

Original Article

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The association between sleep and depressive symptoms in US adults: data from the NHANES (2007–2014)

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Abstract

Aims. To assess the association of sleep factors (sleep duration, trouble sleeping, sleep disorder) and combined sleep behaviours with the risk of clinically relevant depression (CRD). **Methods.** A total of 17 859 participants (8806 males and 9053 females) aged 20–79 years from the National Health and Nutrition Examination Survey (NHANES) 2007–2014 waves were included. Sleep duration, trouble sleeping and sleep disorder were asked in the home by trained interviewers using the Computer-Assisted Personal Interviewing (CAPI) system. The combined sleep behaviours were referred to as ‘sleep patterns (healthy, intermediate and poor)’, with a ‘healthy sleep pattern’ defined as sleeping 7–9 h per night with no self-reported trouble sleeping or sleep disorders. And intermediate and poor sleep patterns indicated 1 and 2–3 sleep problems, respectively. Weighted logistic regression was performed to evaluate the association of sleep factors and sleep patterns with the risk of depressive symptoms.

Results. The total prevalence of CRD was 9.5% among the 17 859 participants analysed, with females having almost twice as frequency than males. Compared to normal sleep duration (7–9 h), both short and long sleep duration were linked with a higher risk of CRD (short sleep: OR: 1.66, 95% CI: 1.39–1.98; long sleep: OR: 2.75, 95% CI: 1.93–3.92). The self-reported sleep complaints, whether trouble sleeping or sleep disorder, were significantly related with CRD (trouble sleeping: OR: 3.04, 95% CI: 2.59–3.56; sleep disorder: OR: 1.83, 95% CI: 1.44–2.34). Furthermore, the correlations appeared to be higher for individuals with poor sleep pattern (OR: 5.98, 95% CI: 4.91–7.29).

Conclusions. In this national representative survey, it was shown that there was a dose-response relationship between sleep patterns and CRD.

Introduction

Major depression is the third leading cause of disease burden worldwide, characterised with limiting psychosocial functions and lowering the quality of life (Malhi and Mann, 2018). From 1990 to 2017, the number of reported instances of depression grew by 49.86% globally, indicating that depression remains a serious public health concern (Liu *et al.*, 2020b). As a complex mental disorder, depression is considered to be impacted by genetic, environmental and gene-environment interactions (Otte *et al.*, 2016), as well as modified by lifestyles (Opie *et al.*, 2017; Huang *et al.*, 2020; Wong *et al.*, 2021)

Aside from the well-known dietary and physical activity factors, several studies have been conducted to examine the impact of sleep in the development of depression, but the results were equivocal. Short sleep duration was associated with depression symptoms in a cross-sectional and prospective manner (Lippman *et al.*, 2017). One study from rural America supported that short sleep duration was associated with depressive symptoms, whereas another study from rural China supported the notion that both long and short sleep were related with depression (Chang *et al.*, 2012; Mohan *et al.*, 2017). A meta-analysis of seven prospective studies comprising 25 271 participants for short sleep duration and 23 663 participants for long sleep duration found that both short and long sleep duration were substantially linked with an elevated risk of depression in adults (Zhai *et al.*, 2015). Meanwhile, recent meta-analyses have revealed a substantial link between insomnia and depression (Li *et al.*, 2016). An analysis of data from the Wisconsin Sleep Cohort Study reveals a substantial long-term relationship between increasing subjective excessive daytime sleepiness and depression (Plante *et al.*, 2017). Moreover, several research studies have investigated the joint effect of multiple sleep issues, and revealed that the combined sleep manners were associated with an increased risk of depression (Fernandez-Mendoza *et al.*, 2015; Sun *et al.*, 2018; Jiang *et al.*, 2020). However, the majority of previous studies focused on the elderly or teenagers, varied in sample size, age group and sleep duration definition. The current study aimed to

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explore the associations between independent sleep factor, as well as combined sleep behaviours, and the risk of depression in general American adults, ranging from 30 to 79 years, utilising National representative data from the NHANES Study.

Methods

Study subjects

The NHANES is a series of cross-sectional, complex, multi-stage surveys, conducted by the Centers for Disease Control and Prevention CDC. The NHANES survey combines interviews and physical examinations. The interview includes questions on demographics, socioeconomics, diet and health. Medical, dental and physiological measures, as well as laboratory tests conducted by highly qualified medical experts, comprise the examination component.

In this cross-sectional study, we examined publicly accessible data from participants aged 20–79 years with complete and reliable information (demographics, dietary and health-related behaviours, body measurements and disease information) gathered between 2007 and 2014 waves.

Assessment of depressive symptoms

Depression was assessed using the Patient Health Questionnaire (PHQ-9), a nine-item screening instrument that asked questions regarding the frequency of symptoms of depression over the past two weeks. Response categories for the nine-item instrument ‘not at all’, ‘several days’, ‘more than half the days’ and ‘nearly every day’ with points ranging from 0 to 3 (Levis *et al.*, 2019). A total score ≥ 10 was considered to be clinically relevant depression (CRD) according to the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (Kroenke *et al.*, 2001; Park and Zarate, 2019).

Assessment of sleep factors and definition of a sleep pattern

Sleep duration was self-reported by the question ‘How much sleep do you usually get at night on weekdays or workdays?’ The quantity of time recorded was grouped as short (<7 h per night), normal (7–9 h per night) and long (>9 h per night) (Chaput *et al.*, 2018). The responses to ‘Have you ever told a doctor or other health professional that you have trouble sleeping?’ and ‘Have you/Has SP ever been told by a doctor or other health professional that you have a sleep disorder?’ were used to assess the trouble sleeping and sleep disorders, respectively. The lower and higher risk sleep factors were classified as 1 and 0 for the above-mentioned sleep behaviours to generate overall sleep scores, ranging from 0 to 3. A sleep score of 0 to 1, 2 or 3 indicated a poor, moderate or healthy sleep pattern, accordingly.

Assessment of potential covariates

The sample person demographics questions involved in the study were administered in the home by trained interviewers using the Computer-Assisted Personal Interviewing (CAPI) system, as follows: age in years at the exam (20–29, 30–44, 45–59, 60–79 years), gender (male, female), ethnicity (Mexican American, Other Hispanic, non-Hispanic White, non-Hispanic Black, non-Hispanic Asian, other Race-including Multi-Racial), education level (less than 9th grade, 9–11th grade/includes 12th grade

with no diploma, high school graduate/GED or equivalent, some college or AA degree, college graduate or above) and marital status (married, living with partner, widowed, divorced, separated, never married). Smoking status was measured by the question ‘Have you smoked at least 100 cigarettes in your entire life?’ and classified as ‘yes’ or ‘no’ based on the replies. The physical activity questionnaire is based on the Global Physical Activity Questionnaire and includes questions related to daily activities, leisure time activities and sedentary activities. The suggested metabolic equivalent (MET) scores of 8 points for vigorous work-related/leisure-time activity, 4 points for moderate work-related/leisure-time activity and walking or bicycling for transportation are used to compute metabolic equivalent. The sedentary time refers to the duration spent sitting in a typical day excluding sleeping. Body measurements were obtained by qualified health technicians in the Mobile Examination Centre. Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared, and then rounded to one decimal place. We utilised the total nutrient intakes (DRITOT) consumed during the 24-h period prior to the interview on the first day to calculate the 13 components of the Healthy Eating Index (HEI) 2015 score (range, 0–100), as detailed in the previous study (Krebs-Smith, 2018; Liu *et al.*, 2020a). Daily alcohol intake was obtained on the first-day dietary recall (DRITOT), and divided into 0 and >0 gm categories. We computed the comorbidity index based on the 11 self-reported diseases (including: arthritis, congestive heart failure, coronary heart disease, angina pectoris, heart attack, stroke, liver condition, diabetes, solid tumour, leukaemia and lymphoma), as detailed in the online Supplementary Table S1.

Statistical analysis

The baseline characteristics of the study population were presented as percentages according to CRD and sleep pattern status, respectively. Weighted logistic regression models were used to evaluate the relationship between sleep factors (sleep duration, trouble sleeping and sleep disorder) or sleep patterns, and the risk of CRD. Model 1 adjusted for age and gender. Model 2 further adjusted for race, marriage status, education level, smoke status and alcohol intake. Model 3 further included HEI-2015 index, physical activity, sedentary time, BMI and comorbidity index.

The STATA version 14.0 (Stata Corp LP, College Station, TX, USA) was applied for data analysis. R software 3.5.3 was used to create the forest graphs. A *p* value < 0.05 was regarded as statistically significant.

Results

The baseline characteristics of study population

Characteristics of the participants according to CRD status are presented in Table 1. Of the 17 859 subjects (49.3% males and 50.7% females, mean (SD) age 47.3 [16.5] years), the overall prevalence of CRD was 9.5%, with 6.7% and 12.3% being in males and females, respectively (Table 1).

Participants with a poor sleep pattern appeared to be middle and older age, had higher comorbidity index and obesity trends, with lower education level, and more likely to be females, living alone, physically inactive and more sedentary time, more likely to be heavy smokers, on poor eating quality (Table 2). The prevalence of CRD rises in tandem with the worsening of sleep patterns (Table 2).

Table 1. Characteristics of participants by CRD status

Characteristics	CRD (Col%)		p value
	No (n = 16 154)	Yes (n = 1705)	
Age (years)			<0.001
20–29	3009 (92.0)	260 (8.0)	
30–44	4353 (90.4)	462 (9.6)	
45–59	4094 (87.9)	563 (12.1)	
60–79	4698 (91.8)	420 (8.2)	
Gender			<0.001
Male	8217 (93.3)	589 (6.7)	
Female	7937 (87.7)	1116 (12.3)	
Race			0.824
Non-white ^a	9107 (90.4)	966 (9.6)	
White	7047 (90.5)	739 (9.5)	
Marital status			<0.001
Married/Living with partner	9937 (92.7)	777 (7.3)	
Widowed/Divorced/Separated	3057 (84.4)	563 (15.6)	
Never married	3160 (89.6)	365 (10.4)	
Education level			<0.001
≤High school	7384 (87.6)	1043 (12.4)	
>High school	8770 (93.0)	662 (7.0)	
Sleep duration (hours)			<0.001
<7	6167 (86.5)	960 (13.5)	
7–9	9659 (93.6)	665 (6.4)	
>9	328 (80.4)	80 (19.6)	
Trouble sleeping			<0.001
No	12 642 (94.3)	765 (5.7)	
Yes	3512 (78.9)	940 (21.1)	
Sleep disorder			<0.001
No	14 997 (92.1)	1295 (7.9)	
Yes	1157 (73.8)	410 (26.2)	
Smoking status ^b			<0.001
No	9086 (93.0)	689 (7.0)	
Yes	7068 (87.4)	1016 (12.6)	
Alcohol intake (gm/day)			<0.001
0	11 985 (89.6)	1395 (10.4)	
>0	4169 (93.1)	310 (6.9)	
HEI-2015 index			<0.001
<60	10 728 (89.1)	1317 (10.9)	
≥60	5426 (93.3)	388 (6.7)	
Physical activity (MET-h/week)			<0.001
0	4109 (85.9)	673 (14.1)	
0–200	10 800 (92.1)	930 (7.9)	
>200	1245 (92.4)	102 (7.6)	

(Continued)

Table 1. (Continued.)

Characteristics	CRD (Col%)		p value
	No (n = 16 154)	Yes (n = 1705)	
Sedentary time (hours)			0.045
<8	10 904 (90.8)	1110 (9.2)	
≥8	5250 (89.8)	595 (10.2)	
BMI (kg/m ²)			<0.001
<30	10 136 (92.1)	868 (7.9)	
≥30	6018 (87.8)	837 (12.2)	
Comorbidity index			<0.001
0	10 189 (93.4)	720 (6.6)	
>0	5965 (85.8)	985 (14.2)	

n, sample size; CRD, clinically relevant depression; BMI, body mass index; HEI-2015, Healthy Eating Index-2015; MET, metabolic equivalent.

^aNon-White: Mexican American, other Hispanic, non-Hispanic Black, other race-including multi-racial.

^bSmoke 100 cigarettes (or other tobacco) in entire life.

Association between sleep and risk of CRD

As shown in Fig. 1, in age- and gender-adjusted model (model 1), participants who slept <7 h or >9 h were 1.91 and 4.06 times more likely to have CRD, respectively. Both short (OR: 1.66, 95% CI: 1.39–1.98) and long sleep duration (OR: 2.75, 95% CI: 1.93–3.92) remained significant after adjusting for potential confounding factors (fully adjusted model). Both sleep complaints (including: trouble sleeping and sleep disorder), particularly trouble sleeping (OR: 3.04, 95% CI: 2.59–3.56), was substantially related with CRD as compared to individuals who reported no sleep complaints (fully adjusted model).

The relationship of combined sleep factors (including: sleep duration, trouble sleep and sleep disorder) with depression was shown in Fig. 2. Compared to the healthy sleep pattern, participants with poor sleep pattern were associated with a higher possibility of CRD (OR: 5.98, 95% CI: 4.91–7.29) (model 3).

The association of sleep patterns with risk of CRD by ages

As shown in Fig. 3, after age stratification, the rising tendency of depression linked with poor sleep pattern remained significant across all age groups, notably in the 30–44 and 45–59 age groups.

Discussion

To the best of our knowledge, this is the first study conducted on the relationship between sleep behaviours and depression in a large national representative study. We observed that both short and long sleep duration, as well as sleep complaints (trouble sleeping and sleep disorder), were shown to be highly related with CRD. Then we measured the combined associations of sleep duration, trouble sleeping and sleep disorders with the risk of CRD, and participants with a poor sleep pattern had a greater risk of getting depression.

Among the 17 859 participants, the total prevalence of CRD was almost twice as common in females (12.3%) than males (6.7%). This was consistent with earlier findings and was most

Table 2. Characteristics of participants by sleep pattern status

Characteristics	Sleep pattern (Col%)			<i>p</i> value
	Healthy (<i>n</i> = 8235)	Intermediate (<i>n</i> = 6464)	Poor (<i>n</i> = 3160)	
Age (years)				<0.001
20–29	1764 (21.4)	1198 (18.5)	307 (9.7)	
30–44	2298 (27.9)	1772 (27.4)	745 (23.6)	
45–59	1851 (22.5)	1751 (27.1)	1055 (33.4)	
60–79	2322 (28.2)	1743 (27.0)	1053 (33.3)	
Gender				<0.001
Male	4164 (50.6)	3260 (50.4)	1382 (43.7)	
Female	4071 (49.4)	3204 (49.6)	1778 (56.3)	
Race				<0.001
Non-white ^a	4649 (56.5)	3850 (59.6)	1574 (49.8)	
White	3586 (43.5)	2614 (40.4)	1586 (50.2)	
Marital status				<0.001
Married/Living with partner	5184 (63.0)	3801 (58.8)	1729 (54.7)	
Widowed/Divorced/Separated	1369 (16.6)	1332 (20.6)	919 (29.1)	
Never married	1682 (20.4)	1331 (20.6)	512 (16.2)	
Education level				0.034
≤High school	3810 (46.3)	3072 (47.5)	1545 (48.9)	
>High school	4425 (53.7)	3392 (52.5)	1615 (51.1)	
Smoking status ^b				<0.001
No	4922 (59.8)	3450 (53.4)	1403 (44.4)	
Yes	3313 (40.2)	3014 (46.6)	1757 (55.6)	
Alcohol intake (gm/day)				<0.001
0	6074 (73.8)	4804 (74.3)	2502 (79.2)	
>0	2161 (26.2)	1660 (25.7)	658 (20.8)	
HEI-2015 index				<0.001
<60	5307 (64.4)	4502 (69.6)	2236 (70.8)	
≥60	2928 (35.6)	1962 (30.4)	924 (29.2)	
Physical activity (MET-h/week)				<0.001
0	2052 (24.9)	1722 (26.6)	1008 (31.9)	
0–200	5639 (68.5)	4164 (64.4)	1927 (61.0)	
>200	544 (6.6)	578 (8.9)	225 (7.1)	
Sedentary time (hours)				<0.001
<8	5648 (68.6)	4377 (67.7)	1989 (62.9)	
≥8	2587 (31.4)	2087 (32.3)	1171 (37.1)	
BMI (kg/m ²)				<0.001
<30	5471 (66.4)	4006 (62.0)	1527 (48.3)	
≥30	2764 (33.6)	2458 (38.0)	1633 (51.7)	
Comorbidity index				<0.001
0	5669 (68.8)	4022 (62.2)	1218 (38.5)	
>0	2566 (31.2)	2442 (37.8)	1942 (61.5)	

(Continued)

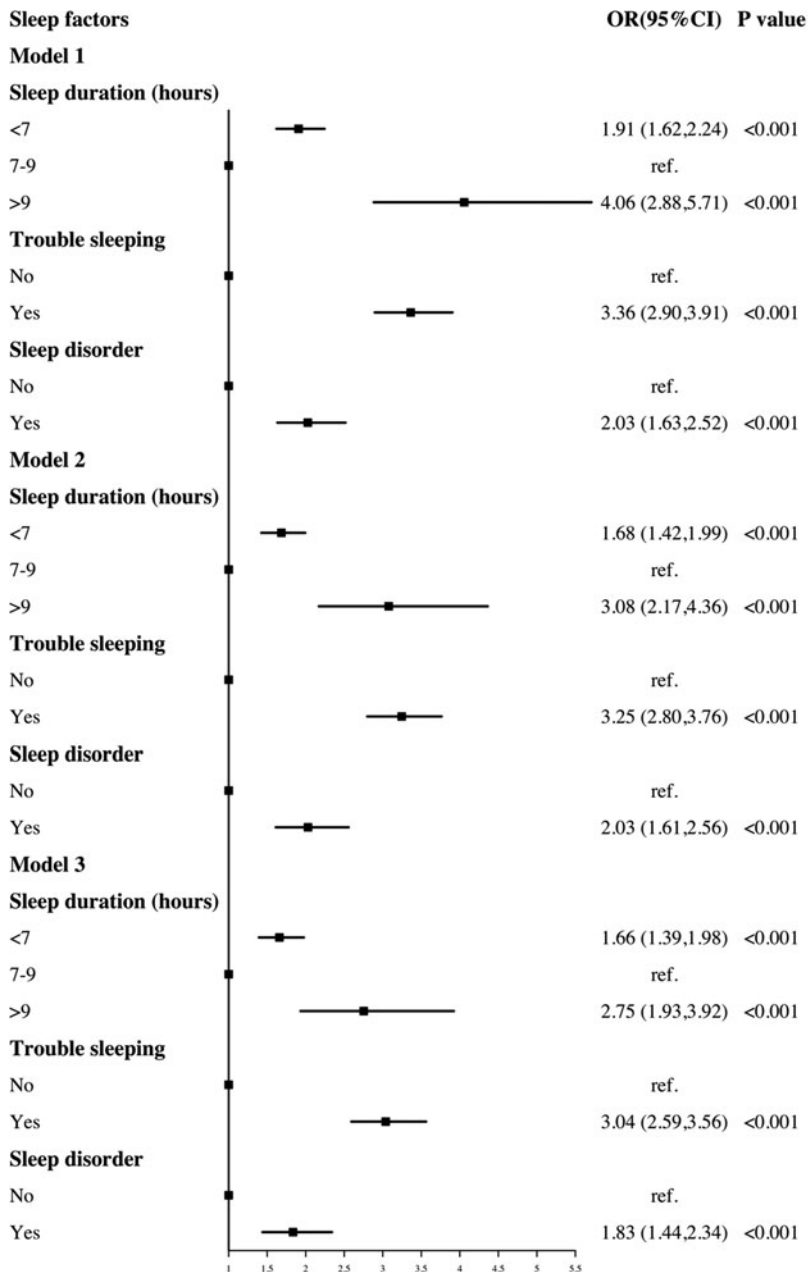
Table 2. (Continued.)

Characteristics	Sleep pattern (Col%)			p value
	Healthy (n = 8235)	Intermediate (n = 6464)	Poor (n = 3160)	
CRD				<0.001
<10	7889 (95.8)	5876 (90.9)	2389 (75.6)	
≥10	346 (4.2)	588 (9.1)	771 (24.4)	

n, sample size; BMI, body mass index; HEI-2015, Healthy Eating Index-2015; MET, metabolic equivalent; CRD, clinically relevant depression.

^aNon-White: Mexican American, other Hispanic, non-Hispanic Black, other race-including multi-racial.

^bSmoke 100 cigarettes (or other tobacco) in entire life.



Adjusted for:

Model 1: age, gender

Model 2: model 1, race, marriage status, education level, smoke status, alcohol intake

Model 3: model 2, HEI-2015 index, physical activity, sedentary time, BMI, comorbidity index

Fig. 1. Logistic regression analyses of the association between sleep factors and CRD. Adjusted for: Model 1: age, gender; Model 2: model 1, race, marital status, education level, smoke status, alcohol intake; Model 3: model 2, HEI-2015 index, physical activity, sedentary time, BMI, comorbidity index.

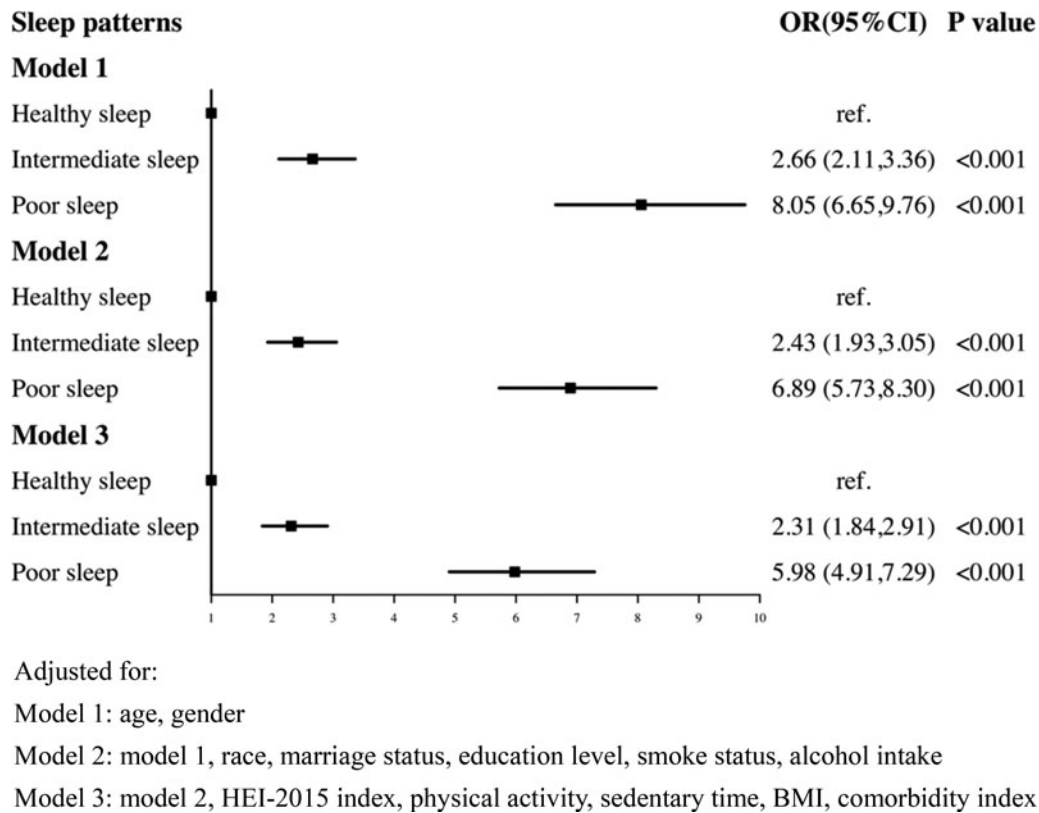


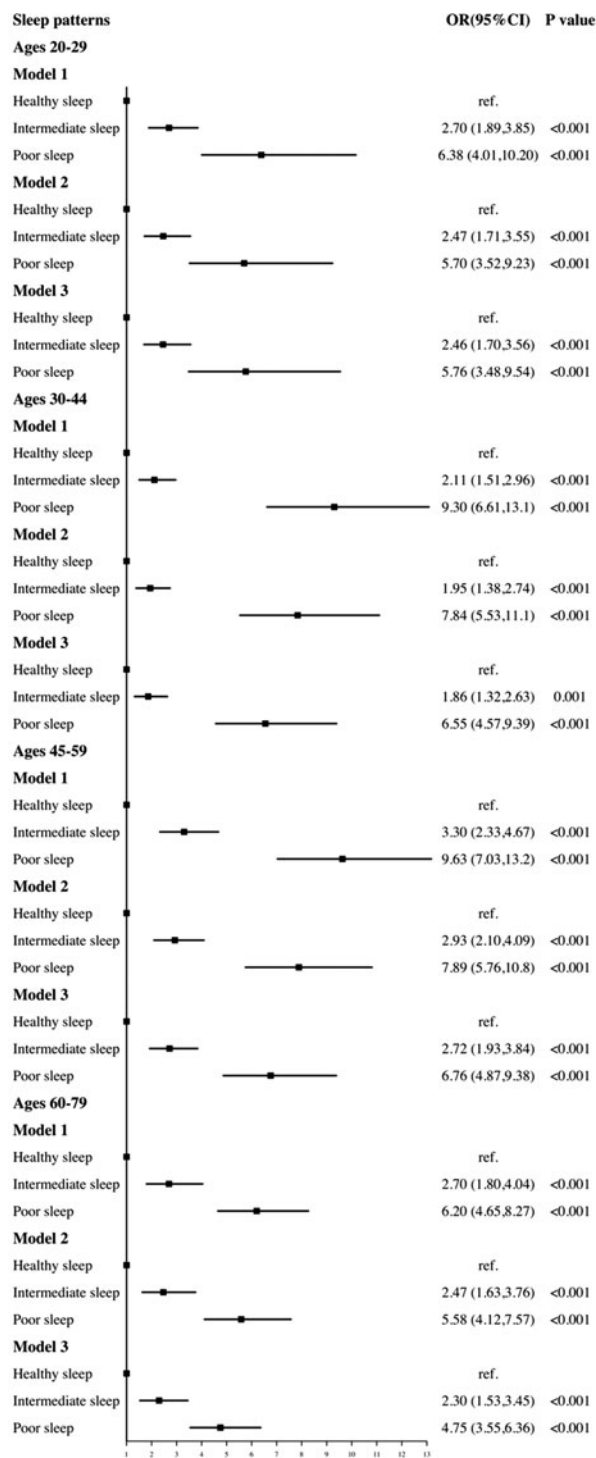
Fig. 2. Logistic regression analyses of the association between sleep patterns and CRD. Adjusted for: Model 1: age, gender; Model 2: model 1, race, marital status, education level, smoke status, alcohol intake; Model 3: model 2, HEI-2015 index, physical activity, sedentary time, BMI, comorbidity index.

likely related to individual difference susceptibility and environmental factors (Seedat *et al.*, 2009; Kuehner, 2017).

The quantity and quality of sleep are the basic units of good sleep. A recent meta-analysis of six prospective studies from the United States and one from Japan revealed a U-shaped relationship between sleep duration and depression risk (Zhai *et al.*, 2015). Another large study, involving over 0.5 million Chinese participants, supported the U-shaped trend as well (Sun *et al.*, 2018). This was consistent with our result that, in the fully adjusted model, both short (OR: 1.66, 95% CI: 1.39–1.98) and long sleep duration (OR: 2.75, 95% CI: 1.93–3.92) were associated with depression. However, two other studies merely supported the longitudinal association between short sleep and depression, possibly due to the varied age ranges included (Jackowska and Poole, 2017; Li *et al.*, 2017). Aside from sleep quantity, sleep quality is also associated with depression risk (Yang *et al.*, 2019; Hu *et al.*, 2020). Longitudinal studies suggested that insomnia symptoms or biomarkers measured by polysomnography enhance the incidence of depression by 2.2- to 5.3-fold (Szklo-Coxe *et al.*, 2010). And the treatment of insomnia in patients with depression has a positive impact on mood (Gebara *et al.*, 2018). Sleep disorders, particularly obstructive sleep apnoea (OSA), are more common in the general population. OSA affects 17% of women and 34% of men in the United States, with a similar prevalence in other countries (Gottlieb *et al.*, 2020). Aside from the high prevalence of OSA, patients often fail to report sleep problems to clinicians, resulting in underdiagnosis, which is linked to an increased risk of a variety of negative health outcomes (Jonas *et al.*, 2017; Gottlieb *et al.*, 2020). For example, a systematic review and meta-analysis of observational studies support the idea that

obstructive sleep apnoea may raise the risk of depression (Edwards *et al.*, 2020). Furthermore, this study extended on earlier findings by revealing that not only was a single sleep trait associated to depression, but the importance of an overall assessment of sleep factors was emphasised. In all three models, a poor sleep pattern was shown to be associated to the incidence of depression. In accordance with this, a study from rural China has examined sleep behaviours in tandem, indicating that the co-occurrence of sleep duration with objectively sleep complaints is related with the greater risk of depression (Jiang *et al.*, 2020). Furthermore, there are significant differences in sleep patterns throughout the lifespan (Hertenstein *et al.*, 2018). Previous research has shown that depressive symptoms are more common in older adults with sleep disorders than in young (Cho *et al.*, 2008; Paudel *et al.*, 2008). A community cohort study of a Chinese population discovered that sleep problems were independently associated with depressive symptoms, particularly among middle-aged and elderly people aged 55–64 (Zhang *et al.*, 2021). Similarly, our results supported the association between sleep problems and depression across age groups, particularly the middle-aged population (45–59 years, OR: 6.76, 95% CI: 4.87–9.38).

To date, multiple genome-wide association studies confirmed genetic correlations between sleep duration, insomnia symptoms, excessive daytime sleepiness and depressive symptoms (Hammerschlag *et al.*, 2017; Lane *et al.*, 2017; Dashti, 2019; Jansen *et al.*, 2019; Wang, 2019). A genetically informed twin design revealed that both short (<7 h per night) and long (>9 h per night) sleep enhanced the heritability of depressed symptoms, suggesting that genetic risk for depressive symptoms rises as twins



Adjusted for:

Model 1: gender

Model 2: model 1, race, marriage status, education level, smoke status, alcohol intake

Model 3: model 2, HEI-2015 index, physical activity, sedentary time, BMI, comorbidity index

Fig. 3. Logistic regression analyses of the association between sleep patterns and CRD stratified by age. Adjusted for: Model 1: gender; Model 2: model 1, race, marital status, education level, smoke status, alcohol intake; Model 3: model 2, HEI-2015 index, physical activity, sedentary time, BMI, comorbidity index.

move away from normal sleep duration (7–8.9 h/night) (Watson *et al.*, 2014). The underlying mechanism of the link between sleep and depression was unknown, and there were numerous potential processes that contribute to the development of depression through sleep. Sleep and the immune system research studies

have revealed that sleep improves immunological defences and that afferent signals from immune cells induce sleep, and immune activation and cytokines may have a role in depression symptoms in some individuals (Dunn *et al.*, 2005; Irwin, 2019). Sleep disturbances were independently associated with an increased risk of

major depressive disorder, the experimental stimulation of inflammation activates brain regions that control positive and negative effects, and was related with an increase in depressed mood, particularly in women, while antagonism of endogenous inflammation appeared to decrease depressive symptoms (Irwin and Opp, 2017). In addition, chronic sleep deprivation may cause alterations in neurotransmitter receptor systems and neuroendocrine response, contributing to the symptomatology of mental disorders (Novati et al., 2008).

Our research was performed using data from a large nationally representative population sample. NHANES's sampling approach ensures that the sample was selected at random and was representative of the whole American population. There were some limitations to the current study. First, as cross-sectional research, we cannot rule out reverse causality due to the nature of the design; Second, the type of sleep disorder is not clearly defined. Finally, all sleep factors were self-reported, which may have recall bias and lack impartiality when compared to sleep monitoring.

Conclusions

Overall, this study emphasises the independent and combined relationship between sleep-related issues and the risk of depression. Further prospective studies should be conducted to investigate causal or bidirectional relationships between sleep complaints and depression risk. Moreover, it is critical to investigate the genetic association and potential mechanism between sleep complaints and depression, for the effective depression prevention and management.

Supplementary material. The supplementary material for this article can be found at <https://doi.org/10.1017/S2045796022000452>.

Data. The data that support the findings of this study are openly available at <https://www.cdc.gov/nchs/nhanes/index.htm>, accessed on 15 June 2022.

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Conflict of interest. The authors declare that there is no conflict of interest.

Ethical standards. NCHS Research Ethics Review Board (ERB) Approval, NHANES 2007–2008 (Continuation of Protocol #2005-06), NHANES 2009–2010 (Continuation of Protocol #2005-06), NHANES 2011–2012 (Protocol #2011-17), NHANES 2013–2014 (Continuation of Protocol #2011-17).

References

- Chang JJ, Salas J, Habicht K, Pien GW, Stamatakis KA and Brownson RC (2012) The association of sleep duration and depressive symptoms in rural communities of Missouri, Tennessee, and Arkansas. *The Journal of Rural Health: Official Journal of the American Rural Health Association and the National Rural Health Care Association* **28**, 268–276.
- Chaput JP, Dutil C and Sampasa-Kanyinga H (2018) Sleeping hours: what is the ideal number and how does age impact this? *Nature and Science of Sleep* **10**, 421–430.
- Cho HJ, Lavretsky H, Olmstead R, Levin MJ, Oxman MN and Irwin MR (2008) Sleep disturbance and depression recurrence in community-dwelling older adults: a prospective study. *The American Journal of Psychiatry* **165**, 1543–1550.
- Dashti HS, Jones SE, Wood AR, Lane JM, van Hees VT, Wang H, Rhodes JA, Song Y, Patel K, Anderson SG, Beaumont RN, Bechtold DA, Bowden J, Cade BE, Garaulet M, Kyle SD, Little MA, Loudon AS, Luik AI, Scheer F, Spiegelhalter K, Tyrrell J, Gottlieb DJ, Tiemeier H, Ray DW, Purcell SM, Frayling TM, Redline S, Lawlor DA, Rutter MK, Weedon MN and Saxena R (2019) Genome-wide association study identifies genetic loci for self-reported habitual sleep duration supported by accelerometer-derived estimates. *Nature Communications* **10**, 1100.
- Dunn AJ, Swiergiel AH and de Beaurepaire R (2005) Cytokines as mediators of depression: what can we learn from animal studies? *Neuroscience and Biobehavioral Reviews* **29**, 891–909.
- Edwards C, Almeida OP and Ford AH (2020) Obstructive sleep apnea and depression: a systematic review and meta-analysis. *Maturitas* **142**, 45–54.
- Fernandez-Mendoza J, Shea S, Vgontzas AN, Calhoun SL, Liao D and Bixler EO (2015) Insomnia and incident depression: role of objective sleep duration and natural history. *Journal of Sleep Research* **24**, 390–398.
- Gebara MA, Siripong N, DiNapoli EA, Maree RD, Germain A, Reynolds CF, Kasckow JW, Weiss PM and Karp JF (2018) Effect of insomnia treatments on depression: a systematic review and meta-analysis. *Depression and Anxiety* **35**, 717–731.
- Gottlieb DJ and Punjabi NM (2020) Diagnosis and management of obstructive sleep apnea: a review. *JAMA* **323**, 1389–1400.
- Hammerschlag AR, Stringer S, de Leeuw CA, Sniekers S, Taskesen E, Watanabe K, Blanken TF, Dekker K, Te Lindert BHW, Wassing R, Jonsdottir I, Thorleifsson G, Stefansson H, Gislason T, Berger K, Schormair B, Wellmann J, Winkelmann J, Stefansson K, Oexle K, Van Someren EJW and Posthuma D (2017) Genome-wide association analysis of insomnia complaints identifies risk genes and genetic overlap with psychiatric and metabolic traits. *Nature Genetics* **49**, 1584–1592.
- Hertenstein E, Gabryelska A, Spiegelhalter K, Nissen C, Johann AF, Umarova R, Riemann D, Baglioni C and Feige B (2018) Reference data for polysomnography-measured and subjective sleep in healthy adults. *Journal of Clinical Sleep Medicine: JCSM: Official Publication of the American Academy of Sleep Medicine* **14**, 523–532.
- Hu Z, Zhu X, Kaminga AC, Zhu T, Nie Y and Xu H (2020) Association between poor sleep quality and depression symptoms among the elderly in nursing homes in Hunan province, China: a cross-sectional study. *BMJ Open* **10**, e036401.
- Huang Y, Li L, Gan Y, Wang C, Jiang H, Cao S and Lu Z (2020) Sedentary behaviors and risk of depression: a meta-analysis of prospective studies. *Translational Psychiatry* **10**, 26.
- Irwin MR (2019) Sleep and inflammation: partners in sickness and in health. *Nature Reviews Immunology* **19**, 702–715.
- Irwin MR and Opp MR (2017) Sleep health: reciprocal regulation of sleep and innate immunity. *Neuropsychopharmacology: Official Publication of the American College of Neuropsychopharmacology* **42**, 129–155.
- Jackowska M and Poole L (2017) Sleep problems, short sleep and a combination of both increase the risk of depressive symptoms in older people: a 6-year follow-up investigation from the English Longitudinal Study of Ageing. *Sleep Medicine* **37**, 60–65.
- Jansen, PR, Watanabe K, Stringer S, Skene N, Bryois J, Hammerschlag AR, de Leeuw CA, Benjamins JS, Munoz-Manchado AB, Nagel M, Savage JE, Tiemeier H, White T, and Me Research T, Tung JY, Hinds DA, Vacic V, Wang X, Sullivan PF, van der Sluis S, Polderman TJC, Smit AB, Hjerling-Leffler J, Van Someren EJW and Posthuma D (2019) Genome-wide analysis of insomnia in 1,331,010 individuals identifies new risk loci and functional pathways. *Nature Genetics* **51**, 394–403.
- Jiang J, Li Y, Mao Z, Wang F, Huo W, Liu R, Zhang H, Tian Z, Liu X, Zhang X, Tu R, Qian X, Liu X, Luo Z, Bie R and Wang C (2020) Abnormal night sleep duration and poor sleep quality are independently and combinedly associated with elevated depressive symptoms in Chinese rural adults: Henan Rural Cohort. *Sleep Medicine* **70**, 71–78.
- Jonas DE, Amick HR, Feltner C, Weber RP, Arvanitis M, Stine A, Lux L and Harris RP (2017) Screening for obstructive sleep apnea in adults: evidence report and systematic review for the US Preventive Services Task Force. *JAMA* **317**, 415–433.

- Krebs-Smith SM, Pannucci TE, Subar AF, Kirkpatrick SI, Lerman JL, Tooze JA, Wilson MM and Reedy J (2018) Update of the healthy eating index: HEI-2015. *Journal of the Academy of Nutrition and Dietetics* **118**, 1591–1602.
- Kronke K, Spitzer RL and Williams JB (2001) The PHQ-9: validity of a brief depression severity measure. *Journal of General Internal Medicine* **16**, 606–613.
- Kuehner C (2017) Why is depression more common among women than among men? *The Lancet Psychiatry* **4**, 146–158.
- Lane JM, Liang J, Vlasac I, Anderson SG, Bechtold DA, Bowden J, Emsley R, Gill S, Little MA, Luik AI, Loudon A, Scheer FA, Purcell SM, Kyle SD, Lawlor DA, Zhu X, Redline S, Ray DW, Rutter MK and Saxena R (2017) Genome-wide association analyses of sleep disturbance traits identify new loci and highlight shared genetics with neuropsychiatric and metabolic traits. *Nature Genetics* **49**, 274–281.
- Levis B, Benedetti A, Thombs BD and DEPRESSion Screening Data (DEPRESSD) Collaboration (2019) Accuracy of patient health questionnaire-9 (PHQ-9) for screening to detect major depression: individual participant data meta-analysis. *BMJ (Clinical Research Ed.)* **365**, 11476.
- Li L, Wu C, Gan Y, Qu X and Lu Z (2016) Insomnia and the risk of depression: a meta-analysis of prospective cohort studies. *BMC Psychiatry* **16**, 375.
- Li Y, Wu Y, Zhai L, Wang T, Sun Y and Zhang D (2017) Longitudinal association of sleep duration with depressive symptoms among middle-aged and older Chinese. *Scientific Reports* **7**, 11794.
- Lippman S, Gardener H, Rundek T, Seixas A, Elkind M, Sacco RL, Wright CB and Ramos AR (2017) Short sleep is associated with more depressive symptoms in a multi-ethnic cohort of older adults. *Sleep Medicine* **40**, 58–62.
- Liu J, Rehm CD, Onopa J and Mozaffarian D (2020a) Trends in diet quality among youth in the United States, 1999–2016. *JAMA* **323**, 1161–1174.
- Liu Q, He H, Yang J, Feng X, Zhao F and Lyu J (2020b) Changes in the global burden of depression from 1990 to 2017: findings from the Global Burden of Disease study. *Journal of Psychiatric Research* **126**, 134–140.
- Malhi GS and Mann JJ (2018) Depression. *Lancet (London, England)* **392**, 2299–2312.
- Mohan J, Xiaofan G and Yingxian S (2017) Association between sleep time and depression: a cross-sectional study from countries in rural Northeastern China. *The Journal of International Medical Research* **45**, 984–992.
- Novati A, Roman V, Cetin T, Hagewoud R, den Boer JA, Luiten PG and Meerlo P (2008) Chronically restricted sleep leads to depression-like changes in neurotransmitter receptor sensitivity and neuroendocrine stress reactivity in rats. *Sleep* **31**, 1579–1585.
- Opie RS, Itsiopoulos C, Parletta N, Sanchez-Villegas A, Akbaraly TN, Ruusunen A and Jacka FN (2017) Dietary recommendations for the prevention of depression. *Nutritional Neuroscience* **20**, 161–171.
- Otte C, Gold SM, Penninx BW, Pariante CM, Etkin A, Fava M, Mohr DC and Schatzberg AF (2016) Major depressive disorder. *Nature Reviews Disease Primers* **2**, 16065.
- Park LT and Zarate CA Jr. (2019) Depression in the primary care setting. *The New England Journal of Medicine* **380**, 559–568.
- Paudel ML, Taylor BC, Diem SJ, Stone KL, Ancoli-Israel S, Redline S, Ensrud KE and Osteoporotic Fractures in Men Study Group (2008) Association between depressive symptoms and sleep disturbances in community-dwelling older men. *Journal of the American Geriatrics Society* **56**, 1228–1235.
- Plante DT, Finn LA, Hagen EW, Mignot E and Peppard PE (2017) Longitudinal associations of hypersomnolence and depression in the Wisconsin Sleep Cohort Study. *Journal of Affective Disorders* **207**, 197–202.
- Seedat S, Scott KM, Angermeyer MC, Berglund P, Bromet EJ, Brugha TS, Demyttenaere K, de Girolamo G, Haro JM, Jin R, Karam EG, Kovess-Masfety V, Levinson D, Medina Mora ME, Ono Y, Ormel J, Pennell BE, Posada-Villa J, Sampson NA, Williams D and Kessler RC (2009) Cross-national associations between gender and mental disorders in the World Health Organization World Mental Health Surveys. *Archives of General Psychiatry* **66**, 785–795.
- Sun X, Zheng B, Lv J, Guo Y, Bian Z, Yang L, Chen Y, Fu Z, Guo H, Liang P, Chen Z, Chen J, Li L, Yu C and China Kadoorie Biobank (CKB) Collaborative Group (2018) Sleep behavior and depression: findings from the China Kadoorie Biobank of 0.5 million Chinese adults. *Journal of Affective Disorders* **229**, 120–124.
- Szklo-Coxe M, Young T, Peppard PE, Finn LA and Benca RM (2010) Prospective associations of insomnia markers and symptoms with depression. *American Journal of Epidemiology* **171**, 709–720.
- Wang H, Lane JM, Jones SE, Dashti HS, Ollila HM, Wood AR, van Hees VT, Brumpton B, Winsvold BS, Kantojarvi K, Palviainen T, Cade BE, Sofer T, Song Y, Patel K, Anderson SG, Bechtold DA, Bowden J, Emsley R, Kyle SD, Little MA, Loudon AS, Scheer F, Purcell SM, Richmond RC, Spiegelhalter K, Tyrrell J, Zhu X, Hublin C, Kaprio JA, Kristiansson K, Sulkava S, Paunio T, Hveem K, Nielsen JB, Willer CJ, Zwart JA, Strand LB, Frayling TM, Ray D, Lawlor DA, Rutter MK, Weedon MN, Redline S and Saxena R (2019) Genome-wide association analysis of self-reported daytime sleepiness identifies 42 loci that suggest biological subtypes. *Nature Communications* **10**, 3503.
- Watson NF, Harden KP, Buchwald D, Vitiello MV, Pack AI, Strachan E and Goldberg J (2014) Sleep duration and depressive symptoms: a gene-environment interaction. *Sleep* **37**, 351–358.
- Wong VW, Ho FY, Shi NK, Sarris J, Chung KF and Yeung WF (2021) Lifestyle medicine for depression: a meta-analysis of randomized controlled trials. *Journal of Affective Disorders* **284**, 203–216.
- Zhai L, Zhang H and Zhang D (2015) Sleep duration and depression among adults: a meta-analysis of prospective studies. *Depression and Anxiety* **32**, 664–670.
- Zhang XF, Liu F, Liu WP, Ye XM, Cui BY and Wang HJ (2021) [Relationship between sleep duration and depressive symptoms in middle-aged and elderly people in four provinces of China]. *Zhonghua Liu Xing Bing Xue Za Zhi* **42**, 1955–1961.