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Dual trajectory of insomnia and depressive symptoms in women from early pregnancy to 6 months postpartum: a prospective cohort study

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Abstract

Background Perinatal insomnia and depression significantly impact maternal-infant health, but their co-developing trajectories are poorly understood. This study examines their heterogeneous progression, interrelationships, and predictive factors across the perinatal period.

Methods This was part of a mother-infant cohort study conducted in the obstetrics outpatient clinic of a tertiary hospital in Wuhan, Hubei Province. Pregnant women were enrolled ($N = 1034$) at early pregnancy (< 14 weeks) from July 2022 to September 2023. The perinatal depressive symptoms, insomnia severity, anxiety symptoms, and social capital were reassessed at 5-time points from enrollment (T0) to 6 months postpartum using the Edinburgh postnatal depression scale, the Insomnia Severity Index, the Pregnancy-related Anxiety Questionnaire, and the Personal Social Capital Scale 16, respectively. The follow-up time points were 16–20 weeks of gestation (T1), 28–36 weeks of gestation (T2), six weeks postpartum (T3) and six months postpartum (T4), respectively. Group-based trajectory modelling and binary logistic regression modelling were used to analyze the data ($n = 436$).

Results We identified three trajectories for perinatal insomnia and depression symptoms. Insomnia: no insomnia (27.7%), subclinical (54.5%), clinical (17.8%). Depression: low-stable (38.7%), moderate-stable (43.9%), high-improving (17.4%). The dual trajectory analysis revealed significant co-occurrence patterns between insomnia and depression trajectories ($p < 0.001$). Members of the high-improving depression group were more likely to have clinical insomnia

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trajectories. Baseline ISI ≥ 8, EPDS ≥ 10, and PRAQ ≥ 24 predicted the higher trajectories of perinatal insomnia and depressive symptoms (all $p < 0.05$).

Conclusions Perinatal insomnia and depression follow three distinct but interrelated trajectories, identifiable through early screening. Risk-stratified interventions should consider their co-occurrence patterns to optimize outcomes.

Keywords Dual trajectory, Group-based trajectory, Insomnia, Perinatal depression, Social capital

Background

Insomnia disorder is a psychological disorder that represents a more distressing clinical presentation of poor sleep quality. Defined by the DSM-5, insomnia disorder encompasses complaints of dissatisfaction with sleep onset, maintenance, or early morning awakening, occurring at least three nights per week and leading to daytime impairment [1].

Insomnia symptoms are prevalent during peripartum and are considered risk factors for peripartum psychopathology. The perinatal period introduces significant physiological, psychological, and hormonal changes, rendering pregnant women susceptible to heightened insomnia symptoms. Factors such as reflux, back pain, hormonal fluctuations, anxiety, and frequent urination contribute to sleep disturbances during pregnancy and postpartum [2]. A Meta-analysis in 2021 reported that the overall prevalence of insomnia reached as high as 42.4% (95% CI: 32.9–52.5%) in the third trimester [3]. Insomnia is also present during the early pregnancy [4] and tends to increase during the first 6 months after childbirth and with 50% of those women still experiencing insomnia at 2 years postpartum [5]. A study in 2023 reported that the prevalence of insomnia was 20.4% across the first 6 months postpartum [6]. Untreated perinatal insomnia poses risks for both mother and fetus, leading to maternal mental health issues and adverse birth outcomes such as stillbirth, miscarriage, preterm birth, and low/high offspring birthweight [5, 7–9]. Perinatal anxiety and depression are among the most common mental health issues [9], with postpartum depression affecting 17.22% (95% CI 16.00-18.51) of the world's population [10]. It was also recognized that insomnia as important predictor, comorbidity, and poor prognostic factors in postpartum depression. Concurrent symptoms of anxiety and/or insomnia in women with postpartum depression are frequent and linked to heightened severity, potentially escalating the risk of suicidal ideation [11, 12].

The comorbidity of insomnia and depression during the perinatal period has been extensively documented, yet the temporal dynamics of their relationship remain poorly understood. While cross-sectional studies support their bidirectional association [2], they fail to account for the dynamic nature of these symptoms, which tend to fluctuate throughout the perinatal period. Several longitudinal studies have attempted to address this gap. For instance, Michele et al. [6] demonstrated that postpartum insomnia predicted greater postpartum depression across the first 6 months, while Linda et al. [13] found that depressive symptoms in early pregnancy were associated with higher levels of insomnia and sleepiness later in pregnancy. However, such designs fall short in capturing how these symptoms evolve together over time. To overcome this limitation, recent advances in trajectory analysis have begun to reveal symptom heterogeneity and highlight the importance of exploring the co-evolution of insomnia and depression. A study conducted in Taipei [12] used group-based trajectory modeling (GBTM) to identify three distinct trajectories of both depressive symptoms and sleep quality among perinatal women, demonstrating a close association between the trajectories of sleep and depression. Likewise, Ivan D et al. [4] reported significant heterogeneity in insomnia trajectories from early pregnancy to early postpartum, with clinical insomnia group membership associated with higher depression and anxiety levels. Despite these advances, several critical gaps remain. First, no study has simultaneously modeled the trajectories of both insomnia and depression to examine their joint evolution and subgroup-level interactions. Second, most studies rely on general sleep quality measures [14] rather than insomnia-specific assessments. Third, findings across longitudinal studies are inconsistent — for example, Borge et al. [15] found no significant longitudinal association between maternal depression and insomnia problems.

Dual trajectory models [16] can explore relationships between two longitudinal data variables. Through identifying various developmental paths within target population outcomes, this method considered both the dynamics and heterogeneity among variables, providing a promising approach to exploring how those time-varying variables interact over time. By simultaneously examining the different developmental patterns of perinatal depression and insomnia, dual-trajectory studies provide insights into their multidimensional relationships and potential implications for women's health.

Understanding the factors influencing perinatal sleep and mood trajectories is essential for identifying intervention points and improving care strategies. Investigating these factors helps uncover the mechanisms of perinatal insomnia and its link to depression, which is key to developing more effective preventive and

therapeutic measures. Women's sleep and mood during pregnancy and postpartum is affected by anatomical, endocrinological, physiological, psychological, behavioral, socioeconomic, and cultural factors [17]. Several factors, including parity, pre-pregnancy BMI, and social support, have been reported to influence both sleep and depression among perinatal women [2, 18, 19]. Social capital refers to the resources, support, and relationships within an individual's social network, which can be accessed through interpersonal connections [20–22]. It has been recognized as a modifiable protective factor for perinatal depression [23]. In other populations, social capital has been confirmed to be a protective factor for sleep problems [24, 25]. However, direct evidence on the relationship between social capital and perinatal insomnia is lacking, necessitating further exploration.

This study aimed to (i) identify the heterogeneous trajectories of insomnia and depression from pregnancy to six months postpartum, (ii) examine their longitudinal interrelationships, and (iii) explore potential baseline predictors associated with trajectory membership. Based on existing literature, we formulated three hypotheses:

H1 Both insomnia and depressive symptoms will demonstrate heterogeneous developmental trajectories from early pregnancy through six months postpartum.

H2 Significant interrelationships will exist between insomnia and depression trajectory groups.

H3 Baseline characteristics will differentially predict membership in different trajectories.

Methods

This study is a part of a maternity cohort study conducted in Wuhan, Hubei Province, aimed at longitudinally investigating the multidimensional factors influencing maternal and offspring health outcomes (Project No. 21BSH073). Detailed information regarding the study design and data collection procedures of the cohort can be found in our previous protocol [26].

This study was reviewed and approved by the Ethics Committee Review Committee of the Department of Medicine, Wuhan University School of Medicine (No. WHU 2021-YF001) in accordance with the Declaration of Helsinki.

Settings and participants

The cohort was conducted at the obstetrics clinic of Renmin Hospital of Wuhan University, Wuhan, China. Eligible pregnant women ($N = 1034$) were enrolled from early pregnancy between July 2022 and September 2023 and followed up to 1 years postpartum.

Inclusion criteria: (a) Aged 18 ~ 50 years old; (b) gestational age < 14 weeks; (c) Singleton pregnancy; (d) Planning to receive regular antenatal check-ups and delivery at the hospital.

Exclusion criteria: Pregnant women who are: (a) Suffering from severe heart, brain, kidney diseases; (b) Have active or severe mental health disorders, such as schizophrenia, bipolar disorder, or severe major depressive disorder diagnosed according to DSM-5 criteria [1]; (c) Are unable to read or write to complete the questionnaire survey; (d) Are unable to use smartphones and the internet.

Meanwhile, during the follow-up period, participants who: (a) withdraw from the study midway; (b) cannot be contacted for three consecutive follow-up sessions; (c) experience miscarriage or pregnancy termination, were removed.

In this cohort, socio-demographics, Covid-19 related information, social capital, sleep, mental health and medical records, including clinical examination and biochemical tests were collected. Detailed information regarding the baseline data collection and follow-up procedures of the cohort were reported in our previous protocol [26].

Sample size

We used the following formula for the sample size calculation:

$$N = \left(\frac{U_{\alpha/2}}{\delta}\right)^2 \pi\,(1-\pi\,)$$

The latest meta-analysis reported that the prevalence of perinatal depression in Chinese pregnant women was 16.3% [27]. Significance level $\alpha = 0.05$ and the tolerance error $\delta = 0.04$ was set to perform the calculation. Considering a 15% dropout rate at each follow-up (4 follow-ups in total), a variance inflation factor was used to adjust the sample size. The final adjusted sample size was 402.

Measurements

Self-designed maternal general information questionnaire, including pregnant women's socio-demographic characteristics, medical history and pregnancy-related characteristics (age, name, date of birth, occupation, education level, monthly family income, place of residence, number of pregnancies, parity, history of adverse pregnancy and labor, pregnancy complications, etc.).

Insomnia Severity Index (ISI), initially developed by Professor Charles Morin and colleagues in Canada [28], is one of the most widely used insomnia assessment scales in clinical practice. The Chinese version of the ISI scale was translated by Li [29], with Spearman Brown split-half reliability and Cronbach's alpha coefficients measured at 0.753 and 0.843, respectively. The questionnaire has

seven entries: the severity of insomnia symptoms, the degree of satisfaction with sleep patterns, the degree of impact of insomnia on daytime functioning, the degree of impact of insomnia problems on subjects' quality of life, and the degree of worry or frustration caused by insomnia, with each entry scored from 0 to 4 points, and the total score scored from 0 to 28 points, with higher scores indicating a more severe degree of insomnia.0–7 points are classified as insomnia with no clinical significance, 8–14 points are classified as mild clinical insomnia, 15 ~ 21 as moderate clinical insomnia, and 22 ~ 28 as severe insomnia. In this study, a score of 8 was used as the cut-off score for the presence of clinically significant insomnia symptoms. In this study, the ISI demonstrated Cronbach's α of 0.824, 0.854, 0.876, 0.893, and 0.868 for the five time points assessed.

Edinburgh postnatal depression scale (EPDS). The Chinese version of the Edinburgh Postnatal Depression Scale was used in this study to investigate maternal depression. The scale was compiled by Cox et al. [30] in 1987, and introduced by Le et al. [31] at the Chinese University of Hong Kong, with good reliability and validity among pregnant women in China [32]. The scale contains 10 entries, each of which investigates the aspects of mindfulness, pleasure, self-blame, anxiety, fear, coping ability, insomnia, sadness, crying and self-harm. The scale is rated on a four-point scale from 0 to 3, with a total score range of 0 to 30. The higher the score, the more serious the depressive condition of the study subjects. In domestic and international studies, there are still differences and controversies about the delineation score used for EPDS, and this study adopts 10 points as the delineation score for EPDS [30, 33]. In this study, the EPDS demonstrated Cronbach's α of 0.747, 0.853, 0.843, 0.884, and 0.887 for the five time points assessed.

Personal Social Capital Scale 16 (PSCS-16). Initially developed by Chen et al. and provided in a Chinese version [34], it comprises 42 items with a Cronbach's alpha of 0.87. Wang et al. simplified it into a 16-item version with a Cronbach's alpha of 0.90 [35]. It includes two subscales: Bonding capital and Bridging capital, each containing 10 items, totaling 16 items. PSCS utilizes two 5-point Likert-type scales for item scoring. The response options for evaluating participants' ratings on their "network size" are: 1 (few), 2 (below average), 3 (average), 4 (above average), and 5 (many), while the response options for assessing participants' perception of "how many network members" they have been: 1 (none), 2 (a few), 3 (some), 4 (most), and 5 (all). In this study, the Cronbach's α for the cohesive social capital dimension scale it was 0.831 and for the bridging social capital dimension scale it was 0.913.

Pregnancy-related Anxiety Questionnaire (PRAQ), developed by Xiao et al. in 2012 [36]. The questionnaire consists of 13 items in 3 dimensions: worry about self, worry about fetal health, and worry about childbirth. The Cronbach's a coefficient of each dimension ranges from 0.64 to 0.8 L [36]. The scale adopts a four-stage scoring method, with a total score of 52 points. A total score of < 24 indicates no pregnancy-related anxiety, while a total score of ≥ 24 indicates the presence of pregnancy-related anxiety [37]. In this study, the Cronbach's α for PRAQ was 0.863.

Data collection

Baseline recruitment took place during participants' initial clinic visit upon registration at the obstetrics clinic in the hospital. According to the inclusion and exclusion criteria, participants are recruited. After obtaining informed consent, the baseline survey (T0) of the study is conducted, wherein pregnant women are guided to fill out paper questionnaires, and their medical histories are collected through interviews and by consulting the hospital's electronic medical record system. Subsequently, participants were added as WeChat friends using work mobile phones for convenient follow-up.

Thereafter, an electronic questionnaire including the EPDS, ISI, PSCS-16, and PRAQ was designed and distributed by the WeChat (a popular social application in China) in the form of QR codes at T0 (baseline), T1 (16–20 weeks), T2 (28–36 weeks), T3 (six weeks postpartum), and T4 (six months postpartum), respectively.

The questionnaire was designed via the most extensive online survey platform in China: https://www.wjx.cn/ (Changsha Ranxing Information Technology Co., Ltd., Hunan, China). Before the main study began, the online survey system was tested by the researcher to check the performance of the online survey system on different types of devices (including mobile phones, computers, and tablets).

To ensure the quality of the responses, questionnaires can only be submitted if all questions are answered to ensure the completeness of the responses and reminders were provided via telephone to ensure completion by pregnant women. Other quality control steps were detailed in our protocol [26].

Statistical analysis

Data were double-entered using EpiData 3. 1 and analyzed using SAS 9.4 software. Statistics were performed in four steps.

First, descriptive statistics was used for general information, ISI, EPDS, PSCS, and PRAQ scores of the participants. Frequency (%) was used for categorical data, and (M ± SD) was used for normally distributed continuous data.

Next, GBTM was employed to identify the trajectory changes of perinatal depression and insomnia, achieved

through modeling using the PROC TRAJ procedure developed by Nagin and his colleagues [38]. The GBTM identifies categories of individuals with similar trajectories using maximum likelihood estimation and determines several subgroups with different trajectory types from the population. Models containing 2–5 trajectory groups were successively fitted, and the best model was determined by comparing the fit parameters of each model. Criteria for determination included: (1) Bayesian Information Criterion (BIC): The closer BIC is to 0, the better the model fit. (2) △BIC: The difference in BIC values between two different models, where a higher value indicates a better fit. (3) Average Posterior Probability (AvePP): Reflecting the conformity of each individual's posterior probability of group membership to the trajectory group, typically > 0.7 is considered acceptable. (4) Proportions per class%: Each trajectory group's proportion should generally not be less than 5%, and the judgment should be based on the total sample size combined with the shape of the trajectory group. (5) Relative Entropy: The closer the entropy value is to 1, the higher the certainty of classification. (6) Odds of Correct Classification (OCC): OCC > 5 generally indicates higher classification accuracy. (7) Distribution closeness: The degree of closeness between the group distribution proportions (πj) obtained based on the probability of group members and the group distribution proportions (Pj) obtained based on the posterior probability of group members. A difference is considered statistically significant at $P \le 0.05$.

Third, after initial trajectory analysis, depression and insomnia model parameters were incorporated into a dual trajectory model as initial values to fit the joint probability, illustrating the degree of association between different level trajectory groups.

Finally, logistic regression analysis was employed to analyze predictors of insomnia and depression symptom development trajectories using SPSS 25.0.

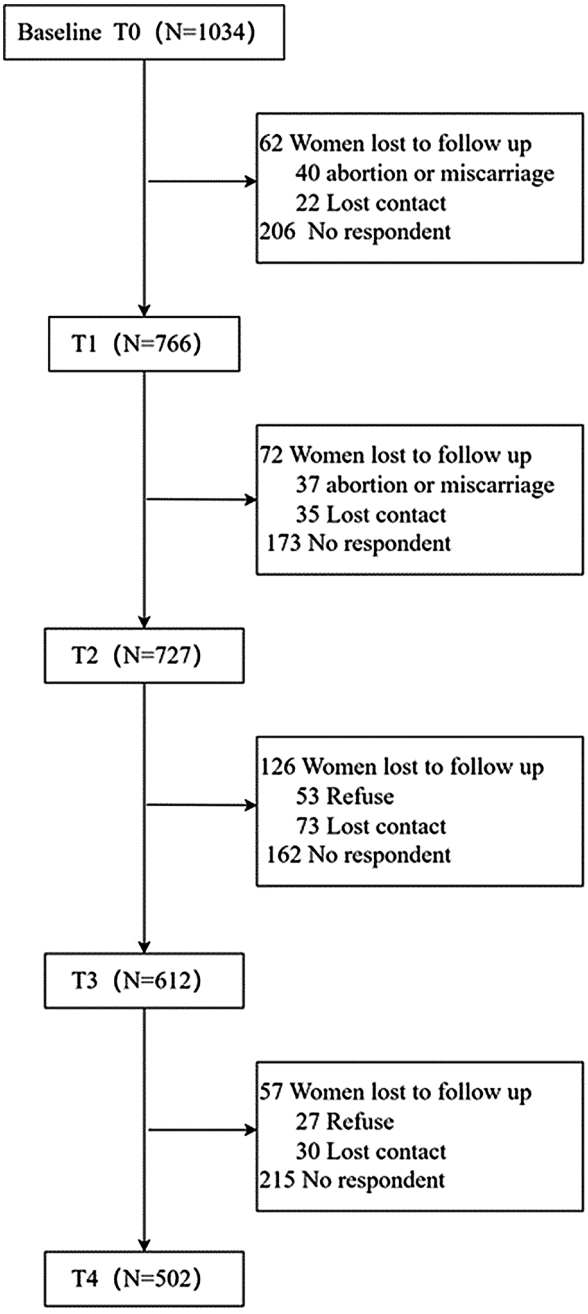

Fig. 1 Flow diagram

Results

The study enrolled 1,034 pregnant women at baseline (T0, < 14 weeks gestation), with 436 participants (42.2%) completing all five assessments. Participant flow and detailed attrition reasons (loss to follow-up, pregnancy loss, contact discontinuation, and non-response) are presented in Fig. 1.

Demographic and health characteristics

The participants' mean (SD) age was 32.7 (3.8) years, and 80.1% of them were planned pregnancy (Table 1). Most (83.9%) had a college education and were employed (85.8%). The mean (SD) social capital and anxiety scores were 46.9 (8.2) and 23.1 (5.8), respectively.

The average scores for insomnia severity index increased steadily from baseline (mean [SD] score 6.3 [4.1]), with a mean (SD) peak of 9.1 (5.5) at 6 weeks postpartum, after which they decreased to 8.9 (4.4) at 6 months postpartum. The mean (SD) depression scores were relatively stable over time, beginning at 7.8 (3.7) at baseline, with a peak of 9.0 (4.9) at 6 weeks postpartum, followed by decrease to 8.4 (4.3) at 6 months postpartum (Table 1).

Perinatal insomnia and depressive symptoms trajectories

The GBTM model fitting results indicate that ISI trajectory models 1–3 all exhibit good goodness of fit, with

Table 1 Baseline characteristics of participants (*N* = 436)

Variable	Category	*N* (%)	Mean (SD)
Age, years			32.7(3.8)
	≤ 35	335(76.8)	
	>35	101(23.2)	
Planned pregnancy	Yes	352(80.7)	
	No	84(19.3)	
Adverse pregnancy history	Yes	134(30.7)	
	No	302(69.3)	
Educational level	≤High school	70(16.1)	
	≥college degree	366(83.9)	
Employment	Employed	381(87.4)	
	Unemployed	55(12.6)	
Family income (¥)	<5000	28(6.4)	
	5000–10,000	134(30.7)	
	≥ 10,000	274(62.8)	
Social capital score			46.9(8.2)
Anxiety score			23.1(5.8)
	<24	276(63.3)	
	≥ 24	160(36.7)	
Baseline EPDS score	<10	307(70.4)	
	≥ 10	129(29.6)	
Baseline ISI score	<8	279(64.0)	
	≥ 8	157(36.0)	
EPDS score at each assessment	Baseline		7.8(3.7)
	16-20week' pregnancy		7.5(4.2)
	28-36week' pregnancy		8.1(4.2)
	Postpartum 6 weeks		9.0(4.9)
	Postpartum 6 months		8.4(4.3)
ISI score at each assessment	Baseline		6.3(4.1)
	16-20week' pregnancy		7.0(4.5)
	28-36week' pregnancy		8.6(5.0)
	Postpartum 6 weeks		9.1(5.5)
	Postpartum 6 months		8.9(4.4)

relative entropy values and average posterior probabilities (Aveep%) exceeding 0.9. Based on the alignment between actual values (dashed line) and predicted values (solid line) in the model trajectory plots, along with the results of parameter estimation tests for the group trajectory model, and considering the professional interpretability of the trajectory morphology, we ultimately selected a group trajectory model containing three trajectory groups. The morphology parameter for the first trajectory is linear, while the second and third trajectories are both quadratic (Table S1).

Among three trajectories of insomnia, the 'no insomnia' group included 27.70% of the women who began with and maintained low ISI scores (Fig. 2). The participants in the 'subclinical insomnia' group (54.53%) began with a mean score of 6.8 and peaked at 9.3 at 6 weeks postpartum. The 'clinical insomnia' group consisted of 17.77% of the mothers, and they began at a high level of insomnia and had elevated ISI scores throughout the perinatal period, which indicated extremely severe insomnia.

The GBTM model fitting results indicate that EPDS trajectory models 1–3 all exhibit good goodness of fit, with relative entropy values and average posterior probabilities (Aveep%) exceeding 0.9. Based on the alignment between actual values (dashed line) and predicted values (solid line) in the model trajectory plots, along with the results of parameter estimation tests for the group trajectory model, and considering the professional interpretability of the trajectory morphology, we ultimately selected a group trajectory model containing three trajectory groups. The morphology parameter for the first trajectory is the intercept, for the second trajectory is the cube, and for the third trajectory is the square (Table S2).

Among three trajectory groups of depressive symptoms (Fig. 3), the mothers in the 'low-stable' group (38.66%) began with low depression scores (mean = 4.23), which remained consistently low throughout the study. In the 'moderate-stable' group (43.90%), the participants began with somewhat elevated EPDS scores of 8.7. The scores then rose rapidly to 10.21 postpartum and were

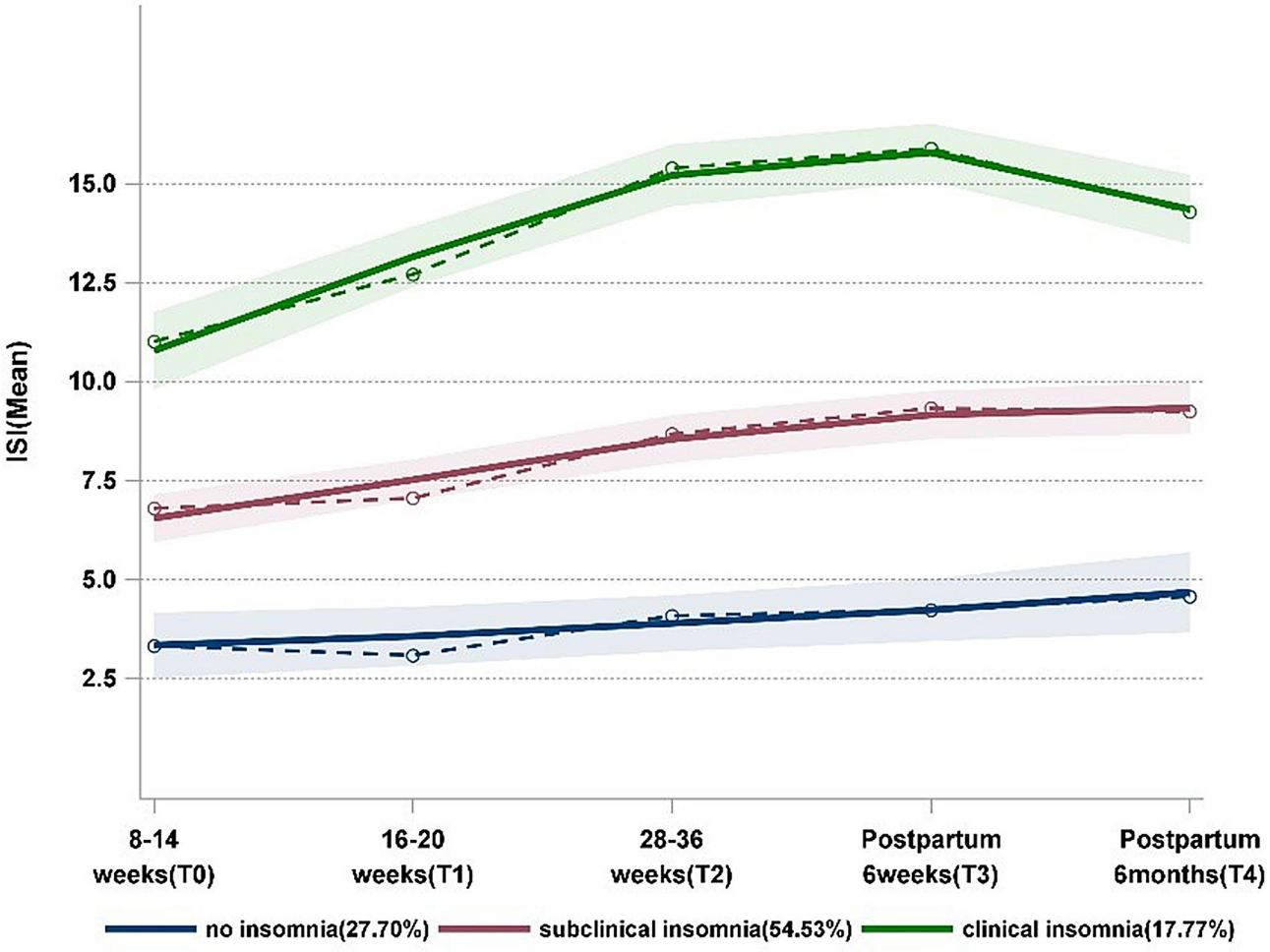

Fig. 2 Trajectories of insomnia among perinatal women (*N* = 436). *Note*: Group 1: 'no insomnia' (27.70%); Group 2: 'subclinical insomnia' (54.53%); Group 3: 'clinical insomnia' (17.77%)

maintained at follow-up. The participants in the 'high-improving' group (17.44%) began with high EPDS scores (mean = 11.71), which were above the EPDS cutoff score of 10, thus indicating probable cases of depression.

Relationships between insomnia and depressive symptoms trajectories

The group-based dual trajectory analysis revealed significant co-occurrence patterns between insomnia and depression trajectories ($p < 0.001$) (Table 2). First, joint membership probabilities showed: 26.38% displayed paired no insomnia with low-stable depression, 38.53% of participants exhibited concurrent subclinical insomnia and moderate-stable depression, and 15.60% presented clinical insomnia with high-improving depression. Other combinations accounted for a small proportion of the sample. Second, conditional probabilities revealed severity-dependent patterns. Among participants in the low-stable depression group, 71.43% had no insomnia, 28.57% had subclinical insomnia, and none were classified as having clinical insomnia. Among participants in the moderate-stable depression group, 4.74% had no insomnia, 88.42% had subclinical insomnia, and 6.84% had clinical insomnia. In the high-improving depression group, 80.00% had clinical insomnia, 20.00% had subclinical insomnia, and none had no insomnia. Cross-combinations between divergent severity levels were minimal. For example, only 2.06% of those with moderate-stable depression were classified as having no insomnia, and no participants were jointly classified into low-stable depression with clinical insomnia or high-improving depression with no insomnia.

Predictors of insomnia and depressive symptoms trajectories

One-way ANOVA, chi-square test and Fisher's exact probability method were used to investigate the factors influencing the trajectories of prenatal depressive symptoms and the trajectories of insomnia symptoms. Results of the univariate analyses are illustrated in Table S3.

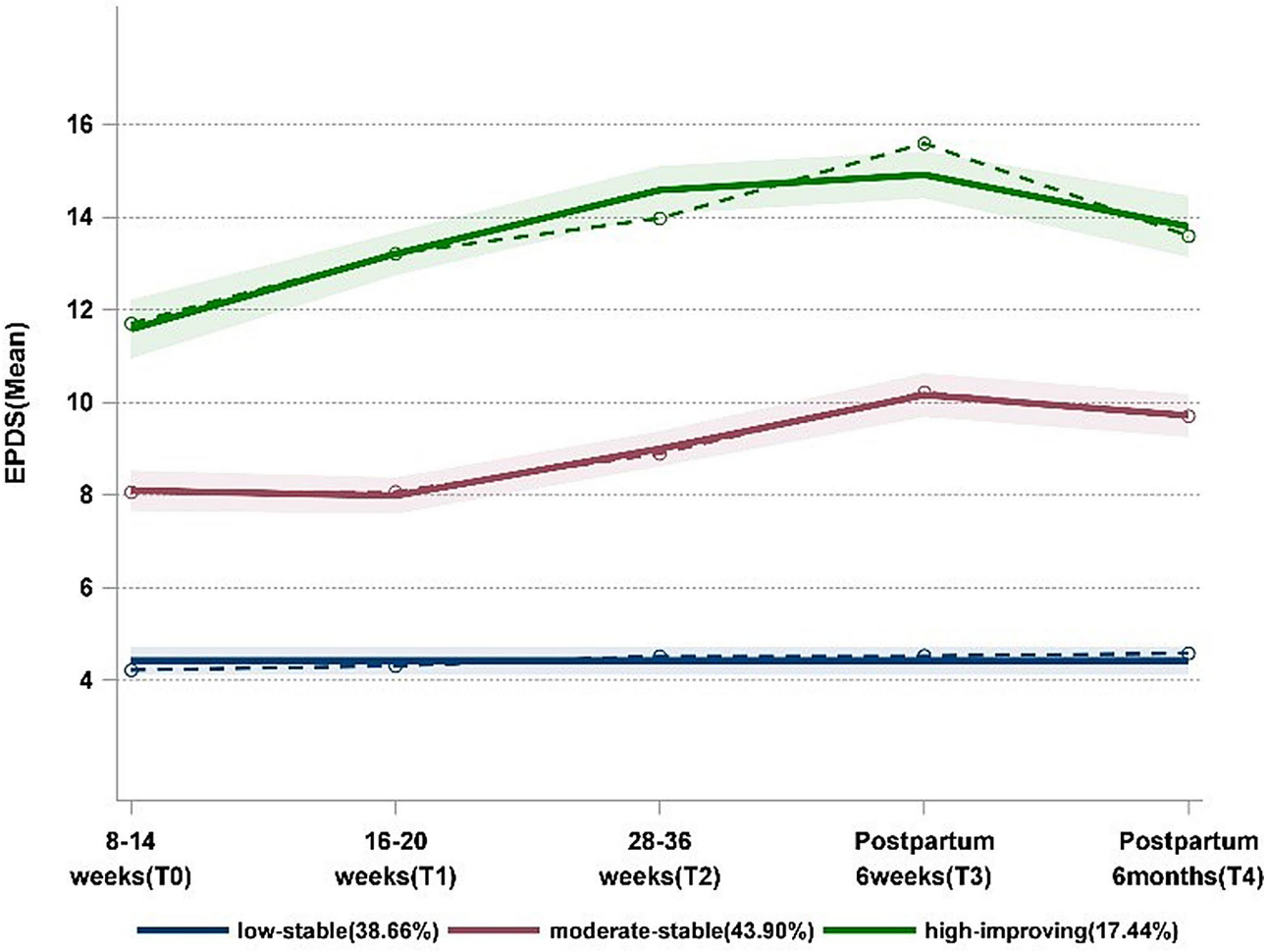

Fig. 3 Trajectories of depressive symptoms among perinatal women (*N* = 436) *Note*: Group 1: 'low stable' (38.66%); Group 2: 'moderate stable' (43.90%); Group 3: 'high-improving' (17.44%)

Table 2 Joint and transitional probabilities (%) of classification in the insomnia severity and depressive symptoms trajectories (*N* = 436)

Depressive symptoms	Insomnia severity, %		
	No insomnia	Subclinical insomnia	Clinical insomnia
2a. Probability of joint trajectory of group membership			
low-stable	26.38	10.55	0
moderate-stable	2.06	38.53	2.98
high-improving	0	3.90	15.60
2b. Probability of insomnia severity based on depressive symptoms			
low-stable	71.43	28.57	0
moderate-stable	4.74	88.42	6.84
high-improving	0	20.00	80.00

For perinatal depression symptom trajectories, the predictors of the moderate-stable and high-improving depression groups were explored using the low-stable group as the control group in the logistic regression analysis (see Table 3). Predictors included: baseline anxiety score ≥ 24 (OR 3.516, 95%CI [2.079, 5.946]); baseline EPDS score ≥ 10 (OR 5.771, 95%CI [2.936, 11.342]); baseline ISI score ≥ 8 (OR 2.680, 95%CI [1.604, 4.477]). Similarly, the predictors of the subclinical insomnia and clinical insomnia groups were explored using the no insomnia group as the control group in the binomial logistic regression analysis (see Table 3). Predictors included: baseline anxiety score ≥ 24 (OR 2.758, 95%CI [1.525, 4.985]); baseline EPDS score ≥ 10 (OR 2.633, 95%CI [1.268, 5.467]); baseline ISI score ≥ 8 (OR 8.069, 95%CI [3.979, 18.626]).

Discussion

In this study, we prospectively examined the time course changes in insomnia disorder and depressive symptoms among women during the perinatal period and identified distinct classes with different patterns of insomnia and depressive symptom trajectories. Further, we found a strong interrelationship between insomnia and depressive trajectories, which suggests that women with severer

Table 3 Binomial logistic regression of insomnia trajectories and depression trajectories ($N=436$)

Variable	Depression trajectories [Mean ± SD/*n* (%)]			Insomnia trajectories [Mean ± SD/*n* (%)]		
	Low-stable($n=168$)	Moderate-stable/high-improving($n=268$)	OR (95%CI)	No insomnia ($n=111$)	Subclinical insomnia/clinical insomnia($n=325$)	OR (95%CI)
Age, years			1.081(0.629–1.857)			1.138(0.631–2.055)
≤ 35	130(77.4)	205(76.5)		87(78.4)	248(76.3)	
> 35	38(22.6)	63(23.5)		24(21.6)	77(23.7)	
Planned pregnancy			1.578(0.864–2.881)			0.797(0.431–1.472)
Yes	143(85.1)	209(78.0)		88(79.3)	264(81.2)	
No	25(14.9)	59(22.0)		23(20.7)	61(18.8)	
Adverse pregnancy history			1.409(0.846–2.347)			1.380(0.788–2.419)
Yes	47(28.0)	87(32.5)		29(26.1)	105(32.3)	
No	121(72.0)	181(67.5)		82(73.9)	220(67.7)	
Educational level			1.042(0.527–2.062)			1.255(0.597–2.637)
≤High school	25(14.9)	45(16.8)		15(13.5)	55(16.9)	
≥College degree	143(85.1)	223(83.2)		96(86.5)	270(83.1)	
Employment			1.504(0.755–2.996)			0.735(0.335–1.613)
Employed	140(83.3)	241(89.9)		98(88.3)	241(87.1)	
Unemployed	28(16.7)	27(10.1)		13(11.7)	42(12.9)	
Family income (¥)			1.032(0.785–1.357)			1.147(0.857–1.534)
< 5000	8(4.8)	20(7.5)		6(5.4)	22(6.8)	
5000–10,000	53(31.5)	81(30.2)		36(32.4)	98(30.2)	
> 10,000	107(63.7)	167(62.3)		69(62.2)	205(63.1)	
Social capital score			0.971(0.942–1.001)			0.982(0.950–1.014)
	48.8 ± 8.0	45.7 ± 8.1		48.8 ± 8.2	46.2 ± 8.1	
Anxiety score			3.516(2.079–5.946) *			2.758(1.525–4.985) *
< 24	141(83.9)	135(50.4)		91(82.0)	185(56.9)	
≥ 24	27(16.1)	133(49.6)		20(18.0)	140(43.1)	
Baseline EPDS score			5.771(2.936–11.342) *			2.633(1.268–5.467) *
< 10	156(92.9)	151(56.3)		100(90.1)	151(56.3)	
≥ 10	12(7.1)	117(43.7)		11(9.9)	117(43.7)	
Baseline ISI score			2.680(1.604–4.477) *			8.069(3.979–18.626) *
< 8	135(80.4)	144(53.7)		103(92.8)	176(54.2)	
≥ 8	33(19.6)	124(46.3)		8(7.2)	149(45.8)	

*$p<0.05$. **$p<0.01$

insomnia are likely to have high depression trajectories during pregnancy and postpartum. Meanwhile, we found that baseline anxiety score ≥ 24, baseline ISI score ≥ 8, and baseline EPDS score ≥ 10 were common predictors to perinatal insomnia and depression trajectories. This study thus elucidates the courses of insomnia and depressive symptoms and can help guide the development of intervention strategies to improve sleep and depression during pregnancy and postpartum.

Our results identified three heterogeneous insomnia trajectories, indicating that insomnia symptoms during the perinatal period follow distinct patterns rather than a single uniform trajectory. A substantial proportion of women in our study experienced either no insomnia (27.70%) or subclinical insomnia (54.54%) symptoms from early pregnancy to six months postpartum. This finding aligns with Ivan D. et al.'s study, which also identified three insomnia trajectory groups from 15 weeks of gestation to six weeks postpartum, with most women presenting with no insomnia (42.3%) or moderate insomnia symptoms (44.3%) [4]. Despite the differences in the follow-up periods, it was consistently evident in both studies that maternal insomnia remained high from pregnancy to postpartum in class 3 (17.77%), which implies that mothers in this group experience persistent and severe insomnia, placing them at high risk for sleep health, necessitating increased attention and care. In this study, these trajectories were relatively stable although it also showed a slow upward trend, especially for class 1 and 2. This was consistent with Ivan D [4]and Borge et

al.' study [15], in which the insomnia trajectories were stable across the perinatal period. In addition, similar to Ivan D et al. 'study, in our study, in class 3 (clinical insomnia), insomnia symptoms demonstrated improvement in postpartum. This may suggest that a potential resolution of postpartum insomnia over time, even in cases of persistent high insomnia levels during the perinatal period. Given these observations, providing tailored support and interventions could help expedite the amelioration of insomnia symptoms for individuals in different classes. For individuals in classes 1 and 2, since their insomnia and depression symptoms were mild, preventive measures such as sleep hygiene education and stress reduction programs may suffice. Conversely, class 3, despite being a smaller proportion of the population, may experience a greater impact on their sleep due to pregnancy and childbirth, especially in late pregnancy. Therefore, they may require more pregnancy-related support and professional insomnia therapy, like cognitive behavioral therapy for insomnia (CBT-I) [39].

We identified three distinct and stable trajectories of depressive symptoms that continued from early pregnancy to 6 months postpartum. This finding is consistent with previous research reports [12], in which the heterogeneity of perinatal depression has been reported as three groups: low-stable, moderate-stable, and chronically high-improving trajectories. In Class 1, pregnant and postpartum women exhibit almost no depressive symptoms and remain stable; in Class 2, women experience mild depressive symptoms, also remaining stable and never reaching the clinical threshold. The majority of pregnant and postpartum women belong to Class 1 (38.66%) or Class 2 (43.90%). For these two groups, women's depressive symptoms were mild, routine psychological and pregnancy-related support is sufficient. While in Class 3, women consistently exhibit high levels of depressive symptoms with a rising trend, peaking at 6 weeks postpartum, and then beginning to decline. This indicates that depressive symptoms in this group are significantly influenced by pregnancy, necessitating more attention, especially professional psychological support, to help them through this critical period [40]. These results partly confirmed our first hypothesis 1.

The study's findings demonstrate a significant longitudinal association between perinatal insomnia and depressive symptom trajectories, confirming our first hypothesis 2 regarding the co-occurrence and interdependence of these symptoms during pregnancy and postpartum. This is in line with Osnes et al.'s [42] findings that perinatal insomnia correlates with co-occurring depressive symptoms but not postpartum depression, possibly due to temporal dynamics in symptom interaction. The bidirectional relationship may be mediated through physiological mechanisms such as HPA axis dysregulation, where depressive symptoms elevate stress hormone levels, subsequently disrupting sleep architecture [43]. Conversely, persistent insomnia may perpetuate negative emotional states through impaired emotional regulation and neural circuit dysfunction [44]. Our trajectory analysis extends current evidence by delineating how these interrelated symptoms co-evolve across the perinatal period, providing a dynamic perspective on their temporal interactions.

The dual-trajectory analysis revealed distinct patterns of insomnia-depression comorbidity across perinatal women. Women with low-stable depressive symptoms predominantly remained free of clinically significant insomnia. In contrast, those with moderate-stable depressive symptoms most commonly developed subclinical insomnia, while clinical insomnia was particularly prevalent among women in the high-improving depressive group. These findings demonstrate that the severity and course of depressive symptoms are closely associated with different levels of insomnia severity during the perinatal period. The results underscore the importance of tailored screening and intervention strategies that account for these specific symptom trajectories. For the low-stable depressive group, preventive mental health education and daily life management are adequate to maintain good sleep and emotional well-being [41]. For the moderate-stable depressive group, combined psychological support and sleep hygiene education should be prioritized to improve sleep quality and manage depressive symptoms [41]. For the high-improving depressive group, a more comprehensive and professional approach is crucial to simultaneously address severe depressive and insomnia symptoms [41]. These personalized interventions can address the specific needs of different trajectory groups, providing effective and individualized interventions to enhance the overall mental health of perinatal women.

Our study demonstrates that maternal anxiety, depression, and insomnia symptoms during early pregnancy (< 14 weeks) serve as significant predictors of adverse mental health trajectories across the perinatal period. Women exhibiting elevated symptom levels in the first trimester showed markedly increased vulnerability to developing severe insomnia and worsening depressive symptoms throughout pregnancy and postpartum. These findings align with existing literature documenting that early pregnancy anxiety predicts postnatal depression [45]and that poor antenatal sleep quality elevates risks for perinatal depression [46]. Linda et al.'s study also suggested that women with higher baseline anxiety tended to experience greater increases in sleep latency and that depressive and anxiety symptoms in early pregnancy were associated with higher insomnia and lethargy symptoms in late pregnancy [13]. The observed associations

may be mediated through shared physiological mechanisms, particularly hypothalamic-pituitary-adrenal (HPA) axis dysregulation, wherein elevated stress hormones simultaneously disrupt emotional regulation and sleep architecture [6, 44]. Notably, our results reinforce the well-established interrelationships among perinatal anxiety, insomnia, and depression symptoms [13, 23, 42], with evidence suggesting these conditions mutually reinforce one another through bidirectional pathways. For instance, baseline insomnia has been shown to exacerbate concurrent anxiety and depressive symptoms [17], while postpartum sleep disturbances may longitudinally worsen affective symptoms [23]. These insights underscore the clinical imperative for early screening and integrated interventions targeting this symptomatic triad during the perinatal period. Future research should further elucidate the temporal dynamics and mechanistic pathways underlying these relationships to optimize preventive strategies and treatment approaches. These results partially confirm our first hypothesis 3.

Our results showed that social capital was not a significant predictor of perinatal insomnia trajectories and depression trajectories, inconsistent with current study. In Chi et al.' study, social capital was protective factor with depression during and after pregnancy [47]. Previous studies have explored the role of social support for perinatal depression and sleep and reported that greater social support is significantly associated with improved sleep and depression [48]. In Marianne et al.' s study, results showed that the women with low social support at baseline were more likely to experience poor sleep trajectories and have high depression trajectories [12]. This suggests that social capital may serve as a factor influencing perinatal depressive and insomnia rather than a predictor of their dynamic trajectory changes. It may be due to the complex influence of a number of factors. Given the limited research evidence on the association between social capital and perinatal depression, particularly perinatal insomnia, further investigation is needed to gain a deeper understanding of this relationship. These results partially support our first hypothesis 3.

In summary, these findings carry three key implications for perinatal mental healthcare: First, the trajectory interdependence supports integrated clinical protocols that simultaneously monitor and manage insomnia-depression comorbidity, rather than treating them as isolated conditions. Second, the predictive value of baseline scores and trajectory membership suggests the need for risk-based interventions: (i) preventive psychoeducation and pregnancy-related support for individuals with no or mild symptoms, (ii) general perinatal care and psychological support for those with subclinical insomnia and moderate depression, and (iii) professional psychological and insomnia treatments for those with severe symptoms. Finally, the observed symptom progression patterns highlight critical windows for secondary prevention—particularly during pregnancy-to-postpartum transition periods where trajectory divergence intensifies.

Strengths

This study has several strengths. Firstly, it is the first study to explore the concurrent and prospective relationship between perinatal depression and insomnia from the perspective of shared temporal changes, considering the heterogeneity of trajectories and establishing a dual trajectory model for both. Secondly, the study included a larger sample size of 427 participants compared to the previous study in Taiwan (190) [12], thus enhancing its representativeness. Finally, our study collected data on insomnia and depression at multiple time points from early pregnancy to within 6 months postpartum (a total of five time points), providing strong support for comprehensive observation and analysis of the longitudinal changes in perinatal depression and insomnia symptoms.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the single-center design may restrict the generalizability of our results. Second, while we identified baseline predictors, our analysis did not account for potential mediating factors that could influence symptom trajectories across different pregnancy trimesters and postpartum periods. Third, the exclusive reliance on the ISI, while validated, captures only certain dimensions of insomnia and may miss other clinically relevant aspects such as specific sleep maintenance difficulties or circadian rhythm disruptions [16]. Importantly, the subjective nature of questionnaire-based assessments like the ISI lacks the objectivity that could be provided by polysomnography or actigraphy measures.

Future studies should prioritize multicenter designs with diverse populations to enhance generalizability, while incorporating both objective sleep measures and extended follow-up periods to better characterize long-term symptom trajectories. Research could systematically examine the temporal relationships and shared mechanisms linking perinatal depression, insomnia, and anxiety, including potential mediators like inflammatory markers or HPA axis dysfunction. Such investigations should ultimately inform the development of integrated interventions targeting this symptom triad, advancing toward precision medicine approaches for perinatal psychosleep health management.

Conclusion

In this study, we identified three distinct trajectories of perinatal insomnia and depression. The patterns of insomnia and depressive symptoms were significantly

correlated. Gestational women with clinical insomnia trajectories are more likely to codevelop severe depression compared to those with no or subclinical insomnia trajectories. Additionally, we identified common predictors for both insomnia trajectories and depression trajectories, including baseline thresholds of: (1) ISI scores ≥ 8 (insomnia), (2) PRAQ scores ≥ 24 (anxiety), and (3) EPDS scores ≥ 10 (depression). These findings underscore two critical implications for perinatal care: first, the necessity of implementing first-trimester screening using these validated cutoffs to identify at-risk women; second, the importance of combined treatment approaches that simultaneously address insomnia and depression. Together, these strategies may improve mental health outcomes during this vulnerable period.

Abbreviations

ISI	Insomnia Severity Index
EPDS	Edinburgh postnatal depression scale
PSCS	Personal Social Capital Scale
PRAQ	Pregnancy-related Anxiety Questionnaire
GBTM	Group-based trajectory modeling
BIC	Bayesian Information Criterion
AvePP	Average Posterior Probability
OCC	Odds of Correct Classification

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12884-025-07649-2.

Supplementary Material 1: Table S1 Indicators for evaluating the fitting effect of EPDS trajectory models in groups 1 to 3. Table S2 Evaluation indexes of fitting effect of ISI trajectory models of 1∽3 groups. Table S3 Relationships of baseline characteristics with depression trajectories and insomnia trajectories.

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Author contributions

Visualization, software, data curation, formal analysis, writing-original draft preparation, and article submission were performed by XL P and LY Z. Writing-original draft preparation, writing-reviewing, and editing were performed by Y C and CL C. Study design, methodology, and investigation were mainly performed by JF C. Methodology, supervision, and project administration were performed by ZJ Z, XL C, and WH L. Investigation and data curation were also performed by YJ C, JR W, and W Z. All authors read and approved the final manuscript.

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Data availability

The datasets used and analyzed during the current study are available from the corresponding authors on reasonable request.

Declarations

Ethics approval and consent to participate

This study was reviewed and approved by the Ethics Committee Review Committee of the Department of Medicine, Wuhan University School of Medicine (No. WHU 2021-YF001) in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants before their enrollment in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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