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Depressive Symptoms and Subjective Daytime Sleepiness in a Population-Based Cross-Sectional Study

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Abstract

Introduction: *Sleep disorders contribute to the development and worsening of depressive symptoms. Therefore, models are necessary to understand the impact of depression on sleep regulation. This study aimed to analyze the influence of depression on sleep patterns.*

Methods: *A cross-sectional study was conducted using the NHANES 2017–2018 dataset, which included 5088 adults. The primary outcome was the presence of daytime sleepiness among participants with depressive symptoms (PHQ-9 $>$ 4) compared with participants without depressive symptoms (PHQ-9 $\leq$ 4). The regression analysis considered the following covariates: age, sex, BMI, and presence of at least one comorbidity. A secondary analysis examined the severity of depression, BMI $>$ 25, and a history of diabetes or cancer. Statistical analyses were performed using StataNow/BE 18.5.*

Results: *Participants with depressive symptoms were significantly more likely to feel sleepy during the day (OR: 4.39; 95% CI: 3.83–5.04). Univariate analysis revealed statistically significant associations for all included variables: age (odds ratio [OR]: 0.99; 95% CI: 0.99–0.99); sex (OR: 1.27; 95% CI: 1.12–1.44); BMI (OR: 1.58; 95% CI: 1.39–1.79); and at least one comorbidity (OR: 1.69; 95% CI: 1.48–1.93). The final model confirmed a significant association between depressive symptoms and daytime sleepiness (odds ratio [OR]: 4.00; 95% CI: 3.48–4.61) after adjusting for confounding factors.*

Conclusion: *There was a significant association between depressive symptoms and daytime sleepiness, underscoring the need for a multifaceted approach to enhance sleep quality, alleviate depressive symptoms, and manage comorbidities.*

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Introduction

Major depressive disorder is a significant public health concern, affecting an estimated 4.4% to 20% of the population worldwide (Pandi-Perumal et al., 2020). Mental illness contributes to approximately 32.4% of the global disability-adjusted life years, with depression being the leading contributor (Vigo et al., 2016). Moreover, understanding modifiable factors, such as sleep disturbances co-occurring with psychiatric disorders, is essential for improving the treatment strategies for these patients. Sleep disorders are also associated with increased cardiovascular risk and all-cause mortality (Cappuccio et al., 2010; Miller & Howarth, 2023; Somers et al., 2008), and both physical and psychological health issues can significantly affect sleep quality and duration (Chennaoui et al., 2015). Poor sleep quality is further linked to decreased productivity and substantial economic consequences (Hirshkowitz et al., 2015).

Research has shown a bidirectional relationship between sleep disturbance and emotional regulation (Dahl & Harvey, 2007; Lollies et al., 2022). Consequently, individuals with depression commonly exhibit significant alterations in sleep architecture, including increased sleep latency, decreased sleep efficiency, and changes in rapid eye movement sleep (Nutt et al., 2008). These findings suggest that the mechanisms underlying sleep regulation may be disrupted in depressed individuals (Nutt et al., 2008), with excessive daytime sleepiness possibly indicating a disturbed circadian rhythm (Chellappa et al., 2009).

Although longitudinal studies have associated both short and long sleep durations with an increased risk of depression (Zhai et al., 2015), the relationship between sleep duration and depression is complex and should be interpreted cautiously. Emerging evidence suggests that sleep disruption, rather than sleep duration, may be a more reliable predictor of depressive symptoms (Goldstone et al., 2020). Additionally, a large body of evidence demonstrates impaired sleep quality and insomnia symptoms in patients with diagnosed depression (Lustberg et al., 2000; Pandi-Perumal et al., 2020). Hypervigilance is a key feature of depression and may contribute to difficulties in initiating and maintaining sleep (Pandi-Perumal et al., 2009; Slyepchenko et al., 2019). Conversely, excessive sleepiness is also reported to be associated with depression, although the nature of this association remains unclear (Goldstone et al., 2020; Yim et al., 2024).

Depression and sleep share complex, multifaceted interactions that are often oversimplified in existing models as non-linear and bidirectional relationships have been reported (Nolen-Hoeksema et al., 2008; Scott et al., 2021). Therefore, this study aimed to investigate the relationship between depressive symptoms and excessive daytime sleepiness using data from the National Health and Nutrition Examination Survey (NHANES) 2017-2018, after adjusting for confounders (National Center for Health Statistics, 2017). We hypothesized that subjective daytime sleepiness is strongly associated with depressive symptoms.

Materials and Methods

This cross-sectional study used the 2017-2018 NHANES dataset. Data recorded by NHANES are publicly available and can be accessed at www.cdc.gov/nchs/nhanes. The survey encompasses information on the health and nutritional status of the U.S. population.

The main outcome of the study was depressive symptoms, assessed using the Patient Health Questionnaire-9 (PHQ-9), a screening tool designed to measure the severity of depressive symptoms (Kroenke et al., 2001), which was chosen as the primary exposure.

The initial dataset enrolled 9,254 participants, but only those aged 18 years or older with complete PHQ-9 data were included in the final sample (N= 5,088) (figure 1).

PHQ-9 scores classify the severity of depressive symptoms as follows: no depressive symptoms (< 4); mild (5–9); moderate (10–14); moderate/severe (15–19); and severe depressive symptoms (> 20). For the primary analysis, PHQ-9 scores were divided into two categories: absence of depressive symptoms (score $\leq$ 4) and presence of depressive symptoms (score > 4).

To evaluate daytime sleepiness, participants were asked, "How often do you feel overly sleepy during the day?" This variable is coded in NHANES as follows: 0 (never), 1 (rarely – once a month), 2 (sometimes – 2 to 4 times/month), 3 (often – 5 to 15 times/month), and 4 (almost always – 16 to 30 times/month). The responses were dichotomized into a binary outcome: category 1 (never, rarely, or sometimes) and category 2 (often or almost always).

Covariates selected based on clinical relevance included age, gender, body mass index (BMI cutoff at 30 kg/m^2), the presence of at least one comorbidity, and average sleep duration (a weighted average of sleep duration during weekdays and weekends).

Statistical Analysis

All analyses were performed using STATA software (StataCorp. 2023. Stata Statistical Software: Release 18. College Station, TX: StataCorp LLC). The statistical significance level was set at a p-value of <0.05.

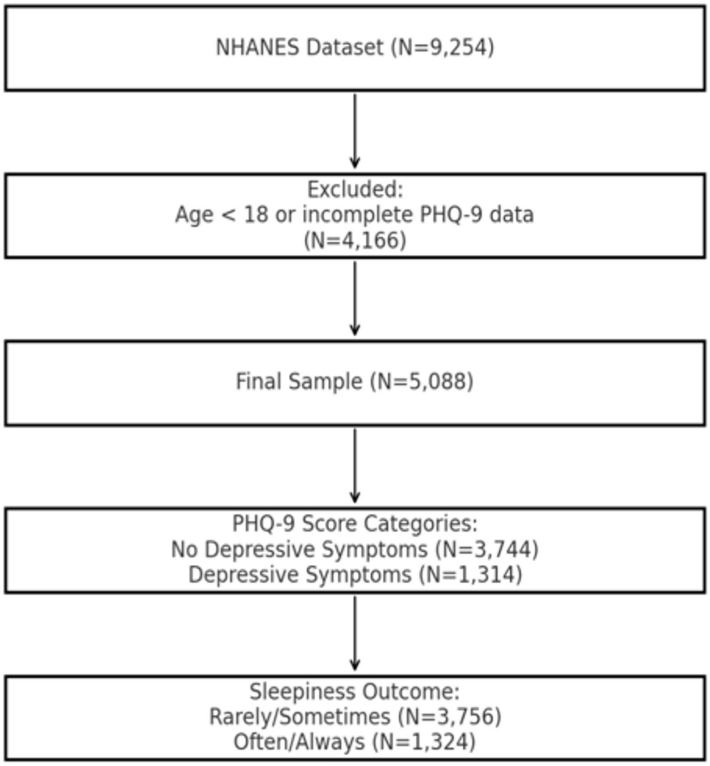

Figure 1: *Flowchart of participant's dataset inclusion.*

Continuous variables were described as medians and interquartile ranges, while categorical variables were reported as percentages. A chi-square test was conducted to assess the relationship between depressive symptoms measured by the PHQ-9 and sleepiness as encoded in NHANES. Univariate logistic regression analysis was performed for sleepiness and the main independent variable (absence vs. presence of depressive symptoms), as well as for each covariate. A multivariate logistic regression model was constructed, with covariates included using a forward selection approach. Changes in odds ratios and likelihood ratios were assessed with each addition to evaluate multicollinearity and model fit. The variance inflation factor (VIF) was used to measure multicollinearity. The influence of possible unmeasured confounders was evaluated by calculating the E-value.

A secondary analysis of sleep duration as outcome was conducted. Short sleep duration (< 7 hours) and long sleep duration (> 9 hours) were compared to the recommended sleep duration (7 to 9 hours) in a univariate logistic regression analysis to assess the association with the presence of depressive symptoms. A multiple linear regression analysis of sleep duration on workdays and gender (female) as outcomes was performed. The independent variables included BMI > 25, diabetes, and cancer history. The overall fit of the model was evaluated using the F-statistic and R-squared values.

A sensitivity analysis of sleepiness addressed the severity of depressive symptoms using the five severity categories of PHQ-9 and comparing the absence of depressive symptoms with mild depressive symptoms (scores 5 to 9), controlling for the same covariates.

Model performance was evaluated through a Receiver Operating Characteristic (ROC) curve analysis (see supplementary section). The resulting models were compared using the ROC curve, as well as the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (BIC).

Results

Participant Demographics

Among 9,254 participants recorded in the NHANES dataset, 5,088 responded to the PHQ-9 and were included in this study. Of these, 3,744 participants (74.17%) were classified as having no depressive symptoms, while 1,314 participants (25.83%) were classified as having the "presence of depressive symptoms," as presented in Figure 1. The demo-

graphic data for each group are presented in Table 1. Overall, 3,756 participants (73.9%) reported never, rarely, or sometimes feeling overly sleepy during the day, while 1,324 participants (26%) reported feeling often or almost always overly sleepy during the day.

Primary Outcome Analysis

PHQ-9 categories and the sleepiness variable, as encoded in NHANES, were significantly associated in the chi-square test ($p < 0.001$). Univariate analyses indicated a significant association between having depressive symptoms and daytime sleepiness. The odds ratio (OR) for reporting often or almost always feeling overly sleepy during the day for individuals with depressive symptoms was 4.39 (95% CI: 3.83–5.04, $p < 0.001$).

All covariates included showed statistically significant associations with sleepiness in the univariate analyses summarized in Table 2.

In the forward selection approach, no two-way interactions were observed. Adding each variable to the model produced minor changes to the likelihood ratio and to the effects of the previous variables (< 10%), suggesting no multicollinearity. The variable "at least one comorbidity" improved the model's likelihood ratio. The final model, presented in Table 3, retained the significant effect of the presence of depressive symptoms on sleepiness (OR: 4.00; 95% CI: 3.49–4.61, $p < 0.001$). The variance inflation factor (VIF) was lower than 10 for all variables.

The estimated value for unmeasured confounders was 4.68 (Risk Ratio > 4.68), with the lower and upper bounds of the confidence interval being 4.33 and 5.02, respectively.

Secondary Analysis

Short sleep duration and long sleep duration were significantly associated with the presence of depressive symptoms in univariate analyses. The OR for long sleep duration compared to recommended sleep duration was 1.45 (95% CI: 1.21–1.73), and the OR for short sleep duration was 1.43 (95% CI: 1.24–1.66). Additionally, long sleep duration was associated with mild depressive symptoms, while short sleep duration was associated with scores > 9.

The overall linear regression model summarized in Table 4 for sleep duration, depression diagnosis, and comorbidities was statistically significant, with an F-value of 12.80 and an R-squared value of 0.0115. An explanatory equation for sleep hours due to depression and covariates was constructed:

1. *Sleep hours work days* $= 7.65$
   $+0.28$ *(if female)*
   -0.14 *(if BMI > 25)*
   $+0.01$ *(if depression, PHQ-9 > 9)*
   -0.20 *(if cancer)*
2. *Sleep hours work days* $= 8.02$
   $+0.24$ *(if female)*
   -0.14 *(if BMI > 25)*
   $+0.15$ *(if depression, PHQ-9 > 9)*
   -0.17 *(if diabetes)*
   -0.21 *(if cancer)*

Sensitivity Analysis

The severity of depressive symptoms was significantly associated with sleepiness in the model presented in Table 5. Additionally, comparing the absence with the presence of mild depressive symptoms revealed a significant association with sleepiness after controlling for the same covariates (OR: 3.49; 95% CI: 2.97–4.11, $p < 0.001$).

Controlling for sleep duration in an alternative model produced minimal changes in the association between depressive symptoms and sleepiness (OR: 3.97; 95% CI: 3.46–4.58). However, the VIF for sleep duration was 13.07, suggesting multicollinearity. Calibration for both models revealed an AIC of 5235.54 for the original model and 5227.37 for the alternative model. Categorizing sleep duration produced only minor changes.

Since minimal changes occurred after controlling for sleep duration, and although the alternative model performed slightly better in the LR chi-square statistic and calibration, the presence of multicollinearity favored the use of the original model.

A direct acyclic graph represents the final model in Figure 2.

Discussion

The results of this study provide valuable insights into the relationships between depressive symptoms, daytime sleepiness, various health conditions, and sleep duration. Individuals with depressive symptoms were four times more likely to experience excessive daytime sleepiness than those without. This robust association aligns with the existing literature suggesting that depression is a major contributor to sleep disturbances (Katon, 2003; Perlis et al., 2006; Wang et al., 2019) and underscores the significant impact of depression on sleep patterns (Figure 2).

Using NHANES data and a PHQ-9 cutoff of >9 for depression diagnosis, Tu et al. (2024) found an association between depression and reported trouble sleeping with a similar OR (National Center for Health Statistics, 2017). Our study complements this finding by examining sleepiness as a diurnal conse-

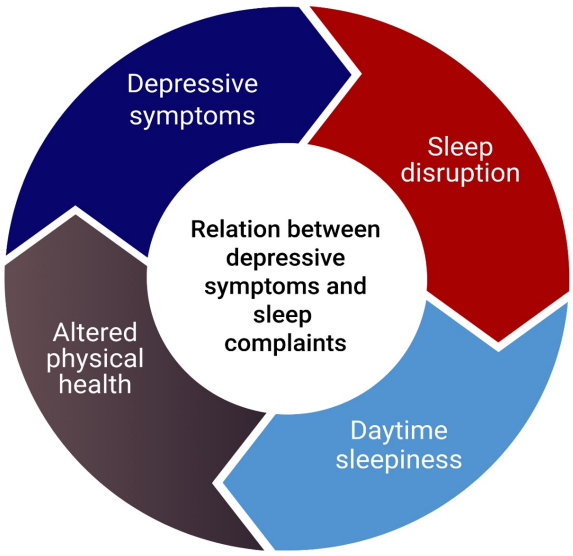

Figure 2: *Association between depressive symptoms and sleep complaints.*

	No depressive symptoms (PHQ-9 score <4)	Presence of depressive symptoms (PHQ-9 score >4)	p-value
Age (median)	51 (IQR: 33-64)	51.5 (IQR: 34-64)	0.93
Gender (% Female)	48.33	59.13	0
Ethnicity (%)			
- **White**	33.7	40	
- **Black**	23.5	21.8	0
- **Hispanic**	22.5	23.4	
- **Not informed**	20.3	14.8	
BMI (median)	28.1 (IQR: 24.4 - 32.9)	30.15 (IQR: 25.5 - 35.2)	0
Marital status (%)			
- **Married**	63	47.8	0
- **Separated**	13.2	21	
- **Single**	17.2	19.9	
Presence of comorbidity	54.98%	69.25%	0
Diabetes	13.88%	18.19%	
History of cancer	10.11%	11.42%	
Average sleep duration	7.8 (IQR: 7-8.6)	7.78 (IQR: 6.6-8.5)	0.15
Sleepiness	679 (20.1%)	645 (49.0%)	0

PHQ-9: The Patient Health Questionnaire; **IQR:** Interquartile Range; **BMI:** Body Mass Index.

Table 1: *Demographic data -median and interquartile range for age, BMI and average sleep duration are presented for the group without depressive symptoms and the group with depressive symptoms.*

Feeling overly sleepy during the day	Odds Ratio	95% CI	p-value
Depressive symptoms (PHQ9)	4.39	3.83 – 5.04	0
Age	0.99	.99 – .99	0.012
Gender	1.28	1.12 – 1.44	0
At least 1 comorbidity	1.7	1.48 – 1.93	0
BMI	1.58	1.39 – 1.79	0

PHQ-9: The Patient Health Questionnaire; BMI: Body Mass Index. CI 95%: 95% confidence interval.

Table 2: *Results of univariate analyses for feeling overly sleepy during the day and each covariate.*

Feeling overly sleepy during the day	Odds ratio	Standard error	95% CI
Depressive symptoms (PHQ9)	4.01	0.28	3.48 – 4.61
Age	0.98	0.002	.98 – .99
Gender	1.07	0.07	.94 – 1.23
BMI	1.02	0.004	1.01 – 1.02
Comorbidity	1.76	0.14	1.50 – 2.07

PHQ-9: The Patient Health Questionnaire; **BMI:** Body Mass Index. **CI 95%:** 95% confidence interval.

Table 3: *Results of multivariate logistic regression for feeling overly sleepy during the day and the presence of depressive symptoms.*

Sleep duration in workdays (hours)	B coefficient	P-value	95% CI
Depression diagnosis (PHQ9 > 9)	0.0971	0.039	.005 – .189
Gender	0.2384	0	.150 – .326
Overweight/ Obesity	-0.139	0.008	.242 – -.036
Diabetes diagnosis	-0.1687	0.001	-.267 – -.070
History of cancer or malignancy	-0.2091	0.002	-.339 – -.078

PHQ-9: The Patient Health Questionnaire; **BMI:** Body Mass Index. **CI 95%:** 95% confidence interval.

Table 4: *Results of multivariate linear regression for the presence of depression diagnosis and comorbidities.*

Feeling overly sleepy	Odds ratio	Standard error	95% CI
Depression severity (PHQ-9 - 5 categories)	2.09	. 087	1.92 – 2.27
Age	0.98	. 002	.98 – .99
Gender	1.09	0.075	.94 – 1.23
BMI	1.02	0.004	1.02 – 1.03
Comorbidity	1.78	0.14	1.52 – 2.09

Table 5: *Results of multivariate logistic regression for feeling overly sleepy during the day and severity of depressive symptoms.*

quence of trouble sleeping, regardless of whether it is related to duration, quality, or timing. Secondary analysis revealed that for each increase in depression severity, individuals were twice as likely to report sleepiness. Even transitioning from the absence of depressive symptoms to mild depressive symptoms, which are not considered diagnostic of depression, was associated with sleepiness with an OR of over three. This result aligns with studies suggesting that sleep impairment can precede depression (Goldstone et al., 2020; Zhai et al., 2015).

In addition, we explored the relationship between various health conditions, depression, and sleep duration. The statistically significant model captures some of the variance in sleep duration, although other unmeasured factors may also play a crucial role. This finding is consistent with previous research identifying multiple determinants of sleep duration beyond depressive symptoms (Dong et al., 2022; Rosekind et al., 2010).

The regression coefficients revealed nuanced relationships. Being female was associated with increased sleep hours, while overweight and obese individuals reported fewer sleep hours. This aligns with research indicating that women often report longer sleep durations (Hirshkowitz et al., 2015) and linking obesity to sleep deprivation (Wong et al., 2022). Individuals diagnosed with depression reported more sleep hours; however, the identified six-minute increase in sleep duration lacks clinical significance. The association of both short and long sleep durations with depression is well recognized (Zhai et al., 2015). We also identified that sleep durations under seven hours or over nine hours were associated with the presence of depressive symptoms, suggesting complexity in sleep patterns among depressed individuals, with some experiencing hypersomnia rather than insomnia (Wang et al., 2019).

Additionally, diabetes and a history of cancer were negatively associated with sleep duration, reinforcing the need for a multifaceted approach to sleep health.

The limitations of the study include its cross-sectional nature, which does not allow for causal inferences and the use of a dataset that represents only the U.S. population. Additionally, there could be bias due to self-reporting, and previous depression diagnosis or medication use was not ascertained. However, we found that any unmeasured confounders would require a strong association with both the exposure and the outcome to fully explain away the observed effect. Another limitation is that sleep complaints are assessed as part of the PHQ-9 through a specific question, meaning that the exposure and outcome were intrinsically linked, and no adjustments for highly correlated data were performed. Although the models considering sleepiness and depression were consistently robust, the models for sleep duration found only minor changes.

These associations highlight the interplay between physical and mental health, suggesting that managing chronic conditions may also support better sleep outcomes.

Longitudinal studies investigating prodromal sleepiness in depression, as well as pre- and post-treatment responses, will be valuable for clarifying this relationship and providing therapeutic insights.

Conclusions

Subjective daytime sleepiness and the presence of depressive symptoms have a robust association. Reporting sleepiness increases with the severity of depressive symptoms, but its presence even in individuals with mild depressive symptoms suggests that it could be an early symptom of depression. Furthermore, there is a complex interplay between sleep duration and depressive symptoms, which may be influenced by depression severity and the presence of chronic diseases, underscoring the need for a multifaceted approach. Interventions aimed at treating depressive symptoms may also alleviate issues related to sleep and daytime sleepiness, potentially improving overall quality of life.

Ethical Considerations

The NHANES dataset is publicly available and adheres to ethical guidelines for research involving human participants. No additional ethical approvals were required for this study, as the data was de-identified and anonymized.

Supplementary Materials

Figure: Receiver Operating Characteristic curve of the adjusted model for sleepiness and depressive symptoms.

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Conflicts of Interest

The authors declare no conflict of interest.

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