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Association of workforce participation with depression among US older adults: results from NHANES 2005–2018

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Abstract

Background The challenges of global aging would boost more workforce participation of older adults, and depression rate was increasing among older adults. This study aimed to explore the associations of workforce participation with depression among US older adults.

Methods This cross-sectional study used data from the National Health and Nutrition Examination Survey (NHANES) 2005–2018. Depression was measured with Patient Health Questionnaire-9 items (PHQ-9). Workforce participation was measured with work status, work types, shift work, and hours worked per week. Multivariate generalised linear and logistic regression models, also with restricted cubic spline (RCS) were performed to examine linear or non-linear associations between workforce participation and depression. Analyses of subgroup and sensitivity were conducted: using data from non-multiple imputation, participants aged over 65, and all non-excluded participants aged 60 or above to execute repeated analysis; recruiting propensity score matching (PSM) method that focused on selected SDoH, lifestyle, and health status-related factors to strengthen essential comaparability between workers and non-workers; employing two-stage least squares (2SLS) model and setting retirement age (over 65 years or not) as an instrumental variable (IV) to solve the potential reverse causation between work status and depression.

Results A total of 10,312 participants aged 60 or above were enrolled with a prevalence of depression of 6.4%. There was a significantly negative association of PHQ-9 score with working (Exp [β] = 0.68; 95%CI: 0.53–0.87), working as private employee (Exp [β] = 0.67; 95%CI: 0.50–0.89), or working on regular daytime (Exp [β] = 0.65; 95%CI: 0.52–0.82). Especially, regular daytime working reduced depression risk by 52% compared with those who not working (OR = 0.48; 95%CI: 0.27–0.87). A significant decreased PHQ-9 score and depression risk as hours worked per week increased until reaching 34.86 and 25.35 in the RCS for generalised linear and logistic regression models, respectively. These effects were consistent across the analyses of subgroup and sensitivity.

Conclusions Regular daytime working was positively related to decreased depression risk among US older adults, and the suggested optimal working hours were 25 to 35 per week. Policymakers should appreciate the potential value of moderate workforce participation to mental health among older adults.

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Keywords Older adults, Depression risk, Labor force participation, Cross-sectional study

Background

Depression, is a common mental disorder associated with low mood, indifference, sadness, weariness, reduced motivation, guilt feelings, and even suicidal tendencies [1–3], and is highly prevalent and severe among older adults [4]. The global depression prevalence among older adults aged 60 years or above was estimated to had increased from 3.8% in 2000 to 6.0% in 2019, and accounted for about 6.4% cause of death or injury among older adults aged between 60 and 70 years in 2021 [5]. The latest estimated 5.7% of older adults aged over 60 years suffered from depression worldwide according to World Health Organization (WHO) in March 2023 [6]. Depression prevalence among US older adults aged 65 years reached 7.0% in April 2020 [7], and major depressive symptom has been confirmed as an independent risk factor for all-cause mortality in the US elderly population [8]. Also, depression and cardiovascular disease were estimated to be the two leading causes of disability by 2030 [9]. In turn, aging brings physiological changes with depression, isolation, and sensory impairment, which further exacerbate the risk of death.

Much of existing studies pay more attention to the association of depression with health behaviors (physical activity, dietary nutrition) and health status (hypertension, diabetes) in older adults [10–13], a few workforce participation-related research confined to the impact of retirement on mental health, the results have been mixed [14]. Previous research suggests that the impact of workforce participation on depression among older adults may vary, based on factors such as age, gender, work types or schedules, which can affect material living and health standards, also the perceptions of workforce participation. For example, a study used the data of UK biobank showed that night shift work was associated with an increased risk of depression regardless of genetic risk [15], shift work disorder increased the poor mental health risks of depression, anxiety, and stress [16]. It has also been suggested that gender inequalities at the labor market substantially explain the gender gap in depression risk in US older adults [17]. In consequence, if workforce participation of older adults affects their depression risk, it would be necessary to further explore potential differences across various populations and determine the impact of specific status, types, schedules, and duration of work on depression risk.

Beyond that, global aging provokes a variety of economic and social challenges exemplified by shrinking workforce and increasing disease burdens [18–20], while boosting the workforce participation rate of older people is widely regarded as one of essential solutions [20, 21]. However, extending working life means that older people would be "exposed" to work for longer periods of time, and this exposure would occur at a time in life that is typically characterized by deteriorating health, with concerns about the influence of older people's workforce participation on their health and longevity [22]. Fortunately, there was no direct evidence from prior research that clear positive correlation of the late-life working with depression among older adults, and previous studies have shown that retirement may increase depressive symptoms, encouraging late-life working participation may alleviate mental health risk of retirement-aged workers [14, 23, 24].

Accordingly, more research is need to confirm the association between workforce participation and depression among older adults. Therefore, we conducted a cross-sectional study to explore the associations of workforce participation with depression among US older adults by using the National Health and Nutrition Examination Survey (NHANES) data. Furthermore, we further evaluated the dose–response relationship between working hours and depression.

Methods

Study population

The data on the participants were obtained from the NHANES, an ongoing national survey conducted by the Centers for Disease Control and Prevention that focused on Americans' dietary nutrition and general health. Signed informed consent from all participants before participating in the study, and all study protocols were approved by the National Center for Health Statistics' ethical review board. Detailed information about the database can be visited at the NHANES website [25]. Specifically, data for this cross-sectional study was gathered from the NHANES 2005–2018. Our study only included individuals aged 60 years or above (N = 13,480). Following elimination for refused response or answered do not know (N = 396), missing data on working status or PHQ-9 items (N = 1,707), and social determinants of health (SDoH) factors (N = 1,065), finally 10,312 eligible participants left for analysis (Fig. 1).

Assessment of depression

The Patient Health Questionnaire-9 items (PHQ-9) was used by the NHANES to assess depression. The PHQ-9 consist of nine signs and symptoms for depression: interest blank, depressed mood, sleeping troubles, fatigue, appetite problems, worthlessness feelings, attention problems, somatization disorders, and suicidal thoughts [26]. Each item on a scale from "0" (not at all) to "3"

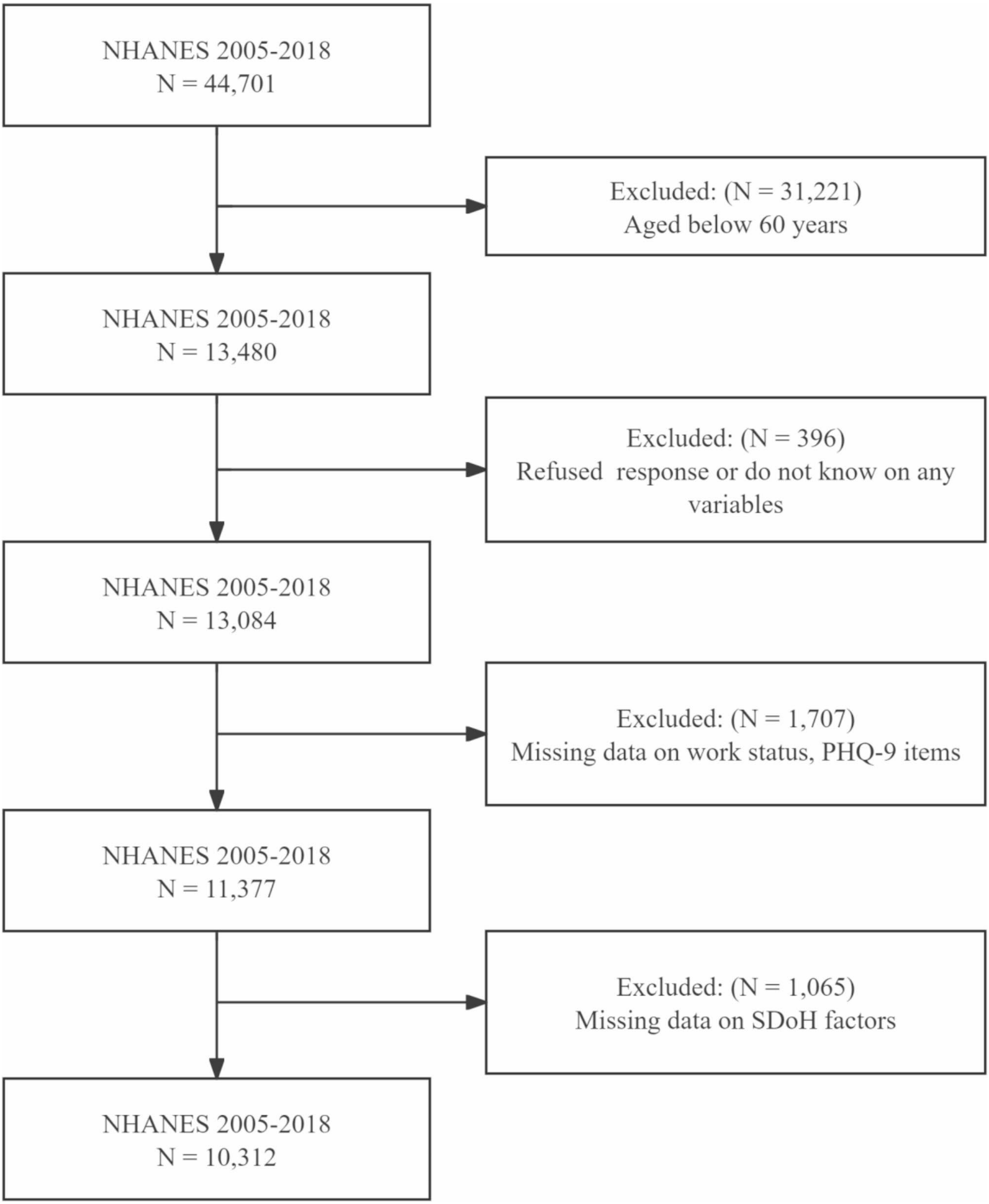

Fig. 1 Flowchart of participants selection
Notes: NHANES, National Health and Nutrition Examination Survey. Social determinants of health (SDoH) factors include age, gender, education, household size, marital status, poverty income ratio (PIR), pension receipt, and race

(nearly every day), total score can range from 0 to 27. A PHQ-9 score was further divided into binary categories: depression with a score ≥ 10, while no depression with a score < 10 [27]. The sensitivity and specificity for detecting major depression was 88% at a cut-off of 10 [28].

Assessment of workforce participation

Based on the previous studies [16, 29], we used four measures of workforce participation at the individual level: work status, hours worked per week, work types, and shift work. According to prior research [30], work status (working vs. not working) in the NHANES was captured by participants reporting whether they were working at a job or business last week. Specifically, working, referring to "working at a job or business last week"; not working, including "not working at a job or business last week", "with a job or business but not at work last week", and "looking for work last week". Furthermore, individual disclosed the number of hours they worked last week at all jobs or businesses, and we used hours worked per week as a continuous indicator for working. Private employee, government (including federal, state, and local) employee, self-employed, and unpaid family business or farm were covered as different types of workforce participation by the NHANES. Shift work was assessed with the following response options: regular daytime, evening shifts, night shifts, rotating shifts, or another schedule. Evening and night shifts were combined, another schedule and other multistates were classified into "other schedules", by referring the study [31].

Assessment of covariates

Based on previous studies [32–36], SDoH, lifestyle, and health status-related factors that may affect the association between workforce participation and depression were included in our study. SDoH factors included age (years), gender (male, female), education (high school graduate or higher, less than high school), household size (large, small), marital status (married or living with a partner, not married nor living with a partner), poverty income ratio (PIR, poor, not poor), pension receipt (yes, no), and race (Black, Hispanic, White, Other). Lifestyle factors included drinking status (drinker, non-drinker), smoking status (smoker, non-smoker), inflammatory diet (anti-inflammatory, pro-inflammatory), and physical activities (inactive, moderate, vigorous). Health status-related factors included body mass index (BMI, underweight, normal, overweight, obese), diabetes (yes, no), hypertension (yes, no), and self-reported perceived health (fair or poor, good or better).

Generally, a PIR value < 1 was considered poor, a PIR value ≥ 1 was defined as not poor [26]. Household size was defined as large if total number of people in the household exceed 2, otherwise was defined as small, given that the average total number of people in the household was 2.31. Pension receipt sources included disability, and retirement or survivor. The dietary inflammatory index (DII) was developed to measure inflammatory diet [37], and was calculated using 28 of 45 dietary parameters generally due to the NHANES data limited: alcohol, carbohydrates, caffeine, carotene, cholesterol, energy, fiber, folic acid, iron, magnesium, monounsaturated fatty acids, niacin, n-3 fatty acids, n-6 fatty acids, polyunsaturated fatty acids, protein, saturated fatty acids, selenium, thiamine, total fat, vitamin A, vitamin B2, vitamin B6, vitamin B12, vitamin C, vitamin D, vitamin E, and zinc [38]. The R package for standardized calculation has been detailed in prior studies [33], and we adopt it. Anti-inflammatory diet with a DII score < 0, while pro-inflammatory diet with a DII score ≥ 0 [39]. For detailed BMI classes: underweight (BMI < 18.5), normal (18.5 ≤ BMI < 25), overweight (25 ≤ BMI < 30), and obese (BMI ≥ 30) [40]. Self-reported diabetes, glycosylated hemoglobin (HbA1c) ≥ 6.5%, or fasting plasma glucose level ≥ 126 mg/dl were considered diabetes [34]. Self-reported high blood pressure told by doctors, four times measured average systolic/diastolic blood pressure of at least 140/90 mmHg, or antihypertensive medication being used were considered hypertension [9].

Statistical analysis

In our study, the statistical software package R (version 4.4.2) was used for all statistical analysis. A two-side P-value < 0.05 was considered statistically significant. We adopted the recommendations for accurate reporting in medical research statistics [41], using multiple imputation to fill in missing data. Mean ± standard deviation (SD) was used to describe the data for continuous variables. Number (proportion [%]) was used to describe the data for categorical variables. Percentages, means, and standard deviations were derived by applying the full sample 2 year Mobile Examination Center (MEC) exam weight provided by the NHANES. Wilcoxon rank-sum test was performed to compare continuous variables. Chi-squared test with Rao & Scott's second-order correction was employed to compare categorical variables. We performed generalised linear and multivariable logistic regression models to explore the association of work status, work types, and shift work with depression. We further employed restricted cubic spline (RCS) for the linear and logistic models to assess the dose–response relationship between hours worked per week and depression.

In addition, we recruited subgroup analysis and interactions for categorical covariates included SDoH factors: age group, gender, education, household size, marital status, PIR, pension receipt, and race, lifestyle factors: drinking and smoking status, and health status-related factors: diabetes and hypertension. Furthermore, in sensitivity analysis, data of non-multiple imputation, older adults aged over 65 years, and all non-excluded older adults aged 60 years or above to ensure robust results. Also the propensity score matching (PSM) method that focused on SDoH factors: age group, gender, education, household size, marital status, PIR, pension receipt, and race, lifestyle factors: drinking and smoking status, and health status-related factors: diabetes and hypertension were used to strengthen essential comaparability between working and not working older adults [42]. To address potential reverse causality issues that depressive older workers more likely to lose their jobs or seek to quit [23, 43], we applied two-stage least squares (2SLS) model and set the suggested retirement age (over 65 years or not) as an instrumental variable (IV) for examining the association between work status and depression [44, 45]. Besides, given that we included participants with depression assessments over 10 years, there is potential for secular trends in depression prevalence and associations with workforce participation, so we controlled for fixed year effects in all models based on the NHANES survey cycle. All above methods we mentioned would contribute to our robust results and conclusions.

Results

Participants' characteristics

Table 1 presents the characteristics of the weighted study samples. Our analysis enrolled a total of 10,312 older adults aged 60 years or above with a 6.4% depression prevalence, of whom 27.7% and 72.3% were workforce participants and nonparticipants. Compared with older adults who not working, working older adults were significantly more likely to be younger at 65.3 years, be male (53.6%), have high school or above education (89.0%), have larger household size (24.0%), be married or living with partner (70.2%), be not poor (96.0%), have no pension receipt (69.5%), be drinker (75.2%), be non-smoker (52.9%), take anti-inflammatory diet (34.0%), do vigorous physical activities (16.5%), have no diabetes (76.6%), have no hypertension (51.3%), and have good or better self-reported health (90.3%).

Association of work status, work types, and shift work with depression

The mean PHQ-9 score were 2.07 and 3.00 for working and not working older adults with a significance ($P < 0.001$). In model 3 of Table 2, compared with older adults who was not working, PHQ-9 score of those who was working, working as private employee, and working on the regular daytime was significantly reduced by 32% (Exp [$\boldsymbol{\beta}$] = 0.68; 95%CI: 0.53–0.87), 33% (Exp [$\boldsymbol{\beta}$] = 0.67; 95%CI: 0.50–0.89), and 35% (Exp [$\boldsymbol{\beta}$] = 0.65; 95%CI: 0.52–0.82). As shown in model 3 of Table 3, the weighted depression rates were 3.72% and 7.46% for working and not working older adults with a significance ($P < 0.001$), for specific shift work, compared with older adults who was not working, depression risk of those who was working on the regular daytime was significantly reduced by 52% (OR = 0.48; 95%CI: 0.27–0.87).

Association between hours worked per week and depression

The RCS for linear regression model displayed a curvilinear dose–response relationship between hours worked per week and PHQ-9 score, with a p value for non-linearity < 0.05. We observed a negative association between hours worked per week and depression, with a significant decreased PHQ-9 score as hours worked per week increased until reaching 34.86 h per week (Fig. 2A). The RCS for logistic regression model also presented a curvilinear dose–response relationship between hours worked per week and depression risk, with a p value for non-linearity < 0.05. We observed a significant decreased depression risk as hours worked per week increased until reaching 25.35 h per week (Fig. 2B). The best hours worked per week were seemly somewhere between 25 and 35 for US older adults to against depression.

Subgroup analysis

Subgroup analysis was performed to further evaluate the association between work status and depression, stratified with SDoH factors (age, gender, education, household size, marital status, PIR, pension receipt, race), lifestyle factors (drinking status, smoking status), and health status-related factors (diabetes, hypertension). No correlation with the p for interaction meeting the statistical significance was detected on age, gender, education, household size, marital status, PIR, pension receipt, drinking status, smoking status, diabetes, and hypertension (P for interaction > 0.05), but for race (Fig. 3).

Sensitivity analysis

Supplementary eTable1 shows the participants' characteristics on SDoH, lifestyle, and health status-related factors with the data from non-multiple imputation, older adults aged over 65 years, and all older adults aged 60 years or above without exclusion. As shown in Supplementary eTable2, using above datasets to execute repeated analysis, the results were consistent with our primary models, working 25 to 35 h per week was still the best for anti-depression (eFig.1, eFig.2, and eFig.3). Supplementary eTable3 reports the results of the multivariate generalised linear and logistic regression models that benchmark to the model 3 in the Tables 2 and 3, which used matched data by applying PSM method to strengthen essential comaparability between workers and non-worker. The PSM results also indicated a negative association of working with depression (Exp [β] = 0.76;

Table 1 Characteristics of participants, weighted [mean ± SD / n (%)]. [A]

Characteristics	Overall (*n* = 10,312)	Working Status	
		Working (*n* = 2,515)	Not working (*n* = 7,797)
Depression (Outcome)			
Yes	776 (6.4)	98 (3.7)	678 (7.5)
No	9,536 (93.6)	2,417 (96.3)	7,119 (92.5)
Social Determinants of Health (SDoH) Factors			
Age (years)	69.6 ± 6.8	65.3 ± 5.1	71.2 ± 6.7
Gender			
Male	5,180 (45.5)	1,419 (53.6)	3,761 (42.4)
Female	5,132 (54.5)	1,096 (46.4)	4,036 (57.6)
Education			
High school graduate or higher	7,312 (82.2)	1,959 (89.0)	5,353 (79.6)
Less than high school	3,000 (17.8)	556 (11.0)	2,444 (20.4)
Household size			
Large	2,749 (19.6)	832 (24.0)	1,917 (17.9)
Small	7,563 (80.4)	1,683 (76.0)	5,880 (82.1)
Marital status			
Married or living with a partner	6,007 (64.0)	1,678 (70.2)	4,329 (61.7)
Not married nor living with a partner	4,305 (36.0)	837 (29.8)	3,468 (38.3)
Poverty income ratio (PIR)			
Poor	1,742 (9.5)	220 (4.0)	1,522 (11.5)
Not poor	8,570 (90.5)	2,295 (96.0)	6,275 (88.5)
Pension receipt			
Yes	4,749 (48.9)	742 (30.5)	4,007 (56.0)
No	5,563 (51.1)	1,773 (69.5)	3,790 (44.0)
Race			
Black	2,165 (8.4)	560 (7.4)	1,605 (8.7)
Hispanic	2,150 (7.0)	634 (7.2)	1,516 (7.0)
White	5,248 (79.5)	1,111 (80.1)	4,137 (79.3)
Other	749 (5.1)	210 (5.3)	539 (5.0)
Lifestyle Factors			
Drinking status			
Drinker	6,724 (69.7)	1,755 (75.2)	4,969 (67.6)
Non-drinker	3,588 (30.3)	760 (24.8)	2,828 (32.4)
Smoking status			
Smoker	5,369 (51.6)	1,210 (47.1)	4,159 (53.3)
Non-smoker	4,943 (48.4)	1,305 (52.9)	3,638 (46.7)
Inflammatory diet			
Anti-inflammatory	2,473 (28.3)	703 (34.0)	1,770 (26.1)
Pro-inflammatory	7,839 (71.7)	1,812 (66.0)	6,027 (73.9)
Physical activities			
Inactive	6,206 (54.3)	1,384 (48.3)	4,822 (56.6)
Moderate	3,131 (34.1)	780 (35.3)	2,351 (33.6)
Vigorous	975 (11.6)	351 (16.5)	624 (9.7)
Health Status-Related Factors			
Body mass index (BMI)			
Underweight	127 (1.0)	24 (0.8)	103 (1.1)
Normal	2,444 (23.8)	582 (23.8)	1,862 (23.8)
Overweight	3,746 (36.0)	953 (35.8)	2,793 (36.0)
Obese	3,995 (39.2)	956 (39.5)	3,039 (39.1)
Diabetes			
Yes	3,478 (28.1)	737 (23.4)	2,741 (29.9)
No	6,834 (71.9)	1,778 (76.6)	5,056 (70.1)
Hypertension			

Table 1 (continued)

Characteristics	Overall (*n* = 10,312)	Working Status	
		Working (*n* = 2,515)	Not working (*n* = 7,797)
Yes	6,322 (58.8)	1,301 (48.7)	5,021 (62.6)
No	3,990 (41.2)	1,214 (51.3)	2,776 (37.4)
Perceived health			
Fair or poor	2,950 (20.2)	455 (9.7)	2,495 (24.3)
Good or better	7,362 (79.8)	2,060 (90.3)	5,302 (75.7)

Notes: SDoH = social determinants of health; PIR = poverty income ratio; BMI = body mass index

[a] Mean ± standard deviation (SD) was used to describe continuous variables, and number (proportion [%]) was used to describe categorical variables. The percentages, means, and standard deviations were derived by applying the full sample 2 year Mobile Examination Center (MEC) exam weight provided in the National Health and Nutrition Examination Survey (NHANES)

Table 2 The association of work status, work types, and shift work with depression, a generalised linear regression model.[a]

Independent Variables	Exp(β) (95%CI)		
	Model 1	Model 2	Model 3
Work Status			
Not working	Reference	Reference	Reference
Working	0.39 (0.30–0.50)***	0.42 (0.32–0.56)***	0.68 (0.53–0.87)**
Work Types			
Not working	Reference	Reference	Reference
Private employee	0.39 (0.29–0.54)***	0.41 (0.29–0.57)***	0.67 (0.50–0.89)**
Government employee	0.39 (0.27–0.57)***	0.41 (0.27–0.62)***	0.69 (0.46–1.02)
Self-employed	0.34 (0.22–0.50)***	0.43 (0.28–0.66)***	0.67 (0.45–0.98)*
Unpaid family business or farm	4.33 (0.08–229)	4.00 (0.07–218)	4.73 (0.13–173)
Shift Work			
Not working	Reference	Reference	Reference
Regular daytime	0.38 (0.29–0.49)***	0.42 (0.32–0.56)***	0.65 (0.52–0.82)***
Evening/Night	1.72 (0.27–11.10)	1.67 (0.23–12.10)	1.58 (0.31–8.02)
Rotating shift	0.78 (0.27–2.21)	0.65 (0.24–1.74)	0.81 (0.36–1.84)
Other schedules	0.37 (0.27–0.52)***	0.40 (0.28–0.58)***	0.68 (0.49–0.93)*

Notes:CI = confidence interval; SDoH = social determinants of health; PIR = poverty income ratio; BMI = body mass index

A the PHQ-9 score was set as a continuous variable for this generalised linear regression model. Model 1 was unadjusted. Model 2 was adjusted for SDoH factors: age, gender, education, household size, marital status, PIR, pension receipt, and race. Model 3 was adjusted for SDoH factors, lifestyle factors: drinking status, smoking status, inflammatory diet, and physical activities, health status factors: BMI, diabetes, hypertension, and self-reported perceived health. All models have considered controlling for fixed year effects. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

95%CI: 0.59–0.98), especially regular daytime working reduced depression risk by 55% (OR = 0.45; 95%CI: 0.25–0.80). Supplementary eTable 4 displays the 2SLS results of the IV analysis mainly. The β value for retirement age was − 0.18 ($P < 0.001$) in the first stage regression, indicating that weak IV is not a threat to this study. In the second stage, the IV analysis revealed that there was a significant negative association between working and depression both in model 1 (β = -7.70, $P < 0.001$) and model 2 (β = -3.73, $P < 0.001$). Mover, the Hasen J test results for predicted work status were significantly consistent with those in model 1 and model 2, indicating that retirement age as an instrumental variable was valid.

Discussion

This cross-sectional study aimed to assess the associations of workforce participation with depression among US older adults aged 60 years or above. With a total of 10,312 participants enrolled in our study, we observed a significant and robust association between reduced depression risk and working on regular daytime, the best working hours were around 35 and 25 per week in the multivariate generalised linear and logistic regression models. Subgroup analysis and interaction evaluations demonstrated that these associations remained stable. These associations persisted even when different datasets, PSM method, and IV were used to test. These findings suggest that regular daytime working between 25 and 35 h per week may be an effective protective factor against depression among US older adults.

Depression in the workforce is a highly prevalent and prominent public health problem [46], and major depressive symptom is an independent risk factor for all-cause mortality in the elderly population [8]. Especially, boosting the workforce participation rate of older adults as an essential component of the solutions for addressing global aging challenges, some evidence on the association of workforce participation with cognitive function, mental health risk, and mortality among older adults have been showed [29, 47, 48]. Nevertheless, although the relationship between workforce participation and depression has been discussed repeatedly, but limited attention has been paid to the elderly population, and remains inconclusive [14, 49]. For example, there previous studies have shown that retirement may increase depressive symptoms [23, 24], while the other studies show that retirement could significantly reduce depression risk [35, 43]. These opposite results may be due to the reverse causation between work status and depression, depressive

Table 3 The association of work status, work types, and shift work with depression, a logistic regression model.[a]

Independent Variables	Number of Depressions/ Participants	Weighted Depression Rate (%)	OR (95CI%)		
			Model 1	Model 2	Model 3
Work Status					
Not Working	678/7,797	7.46	Reference	Reference	Reference
Working	98/2,515	3.72	0.45 (0.30–0.66)***	0.47 (0.33–0.69)***	0.68 (0.46-1.00)*
Work Types					
Not working	678/7,797	7.46	Reference	Reference	Reference
Private employee	63/1,598	3.80	0.43 (0.26–0.71)**	0.48 (0.29–0.78)**	0.67 (0.42–1.09)
Government employee	14/423	2.38	0.28 (0.12–0.63)*	0.30 (0.14–0.66)**	0.47 (0.20–1.09)
Self-employed	17/474	3.69	0.48 (0.25–0.94)*	0.52 (0.26–1.03)	0.77 (0.39–1.53)
Unpaid family business or farm	4/20	28.46	8.44 (1.91–37.30)**	5.88 (1.43–24.20)*	5.60 (1.44–21.7)*
Shift Work					
Not working	678/7,797	7.46	Reference	Reference	Reference
Regular daytime	20/781	2.03	0.33 (0.18–0.60)***	0.33 (0.18–0.61)***	0.48 (0.27–0.87)**
Evening/Night	6/69	10.24	1.86 (0.50–6.91)	1.61 (0.35–7.36)	1.55 (0.35–6.92)
Rotating shift	3/45	3.39	0.47 (0.12–1.88)	0.54 (0.11–2.70)	0.58 (0.15–2.23)
Other schedules	69/1,620	4.25	0.46 (0.29–0.73)**	0.49 (0.31–0.77)**	0.74 (0.47–1.16)

Notes: OR = odds ratio; CI = confidence interval; SDoH = social determinants of health; PIR = poverty income ratio; BMI = body mass index

[a] The PHQ-9 score was divided into binary categories for this logistic regression model: depression with a score ≥ 10, while no depression with a score < 10. Model 1 was unadjusted. Model 2 was adjusted for SDoH factors: age, gender, education, household size, marital status, PIR, pension receipt, and race. Model 3 was adjusted for SDoH factors, lifestyle factors: drinking status, smoking status, inflammatory diet, and physical activities, health status-related factors: BMI, diabetes, hypertension, and self-reported perceived health. All models have considered controlling for fixed year effects. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

older workers more likely to lose their jobs or seek to quit [23, 43]. Besides, prior research presented that self-employment was negatively associated with depression among aging workers [50], night shift work was associated with an increased risk of depression [15], our results agree with these arguments but not significant.

Many studies have reported the noticeable increased depression risk in employees with mismatched working hours, such as underemployed workers had a higher risk of depression than that of overemployed workers [51]. And a study of adults aged between 18 and 65 years indicated that a positive association of long working hours with depression risk increased [52], which was consistent with our primary results in this study for older adults aged 60 years or above. However, another research argued that producing estimates of the burden of depression attributable to exposure to long working hours appears insufficient evidence, examinations for the association between long working hours and risk of depression are needed to address the limitations of the current evidence [49]. Further, our study estimated that a range of 25 to 35 working hours per week was the most appropriate for protecting older adults against the risk of depression, based on both RCS for linear and logistic regression models.

Successive literature continues to indicate that depression risk distributes disproportionately in population with different demographic characteristics. For example, black or brown/mixed Brazilians were more likely to suffer from untreated depression, region of residence was the most prominent determinant of these racial inequalities, and employment was one of the main contributing factors to these inequalities in depression [53]. Moreover, male and female workers at various depression risk when with under-employed or over-employed hours worked [51], gender inequalities at the labor market has been confirmed as substantially explaining the gender gap in depression risk among US older adults [17]. To our surprise, in this study, there was no statistical difference in work status (working vs. not working) between races, but the interaction of work status and race had a significant effect on depression risk, which may potentially be due to discrimination or difficulties in accessing treatment because of other non-observable characteristics [53]. Correspondingly, more research is needed on socioeconomic and demographic disparities in the relationship between workforce participation and depression, especially for aging, ethnicity/race, and gender.

The notable strength of this study lies in its status as the latest and first cross-section exploration of the correlation between workforce participation and depression among older adults based on the NHANES data, encompassing a substantial and representative sample size. Nonetheless, several limitations are needed to be acknowledged during our study. Firstly, self-reported responses derived from designated cross-sectional survey may be at a risk of interference with recall bias, and it does not support us to make causal claims for the relationship between

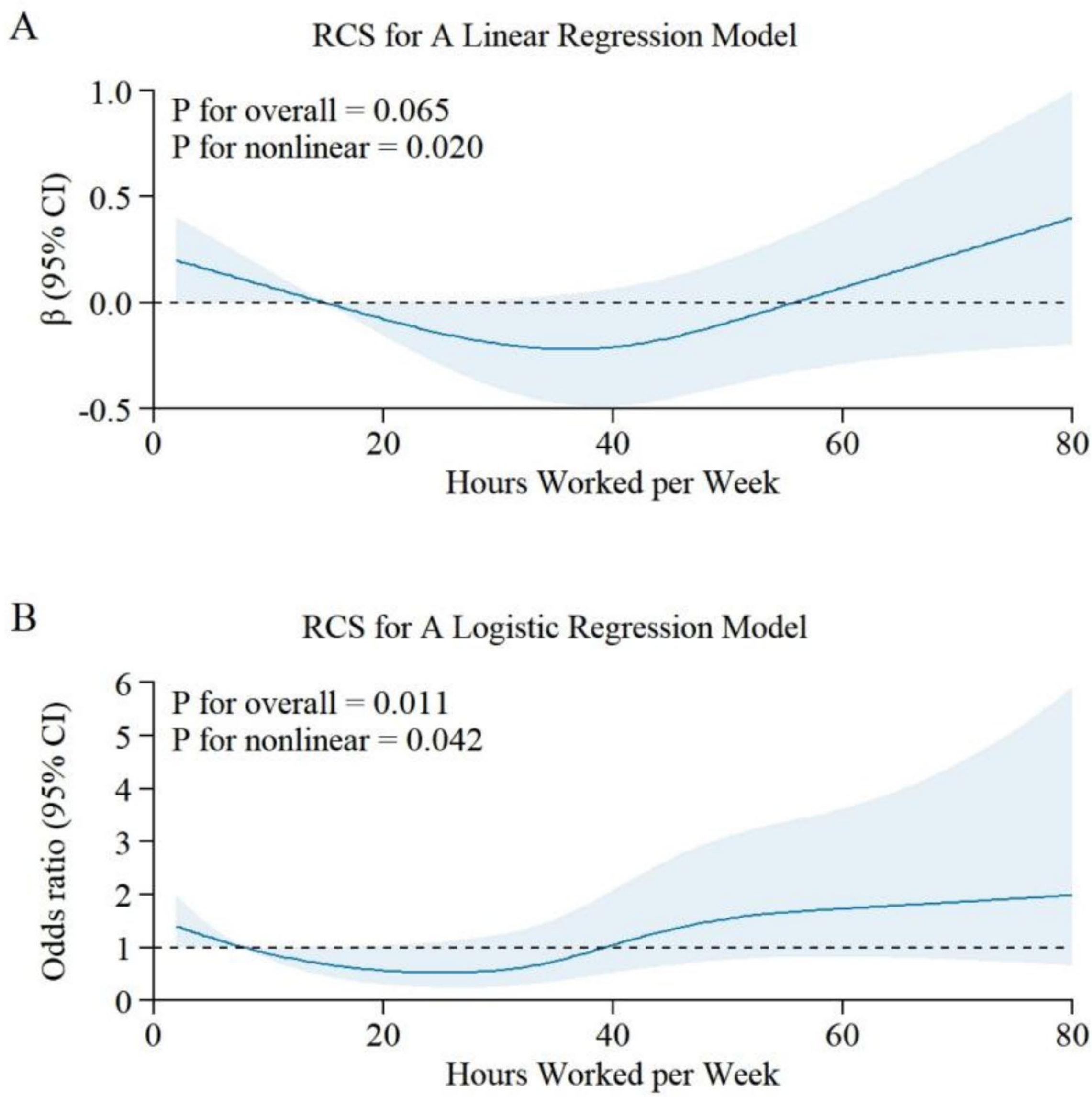

Fig. 2 The restricted cubic spline (RCS) for the association between hours worked per week and depression among US working older adults
Notes: (**A**) Non-linearity of hours worked per week with continuous PHQ-9 score. The solid blue line represents estimates of the adjusted β coefficients, the shadow represents 95% confidence intervals, and the reference β value was set to zero (dashed black line). (**B**) Non-linearity of hours worked per week with binary PHQ-9 score, depression with a score ≥ 10, while no depression with a score < 10. The solid blue line represents estimates of the adjusted OR coefficients, the shadow represents 95% confidence intervals, and the reference OR value was set to 1 (dashed black line). All models were adjusted for SDoH factors: age, gender, education, household size, marital status, PIR, pension receipt, and race, lifestyle factors: drinking status, smoking status, inflammatory diet, and physical activities, health status-related factors: BMI, diabetes, hypertension, and self-reported perceived health. All models have considered controlling for fixed year effects. OR = odds ratio; CI = confidence interval; SDoH = social determinants of health; PIR = poverty income ratio; BMI = body mass index

workforce participation and depression. Secondly, multiple potential confounding factors could affect both workforce participation and depression. Despite incorporating numerous most likely relevant covariates into all our models, it remains challenging to fully eliminate the influences of other potential confounding variables. Thirdly, the external validity of the study is limited due to the fact that the NHANES database only uses the PHQ-9 as depressive symptom assessment tool.

Subgroup	Number (%)	OR [95%CI]	P for interaction
Age (years)			**0.495**
60-69	5,266 (54.0)	0.46 [0.36, 0.60]	
70-79	3,240 (30.8)	0.65 [0.37, 1.15]	
80 or above	1,806 (15.2)	0.70 [0.21, 2.32]	
Gender			**0.127**
Male	5,180 (45.5)	0.49 [0.34, 0.71]	
Female	5,132 (54.5)	0.70 [0.52, 0.93]	
Education			**0.204**
High school graduate or higher	7,312 (82.2)	0.66 [0.50, 0.87]	
Less than high school	3,000 (17.8)	0.49 [0.33, 0.72]	
Household Size			**0.481**
Large	2,749 (19.6)	0.52 [0.36, 0.76]	
Small	7,563 (80.4)	0.63 [0.48, 0.83]	
Marital Status			**0.726**
Married or living with a partner	6,007 (64.0)	0.66 [0.49, 0.90]	
Not married nor living with a partner	4,305 (36.0)	0.59 [0.42, 0.83]	
Poverty Income Ratio (PIR)			**0.787**
Poor	1,742 (9.5)	0.57 [0.34, 0.95]	
Not poor	8,570 (90.5)	0.63 [0.49, 0.81]	
Pension Receipt			**0.745**
Yes	4,749 (48.9)	0.55 [0.36, 0.84]	
No	5,563 (51.1)	0.60 [0.46, 0.78]	
Race			**0.036**
Black	2,165 (8.4)	0.38 [0.21, 0.66]	
Hispanic	2,150 (7.0)	0.47 [0.32, 0.69]	
White	5,248 (79.5)	0.91 [0.65, 1.28]	
Other	749 (5.1)	0.41 [0.15, 1.10]	
Drinking Status			**0.957**
Drinker	6,724 (69.7)	0.58 [0.45, 0.77]	
Non-drinker	3,588 (30.3)	0.58 [0.39, 0.87]	
Smoking Status			**0.919**
Smoker	5,369 (51.6)	0.59 [0.44, 0.80]	
Non-smoker	4,943 (48.4)	0.59 [0.43, 0.83]	
Diabetes			**0.668**
Yes	3,478 (28.1)	0.53 [0.37, 0.77]	
No	6,834 (71.9)	0.63 [0.48, 0.84]	
Hypertension			**0.781**
Yes	6,322 (58.8)	0.57 [0.43, 0.76]	
No	3,990 (41.2)	0.65 [0.45, 0.94]	

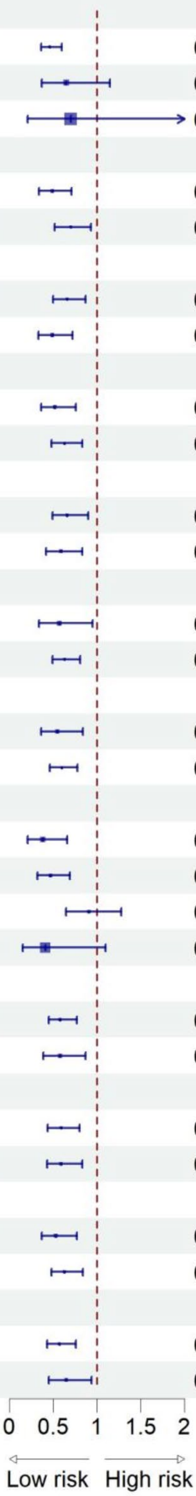

Fig. 3 Subgroup analysis for the association between work status and depression

Notes: The subgroup analysis was based on the model 3 in the Table 3. The percentage (%) for number were derived by applying the full sample 2 year Mobile Examination Center (MEC) exam weight provided in the National Health and Nutrition Examination Survey (NHANES). OR = odds ratio; CI = confidence interval; PIR = poverty income ratio

Despite these limitations, we firmly believe that this study demonstrates a significant association between workforce participation and depression among US older adults, and the contributions would beyond the US in at least two key areas. Firstly, the PSM and IV methods were applied jointly in this study to enhance prospective nature and reduce the possibility of reverse causation bias, thus our results provide reliable insights into depression prevention among older adults in developed countries. Secondly, representative developing countries such as China are moving previous implemented retirement policies away from fixed-age (60 for men, and 50 or 55 for women) to flexible-age that raise the retirement age gradually, to meet the challenge of aging before affluence. Therefore, our findings also provide valuable implications from a mental health perspective for developing countries experiencing population aging, such as the retirement age setting, shift work arrangement, and working hours recommendation for older adults.

Conclusions

According to this cross-sectional study, regular daytime working between 25 and 35 h per week may be an effective protective factor against depression among US older adults. These findings highlight the potential benefits of maintaining moderate workforce participation for older adults' mental health. In practice, especially for these countries struggling with aging before affluence, policymakers and employers should give more considerations such as flexible retirement policies, appropriate working hours, and regular daytime employment for older adults. Further extensive prospective studies are needed to better understand the causality between workforce participation and depression in the elderly population, ensuring that such practices could be safely and effectively implemented in diverse settings.

Abbreviations

BMI	Body Mass Index
CI	Confidence Interval
DII	Dietary Inflammatory Index
NHANES	National Health and Nutrition Examination Survey
OR	Odds Ratio
PHQ	Patient Health Questionnaire
PIR	Poverty Income Ratio
PSM	Propensity Score Matching
RCS	Restricted Cubic Spline
SDoH	Social Determinants of Health

Supplementary Information

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Supplementary Material 1

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Author contributions

ZYS, XC and DFQ contributed to the study design. ZYS and YW preformed the data analysis. ZYS and YW wrote the manuscript. ZYS, XC and DFQ revised the manuscript. All authors have read and approved the final manuscript.

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Data availability

Data for this study was gathered from the National Health and Nutrition Examination Survey (NHANES) 2005-2018. All NHANES data for this study are publicly available and can be visited at: https://www.cdc.gov/nchs/nhanes/.

Declarations

Ethics approval and consent to participate

Data for this study was gathered from the National Health and Nutrition Examination Survey (NHANES) 2005–2018. The survey was carried out according to the guidelines of the Declaration of Helsinki, and approved by the Research Ethics Review Board of the National Center for Health Statistics. All participants provided informed consent before enrollment.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Clinical trial number

Not applicable.

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