the past, higher fertility and increased international migration contributed to keeping the U.S. a "younger" nation. However, trends are changing. Americans are having fewer children and life expectancy is longer, resulting in a nation that is aging faster. Another driving force behind the aging of the U.S. is the baby boomers of the 1950s and 1960s, one of the largest generations in the country. The aging of this generation is causing a demographic transformation of the U.S. In 2019, 54.1 million adults in the U.S. were 65 or older, representing 16% of the population (Centers for Disease Control and Prevention [CDC], 2022). By 2060, this group is expected to reach 94.7 million, constituting around 25% of the population (CDC, 2022).

Aging increases the risk for many health issues. Cognitive decline is one such risk that increases with age and is most common among adults over 65. The American Psychological Association defines cognitive decline as "reduction in one or more cognitive abilities, such as memory, awareness, judgment, and mental acuity, across the adult lifespan" (American Psychological Association, n.d.). Cognitive impairment can range from mild to severe, at which point it becomes classified as dementia. Dementia is a broad diagnosis that includes Alzheimer's Disease, Lewy body dementia, cerebrovascular dementia, and mixed dementias (Hale et al., 2020). Approximately 2 out of 3 Americans experience some form of cognitive impairment at an average age of around 70 (Hale et al., 2020). Cognitive decline often results in functional impairments, which limit the ability of affected individuals to carry out their day-to-day activities. This can lead to a need for caregivers or long-term care facilities. Diseases resulting from cognitive decline are a costly health care burden. In 2021, the U.S. spent $355 billion in

health care and long-term care costs associated with dementia (CDC, 2022). It is important to identify factors associated with cognitive decline in order to reduce risk and promote healthier aging.

Health Disparities and Geographic Residence

This analysis will focus on the relationship between cognitive decline and geographic residence in the U.S. To further refine the analysis, the population of interest will be limited to individuals living in the southeastern U.S., as this region exhibits higher rates of chronic illnesses, worse health outcomes, and lower rates of health coverage. It has been well established that living in rural areas is linked to poorer health outcomes. Rural populations experience increased rates of multiple chronic conditions compared to urban populations (Harris et al., 2016). Individuals living in rural jurisdictions have higher rates of risky health behaviors and face greater barriers to receiving care. Access to healthcare is often cited as the biggest problem for rural health (Bolin et al., 2015). Within this category, access to emergency services, insurance, and primary care cause the most concern (Bolin et al., 2015). Rural communities are often served by smaller local health departments, which are more understaffed and have fewer resources than their urban counterparts (Harris et al., 2016). Limited financial resources influence health outcomes for rural residents, as many rural areas face persistent poverty. Two thirds of the nation's rural counties have poverty rates at or above the national average of 14.4% (Bolin et al., 2015). Information on the relationship between cognitive decline and geographic residence in the U.S. is limited, but available evidence suggests that older adults living in rural areas tend to have poorer cognitive functioning compared to sociodemographically similar adults

living in urban areas. Determining what factors put rural residents at a health disadvantage is necessary in order to promote healthier lifestyles and generate better health outcomes.

Cognitive Decline in Women

In addition to a focus on geographic residence, this analysis will also concentrate on women. It is unclear what role sex differences play in cognitive decline risk. It is hypothesized that sex differences in biological factors, health factors, and social factors may contribute to dementia risk (Levine et al., 2021). Some studies suggest that Alzheimer's Disease has a higher incidence among women (Levine et al., 2021). A study by Levine et al. suggested that while women may have greater cognitive reserve than men, they might have faster cognitive decline later in life (Levine et al., 2021). She suggests that women are at risk for delayed identification of cognitive decline, yet the trajectory for decline is more rapid (Levine et al., 2021). This could indicate increased risk of dementia and disability compared with men (Levine et al., 2021). This evidence, coupled with the fact that women tend to have longer life expectancies than men, could suggest that women might have greater need for caregiving resources and functional support. Recognizing the factors that could place women at an increased risk for cognitive decline is important in order to target and mitigate those risks.

Objectives

The purpose of this analysis is to determine whether there is an association between cognitive decline and geographic residence among women over 65 living in the southeastern United States. A secondary objective is to investigate variables of interest contributing to possible relationships between cognitive decline and geographic residence, such as level of

education, income level, exercise, social support, and healthcare access. The contribution of this analysis is to increase the body of evidence on what is known about cognitive decline among women, particularly those living in rural areas. There are limited findings concerning this particular population in terms of cognitive decline. As the nation's population grows older, it is increasingly important to understand what factors contribute to cognitive decline, particularly in more vulnerable populations. Then, interventions can be targeted to these populations to promote healthier aging.

Literature Review

Cognitive Decline and Geographic Residence

Information on the relationship between cognitive decline and geographic residence in the U.S. is limited. Population aging in rural communities proceeds at a more rapid pace than in urban communities (Glasgow et al., 2012). This, combined with longstanding healthcare challenges, makes rural communities more susceptible to diseases of aging (Harris et al., 2016). Available evidence suggests that adults who live in rural areas tend to suffer persistent disadvantages in cognitive functioning when compared to sociodemographically similar urban peers (Weden et al., 2018). However, reasons for potential differences in rural versus urban adult cognitive health are not well understood (Weden et al., 2018). Reduced access to preventive health infrastructure likely plays a role in poorer cognitive health outcomes among rural residents. Studies have consistently demonstrated that rural residents also have higher rates of chronic conditions and comorbidities, such as diabetes, hypertension, and obesity, which are thought to be precursors to cognitive decline (Glasgow et al., 2012). The REGARDS study (Reasons for Geographic and Racial Differences in Stroke) found that the odds of incident

cognitive impairment were 18% higher among residents of the Stroke Belt than among those not living in that region, after adjusting for strong independent predictors of cognitive decline, including age, sex, and education level (Wadley, 2011). The Stroke Belt is a region of the southeastern U.S. that was first described in 1965 as having 50% higher stroke mortality rates than the remaining U.S. (Wadley, 2011). European studies in Portugal, Spain, and Ireland have reported higher levels of cognitive impairment among rural populations than urban populations, due at least partially to differences in sociodemographic composition of the groups by age and education (Cassarino et al., 2015).

However, there is also evidence that the noise and traffic pollution common to urban areas may negatively impact cognition (Clifford et al., 2016). Exposure to traffic-related pollutions has been associated with measurable impairment of brain development in the young and cognitive decline in the elderly (Clifford et al., 2016). Plausible toxicological mechanisms and the evidence as a whole suggests that vehicular pollution may contribute to cognitive impairment (Clifford et al., 2016). A growing number of epidemiologic studies have examined the relationship between air pollution and dementia-related outcomes, providing support for a significant association (Power, 2016). Due to the higher levels of pollution in urban areas, urban residents would have greater exposure to pollutants that urban residents.

Contributing Factors to Cognitive Decline

A secondary objective of this analysis is to investigate variables of interest contributing to possible relationships between cognitive decline and geographic residence. There are several factors associated with cognitive decline that are already characterized in the literature. The

variables of interest that will be included in this analysis are level of education, income level, social support, exercise, and healthcare access.

Cognitive Decline and Education/Income

Level of education is a factor that is thought to have an effect on cognitive decline. Educational attainment is an important component of healthy cognitive aging and serves as a protective factor against dementia. Education may function directly by establishing higher initial levels of cognition or improving the ability of brain networks to compensate for stressors (Stern, 2006). It may also function indirectly by increasing cognition related to work and leisure activities, or through improved healthcare utilization and health behaviors that promote cerebrovascular health (Langa et al., 2017). More years of education are associated with higher cognitive functioning and slower cognitive decline (Zahodne et al., 2015). A recent downward trend in the nationwide incidence of dementia is thought to be attributable to increased educational attainment and demonstrates the long-term benefits of investment in secondary education (Weden et al., 2018). However, educational differences still persist between rural and urban areas, with rural residents lagging behind in college and advanced degree completion (U.S. Department of Agriculture [USDA], n.d.). Income level is a related factor that influences cognitive decline. In general, income level increases as educational attainment increases. Socioeconomic status influences many aspects of an individual's life, such as access to healthcare, home and work environment, and participation in leisure activities. In older populations, lower socioeconomic status is associated with a greater risk of cognitive decline (Koster et al., 2005). Rural areas tend to have more individuals who are of a lower socioeconomic status.

Cognitive Decline and Social Support

Social support is a factor that is thought to have an effect on cognitive health. A lifestyle that is socially engaging is thought to be protective against cognitive decline. Social support is important in daily activities for the elderly, particularly those who live in community settings (Yeh et al., 2003). Social activities promote participation in complex interpersonal exchanges and provide opportunities to practice effective communication (Yeh et al., 2003). Having more social ties allows older adults to remain engaged with those around them, and also ensures that they are monitored more closely for signs of worsening cognition. Widowhood has also been found to accelerate cognitive decline in older widowed adults (Shin et al., 2018). Loss of a spouse not only subjects an individual to stress from the grieving process, but also presents a significant burden in the loss of emotional, social, and financial support (Shin et al., 2018). This can result in the deterioration of an individual's mental state. Rural residents may have limited access to social support due to geographic isolation. Limited resources and reduced access to transportation systems can make it more difficult to maintain social ties.

Cognitive Decline and Exercise

Exercise is an intervention that is correlated with better cognitive function. It is well known that regular exercise provides health benefits to individuals of all ages. Exercising helps to maintain a healthy body weight and can lower risks for developing certain diseases. Exercise has been shown to improve executive functioning in adults of all ages (Behrman et al., 2014). Regular exercise has been shown to have a moderate effect on the capacity of people with dementia to perform daily activities and is thought to improve cognitive function (Behrman et al., 2014). Exercise regimens that require some cognitive input, such as dance routines, may

provide additional benefits to improve cognition. Epidemiological studies have shown that regular physical exercise can delay, limit, or even prevent the onset of dementia (Nelson, 2005). People who live in rural areas tend to be less physically active than those who live in urban areas (Whitfield, 2019). While there has been an increase in meeting the recommended physical activity guidelines in recent years, physical activity prevalence remains low, particularly for rural subgroups that have high incidences of chronic diseases (Whitfield, 2019). Access to exercise opportunities is often more limited for rural residents when compared to urban residents. Rural communities generally lack built environment features such as sidewalks, parks, or recreational areas. A typical rural adult is more at risk for being sedentary due to limited access to exercise facilities, lower income, and less available information detailing the benefits of an active lifestyle (Chrisman et al., 2015).

Cognitive Decline and Healthcare Access

Healthcare access is a factor that has an influence on cognitive decline. Utilization of primary care services helps to manage risk-causing conditions and reduce risk behaviors for dementia. Individuals with barriers to healthcare access may not be able to take advantage of these preventive services. It has been shown that not having a regular source of medical care is associated with higher odds of cognitive decline (Mullins et al., 2021). Additionally, living in an area with a greater supply of primary care physicians has also been correlated with better cognitive health in the elderly (Mullins et al., 2021). This puts rural Americans at a disadvantage. Rural areas tend to have a smaller supply of healthcare personnel. It has been documented that rural America has an undersupply of primary care physicians, registered nurses, nurse practitioners, pharmacists, and dentists, as well as limited access to specialty care (Bolin et al.,

2015). Healthcare access challenges can be even more severe for racial and ethnic minorities or disabled individuals living in rural areas.

Methods

The Behavioral Risk Factor Surveillance System (BRFSS) is the nation's foremost system of telephone surveys regarding health data. These surveys collect information from U.S. residents on health-related risk behaviors, chronic health conditions, and use of preventive services. The BRFSS, established in 1984, now collects data from all 50 states, the District of Columbia, and three U.S. territories. More than 400,000 adult interviews are completed each year, making the BRFSS the largest continuously conducted health survey system in the world. The BRFSS is a powerful tool for targeting and building health promotion activities because it collects behavioral health risk data at the state and local level. To conduct the survey, state health departments use in-house interviewers or contracted telephone call centers or universities to administer the survey questions. All states use a standard core questionnaire, and optional modules or state-added questions can be used as well. Random digit dialing techniques are used to conduct the survey, utilizing both landlines and cell phones. Adults 18 years old or older are eligible to take part in the survey.

This study is a secondary data analysis of panel data. The data used for this analysis is the BRFSS 2019 survey. In 2019, the survey collected responses from 418,268 subjects. 74,137 subjects were from southeastern states that used the optional Cognitive Decline module in 2019. Of these subjects, 41,503 were female. Of female subjects, 15,922 were age 65 or older. After removing responses that were "Don't know/Not sure", "Refused", or "Missing" from all

variables, the sample size was 9,836 subjects. Table 1 shows descriptive statistics for the full sample.

Table 1: Descriptive statistics for full sample (n=9836)

	n (%)
Geographic location	
Urban	7957 (80.9)
Rural	1879 (19.1)
Education	
Did not graduate high school	972 (9.88)
Graduated high school	3028 (30.78)
Attended college or technical school	2844 (28.91)
Graduated from college or technical school	2992 (30.42)
Marital status	
Married	3735 (37.97)
Divorced	1596 (16.23)
Widowed	3853 (39.17)
Separated	139 (1.41)
Never married	435 (4.42)
A member of an unmarried couple	78 (0.79)
Income	
Less than $15,000	1368 (13.91)
$15,000-$25,000	2438 (24.79)
$25,000-$35,000	1492 (15.17)
$35,000 to less than $50,000	1565 (15.91)
$50,000 or more	2973 (30.23)
Healthcare access	
Yes	9707 (98.69)
No	129 (1.31)
Exercise	
Yes	6239 (63.43)
No	3597 (36.57)
Cognitive Decline	
Yes	1155 (11.74)
No	8681 (88.26)

To filter the dataset to include only women, aged 65+, from a southeastern state that used the optional Cognitive Decline module in 2019, three variables were used. These variables are shown in Table 2. Southeastern states that used the optional Cognitive Decline module in 2019 were Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, Tennessee, Virginia,

and West Virginia. For the sake of brevity, only the responses corresponding to these states are included in the table below.

Table 2: BRFSS variables used to filter the dataset to include women aged 65+ who lived in a southeastern state that used the Cognitive Decline module in 2019

Variable	Question	Responses
SEXVAR	Sex of respondent	1-Male 2-Female
_AGE65YR	Two-level age category	1-Age 18 to 64 2-Age 65 or older
_STATE	State FIPS code	1-Alabama 12-Florida 13-Georgia 22-Louisiana 28-Mississippi 45-South Carolina 47-Tenneessee 51-Virginia 54-West Virginia

The independent variable for this analysis is geographic residence. This variable, shown in Table 3, splits the sample population into urban and rural counties.

Table 3: BRFSS variable for geographic residence (independent variable)

Variable	Question	Responses
_URBSTAT	Urban/rural status	1-Urban counties 2-Rural counties

The dependent variable is cognitive decline. This variable will be assessed using the optional Cognitive Decline module. Table 4 lists the variables that comprise this module. The first variable in the module, CIMEMLOS, is considered in this research as the primary dependent variable for cognitive decline. The other items in the module will be utilized for a subgroup analysis. To create dichotomous variables, any Cognitive Decline module questions that are not

Yes/No will be recoded. Data points labeled “Always” and “Usually” will be considered in this research as exhibiting cognitive decline, and data points labeled “Sometimes”, “Rarely”, and “Never” will be considered as not exhibiting cognitive decline.

Table 4: BRFSS Cognitive Decline module items

Variable	Question	Responses
CIMEMLOS	During the past 12 months, have you experienced confusion or memory loss that is happening more often or is getting worse?	1-Yes 2-No
CDHOUSE	During the past 12 months, as a result of confusion or memory loss, how often have you given up day-to-day household activities or chores you used to do, such as cooking, cleaning, taking medications, driving, or paying bills?	1-Always/Usually 2-Sometimes/Rarely/ Never
CDASSIST	As a result of confusion or memory loss, how often do you need assistance with these day-to-day activities?	1-Always/Usually 2-Sometimes/Rarely/ Never
CDHELP	When you need help with these day-to-day activities, how often are you able to get the help that you need?	1-Always/Usually 2-Sometimes/Rarely/ Never
CDSOCIAL	During the past 12 months, how often has confusion or memory loss interfered with your ability to work, volunteer, or engage in social activities outside the home?	1-Always/Usually 2-Sometimes/Rarely/ Never
CDDISCUS	Have you or anyone else discussed your confusion or memory loss with a health care professional?	1-Yes 2-No

Variables of interest used in this analysis are level of education, income level, exercise, social support (assessed by marital status), and healthcare access. These variables are listed in Table 5. The social support variable will be recoded so that responses “Married” and “A member of an unmarried couple” will be considered as having social support, and responses “Divorced”, “Widowed”, “Separated”, and “Never married” will be considered as not having social support.

Table 5: BRFSS variables to be variables of interest

Variable	Question	Responses
MARITAL	Are you: (marital status)	1-Married 2-Divorced 3-Widowed 4-Separated 5-Never married 6-A member of an unmarried couple
_EDUCAG	Calculated variable for level of education completed	1-Did not graduate high school 2-Graduated high school 3-Attended college or technical school 4-Graduated from college or technical school
_INCOMG	Calculated variable for income categories	1-Less than $15,000 2-$15,000-$25,000 3-$25,000-$35,000 4-$35,000 to <$50,000 5-$50,000 or more
HLTHPLN1	Do you have any kind of health care coverage, including health insurance, prepaid plans such as HMOs, or government plans such as Medicare, or Indian Health Service?	1-Yes 2-No
EXERANY2	During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?	1-Yes 2-No

Analytic Strategy

SAS 9.4 is the analytic statistical software used for this research. A Chi-square test for independence will be performed with the geographic location variable (_URBSTAT) and the cognitive decline variable (CIMEMLOS). A Chi-square test for independence is used because it is a hypothesis test that is designed to determine whether there is a statistically significant

relationship between nominal and ordinal variables. Variables of interest are also analyzed using a Chi-square test to investigate the possibility of a significant relationship. A Chi-square test will be performed with each variable of interest (education level, income level, exercise, social support, and healthcare access) and geographic residence. A Chi-square test will also be performed with each variable of interest and the cognitive decline variable. An ANOVA will be performed with education level/geographic residence to determine if mean educational attainment varies by geography, and an ANOVA will also be performed with income level/geographic residence to determine if mean income varies by geography. ANOVA is used because it helps determine whether differences between groups of data are statistically significant by analyzing the levels of variance within the groups. To utilize the other variables in the Cognitive Decline module, a frequency table and an array will be used to determine 1) the number of subjects that responded "Yes" to each variable, and 2) the number of times subjects responded "Yes" to a variable.

The significance level is set to $\alpha=0.05$. The null hypothesis is that there will not be a significant relationship between cognitive decline and geographic residence. The alternative hypothesis is that there will be a significant relationship between cognitive decline and geographic residence.

Results

Chi-square tests investigating the relationship between cognitive decline and geographic location did not reveal a statistically significant relationship (see Table 6). Thus, we do not have sufficient evidence to reject the null hypothesis. However, there were significant relationships between several variables of interest and geographic residence. Level of education, income level,

and exercise were all found to have significant relationships with geographic residence with p-values less than 0.05 (see Table 6). Neither healthcare access nor social support showed a significant relationship with geographic residence (Table 6).

Table 6: Results of Chi-square tests with geographic residence variable

	Urban n (%)	**Rural n (%)**	**Total n (%)**	**Pearson Chi-square**	**p-value**
Cognitive Decline				0.16	0.75
Yes	926 (11.09)	229 (1.38)	1155 (12.47)		
No	7031 (78.21)	1650 (9.33)	8681 (87.53)		
Education				82.21	<0.0001
Less than HS	709 (12.24)	263 (1.99)	972 (14.23)		
High school	2334 (27.49)	694 (4.31)	3028 (31.81)		
Some college	2344 (29.22)	500 (2.83)	2844 (32.04)		
College	2570 (20.34)	422 (1.57)	2992 (21.92)		
Income				110.69	<0.0001
Less than 15k	996 (11.55)	372 (2.21)	1368 (13.76)		
15k—25k	1893 (20.39)	545 (3.04)	2438 (23.43)		
25k—35k	1191 (14.19)	301 (1.87)	1492 (16.06)		
35k to <50k	1289 (13.53)	276 (1.49)	1565 (15.02)		
50k or more	2588 (29.64)	385 (2.09)	2973 (31.73)		
Healthcare				0.19	0.77
Yes	7854 (87.66)	1853 (10.49)	9707 (98.14)		
No	103 (1.64)	26 (0.22)	129 (1.86)		
Exercise				32.96	<0.0001
Yes	5138 (58.29)	1101 (6.03)	6239 (64.31)		
No	2819 (31.01)	778 (4.68)	3597 (35.69)		
Social Support				0.01	0.95
Yes	3062 (42.33)	751 (5.06)	3813 (47.39)		
No	4895 (46.97)	1128 (5.64)	6023 (52.61)		

Table 7 shows the results of Chi-square tests between the cognitive decline variable and variables of interest. As can be seen from the table, all variables of interest, with the exception of healthcare access, had a significant relationship with cognitive decline.

Table 7: Results of Chi-square tests with cognitive decline variable

	CD Yes n (%)	CD No n (%)	Total n (%)	Pearson Chi-square	p-value
Education				75.13	0.0002
Less than HS	161 (2.65)	811 (11.58)	972 (14.23)		
High school	384 (4.25)	2644 (27.56)	3028 (31.81)		
Some college	321 (3.44)	2523 (28.60)	2844 (32.04)		
College	289 (2.12)	2703 (19.80)	2992 (21.92)		
Income				73.50	0.0008
Less than 15k	220 (2.42)	1148 (11.34)	1368 (13.76)		
15k—25k	355 (3.10)	2083 (20.33)	2438 (23.43)		
25k—35k	192 (2.34)	1300 (13.72)	1492 (16.06)		
35k to <50k	157 (1.72)	1408 (13.31)	1565 (15.02)		
50k or more	231 (2.89)	2742 (28.84)	2973 (31.73)		
Healthcare				23.52	0.18
Yes	1138 (12.02)	8569 (86.12)	9707 (98.14)		
No	17 (0.45)	112 (1.41)	129 (1.86)		
Exercise				58.66	<0.0001
Yes	596 (6.80)	5643 (57.52)	6239 (64.31)		
No	559 (5.67)	3038 (30.02)	3597 (35.69)		
Social Support				19.50	0.02
Yes	370 (5.17)	3443 (42.21)	3813 (47.39)		
No	785 (7.29)	5238 (45.32)	6023 (52.61)		

Tables 8 and 9 show the results from the ANOVA tests performed with geographic residence/education level and geographic residence/income level, respectively. As can be seen from the tables, mean educational attainment and mean income level vary by geographic residence.

Table 8: ANOVA results for education and geographic residence

Mean educational level for urban residents	2.85
Mean educational level for rural residents	2.58
p-value	<0.0001

Table 9: ANOVA results for income and geographic residence

Mean income for urban residents	3.32
Mean income for rural residents	2.87
p-value	<0.0001

Table 10 and Figure 1 show the number of subjects that responded "Yes" to each of the cognitive decline assessors. The assessor CDDISCUS, which asks respondents if they have discussed confusion or memory loss with a healthcare provider, was the most selected. Table 11 and Figure 2 display the number of times a subject who had answered "Yes" to exhibiting cognitive decline subsequently answered "Yes" to any of the other cognitive decline assessors in the module. As can be seen from the graph, the majority of respondents did not answer "Yes" to any of the cognitive decline assessors, with the next largest respondent group being those that answered "Yes" to only one of the cognitive decline assessors. The assessor CDHELP was excluded from this analysis, as it does not directly measure cognitive decline but rather a subject's access to assistance.

Table 10: Number of subjects that responded "Yes" to each CD assessor (n=1155)

	n (%)
CDDISCUS	546 (47.77)
CDHOUSE	134 (11.86)
CDASSIST	119 (10.46)
CDSOCIAL	112 (9.89)

CD=cognitive decline

Figure 1: Number of subjects that responded "Yes" to each CD assessor (n=1155)

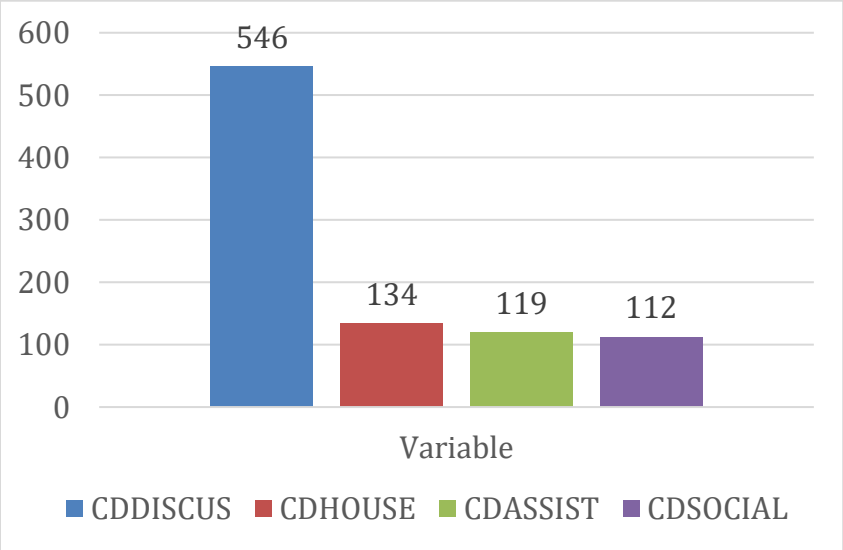
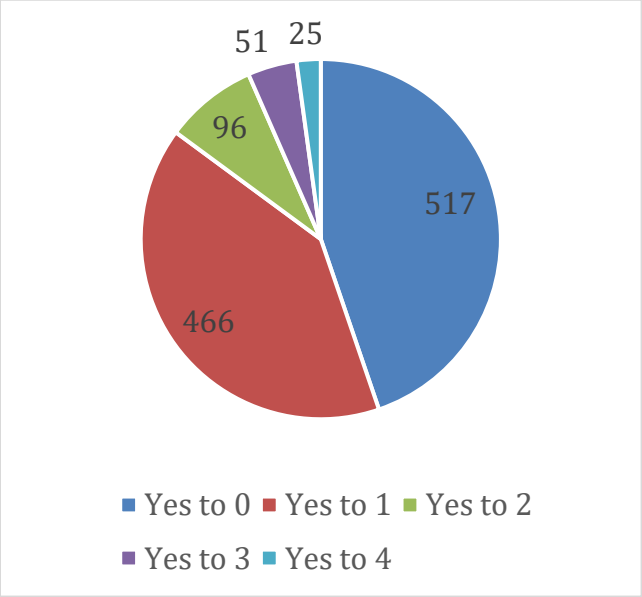


Table 11: Number of times subjects responded “Yes” to a CD assessor (n=1155)

	n (%)
Subjects that answered “Yes” to 0 CD assesors	517 (44.76)
Subjects that answered “Yes” to 1 CD assesor	466 (40.35)
Subjects that answered “Yes” to 2 CD assesors	96 (8.31)
Subjects that answered “Yes” to 3 CD assesors	51 (4.42)
Subjects that answered “Yes” to 4 CD assesors	25 (2.16)

CD=cognitive decline

Figure 2: Number of times subjects responded “Yes” to a CD assessor (n=1155)



Discussion

The purpose of this research is to further investigate the relationship between cognitive decline and geographic residence among women living in the southeastern U.S. The alternative hypothesis of this analysis was that there would be a significant association between cognitive decline and geographic residence. The results of the analysis did not reveal a significant relationship. Thus, the alternative hypothesis was not supported. There is limited evidence on the effect of geographic residence on cognitive decline in the U.S. Although little is known about the potential differences in cognitive impairment between rural and urban areas, the existing body of knowledge suggests that, in general, adults who live in rural areas tend to suffer persistent

disadvantages in cognitive functioning when compared to sociodemographically similar urban peers. The results of this analysis do not provide support for the scientific consensus. However, despite these null results, this analysis attempts to add to the body of knowledge on what is known about the relationship between cognitive decline and geographic residence, particularly among women living in the south. It is important to consider that geographic residence, by itself, is unlikely to be a cause of cognitive decline. Rather, the interaction of various factors related to geographic residence is more likely to have an effect on cognition. Where an individual lives can influence access to healthcare, access to recreational/exercise opportunities, access to educational and employment opportunities, access to support groups, social engagement, and leisure activities, and access to healthy nutrition. These factors, rather than location alone, can have an effect on the progression of cognitive impairment.

Significant associations with geographic residence were found with three variables of interest: education level, income level, and exercise. Previous research has indicated that level of educational attainment is lower among rural populations. Similarly, existing evidence suggests that rural populations are more likely to be of lower socioeconomic status, and therefore have lower incomes. Both of these statements are supported by the results of this analysis. As a result of limited access to exercise opportunities and a sedentary lifestyle, levels of daily physical activity are thought to be lower among rural populations, which was also supported by this analysis. Previous research has shown that access to healthcare coverage is usually lower among rural populations. This was not supported by the results of this analysis, as less than 2% of the sample population indicated they did not have healthcare coverage. This could be due to the fact that the sample population in this analysis included only women aged 65+, the age at which

people become eligible for Medicare. Marital status, used in this analysis to assess social support, did not have a significant association with geographic residence.

Significant associations with cognitive decline were found with four variables of interest: education level, income level, exercise, and social support. This is consistent with what is found in the literature. It has been shown that lower educational attainment, lower socioeconomic status, lower social support, and an inactive lifestyle result in a higher risk of cognitive decline. The only variable of interest that did not show a significant relationship with cognitive decline was healthcare access. Again, this is likely due to the fact that the number of women who reported not having healthcare coverage was extremely small. Available evidence suggests that reduced access to preventive services increases the risk of cognitive decline.

It is interesting that while no significant association was found between cognitive decline and geographic residence, both had significant relationships with common factors, namely education level, income level, and exercise. This could demonstrate how the interaction of various factors related to geographic residence affect cognitive decline. While an individual's geographic residence alone won't cause cognitive impairment, certain demographic and lifestyle factors are influenced by geographic area and are also related to cognitive decline. Economic and social conditions, which vary by geography, have an effect on the differences in health status between urban and rural populations. The interaction of factors related to both geographic residence and cognitive decline has a greater effect on cognition than location alone.

A subgroup analysis performed using the variables in the Cognitive Decline module provided interesting results. In this subgroup analysis, only women who reported that they had experienced worsening confusion and memory loss were analyzed. Among these women who self-reported cognitive decline, only around 50% reported discussing confusion and memory loss

with a healthcare provider. This could be indicative of a common trend of under-diagnosis of cognitive impairments. It is thought that rural patients may be more likely to remain undiagnosed when a cognitive impairment is present (Abner, 2015). The higher rates of multimorbidity among rural patients may leave rural clinicians with less time to assess patients for emerging cognitive disfunction (Abner, 2015). The other variables in the module, which ask about the involvement of cognitive decline in giving up day-to-day household activities, needing assistance with day-to-day activities, and interfering with work and social life, were each only selected around 10% of the time. It was then assessed how many times a subject who reported experiencing cognitive decline subsequently responded "Yes" to the other cognitive decline assessors. Around 44% of subjects did not answer "Yes" to any of the other cognitive decline assessors, and around 40% answered "Yes" to only one of the assessors. Around 2% of respondents answered "Yes" to all 4 of the subsequent cognitive decline assessors, which would indicate significant impairments due to cognitive disfunction.

Implications

Despite the null results found from this analysis, it is important that further research be done to explore the relationship between geographic residence and cognitive decline. While the mechanisms of the association between cognitive decline and geographic location remains unclear, rural residence has been established as a predictor of various diseases and conditions, and available evidence points to rural residence being linked to poorer cognitive functioning in older adults. The documented persistence of health disadvantages among rural adults relative to similar urban counterparts reinforces the need for investment in rural health care and long-term services. Future studies should aim to identify disparate cognitive health outcomes to determine

what factors affect cognitive functioning, and whether these factors differ among urban and rural residents. Identifying regional patterns in the contribution of modifiable risk factors to cognitive decline can lead to geographically concentrated prevention and intervention efforts (Wadley, 2011). These efforts are particularly important for the individuals who are most vulnerable to the development of cognitive impairment.

This analysis found significant relationships between geographic residence and education level, income level, and exercise. Results also showed significant relationships between cognitive decline and education level, income level, exercise, and social support. There are common factors here that are related to both geographic residence and cognitive decline. These are modifiable risk factors that deserve attention. Lower educational attainment, lower socioeconomic status, and a sedentary lifestyle are thought to be precursors to cognitive decline. It is important that future policies and interventions focus on closing the gap between urban and rural areas in terms of quality of education and educational opportunities. Similarly, interventions aimed at increasing physical activity levels in rural areas is an important step in reducing health disparities among rural residents. To improve health outcomes in rural populations, it is necessary to address the social determinants of health across the life course.

Limitations

One limitation to this study is the nature of the survey itself. The BRFSS is a cross-sectional, self-reported survey. Thus, it is subject to biases, such as social desirability bias and recall bias. These biases can influence what participants share with the interviewer. Additionally, the BRFSS is a telephone survey. This means participants are limited to those with a landline or cell phone. Although the BRFSS attempts to account for non-coverage and non-response by

including weights for certain variables, exclusively using telephones to access survey participants can reduce representation in the data. In particular, this could reduce representation in rural areas, where access to telephones or cell service is often reduced. Due to this limitation, the sample size of rural residents in this study was much smaller than that of urban residents. After filtering the dataset to include only women aged 65+ who lived in a southeastern state, 7,957 were from urban counties and only 1,879 were from rural counties. Small respondent sample sizes may not be truly indicative of the rates of cognitive decline analyzed in this study. It is possible that, with a larger respondent sample size, a significant relationship between cognitive decline and geographic residence might have been observed.

Another limitation to this study could be the extent to which certain variables actually measured what they were intended to measure. For example, the healthcare access variable HLTHPLN1 asks an individual if they have any form of healthcare coverage. Having "any form of healthcare coverage" does not necessarily mean having access to the services that monitor, diagnose, and treat cognitive decline. Similarly, the social support variable, assessed in this study by the marital status variable MARITAL, may be limited in the extent to which it measures social support. The presence or absence of a spouse, while an important component of social support, does not take into account an individual's family, friends, or social groups.

Conclusions

Cognitive decline is both a devastating disease and a costly healthcare burden. With an increasingly aging population, this is an issue that deserves further attention. The aims of this study are to increase the body of knowledge on what is known about the relationship between cognitive decline and geographic residence. Despite the null results of this analysis, the

association between cognitive decline and geographic residence is still an area of research that deserves further study. Available evidence that suggests rural residents have higher rates of comorbidities and conditions that are precursors to cognitive decline, coupled with evidence that rural populations suffer disadvantages in cognitive functioning compared to their urban counterparts, indicate that this is an area worthy of further investigation. Addressing the root causes in health disparities between urban and rural populations is an important first step in recognizing what social determinants of health are contributing to poorer health outcomes among rural residents. Understanding the social determinants of health, and particularly of cognitive health, and how these factors affect urban and rural populations differently, is an important step in improving health outcomes and promoting healthier aging.

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