Examining the association between diabetes and subjective cognitive decline in Georgia: a behavioral risk factor surveillance system (BRFSS) Study

Sterling Campbell, MPH, and Usha Kundu, MD
University of West Florida

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Abstract

Diabetes is strongly associated with various complications, including cognitive decline. Diabetic complications are related to structural and functional changes in the brain. This study aims to examine the association between diabetes and cognitive decline. Data was collected from the 2021 Behavioral Risk Factor Surveillance System for the state of Georgia. The study involved 4,616 participants who reported experiencing cognitive decline. A chi-square test was used to understand the relationship between diabetes, age group, race, and sex. A logistic regression was used to understand the relationship between age group, race, sex, and diabetes with cognitive decline. Overall, the findings showed that individuals with diabetes were more likely to experience cognitive decline within the past 12 months (OR: 1.463, CI: 1.212 – 1.765, $p < .0001$). Individuals who were 65 years or older were also more likely to report experiencing cognitive decline within the past 12 months (OR: 1.281, CI: 1.074 – 1.527, $p = .0059$).

Introduction

According to the 2020 National Diabetes Statistics Report published by the Centers for Disease Control and Prevention (CDC), 34.2 million people in the United States had diabetes [1]. Diabetes is a lifelong chronic disease in which the pancreas does not produce enough insulin hormone (Type 1 Diabetes), or the body does not use the insulin hormone properly (Type 2 Diabetes). Both types of diabetes affect how the body turns food into energy. Usually, cells in the body access the energy stored in glucose, a form of sugar created from the digestion of food, through the hormone insulin. Insulin moves glucose out of the bloodstream and into cells throughout the body. The cells then use the glucose for energy while storing the excess in the liver, muscles, and fatty tissues [2].

Studies have shown that diabetes may be a risk factor for developing multiple subtypes of dementia and mild cognitive decline. Researchers have yet to understand precisely how cognitive decline and diabetes are connected, but they know that high blood sugar or insulin can harm the brain in several ways [3]. Diabetes raises the risk of heart disease and stroke, both of which hurt the heart and blood vessels, causing damaged blood vessels in the brain that may contribute to cognitive decline. High glucose levels (blood sugar) cause inflammation within the body, which may cause damage to the brain cells and the brain depending on many different chemical factors. An imbalance among the chemical components of the brain may trigger cognitive decline [4].

Cognitive function serves a critical role in everyday behavior and social behavior. Researchers define cognitive decline as the gradual deterioration of mental faculties due to a neurological and psychological disturbance, with individuals experiencing varying symptoms including memory lapses, poor judgment, lack of focus, volatile behavior, and general confusion. Many cognitive issues stem from environmental circumstances, genetic traits, and hormonal changes, with hormonal changes affecting the neuronal network and mechanisms of cognitive function [4].

The Alzheimer's Association has found that individuals with diabetes for less than ten years had deficits in memory function associated with the brain's hippocampus region. Individuals with diabetes have smaller hippocampal sizes than people without diabetes. The reduction in hippocampal size is strongly correlated to hemoglobin A1C (HbA1C), suggesting that HbA1C levels may indicate hippocampal dysfunction or the onset of memory loss [4].

Multiple studies have examined the relationship between hormonal effects on the brain and cognitive functions. Hormonal changes may affect the neuronal network and mechanisms of cognitive function [5-8]. Furthermore, cognitive function does not rely on a specific brain region but on the neuronal network interactions that determine them. Thus, it is worthwhile to know the neural mecha-

nisms behind cognitive functions that are affected by hormones [2]. Before being diagnosed with Type 2 diabetes, individuals typically experience a period in which they are pre-diabetic. Prediabetes is a condition where blood sugar levels are higher than normal but not high enough to be diagnosed with Type 2 diabetes, meaning these individuals have a higher risk of developing Type 2 diabetes.

A study conducted by the United Kingdom Biobank found that individuals with prediabetes, with higher-than-normal blood sugar levels, may have an increased risk of cognitive decline and vascular dementia [5]. Although the authors performed a cross-sectional and longitudinal analysis, a subpopulation of participants (4%) participated in follow-up cognition testing. One of the cognitive tests, the visual memory test, did not have good reliability ($r = 0.16$). Thus, selection bias may have taken place in this United Kingdom study [5].

An important limitation of this planned study is that the cross-sectional data pulled from the 2021 Behavioral Risk Factor Surveillance System survey makes it difficult to establish a temporal link between the exposure and the outcome due to both being examined at the same time. The second limitation is self-reported data on cognitive decline that, like any self-reported measurements, are also prone to self-reporting bias [4]. Social desirability, recall period, sampling approach, or selective recall are significant factors resulting in self-reporting bias [4].

Despite these limitations, the current study will fill the gap in our knowledge of the relationship between diabetes and cognitive decline in the United States. The primary goal of this study is to determine if there is an association among individuals with diabetes experiencing cognitive decline.

Methods

Study Design

The 2021 Behavioral Risk Factor Surveillance System (BRFSS) survey dataset was used to assess cognitive decline among individuals diagnosed with diabetes. The BRFSS is a national, cross-sectional, health-related telephone survey that state health departments use to conduct monthly surveys over landline and cellular telephones on health-related risk behaviors, chronic health conditions, and preventive care services. The BRFSS questionnaire was developed in collaboration with the CDC and public health departments in each state, the District of Columbia, Puerto Rico, and the United States Virgin Islands.

The BRFSS questionnaire consists of an annual standard core, a biannual rotating core, optional modules, and state-added questions. Standard core questions are included each year and must be asked by all states. Rotating core questions are asked by all states every other year. Optional modules are a set of standardized questions on various topics that each state may include in its questionnaire. Once selected, a module must be used in its entirety and asked of all eligible respondents.

Cognitive decline was measured by asking participants in the survey if they had experienced confusion or memory loss that was happening more often or getting worse within the past 12 months. The categories for answering this question are yes, no, don't know, or refused.

Selection of Participants

Diabetes was formatted in the original BRFSS survey with several possible responses: yes, yes – during pregnancy, no, no – prediabetic or borderline diabetes, don't know, or refused. Due to the wide variety of answer choices in the original BRFSS, the data was re-coded into yes or no categories for this study. Survey participants who answered yes and yes – during pregnancy were placed in the yes category, and all other answers were placed in the no category.

After the recategorization of the answer choices in the diabetes variable, there were a total of 4,616 participants that participated in the cognitive decline portion of the survey in Georgia. Of those participants, 486 (44.83%) males and 598 (55.17%) females had diabetes.

Statistical Analysis

SAS Studio 9.4 was used to compute the descriptive analysis. A chi-square analysis was used to understand the bivariate relationship between diabetes, cognitive decline, race, and the 65-year age group. A logistic regression was conducted to understand the relationship between diabetes, cognitive decline, race, and age group.

Results

Descriptive Statistics

The total number of respondents who participated in the study was 4,616. Of the participants who reported having diabetes, 17.8% (n=193) reported experiencing cognitive decline within the past 12 months, and of the participants

who did not report having diabetes, 12.46% (n=440) experienced cognitive decline within the past 12 months (Table 1).

Of the 603 participants who reported experiencing cognitive decline, females represented about 56% (n=339), and a majority belonged to the White racial group (n=402). For this survey, the age of participants was arranged into two different age groups: the 18 to 64 years of age group, or the 65 years or older age group. 56.52% (n=2,609) of the participants were in the 65 years or older group range.

Table 1: *Bivariate analysis of individuals with cognitive decline*
Created by author using data from the 2021 BRFSS survey for Georgia

	Cognitive Decline N = 4,616	
	Yes	No
	633 (13.71%)	3,983 (87.14%)
Sex		
Male	279 (14.97%)	1,585 (85.03%)
Female	354 (12.86%)	2,398 (87.14%)
X^2=4.1287; p = .0422		
Race		
White	421 (13.49%)	2,700 (86.51%)
African American	162 (14.2%)	979 (85.8%)
Other	37 (17.54%)	174 (82.46%)
Hispanic	13 (9.09%)	130 (90.91%)
X^2 = 5.6637; p = .1292		
Age Group (years)		
18 – 64 years	240 (11.96%)	1,767 (88.04%)
65+ years	393 (15.06%)	2,216 (84.94%)
X^2 = 9.3384; p =.0022		
Diabetes		
Yes	193 (17.8%)	891 (82.20%)
No	440 (15.06%)	3,092 (87.54%)
X^2 = 19.0523; p<.0001		

Predictors of Cognitive Decline

A logistic regression model was performed to predict the event of cognitive decline. A test of the full model compared with a constant-only or null model was statistically significant (X2(6) = 35.24; p <.0001). The lack of fit test was insignificant, and 86.3% of the cases were correctly classified, indicating that the overall model fit was good.

There was no evidence of multicollinearity among the predictor variables, and the dependent variable had an acceptable split between individuals who did not experience cognitive decline (86.3%) and those who did experience cognitive decline (13.7%).

As shown in Table 2, age and diabetes were the only two significant predictors of cognitive decline. Individuals who had diabetes were 1.463 times more likely to report experiencing cognitive decline within the past 12 months, controlling for sex, age group, and race (AOR = 1.463, CI: 1.212 – 1.765, p <.0001). Individuals who were 65 years or older, were 1.281 times more likely to report experiencing cognitive decline than those 65 years or younger, controlling for sex, race, and diabetes (AOR = 1.281, CI: 1.074 – 1.527, p =.0059).

Table 2: *Logistic Regression Model for Cognitive Decline*
Created by author using data from the 2021 BRFSS survey for Georgia

	aOR	SE	95% CI	p-value
Sex				
Male (ref)	1	-	-	-
Female	0.845	0.874	0.712 – 1.003	0.0538
Race				
White (ref)	1	-	-	-
African American	1.057	0.1015	0.866 – 1.289	0.5867
Other	1.398	0.1904	0.962 – 2.030	0.0787
Hispanic	0.683	0.2980	0.381 – 1.225	0.2012
Age Group (years)				
18 – 64 years (ref)	1	-	-	-
65+ years	1.281	0.0898	1.074 – 1.527	0.0059
Diabetes				
No (ref)	1	-	-	-
Yes	1.463	0.0958	1.212 – 1.765	<.0001

aOR*: adjusted Odds Ratio

Discussion

The findings suggest that an individual's age and diabetes are important considerations when experiencing cognitive decline. In general, most of the participants in the survey self-reported that they did not experience any cognitive decline within the past 12 months. More than half of the participants in this study were female. Compared with males, women were less likely to report experiencing any signs of cognitive decline within the past 12 months.

A chi-square test revealed that there is an association between individuals with diabetes and those experiencing cognitive decline within the past 12 months (Table 1). A logistic regression test revealed that individuals with diabetes had an odds ratio of 1.463, indicating that the chance of individuals with diabetes experiencing cognitive decline within the past 12 months is 1.463 times more likely compared to individuals without diabetes. Among individuals with diabetes, females were 0.845 times less likely to experience cognitive decline compared to males.

When further broken down between racial groups, individuals of Other racial groups (Asian, Native, Pacific Islander, Multi-Racial) and African American individuals were 1.398 times and 1.057 times more likely to experience cognitive decline when compared to the White reference racial group, respectively. A previous study on the difference in cognitive function among older adults belonging to different racial groups supports this finding, suggesting that a person's race may have some effect on their cognitive function as they get older [9]. This can be attributed to different social and cultural factors that accumulate through the life of those racial groups that may play an important role in cognitive aging of the brain [9].

Prior cross-sectional and longitudinal studies have focused on epidemiological evidence that suggests diabetes is associated with cognitive impairment [10-12]. It is unclear if there is a specific pattern for impaired function in terms of the affected cognitive domains [13]. However, most cohort studies conducted in developed countries consisted of patients 60 years or older and focused on cognitive diagnoses of conditions such as mild cognitive impairment and dementia [14-16].

Strengths and Limitations

A strength of this study was that data was collected from a large statewide survey where participants were selected through randomization. Randomization ensured that the survey data had a high level of generalizability in representing a large population.

The study had several limitations. First, majority of participants were 65 years of age or older. Since most of the participants fell within this age range, it is difficult to

determine if there is a true association between cognitive decline and diabetes, or if the cognitive decline that the participants experienced is due to the natural aging process. A second limitation of the study was that the participants self-reported their experience with cognitive decline. Respondents may not feel comfortable providing answers that present themselves in an unfavorable manner. Some respondents may exaggerate or underreport their answers based on what they may think the more socially acceptable answer is, rather than being truthful. The last limitation is that this study did not consider other possible contributing factors to cognitive decline, such as medication, family history, and proper cognitive decline assessments.

Conclusion

The overall findings of this study suggest that there is an association between diabetes and cognitive decline, aligning with results from several previous studies. However, further research should be conducted to examine more areas of direct and indirect influences of diabetes on cognitive decline, such as medication, medical history, and cognitive decline assessment tools.

Author Contact Information

Sterling Campbell: sterlingocampbell@gmail.com

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