Research Article

The differentiation of health behaviors by depression in U.S. diabetic patients

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Abstract

Background: Diabetes and depression are a growing public health concern. Several behavioral factors predispose the development of type 2 diabetes and depression, which warrants their evaluation when examining the association between depression and adverse health outcomes in type 2 diabetes.

Methods: Data were from four cycles, 2011-2018, of the National Health and Nutrition Examination Survey (NHANES). Status of depression was self-reported using the Patient Health Questionnaire while diabetes status was determined using an examination. A Rao-Scott chi-square test measured the bivariate association of depression and health behaviors (smoking status, alcohol use, physical activity, diet). Logistic regression models were used to determine effects of behavioral factors and demographics (age, gender, ethnicity, poverty, education).

Results: Of 1467 participants, more than half of respondents reported feeling tired or having little energy and trouble sleeping or sleeping too much. Prevalence of non-smokers (69.9, 95% CI: 66.4-73.5) and those with a good diet (68.4, 95% CI: 64.8-71.9) are significantly higher among participants who reported no to mild depression. Heavy alcohol drinking (81.6, 95% CI: 76.7-86.5) is more prevalent among moderate-severely depressed participants.

Conclusion: We recommend strategies be enacted to decrease depression and increase healthy behaviors to help improve the quality of life of diabetic patients.

Introduction

In the 21st century, chronic debilitating conditions like depression and diabetes are rising as major public health concerns, especially in the Western world. The Centers for Disease Control and Prevention (CDC) estimates that more than 130 million adults are living with diabetes or pre diabetes in the United States in 2022 National Diabetes Statistics Report.[1] In 2020, the National Survey on Drug Use and Health (NSDUH), 8.4% of adults suffered at least one major depressive disorder (MDD).[2] In individuals with type 2 diabetes mellitus (T2DM), depression is a frequent co-morbid condition, with the prevalence estimated to be 17.6% among them.[3] When compared to the general population, type 2 diabetes patients have two times higher prevalence of MDD, whereas type 1 diabetes patients have three times higher prevalence of MDD among them.[4] It is suggested that every one in four patients of diabetes mellitus presents with symptoms of depressive disorder.[5]

Katon et al.,[6] found in their study that a large cohort of Medicare beneficiaries with diabetes and comorbid depression was associated with 36% to 38% increased risk of all-cause mortality over a two-year period. These comorbidities have also been associated with other factors such as higher health care costs, more days of missed work, and more hospital days.[5]

Another emerging descriptive term is 'diabetes specific distress' which is defined as an emotional state causing significant emotional distress but is not enough to cause MDD.[7] Fisher et al. found in their study only 9% of patients with diabetes and depressive symptoms meet the criteria of MDD clinically, but a large proportion of rest of the patients, who were not diagnosed as having MDD, still had a high score on stress scale.[7] Results from such studies speaks for itself about the vastness of number of diabetic patients with diagnosed or undiagnosed comorbid psychological distress.

The underlying etiological relation between diabetes and depression is still not certain, but a bidirectional link has been suggested in many studies. Dooren et al. presented multiple potential mechanisms to explain the relationship in their study. According to the "psychological burden hypothesis" they stated, just knowing that one has been diagnosed with diabetes can intuitively elevate the level of stress due to burdensome self-management of the disease.[8] The theory has been underscored by the findings of another meta-analysis showing that depression is significantly higher among known cases of diabetes compared with the patients who have been diagnosed through screening.[9] Moreover, functional limitations resulting from complications of diabetes can be responsible for reduced quality of life as well as increased depressive symptoms.[10]

Since the prognosis of diabetic patients largely depends on self-care, therefore a willingness and emotional capacity to medicate and manage associated factors, the large group of people with concurrent diabetes and depressive symptoms belong to a high-risk group for uncontrolled diabetes. There is strong evidence that people with diabetes and co-morbid depression are at higher risk of poor glycemic control, reduced treatment adherence, and poor self-care.[4] Additionally, depressed patients are more vulnerable to engage in unhealthy life-styles such as heavy alcohol intake, smoking, and physical inactivity, which in terms can lead to the development of diabetes related micro- and macro-vascular complications.

Several behavioral factors, such as heavy alcohol drinking, smoking, physical inactivity, and poor diet predispose the development of type 2 diabetes and, at the same time, depression as well, which warrants their evaluation when examining the association between depression and adverse health outcomes in type 2 diabetes. Many studies have stated the necessity of further research to determine whether the increase in adverse health outcomes in diabetic patients with depression is due to potential behavioral mediators or physiologic abnormalities

such as hypothalamic-pituitary axis dysregulation. To the best of our knowledge, this is the first comprehensive epidemiologic study that looks into the potential behavioral mediators of diabetic patients with co morbid depression using a large national representative sample.

Methods

Study design and population

This current study combined four biennial cross-sectional NHANES (2011-2018) surveys which aimed to assess the health and nutritional status of Americans. The well stratified, multistage, probability sampling approach was applied to non-institutionalized U.S. population. The U.S. CDC collected data from both interviews and physical examinations according to different survey questions. This study identified 1466 individuals aged 20 to 80 years representing more than 56 million US adults who had completed interviews related to demographics, mental health-depression screening and health behaviors and physical examinations related to diabetic measures such as plasma glucose. The National Center for Health Statistics (NCHS) research Ethics Review Board (ERB) approved the study (NCHS IRB/ERB Protocol #2011-2017).

Depression assessment

In this study, the participants were interviewed in the mobile examination center (MEC) by trained interviewers using the computer assistant personal interviewing system. The degree of depression was evaluated with the Patient Health Questionnaire (PHQ-9) consists of nine symptoms. A 4-point (0 to 3) ascending Likert scale scored each symptom. Zero means the individual has not suffered the symptom at all over the past two weeks and 3 indicates that the individual suffered the symptom "nearly every day". The total score of PHQ-9 can range from 0 to 27. If a total score greater than 10 was used to indicate the individual has at least moderate depression and this cut-off point had been validated by previous studies with evidence showing a high sensitivity (88%) and specificity (88%).[11]

Diabetes

Diabetes status was defined as any participant who had at least one of four conditions: (i) a hemoglobin A_{1c} at least 6.5%, (ii) fasting plasma glucose (FPG) at least 126mg/dL, (iii) a 2-hour plasma glucose (PG) at least 200mg/dL, (iv) diagnosed with diabetes by a doctor or other health professional.

Health behaviors

These included four variables: smoking status, alcohol use, physical activity and diet. Smoking status indicates whether the participant is a current smoker or not. Alcohol consumption indicates whether the individuals drank more than 12 alcohol beverages in the past year or not. A drink means a 12 oz. beer, or a 5 oz. glass of wine or 1.5 oz of liquor. Physical activity was categorized into three intensity levels upon metabolic equivalent of task score: light, moderate and vigorous. The participants self-evaluated how healthy their diet was using a five-point Likert scale: excellent, very good, good, fair, and poor.

Demographics and socioeconomic status (SES)

Three demographic variables included age, gender and ethnicity (Mexican American, other Hispanic, White, African American and other races). Three age groups were used in this study: 20-39 years old, 40-59 years and 60 years and over. SES included family poverty status and education level. Family poverty income ratio (PIR), a ratio of poverty income to the federal poverty threshold adjusted by location and family member, was categorized into three groups: poor, near poor and non-poor. Education had three categories: less than 12 years of education, 12 years (equivalent to high school diploma), and greater than 12 years.

Statistical analysis

First, the SAS PROC SURVEYFREQ was used to weight and estimate population proportions by exploratory variables interested in this study. The bivariate association between each health behavior and depression were measured with Rao-Scott chi-square test. A series of weighted logistic regression models using SAS PROC SURVEYLOGISTIC were carried out and analyzed. Model 1 only contained lifestyle factors such as smoking status, alcohol consumption, physical activity and diet. Model 2 additionally adjusted for demographics (age, gender and ethnicity). The third model additionally adjusted for poverty status and education level, in order to assess whether the relationship between diabetes status and lifestyle remained significant after adjustment for SES. The odds ratio (OR) with 95% confidence interval (CI) were estimated. All statistical analyses were performed using the Statistical Analysis System (SAS, version 9.4, Cary NC). A p-value<0.05 was considered to indicate statistical significance.

Results

Our study analyzed four cross-sectional of NHANES survey data (2011-2018) to report the association between depressive symptoms and behavioral risk factors in diabetic patients. The NHANES dataset illustrates the overall health related information of adult U.S. population, collected from a nationally representative sample. The most unique and reliable feature of this dataset is that it combines the information from individual surveys and physical examinations. A total of 1466 participants were selected for our analyses after cleaning the data for missing values and outliers.

Table 1 listed all the survey questions and their response options used to assess the level of depression along with the frequency, weighted frequency, and 95% confidence interval pertinent to each response. More than 50% of respondents reported feeling tired or having little energy and trouble sleeping or sleeping too much. The highest percentage of participants reported not having the symptoms of thinking they would be better off dead (93.3%) and moving or speaking slowly or too fast (80.9%).

Table 2 illustrated the prevalence of depression, total and moderate-severe, according to demographic characteristics and health risk behaviors. The Rao-Scott chi-square test indicated exploratory variables: age, gender, SES status, smoking status, physical activities and diet were statistically associated with depression in diabetic patients. More specifically, both total and a high level of depression was most prevalent among 40-59 years old participants, 43.7% and 17.8% respectively. In terms of gender and ethnic background respectively, female (total- 47.1%, high level- 21.9%) and African-American (total- 49.0%, high level- 22.2%) participants were most prevalent in reporting depression according to PHQ-9 score. Participants who did not complete high school (total- 53.9%, high level- 27.1%) and had poor economic condition (total- 60.0%, high level- 31.8%) also found to have high prevalence of depression. Depressive symptoms, as a whole, were also more prevalent among current smokers (total- 56.3%, high level- 27.4%), heavy alcohol drinkers (total- 43.5%, high level- 18.6%), and those with less physically active (total- 47.8%, high level- 22.2%), and those with a poor diet (total- 52.6%, high level- 26.2%) participants.

Table 1 Percent of PHQ-9 items among U.S. diabetic patients from NHANES 2011-2018

Mental health-related quality of life questions	Frequency	Weighted frequency	Weighted Percent % (95%CI)
Q1 Have little interest in doing things			
0=Not at all	868	5749902	62.2(58.9-65.5)
1=Several days	338	2038412	22.0(19.2-24.9)
2=More than half the days	123	703552	7.6(5.9-9.3)
3=Nearly every day	137	755620	8.2(6.5-9.9)
Q2 Feeling down, depressed, or hopeless			
0=Not at all	838	5602095	60.6(57.3-63.9)
1=Several days	382	2363668	25.6(22.6-28.5)
2=More than half the days	113	597626	6.5(5.0-7.9)
3=Nearly every day	133	684097	7.4(5.8-9.0)
Q3 Trouble sleeping or sleeping too much			
0=Not at all	605	3934307	42.5(39.1-45.9)
1=Several days	397	2677588	29.0(25.8-32.1)
2=More than half the days	176	1072992	11.6(9.5-13.7)
3=Nearly every day	288	1562600	16.9(14.5-19.3)
Q4 Feeling tired or having little energy			
0=Not at all	342	2184227	23.6(20.6-26.6)
1=Several days	642	4205517	45.5(42.1-48.9)
2=More than half the days	183	1075490	11.6(9.5-13.8)
3=Nearly every day	299	1782252	19.3(16.7-21.9)
Q5 Poor appetite or overeating			
0=Not at all	878	5546448	60.0(56.7-63.3)
1=Several days	338	2250184	24.3(21.4-27.3)
2=More than half the days	117	710931	7.6(5.9-9.4)
3=Nearly every day	133	739923	8.0(6.3-9.9)
Q6 Feeling bad about yourself			
0=Not at all	1050	6776971	73.3(70.4-76.2)
1=Several days	240	1491553	16.1(13.7-18.6)
2=More than half the days	76	463965	5.0(3.5-6.5)
3=Nearly every day	100	514996	5.57(4.33-6.80)
Q7 Troubling concentrating on things			
0=Not at all	1048	6676784	72.2(69.1-75.2)
1=Several days	243	1535131	16.6(14.0-19.2)
2=More than half the days	76	480013	5.2(3.6-6.8)
3=Nearly every day	99	555558	6.0(4.5-7.5)
Q8 Moving or speaking slowly or too fast			
0=Not at all	1167	7476779	80.9(78.2-83.5)
1=Several days	177	1167167	12.6(10.3-15.0)
2=More than half the days	65	359579	3.9(2.7-5.1)
3=Nearly every day	57	243962	2.6(1.7-3.6)
Q9 Thought you would be better off dead			
0=Not at all	1340	8631258	93.3(91.9-94.8)
1=Several days	79	405328	4.4(3.2-5.6)
2=More than half the days	23	116967	1.3(0.6-1.9)
3=Nearly every day	24	93934	1.0(0.6-1.5)

Table 2 Prevalence of depression by exploratory variables

Explanatory variables (n)	Total depression (n=336) % (95%CI)	P value	Moderate-severe (136) % (95%CI)	P value
Overall (1466	42.5(39.2-45.9)		18.3(15.8-20.6)	
Age (years)		0.0018		0.0007
20-39 (99)	42.7(27.6,57.8)		16.7(6.4-27.1)	
40-59(485)	43.6(35.4-51.9)		17.8(11.8-23.7)	
60 and over (882)	33.8(28.0-39.7)		12.2(8.7-15.8)	
Gender		0.0126		0.004
Male (818)	38.5(33.8-43.1)		14.8(11.7-18.0)	
Female(648)	47.1(42.2-52.0)		21.9(18.2-25.6)	
Race		0.0554		0.3663
White(680)	39.7(35.3-44.2)		17.3(14.1-20.4)	
Black(376)	49.0(43.5-54.6)		22.2(17.5-27.0)	
Hispanic(342)	48.6(42.1-55.1)		19.6(14.7-24.5)	
Other race(68)	48.2(30.7-65.7)		16.1(6.5-25.8)	
Family PIR		<0.0001		<0.0001
Poor(382)	60.0(53.8-66.2)		31.8(26.2-37.5)	
Near poor(696)	44.5(39.7-49.3)		19.3(15.8-22.9)	
Non-poor(388)	31.3(25.2-37.5)		9.8(5.9-13.7)	
Education		<0.0001		<0.0001
<12(531)	53.9(48.4-59.5)		27.1(22.4-31.8)	
12(372)	44.5(37.7-51.2)		19.6(14.5-24.7)	
>12(578)	34.6(29.6-39.5)		12.0(8.9-15.1)	
Current Smoking		<0.0001		<0.0001
Yes(508)	56.3(50.7-62.0)		27.4(22.6-32.2)	
No(958)	35.4(31.4-39.5)		13.4(10.8-16.1)	
Alcohol (≥12 drinks/year)		0.2046		0.3969
Yes (256)	43.5(39.6-47.4)		18.6(15.8-21.4)	
No (1210)	38.7(32.4-45.0)		16.3(11.9-20.7)	
Physical activity		<0.0001		<0.0001
Vigorous(101)	20.8(12.3-29.3)		60(1.4-10.6)	
Moderate(375)	35.9(29.5-42.4)		11.9(7.8-16.1)	
Light(990)	47.8(43.6-52.0)		22.2(19.0-25.4)	
Diet		<0.0001		<0.0001
Good (923)	37.1(32.9-41.3)		13.8(11.1-16.6)	
Poor(543)	52.6(47.0-58.2)		26.2(21.7-30.7)	

Note:* P was calculated by Rao-Scott chi-square test

Table 3 presents the prevalence of risk behaviors by level of depression. Prevalence of non-smokers (69.9, 95% CI: 66.4-73.5) and those with a good diet (68.4, 95% CI: 64.8-71.9) are significantly higher among participants who reported no to mild depression. Heavy alcohol drinking (81.6, 95% CI: 76.7-86.5) is more prevalent among moderate-severely depressed participants. Moderate to vigorous physical activities are significantly more prevalent among those who had no to mildly depressed participants.

Table 4 presented odds ratios of health risk behaviors among moderate-severely depressed persons using three different regression models. The first model is a simple logistic regression model between individual health risk behavior and depression score. It indicated participants who were moderate- severely depressed have significantly higher odds of smoking (2.2; 95% CI: 1.5-3.0), greater light physical activity (4.0; 95% CI: 1.8-9.0), and poorer diet (1.9; 95% CI: 1.4-2.7). The second model was adjusted for age, gender, and race; and showed similar results as in the first model. The third model additionally included education and economic status in the regression model and showed moderate- severely depressed persons have significantly higher odds of all the risk behaviors.

Table 3 Distribution of health behaviors status within depression category

Health condition	Moderate-severe depression (reference)	no to mild depression
	% (95% C.I.)	% (95% C.I.)
Smoking		
No	48.8(41.7-56.0)	69.9(66.4-73.5)***
Yes	51.2(44.0-58.3)	30.1(26.6-33.6)***
Alcohol (≥12 drinks/year)		
YES	81.6(76.7-86.5)	79.1(76.2-82.0)
NO	18.4(13.5-23.3)	20.9(18.0-23.8)
Physical activity		
Vigorous (reference)	2.5(0.6-4.3)	8.6(6.3-10.8)**
Moderate	18.0(12.1-23.9)	29.4(25.9-33.0)***
Light	79.6(73.5-85.6)	62.0(58.2-65.8)***
Diet		
Good	49.4(42.3-56.6)	68.4(64.8-71.9)***
Poor	50.6(43.4-57.7)	31.6(28.1-35.2)***

Note: *p<0.05, **p<0.01, ***p<0.001 with one- sided proportional test.

Table 4 Odds ratios of health risk behaviors among moderate-severely depressed persons from weighted logistic regression models

Health condition (probability=fair/poor)	Model 1	Model 2	Model 3
	OR (95% C.I.)	OR (95% C.I.)	OR (95% C.I.)
Smoking			
No (reference)			
Yes	2.2(1.5, 3.0)***	1.9(1.4, 2.8)***	1.6(1.1, 2.3)**
Alcohol (≥12 drinks/year)			
YES (reference)			
NO	1.2(0.8,1.8)	1.4(1.0, 2.2)	1.7(1.1, 2.5)*
Physical activity			
Vigorous (reference)			
Moderate	2.3(0.9, 5.6)	2.3(0.9, 5.6)	2.1(0.9, 5.2)
Light	4.0(1.8, 9.0)***	4.2(1.8, 9.6)***	3.2(1.4, 7.3)**
Diet			
Excellent/very good/good(reference)			
Fair/poor	1.9(1.4, 2.7)***	1.9(1.4, 2.7)***	1.8(1.3, 2.6)***

*p<0.05, **p<0.01, ***p<0.001

Model 1: only contains health risk behavior and depression score.

Model 2, contain model 1 and additionally adjusted by demographics.

Model 3, additionally adjusted by SES status.

Discussion

In this study, four health behaviors, smoking, alcohol consumption, diet and physical activity, were statistically associated with the depression in diabetic patients. These behaviors kept significant associated after adjusted for demographics and social economic status. The findings also suggested disparities of depression also existed by gender and age. This current studied found that the prevalence of depression among diabetic patients is least in the age group of 60 and above, and highest in the age group of 40- 59 years. Our study supports the findings from a previous study done by Fisher et al.,[7] where they found that diabetic patients who are distressed according to the Center for Epidemiological Studies Depression Scale (CESD) are more likely to be younger, less educated, and have a lower family income. They suggested CESD as a more sensitive tool to measure chronic disease related stress and socioeconomic factors. To our knowledge, this is the first study that tests the association between four major health risk behaviors (smoking, alcohol drinking, physical inactivity, and poor diet) and depression among diabetic patients using

nationally representative data. Our analysis has found significant association between each of these risk behaviors and diabetic patients who are moderate-severely depressed.

The findings present strong evidence on behalf of explaining why glycemic control in diabetic patients with depressive symptoms is worse compared to patients without depressive symptoms. Poor glycemic control is highly responsible for developing micro and macro vascular complications of diabetes including neuropathy and cardiomyopathy. Microvascular complications from type 2 diabetes can cause lesions in cerebral small vessels leading to structural damage of mood regulator region of the brain.[8,12,13] Mediators of systemic low grade inflammation, a complication of type 2 diabetes mellitus, can also play role in the etiology of depression.[8,14] Since neurons do not have their active glucose transporters, high blood glucose level itself can act as a direct regulator of glucose metabolism in the neuron and thus promote negative emotional states.[8,15] On the other hand, hypothalamic–pituitary–adrenal (HPA) axis and sympathomedulary activation due to MDD can lead to reduced glucose transport and insulin resistance, thus resulting into diabetes.[16] MDD can also affect a number of lifestyle factors that in turn cause a rise in cortisol level, and insulin resistance. The whole process eventuates in a cyclic manner and exponentially increases the risk of developing complications.[17]

Our study supports previous findings in the bi-directional relationship between depression and behavioral factors. Among the general population, rates of tobacco cessation have remained lower for depressed smokers than for smokers who were not experiencing depression.[18] A systematic review identified this was due to low positive affect, high negative affect, and cognitive impairment.[19] Another study identified that, of nearly 150 studies, half reported depression was related to some type of smoking later in life, another one third of studies found that smoking was associated with later depression.[20] Our results support this association in that moderate-severely depressed individuals were twice as likely to smoke than to not smoke.

Previous research suggests that the lack of exercise is linked to many chronic diseases, including depression.[21] A study monitoring 106 participants (53 controls, 53 diagnosed with depression) found that the level and duration of exercise affected the intensity of depression symptoms.[22] This study also showed that moderate-severely depressed individuals were more likely to engage in no to a light physical activities than a vigorous exercise.

Results of this study found that individuals with moderate-severe depression were also more likely to have a fair/poor diet. An Australian study looked at the relationship between diet and current and prior depression.[23] They found that those currently suffering from depression had unhealthier diets than those that had previously suffered and those without prior depression.[23]

Many studies found there is a bidirectional association between depression and diabetes.[24-26] The diabetic patients are more likely to have depression that non-diabetes individuals. Schram et al. found in their literature review that both generic and diabetes specific quality of life is poorer among diabetic patients with depressive symptoms.[18] They also supported the evidence suggesting causal relationship between depressive symptoms and future development of functional disabilities. Previous studies suggested that all diabetic patients should be screened for depression and be treated to reduced the complication of diabetes and better treatment result.[27,28]

Depression is influenced by many external and internal factors such as age, gender, race, education level, and economic status.

Strength of our study is that our analysis has considered these potential confounder factors and adjusted the analyses for these influential factors. As previously stated, CESD may be a more sensitive tool in measuring chronic disease as PHQ-9. However, NHANES is a nationally, representative database that collects all necessary external and internal factors needed for this study.

Conclusion

Our result shows significant associations between all of the risk behavior factors and depression, even after adjusting for the confounding factors. Therefore, we recommend strategies be enacted to decrease depression and increase healthy lifestyles to help improve the quality of life of diabetic patients.

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None

Conflicts of interest

The authors declare that there is no conflict of interest.

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