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ORIGINAL RESEARCH

Factors Affecting Sleep Quality in Pregnant Women During the Second Trimester and Its Association with Birth Outcomes

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Purpose: To evaluate the sleep quality of pregnant women in mid-pregnancy in Wuhan study and analyze its association with birth outcomes in a cross-sectional study.

Patients and Methods: The sleep quality of 2210 pregnant women in the second trimester from Wuhan were evaluated using the Pittsburgh Sleep Quality Index (PSQI). Dietary quality and prenatal depression were assessed by the dietary variety score (DVS) and the Edinburgh Postnatal Depression Scale (EPDS), respectively. Birth outcomes were retrieved from the Maternal and Child Health Information System. Principal component analysis, stratified analysis, and binary Logistic regression were used for statistical analysis.

Results: Among the 2210 pregnant women, the prevalence of sleep disturbance during the second trimester was 18.14%. After adjusting for confounding factors, a EPDS score ≥ 11, pre-pregnancy alcohol consumption, and moderate to severe vomiting during pregnancy were risk factors for sleep disturbance; while a DVS score ≥ 28 points and exercise during pregnancy were protective factors for sleep disturbance. Sleep disturbance were significantly associated with a reduced risk of large for gestational age (LGA) (OR = 0.65, 95% CI: 0.45–0.94, P = 0.023), macrosomia (OR = 0.34, 95% CI: 0.13–0.86, P = 0.023), and a marginal association with an increased risk of preterm birth (PTB) (OR = 1.51, 95% CI: 0.97–2.35, P = 0.065), but stratified interaction analysis showed that sleep disturbance increased the risk of PTB, low birth weight, small for gestational age and small vulnerable neonates in mothers with pre-pregnancy BMI ≥ 24 kg/m^2 or delivering a male fetus.

Conclusion: Clinically, it is crucial to enhance sleep quality screening during the second trimester and provide targeted interventions for high-risk groups to improve maternal and infant outcomes.

Keywords: Pittsburgh Sleep Quality Index, dietary variety score, sleep disturbance, principal component analysis

Introduction

Sleep is a core activity for maintaining human physiological functions and is crucial for the health of both mother and baby during pregnancy.[1] Pregnant women often experience fluctuations in hormone levels, uterine enlargement, psychological stress, and other factors that can negatively impact sleep quality, leading to sleep disturbance such as insomnia, excessive daytime sleepiness, nighttime awakenings, and snoring.[2,3] A multicenter cross-sectional study showed that the detection rate of sleep disturbance among pregnant women in mid-pregnancy in China has reached 28.6%, indicating that sleep disturbance are relatively common during this critical period.[4] Numerous studies have confirmed that sleep disturbance during pregnancy are not only risk factors for maternal complications such as gestational hypertension, preeclampsia, and prenatal depression, but may also directly increase the risk of adverse birth outcomes like preterm birth and low birth weight by triggering common pathophysiological pathways including chronic inflammation, oxidative stress, and placental dysfunction.[5–7] Currently, research in this field mostly focuses on the late pregnancy stage, where sleep problems are more prominent.[8] However, the mid-pregnancy period is not only a critical window for fetal organ

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system development but also a key phase for maternal metabolic adaptation and placental function maturation, theoretically providing the optimal timing for early intervention.[9] Currently, there is a lack of studies that systematically examine the association between mid-pregnancy sleep and various birth outcomes within a comprehensive model that includes multiple potential confounding factors such as depressive symptoms, dietary factors, and pre-pregnancy alcohol consumption.

Therefore, this study focuses on the sleep quality of a group of mid-pregnancy women from Central China-Wuhan to explore the factors influencing sleep disturbance and their effects on birth outcomes, in order to provide theoretical support for local prenatal health management and the development of pregnancy sleep intervention strategies tailored to the regional and cultural characteristics.

Subjects and Methods

Ethical Statement

This study was approved by the Ethics Review Committee of the Maternal and Child Health Hospital of Hanyang District, Wuhan City (2024–01-002-F01). All subjects voluntarily signed informed consent after being fully informed of the relevant information. The study was conducted according to the criteria set by the Declaration of Helsinki.

Research Subjects

The subjects of this study were pregnant women who underwent routine prenatal examinations at the Maternal and Child Health Hospital of Hanyang District, Wuhan City, from July 1, 2023, to March 1, 2024. Inclusion criteria were: age over 18 years, gestational age between 14 weeks and 27 weeks plus 6 days, no abnormalities in mental or cognitive function and able to complete the survey independently, and voluntary participation in the study after being informed and signing the consent form. Exclusion criteria included: pre-pregnancy diagnosis of sleep disturbance, dysfunction of organs such as the heart, liver, or kidneys, presence of other severe primary diseases or chronic illnesses, and incomplete questionnaire responses. A total of 3000 mid-pregnancy women were randomly invited to participate in the study, of whom 472 declined, 48 had pre-existing sleep disturbance, 103 had chronic diseases, 67 submitted incomplete questionnaires, 68 participants had no available birth outcome data, and 32 experienced miscarriage. Ultimately, 2210 pregnant women were included in the study.

Data Collection

The data were collected through an online questionnaire, which participants were required to complete during the second trimester of pregnancy. The questionnaire included five sections: demographic characteristics, lifestyle, the Edinburgh Postnatal Depression Scale (EPDS), the Pittsburgh Sleep Quality Index (PSQI), and Dietary Quality Assessment (the questionnaire is detailed in the Appendix 1). The questionnaire covered general demographic characteristics such as age, ethnicity, education level, monthly household income, occupation, and pre-pregnancy body mass index (BMI); pregnancy-related information including gestational age, parity, history of abnormal pregnancy or delivery, cesarean section history, assisted reproductive history, anemia status (hemoglobin <110 g/L), severity of pregnancy-related nausea and vomiting (categorized as “none or mild” and “moderate to severe”), and pregnancy complications; as well as lifestyle factors such as pre-pregnancy smoking (defined as regular or intermittent smoking within one month before pregnancy), pre-pregnancy alcohol consumption (drinking liquor, beer, or wine within one month before pregnancy), exercise during pregnancy (moderate to high-intensity exercise at least three times per week, with each session lasting 30 minutes or more), and dietary taste preferences (light, moderate, or greasy).

Scale Assessments

Edinburgh Postnatal Depression Scale (EPDS)

The Edinburgh Postnatal Depression Scale (EPDS) was used for prenatal depression screening[10] it includes 10 items. Each item is scored as “Never (0 points)”, “Occasionally (1 point)”, “Often (2 points)”, and “Always (3 points)”, with a total score ranging from 0 to 30.[10] A score of EPDS ≥ 11 is considered positive for depressive symptoms (sensitivity

0.81, specificity 0.88).[11] The Chinese version of the EPDS has good reliability (Cronbach'α=0.79).[12] In this study, the Cronbach'α of EPDS was 0.72.

Pittsburgh Sleep Quality Index (PSQI)

The Pittsburgh Sleep Quality Index (PSQI) was used to assess sleep quality over the past month.[13] It consists of 19 self-rated items and 5 observer-rated items (only the 19 self-rated items are scored). It covers seven dimensions: sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Each dimension is scored from 0 to 3, with a total score ranging from 0 to 21. Higher scores indicate poorer sleep quality.[13] A PSQI score greater than 7 is used as the diagnostic criterion for sleep disturbance (sensitivity 0.98, specificity 0.90).[14] The Chinese version of the PSQI has good reliability (Cronbach'α=0.84).[15] In this study, the Cronbach'α of PSQI was 0.70.

Dietary Quality Assessment

Dietary variety score (DVS) was used to evaluate dietary intake over the past week, covering 10 food categories: livestock and poultry meat, fish and shellfish, eggs, dairy products, legumes, dark-colored vegetables, fresh fruits, seaweed, tubers, and nuts. Scores were assigned based on consumption frequency: "rarely eat" = 1 point, "1–2 times/week" = 2 points, "3–5 times/week" = 3 points, and "almost daily" = 4 points. The total score ranged from 10 to 40, with higher scores indicating better dietary diversity.[16,17] Traditional dietary surveys are time-consuming and labor-intensive, and due to the complexity of data processing, they cannot provide a quick assessment of patients' dietary quality. In contrast, the Diet Quality Score (DVS), as a convenient and cost-effective comprehensive dietary quality indicator, is now widely used in China.[18] The specific investigation details can be found in the Appendix 1.

Birth Outcome Indicators

After the pregnant women have given birth, information regarding the mode of delivery, gestational age at birth, birth weight and length were all obtained from the Maternal and Child Health Information System. Preterm birth (PTB) was defined as delivery between 28 weeks and less than 37 weeks of gestation. Low birth weight (LBW) was defined as birth weight less than 2500 grams, and macrosomia as birth weight equal to or greater than 4000 grams. Small for gestational age (SGA) and large for gestational age (LGA) refer to birth weights below the 10th percentile and above the 90th percentile, respectively, for the same gestational age and sex based on reference populations. Small vulnerable neonates (SVN) were defined as newborns meeting any of the following criteria: preterm birth, SGA, or low birth weight.

Statistical Methods

Data organization and statistical analysis were performed using SPSS 27.0 software. Continuous data are presented as "mean ± standard deviation (x±s)", with independent samples *t*-tests used for comparisons between groups. Discrete data are expressed as "frequency (composition ratio) [n (%)]", with chi-square tests used for group comparisons. Considering the particular characteristics of the pregnant population, in order to optimise the analysis of associations with birth outcomes and to avoid the interference of multicollinearity among the seven dimensions of the PSQI in the regression model, principal component analysis was employed to extract common factors from the PSQI dimensions (eigenvalues > 0.99), and the factor loading matrix was optimized using the varimax rotation method. Binary logistic regression analysis was used to identify factors influencing sleep disturbance and their association with birth outcomes. To investigate whether there is heterogeneity in the association between sleep quality and birth outcomes, this study, based on their known biological significance, pre-specified pre-pregnancy BMI (a key metabolic-inflammatory regulatory factor) and fetal sex (a critical determinant of placental function and response differences) as effect modifier variables, and conducted stratified analyses and interaction tests. All statistical analyses were two-sided, with $P < 0.05$ considered statistically significant. For all multivariate logistic regression models, the variance inflation factor (VIF) was calculated to assess multicollinearity (VIF < 5 considered acceptable), and the Hosmer-Lemeshow test was used to evaluate model goodness-of-fit ($P > 0.05$ indicating good fit).

Results

Basic Information and Behavioral Lifestyle Description of the Study Subjects

Demographic Characteristics

Participants were divided into a normal group (n=1809, 81.86%) and a sleep disturbance group (n=401, 18.14%) based on whether their mid-pregnancy PSQI score was greater than 7. The age range of pregnant women was 22 to 44 years, with 369 cases of advanced maternal age (≥35 years), accounting for 16.7%. There were no statistically significant differences between the two groups in terms of education level, age, ethnicity, occupation, average monthly income per person, pre-pregnancy BMI, parity, abnormal pregnancy history, cesarean section history, assisted reproduction, pre-pregnancy smoking, pregnancy complications, and mid-pregnancy weight gain (all $P > 0.05$). However, there were statistically significant differences in past medical history, DVS scores, pregnancy dietary taste, EPDS scores, pregnancy exercise, pre-pregnancy drinking, anemia in early pregnancy, and pregnancy vomiting (all $P < 0.05$). Specifically, the group with sleep disturbance had higher proportions of past medical history, preference for greasy foods, high EPDS scores, pre-pregnancy drinking, anemia in early pregnancy, and moderate to severe vomiting, while the proportion with DVS scores ≥28 and the rate of exercise during pregnancy were lower as illustrated in Table 1.

Table 1 Basic Characteristics of Pregnant Women in the Sleep Disturbance Group and the Normal Group [n (%)]

Basic Characteristics	Overall (N=2210)	Normal Group (N=1809)	Sleep Disturbance Group (N=401)	χ^2-value	P-value
Age (years)				0.56	0.455
22–34	1841(83.3)	1512(83.6)	329(82.0)		
≥35	369(16.7)	297(16.4)	72(18.0)		
Ethnicity				0.09	0.763
Han	2150(97.3)	1759(97.2)	391(97.5)		
Ethnic minorities	60(2.7)	50(2.8)	10(2.5)		
Education level				3.02	0.221
High school, technical secondary school, or below	294(13.3)	230(12.7)	64(16.0)		
Junior college/Bachelor's degree	1667(75.4)	1373(75.9)	294(73.3)		
Graduate degree or above	249(11.3)	206(11.4)	43(10.7)		
Occupation				2.54	0.469
Administrative staff	114(5.2)	92(5.1)	22(5.5)		
Professional and technical personnel	676(30.6)	565(31.2)	111(27.7)		
Commercial service personnel	228(10.3)	189(10.5)	39(9.7)		
Others	1192(53.9)	963(53.2)	229(57.1)		
Average monthly income per person (yuan)				3.44	0.179
<5000	378(17.1)	302(16.7)	76(19.9)		
5000-9999	1127(51.0)	915(50.6)	212(52.9)		
≥10,000	705(31.9)	592(32.7)	113(28.2)		

(*Continued*)

Table 1 (Continued).

Basic Characteristics	Overall (N=2210)	Normal Group (N=1809)	Sleep Disturbance Group (N=401)	χ^2-value	P-value
Pre-pregnancy BMI (kg/m^2)				0.04	0.845
<18.5	325(14.7)	264(14.6)	61(15.2)		
18.5–23.9	1461(66.1)	1197(66.2)	264(65.8)		
>23.9	424(19.2)	346(19.2)	76(19.0)		
Number of births (times)				0.04	0.841
0	1415(64.0)	1160(64.1)	255(63.6)		
≥1	795(36.0)	649(35.9)	146(36.4)		
Abnormal pregnancy history				0.99	0.319
No	1674(75.7)	1378(76.2)	296(73.8)		
Yes	536(24.3)	431(23.8)	105(26.2)		
Cesarean section history				3.50	0.061
No	1895(85.7)	1563(86.4)	332(82.8)		
Yes	315(14.3)	246(13.6)	69(17.2)		
Assisted reproduction				0.21	0.644
No	1998(90.4)	1633(90.3)	365(91.0)		
Yes	212(9.6)	176(9.7)	36(9.0)		
Past medical history				4.81	0.028
No	1940(87.8)	1601(88.5)	339(84.5)		
Yes	270(12.2)	208(11.5)	62(15.5)		
DVS score				22.65	<0.001
<22	455(20.6)	344(19.0)	111(27.7)		
22–24	515(23.3)	417(23.0)	98(24.4)		
25–27	611(27.6)	502(27.8)	109(27.2)		
≥28	629(28.5)	546(30.2)	83(20.7)		
Pregnancy dietary taste				6.06	0.048
Light	563(25.5)	472(26.1)	91(22.7)		
Moderate	1281(58.0)	1053(58.2)	228(56.9)		
Greasy	366(16.5)	284(15.7)	82(20.4)		
EPDS score				75.26	<0.001
<11	1979(89.5)	1668(92.2)	311(77.6)		
≥11	231(10.5)	141(7.8)	90(22.4)		

(*Continued*)

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Table 1 (Continued).

Basic Characteristics	Overall (N=2210)	Normal Group (N=1809)	Sleep Disturbance Group (N=401)	χ^2-value	P-value
Pregnancy exercise				6.41	0.011
No	1902(86.1)	1541(85.2)	361(90.0)		
Yes	308(13.9)	268(14.8)	40(10.0)		
Pre-pregnancy smoking				0.47	0.494
No	2124(96.1)	1741(96.2)	383(95.5)		
Yes	86(3.9)	68(3.8)	18(4.5)		
Pre-pregnancy drinking				7.53	0.006
No	2099(95.0)	1729(95.6)	370(92.3)		
Yes	111(5.0)	80(4.4)	31(7.7)		
Early pregnancy anemia				4.40	0.036
No	1962(88.8)	1618(89.4)	344(85.8)		
Yes	248(11.2)	191(10.6)	57(14.2)		
Pregnancy vomiting				33.51	<0.001
None or mild	1514(68.5)	1288(71.2)	226(56.4)		
Moderate to severe	696(31.5)	521(28.8)	175(43.6)		
Pregnancy complications				3.14	0.076
No	1820(82.4)	1502(84.0)	318(79.3)		
Yes	390(17.6)	307(16.0)	83(20.7)		
GDM (Gestational Diabetes Mellitus)				1.25	0.149
No	1870(84.6)	1538(85.0)	332(82.8)		
Yes	340(15.4)	271(15.0)	69(17.2)		
Mid-pregnancy weight gain				0.12	0.940
Insufficient	1711(77.4)	1403(77.6)	308(76.8)		
Appropriate	292(13.2)	237(13.1)	55(13.7)		
Excessive	207(9.4)	169(9.3)	38(9.5)		

Sleep Quality Status of Pregnant Women in Mid-Pregnancy and PSQI Principal Component Analysis

Overall Sleep Quality

The PSQI score of 2210 pregnant women was 5.32 ± 2.60. Among the seven dimensions of sleep quality, daytime dysfunction had the highest average score, while the use of sleep medication had the lowest average score. The sleep disturbance group scored significantly higher than the normal sleep group on all factors except for sleep medication, as illustrated in Appendix Table 1.

PSQI Principal Component Analysis

Three principal components were extracted (cumulative variance contribution rate of 61.36%), which can adequately explain the original data, as illustrated in Table 2. Principal Component 1 (Subjective Sleep Perception and Disturbance) has high loadings on sleep disturbances, daytime dysfunction, and sleep quality scores; Principal Component 2 (Sleep Efficiency and Duration) is mainly defined by sleep efficiency and sleep duration; Principal Component 3 (Medication-Assisted Sleep) is almost exclusively composed of the hypnotic medication score. The factor common variance for the sleep latency score was relatively low (0.25), suggesting that its influencing factors may be more independent and require further study.

The mean value of the subjective sleep perception and distress dimension (PC1) was 0.00 (SD = 1.19), with a score range of −2.88 to 4.89; the mean value of the sleep efficiency and duration dimension (PC2) was 0.00 (SD = 1.59), with a score range of −2.04 to 7.07, and its variability was the greatest among the three dimensions; the mean value of the drug-assisted sleep dimension (PC3) was 0.00 (SD = 0.99), with a score range of −1.98 to 1.56, and its distribution was the most concentrated. The extreme cases indicate that some pregnant women had extreme scores in the PC1 and PC2 dimensions.

Multivariate Logistic Regression Analysis of Factors Influencing Sleep Disturbance in Mid-Pregnancy

Variables with P<0.1 in the univariate analysis were included in the logistic regression analysis. After adjusting for confounding factors such as age, monthly household income, education level, occupation, parity, history of abnormal pregnancy and childbirth, and smoking, the results showed that an EPDS score ≥11 (OR = 2.99, P < 0.001), pre-pregnancy alcohol consumption (OR = 1.72, P = 0.021), and moderate to severe vomiting during pregnancy (OR = 1.81, P < 0.001) were risk factors for sleep disturbance; a DVS score ≥28 (OR = 0.64, P = 0.008) was a protective factor against sleep disturbance. History of cesarean section, dietary taste during pregnancy, anemia in early pregnancy, and exercise during pregnancy were not significantly associated with sleep disturbance (all P > 0.05), as illustrated in Table 3.

Analysis of the Association Between Sleep Disturbance and Birth Outcomes

Description of Birth Outcomes in the Study Population

Gestational age at delivery, birth weight, and birth BMI in the sleep disturbance group were significantly lower than those in the normal group (all P < 0.05); there were no statistically significant differences between the two groups in birth

Table 2 Principal Component Analysis Results of the PSQI Scale (N=2210)

PSQI Factors	Common Factor Variance	Principal Component 1: Subjective Sleep Perception and Disturbances	Principal Component 2: Sleep Efficiency and Duration	Principal Component 3: Use of Sleep Medication
Sleep Quality Score	0.56	0.65	0.38	0.002
Sleep Latency Score	0.25	0.41	0.27	−0.14
Sleep Duration Score	0.69	0.15	0.82	0.007
Sleep Efficiency Score	0.74	0.04	0.86	0.02
Sleep Disturbance Score	0.51	0.74	0.08	0.06
Use of Sleeping Medication Score	0.98	−0.02	0.02	0.99
Daytime Dysfunction Score	0.52	0.71	−0.09	−0.02
Eigenvalue	–	1.66	1.63	1.00
Variance Contribution (%)	–	30.69	16.48	14.19
Cumulative Contribution (%)	–	30.69	47.17	61.36

Table 3 Binary Logistic Regression Analysis of Factors Influencing Sleep Disturbance in Mid-Pregnancy

Variable	Model 1		Model 2	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Cesarean section history				
No	Ref		Ref	
Yes	1.33(0.98–1.80)	0.068	1.37(0.95–1.98)	0.092
Past medical history				
No	Ref		Ref	
Yes	1.53(1.12–2.11)	0.009	1.54(1.09–2.17)	0.015
DVS (score)				
<22	Ref		Ref	
22–24	0.81(0.59–1.11)	0.190	0.82(0.60–1.13)	0.276
25–27	0.77(0.57–1.05)	0.101	0.79(0.58–1.08)	0.149
≥28	0.61(0.44–0.85)	0.003	0.64(0.46–0.89)	0.008
P-trend	<0.001		<0.001	
Pregnancy dietary taste				
Light	Ref		Ref	
Moderate	1.16(0.88–1.53)	0.284	1.16(0.88–1.53)	0.295
Greasy	1.38(0.98–1.96)	0.068	1.39(0.97–1.97)	0.070
EPDS score				
<11	Ref		Ref	
≥11	2.98(2.20–4.02)	<0.001	2.99(2.21–4.04)	<0.001
Pregnancy exercise				
No	Ref		Ref	
Yes	0.75(0.52–1.08)	0.126	0.74(0.51–1.07)	0.112
Pre-pregnancy drinking				
No	Ref		Ref	
Yes	1.65(1.05–2.58)	0.030	1.72(1.08–2.72)	0.021
Early pregnancy anemia				
No	Ref		Ref	
Yes	1.31(0.94–1.82)	0.117	1.35(0.96–1.89)	0.081
Pregnancy vomiting				
None or mild	Ref		Ref	
Moderate to severe	1.78(1.41–2.24)	<0.001	1.81(1.43–2.28)	<0.001

(*Continued*)

Table 3 (Continued).

Variable	Model 1		Model 2	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Pregnancy complications				
No	Ref		Ref	
Yes	1.28(0.97–1.67)	0.077	1.31(0.99–1.75)	0.062

Notes: Model 1: Unadjusted for confounding factors; Model 2: Adjusted for confounding factors including ethnicity, age, monthly household income, education level, occupation, pre-pregnancy BMI, weight gain during mid-pregnancy, parity, history of adverse pregnancy outcomes, smoking, and mid-pregnancy weight gain; P-trend: Trend P-value calculated using the median values of quartiles. All models were validated for multicollinearity (VIF < 5) and goodness of fit (Hosmer-Lemeshow test P > 0.05).

length and head circumference (both P > 0.05). Among the categorical outcome indicators, the prevalence of LGA (large for gestational age) (9.7% vs. 13.8%, P = 0.028) and macrosomia (1.3% vs. 3.6%, P = 0.015) in the sleep disturbance group was significantly lower than that in the normal group; the rates of cesarean section, preterm birth, low birth weight, SGA (small for gestational age), and SVN showed no statistically significant differences between the two groups (all P > 0.05), as illustrated in Table 4.

The scores of PC2 were higher for those who had a LBW baby than for those who had normal or macrosomic babies; in addition, they were higher for those who had SGA babies than those who had AGA or LGA babies. No difference in other PCs between groups of birth outcomes were found. Detailed data can be found in Appendix Table 2.

Table 4 Birth Outcomes of Pregnant Women in the Sleep Disturbance Group and the Normal Group [X±s/n(%)]

Birth Outcomes	Overall (N=2210)	Normal Group (N=1809)	Sleep Disturbance Group (N=401)	χ^2 /t-value	P-value
Gestational Age at Delivery (weeks)	38.74±1.32	38.78±1.28	38.56±1.48	2.67	0.008
Birth Weight (g)	3215.49±437.62	3227.45±433.31	3161.54±453.21	2.73	0.006
Birth Length (cm)	49.83±1.90	49.86±1.88	49.70±1.97	1.54	0.124
Birth Head Circumference (cm)	33.66±1.25	33.66±1.25	33.63±1.27	0.38	0.703
Birth BMI (kg/m^2)	12.92±1.96	12.96±2.06	12.75±1.38	2.50	0.013
Delivery Method				3.17	0.075
Vaginal Delivery	931(42.1)	778(43.0)	153(38.2)		
Cesarean Section	1279(57.9)	1031(57.0)	248(61.8)		
Gender				0.41	0.817
Male	1135(51.4)	925(51.1)	210(52.4)		
Female	1075(48.6)	884(48.9)	191(47.6)		
PTB				3.20	0.074
No	2081(94.2)	1711(94.6)	370(92.3)		
Yes	129(5.8)	98(5.4)	31(7.7)		

(*Continued*)

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Table 4 (Continued).

Birth Outcomes	Overall (N=2210)	Normal Group (N=1809)	Sleep Disturbance Group (N=401)	χ^2 /t-value	P-value
LBW				1.66	0.197
No	2110(95.5)	1732(95.7)	378(94.3)		
Yes	100(4.5)	77(4.3)	23(5.7)		
SGA				0.55	0.457
No	2059(93.2)	1682(93.0)	377(94.0)		
Yes	151(6.8)	127(7.0)	24(6.0)		
SVN				0.20	0.657
No	1938(87.7)	1589(87.8)	349(87.0)		
Yes	272(12.3)	220(12.2)	52(13.0)		
LGA				4.84	0.028
No	1921(86.9)	1559(86.2)	362(90.3)		
Yes	289(13.1)	250(13.8)	39(9.7)		
Macrosomia				5.89	0.015
No	2140(96.8)	1744(96.4)	396(98.7)		
Yes	70(3.2)	65(3.6)	5(1.3)		

Multivariate Associations Between Sleep Disturbance and Birth Outcomes

After adjusting for confounding factors, sleep disturbance were significantly associated with a decreased risk of LGA (Large for Gestational Age) (OR = 0.65, 95% CI: 0.45–0.94, P = 0.023) and macrosomia (OR = 0.34, 95% CI: 0.13–0.86, P = 0.023). There was a marginal association between sleep disturbance and an increased risk of PTB (OR = 1.51, 95% CI: 0.97–2.35, P = 0.065). No significant associations were found between sleep disturbance and cesarean section, LBW, SGA, or SVN (all P > 0.05), as illustrated in Table 5.

Associations Between PSQI Factors and Birth Outcomes

Based on the finding that overall sleep disturbances are associated with specific birth outcomes, we further conducted exploratory analyses of the associations between each specific dimension of the PSQI and these outcomes, aiming to identify key sleep characteristics that may drive this relationship. The PSQI consists of seven components: sleep quality score, sleep latency score, sleep duration score, sleep efficiency score, sleep disturbances score, use of sleeping medication score, and daytime dysfunction score. In this study, only one pregnant woman used sleeping medication; therefore, the analysis focused on the association between the six components—excluding the use of sleeping medication score—and birth outcomes. Regarding sleep quality, the group with a score of 1 had a higher risk of SGA compared to the group with a score of 0 (OR = 1.60, P = 0.048). For sleep latency, the group with a score of 3 had a higher risk of LBW compared to the group with a score of 0 (OR = 3.41, P = 0.025). In terms of sleep duration, the group with a score of 3 showed significantly increased risks of PTB (OR = 4.26, P = 0.039), LBW (OR = 5.25, P = 0.028), SGA (OR = 5.53, P = 0.011), and SVN (OR = 4.14, P = 0.010) compared to the group with a score of 0. Regarding sleep efficiency, the group with a score of 1 had a lower risk of cesarean section compared to the group with a score of 0 (OR = 0.79, P = 0.044). For daytime dysfunction, the group with a score of 3 had a higher risk of LGA infants compared to the group with a score of 0 (OR = 1.54, P = 0.045). Detailed data can be found in Appendix Tables 3–8.

Table 5 Logistic Regression Analysis of Mid-Pregnancy Sleep Quality and Birth Outcomes

Birth Outcome		Normal Group	Sleep Disturbance Group	P-value
Cesarean Section	Number of Cases(%)	1085(60.0)	248(61.8)	
	Model 1	Ref	1.10(0.98–1.53)	0.075
	Model 2	Ref	1.08(0.85–1.38)	0.408
PTB	Number of cases(%)	98(5.4)	31(7.7)	
	Model 1	Ref	1.46(0.96–2.23)	0.075
	Model 2	Ref	1.51(0.97–2.35)	0.065
LBW	Number of case(%)	78(4.3)	23(5.7)	
	Model 1	Ref	1.37(0.85–2.21)	0.199
	Model 2	Ref	1.48(0.90–2.44)	0.126
SGA	Number of case(%)	127(7.0)	24(6.0)	
	Model 1	Ref	1.19(0.76–1.86)	0.458
	Model 2	Ref	0.81(0.51–1.30)	0.387
SVN	Number of case(%)	221(12.2)	52(13.0)	
	Model 1	Ref	1.08(0.78–1.49)	0.657
	Model 2	Ref	1.10(0.79–1.54)	0.573
LGA	Number of case(%)	250(13.8)	39(9.7)	
	Model 1	Ref	0.67(0.47–0.96)	0.029
	Model 2	Ref	0.65(0.45–0.94)	0.023
Macrosomia	Number of case(%)	65(3.6)	5(1.2)	
	Model 1	Ref	0.34(0.14–0.85)	0.025
	Model 2	Ref	0.34(0.13–0.86)	0.023

Notes: Model 1: Unadjusted for confounding factors; Model 2: Adjusted for confounding factors including ethnicity, age, monthly household income, education level, occupation, pre-pregnancy BMI, EPDS score, DVS score, weight gain during mid-pregnancy, parity, history of adverse pregnancy outcomes, smoking, pregnancy complications, and infant sex at birth. All models were validated for multicollinearity (VIF < 5) and goodness of fit (Hosmer-Lemeshow test P > 0.05).

Stratified Interaction Analysis

Among individuals with a BMI ≥ 24 kg/m^2, sleep disturbance showed a stronger association with the risks of PTB (OR = 2.54, 95% CI: 1.29–4.99), LBW (OR = 2.80, 95% CI: 1.28–6.13), SGA (OR = 2.31, 95% CI: 0.96–5.57), and SVN (OR = 2.41, 95% CI: 1.34–4.35). Among male fetuses, sleep disturbance were more strongly associated with the risks of PTB (OR = 2.15, 95% CI: 1.28–3.62), LBW (OR = 2.90, 95% CI: 1.58–5.32), and SGA (OR = 1.58, 95% CI: 1.04–2.39), as illustrated in Table 6.

Model Robustness Diagnostics

To ensure the reliability of the research findings, we conducted diagnostics on all multivariate logistic regression models. The multicollinearity test showed that the variance inflation factors (VIFs) of the independent variables in each model ranged from 1.01 to 1.80, well below the critical value of 5, indicating no serious multicollinearity issues. For the binary logistic regression models in Tables 4, 6, and 7, the Hosmer-Lemeshow test results all indicated good model fit (all P-values > 0.05). Detailed results can be found in Appendix Tables 9 and 10.

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Table 6 Results of Stratified and Interaction Analyses

Birth Outcome	Pre-Pregnancy BMI		$P_{-interaction}$	Gender		$P_{-Interaction}$
	<24	≥24		Male	Female	
Cesarean Section	989/1789	290/421	0.664	669/1135	610/1075	0.634
Normal Group	Ref	Ref		Ref	Ref	
Sleep Disturbance Group	1.24(0.97–1.58)	1.20(0.69–2.08)		1.14(0.84–1.54)	1.33(0.96–1.83)	
PTB	83/1789	46/421	0.042	73/1135	56/1075	0.052
Normal Group	Ref	Ref		Ref	Ref	
Sleep Disturbance Group	1.08(0.62–1.88)	2.54(1.29–4.99)		2.15(1.28–3.62)	0.76(0.35–1.63)	
LBW	69/1789	31/421	0.032	47/1135	53/1075	0.003
Normal Group	Ref	Ref		Ref	Ref	
Sleep Disturbance Group	0.94(0.50–1.78)	2.80(1.28–6.13)		2.90(1.58–5.32)	0.48(0.19–1.22)	
SGA	126/1789	25/421	0.014	73/1135	78/1075	0.186
Normal Group	Ref	Ref		Ref	Ref	
Sleep Disturbance Group	0.64(0.37–1.09)	2.31(0.96–5.57)		1.58(1.04–2.39)	0.65(0.38–1.11)	
SVN	203/1789	69/421	0.001	139/1135	133/1075	0.017
Normal Group	Ref	Ref		Ref	Ref	
Sleep Disturbance Group	0.79(0.53–1.18)	2.41(1.34–4.35)		1.58(1.04–2.39)	0.65(0.38–1.11)	
LGA	198/1789	91/421	0.649	146/1135	143/1075	0.108
Normal Group	Ref	Ref		Ref	Ref	
Sleep Disturbance Group	0.72(0.47–1.09)	0.57(0.29–1.14)		0.90(0.57–1.42)	0.46(0.26–0.82)	
Macrosomia	45/1789	25/421	0.449	44/1135	26/1075	0.465
Normal Group	Ref	Ref		Ref	Ref	
Sleep Disturbance Group	0.43(0.15–1.21)	0.18(0.02–1.36)		0.43(0.15–1.21)	0.18(0.02–1.34)	

Notes: Adjusted for confounding factors including ethnicity, age, monthly household income, education level, occupation, pre-pregnancy BMI, EPDS score, DVS score, weight gain during mid-pregnancy, parity, history of adverse pregnancy outcomes, smoking, pregnancy complications, and infant sex at birth. All models were validated for multicollinearity (VIF < 5) and goodness of fit (Hosmer-Lemeshow test P > 0.05).

Discussion

Prevalence and Characteristics of Sleep Disturbance in Mid-Pregnancy

This study shows that the prevalence of sleep disturbance among mid-pregnancy women in Wuhan is 18.14%, consistent with the prevalence of sleep disturbance (18.2%) among mid-pregnancy women in Shandong, China.[19] It is lower than the prevalence of sleep disturbance during mid-pregnancy in other countries (25–30%).[20] This difference may be related to the fact that the study subjects in China all received regular prenatal care and had a better understanding of physiological changes during pregnancy. Analysis of the PSQI dimensions revealed that the "daytime dysfunction" score was highest in the sleep disturbance group, suggesting that sleep problems may affect daytime energy restoration, forming a vicious cycle of "sleep disturbance – decreased daytime function – increased physical and mental burden". Both the sleep disturbance group and the normal group had an extremely low rate of hypnotic drug use (<0.1%), reflecting pregnant women's concerns about medication intervention and highlighting the importance of non-pharmacological interventions. Principal component analysis found that the independent influence of the sleep onset latency dimension was not fully explained, indicating that difficulty

falling asleep during pregnancy may be affected by unique factors (such as pre-sleep anxiety and hormonal rhythm fluctuations), which warrants further targeted research.

Influencing Factors of Sleep Disturbance in Mid-Pregnancy

This study found that pregnant women with depressive symptoms have a 2.986 times higher risk of sleep disturbance compared to those without depressive symptoms, consistent with the findings of Zhang et al[21] The mechanism lies in the fact that depression-related inflammatory factors, combined with dysfunction of the HPA axis, jointly exacerbate sleep fragmentation.[22] Furthermore, the core symptoms of depression (such as sleep disturbances) often form a bidirectional vicious cycle with other symptom dimensions.[23] Therefore, in clinical practice, targeted assessment and intervention for sleep problems are of great importance in breaking this cycle.

Pre-pregnancy alcohol consumption is a risk factor for sleep disturbance, possibly related to alcohol's long-term interference with REM sleep and reduced sleep efficiency, effects that may be amplified by hormonal changes during pregnancy.[24] This study did not find an association between pre-pregnancy smoking and sleep disturbance, possibly due to the very low rate of pre-pregnancy smoking (3.9%) and insufficient statistical power. In contrast, dietary diversity (DVS $\geq$ 28 points) is an important protective factor, consistent with studies showing that a Mediterranean diet improves sleep during pregnancy.[25] Its mechanism involves tryptophan promoting melatonin synthesis, EPA and DHA regulating neuroinflammation, and B vitamins maintaining neurotransmitter balance.[26] A diet high in greasy foods may increase gastrointestinal burden, leading to nocturnal gastroesophageal reflux and disrupting sleep. This also explains the marginal association between greasy taste and sleep disturbances observed in this study (P = 0.070).[27] The aforementioned influencing factors collectively reflect a deeper underlying risk factor — an unhealthy overall lifestyle or poor sleep hygiene habits. Therefore, future public health intervention strategies should consider comprehensive measures aimed at improving overall lifestyle and sleep hygiene, which may produce greater synergistic benefits for maternal and infant health.

Moderate to severe vomiting during pregnancy is an important trigger for sh.leep disturbances. Vomiting can cause nutritional imbalances, electrolyte disturbances, and nighttime discomforts such as acid reflux and nausea, which directly affect sleep continuity. Additionally, anxiety resulting from prolonged vomiting may indirectly exacerbate sleep problems.[28] Furthermore, a history of previous illnesses is associated with sleep disturbances, suggesting that chronic diseases (such as hypertension and diabetes) may impact sleep through physiological discomforts (such as nocturia, pain) or psychological concerns, necessitating targeted management.

The Association Between Sleep Disturbance and Birth Outcomes

This study did not observe the conclusion found in other research that "sleep disturbance increase the risk of LBW".[29–31] It is speculated that the difference stems from the type and severity of sleep disturbance: mild sleep disturbance (the main type in this study) may indirectly inhibit excessive fetal growth by reducing nighttime eating and lowering insulin resistance; severe sleep disturbance (such as obstructive sleep apnea) may cause fetal growth restriction and increase the risk of low birth weight due to hypoxia and reduced placental blood flow.[32,33] This suggests that the impact of sleep disturbance on fetal growth exhibits significant heterogeneity and complexity.

Studies from Chengdu, China, and Peru have found that sleep disturbance during pregnancy increase the risk of preterm birth, while other studies have found no association between sleep disturbance during pregnancy and the risk of preterm birth.[34–37] After adjusting for confounding factors, this study found a marginal association between sleep disturbance and an increased risk of preterm birth. Stratified analysis showed that this association was stronger among women with a pre-pregnancy BMI $\geq$24 kg/m^2 and those carrying male fetuses. The possible mechanism is that sleep deprivation leads to elevated IL-6 levels, which stimulate prostaglandin secretion, promoting cervical ripening and triggering uterine contractions.[38] Due to the inherently more active and pro-inflammatory genetic and functional characteristics of the male placenta, it responds more intensely to adverse maternal environments than the female placenta, making it more likely to trigger the cascade reaction of "uterine contractions – cervical ripening – fetal membrane activation", thereby increasing the risk of preterm birth.[39] Additionally, pre-pregnancy obesity may exacerbate sleep apnea and amplify inflammatory responses, further increasing the risk of preterm birth.

Sleep efficiency and duration are key factors affecting fetal growth (scores were significantly higher in the low birth weight and SGA groups). Insufficient sleep duration (score of 3) was significantly associated with multiple adverse outcomes (preterm birth, low birth weight, SGA, SVN), suggesting that sleep duration is a core protective factor for maternal and infant health. However, due to the limited number of adverse pregnancy outcomes, this result may be unstable and susceptible to the influence of individual cases, with lower precision of the effect (reflected by wider confidence intervals). Therefore, this association needs to be further validated in prospective studies or cohorts with larger sample sizes.

Research Strengths and Limitations

The main strengths of this study lie in its large sample size (2210 cases), covering mid-pregnancy women in urban areas of Wuhan, which provides good representativeness. Additionally, the study comprehensively assessed various factors such as lifestyle, depressive symptoms, and diet, allowing for an in-depth analysis of the associations between different dimensions of sleep quality and pregnancy outcomes. Furthermore, stratified interaction analyses identified high-risk groups, such as those with pre-pregnancy obesity, offering a basis for targeted interventions. However, this study also has several limitations: the cross-sectional design prevents establishing causal relationships between variables like depressive symptoms and sleep disturbance; sleep quality assessment relied on self-reported questionnaires, which may be subject to recall bias; there are still some residual factors (such as prenatal environmental exposures and paternal-related influences) that have not been adjusted for; the number of adverse birth outcomes was insufficient, and the related conclusions still need to be validated in larger-scale studies; objective indicators such as sleep apnea were not included, making it difficult to differentiate types of sleep disturbance.

Prospects for Interventions on Sleep Disturbance During Mid-Pregnancy

Currently, most sleep interventions during pregnancy are still in the observational stage. A few studies have confirmed that music therapy, psychological counseling, and regular exercise can improve sleep quality, but large-scale intervention studies are lacking.[40,41] The late pregnancy period is when pregnant women experience a significant decline in sleep quality, and mid-pregnancy, as the stage preceding late pregnancy, may be a relatively critical period for actively taking measures to improve sleep quality.[20] Therefore, it is recommended to incorporate the PSQI into routine screening during the second trimester and implement it simultaneously with the EPDS assessment. Personalized interventions should be provided for pregnant women with high-risk factors such as depressive symptoms, pre-pregnancy alcohol consumption, moderate to severe vomiting, and pre-pregnancy obesity. These interventions include dietary guidance to increase the intake of dairy products, fish, and dark leafy vegetables to enhance dietary diversity; cognitive behavioral therapy to alleviate anxiety and depressive symptoms; and lifestyle adjustments promoting regular exercise and avoiding stimulating activities before bedtime. At the same time, efforts should be made to explore the establishment of a hospital-community-family collaborative intervention model, leveraging prenatal classes and online guidance platforms to extend services and achieve continuous improvement in sleep quality.

Conclusion

The prevalence of sleep disturbance among pregnant women in Wuhan during the second trimester is 18.15%. Depressive symptoms, pre-pregnancy alcohol consumption, and moderate to severe vomiting during pregnancy are the main risk factors, while a high Dietary Variety Score serves as a protective factor. Stratified analysis showed that among individuals with a pre-pregnancy BMI $\geq$ 24 kg/m^2, the association strength (OR) between sleep disturbance and both preterm birth and low birth weight was greater than 2.5; this effect was more pronounced in the male fetus subgroup, where the risk of low birth weight increased to nearly threefold. Clinically, it is important to strengthen screening for sleep quality and implement multidimensional interventions during the second trimester to improve maternal and infant outcomes. Future cohort studies and randomized controlled trials are needed to further verify the effectiveness and causal relationship of sleep interventions.

Abbreviations

PSQI, pittsburgh sleep quality Index; EPDS, edinburgh postnatal depression xcale; DVS, dietary variety score; PTB, preterm birth; LBW, low birth weight; SGA, small for gestational age; LGA, large for gestational age; SVN, small vulnerable neonates; GDM, Gestational Diabetes Mellitus.

Data Sharing Statement

The data will be made available by the authors upon reasonable request. It's available from the two corresponding authors.

Author Contributions

Li Zou: Conceptualization, Investigation, Formal analysis, Writing – original draft, Writing – review & editing.
Yuqiao Ma, Zhaozhao Hu, Hong Ming, Sa Xu, Kun Xu, Xuefeng Yang: Conceptualization, Investigation, Formal analysis, Writing – review & editing.
Yueting Jiang: Investigation, Formal analysis, Writing – original draft, Writing – review & editing.
Shujie Weng, Meitong Bao, Han Cao, Anyu Luo: Investigation, Formal analysis, Writing – original draft.

All authors have agreed on the journal to which the article will be submitted; reviewed and agreed on the final version accepted for publication; and agree to take responsibility and be accountable for the contents of the article.

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Disclosure

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