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Relationship between multidimensional sleep health and depression during late pregnancy: a cross-sectional study

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Abstract

Background Depression is common among pregnant women and identifying modifiable risk factors is critical (e.g., sleep). Individual sleep dimensions, e.g., short sleep duration and poor sleep quality, were associated with a higher risk of depression, while whether the multidimensional construct of sleep health could be a protective or risk factor for prenatal depression remains unknown. This study aimed to examine the relationship between multidimensional sleep health and depression during late pregnancy.

Methods This study was conducted among women during late pregnancy (28–40 weeks). Sleep health was measured by self-report questionnaires. Each dimension (sleep quality, duration, efficiency, timing, regularity and daytime sleepiness) was categorized as "good" or "poor". A composite sleep health score was calculated. Depression was measured using the Edinburgh Postnatal Depression Scale. Logistic regression analyses were used to examine the associations between individual sleep health dimensions and depression. Restricted cubic spline analysis was used to explore the dose-response relationship between overall sleep health and depression.

Results A total of 329 women were included. Their mean age was 31.6 years and the mean gestational age was 34.7 weeks. Sixty (18.2%) had clinically elevated depression. There was a dose-response relationship between composite sleep health score and depression, with a higher sleep health score associated with a lower risk of depression (OR = 0.572, 95%CI = 0.423–0.774, p for linearity < 0.001). Controlling for covariates, poor sleep quality (OR = 3.485, 95%CI = 1.817–6.683, $p < 0.001$), short sleep duration (OR = 3.462, 95%CI = 1.513–7.924, $p = 0.003$), and excessive daytime sleepiness (OR = 3.409, 95%CI = 1.804–6.442, $p < 0.001$) were associated with a higher risk of depression.

Conclusion Both overall sleep health and individual dimensions (sleep quality, short sleep duration, and daytime sleepiness) were associated with depression during late pregnancy. These findings highlight the potential benefits of maintaining sleep health to achieve mental wellbeing in pregnant women. Healthcare providers may consider adding the assessment and management of sleep health as part of routine prenatal care.

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Introduction

Prenatal depression is a depressive disorder that occurs during pregnancy, characterized by poor mood, low interest, and other depressive symptoms [1]. Globally, prenatal depression was estimated to affect 20.7% of pregnant women [2], with a pooled prevalence of 19.7% in China [3]. The incidence of depression increases significantly with progressing gestation [4], up to 46.1% during late pregnancy [5]. Prenatal depression may bring serious and long-lasting adverse consequences for both mothers and children, including an increased risk of premature birth, low birth weight, preeclampsia, and postpartum depression, as well as an increased incidence of developing mental health problems during later stages of life in children [1, 6]. Prenatal depression is also a risk factor for suicide, a leading cause of pregnancy-related death [7]. Prenatal depression could also cause significant economic burdens. Based on a cohort study, perinatal mental health issues cost $14 billion, with an average cost of approximately $31,800 for each mother and their babies [8]. Therefore, identifying risk factors that can be modified is crucial to preventing depression and its associated burdens.

Women are vulnerable to sleep disturbance, especially during pregnancy. As pregnancy progresses, the amount of sleep gradually decreases and the quality of sleep deteriorates, reaching its most severe level during late pregnancy [9]. Over 45% of pregnant women complained of poor sleep quality during pregnancy which increased with the increasing gestational age [10]. The above changes in sleep are possibly due to pregnancy-related physiological changes, such as nocturia, heartburn, fetal movement, restless legs, and hormonal changes [11]. Systematic reviews suggest that sleep disturbance is one of the key factors related to perinatal depression [12]. Specifically, late sleep, short sleep duration, and poor sleep quality are closely related to depression [13]. However, prior studies have typically focused on a single dimension of sleep. Emerging evidence indicates that sleep is a complex phenomenon that cannot merely be described by one single dimension (e.g., duration or quality). It needs to be investigated using a holistic approach, considering the 24-hour sleep/wake cycle [14], which could offer a more complete understanding of how sleep impacts health.

In 2014, the concept of "sleep health" was proposed [14], defined as "a multidimensional pattern of sleep-wakefulness, adapted to individual, social, and environmental demands, that promotes physical and mental well-being". It includes several dimensions, such as quality, sleepiness, timing, efficiency, duration, and regularity. In this definition, sleep can be viewed through a positive lens that applies to everyone. With the emergence of this concept, researchers have started to investigate sleep health and its impact on health. However, only a few studies have examined sleep health and its association with depression during pregnancy, with inconsistent results. Specifically, one study showed multiple dimensions of sleep health, including poor sleep quality and increased daytime sleepiness, but not sleep duration, was related to persistent depression [15]. Other studies focused on a single sleep dimension and found that sleep duration was associated with depression [9, 16]. Meanwhile, previous studies were mostly conducted in Western countries whose results may not be applicable to Asian countries. There are cultural differences in sleep between Western and Asian countries. For example, nocturnal sleep had a later onset in Asia than in other regions; weekend sleep extension was longer in the United States and Europe than in Asia [17].

Building upon previous evidence, this study aimed to examine the relationship between multidimensional sleep health and depression among a sample of pregnant women in China. We hypothesized that both individual dimensions of sleep, as well as overall multidimensional sleep health, were associated with prenatal depression in women during late pregnancy. Findings from this study may contribute to the existing literature on the potential impact of multidimensional sleep health on health.

Methods

Design

A cross-sectional design was used.

Participants

Participants were recruited from three hospitals in Shanghai and Yunnan, China, from August 2022 to April 2024. The inclusion criteria were: (1) pregnant women in the third trimester (28–40 weeks); and (2) aged 18 to 45 years. The exclusion criteria were: (1) current multiple pregnancy (e.g., twins or triplets); (2) shift work during the past three months; (3) self-report diagnosis of chronic or severe diseases before pregnancy (including heart disease, and renal failure); and (4) self-report diagnosis of major psychiatric disorders (e.g., schizophrenia and bipolar disorder) or severe cognitive impairment. The sample size was calculated using G*Power 3.1 (Franz Fail, Germany). According to previous evidence, sleep duration and sleep quality were significantly related to depression (adjusted $OR = 1.60 \sim 3.42$) [16, 18]. Based on the above parameters, setting $\alpha = 0.05$, $1\text{-}\beta = 0.90$, a minimum of 307 participants was needed. A total of 356 women were screened and 329 were recruited.

Data collection

Depression

Depression was measured by the Edinburgh Postnatal Depression Scale (EPDS) [19]. It is a 10-item self-report scale, with each item ranging from 0 to 3. The total score ranges from 0 to 30, and a higher score indicates a higher level of depression [20]. A score of ≥ 13 was considered clinically elevated depression [21]. In this study, the Cronbach's α of EPDS was 0.75.

Sleep health

Sleep health includes sleep quality, sleep duration, sleep timing, sleep efficiency, sleep regularity, and daytime sleepiness [14]. It was measured by a combination of self-report questions and scales [22, 23]. Each of the following dimensions was rated as good (1) or poor (0). By adding up the scores of each dimension, a composite score was obtained, ranging from 0 to 6. A higher score indicates a higher level of sleep health [23].

1) *Sleep quality* was obtained from one question of the Pittsburgh Sleep Quality Index (PSQI) [24]: During the past month, how would you rate your sleep quality overall? It was rated as very good, fairly good, fairly bad, and very bad. Very good and fairly good were considered good, fairly bad and very bad were considered poor.
2) *Sleep duration* was obtained from one question of the PSQI: During the past month, how many hours of actual sleep did you get at night? (This may be different from the number of hours you spent in bed) [25]. Sleep duration was categorized based on current recommendations: 7–9 h = healthy sleep duration, <7 h = short sleep duration, and > 9 h = long sleep duration. Both short and long sleep duration were considered poor [26].
3) *Sleep efficiency* was calculated using three items from PSQI [24]. A threshold of < 85% was used to indicate poor sleep efficiency [27].
4) *Daytime sleepiness* was measured using the Epworth Sleepiness Scale (ESS). The ESS is an eight-item self-report scale, with each item ranging from 0 to 3. The total score ranges from 0 to 24, and a higher score indicates a higher level of daytime sleepiness. A total score > 10 indicated poor [28]. In this study, the Cronbach'α of ESS was 0.86.
5) *Sleep midpoint* refers to the midpoint between bedtime and wake-up time, a measure for sleep timing. It was calculated from two questions. Participants were asked to report their sleep time and wake time during weekdays and weekends, respectively. The sleep midpoint was calculated as: "bedtime" + ("wake-up time"–"bedtime")/2 [29]. The average sleep midpoint was calculated using the following weighted mean value: (5*weekday sleep midpoint + 2*weekend sleep midpoint)/7 [30]. A cutoff of later than 4:00 AM was defined as "late sleep midpoint" (poor) [31].
6) *Sleep regularity* refers to the consistency of sleep timing or duration. It can be represented in several ways, such as weekday-weekend discrepancy (i.e., social jetlag) or other computed metrics describing variability in sleep duration or timing variables [32]. In this study, we used social jetlag to present sleep regularity and it was calculated as the absolute value of the difference between weekday and weekend sleep midpoint, based on the following questions: Bedtime on weekdays and weekends in the past seven days, wake-up time on weekdays and weekends in the past seven days [33]. An over 60-minute difference was defined as poor sleep regularity [34].

Covariates

Potential covariates include socio-demographics (e.g., age, education, marital status, working status), lifestyle factors (e.g., coffee, nap), and pregnancy-related variables [e.g., gestational age, pre-pregnancy body mass index (BMI), and whether the pregnancy was planned]. They were measured using a survey designed by the research team.

Procedures

Participants were recruited from the outpatient clinic providing prenatal care among three tertiary hospitals in Shanghai and Yunnan, China. Women who agreed to participate in the study provided informed consent. Data were collected via REDCap hosted at Shanghai Jiao Tong University. Participants were provided with a QR code linking to the questionnaires, along with the password for access. A total of 356 women were contacted and nine were excluded due to in-eligibility. Data from 18 (5.2%) participants were excluded due to missing data on any variables. Thus, data from 329 participants were included in the final analyses.

Ethical considerations

Ethical approval of the study was approved by the Institutional Review Board of Shanghai Jiao Tong University School of Medicine, Approval Number: SJUPN-202,134, 20th June 2022. The study was undertaken according to research ethics guidelines, participation was voluntary, and informed consent was obtained from all participants.

Statistical analysis

Data analyses were performed using SPSS (version 27.0, IBM Corp, USA) and R (version 4.2.2, R Foundation for Statistical Computing, Vienna, Austria). Data were presented as mean (standard deviation, SD) or frequency (%). Independent sample t-tests were used to detect group differences for continuous variables as the data were (close to) normal distribution based on both stats and histograms. Chi-square test was used to detect group differences for categorical variables. The relationship between each sleep dimension and depression was examined using logistic regression analysis. In the adjusted models, factors associated with the outcome at $p < 0.1$ in the bivariate analyses were included. Similar to a recent study on sleep health [35], separate models were obtained for each sleep dimension to avoid multicollinearity or interaction effects. This approach also facilitates interpretation of the results by concentrating on the unique contribution of each sleep dimension. To investigate the nature of the relationship between sleep health and depression, we used a restricted cubic spline model. It allows for a more flexible examination of the association between the two variables, beyond a simple linear relationship. The model was adjusted for potential covariates. Initial analysis revealed that the optimal number of knots was three. Three knots were thus positioned at the 10th, 50th, and 90th percentiles of the sleep health score, in line with Harrell's recommendations [36]. The Akaike Information Criterion was used to determine the appropriate number of knots [36]. This analysis enabled us to assess whether there was a dose-response relationship between sleep health and depression. A two-tailed $p < 0.05$ was considered statistically significant.

Results

Characteristics of the participants

Table 1 shows the characteristics of the participants ($N = 329$). Their mean age was 31.6 (SD 4.4) years. Their average gestational age was 34.7 (SD 2.5) weeks. The average pre-pregnancy BMI was 21.6 (SD 3.0) kg/m^2. About half of them had a college educational level (50.5%) and were working (53.8%) during pregnancy. Based on the EPDS, 60 (18.2%) had clinically elevated depression. Table 1 also shows group comparisons between those with depression and those without. Overall, gestational age, hospital, education, working status, snoring, planned pregnancy, and abortion were significantly related to depression ($p < 0.05$).

Sleep health of the participants

Table 2 shows sleep health of the participants. According to the composite score of sleep health, 0.9%, 6.4%, 17.0%, 18.5%, 35.9%, and 21.3% of the participants had a score of 1, 2, 3, 4, 5, and 6, respectively. Nearly half (42.8%) of them had at least two dimensions compromised. For the individual sleep dimension, 95 (28.9%) had poor sleep quality; 39 (11.9%) had short sleep duration (< 7 h), 11 (3.3%) had long sleep duration (> 9 h); 173 (52.6%) had low sleep efficiency; and 90 (27.4%) had excessive daytime sleepiness. The mean sleep midpoint was 3:22 am. Sixty of them (18.2%) had a late sleep midpoint. Thirty-eight (11.6%) had poor sleep regularity between weekdays and weekends.

Multivariate associations between sleep health and depression

The relationship between overall sleep health and depression is shown in Fig. 1. After controlling for covariates, there was a dose-response relationship between sleep health and depression. The restricted cubic spline analysis demonstrated a linear correlation between sleep health composite score and depression (p for linearity < 0.001). Specifically, each one-point increase in sleep health composite score was associated with a 42.8% reduction in the risk of having depression (OR = 0.572, 95%CI = 0.423–0.774).

To probe the individual dimensions of sleep health driving the multidimensional results, we derived separate regression models (Table 3). In the unadjusted models, poor sleep quality (OR = 3.424, 95%CI = 1.919–6.109), short sleep duration (OR = 3.191, 95%CI = 1.559–6.533) and sleepiness (OR = 3.483, 95%CI = 1.947–6.233) were associated with depression. After controlling for the covariates, poor sleep quality (OR = 3.485, 95%CI = 1.817–6.683), short sleep duration (OR = 3.462, 95%CI = 1.513–7.924), and sleepiness (OR = 3.409, 95%CI = 1.804–6.442) remained significant predictors of depression.

Discussion

To the best of our knowledge, this study was among the first that focused on the holistic concept of sleep health and its association with depression among women during late pregnancy in China. Our results showed that 18.2% women during late pregnancy had clinically elevated depression, slightly lower than the pooled prevalence of perinatal depression using data from upper-middle-income countries (24.7%) [37]. More importantly, the higher the sleep health score, the lower the risk of having depression. Additionally, several dimensions of sleep health, including poor sleep quality, short sleep duration, and sleepiness were associated with depression. These findings coincide with prospective studies showing that prenatal sleep could influence postpartum depression [38, 39]. Sleep health is modifiable and non-clinical in nature. This study highlights the potential benefits of maintaining sleep health in achieving mental wellbeing among pregnant women.

Table 1 Participant characteristics and group comparison for depression (*N*=329)

Variables	Total (*N*=329)	Depression		*p*
		Yes (*n*=60)	No (*n*=269)	
Age (year)	31.6 (4.4)	30.9 (5.1)	31.8 (4.2)	0.264
Gestational age (week)	34.7 (2.5)	35.4 (2.5)	34.5 (2.5)	0.018
Pre-pregnancy BMI (kg/m^2)	21.6 (3.0)	21.9 (3.2)	21.5 (2.9)	0.429
Hospital location				
Shanghai	163 (49.5%)	15 (25.0%)	148 (55.0%)	<0.001
Yunnan	166 (50.5%)	45 (75.0%)	121 (45.0%)	
Education				
High school and below	163 (49.5%)	44 (73.3%)	119 (44.2%)	<0.001
College education	166 (50.5%)	16 (26.7%)	150 (55.8%)	
Working status				
Yes	177 (53.8%)	22 (36.7%)	155 (57.6%)	0.003
No	152 (46.2%)	38 (63.3%)	114 (42.4%)	
Children				
0	205 (62.3%)	36 (60.0%)	169 (62.8%)	0.683
1-2	124 (37.7%)	24 (40.0%)	100 (37.2%)	
Marital status				
Yes	323 (98.2%)	59 (98.3%)	264 (98.1%)	0.919
Single/divorce/separation	6 (1.8%)	1 (1.7%)	5 (1.9%)	
Coffee				
Never	159 (48.3%)	25 (41.7%)	134 (49.8%)	0.496
Pre-pregnancy	148 (45.0%)	31 (51.7%)	117 (43.5%)	
Yes	22 (6.7%)	4 (6.6%)	18 (6.7%)	
Nap				
0-2 times/week	124 (37.7%)	16 (26.7%)	108 (40.1%)	0.150
3-5 times/week	70 (21.3%)	15 (25.0%)	55 (20.4%)	
Every day	135 (41.0%)	29 (48.3%)	106 (39.5%)	
Snoring				
Yes	156 (47.4%)	37 (61.7%)	119 (44.2%)	0.014
No	173 (52.6%)	23 (38.3%)	150 (55.8%)	
Planned pregnancy				
Yes	124 (37.7%)	32 (53.3%)	92 (34.2%)	0.006
No	205 (62.3%)	28 (46.7%)	177 (65.8%)	
Abortion				
Yes	29 (8.8%)	10 (16.7%)	19 (7.1%)	0.018
No	300 (91.2%)	50 (83.3%)	250 (92.9%)	
Assisted				
Yes	20 (6.1%)	5 (8.3%)	15 (5.6%)	0.610
No	309 (93.9%)	55 (91.7%)	254 (94.4%)	

Notes: BMI=Body Mass Index; data were presented as mean (SD) or n (%)

The composite score was designed to capture the complexity of sleep health more comprehensively than a single dimension. By including multiple sleep health dimensions, it provides a more accurate representation of overall sleep health and its potential impact on mental health. Our study found a dose-response relationship between sleep health and prenatal depression: a composite score below 5 was associated with a higher likelihood of having depression. Specifically, 42.8% of participants had at least two sleep dimensions compromised, which is concerning. Few studies have explored the relationship between overall sleep health and depression during pregnancy though similar associations have been observed in other populations. For example, a study conducted in American adults with type 2 diabetes showed that the composite sleep health was associated with depressive symptoms, with an OR of 0.58 (95%CI = 0.46–0.73) [40]. In a prospective cohort study (N = 18,776) conducted in people with cardiovascular disease, a linear dose-response association was reported between a composite healthy sleep score and incident depression, with a hazard ratio of 0.82 (95%CI = 0.77–0.87) [23]. Our findings extend this evidence to pregnant women. Future research should explore how different

Table 2 Sleep health of the participants ($N=329$)

Variables	Mean (SD)/*N* (%)	Range
Sleep health	4.5 (1.2)	1–6
Composite score = 1	3 (0.9%)	
Composite score = 2	21 (6.4%)	
Composite score = 3	56 (17.0%)	
Composite score = 4	61 (18.5%)	
Composite score = 5	118 (35.9%)	
Composite score = 6	70 (21.3%)	
Individual sleep dimension		
Sleep quality	1.1 (0.7)	0–3
PSQI item 6 > 1	95 (28.9%)	
Sleep duration (hours)	7.7 (1.0)	5.0–12.0
<7 h	39 (11.9%)	
>9 h	11 (3.3%)	
Sleep efficiency (%)	82.9 (12.6)	41.67–100.0
<85%	173 (52.6%)	
Sleepiness	8.3 (4.9)	0–24
ESS > 10	90 (27.4%)	
Sleep midpoint (am)	3:22 (0:47)	1:00–6:08
>4:00 am	60 (18.2%)	
Sleep regularity (min)	18.8 (30.1)	0-180
≥60 min	38 (11.6%)	

Notes: Pittsburgh Sleep Quality Index = PSQI; ESS = Epworth Sleepiness Scale

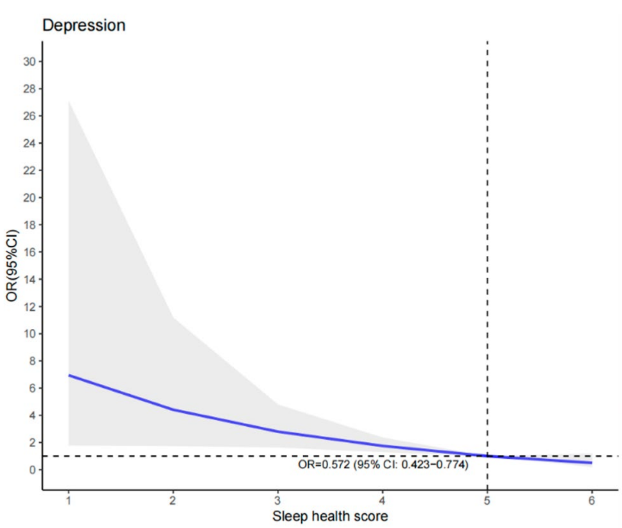

Fig. 1 Dose-response relationship between sleep health and depression. *Notes*: Blue line is multivariate adjusted OR, with grey areas showing 95% confidence interval derived from restricted cubic spline regressions with three knots; OR = Odds ratio; adjusted for gestational age, hospital, education, working status, snoring, planned pregnancy, and abortion

dimensions of sleep health interact, influencing individual's health to inform the theoretical basis for more targeted interventions.

Poor sleep quality was associated with an increased risk of prenatal depression. In this study, poor sleep quality was linked to a higher prevalence of prenatal depression, with women experiencing poor sleep quality being 3.49 times more likely to report depression, similar to the pooled estimate from a recent systematic review of seven observational studies (OR = 3.72, 95%CI = 3.20–4.32) [41]. Several mechanisms may underlie this relationship. One possible biological mechanism is that poor sleep quality may induce a disruption of rapid eye movement sleep which is usually accompanied by a significant decrease in the secretion of neurotransmitters, e.g., serotonin and dopamine. These neurotransmitters are significantly involved in the regulation of mood [42], and their disruption is associated with the presence of depression. Activation of the inflammation pathway can be another mechanism. Poor sleep quality is associated with an increase in systemic inflammatory cytokines, such as IL-6 and CRP [43]. This increase in inflammation may be linked to emotional regulation disorders, which are also observed in individuals with depression [44]. Psychologically, pregnant women who have difficulty sleeping might experience a prolonged period of wakefulness in bed, which could reinforce unpleasant thoughts and low mood [43]. Similarly, staying awake late at night provides an opportunity for rumination, worry, and loneliness, which may be related to depression [42]. Socially, poor sleep may negatively impact pregnant women's social relationships by compromising their ability to make decisions, control impulses, express and recognize their emotions, thus, making them more likely to feel depressed [42].

Short sleep duration was associated with an increased risk of prenatal depression, consistent with previous studies [16, 45]. Several reasons may explain this relationship. First, inflammation is recognized as a significant factor related to depression. Research indicates that elevated levels of inflammatory cytokines, e.g., CRP and IL-6, are strongly associated with short sleep duration [43]. Second, short sleep duration may activate the hypothalamic-pituitary-adrenal (HPA) axis. Overactivation of the HPA axis has been linked to the presence of depression [46]. Third, physical and psychological fatigue during the day, resulting from short sleep duration, can potentially disrupt circadian rhythms and lead to hormonal changes, particularly fluctuations in estrogen and progesterone levels [47]. These hormonal fluctuations are critical biological drivers of depression, as they can impair neurotransmitter balance (e.g., serotonin and gamma-aminobutyric acid), dysregulate HPA axis function, and reduce neuroplasticity in the hippocampus and prefrontal cortex, which are key mechanisms underlying depressive pathophysiology [48]. Fourth, individuals with short sleep duration may experience reduced rest and increased stress levels, which are associated with diminished cognitive function, mood disturbances, and decreased physical activity, potentially exacerbating depressive symptoms [49].

Table 3 Logistic regression models using each dimension of sleep health predicting depression (N = 329)

Variable	Unadjusted model OR (95% CI)	*p*	Adjusted model OR (95% CI)	*p*
Sleep quality[1]	3.424 (1.919, 6.109)	< 0.001	3.485 (1.817, 6.683)	< 0.001
Sleep duration[2]				
Short sleep duration	3.191 (1.559, 6.533)	0.002	3.462 (1.513, 7.924)	0.003
Long sleep duration	0.532 (0.066, 4.260)	0.552	0.385 (0.045, 3.290)	0.383
Sleep efficiency[3]	1.573 (0.887, 2.789)	0.121	1.817 (0.965, 3.422)	0.065
Sleepiness[4]	3.483 (1.947, 6.233)	< 0.001	3.409 (1.804, 6.442)	< 0.001
Sleep midpoint[5]	1.151 (0.569, 2.330)	0.696	1.035 (0.479, 2.234)	0.931
Sleep regularity[6]	0.650 (0.243, 1.741)	0.392	0.726 (0.256, 2.058)	0.546

Notes: [1]Reference group = Good sleep quality; [2]Reference group = Sleep duration of 7–9 h; [3]Reference group = Good sleep efficiency; [4]Reference group = Good sleepiness; [5]Reference group = Good sleep midpoint; [6]Reference group = Good sleep regularity; OR = Odds ratio; 95%CI = 95% Confidence Interval; adjusted for gestational age, hospital, education, working status, snoring, planned pregnancy, and abortion in all models

There has been limited research investigating the relationship between daytime sleepiness and depression in pregnant women. A study showed that excessive daytime sleepiness defined as an ESS score ≥ 10 during late pregnancy was associated with postpartum depressive symptoms (N = 293) [38]. The prevalence and severity of daytime sleepiness increase as pregnancy progresses. The association between daytime sleepiness and depression during pregnancy may be explained by several potential mechanisms. Hormone fluctuations, anxiety, and physical discomfort may contribute to excessive daytime sleepiness, which could exacerbate mood disorders (e.g., depression) [38]. Significant daytime sleepiness may also suggest underlying sleep disorders, such as sleep apnea, which has been linked to an increased risk of depression during late pregnancy (OR = 8.36, 95%CI = 1.57–44.46) [50]. In pregnant women, the pooled prevalence of sleep apnea was 15% worldwide [51], and 6.4% in China [52]. Sleep apnea is characterized by repeated partial or complete airway obstruction during sleep leading to intermittent hypoxia, cerebral microvasculature changes and hypoxic brain damage, which are similar to those observed in depressed people [53]. Sleep fragmentation caused by sleep apnea may also exacerbate depression symptoms [54]. In this study, sleep apnea was evaluated using a proxy measure from one item of PSQI which asks about "snoring". Similar to a previous study, snoring was a significant risk factor for depression [55]. However, even after controlling for snoring, the association between daytime sleepiness and depression remained significant.

We did not find significant associations between sleep efficiency with depression. It is possible that other dimensions of sleep health, such as sleep quality, might be more closely related to depression. Previous evidence on the relationship between sleep efficiency and depression has not been consistent. A prospective cohort study showed that poor sleep efficiency (< 85%) measured by actigraphy during the first trimester was associated with 2.71- and 3.87-fold increased odds of having depression in the second and third trimester, respectively [56]. However, other studies showed no correlation between objective [57] or subjective [58] sleep efficiency with depression. In this study, we dichotomized each sleep dimension into good or poor for easier interpretation, consistent with previous study [22]. This statistical approach may have led to the null findings. Further research is needed to fully understand the relationship between sleep duration, sleep efficiency, and depression during pregnancy. Future studies should consider using objective measures of sleep and assessing multiple dimensions of sleep health to better understand the complex interplay between these factors and their impact on mental health during pregnancy.

Sleep timing and sleep regularity have been previously associated with depression in non-pregnant populations, and there is some evidence in pregnant populations. However, we did not find a significant relationship between sleep timing, sleep regularity with depression. Regarding sleep timing, a previous study found that chronotype, which is a measure of an individual's natural sleep-wake preference, was not significantly associated with depression during pregnancy [58]. However, another study of 51 women with a previous, but not active, episode of unipolar or bipolar depression, "late sleeper" (those with sleep onset time later than 11:27 pm) reported significantly higher depressive symptoms at 2-week postpartum, but not during late pregnancy [59]. We hypothesized that sleep timing may be associated with depression during late pregnancy due to the shift towards the evening type and delayed sleep that can occur during this period [58]. However, we did not find a significant relationship. In our sample, only around 18% had a sleep midpoint later than 4 am. This finding might be explained by the Chinese culture. In China, "sleep early and get up early" is a tradition which is particularly encouraged among pregnant women [60]. A more balanced sample may be needed to capture the relationship between sleep timing and depression in the future. Sleep regularity is the day-to-day variability in sleep and was operationalized as the difference in sleep timing between weekdays and weekends in this sample, i.e., social jetlag.

Based on a study conducted in 1042 college students, low sleep regularity operationalized as social jetlag ≥ 2 h was associated with a higher risk of moderate to severe depressive symptoms (OR = 2.67, 95%CI = 1.39–5.15) [61]. Similarly, a population-based study showed that depressive symptoms were more common in adolescents with social jetlag ≥ 2 h (OR = 1.51, 95%CI = 1.39–1.65) [33]. The above evidence suggests that sleep regularity operationalized as social jetlag may be a predictor of depression. There are several potential explanations for our null finding. It is possible that our measurement approach, which relied on two questions rather than a more thorough sleep diary or actigraphy, may have been insufficiently sensitive to detect an association. Additionally, our dichotomization of sleep regularity into “good” or “poor” may have resulted in a loss of information and reduced statistical power. In addition, as mentioned earlier, many Chinese pregnant women were not working during late pregnancy, so their sleep may not be significantly different across the week. Overall, more studies in this population are needed to confirm the above findings. Future studies should consider using more comprehensive measures of sleep timing and regularity to better understand the potential role of these factors in depression during pregnancy.

In this study, we examined the multidimensional concept of sleep health and its relationship with perinatal depression. Both the overall sleep health and individual dimensions were assessed. This holistic approach enabled us to have a deeper understanding of sleep among this population. However, there are several limitations. The cross-sectional design precluded us from determining the causal relationship between sleep health and depression. It is likely that these two have a bi-bidirectional association [62, 63]. Longitudinal or interventional studies are warranted to reveal the causality as well as the underlying mechanisms. Sleep and depression both fluctuate at different trimesters and tend to display different trajectories. In this study, we included a homogenous sample of women in late pregnancy to have a cleaner view of the association. Study findings cannot be generalized to other trimesters. Additionally, we used a score of ≥ 13 on EPDS as a proxy for depression instead of a clinical diagnosis. Similarly, sleep health was only measured using subjective questionnaires. Potential associations of interest may have been missed as objective and subjective methods can offer slightly different information about individuals’ sleep. Given the influence of hormonal changes on mood during the perinatal period, the absence of hormonal data also represents a limitation of our research. Overall, more studies are needed to address the above limitations. Such studies could consider including women of different trimesters and using subjective and objective measurements (e.g., sleep diary and wearable devices). Studies incorporating hormonal assessments are also needed to provide stronger evidence on the impact of sleep on perinatal depression. In future clinical practice, healthcare professionals may consider assessing and managing sleep health during prenatal care, particularly in women with poor sleep quality, short sleep duration, and excessive daytime sleepiness. Such practice may have potential benefits for reducing the risk of depression during pregnancy.

Conclusions

In conclusion, this study found that impaired overall sleep health as well as individual sleep dimensions, specifically sleep quality, sleep duration, and daytime sleepiness were associated with a higher risk of depression in women during late pregnancy. There was a dose-response relationship between overall sleep health and depression. These findings not only add to the current body of evidence on the association between sleep and mental health but also underscore the complexity of sleep health. Overall, this study highlights the importance of considering sleep health as a critical component of perinatal mental health care.

Abbreviations

BMI	Body mass index
CRP	C-reactive protein
EPDS	Edinburgh Postnatal Depression Scale
ESS	Epworth Sleepiness Scale
HPA	Hypothalamic–pituitary–adrenal axis
IL-6	Interleukin-6
PSQI	Pittsburgh Sleep Quality Index

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Author contributions

Y.W. and J.W.: Conceptualization; Methodology, Data collection, Data analysis and interpretation, Original draft, Review and editing; P.C.: Methodology, Data curation and analysis, Review and editing; J.W. and Q.L.: Data collection, Data curation and analysis, Review and editing; B.I.B., Y.L. and B.B.: Data interpretation, Review and editing; B.Z.: Conceptualization, Methodology, Supervision, Funding acquisition, Review and editing. All authors read and approved the final manuscript.

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Ethical approval of the study was approved by the Institutional Review Board of Shanghai Jiao Tong University School of Medicine, Approval Number: SJUPN-202134, 20th June 2022. The study was undertaken according to research ethics guidelines, participation was voluntary, and informed consent was obtained from all participants.

Consent to publish
Not applicable.

Competing interests
The authors declare no competing interests.

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