

Research Article

The Association between Depression and Diabetes and Associated Risk Factors by Racial/Ethnic Status among Adults in Arizona: Arizona Behavioral Risk Factor Surveillance System, 2014-2017

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ABSTRACT

Objective: The purpose of our study was to examine the association between depression with diabetes, current smokers, and overweight or obesity among adults in four racial/ethnic groups: non-Hispanic whites (NHWs), non-Hispanic African Americans/blacks (NHAA/blacks), Hispanics, and American Indians/Alaskan Natives (AI/ANs), in Arizona.

Methods: Data from the 2014-2017 Arizona Behavioral Risk Factor Surveillance System was used to examine the association between self-reported provider-diagnosed depression and self-reported provider-diagnosed diabetes and associated risk factors for each racial/ethnic group (n=31,671). The analysis was extended to test whether current smoking status or overweight or having obesity status modified the association between depression and diabetes among all Arizona adults. Weighted adjusted prevalence ratios (APRs) accounting for potential confounders were estimated using Cox's proportional hazards regression analysis.

Results: For all Arizona adults after adjusting for potential

confounders, the prevalence of diabetes (APR =1.60: 95% confidence interval=1.43-1.72), current smoking status (APR=1.04: 1.02-1.07), and overweight or obesity status (APR=1.07:1.03-1.11) was greater among adults with depression versus without depression. For NHWs (APR=1.63:1.47-1.80), Hispanics (APR=1.71:1.39-2.12), and AI/ANs (APR=1.44:1.11-2.05) the prevalence of diabetes was greater among adults with depression versus without depression. In addition, the association between depression and diabetes was greater for current smokers and those overweight or with obesity than their counterparts in all Arizona adults (p<0.05 for both).

Conclusion: Depression was associated with diabetes among all Arizona adults and NHWs, Hispanics, and AI/ANs. Current smoking status and overweight/obese status modified the association between depression and diabetes for all Arizona adults.

Keywords: Diabetes; Depression; Risk factors; Health disparities; Racial/Ethnic; Minorities

KEY POINTS

- Although research has shown that depression symptoms are common among individuals with diabetes, limited research has been conducted exploring the relationship between diabetes and depression among racial/ethnic groups.
- As the nation's lead public health agency, the Centers for Disease Control and Prevention support health departments on innovative projects that help raise awareness of type 2 diabetes and its comorbidities. While African Americans are at greatest risk for type 2 diabetes,

the Hispanic community being the fastest and largest growing ethnic group in the country, and Arizona being the home to the largest Native American/Alaska Native population, this study advances the body of science on the association between diabetes and depression pertaining to three groups with the highest prevalence of diabetes.

- Culturally tailored interventions need to be developed to address depression and diabetes among minority populations who are disproportionately impacted by diabetes.

Introduction

More than 30 million people (9.4% of United States [U.S.] population) in the U.S. have diabetes with 1.5 million new cases of diabetes in 2015 [1]. In 2014-2015, diabetes was the 7th leading cause of death in the U.S. and in Arizona [2].

However, in Arizona, diabetes was the 3rd leading cause of death for non-Hispanic African Americans/blacks (NHAA/blacks), and Hispanics and the 5th leading cause of death for American Indians/Alaska Natives (AI/ANs) in 2014-2015 [3]. In Arizona, 42.8% of the population is comprised of racial and

ethnic minorities with 30.9% Hispanics, 5.4% AI/ANs, and 4.9% NHAA/Blacks [4].

Depressive symptoms are common among patients with diabetes and may have a large impact on disease self-management and health outcomes [5]. With depression affecting more people than any other mental health disorder and a leading cause of disability, it is unclear if depression increases the risk of developing diabetes or if individuals with diabetes may be at an increased risk for depression or depression-like symptoms [5-8]. Diabetes compounded with depression has been associated with a higher risk of diabetes-specific complications, such as decreased treatment adherence, unhealthy eating, smoking, weight gain, decrease quality of life, increased healthcare expenditures, and loss of productivity and early disability [9,10]. Furthermore, people with diabetes experience greater levels of depression and the depressive symptoms play a greater role in mortality among people with diabetes than among people without diabetes [11].

Greater prevalence of comorbid diabetes and depression have been found among NHAA/blacks and AI/ANs compared to NHWs [12,13]. Also, compared to non-Hispanic whites (NHWs), major depression and factors associated with depression were more frequently identified among individuals of minority groups [14]. However, these findings were limited to national or local settings and not state level, especially one like Arizona with a greater number of minority populations. Relatively little information is known about the relationship between diabetes and depression among racial/ethnic communities in the state of Arizona. To address these gaps, we examined the association between depression and diabetes among adults in four racial/ethnic groups: NHWs, NHAA/blacks, Hispanics, and AI/ANs, in Arizona. We hypothesized that having diabetes would be associated with having depression and that current smoking and overweight or obesity status will modify this relationship. In addition, this study aimed at exploring the associations between depression and risk factors associated with diabetes, including overweight or obesity and current smoking.

Methods and Materials

The Behavioral Risk Factor Surveillance System (BRFSS) is a population-based telephone survey conducted annually in all 50 states, the District of Columbia and U.S. territories to collect information on health-related behavioral risk factors, preventable health practices, health care access, and chronic conditions among noninstitutionalized U.S. adults aged 18 years or older [15]. Additional detailed information about the BRFSS survey design, sampling methods, data collection, and weights is available at <https://www.cdc.gov/brfss/index.html>.

Data from the 2014-2017 Arizona BRFSS (N=31,671), gathered by the Arizona Department of Health Services (ADHS), was used to examine the association between self-reported provider diagnosed depression (hereafter depression) and self-reported provider diagnosed diabetes (hereafter diabetes).

In the BRFSS, race/ethnicity was self-reported based on which one or more subgroups a respondent self-identified (*Race: white, black or African American, American Indian or Alaskan Native, Asian, Asian Indian, Chinese, Filipino, Japanese,*

Korean, Vietnamese, Other Asian, Pacific Islander, Native Hawaiian, Guamanian or Chamorro, Samoan, Other Pacific Islander; ethnicity: Are you Hispanic, Latino/a, or Spanish origin). Depression was defined as responding YES to the question – “Has a doctor, nurse, or health professional ever told you that you have a depressive disorder, including depression, major depression, dysthymia, or minor depression?” Diabetes was defined as responding YES to the question – “Has a doctor, nurse, or health professional ever told you that you have diabetes?” Individuals noting they had prediabetes or diabetes only while pregnant were not included.

Chi-square tests were performed to examine differences in selected categorical characteristics across racial/ethnic groups (NHWs, NHAA/blacks, Hispanics, and AI/ANs). Prevalence and age-adjusted prevalence for diabetes and depression were calculated. Age-adjusted prevalence was standardized to the projected 2000 U.S. population. To examine the association between depression, diabetes and selected risk factors, weighted adjusted prevalence ratios (APRs) and corresponding 95% confidence intervals were estimated using Cox’s proportional hazards regression analysis. The Cox’s proportional model is a tool for estimating prevalence ratios if one assumes a constant risk period [16]. Multiple models were tested where diabetes, current smoking status, and having overweight or obesity status were treated as the dependent variable and depression as the independent variable. Models were adjusted for the following categorical variables: gender, age group (18-44; 45-54; 55-64; ≥ 65 years), educational attainment (less than high school diploma; high school diploma, at least some college), income (<\$15,000, \$15,000 to <\$25,000, \$25,000 to <\$35,000, \$35,000 to <\$50,000, and \$50,000+), body mass index (BMI) category (obesity (≥ 30 kg/m²) or overweight (25-<30 kg/m²)) status versus normal/underweight (<25 kg/m²), and current smoking status (current versus former or never smoker). Current smoker was defined as smokes now everyday or smokes now on some days. Former smoker was defined as responding YES to smoking 100 cigarettes in your entire life and currently does not smoke at all. Never smoking was defined as responding NO to smoking 100 cigarettes in your entire life. Proportional hazards assumption for the Cox model was tested and the association among independent variables was not strong. A separate model for current smoking status or overweight/obese status was developed to examine if either modified the association between depression and diabetes among all Arizona adults. Interaction was only tested among all Arizona adults and not for each racial/ethnic group with depression and diabetes due to statistical power limitations. Analyses were conducted using SAS Survey Procedure and accounted for the complex sampling design. Results were considered significant if p-value was <0.05. Data were weighted to generate estimates that are representative of the Arizona adult population.

Results

In 2014-2017, 63.1% of adults aged ≥ 18 years in Arizona were NHW, 28.5% were Hispanics, 4.3% were NHAA/black, and 4.0% were AI/AN. The prevalence of reported depression was 18.2% (age-standardized=18.0%) and the prevalence of diabetes was 10.4% (age-standardized=9.4%). Among Arizona adults, 46.5% were age 18-44 years, 58.7% had some college

education, 65.3% reported being overweight or having obesity, and 15.2% reported current smoking. Age, education, and income differed by racial/ethnic groups ($p < 0.01$) (Table 1). The prevalence of depression varied by race/ethnicity ($p < 0.01$), with 20.0% NHWs, 18.7% NHAA/blacks, 15.4% Hispanic, and 17.0% AI/AN with depression. The prevalence of diabetes also differed across race/ethnicity ($p < 0.01$), with 9.8% NHWs, 12.0% NHAA/Blacks, 10.7% Hispanics, and 18.5% AI/AN with diabetes. Characteristics of those with diagnosed depression varied across race/ethnicity ($p < 0.01$) (Table 2). The prevalence of depression varied across categories of gender, age, education, income, current smoking status, and overweight/obesity status by race/ethnicity. Similar to depression, characteristics of those with diabetes varied across race/ethnicity (Table 3).

For all adults after adjusting for potential confounders, having diabetes (APR=1.60: 95% confidence interval=1.43-1.72), current smoking (APR=1.04: 1.02-1.07), and being overweight

or having obesity (APR=1.07: 1.03-1.11) were greater among adults with depression versus without depression (Table 4). Similar to all Arizona adults, for NHWs, the prevalence of diabetes (APR=1.63: 1.47-1.80) among current smokers (APR=1.04: 1.02-1.06), and those who were overweight or obesity (APR=1.12: 1.87-1.15) was greater among those with depression than adults without depression. For Hispanics, the positive association between depression and diabetes (APR=1.71:1.39-2.12) remained significant but not for the association between depression and current smokers, and overweight or having obesity in adjusted models. In adjusted models, for AI/ANs, the association between depression and diabetes (APR=1.44:1.01-2.05) and between depression and current smokers (APR=1.11: 1.03-1.20) remained significant but not the association between depression and overweight or having obesity. There were no significant associations among NHAA/blacks (Table 4).

Table 1: *Characteristics of Arizona Adults Aged ≥ 18 Years in 2014-2017 and by Race/Ethnicity, BRFSS

Characteristics	Overall Unweighted Sample Size =46,121	NHW (Unweighted Sample Size =36,193) (63.10%)	NHAA/blacks Unweighted Sample Size =1331 (4.33%)	Hispanic (Unweighted Sample Size = 6965) (28.5%)	AI/AN (Unweighted Sample Size = 1,632) (4.03%)	†p-value
Characteristics	% (95 % CIs)	% (95 % CIs)	% (95 % CIs)	% (95 % CIs)	% (95 % CIs)	
Gender						
Male	48.9 (48.2-49.6)	48.7 (48.0-49.6)	47.4 (43.4- 51.4)	50.0 (48.2-51.7)	45.1 (41.2 - 49.1)	0.13
Female	51.1 (50.4-51.8)	51.2 (50.4-52.0)	52.6 (48.6 - 56.6)	50.0 (48.3 - 51.8)	54.9 (51.0 - 58.8)	
Age, Years						
18-44	46.5 (45.8-47.3)	37.3 (36.5-38.2)	55.9 (52.1-59.7)	63.9 (62.4-65.4)	58.0 (54.2-61.7)	<0.01
45-54	15.7 (15.2-16.2)	15.5 (15.0-16.1)	17.1 (14.5-19.6)	15.7 (14.6-16.8)	17.1 (14.5-20.0)	
55-64	15.8 (15.3-16.2)	18.2 (17.6-18.7)	13.0 (10.9-15.2)	11.1 (10.3-12.0)	13.9 (11.6-16.2)	
≥ 65	22.0 (21.5-22.4)	29.0 (28.4-29.6)	14.0 (11.9-16.1)	9.3 (8.6-10.0)	10.9 (9.0-12.8)	
Education						
Less than High School Diploma	15.5 (14.8-16.1)	7.2 (6.6-7.8)	9.9 (7.1-12.7)	33.8 (32.1-35.5)	21.1 (17.4-24.7)	<0.01
High school Diploma	25.8 (25.2-26.5)	24.2 (23.5-25.0)	26.9 (23.3-30.5)	27.9 (6.4-29.4)	36.4 (32.6-40.2)	
At Least Some College	58.7 (58.0-59.5)	68.6 (67.9-69.4)	63.2 (59.2-67.2)	38.3 (36.7-39.9)	42.5 (38.7-46.4)	
Income						
<15,000	11.5 (11.0-12.7)	7.5 (7.1-8.0)	13.9 (10.9-17.0)	17.2 (15.8-18.6)	31.4 (27.2-35.5)	<0.01
15,000 – 25,000	20.0 (19.3-20.7)	14.6 (14.0-15.2)	22.6 (18.8-26.4)	30.1 (28.3-32.0)	29.5 (25.2-33.9)	
25,000 – 35,000	11.0 (10.5-11.6)	9.8 (9.3-10.3)	13.1 (9.8-16.3)	13.2 (11.9-14.5)	13.2 (10.0-16.3)	
35,000 – 50,000	15.1 (14.5-15.7)	15.4 (14.8-16.0)	16.5 (13.3-19.7)	15.0 (13.7-16.4)	9.0 (6.9-11.2)	
>50,000	42.4 (41.6-43.2)	52.7 (51.8-53.6)	33.9 (30.0-37.9)	24.4 (22.9-25.9)	16.9 (14.2-19.7)	
Depression	18.2 (18.0-18.7)	20.0 (19.4 - 20.7)	18.7 (15.6 - 221.8)	15.4 (14.2 - 16.6)	17.0 (14.0-20.0)	<0.01
Diabetes	10.4 (10.0-10.7)	9.8 (9.4-10.2)	12.0 (10.0-13.9)	10.7 (9.8-11.5)	18.5 (15.7-21.3)	<0.01
Overweight or obesity	65.3 (64.6-66.1)	62.3 (61.4 - 63.1)	65.2 (60.8 - 69.5)	70.9 (69.2 - 72.6)	76.5 (72.7 - 80.2)	<0.01
Current smoker	15.2 (14.7-15.9)	16.0 (15.4 - 16.7)	17.8 (14.7 - 20.9)	13.2 (11.9 - 14.4)	16.1 (12.7 - 19.5)	<0.01

Abbreviation: CIs = confidence intervals; BRFSS= Behavioral Risk Factor Surveillance System

*Weighted percentages might not sum to 100% because of rounding

†Chi-square tests were performed to examine differences in study characteristics across race/ethnicity subgroups.

Table 2: *Prevalence of Self-Reported Diagnosed Depression by Characteristics for Each Race/Ethnicity Group among Adults Aged ≥ 18 Years, 2014 – 2017 BRFSS

Variable	NHWs % (95 % CIs)	NHAA/blacks % (95 % CIs)	Hispanics % (95 % CIs)	AI/ANs % (95 % CIs)	†p-value
Gender					
Male	15.3 (14.4-16.2)	17.8 (13.2-22.4)	12.0 (10.4-13.6)	14.9 (10.3-19.4)	<0.01
Female	24.6 (23.6-25.5)	19.6 (15.3-23.8)	18.8 (17.1-20.6)	18.7 (14.7-22.7)	<0.01
Age, years					
18-44	21.3 (20.0-22.7)	17.0 (12.5-21.5)	14.0 (12.5-15.6)	15.8 (11.6-19.9)	<0.01
45-54	22.6 (21.0- 24.2)	21.8 (14.8-28.8)	16.9 (14.1-19.8)	19.8 (11.7-27.8)	<0.05
55-65	23.5 (22.3-24.8)	24.8 (17.9-31.8)	21.0 (17.8-24.2)	19.9 (12.9-26.8)	0.38
≥ 65	15.2 (14.6-16.0)	18.7 (10.3-27.0)	16.8 (14.1-19.5)	16.4 (10.7-22.0)	0.55
Education attainment					
Less than high school diploma	28.2 (24.6-31.8)	23.3 (9.9-36.6)	15.6 (13.2-17.9)	16.3 (8.8-23.9)	<0.01
High school diploma	20.0 (18.7-21.3)	17.5 (11.5-23.5)	12.9 (11.0-14.8)	13.6 (9.3-17.8)	<0.01
At least some college	19.3 (18.5-20.0)	18.5 (14.8-22.1)	17.2 (15.4-19.1)	20.3 (15.6-25.0)	0.25
Income					
<15,000	39.0 (35.8-42.2)	29.3 (18.6-39.9)	21.7 (18.3-25.2)	19.7 (13.3-26.1)	<0.01
15,000 – 25,000	29.9 (27.7-32.1)	18.4 (10.8-26.1)	14.2 (11.8-16.7)	13.2 (7.0-19.4)	<0.01
25,000 – 35,000	22.2 (19.8-24.6)	23.3 (13.5-33.1)	13.0 (9.7-16.3)	13.2 (5.5-21.0)	<0.01
35,000 – 50,000	18.4 (16.7-20.1)	16.4 (8.4-24.4)	14.6 (11.4-17.8)	20.9 (8.2-38.5)	0.24
>50,000	15.4 (14.5-16.3)	17.9 (12.2-23.6)	12.4 (10.2-14.6)	13.2 (7.3-19.0)	0.06
Diabetes	28.6 (26.6-30.6)	23.3 (15.7-31.0)	27.6 (23.7-31.4)	22.4 (14.7-30.1)	0.33
Current Smoker	32.8 (30.7-34.9)	38.8 (29.1-48.5)	23.1 (18.9-27.3)	22.8 (14.6-31.0)	<0.01
Overweight or obesity	21.5 (20.4-22.5)	18.6 (15.0-22.2)	16.7 (15.1-18.2)	17.3 (13.8-20.8)	<0.01

Abbreviation: CI = Confidence Interval

*Weighted percentages might not sum to 100% because of round

†Chi-square tests were performed to examine differences in study characteristics across race/ethnicity subgroups.

In addition, when considering the association between depression and diabetes for all Arizona adults, current smoking status and overweight or obese status modified this association (p -value= <0.01 for both interaction terms). The prevalence ratio of diabetes between those with and without depression was greater among all adults who were current smokers (APR: 1.71: 1.38-2.13; $p<0.05$) than nonsmokers (APR: 1.55: 1.40-1.72; $p<0.05$) (Table 4). Among all adults who were overweight or who had obesity, the prevalence ratio of diabetes for those with depression compared to those without (APR: 1.70: 1.30-1.72; $p<0.05$) was greater than among normal weight adults (APR: 1.55: 1.41-1.70; $p<0.05$) (Table 4).

Discussion

Our findings highlight a significant association between depression and diabetes among all Arizona adults, NHWs, Hispanics and AI/ANs, and found a stronger association for current smokers and those overweight or who had obesity in the overall population.

Almost one in five adults in Arizona reported depression with variation across racial/ethnic groups (15.4-20.0%). Across

racial/ethnic groups, the prevalence of depression varied across gender, age, lower socioeconomic status, those who were overweight or obese and current smokers. In our study, NHWs, AI/ANs and Hispanics had a greater prevalence of depression among those with diabetes when adjusting for potential confounders. Racial/ethnic differences among individuals with depression has been previously reported with major depression and factors associated with depression more commonly found among individuals of minority groups compared to NHWs [14]. Greater health burdens and lack of insurance have been largely associated with elevated depression rates among minority groups [14]. In addition, studies have found that patients with depression and diabetes, compared with those with diabetes alone, have been found to have poor adherence to diet, smoking cessation, and physical activity recommendations [17].

While one in 10 people reported diabetes in 2014-2016, there was significant variation in the prevalence of diabetes by race/ethnicity (9.8-18.5%). The prevalence of diabetes was greater for AI/ANs compared to the other racial/ethnic groups for middle age adults (aged 45-64 years), higher socioeconomic status, adults with depression, and those overweight or who had obesity. Consistent with previous studies, we found a

Table 3: *Prevalence of Self-Reported Diagnosed Diabetes by Characteristics for Each Race/Ethnicity Group among Adults Aged ≥18 Years, 2014 – 2017 BRFSS.

Variable	NHWs % (95 % CIs)	NHAA/blacks % (95 % CIs)	Hispanics % (95 % CIs)	AI/ANs % (95 % CIs)	†p-value
Male	10.7 (10.1-11.3)	13.3 (10.2-16.5)	11.0 (9.7-12.3)	18.5 (13.9-23.1)	<0.01
Female	9.0 (8.4-9.5)	10.6 (8.1-13.0)	10.3 (9.2-11.4)	18.5 (15.0-22.0)	<0.01
18-44	2.3 (1.7-2.8)	2.6 (1.1-4.1)	2.9 (2.2-3.6)	5.8 (3.5-8.1)	<0.01
45-54	8.8 (7.8-9.9)	17.8 (11.8-23.8)	15.0 (12.2-17.7)	33.0 (24.0-41.8)	<0.01
55-65	13.6 (12.6-14.7)	19.3 (13.5-25.2)	28.8 (25.2-32.5)	41.1 (32.6-49.6)	<0.01
≥65	17.6 (16.9-18.4)	33.7 (26.9-40.6)	34.9 (31.5-38.3)	33.1 (25.5-40.7)	<0.01
Less than high school diploma	13.0 (10.5-15.5)	27.2 (15.7-38.6)	15.4 (13.4-17.4)	25.7 (17.2-34.2)	<0.05
High school diploma	10.8 (9.8-11.8)	9.6 (5.6-13.5)	8.4 (6.8-10.0)	16.0 (10.6-21.4)	<0.01
At least some college	9.2 (8.7-9.6)	9.8 (7.7-12.0)	8.4 (7.3-9.5)	15.8 (12.3-19.2)	<0.01
<15,000	14.0 (12.0-15.8)	22.8 (14.1-31.4)	15.4 (12.7-18.2)	22.5 (16.2-28.8)	<0.01
15,000 – 25,000	14.4 (12.9-15.9)	11.6 (7.3-16.0)	11.0 (8.8-12.6)	20.5 (13.8-27.3)	<0.01
25,000 – 35,000	12.4 (10.9-13.9)	8.6 (3.7-13.6)	11.0 (8.3-13.7)	10.5 (5.4-15.5)	0.53
35,000 – 50,000	10.1 (8.9-11.4)	8.5 (3.8-13.3)	8.6 (6.1-11.0)	19.2 (6.3-32.2)	0.12
>50,000	7.4 (6.8-7.9)	12.0 (8.4-15.7)	6.9 (5.5-8.3)	13.5 (8.4-18.7)	<0.01
depression	14.0 (12.9-15.2)	14.5 (9.1-20.0)	19.1 (16.1-22.0)	24.3 (15.8-32.8)	<0.01
Current smoker	8.1 (7.1-9.1)	15.3 (9.2-21.5)	10.7 (8.2-13.3)	10.8 (5.1-16.5)	<0.01
Overweight or obesity	13.4 (12.8-14.0)	16.2 (13.3-19.1)	13.0 (11.8-14.2)	21.4 (17.9-24.9)	<0.01

Abbreviation: CIs = Confidence Intervals; BRFSS= Behavioral Risk Factor Surveillance System

*Weighted percentages might not sum to 100% because of round

†Chi-square tests were performed to examine differences in study characteristics across race/ethnicity subgroups.

higher prevalence of diabetes among AI/ANs, NHAA/black, and Hispanics [8,12,18]. There are several factors that could be making diabetes more common among certain racial/ethnic groups. Factors contributing to the high rates of type 2 diabetes among AI/ANs have been identified as genetic, environmental, and behavioral issues [18]. The high obesity rates, having a sedentary lifestyle and living in a stressful environment due to poverty, historical trauma and violence, can impact mental and physical health, contributing to the high rates of diabetes and complications due to diabetes [18]. In addition to having diabetes and having greater prevalence of overweight or obesity, AI/ANs and NH AA/blacks had the highest prevalence of current smokers in our study. Smoking is a major cardiovascular risk factor for patients with diabetes as smoking can lead to secondary cardiovascular complications, such as high blood pressure and stroke [19,20].

Depression prevalence was slightly higher among current smokers than in non-smokers and smoking status was an effect modifier between depression and diabetes with the association being stronger among current smokers. Previous studies have found a strong association between depression and smoking in aspects of quantity and frequency of smoking. Adults with

depression are more likely to smoke more a pack a day and smoke their first cigarette within 5 minutes of waking up than adults without depression [21,22]. The sooner a person smokes upon waking is a measure of the level of nicotine addiction [21,22]. Also, adults with depression were more likely to be heavier smokers and smoke at greater rates than those without depression [22,23]. Furthermore, adults with depression have been found to have a higher rate of smoking initiation as well as a lower quit rate, compared to those without depression [22,23]. Although smoking rates continue to decline among the general population, smoking continues to increase among individuals with depression and other mental health illnesses [24]. Similar to the findings in this study, smoking has been reported to be a potential effect modifier between depression and diabetes [25]. Individuals who smoke have a 30-40% greater risk of developing type 2 diabetes and are more likely to have a difficult time controlling their diabetes, causing serious health problems resulting from diabetes [19].

Several cross-sectional studies have found an association between depression and overweight or having obesity [26]. In addition, studies have found a reciprocal association where obesity was found to increase the risk of depression and

Table 4: The Association of Depression with Diabetes, Current Smoker, and Overweight/Obese by Race/Ethnicity Group among Adults in Arizona, 2014-2017 BRFSS.

Dependent Variables	Overall APR (95% CIs)	NHWs APR (95% CIs)	NHAA/blacks APR (95% CIs)	Hispanics APR (95% CIs)	AI/ANs APR (95% CIs)
*Diabetes <i>All</i>	†1.60 (1.43-1.72)	†1.63 (1.47-1.80)	1.29 (0.86-1.93)	†1.71 (1.39 – 2.12)	†1.44 (1.01-2.05)
‡ <i>Subgroup</i>					
§ <i>Overweight or has obesity^b</i>	†1.70 (1.30-2.52)				
<i>Normal or underweight^c</i>	†1.55 (1.41-1.70)				
¶ <i>Current smoker^d</i>	†1.71 (1.38-2.13)				
# <i>Non Current smoker</i>	†1.55 (1.40-1.72)				
** Current smoker	†1.04 (1.02-1.07)	†1.04 (1.02-1.06)	0.99 (0.85-1.14)	1.01 (0.96-1.06)	†1.11 (1.03-1.20)
†† Overweight or obesity	†1.07 (1.04-1.10)	†1.12 (1.87-1.15)	1.01 (0.86-1.19)	1.05 (0.99-1.12)	0.98 (0.85-1.15)

Abbreviation: CIs = confidence intervals; BRFSS= Behavioral Risk Factor Surveillance System

*Cox's proportional hazards regression models were used to estimate the APR with 95% CIs after adjusting for age, gender, education, income, overweight/obesity status, current smoking status

†Statistically significant at $p < 0.05$

‡Interaction was only tested among all Arizona adults and not for each racial/ethnic group with depression and diabetes due to statistical power limitation.

§ Cox's proportional hazards regression models were used to estimate the APR for the association between depression and diabetes among those who are overweight or have obesity. Adjusted for age, gender, education, income, and current smoking status.

|| Cox's proportional hazards regression models were used to estimate the APR for the association between depression and diabetes among those who are not overweight or have obesity. Adjusted for age, gender, education, income, and current smoking status

¶Cox's proportional hazards regression models were used to estimate the APR for the association between depression and diabetes among current smokers. Adjusted for age, gender, education, income, and overweight/obesity status.

#Cox's proportional hazards regression models were used to estimate the APR for the association between depression and diabetes among non current smokers. Adjusted for age, gender, education, income, and overweight/obesity status.

**Cox's proportional hazards regression models were used to estimate the APR for the association between depression and current smoking status. Adjusted for age, gender, education, income, and overweight/obesity status.

††Cox's proportional hazards regression models were used to estimate the APR for the association between depression and overweight/obesity status. Adjusted for age, gender, education, income, and current smoking status.

depression was also found to increase the risk of becoming obesity [27]. Individuals with obesity have a 55% increased risk of developing depression and those with depression have a 58% increased risk of becoming obesity [26]. One potential explanation for the association between depression and obesity could be due to the side effects of antidepressive medication, such as weight gain and fatigue [26]. Physical inactivity resulting from fatigue due to antidepressive medication and depression can contribute to weight gain, and increase the risk for developing type 2 diabetes [26]. Although obesity has been found to be an individual risk factor for depression and type 2 diabetes [27], it has also been found to be an effect modifier in the association between depression and diabetes as demonstrated in this study and in others [28].

This study has several limitations which require thoughtful consideration when interpreting our findings. One significant limitation relates to self-reported diagnosed diabetes and depression status. This study did not verify depression and diabetes; many participants may not have been diagnosed

with clinically present depression or diabetes and many may misreport condition status due to the stigma associated with depression or diabetes. Thus, diabetes and depression status may be subject to recall and social desirability biases. Self-reported tobacco use, BMI, income, and education are also subject to social desirability bias [29]. Additionally, it is possible that participants with diagnosed diabetes or depression are more likely to be diagnosed with the condition based on their access to or seeking of health care. Secondly, this is a cross-sectional designed study and exploration of causality cannot be determined. Therefore, we do not know the temporal association between depression, diabetes, and associated risk factors. Finally, due to a limitation of statistical power resulting from a small sample size in certain groups, there is potential for a type II error, which tells you the probability of falsely accepting the null hypothesis. Despite these limitations, our findings provide important information about the role of depression on diabetes and related risk factors among racial/ethnic groups supporting further investigation.

Depression and diabetes are important health issues that need to be addressed in a multifaceted approach considering effect modifying factors such as overweight or having obesity and smoking status. Similar to our findings, several studies have identified the association between diabetes and depression and associated risk factors such as overweight/obesity and smoking [30-34]. In a study looking at the association between depression and diabetes, authors found that patients who reported high levels of depression symptoms, reported higher levels of diabetes nonadherence regimens [34]. In addition, authors found depressive symptoms associated with poorer diet and lack of medication regimen adherence [35]. Despite the availability of mental health screening tools, depression among individuals with diabetes and chronic diseases can be overlooked [30]. Individuals with depression and diabetes are more likely to rate their health as poor in comparison to individuals with depression only [36]. The negative health outcomes associated with diabetes and depression call for both conditions to be treated at the same time [37]. Health care providers, including diabetes educators, nurses, physicians, and dietitians caring for individuals with diabetes and other chronic diseases should consider screening, referring to self-management programs, and treating depression to reduce the effects and the racial/ethnic disparities in diabetes outcomes and risk factors associated with diabetes (i.e., tobacco use, nutrition, and physical activity) and medication compliance [33]. In addition, involving a multidisciplinary team in healthcare systems through a team-based care model [31] and providing culturally tailored services and traditional healing practices can optimize treatment outcomes and increase referral capacity. Funding received from the CDC allowed for the implementation of the program “State Public Health Actions to Prevent Obesity, Diabetes and Heart Disease and Stroke”, commonly known as the 1305 cooperative agreement. The funding afforded the ADHS, as well as other state health departments across the nation, integration of a team-based care approach to promote the prevention and control of chronic diseases and their associated risk factors [34]. Although the 1305 cooperative agreement did not award funding to address depression or mental health, it provided the opportunity for health authorities to design statewide public health interventions and collaborate with diabetes educators, allied health care professionals, academic institutions, and the greater Arizona diabetes stakeholder community to reduce comorbidities associated with depression and diabetes. Therefore, prioritizing and embedding surveillance efforts into statewide health assessments and improvement plans can potentially increase awareness of this comorbid condition and identify public health strategies to alleviate diabetes and depression.

Conclusion

In conclusion, we found robust associations between depression and diabetes among all Arizona adults, NHWs, Hispanics and AI/ANs. Among all Arizona adults, the association between depression and diabetes was even greater for current smokers and those who were overweight or had obesity.

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