

Depression and Diabetes in Workers Across the Life Span: Addressing the Health of America's Workforce—Behavioral Risk Factor Surveillance System, 2014–2018

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OBJECTIVE | Diabetes affects nearly 12.2% of U.S. adults. Comorbid depressive symptoms among U.S. workers with diabetes are associated with increased unemployment and reduced work performance. This study examined the age-group-specific prevalence of depression among U.S. workers with self-reported diabetes and identified factors associated with depression.

METHODS | Data from the 2014–2018 Behavioral Risk Factor Surveillance System were used to examine the prevalence of depression among adult workers with diabetes in the United States. Relationships between depression prevalence and diabetes and demographic, physical, and behavioral risk factors were examined through bivariate and multivariable analyses. Age was categorized into four groups: 18–34, 35–54, 55–64, and ≥ 65 years.

RESULTS | The overall prevalence of self-reported depression among U.S. workers with diabetes was 17.4–30% higher than among those without diabetes. Workers with diabetes aged 18–34 years had the highest depression prevalence (28.7%) compared with other age-groups. Female workers with diabetes were significantly more likely than male workers to report depression in all age-groups. Young adult workers with diabetes who had another chronic disease were nearly three times more likely to report depression than those without another chronic condition. There were no overlapping patterns of prevalence of diabetes and depression by state.

CONCLUSION | Workers with diabetes are at an increased risk of depression, which can affect their overall health and productivity. These findings indicate that, among those with diabetes, young adult workers and women are most likely to have depression. Employee wellness programs may address the specific needs of individuals with diabetes and depression.

Diabetes is a serious, chronic illness that affects more than 34 million adults ≥ 18 years of age (10.5%) in the United States (1). Diabetes can result in numerous physical and mental health complications such as heart disease and stroke, kidney disease, lower-limb amputations, and depression (2). In addition, people with diabetes may experience reduced earnings as a result of absenteeism and presenteeism (3).

The comorbidity of diabetes and depression is well known (4,5). Research suggests that there is a bidirectional relationship between diabetes and depression (4,6). One meta-analysis reported a 24% increased risk of depression among people with type 2 diabetes compared with people without diabetes (6). Conversely, people with depression have a 32% increased

risk of developing type 2 diabetes (5). The coexistence of diabetes and depression increases the risk of numerous complications such as cognitive decline, blindness, and cardiovascular disease (5). This comorbidity accounts for medical costs that result in financial burden for patients and for the U.S. health care system (7). Comorbidity of diabetes and depression also negatively affects overall quality of life and increases the risk of premature death (8).

The typical age of onset for depressive symptoms is in the third decade of life (9), at a time when people are usually working. As a highly comorbid condition with chronic diseases such as diabetes, depression potentially affects the ability to work or to perform work functions sufficiently (10).

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For example, workers with diabetes and depression can experience loss of workdays, presenteeism (i.e., not being fully functional at work because of their illness or condition), absenteeism, and an inability to concentrate and complete work tasks, as well as workplace injuries (11,12). It is vital to examine depression among people with diabetes because depression is often missed in people with this chronic condition despite available screening tools (13). Data are currently lacking in the literature on how both diabetes and depression affect U.S. workers, particularly by age-group and geographic region.

The purpose of this study was to estimate the age-group-specific prevalence of depression among U.S. workers with diabetes and to identify factors associated with depression such as sex, race/ethnicity, education, marital status, any chronic disease other than diabetes, BMI, smoking status, binge drinking, and physical activity. Examining how depression affects workers by location, age, and sex could help tailor workplace health promotion programs to address the specific needs of workers with diabetes and depression.

Research Design and Methods

The U.S. Behavioral Risk Factor Surveillance System (BRFSS) is a repeated cross-sectional, state-based, random digit-dialed telephone survey that collects data on health-related risk behaviors, chronic health conditions, and the use of preventive services from noninstitutionalized adults ≥ 18 years of age. This study used data from the core component of the BRFSS questionnaire, which has a standard set of questions that all states administered between 2014 and 2018.

BRFSS participants were asked about their current (at the time of the survey) employment status, and respondents who answered that they were “employed for wages” or “self-employed” were included in the analyses. Of the 1,098,228 adult respondents who were employed for wages or self-employed at the time of the survey (2014–2018), 6.4% reported having diabetes, yielding a study sample of 84,659 (69,213 employed for wages and 15,446 self-employed). The overall combined landline and cellular phone response rates among states, Puerto Rico, Guam, the U.S. Virgin Islands, and Washington, DC, ranged from 38.8 to 67.2% (median 49.9%) between 2014 and 2018. A detailed description of the survey design and sampling methodology is available elsewhere (14).

Study Definitions

Self-Reported Diabetes

Diabetes was defined as a “yes” response to the question, “Has a doctor, nurse, or other health professional ever told you that you have diabetes?” Females who reported only

gestational diabetes (diabetes during pregnancy) were not included in the “yes” response of the study definition. The type of diabetes was not available in the core questionnaire.

Self-Reported Depression

Depression was defined as a “yes” response to the question, “Has a doctor, nurse, or other health professional ever told you that you have a depressive disorder (including depression, major depression, dysthymia, or minor depression)?”

Employment Status

Respondents’ employment status was categorized as “employed” when the answer to, “Are you currently (select the category which best describes you)?” was either “employed for wages” or “self-employed.” The status was considered to be “unemployed/unable to work” when the answer was “retired,” “out of work for 1 year or more,” “out of work for less than 1 year,” or “unable to work.” Home-makers and students were excluded from the analysis.

Age

Respondents’ age responses were placed into one of four categories: 18–34, 35–54, 55–64, and ≥ 65 years.

Risk Factors

On the basis of the literature (15,16), we adjusted for nine risk factors, all self-reported by the respondent: sex, race/ethnicity, education, marital status, any chronic disease other than diabetes (including coronary heart disease, asthma, arthritis, chronic obstructive pulmonary disease, chronic kidney disease, and cancer [except skin cancer]), weight status, cigarette smoking status, binge drinking, and physical inactivity. Weight status was classified as underweight/normal (BMI < 25 kg/m²), overweight (BMI 25–29.9 kg/m²), or obesity (≥ 30 kg/m²). Physical inactivity was defined as never engaging in any physical activity or exercise during the past 30 days other than the respondent’s regular job.

Statistical Analysis

To account for the complex sampling design, survey weights were included, and analyses were completed with SAS software for survey procedures (2002–2010) (SAS Institute, Cary, NC). Bivariate analyses were performed to assess the relationship between self-reported depression among those who have diabetes (dependent variable) and each independent demographic characteristic, physical health condition, and behavior (categorical variables). Logistic regression analyses were performed to assess the relationship between self-reported depression among those with diabetes and each of the independent variables: sex, race/ethnicity, education, marital status, chronic disease other than diabetes, weight

status, cigarette smoking status, binge drinking, and physical inactivity. Multivariable models for each of the primary independent variables were built to adjust for all other risk factors for self-reported depression among those with diabetes. Univariate and multivariable survey logistic regression analyses were conducted to examine associations between depression and diabetes by age-group. Least squares means were used to compare prevalence rates across years. A *P* value <0.05 was considered significant.

Results

The weighted prevalence of depression among individuals with diabetes was 17.4%, which was 30% higher than in those without diabetes (13.3%, *P* <0.0001). The overall weighted prevalence of depression among U.S. workers with diabetes dropped in 2018 and was significantly different from that of 2017 (*P* <0.001). However, the prevalence in 2018 was still higher than during the 2014–2016 period. Also, the prevalence of depression among U.S. workers with diabetes was significantly different from both the prevalence of diabetes alone and the prevalence of depression alone among workers (*P* <0.001) (Figure 1). We found that the prevalence of diabetes has not significantly changed from the 2014–2017 period. However, the prevalence of diabetes in 2018 was significantly higher than that in 2014 (*P* <0.001), 2015 (*P* <0.001), 2016 (*P* <0.001), and 2017 (*P* <0.001).

Table 1 shows the prevalence of self-reported depression among U.S. workers with diabetes by age-group and selected characteristics. The prevalence of depression was higher

among U.S. workers with diabetes who were non-Hispanic White than other races/ethnicities and was higher among workers with some college compared with workers in other education categories. Additionally, the prevalence of depression was highest among workers 18–34 years of age (28.7%) and lowest among those ≥65 years of age (11.4%) (*P* <0.001). This pattern of depression prevalence by age was similar when examined by demographic characteristics, physical health conditions, and behaviors.

The prevalence of depression among workers with diabetes and any other chronic disease was 50.6% among those 18–34 years of age, whereas it was 15% among workers ≥65 years of age (*P* <0.001). Similarly, the prevalence of depression in current cigarette smokers with diabetes was 44.4% in those 18–34 years of age compared with 25.8, 33.8, and 23.9% among those 35–54, 55–64, and ≥65 years of age, respectively (*P* <0.001).

Table 2 shows the factors associated with the prevalence of depression among current U.S. workers with diabetes by age-group. Some of the factors such as sex, any other chronic disease, smoking status, obesity, and physical inactivity were significantly associated with increased risk of reporting depression among workers for most age-groups. For example, young female workers (18–34 years of age) with diabetes had 1.7 times greater odds of reporting depression than males of the same age-group after adjusting for risk factors (adjusted odds ratio [aOR] 1.69, 95%CI 1.20–2.38). Female workers aged 35–54 and 55–64 years with diabetes had 2.5 and 2.2 times higher odds of reporting depression compared with males,

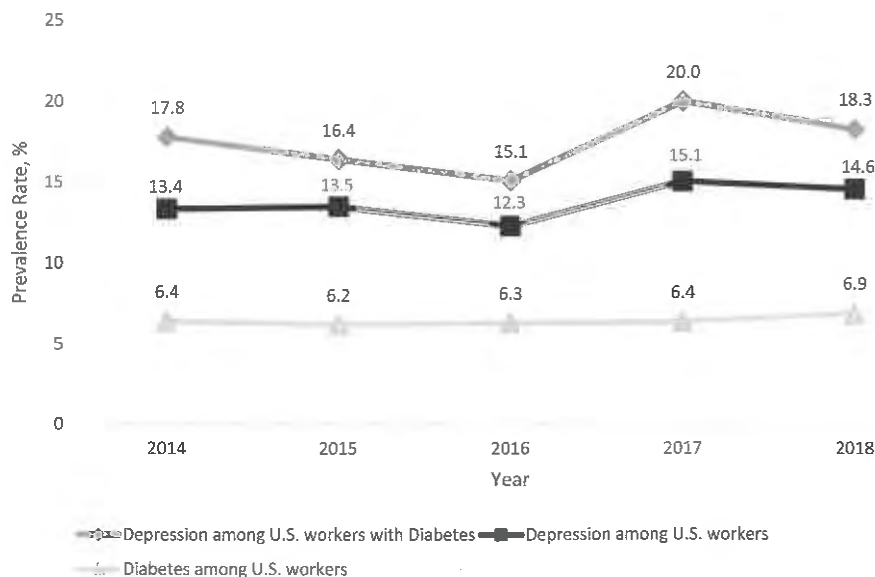


FIGURE 1 Weighted prevalence (%) among U.S. workers of depression, diabetes, and depression with diabetes, BRFSS 2014–2018.

TABLE 1 Prevalence of Depression Among U.S. Workers With Diabetes by Age-Group and Selected Characteristics, BRFSS 2014–2018

Characteristics	Unweighted Sample Size*	Overall		Age-Group Weighted Prevalence, % (SE)				P
		Estimated Cases, million†	Weighted Prevalence, % (SE)	18–34 Years	35–54 Years	55–64 Years	≥65 Years	
Overall	84,659	1.5	17.4 (0.3)	28.7 (1.3)	18.9 (0.4)	15.8 (0.4)	11.4 (0.5)	<0.001
<i>Demographics</i>								
<i>Sex</i>								
Male	35,943	0.5	12.2 (0.3)	21.4 (1.8)	12.6 (0.5)	11.4 (0.6)	8.9 (0.6)	<0.001
Female	31,378	0.7	24.8 (0.5)	32.2 (2.1)	28.0 (0.8)	22.1 (0.8)	16.4 (1.0)	<0.001
<i>Age, years</i>								
18–34	3601	0.2	28.7 (1.3)	–	–	–	–	–
35–54	29,063	0.7	18.9 (0.4)	–	–	–	–	–
55–64	32,745	0.5	15.8 (0.4)	–	–	–	–	–
≥65	19,250	0.2	11.4 (0.5)	–	–	–	–	–
<i>Race/ethnicity</i>								
Non-Hispanic White	59,074	1.0	20.5 (0.3)	33.5 (1.7)	23.3 (0.5)	19.3 (0.5)	12.8 (0.5)	<0.001
Non-Hispanic Black	9,065	0.2	13.1 (0.6)	20.6 (2.8)	15.0 (1.0)	9.9 (1.1)	7.6 (1.4)	<0.001
Non-Hispanic other	7,213	0.1	13.0 (1.0)	22.9 (3.5)	14.7 (1.5)	10.4 (1.9)	8.2 (1.7)	<0.001
Hispanic	7,939	0.2	14.4 (0.7)	27.4 (3.2)	14.5 (0.9)	11.6 (1.2)	8.4 (1.6)	<0.001
<i>Education</i>								
Less than high school	5,555	0.2	15.6 (0.8)	33.8 (4.6)	15.3 (1.1)	14.4 (1.6)	9.5 (1.5)	<0.001
High school diploma	23,357	0.4	16.2 (0.5)	28.6 (2.2)	17.3 (0.7)	14.4 (0.7)	10.3 (0.7)	<0.001
Some college	25,213	0.6	20.1 (0.5)	32.1 (2.4)	22.3 (0.8)	17.3 (0.8)	13.9 (1.0)	<0.001
College degree or more	30,350	0.4	16.6 (0.4)	20.1 (1.7)	18.7 (0.7)	16.5 (0.7)	10.7 (0.6)	<0.001
<i>Marital status</i>								
Married/living with partner	51,914	0.8	14.8 (0.3)	26.8 (2.0)	16.3 (0.5)	13.8 (0.5)	9.3 (0.5)	<0.001
Never married	10,777	0.3	23.2 (0.8)	28.3 (1.8)	22.9 (1.2)	20.3 (1.4)	12.0 (1.8)	<0.001
Widowed/divorced/separated	21,558	0.4	22.0 (0.6)	38.2 (4.3)	25.2 (0.9)	20.4 (1.1)	15.8 (1.1)	<0.001
<i>Physical health conditions</i>								
<i>Any other chronic disease‡</i>								
Yes	39,512	0.9	24.5 (0.4)	50.6 (3.2)	30.3 (0.8)	22.1 (0.7)	15.0 (0.7)	<0.001
No	45,147	0.7	12.8 (0.3)	23.7 (1.4)	13.4 (0.4)	10.5 (0.5)	6.6 (0.5)	<0.001
<i>Weight status</i>								
Underweight/normal	9,180	0.2	15.0 (0.7)	27.4 (2.7)	16.0 (1.1)	11.9 (1.4)	8.6 (1.0)	<0.001
Overweight	24,177	0.3	13.1 (0.4)	22.6 (2.7)	13.3 (0.6)	13.4 (0.7)	9.5 (0.7)	<0.001
Obesity	44,856	0.9	20.5 (0.4)	31.6 (1.9)	22.1 (0.5)	18.4 (0.7)	14.2 (0.8)	<0.001
<i>Behaviors</i>								
<i>Smoking status</i>								
Current smoker	10,839	0.3	25.8 (0.8)	44.4 (3.0)	25.8 (1.0)	33.8 (1.7)	23.9 (0.9)	<0.001
Former smoker	25,242	0.5	18.5 (0.5)	32.6 (3.4)	20.7 (0.8)	26.3 (1.2)	17.9 (0.4)	<0.001
Never smoker	45,409	0.7	15.3 (0.3)	22.2 (1.6)	16.6 (0.5)	25.1 (0.9)	16.1 (0.4)	<0.001
<i>Binge drinking</i>								
Yes	7,658	0.2	20.0 (0.9)	32.5 (3.0)	19.2 (1.2)	16.4 (1.9)	15.1 (2.9)	<0.001
No	72,499	1.3	17.4 (0.3)	27.6 (1.5)	19.2 (0.4)	16.1 (0.5)	11.6 (0.5)	<0.001
<i>Physically inactive</i>								
Yes	25,953	0.5	20.0 (0.5)	30.6 (2.7)	22.4 (0.8)	18.7 (0.8)	13.6 (0.9)	<0.001
No	56,140	1.0	16.7 (0.3)	28.7 (1.5)	18.0 (0.5)	14.8 (0.5)	10.3 (0.5)	<0.001

*Missing data not shown. †Estimated cases are the weighted frequency of depression among current workers with diabetes. ‡Any other chronic disease includes coronary heart disease, asthma, arthritis, chronic obstructive pulmonary disease, chronic kidney disease, and cancer (except skin cancer).

respectively (aOR 2.51, 95% CI 2.19–2.87, and aOR 2.22, 95% CI 1.89–2.60, respectively). Similarly, in a comparison of workers with diabetes who had any other chronic condition versus those without any other chronic disease, for young adult

workers, the odds of reporting depression were 2.6 times greater (aOR 2.59, 95% CI 1.77–3.80), and for those 35–54, 55–64, and ≥65 years of age, the odds were 2.2, 2.0, and 2.0 times greater, respectively (aOR 2.16, 95% CI

TABLE 2 Factors Associated With Prevalence of Depression Among Current U.S. Workers With Diabetes by Age-Group, BRFSS 2014–2018

Characteristics	18–34 Years		35–54 Years		55–64 Years		≥65 Years	
	Crude OR (95% CI)	aOR (95% CI)*	Crude OR (95% CI)	aOR (95% CI)*	Crude OR (95% CI)	aOR (95% CI)*	Crude OR (95% CI)	aOR (95% CI)*
Demographics								
Sex								
Male	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Female	1.74 (1.31–2.31)	1.69 (1.20–2.38)	2.69 (2.38–3.05)	2.51 (2.19–2.87)	2.21 (1.91–2.56)	2.22 (1.89–2.60)	2.00 (1.65–2.44)	2.03 (1.64–2.52)
Race/ethnicity								
Hispanic	1.27 (0.75–2.16)	1.26 (0.66–2.42)	0.98 (0.74–1.30)	1.04 (0.75–1.43)	1.14 (0.72–1.79)	0.97 (0.53–1.77)	1.04 (0.57–1.87)	0.79 (0.39–1.62)
Non-Hispanic Black	0.87 (0.50–1.50)	0.70 (0.37–1.32)	1.02 (0.77–1.36)	0.71 (0.51–0.98)	0.95 (0.60–1.50)	0.63 (0.35–1.15)	0.93 (0.52–1.66)	0.64 (0.32–1.26)
Non-Hispanic White	1.69 (1.07–2.68)	1.68 (0.98–2.88)	1.76 (1.37–2.26)	1.54 (1.18–1.99)	2.07 (1.39–3.07)	1.56 (0.94–2.58)	1.65 (1.06–2.57)	1.15 (0.70–1.89)
Non-Hispanic other	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Education								
Less than high school	2.02 (1.29–3.18)	1.46 (0.77–2.79)	0.79 (0.65–0.96)	0.81 (0.63–1.05)	0.85 (0.65–1.12)	0.80 (0.54–1.19)	0.87 (0.61–1.25)	0.77 (0.50–1.18)
High school diploma	1.59 (1.18–2.15)	1.50 (0.99–2.27)	0.91 (0.79–1.04)	0.72 (0.61–0.85)	0.86 (0.74–0.99)	0.65 (0.55–0.78)	0.95 (0.78–1.16)	0.71 (0.56–0.89)
Some college	1.88 (1.39–2.54)	1.70 (1.16–2.49)	1.25 (1.09–1.43)	0.98 (0.84–1.15)	1.06 (0.92–1.23)	0.79 (0.65–0.95)	1.34 (1.09–1.66)	0.90 (0.71–1.15)
College degree or more	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Marital status								
Widowed/divorced/separated	1.69 (1.12–2.55)	1.00 (0.57–1.76)	1.73 (1.58–1.96)	1.56 (1.33–1.83)	1.60 (1.38–1.86)	1.29 (1.07–1.56)	1.83 (1.51–2.21)	1.55 (1.24–1.94)
Never married	1.08 (0.82–1.42)	1.06 (0.74–1.50)	1.53 (1.32–1.79)	1.60 (1.31–1.95)	1.59 (1.32–1.92)	1.40 (1.12–1.76)	1.32 (0.93–1.87)	0.86 (0.59–1.24)
Married/living with partner	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Physical health conditions								
Any other chronic disease								
Yes	3.30 (2.47–4.40)	2.59 (1.77–3.80)	2.81 (2.52–3.12)	2.16 (1.89–2.47)	2.43 (2.13–2.78)	2.00 (1.69–2.36)	2.49 (2.04–3.04)	2.02 (1.58–2.58)
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Weight status								
Obesity	1.22 (0.89–1.68)	1.16 (0.79–1.70)	1.49 (1.23–1.80)	1.74 (1.37–2.20)	1.68 (1.28–2.21)	1.55 (1.13–2.13)	1.76 (1.34–2.32)	1.89 (1.43–2.50)
Overweight	0.77 (0.52–1.15)	0.66 (0.43–1.03)	0.81 (0.65–1.00)	1.02 (0.78–1.32)	1.15 (0.86–1.52)	1.12 (0.81–1.54)	1.11 (0.83–1.49)	1.45 (1.07–1.96)
Underweight/normal	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Behaviors								
Smoking status								
Current smoker	2.80 (2.07–3.78)	2.31 (1.52–3.51)	1.76 (1.53–2.01)	1.58 (1.33–1.88)	1.59 (1.35–1.88)	1.49 (1.22–1.83)	1.76 (1.24–2.49)	1.68 (1.15–2.46)
Former smoker	1.70 (1.19–2.42)	1.43 (0.92–2.21)	1.31 (1.15–1.50)	1.30 (1.10–1.53)	1.41 (1.22–1.64)	1.34 (1.13–1.60)	1.21 (1.00–1.45)	1.14 (0.91–1.43)
Never smoker	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Binge drinking								
Yes	1.27 (0.93–1.72)	0.87 (0.59–1.27)	1.00 (0.85–1.18)	1.00 (0.82–1.23)	1.02 (0.77–1.35)	1.11 (0.81–1.52)	1.35 (0.85–2.13)	1.91 (1.12–3.25)
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Physically inactive								
Yes	1.09 (0.81–1.46)	0.90 (0.62–1.32)	1.31 (1.17–1.48)	1.17 (1.01–1.36)	1.33 (1.17–1.52)	1.27 (1.06–1.52)	1.38 (1.15–1.66)	1.09 (0.88–1.34)
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.

Bold type indicates statistical significance. *Adjusted for sex, age, race/ethnicity, education, marital status, any other chronic condition, BMI, smoking status, binge drinking, and physically inactivity. Ref., reference category.

1.89–2.47; 2.00, 95% CI 1.69–2.36; and 2.02, 95% CI 1.58–2.58, respectively). For young workers with diabetes who currently smoked cigarettes, the odds of reporting depression were 2.31 times greater than those who never smoked (aOR 2.31, 95% CI 1.52–3.51).

Figure 2 shows the prevalence of depression, diabetes, and depression plus diabetes among U.S. workers by state in the 2014–2018 period. The prevalence of depression was among workers in Washington, Oregon, West Virginia, Vermont, and Maine, with prevalence rates ranging from 18 to 21.9%. The prevalence of diabetes was highest among workers in the southern and Appalachian states, including Texas, Louisiana, Mississippi, Tennessee, Alabama, Arkansas, Kentucky, West Virginia, Maryland, and Delaware, with prevalence rates ranging from 7 to 8.9%. The prevalence of depression among U.S. workers with diabetes was highest among workers living in Washington, Oregon, Montana, and Vermont, with prevalence rates ranging from 25 to 30%. Supplementary Table S1 lists U.S. prevalence rates by state.

Discussion

In this study, we found that depression was more prevalent in workers with diabetes than in those without diabetes. Also, the prevalence of depression among workers with diabetes was found to be inversely related to age. Although the prevalence of depression is related to age, in general, the prevalence is much higher among individuals with diabetes. The prevalence was highest among 18- to 34-year-old workers with diabetes, followed by those 35–54, 55–64, and ≥ 65 years of age.

Our findings are consistent with previous studies that found that young adults with diabetes are more likely than older adults to have clinically meaningful symptoms of depression (17–19). Young adult workers (aged 18–34 years) are at a life stage during which they are focused on building their careers, and additional responsibilities such as school, family, and relationships may compete with the demands of managing diabetes (e.g., self-care, physician appointments, and adherence to a healthful diet) (19,20). This is the period during which young

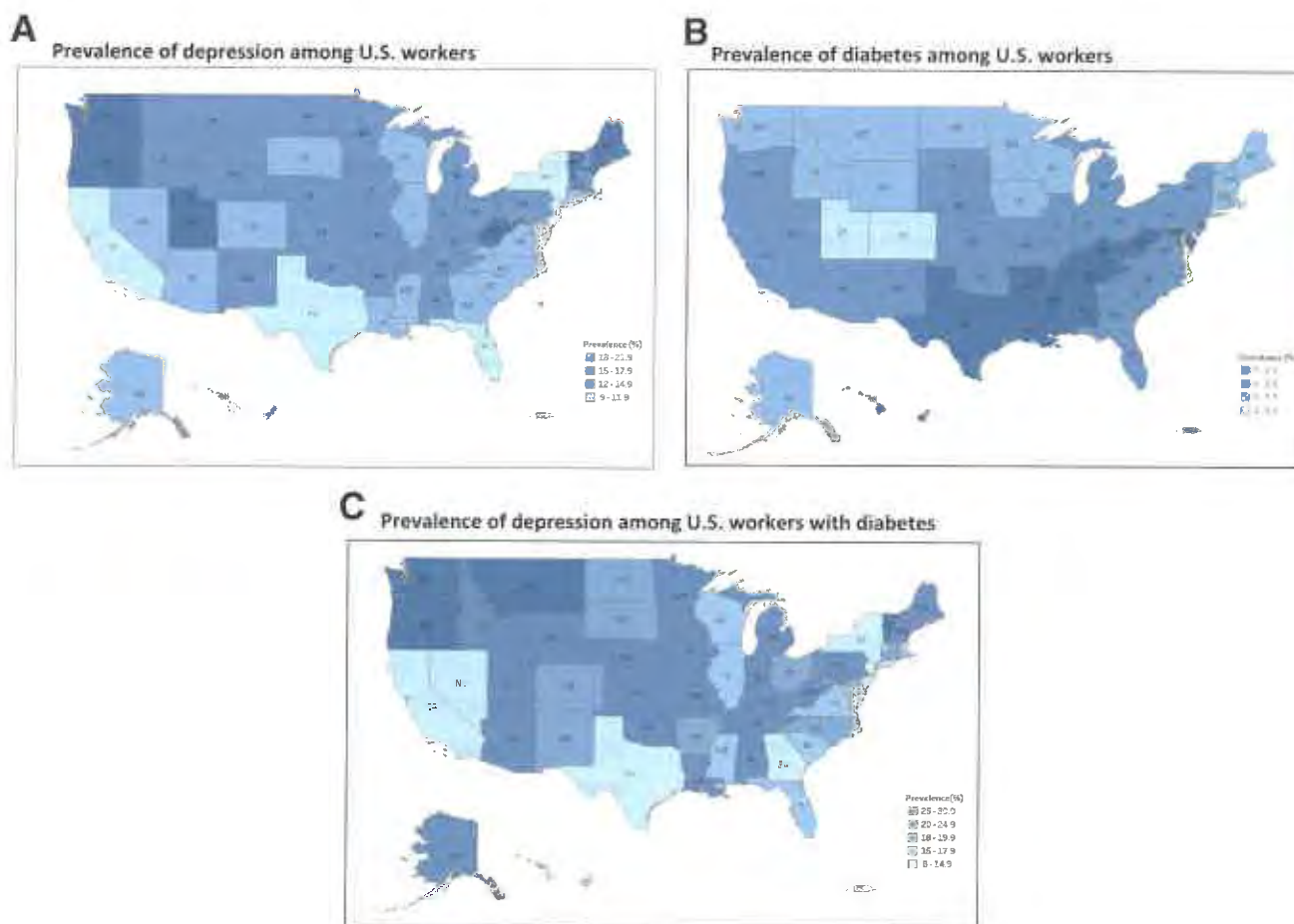


FIGURE 2 Prevalence of depression (A), diabetes (B), and depression plus diabetes (C) among U.S. workers by state or territory, BRFSS 2014–2018.

adults tend to take risks and have increased exposure to cigarette smoking, alcohol, and illicit drugs (21). We also found that workers with diabetes in the 18- to 34-year-old age-group who were current smokers were 2.8 times more likely to self-report depression than individuals who never smoked. Additionally, young adult workers with diabetes may also experience negative stereotypes, discrimination, and lost opportunities that may affect their mental health (22,23).

This study also found that, regardless of age, female workers with diabetes in the United States are more likely to self-report depression than their male counterparts. In the general population as well, women experience depression about twice as often as men (24). However, the prevalence of depression is higher among women with diabetes than among those without diabetes. Moreover, the association between the prevalence of depression in U.S. workers with diabetes tended to be stronger among female workers. Another study found a significantly higher prevalence of depression among women with diabetes than among their male counterparts (25). This study indicated that the prevalence of depressive disorders among women with diabetes was nearly one-third higher than among men with diabetes (25).

According to American Diabetes Association, various biological factors related to menstrual cycle changes, pregnancy, and the pre- and post-menopause periods and additional stressors related to caregiver responsibilities and work/family balance issues may contribute to increased rates of depression in U.S. women (26). Conversely, there is some evidence suggesting that depression may be more underdiagnosed in men, particularly because it is expressed differently for men than for women (24). Unfortunately, examining biological and psychosocial factors and their association with comorbid diabetes and depression was beyond the scope of this study; future studies should consider exploring this area.

Our study results indicate that workers with diabetes who had any other coexisting chronic condition were significantly more likely to report depression than those who did not have another chronic condition, irrespective of age. Specifically, for young adult workers with diabetes (18–34 years of age) who had a coexisting chronic disease, the odds of self-reporting depression were 2.59 times higher than for those who did not. A prior study found that, among people with diabetes, the odds of having depression increases from 1.31 for those with one additional chronic condition to 4.09 for those with three or more chronic conditions compared with those with diabetes alone (27). One of the plausible reasons could be that having additional chronic conditions and managing them may increase the psychosocial burden of illness. In addition, these conditions may have biological effects that individually or

collectively increase the risk of depression. The association might also be the reverse. Having depression might also lead to unhealthy eating habits and physical inactivity (28).

Consistent with other studies, we found that current and former smoking was independently associated with depression among workers with diabetes across most age-groups except for former smokers who were 18–34 or ≥ 65 years of age. A cross-sectional study found that the number of cigarettes smoked was significantly associated with depression among people with diabetes (29). Another study reported that smokers with diabetes were 60% more likely than nonsmokers with diabetes to report often feeling sad or depressed, even after adjusting for risk factors (30). Although smoking prevalence among individuals with diabetes is comparable to that in the general population, smoking increases insulin resistance, thus increasing a person's risk of type 2 diabetes (31,32). Future studies might consider exploring whether smoking as an adolescent or at a young age predisposes workers to diabetes or depression and the extent to which it affects their work performance or productivity.

Surprisingly, we did not find overlapping patterns of prevalence of diabetes and depression by state. We expected states with a higher prevalence of diabetes to also have a higher prevalence of depression because of past studies demonstrating links between these two conditions (6); it is unclear why we did not see that pattern. This unexpected finding could be the result of possible underreporting of depression, which has been shown in previous studies (33,34). Future studies should explore the regional/geographic factors that affect the association between diabetes and depression among U.S. workers.

Although the trend in diabetes among U.S. workers has not changed much over time, the prevalence of depression alone and of depression with diabetes among U.S. workers has increased since 2016, with only a slight decrease in 2018. All people, including those with diabetes, may benefit from routine screenings for depression (35). Also, future studies are needed to examine the psychosocial factors that may put workers with diabetes at higher risk for depression, particularly socioeconomic factors such as food insecurity, adverse life events, and lack of social support (36–38).

This study has some limitations. First, this was a cross-sectional study; therefore, we cannot infer causality of the relationship between depression and diabetes. Second, we were unable to classify diabetes by type due to data limitations. However, according to the Centers for Disease Control and Prevention, 90–95% of Americans with diabetes have type 2 diabetes (39). Third, diabetes and depression were self-reported, making underreporting likely. Nevertheless, there is substantial agreement between self-report and medical records for diabetes and depression (40).

Conclusion

A significant contribution of this study is its exploration of the relationship between diabetes and depression among U.S. workers by age-group in a large population-based sample. The results indicate that workers with diabetes who were 18–34 years of age, non-Hispanic White, and female were most likely to experience depression. Depression care that focuses on the specific needs of younger adult workers is needed. During young adulthood, workers are in a transitional period characterized by efforts to define their identity, purpose, career path and interests, and work goals. Transition into adulthood can be challenging and may increase the risk for depression. Adding diabetes as a comorbid condition that young adult workers may experience can increase stress and affect young adult workers' ability to cope on the job.

Workplace wellness programs can aid young workers and women with diabetes in addressing depression as well as stress management. Preventive measures such as tailored educational messages and health promotion resources can focus on stressors specific to women and ways to manage depression and diabetes during specific periods in a woman's life such as postpartum or around menopause. Younger workers might also benefit from wellness initiatives that educate them on the effects of stress on diabetes management and the ability to function at work.

Addressing depression and diabetes at work can have a positive impact on the physical and mental health and productivity of all employees (41). Moreover, increasing opportunities for employees to receive depression care interventions can help to reduce both the burden of these conditions on the workplace and their overall costs (42). Health promotion programs at work might also address multiple, instead of single, risk factors that affect workers. Also, employee assessment (e.g., biometric screening and/or health assessment as part of health promotion programs) would allow for messages to be tailored for high-risk populations and provide opportunities to explore workers' needs and interests in health promotion interventions. Lastly, effective workplace efforts should extend beyond worker education interventions to include policies and environmental supports that enable behavior change.

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DUALITY OF INTEREST

No potential conflicts of interest relevant to this article were reported.

AUTHOR CONTRIBUTIONS

H.K. analyzed and wrote the manuscript. J.C.S. reviewed/edited the manuscript and contributed to the discussion. M.O.-G. reviewed/edited the manuscript and contributed to the discussion and conclusion. All authors contributed to conceptualization of this manuscript. H.K. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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