

Diabetes Mellitus and Stroke – A cross Sectional Study of 2.5 Million Adults in the United States

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ABSTRACT

Objectives: The main purpose of this work is to study diabetes mellitus and stroke in the United States during the years 2007-2017 and to find not only statistically significant predictors for diabetes, but also a possible association between diabetes and stroke.

Methods: Chi-square test and One-way analysis of variance (ANOVA) were the statistical methods used to derive the results of this work in order to check the statistical significance of diabetes mellitus in relation to patients' socioeconomic factors. In addition, a multivariate logistic regression analysis was used to obtain odds ratio and find statistically significant prognostic factors for both diabetes and stroke.

Results: According to multiple logistic regression analysis, the risk for diabetes mellitus is four times higher in widowed men and two times higher in unemployed male subjects who had previously worked. In addition, marital status and employment have been shown to be prognostic risks for stroke.

Conclusions: The results describe for the first time the importance of deprivation (of work and partner) as a primary prognostic risk factor for diabetes. Moreover, the same factor was proved to be the primary prognostic risk factor for both stroke and diabetes, which implies a nexus between diabetes mellitus and stroke.

Keywords: prognostic factors, diabetes mellitus, stroke, socioeconomic factors.

INTRODUCTION

The incidence of diabetes mellitus is rapidly increasing worldwide. More specifically, diabetes mellitus ranks as the ninth leading cause of death globally, with an estimated 415 million new cases in 2015 (1). According to the International Diabetes Federation (IDF), 1 in 11 adults aged 20–79 had diabetes mellitus in 2015, 90% of whom having type 2 diabetes mellitus (2). This is due to population aging and growth, but also to changes in prevalence of the main risk factors for diabetes, several of which are associated with socioeconomic development (3-5). Low socioeconomic status is asso-

ciated with increased incidence and mortality from type 1 diabetes or insulin-dependent diabetes mellitus (6), mainly due to non-attendance to intensive insulin regimen (7), non-monitoring blood glucose levels (8), and complications arising from diabetes (9, 10). On the other hand, low socioeconomic status of patients with type 2 diabetes is associated with cardiovascular complications, which are the leading cause of morbidity and mortality from this type of diabetes (4). Moreover, low education is associated with an increased prevalence of type 2 diabetes, while retired people and persons working in white collar jobs were reported to have a higher risk of this type of diabetes (11).

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Prior studies have found an increased risk of stroke in patients with diabetes (12-18). More specifically, it has been found that the risk for stroke posed by diabetes mellitus was about four times higher (19). There are several underlying mechanisms wherein diabetes leads to stroke, including vascular endothelial dysfunction, increased early-age arterial stiffness, systemic inflammation and thickening of the capillary basal membrane (20).

This work studies diabetes mellitus and stroke in the United States (US) between the years 2007 and 2017 in order to find statistically significant predictors for diabetes and a possible link between diabetes and stroke. □

MATERIALS AND METHODS

The data used in this work come from the National Health Interview Survey (NHIS) dataset and cover the period 2007–2017. The target population for NHIS is the civilian non-institutionalized population of the US. NHIS data are collected through personal household interviews. The main objective of NHIS is to monitor the health of the US population through the collection and analysis of data on a broad range of health topics. The number of examined adult patients with diabetes mellitus was 232,653. Moreover, in the geographic classification of the US population, states are grouped into four regions used by the US Census Bureau:

- Northeast: Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania.

- Midwest: Ohio, Illinois, Indiana, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Kansas, and Nebraska.

- South: Delaware, Maryland, District of Columbia, West Virginia, Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Oklahoma, Arkansas, and Texas.

- West: Washington, Oregon, California, Nevada, New Mexico, Arizona, Idaho, Utah, Colorado, Montana, Wyoming, Alaska, and Hawaii.

Statistical analysis

To extract the results of this work, two statistical methods – Chi-square test for categorical and One-way analysis of variance (ANOVA) for con-

tinues variables – were used in order to check the statistical significance of diabetes in relation to patients' socioeconomic characteristics such as age, race, origin, education, family income, poverty status, health insurance coverage, place of residence and region. Factors that determine the prevalence of diabetes were assessed by using multiple logistic regression analysis. To assess the predictors of diabetes, we used data from patients with a new diagnosis of diabetes compared to a matched cohort of patients without diabetes. More specifically, the control group included target population without diabetes with the same socioeconomic characteristics as the patient group. Data were weighted prior to analysis. Predictors were represented using odds ratio (OR) and 95% confidence intervals, and $P < 0.05$ was considered to be statistically significant. The study was carried out using IBMSPSS 25 software package for Windows. □

RESULTS

To check the zero hypotheses that the mean of diabetes mellitus patients in the US did not differ according to their socioeconomic characteristics, the Chi-square test and One-way analysis of variance (ANOVA) were used. As shown in Table 1, there is a statistically significant difference in the number of diabetes patients in relation to both gender and age, the disease occurring mainly in men (50.1%) aged 45-64 (46.5%) and having the greatest frequency in white race people (78.9%), not Hispanic or Latino (45.2%) persons. The following socioeconomic characteristics were found to be statistically significant: “High school diploma” for education (30.4%), “Not employed

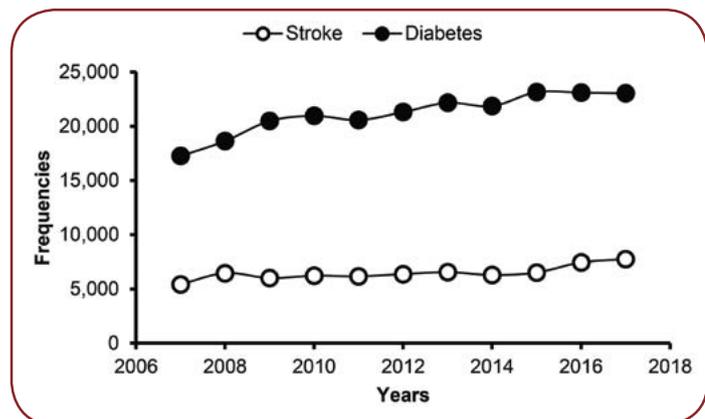


FIGURE 1. Trends in diabetes mellitus and stroke during 2007-2017 in the United States

Socioeconomic characteristics of diabetes patients: United States, 2007-2017		Number of patients	Percentages	p- value
Gender	Male	116.585	50.1%	0.000
	Female	116.068	49.9%	
Age	18-44	30.921	13.3%	0.000
	45-64	108.197	46.5%	
	65-74	55.007	23.6%	
	75 and over	38.528	16.6%	
Race	White	177.540	78.9%	0.000
	Black or African American	36.635	16.3%	
	Asian	10.756	4.8%	
Origin	Hispanic or Latino	35.431	8.1%	0.000
	Mexican or Mexican American	22.577	5.2%	
	Not Hispanic or Latino	197.223	45.2%	
	White, single race	145.016	33.3%	
	Black or African American, single race	35.672	8.2%	
	Less than a high school diploma	50.578	22.2%	
Education	High school diploma	69.401	30.4%	0.000
	Some college	63.865	28.0%	
	Bachelor's degree or higher	44.360	19.4%	
	Employment			
	Employed	48.947	26.8%	0.000
	Full-time	38.491	21.1%	
	Part-time	9.487	5.2%	
	Not employed but has worked previously	78.013	42.7%	
	Not employed and has never worked	7.679	4.2%	
Family income	Less than \$35,000	93.529	28.4%	0.000
	\$35,000 or more	117.762	35.8%	
	\$35,000-\$49,999	31.584	9.6%	
	\$50,000-\$74,999	35.696	10.8%	
	\$75,000-\$99,999	20.391	6.2%	
	\$100,000 or more	30.091	9.1%	
Poverty status	Poor	33.302	15.8%	0.000
	Near poor	47.500	22.5%	
	Not poor	129.928	61.7%	
Health insurance coverage				0.000
Under 65:	Private	79.429	57.2%	
	Medicaid	25.825	18.6%	
	Other coverage	14.330	10.3%	
65 and over:	Uninsured	19.213	13.8%	0.000
	Private	42.008	49.1%	
	Medicare and Medicaid	9.836	11.5%	
	Medicare only	25.757	30.1%	
	Other coverage	8.020	9.4%	
Marital status	Married	131.713	56.7%	0.000
	Widowed	30.116	13.0%	
	Divorced or separated	37.077	16.0%	
	Never married	23.951	10.3%	
	Living with a partner	9.480	4.1%	
Place of residence (MSA=Metropolitan statistical area)	Large MSA (population size 1 million or more)	113.859	48.9%	0.000
	Small MSA (less than 1 million)	72.879	31.3%	
	Not in MSA	45.917	19.7%	
Region	Northeast	37.886	16.3%	0.000
	Midwest	53.948	23.2%	
	South	93.073	40.0%	

TABLE 1. Chi-square and One-way Anova test

Socioeconomic characteristics of diabetes patients: United States, 2007-2017		Patients	Controls	Odds ratio (95%CI)	p-value
Gender				1.08	0.000
	Male	116.585	1.129.820	(1.07-1.09)	
	Female	116.068	1.220.546	1.0 (ref)	0.000
Age				0.1	
	18-44	30.921	1.197.048	(0.1-0.11)	
	45-64	108.197	782.881	0.58 (0.57-0.58)	
	65-74	55.007	208.401	1.1 (1.0-1.1)	
	75 and over	38.528	161.982	1.0 (ref)	0.000
Race				1.1 (1.0-1.1)	
	White	177.540	1.885.141		
	Black or African American	36.635	275.605	1.6 (1.5-1.6)	
	Asian	10.756	127.908	1.0 (ref)	0.000
Origin				0.76	
	Hispanic or Latino	35.431	344.351	(0.75-0.77)	
	Mexican or Mexican American	22.577	210.554	0.79 (0.78-0.80)	
	Not Hispanic or Latino	197.223	2.005.959	0.72 (0.71-0.73)	
	White single race	145.016	1.573.365	0.68 (0.67-0.69)	
	Black or African American, single race	35.672	263.960	1.0 (ref)	0.000
Education				3.0 (2.9-3.0)	
	Less than a high school diploma	50.578	254.393		
	High school diploma	69.401	511.964	2.1 (2.0-2.1)	
	Some college	63.865	578.096	1.6 (1.6-1.7)	
	Bachelor's degree or higher	44.360	671.194	1.0 (ref)	0.000
Employment				0.6 (0.5-0.6)	
	Employed	48.947	838.047		
	Full-time	38.491	678.889	0.5 (0.5-0.6)	
	Part-time	9.487	147.364	0.6 (0.5-0.6)	
	Not employed but has worked previously	78.013	399.694	1.9 (1.8-1.9)	
	Not employed and has never worked	7.679	72.907	1.0 (ref)	0.000
Family income				2.4 (2.4-2.5)	
	Less than \$35,000	93.529	675.491		
	\$35,000 or more	117.762	1.478.646	1.4 (1.3-1.4)	
	\$35,000-\$49,999	31.584	289.089	1.9 (1.8-1.9)	
	\$50,000-\$74,999	35.696	387.456	1.6 (1.5-1.6)	
	\$75,000-\$99,999	20.391	273.347	1.3 (1.2-1.3)	
	\$100,000 or more	30.091	528.753	1.0 (ref)	0.000
Poverty status				1.42	
	Poor	33.302	274.682	(1.41-1.44)	
	Near poor	47.500	366.473	1.52 (1.50-1.54)	
	Not poor	129.928	1.530.006	1.0 (ref)	0.000
Health insurance coverage				1.1 (1.0-1.1)	
Under 65:	Private	79.429	1.333.531		
	Medicaid	25.825	200.069	2.2 (2.3-2.4)	
	Other coverage	14.330	78.740	3.3 (3.3-3.4)	
	Uninsured	19.213	356.982	1.0 (ref)	0.000
65 and over:	Private	42.008	188.747	0.7 (0.6-0.7)	
	Medicare and Medicaid	9.836	21.352	1.5 (1.4-1.5)	
	Medicare only	25.757	101.234	0.8 (0.7-0.8)	
	Other coverage	8.020	25.771	1.0 (ref)	

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Marital status	Married	131.713	1.252.069	1.9 (1.9-2.0)	0.000
	Widowed	30.116	124.658	4.5 (4.3-4.6)	
	Divorced or separated	37.077	254.578	2.7 (2.6-2.8)	
	Never married	23.951	538.508	0.82 (0.80-0.84)	
Place of residence	Living with a partner	9.480	176.399	1.0 (ref)	0.000
	Large MSA (population size 1 million or more)	113.859	1.269.433	0.7 (0.6-0.7)	
(MSA=Metropolitan statistical area)	Small MSA (less than 1 million)	72.879	730.198	0.8 (0.7-0.8)	0.000
	Not in MSA	45.917	350.680	1.0 (ref)	
Region	Northeast	37.886	418.980	1.03 (1.01-1.04)	0.000
	Midwest	53.948	540.659	1.14 (1.12-1.15)	
	South	93.073	844.839	1.25 (1.24-1.27)	
	West	47.746	545.833	1.0 (ref)	

TABLE 2. Statistically significant predictors of diabetes in the US using multivariate logistic regression

but has previously worked” for employment status (42.7%), “not poor” for poverty status (61.7%), the range of \$35,000 or more for family income (35.8%), private health insurance in age groups under 65 (57.2%) and 65 and over (49.1%) for health insurance coverage, “married” for the marital status (56.7%), “South” for the region with the highest occurrence of diabetes (40%) and a population size of one million or more (48.9%).

Table 2 shows the multiple logistic regression analysis and odds ratios in order to find the predictors for the occurrence of diabetes mellitus.

As shown in Table 2, all prognostic factors are statistically significant ($p < 0.05$). According to multiple logistic regression, the risk of diabetes is significantly higher in men (OR 1.08), age group of 65-74 (OR 1.1), Black or African American race (OR 1.6) and “less than a high school diploma” education status (OR 3.0). Moreover, unemployed people who have previously worked had two times the risk of developing diabetes (OR 1.9). In addition, the risk of diabetes is significantly higher with “less than \$35,000” family income (OR 2.4), “near poor” poverty status (OR 1.52), and health insurance coverage – “other coverage” in the age group under 65 (OR 3.3) and “Medicare and Medicaid” in the age group of 65 and over (OR 1.5). Widowed adults have higher risk of developing diabetes (OR 4.5). Finally, the risk of diabetes is significantly higher with “South” region (OR 1.25) and “not in Metropolitan statistical area” place of residence (OR 1.0).

Figure 1 shows the trends in diabetes and stroke between the years 2007 and 2017 in the United States. The incidence of both diseases continues to increase during this period.

In order to find a possible link between diabetes and stroke, a multivariate logistic regression analysis was used for stroke patients. As can be seen from Table 3, marital status plays a crucial role in the incidence of stroke. Widowed adults have the highest risk for the occurrence of stroke (OR 6.0). Family income and education are also prognostic risks for stroke; more specifically, “less than \$35,000” family income (OR 4.0) and “less than a high school diploma” education status (OR 3.7) have a four times higher risk for stroke. Finally, unemployed adults who have previously worked have two times the risk of stroke (OR 1.9). Moreover, the risk of stroke is significantly higher with female gender (OR 1.0), age over 75 (OR 1.0), Black or African American race (OR 2.4), poverty status (“near poor”) (OR 2.0), health insurance coverage (“other coverage” under 65 years old and “Medicare and Medicaid” over 65) (OR 5.6 and 1.3, respectively), region (“South”) (OR 1.32) and place of residence (“not in Metropolitan statistical area”) (OR 1.0). □

DISCUSSION

Increasing attention should be given to prognostic factors that had the highest odds ratio. It is noted that marital status is the socioeconomic

Socioeconomic characteristics of stroke patients: United States, 2007-2017		Patients	Controls	Odds ratio (95% CI)	p value
Gender					0.000
	Male	33.439	1.212.966	0.94 (0.93-0.96)	
	Female	37.788	2.512.279	1.0 (ref)	
Age					0.000
	18-44	6.670	1.221.299	0.0 (0.04-0.05)	
	45-64	25.876	865.202	0.26 (0.25-0.26)	
	65-74	16.350	247.058	0.57 (0.56-0.58)	
	75 and over	20.650	179.860	1.0 (ref)	
Race					0.000
	White	55.820	2.006.861	1.8 (1.7-1.9)	
	Black or African American	11.216	301.024	2.4 (2.3-2.5)	
	Asian	2.059	136.605	1.0 (ref)	
Origin					0.000
	Hispanic or Latino	7.046	372.736	0.49 (0.48-0.5)	
	Mexican or Mexican American	4.141	228.990	0.47 (0.45-0.49)	
	Not Hispanic or Latino	64.183	2.138.999	0.78 (0.77-0.8)	
	White single race	49.431	1.668.950	0.77 (0.76-0.79)	
	Black or African American, single race	10.980	288.652	1.0 (ref)	
Education					0.000
	Less than a high school diploma	17.321	287.650	3.7 (3.6-3.8)	
	High school diploma	21.698	559.667	2.4 (2.3-2.5)	
	Some college	18.229	623.732	1.8 (1.7-1.9)	
	Bachelor's degree or higher	11.281	704.273	1.0 (ref)	
Employment					0.000
	Employed	8.092	878.902	0.26 (0.25-0.27)	
	Full-time	5.809	711.571	0.23 (0.22-0.24)	
	Part-time	2.048	154.803	0.38 (0.36-0.4)	
	Not employed but has worked previously	30.099	447.608	1.9 (1.8-2.0)	
	Not employed and has never worked	2.703	77.883	1.0 (ref)	
Family income					0.000
	Less than \$35,000	35.167	733.853	4.0 (3.9-4.1)	
	\$35,000 or more	29.159	1.567.249	1.58 (1.54-1.6)	
	\$35,000-\$49,999	9.434	311.239	2.6 (2.5-2.7)	
	\$50,000-\$74,999	8.885	414.267	1.8 (1.7-1.9)	
	\$75,000-\$99,999	4.352	289.386	1.28 (1.23-1.33)	
	\$100,000 or more	6.487	552.357	1.0 (ref)	
Poverty status					0.000
	Poor	11.412	296.572	1.84 (1.8-1.88)	
	Near poor	17.036	396.937	2.0 (2.0-2.1)	
	Not poor	33.938	1.625.996	1.0 (ref)	
Health insurance coverage					0.000
Under 65:	Private	13.674	1.399.286	0.9 (0.8-0.9)	
	Medicaid	9.113	216.781	3.7 (3.6-3.9)	
	Other coverage	5.522	87.548	5.6 (5.4-5.9)	
	Uninsured	4.132	372.063	1.0 (ref)	
65 and over:	Private	16.903	213.852	0.62 (0.6-0.65)	
	Medicare and Medicaid	4.465	26.723	1.3 (1.2-1.4)	
	Medicare only	9.540	105.428	0.7 (0.68-0.74)	
	Other coverage	3.427	27.164	1.0 (ref)	

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Marital status	Married	34.946	1.348.836	1.5 (1.4-1.6)	0.000
	Widowed	14.517	140.257	6.0 (5.8-6.2)	
	Divorced or separated	12.491	279.164	2.6 (2.5-2.7)	
	Never married	6.068	556.391	0.6 (0.61-0.66)	
	Living with a partner	3.128	182.751	1.0 (ref)	
Place of residence (MSA=Metropolitan statistical area)	Large MSA (population size 1 million or more)	32.809	1.350.483	0.61 (0.6-0.62)	0.000
	Small MSA (less than 1 million)	21.500	781.577	0.7 (0.67-0.7)	
	Not in MSA	15.148	381.449	1.0 (ref)	
Region	Northeast	10.867	445.999	1.08 (1.05-1.1)	0.000
	Midwest	16.569	578.038	1.27 (1.24-1.3)	
	South	27.173	910.739	1.32 (1.29-1.35)	
	West	13.083	580.496	1.0 (ref)	

TABLE 3. Statistically significant predictors of stroke in the US using multivariate logistic regression

characteristic of diabetes mellitus patients with the highest risk; more specifically, it was found that widowed adults had the highest risk of developing diabetes (OR 4.5). Moreover, education plays a crucial role in developing this type of disease. Adults with “less than a high school diploma” have a three-fold increased risk of developing diabetes (OR 3.0). Finally, employment is a prognostic risk for this type of disease, as unemployed adults who have previously worked were found to have a two-fold higher risk for diabetes (OR 1.9).

It is also noteworthy that stroke patients with the highest OR had the same socioeconomic characteristics as those of diabetes mellitus patients. Deprivation of work and partner proved to be the primary prognostic risk factor for both stroke and diabetes, which implies a link between diabetes and stroke.

The importance of this study lies in the association of multiple socioeconomic variables with diabetes and stroke, which reflects the complexity and multidimensional nature of deprivation as well as the various roles of these dimensions during the course of life, which in turn reflects the longest gestation period for both diabetes and

stroke. More specifically, we found that partner and work deprivation, two determinants in the life of an adult, are rapidly increasing the risk of diabetes as well as stroke. We found that not only deprivation but also partner’s death plays a key role in the increased risk of developing these two diseases. □

CONCLUSIONS

This paper has highlighted that different socioeconomic variables were associated with different risks of diabetes mellitus, while deprivation (of work and partner) proved to be the primary prognostic risk factor for diabetes. Moreover, the same factor was shown to be the primary prognostic risk factor for stroke as for diabetes, which implies a link between diabetes and stroke. □

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflicts of interest: none declared.

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