BMC Pregnancy and Childbirth

RESEARCH

Open Access

Development and validation of a predictive nomogram for antenatal depression in China

Renjie Yu[1†], Luyang Guan[1†], Hongbao Chen[1†], Jun Zhang[1†], Xiaohong Li[2], Shengying Zhang[3], Jia Liu[4], Peiyun Zhang[1,5], Linghua Kong[1], Lanlan Zhang[1], Tingting Jin[1], Ju Gao[1], Xiaobin Zhang[1*] and Yong Yang[1*]

Abstract

Background Antenatal depression is a significant public health concern, with detrimental effects on maternal and infant health. However, there is currently a lack of comprehensive predictive tools specifically tailored for antenatal depression in China. The present study aimed to develop and validate a predictive nomogram for antenatal depression in the Chinese population.

Methods A cross-sectional study was conducted in multiple healthcare settings in Suzhou, Jiangsu Province, China, spanning from March 2017 to December 2019. A total of 3694 pregnant women were included in the study. Demographic and clinical characteristics were collected using structured questionnaires. The Edinburgh Postnatal Depression Scale and various psychological assessments were used to assess antenatal depression and associated factors. LASSO regression and logistic regression analyses were employed to develop the predictive model, and internal validation was performed to assess its performance.

Results Among the 3694 participants, 473 (12.8%) pregnant women were positive for antenatal depression. The developed predictive Model incorporated neuroticism, negative coping strategies, and anxiety as significant predictors. The nomogram demonstrated accurate risk assessment capabilities, with an AUC of 0.90 in the validation set. The model exhibited good calibration and clinical utility.

Limitations Limitations of this paper include the cross-sectional design, biases like self-reporting and non-randomized sampling, highlighting the need for future longitudinal studies and diverse population validation to enhance the model's robustness in varied sociocultural contexts.

Conclusion The predictive model for antenatal depression in the Chinese population provides a valuable tool for early detection, intervention, and personalized care for pregnant women.

Keywords Antenatal depression, Edinburgh postpartum depression scale, Nomogram, Prediction models

†Renjie Yu, Luyang Guan, Hongbao Chen and Jun Zhang contributed equally to this work.

*Correspondence:
Xiaobin Zhang
zhangxiaobim@163.com
Yong Yang
szgjyy@126.com
[1]Suzhou Guangji Hospital & Affiliated Guangji Hospital of Soochow University, Soochow Univeristy, No. 11 Guangqian Road, Suzhou 215137, Jiangsu Province, PR China
[2]Affiliated Hospital of Medical School, Suzhou Hospital, Nanjing University, Suzhou 215000, Jiangsu Province, PR China
[3]Suzhou Wuzhong People's Hospital, No. 61, Dongwu North Road, Wuzhong District, Suzhou 215128, Jiangsu Province, PR China
[4]Suzhou Municipal Hospital, 26 Daoqian Street, Suzhou City 215002, Jiangsu Province, PR China
[5]Nantong Fourth People's Hospital, No.37 Chenggang Road, Chongchuan District, Nantong 226000, Jiangsu Province, PR China

© The Author(s) 2025. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by-nc-nd/4.0/.

Introduction

Antenatal depression, characterized by a spectrum of depressive episodes ranging from mild to severe, represents a significant public health concern due to its prevalence and detrimental impact on maternal and infant health. Despite pregnancy being generally viewed as a positive experience, women are at an increased vulnerability to depression during and after pregnancy [1]. Evidence suggests that two-thirds of postnatal depression occurs during the antenatal period [2, 3]. Therefore, targeting the antenatal phase with screening and interventions becomes crucial. The global incidence of antenatal depression is estimated to range between 10 and 20% [4], with substantial variability observed across different socioeconomic contexts, specifically indicating higher prevalence rates in low- and middle-income countries than in high-income countries [5, 6]. In China, the prevalence of antenatal depression varies widely and has shown an upward trend in recent years, influenced by factors such as rapid urbanization, high societal expectations, and gaps in mental health services.

The adverse maternal and neonatal outcomes associated with antenatal depression are multifaceted and far-reaching. Maternal complications encompass an elevated risk of gestational diabetes and preterm birth [7, 8], long-term mental health implications including postpartum depression, and the potential impairment of mother-infant bonding [9]. Neonatal consequences involve a propensity for developmental delays, low birth weight, and compromised cognitive and emotional functioning [10–12]. Moreover, the impact of antenatal depression can persist into childhood, facilitating behavioral issues and an elevated risk of psychiatric disorders [13, 14].

Early detection and intervention for antenatal depression are crucial to mitigate these adverse outcomes. However, the identification of susceptible women remains challenging, as symptoms are often misattributed to typical pregnancy changes, resulting in undiagnosed and untreated cases [15]. A considerable percentage of individuals with antenatal depression, ranging from 32 to 57%, were observed to be inadequately identified within a timely manner [16]. Moreover, the prevalence of limited awareness concerning depression, coupled with social and cultural factors, contributes to the fact that only one-third of women who exhibit positive results in depression screening receive subsequent psychological counseling [17]. Consequently, there is a pressing need for efficacious screening and risk assessment tools to facilitate early intervention. Predictive models, such as nomograms, which graphically represent the multivariate probability of a specific outcome, have recently emerged as a popular tool for disease prediction in various medical fields [18]. Within the context of antenatal depression, such a predictive nomogram could offer a pragmatic approach for healthcare professionals to identify high-risk women and allocate resources for early intervention optimally.

In this study, we aim to develop and validate a predictive nomogram for antenatal depression within the Chinese population. Previous systematic reviews have established a range of risk factors, including lack of social support, history of abuse or domestic violence, lower income levels, personal history of mental illness, specific personality traits, unplanned or unwanted pregnancy, pregnancy complications, adverse life events, and high perceived stress [19, 20]. By incorporating these demographic, clinical, and psychosocial factors into a nomogram tailored for the Chinese population, we aim to provide a practical tool for estimating antenatal depression risk. The study's findings will contribute to the development of personalized care plans and interventions, enabling early detection, treatment, and support for pregnant women at risk of antenatal depression in China.

Methods

Study design and setting

This research utilized a cross-sectional study design across multiple healthcare settings, including antenatal clinics, Maternity hospitals, and community health centers. The data collection period was from March 2017 to December 2019 in Suzhou, Jiangsu Province, China. Ethical approval for this study was obtained from the Institutional Review Board of the Affiliated Guangji Hospital of Soochow University (Approval No. 2016010). Informed consent was obtained from all participants before their inclusion in the study. Confidentiality and privacy of participants' data were strictly maintained throughout the research process.

In order to estimate the appropriate sample size for our study, we reviewed previous research on the prevalence of our target condition in the relevant population. Although the prevalence of antenatal depression varies across studies worldwide, typically ranging between 10% and 20% [21], there is a lack of precise estimates specific to our target population. Consequently, we conservatively assumed a prevalence of 15% for sample size calculation. Using a desired margin of error (d) of 5% and a confidence level of 95% ($Z = 1.96$), we calculated that a sample size of approximately 196 participants would be required to achieve sufficient statistical power for our study.

Participant selection and inclusion criteria

Pregnant women from the Chinese population, regardless of gestational age, were eligible for inclusion in the study. The age range for participants was set between 18 and 40 years to ensure a specific demographic representation. Additionally, to enhance the model's generalizability

and relevance in the targeted region, the study exclusively included individuals from the Chinese Han ethnic group. Participants were required to have the ability to comprehend the study's purpose, procedures, and potential risks, and provide informed consent voluntarily through written documentation before enrollment. Exclusion criteria encompassed individuals with a history of mental illness or current psychotic disorders, as well as those with severe underlying physical illnesses.

Data collection and measures

Data collection was carried out through face-to-face interviews with participants using structured questionnaires. Trained research personnel collected demographic and clinical characteristics, including age, educational level, occupation, gestational age, medical history, and obstetric history. The Edinburgh Postnatal Depression Scale (EPDS), a widely validated and reliable instrument, served as the primary tool for screening antenatal depression. Additionally, various factors associated with antenatal depression, including personality traits, anxiety symptoms, social support, and coping strategies were assessed. These measures were selected to capture a comprehensive range of factors that may influence the risk of antenatal depression. Specifically, the measurement tools used in this study included the EPDS, Eysenck Personality Questionnaire (EPQ), General Anxiety Disorder 7 (GAD-7), Social Support Rating Scale (SSRS), and Trait Coping Style Questionnaire (TCSQ).

EPDS

The EPDS is the Most common and acceptable screening tool for identifying depressive symptoms in the perinatal period worldwide, with a reported sensitivity of 0.68–0.86 and specificity of 0.78–0.96 [22, 23]. It consists of 10 items that evaluate various aspects including mood, optimism, self-blame, anxiety, fear, coping ability, sleep, sadness, crying, and self-harm [24]. In this study, pregnant women were categorized into two groups, antenatal depression groups and non-antenatal depression, based on whether their total score on the EPDS was greater than or equal to 13, a widely accepted cutoff in recent studies focused on antenatal populations. We selected the EPDS over general depression tools like the PHQ-9 because the EPDS was specifically developed for perinatal populations and avoids confounding by somatic symptoms that are common during pregnancy but not necessarily indicative of depression [25]. Several studies have shown that EPDS demonstrates higher sensitivity (up to 86%) and better specificity (up to 78%) in detecting perinatal depression compared to the PHQ-9 [26], especially in distinguishing varying levels of depressive severity. International clinical guidelines also recommend EPDS as the preferred screening tool for antenatal and postnatal depression due to its superior diagnostic accuracy in this population [27]. The Chinese version of the EPDS has demonstrated excellent psychometric properties, with a Cronbach's α of 0.87–0.91 and an AUC of 0.91 [24].

EPQ

The EPQ is employed to assess the personality traits of pregnant women. This questionnaire primarily examines personality traits based on three dimensions: extraversion (E), neuroticism (N), and psychoticism (P). It assesses factors such as introversion/extroversion, self-control, and adaptability to the environment [28]. Despite the existence of newer personality assessment tools, the EPQ remains one of the most widely used instruments in China due to its strong reliability, concise format, and established clinical relevance. Other personality inventories, such as the Minnesota Multiphasic Personality Inventory (MMPI), the NEO Personality Inventory-Revised, or the Big Five Inventory, either lack cultural adaptation, are too lengthy for clinical settings, or show limited applicability in perinatal populations [29–31]. The Chinese version of the EPQ shows good reliability (split-half reliability = 0.68–0.81; test–retest reliability = 0.83–0.90) and acceptable construct validity (correlation with MMPI subscale: $r = 0.52$) [32].

GAD-7

The GAD-7 is utilized to evaluate the level of anxiety in pregnant women. This questionnaire employs a 4-point scoring system, with scores ranging from 0 to 4 indicating no anxiety disorder, 5 to 9 indicating mild anxiety, 10 to 14 indicating moderate anxiety, and ≥ 15 indicating severe anxiety [33]. Higher scores indicate more pronounced symptoms of anxiety. The Chinese version of the GAD-7 has been validated in large Chinese populations, demonstrating strong internal consistency ($\alpha = 0.908$), test–retest reliability ($r = 0.856$), and good construct validity (CFI = 0.98, RMSEA = 0.07) [34].

SSRS

The SSRS is a widely used instrument designed to assess an individual's perceived level of social support. It measures the degree of social support individuals perceive when facing difficulties or stressors. The scale encompasses various dimensions, including family support, friend support, and professional support [35]. Each dimension consists of several items that capture different aspects of social support. The Chinese version demonstrates excellent reliability (α = 0.89–0.94) and a well-validated three-factor structure [36].

Table 1 Baseline characteristics of all the pregnant women in the training set and validation set

Variables	Training set (*n* = 2955)	Validation set (*n* = 739)	t/χ^2	*P*
Age (years)	28.6 ± 3.8	28.5 ± 3.8	1.06	0.77
Education (years)	14.2 ± 2.8	14.1 ± 2.8	0.92	0.58
Gestational weeks (n, %)			1.83	0.19
0-20w	1820 (61.6)	467 (63.2)		
21-27w	403 (13.6)	103 (13.9)		
28-36w	579 (19.6)	136 (18.4)		
37-44w	153 (5.2)	33 (4.5)		
Hometown (n, %)			0.36	0.80
Local	897 (30.4)	216 (29.2)		
Non-Local	2058 (69.6)	523 (70.8)		
Former place of residence (n, %)			8.58	0.05
City	522 (17.7)	101 (13.7)		
Town	647 (21.9)	153 (20.7)		
Rural	1786 (60.4)	485 (65.6)		
Only child (n, %)			0.01	0.59
No	1961 (66.4)	492 (66.6)		
Yes	994 (33.6)	247 (33.4)		
Comorbidities during pregnancy (n, %)			6.15	0.98
No	2769 (93.7)	709 (95.9)		
Diabetes	76 (2.6)	10 (1.4)		
Gestational hypertension	17 (0.6)	2 (0.3)		
Other	93 (3.2)	18 (2.4)		
Pre-pregnancy annual income (yuan, n, %)			4.88	0.62
≤ 50 K	1243 (42.1)	324 (43.8)		
50–150 K	1596 (54.0)	382 (51.7)		
≥ 150 K	116 (3.9)	33 (4.5)		
Family annual income (yuan, n, %)			2.90	0.46
≤ 50 K	155 (5.3)	32 (4.3)		
50–150 K	1120 (37.9)	295 (39.9)		
150–300 K	1408 (47.6)	341 (46.1)		
≥ 300 K	272 (9.1)	71 (9.6)		
Living conditions (n, %)			0.39	0.72
Renting	564 (19.1)	142 (19.2)		
Owing a house	2366 (80.1)	589 (79.7)		
Other	25 (0.9)	8 (1.1)		
EPQ-P	58.3 ± 12.5	58.6 ± 13.2	0.61	0.15
EPQ-E	62.1 ± 13.2	61.6 ± 13.5	0.93	0.83
EPQ-N	67.1 ± 18.5	67.5 ± 18.1	0.53	0.62
EPQ-L	77.3 ± 11.8	77.0 ± 11.7	0.71	0.56
SSRS	38.9 ± 6.3	39.0 ± 6.3	0.07	0.81
TCSQ-PC	34.3 ± 5.6	34.3 ± 5.4	0.08	0.10
TCSQ-NC	25.6 ± 6.3	25.5 ± 6.3	0.13	0.07
GAD-7	2.8 ± 3.1	2.7 ± 2.9	0.93	0.67

EPQ-P Eysenck Personality Questionnaire P scale T score *EPQ-E* Eysenck Personality Questionnaire E scale T score, *EPQ-N* Eysenck Personality Questionnaire N scale T score, *EPQ-L* Eysenck Personality Questionnaire L scale T score, *SSRS* Total score of SSR, TCSQ-PC, *TCSQ* positive coping *TCSQ-NC* TCSQ negative coping *GAD-7* Total score of GAD-7

TCSQ

The TCSQ is employed to assess individual traits and coping styles related to physical and mental health in pregnant women. It consists of 16 items that evaluate positive coping (PC) and negative coping (NC), with each dimension containing 8 items. Higher scores indicate more prominent characteristics of positive or negative coping styles [37]. The Chinese version shows good reliability (α = 0.75–0.82) and validity (CFI = 0.91), and has been applied in Chinese studies on stress and psychological health [38].

Statistical analysis

Data analysis was conducted using R software (version 4.0.3) in this study. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. In this study, pregnant women were divided into training and validation sets in an 8:2 ratio for subsequent internal validation, following common practice in predictive modeling and prior experience in similar studies [39]. Baseline comparisons confirmed no significant differences in key demographic and clinical variables between the two sets. To identify the most relevant predictors of antenatal depression, we employed the least absolute shrinkage and selection operator (LASSO) regression, a regularization technique that effectively reduces overfitting by penalizing the absolute size of regression coefficients. This method is particularly suitable for high-dimensional data with potentially correlated variables. The optimal value of the regularization parameter (lambda) was selected using 10-fold cross-validation to ensure model stability. The variables selected by LASSO were then entered into a multivariate logistic regression model to construct the predictive nomogram. Model performance was evaluated in terms of discrimination, calibration, and clinical utility. Discrimination was assessed using the area under the receiver operating characteristic curve (AUC), while calibration was evaluated through calibration plots and the Hosmer-Lemeshow goodness-of-fit test. Finally, clinical utility was assessed using decision curve analysis (DCA), which quantifies the net benefit of the predictive model across a range of threshold probabilities. Statistical significance was defined as $P < 0.05$.

Results

Participant characteristics

In this study, a total of 3833 pregnant women were initially included. However, due to some missing data, the sample loss rate was 3.6%, resulting in a final sample size of 3694 pregnant women. Of these participants, 473 (12.8%; 95% CI: 11.7–14.2) were found to have a total EPDS score above 13. Table 1 presents the baseline characteristics of all pregnant women in both the training and

validation sets. The training set consisted of 2955 participants, while the validation set included 739 participants. The mean age of participants in the training set was 28.6 ± 3.8 years, and in the validation set, it was 28.5 ± 3.8 years ($t = 1.06$, $P = 0.77$). The average education level, gestational weeks, hometown distribution, only child status, comorbidities during pregnancy, and pre-pregnancy and family annual income showed no significant differences between the training and validation sets (all $P > 0.05$). The psychological and emotional characteristics of participants, as measured by various scales (EPQ-P, EPQ-E, EPQ-N, EPQ-L, SSRS, TCSQ-PC, TCSQ-NC, and GAD-7), did not show significant differences between the training and validation sets (all $P > 0.05$).

Table 2 presents the baseline characteristics comparison between the antenatal depression groups and non-antenatal depression groups in the training set. Participants in the antenatal depression group ($n = 381$) had a significantly lower mean age (28.0 ± 3.8 years) compared to the non-antenatal depression group ($n = 2574$, 28.7 ± 3.8 years, $t = 3.61$, $P < 0.01$). Additionally, participants in the antenatal depression group had lower mean education years (13.44 ± 2.9) compared to the non-antenatal depression group (14.3 ± 2.7, $t = 5.71$, $P < 0.01$). There were no significant differences in gestational weeks ($\chi 2 = 9.35$, $P = 0.06$). However, there were significant differences in hometown distribution ($\chi 2 = 7.97$, $P < 0.01$), former place of residence ($\chi 2 = 13.59$, $P < 0.01$), being the only child ($\chi 2 = 15.75$, $P < 0.01$), comorbidities during pregnancy ($\chi 2 = 15.66$, $P < 0.01$), pre-pregnancy annual income ($\chi 2 = 14.77$, $P < 0.01$), family annual income ($\chi 2 = 18.82$, $P < 0.01$), and living conditions ($\chi 2 = 12.80$, $P < 0.01$) between the two groups. Moreover, significant differences were observed in various psychological and emotional characteristics, including EPQ-P, EPQ-E, EPQ-N, EPQ-L, SSRS, TCSQ-PC, TCSQ-NC, and GAD-7 scores (all $P < 0.01$).

Table 2 Baseline characteristics between antenatal depression groups and non-antenatal depression groups in the training set

Variables	Antenatal depression groups ($n = 381$)	Non-antenatal depression groups ($n = 2574$)	t/χ^2	*P*
Age (years)	28.0 ± 3.8	28.7 ± 3.8	3.61	< 0.01
Education (years)	13.44 ± 2.9	14.3 ± 2.7	5.71	< 0.01
Gestational weeks (n, %)			9.35	0.06
0-20w	218(57.2)	1602(62.3)		
21-27w	67(17.6)	336(13.1)		
28-36w	82(21.5)	497(19.3)		
37-44w	14(3.7)	139(5.4)		
Hometown (n, %)			7.97	< 0.01
Local	92(24.1)	805(31.3)		
Non-Local	289(75.9)	1769(68.7)		
Former place of residence (n, %)			13.59	< 0.01
City	42(11.0)	480(18.6)		
Town	86(22.6)	561(21.8)		
Rural	253(66.4)	1533(59.6)		
Only child (n, %)			15.75	< 0.01
No	287(75.3)	1674(65.0)		
Yes	94(24.7)	900(35.0)		
Comorbidities during pregnancy (n, %)			15.66	< 0.01
No	344(90.3)	2425(94.2)		
Diabetes	12(3.2)	64(2.5)		
Gestational hypertension	1(0.3)	16(0.6)		
Other	24(6.3)	69(2.7)		
Pre-pregnancy annual income (yuan, n, %)			14.77	< 0.01
≤ 50 K	192(50.4)	1051(40.8)		
50–150 K	181(47.5)	1415(55.0)		
≥ 150 K	8(2.1)	108(4.2)		
Family annual income (yuan, n, %)			18.82	< 0.01
≤ 50 K	33(8.7)	122(4.7)		
50–150 K	162(42.5)	958(37.2)		
150–300 K	161(42.3)	1247(48.4)		
≥ 300 K	25(6.6)	247(9.6)		
Living conditions (n, %)			12.80	< 0.01
Renting	98(25.7)	466(18.1)		
Owing a house	281(73.8)	2085(81.0)		
Other	2(0.5%)	23(0.9%)		
EPQ-P	64.0 ± 15.6	57.4 ± 11.7	7.98	< 0.01
EPQ-E	57.3 ± 13.9	62.8 ± 12.9	7.60	< 0.01
EPQ-N	87.5 ± 17.4	64.1 ± 16.7	25.48	< 0.01
EPQ-L	73.4 ± 12.7	77.9 ± 11.6	6.97	< 0.01
SSRS	35.9 ± 6.2	39.4 ± 6.1	10.42	< 0.01
TCSQ-PC	31.2 ± 5.9	34.8 ± 5.4	11.85	< 0.01

Development of prediction model

The development of the prediction model involved a comprehensive statistical analysis and model-building process. Initially, a univariate logistic regression analysis was conducted to identify potential predictive factors for antenatal depression, considering variables such as age, education level, occupation, gestational weeks, medical history, and obstetric history. Subsequently, LASSO regression analysis was employed to select the most relevant predictors from Table 2, and a multivariate logistic regression Model was constructed. Among the 19 original variables, three factors—EPQ-N ($OR = 1.04$, 95% CI: 1.03–1.05), TCSQ-NC ($OR = 1.08$, 95% CI: 1.06–1.11), and GAD-7 ($OR = 1.33$, 95% CI: 1.27–1.39). These results are shown in Fig. 1(a) and Fig. 1(b) and are detailed in Table 3. To examine the independent predictive value

Table 2 (continued)

Variables	Antenatal depression groups (*n* = 381)	Non-antenatal depression groups (*n* = 2574)	t/χ^2	*P*
TCSQ-NC	31.5 ± 5.6	24.7 ± 5.9	21.50	< 0.01
GAD-7	6.5 ± 3.7	2.3 ± 2.5	21.82	< 0.01

EPQ-P Eysenck Personality Questionnaire P scale T score, *EPQ-E* Eysenck Personality Questionnaire E scale T score, *EPQ-N* Eysenck Personality Questionnaire N scale T score, *EPQ-L* Eysenck Personality Questionnaire L scale T score, *SSRS* Total score of SSRS, *TCSQ-PC* TCSQ positive coping, *TCSQ-NC* TCSQ negative coping, *GAD-7* Total score of GAD-7

of EPQ-N and TCSQ-NC, a sensitivity analysis was performed by excluding GAD-7 from the Model. The ORs of EPQ-N and TCSQ-NC changed by less than 5% (EPQ-N: 1.04 → 1.03; TCSQ-NC: 1.08 → 1.05), indicating their independent associations with antenatal depression. These predictors, along with their corresponding weights, were used to construct the predictive model. The nomogram in Fig. 1(c) visually represents the contribution of each predictor to the probability of developing antenatal depression.

Validation of the predictive model

To validate the performance of the prediction Model, we internally validated it with a validation set of 739 pregnant women, which constituted 20% of the total sample. We assessed the predictive model's performance in identifying pregnant women at risk for antenatal depression using statistical methods, including sensitivity, specificity, positive predictive value, and negative predictive value. In the validation set, the AUC was 0.90 (95% CI: 0.86–0.93), with a sensitivity of 0.76 and specificity of 0.91. These results demonstrate that the nomogram exhibits diagnostic capability above the moderate level, as showed in Fig. 1(d). The predictive Model was effectively calibrated using a calibration plot and the Hosmer-Lemeshow test. The calibration curve indicates a close-to-ideal slope of 1, affirming the model's excellent fit. Moreover, the Hosmer-Lemeshow goodness-of-fit test yielded a p-value of 0.165, signifying a high level of agreement between the model's predictions and actual observations, as shown in Fig. 1(e). The decision curve analysis in Fig. 1(f) provides valuable insight into the threshold probabilities of the predictive Model. This indicates that the Model has a higher net benefit rate and a broader range of applicability within the risk threshold range of 1%–64%, achieving good net benefits.

Discussion

The present study contributes to the understanding of antenatal depression in the Chinese population by providing valuable insights into its prevalence and developing a predictive Model. The high prevalence rate of 12.8% highlights the urgent need for effective strategies to address antenatal depression in China. The developed predictive model exhibited robust performance in accurately identifying pregnant women at risk of developing antenatal depression. Notably, neuroticism, negative coping strategies, and anxiety emerged as significant predictors in the model.

The estimated prevalence of antenatal depression varies between studies. In high-income countries, antenatal depression is estimated to be between 7% and 20% [40–44]. Conversely, low- and middle-income countries have reported rates of 20% or more, although limited research has been conducted in these areas [45–49]. For example, in Bangladesh, a developing country, the prevalence rate is approximately 18% [13], while in Australia, a developed country, it is around 7% [10]. Notably, Gavin et al. found that antenatal depression prevalence in the first trimester is 11.0%, which then drops to 8.5% in the second and third trimesters [16]. In contrast, Bennett et al. found an opposite trend, with a prevalence of 7.4% during the first trimester, 12.8% during the second, and 12% during the third trimester [50]. Understanding the prevalence rate of antenatal depression in China is crucial, as it emphasizes the need for effective interventions and support systems. Previous studies have reported a range of 5.3–28.5% for the prevalence of antenatal depression among Chinese pregnant women [51, 52], indicating a substantial population affected by antenatal depression in China. Moreover, the prevalence of antenatal depression has shown a significant increasing trend in the last decade [53], highlighting the need for increased attention to the mental and psychological state of pregnant women during the antenatal period. Our study revealed that approximately 12.8% of pregnant women in our sample experienced antenatal depression, providing insights into its prevalence in the Chinese population. Although the age difference between the antenatal depression group and the non-depressed group was Modest, it was statistically significant, which aligns with prior studies showing that younger Maternal age is associated with higher risk of antenatal depression. For example, a study found that women under 25 had significantly higher depression risk due to financial stress and lack of parenting experience [54]. Similarly, another report indicated that younger age groups in China faced increased vulnerability to perinatal depression, especially when coupled with low social support [53]. Comparing with other Chinese cities, Suzhou had a relatively lower prevalence attributed to higher socioeconomic status, lower financial pressures, and better education [55].

Our predictive model includes EPQ-N, TCSQ-NC, and GAD-7 as predictors, supported by their relevance to antenatal depression and the existing literature. Several studies have demonstrated that certain personality factors increase the risk of experiencing psychological

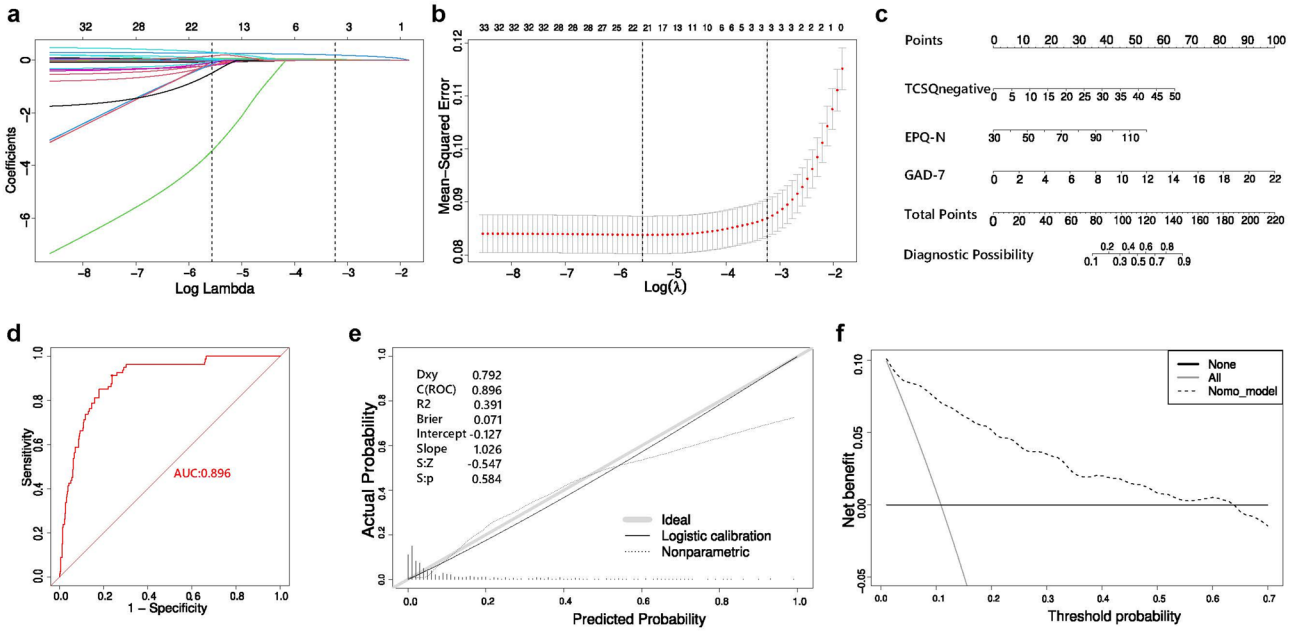


Fig. 1 Construction and validation of the prediction model. **a** LASSO logistic regression for variable selection: The LASSO regression was applied to select the Most relevant predictors from 18 candidate variables. By imposing a penalty on the absolute size of coefficients, LASSO shrinks less informative coefficients to zero, thereby enhancing model simplicity and interpretability. **b** Selection of the optimal penalty parameter (lambda): Ten-fold cross-validation was used to determine the optimal value of the penalty parameter (λ) in the LASSO model. The cross-validation curve shows the relationship between mean squared error and log(λ), with the optimal λ corresponding to the minimum error and one-standard-error rule for enhanced generalizability. **c** Nomogram for prenatal depression prediction: Visual graph representing the predictive model. Shows each predictor's contribution to antenatal depression probability. It serves as a practical tool for clinical risk assessment. **d** Receiver operating characteristic (ROC) curve: The ROC curve illustrates the model's discrimination ability in the validation set, plotting the true positive rate against the false positive rate. The area under the ROC curve (AUC) was 0.90 (95% CI: 0.86–0.93), indicating excellent predictive performance. The sensitivity and specificity were 0.76 and 0.91, respectively. **e** Calibration curve for antenatal depression risk: Assesses predicted probabilities alignment with actual outcomes. Horizontal axis displays predicted risk, vertical axis shows diagnosed cases. A curve closer to the diagonal reference Line indicates better calibration. The D-xy value is 0.79, R-squared is 0.39, Brier score is 0.07, p-value is 0.58, and the Hosmer-Lemeshow statistic is 0.165. **f** Decision curve analysis of depression risk chart: Evaluates model's clinical usefulness. Assesses net benefit for decision-making compared to assuming all have or don't have depression. Helps identify the threshold probability for effective clinical use. The Model demonstrated a favorable net benefit for threshold probabilities between 0.01 and 0.64, suggesting a wide and practical application range for clinical decision-making

Table 3 Logistic regression analysis of the predictors for the risk of antenatal depression in pregnant women

Variable	B	OR (95% CI)	*P*
EPQ-N	0.04	1.04 (1.03–1.05)	< 0.01
TCSQ-NC	0.08	1.08 (1.06–1.11)	< 0.01
GAD-7	0.28	1.33 (1.27–1.39)	< 0.01

EPQ-N Eysenck Personality Questionnaire N scale T score, *TCSQ-NC* TCSQ negative coping, *GAD-7* Total score of GAD-7

difficulties during the antenatal period, particularly negative cognitive styles such as pessimism, anger, and rumination. Additionally, individuals with a tendency to be nervous, worried, or shy, along with low self-esteem and self-efficacy, and high levels of neuroticism or psychoticism, are more susceptible to antenatal depression [9, 41, 52]56– [60]. On the contrary, active coping and high self-esteem/self-efficacy have been identified as protective factors [52, 61]. Our findings supported previous research, demonstrating that pregnant women with antenatal depression scored higher on EPQ-N, indicating a significant difference compared to the non-antenatal depression group [52]. This result is consistent with previous studies and suggests that individuals with depression are more likely to exhibit stronger neuroticism personality traits [56]. Neuroticism is a personality trait associated with emotional instability, anxiety, irritability, and emotional sensitivity. Women with higher levels of neuroticism tend to be more susceptible to anxiety and depression [28]. However, we acknowledge that administering a full personality inventory such as the EPQ to all pregnant women may not be feasible in real-world clinical settings due to its length and complexity. Notably, our findings suggest that the EPQ-N subscale alone is the most predictive component in the model. Future studies could explore the development or validation of a brief screening version focusing exclusively on EPQ-N, which may improve the practicality and efficiency of large-scale risk assessment. This may be attributed to the physiological and psychological changes they experience during pregnancy, such as hormonal fluctuations

and anxiety about impending parental responsibilities. Furthermore, our study found that pregnant women with antenatal depression tended to adopt negative coping strategies, as evidenced by significantly higher TCSQ scores compared to the non-antenatal depression group. These maladaptive coping strategies may further exacerbate symptoms and discomfort associated with antenatal depression. Previous research has shown that negative coping strategies are unfavorable for pregnant women in managing their physiological conditions, and negative thoughts can increase stress levels during pregnancy [62, 63]. This can contribute to confusion, negative pessimism, and even an increased risk of suicidal ideation among pregnant women [64]. Lastly, our study revealed a significant association between antenatal depression and higher levels of anxiety among women. High anxiety during pregnancy has been identified as one of the strongest risk factors for depression, as supported by previous studies [20, 65]. Women experiencing feelings of anxiety face an increased risk of developing depression during pregnancy [61]. For instance, a study reported that women with antenatal anxiety were approximately three times more likely to experience depression during pregnancy [66]. By incorporating these predictors into the model, we aimed to capture the multifaceted nature of antenatal depression and provide healthcare professionals with a valuable tool for identifying pregnant women at higher risk.

The predictive model developed in this study exhibits robust discriminative ability, precision, and consistency in forecasting the risk of antenatal depression in pregnant women, demonstrating moderate to above-average diagnostic performance. We randomly divided the dataset into training and validation subsets and confirmed that the two sets were comparable in terms of key baseline characteristics. The model demonstrated similarly strong performance in the validation set, supporting its stability and internal generalizability. Previous research has predominantly focused on general demographic factors or limited psychological factors of pregnant women, lacking a comprehensive analysis of multiple determinants [13, 67]. By learning and identifying patterns and characteristics related to antenatal depression from a large dataset, our model offers a comprehensive and accurate risk assessment, facilitating the development of targeted interventions. It is still inconvenient for people in rural China to seek medical treatment for psychological illness, as a result of a severe lack of medical resources [68]. What makes it worse, since the stigma towards people with psychological problems still exists, some depressed pregnant women might hesitate to seek treatment and assistance. Additionally, in order to avoid the risk of medication, some Asian pregnant women are more hesitant to take antidepressants such as SSRIs [69]. Given the challenges of antenatal depression identification, particularly for obstetricians, the establishment of a predictive model empowers healthcare professionals to identify high-risk individuals before the onset of depressive symptoms, enabling timely interventions and support. In real-world clinical settings, the nomogram can serve as a simple and intuitive tool that integrates easily into routine antenatal care workflows. Healthcare providers can calculate individual risk scores using readily available psychological assessments (e.g., GAD-7 and EPQ-N), allowing early recognition of women who may benefit from psychological counseling or monitoring. This alleviates the psychological burden on pregnant women and prevents or mitigates the occurrence of antenatal depression. The construction of a nomogram enables an understanding of the impact of various factors on antenatal depression, serving as a foundation for personalized intervention and treatment plans. In addition, the decision curve analysis demonstrated that the model offers a net clinical benefit across a wide range of risk thresholds (1–64%), supporting its applicability for population-level screening and individualized decision-making. This strengthens its potential for use not only by mental health professionals but also by frontline obstetricians, nurses, and public health workers. However, it is worth noting that a wide range of demographic factors were initially considered during model development but were ultimately excluded from the final predictive model. This exclusion was motivated by their minimal contributions to predicting the risk of antenatal depression and potential correlations with other crucial factors. Incorporating numerous demographic factors could escalate model complexity and potentially lead to overfitting issues. Consequently, these demographic factors were omitted from the final predictive model to ensure simplicity, feasibility of implementation, and generalizability stability. This decision aimed to enhance the model's predictive performance and provide practical, actionable outcomes for healthcare professionals to guide timely interventions and support measures.

The study has several advantages worth considering. The use of a large sample size enhances the robustness and generalizability of the findings, contributing to more reliable conclusions. Additionally, the inclusion of diverse demographic and clinical characteristics increases the representativeness of the study population, making the results more applicable to a broader context. However, it is important to acknowledge certain limitations in the interpretation of the study findings. First, the cross-sectional design restricts the establishment of causal relationships between predictors and antenatal depression. Longitudinal research would allow for the investigation of how these predictors may change over time and affect the risk of antenatal depression, providing more insight

into the dynamic nature of the condition. Second, the sample was recruited exclusively from Suzhou, Jiangsu Province, China, and comprised only Han Chinese pregnant women. While this enhances internal consistency, it limits the generalizability of the findings. Future research should aim to validate the nomogram in more diverse populations across different regions and sociocultural contexts. Third, although the sample size was sufficiently large, it was calculated based on the estimated prevalence of antenatal depression rather than specific effect sizes or risk ratios. Future studies should consider stratified or power-based sampling designs to optimize predictive performance. Fourth, the use of the EPDS as the reference standard may introduce limitations, as it is a screening rather than a diagnostic tool. Incorporating diagnostic interviews conducted by mental health professionals in future studies would improve the precision of outcome classification. Finally, potential sources of bias, such as self-reporting bias and non-randomized sampling methods, should be considered as they may impact the validity of the nomogram. Despite these limitations, the predictive nomogram offers a practical and feasible tool for early identification of antenatal depression risk. Integrating it into routine prenatal care may enable timely psychological support and personalized intervention strategies. Further prospective, multicenter, and cost-effectiveness studies are warranted to confirm its clinical utility and long-term impact.

Conclusion

In conclusion, this study developed and validated a predictive model for antenatal depression in a Chinese population. The nomogram demonstrated accurate risk assessment capabilities, providing a valuable tool for early detection, intervention, and personalized care for pregnant women. By identifying the prevalence and predictors of antenatal depression, this study contributes to the understanding of the condition and its management. The predictive model has the potential to improve antenatal depression management in China, leading to better outcomes for both maternal and infant health.

Abbreviations

EPDS	The edinburgh postnatal depression scale
EPQ	Eysenck personality questionnaire
GAD-7	General anxiety disorder 7
SSRS	Social Support Rating Scale
TCSQ	Trait coping style questionnaire
E	Extraversion
N	Neuroticism
P	Psychoticism
PC	Positive coping
NC	Negative coping
LASSO	the least absolute shrinkage and selection operator
ROC	Receiver operating characteristic curve
AUC	the area under the receiver operating characteristic curve

Acknowledgements

The authors would like to express gratitude to all individuals who participated in this study.

Authors' contributions

H.C. and J.Z. contributed to the conception and design. L.G. and R.Y. contributed to writing and editing. X.L., S.Z., J.L., P.Z., L.K., L.Z., T.J., and J.G. were responsible for data collection and quality control. Y.Y. and X.Z. contributed to the critical revision, final approval, and patient management. All authors contributed to the drafting of the article, critical revision, and approval of the submitted version.

Funding

The study was supported by grant GSWS2020096 from the Suzhou Health Talent Project, grant Szlcyxzx202109 from the Suzhou Clinical Medical Center for Mood Disorders, grant SKY2022066 from the Suzhou Municipal Sci-Tech Bureau Program, grant LCZX201616 from the Suzhou Key Diagnosis and Treatment Program, grant LCZX202326 from the Suzhou Key Diagnosis and Treatment Program, grant MSXM2024034 from the Suzhou Municipal Health Commission General Project, and grant SKY2021063 from the Suzhou Key Technologies Program.

Data availability

The data and materials for this study can get from corresponding author.

Declarations

Ethics approval and consent to participate

Ethical approval for this study was obtained from the Institutional Review Board of the Affiliated Guangji Hospital of Soochow University (Approval No. 2016010). Informed consent was obtained from all participants before their inclusion in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 6 November 2023 / Accepted: 5 September 2025
Published online: 03 October 2025

References

1. Nasreen HE, et al. Prevalence and associated factors of depressive and anxiety symptoms during pregnancy: a population based study in rural Bangladesh. BMC Womens Health. 2011;11(1):1–9.
2. Chandran M, et al. Post-partum depression in a cohort of women from a rural area of Tamil Nadu, India: incidence and risk factors. Br J Psychiatry. 2002;181(6):499–504.
3. Rahman A, Iqbal Z, Harrington R. Life events, social support and depression in childbirth: perspectives from a rural community in the developing world. Psychol Med. 2003;33(7):1161–7.
4. Pearson RM, et al. Prevalence of prenatal depression symptoms among 2 generations of pregnant mothers: the Avon longitudinal study of parents and children. JAMA Netw Open. 2018;1(3):e180725–180725.
5. Gelaye B, et al. Epidemiology of maternal depression, risk factors, and child outcomes in low-income and middle-income countries. Lancet Psychiatry. 2016;3(10):973–82.
6. Insan N, et al. Social determinants of antenatal depression and anxiety among women in South Asia: a systematic review & meta-analysis. PLoS ONE. 2022. https://doi.org/10.1371/journal.pone.0263760.
7. Khanam R, et al. Burden and risk factors for antenatal depression and its effect on preterm birth in South Asia: a population-based cohort study. PLoS ONE. 2022;17(2):e0263091.
8. Tasnim S et al. Antenatal depression among women with gestational diabetes mellitus: a pilot study. Reprod Health, 2022. 19.
9. Leigh B, Milgrom J. Risk factors for antenatal depression, postnatal depression and parenting stress. BMC Psychiatry. 2008;8:24.

10. Eastwood J, et al. The impact of antenatal depression on perinatal outcomes in Australian women. PLoS ONE. 2017;12(1):e0169907.
11. Haas DM, et al. A comparison of depression symptoms and histories in pregnant women. J Reprod Med. 2011;56(1–2):39–43.
12. Otake Y, et al. Association between maternal antenatal depression and infant development: a hospital-based prospective cohort study. Environ Health Prev Med. 2014;19(1):30–45.
13. Insan N, et al. Social determinants and prevalence of antenatal depression among women in rural Bangladesh: a cross-sectional study. Int J Environ Res Public Health. 2023;20(3):2364.
14. Giallo R, et al. The emotional–behavioural functioning of children exposed to maternal depressive symptoms across pregnancy and early childhood: a prospective Australian pregnancy cohort study. Eur Child Adolesc Psychiatry. 2015;24:1233–44.
15. Pereira AT, et al. Short forms of the postpartum depression screening scale: as accurate as the original form. Arch Womens Ment Health. 2013;16:67–77.
16. Gavin NI et al. *Perinatal depression: a systematic review of prevalence and incidence.* Obstetrics & Gynecology, 2005. 106(5 Part 1): pp. 1071–1083.
17. Pearlstein T. Depression during pregnancy. Best Pract Res Clin Obstet Gynaecol. 2015;29(5):754–64.
18. Li X, Wang Y, Xu J. Development of a machine learning-based risk prediction model for cerebral infarction and comparison with nomogram model. J Affect Disord. 2022;314:341–8.
19. Biaggi A, et al. Identifying the women at risk of antenatal anxiety and depression: a systematic review. J Affect Disord. 2016;191:62–77.
20. Lancaster CA, et al. Risk factors for depressive symptoms during pregnancy: a systematic review. Am J Obstet Gynecol. 2010;202(1):5–14.
21. Netsi E, et al. Association of persistent and severe postnatal depression with child outcomes. JAMA Psychiatr. 2018. https://doi.org/10.1001/jamapsychiatry.2017.4363.
22. Murray L, Carothers AD. The validation of the Edinburgh post-natal depression scale on a community sample. Br J Psychiatry. 1990;157:288–90.
23. Cox JL, Holden JM, Sagovsky R. Detection of postnatal depression. Development of the 10-item Edinburgh postnatal depression scale. Br J Psychiatry. 1987;150:782–6.
24. Lee DTS, et al. Detecting postnatal depression in Chinese women. Br J Psychiatry. 1998. https://doi.org/10.1192/bjp.172.5.433.
25. Yawn BP, et al. Concordance of Edinburgh postnatal depression scale (EPDS) and patient health questionnaire (PHQ-9) to assess increased risk of depression among postpartum women. J Am Board Fam Med. 2009;22(5):483–91.
26. Peng Y, et al. Unidimensional or multidimensional? Revisiting the psychometrics of PHQ-9 and EPDS using bifactor model and item response theory in 2939 Chinese perinatal women. J Affect Disord. 2024;367:686–95.
27. Moraes GPdA, et al. Screening and diagnosing postpartum depression: when and how? Trends Psychiatry Psychother. 2017;39:54–61.
28. Wei Y, et al. Psychological status of volunteers in a phase I clinical trial assessed by symptom checklist 90 (SCL-90) and Eysenck personality questionnaire (EPQ). Med Sci Monit. 2018;24:4968–73.
29. Cheung FM, Leung K. Indigenous personality measures: Chinese examples. Journal of Cross-Cultural Psychology. 1998;29(1):233–48.
30. Butcher JN. *Minnesota multiphasic personality inventory.* The Corsini Encyclopedia of Psychology, 2010: pp. 1–3.
31. Stanton K, Watson D. Positive and negative affective dysfunction in psychopathology. Soc Personal Psychol Compass. 2014;8(9):555–67.
32. Gong Y. Use of the Eysenck personality questionnaire in China. Pers Individ Differ. 1984. https://doi.org/10.1016/0191-8869(84)90008-4.
33. Stocker R, et al. Patient health questionnaire 9 (PHQ-9) and general anxiety disorder 7 (GAD-7) data contributed by 13,829 respondents to a National survey about COVID-19 restrictions in Australia. Psychiatry Res. 2021;298:p113792.
34. Yang CF, Liu YH, Li PB, et al. [Validity and reliability of the generalized anxiety Disorder-7 (GAD-7) in Chinese population]. Chin J Prev Med. 2008;42(9):762–7.
35. Sun J, et al. The relationship between psychological health and social support: evidence from physicians in China. PLoS ONE. 2020. https://doi.org/10.1371/journal.pone.0228152.
36. Xiao SY. [Theoretical foundation and research application of the social support rating scale]. J Clin Psychol Med. 1994;4(2):98–100.
37. Ma H et al. Relationships among smoking abstinence self-efficacy, trait coping style and nicotine dependence of smokers in Beijing. Tob Induc Dis, 2020. 18.
38. Jiang QJ, Zhu YH. Further exploration of the trait coping style questionnaire (TCSQ). Chin J Behav Med Sci. 1999;8(1):67–70.
39. Steyerberg EW, et al. Internal validation of predictive models: efficiency of some procedures for logistic regression analysis. J Clin Epidemiol. 2001;54(8):774–81.
40. Andersson L, et al. Point prevalence of psychiatric disorders during the second trimester of pregnancy: a population-based study. Am J Obstet Gynecol. 2003;189(1):148–54.
41. Lee AM, et al. Prevalence, course, and risk factors for antenatal anxiety and depression. Obstet Gynecol. 2007;110(5):1102–12.
42. Marcus SM, et al. Depressive symptoms among pregnant women screened in obstetrics settings. J Womens Health. 2003;12(4):373–80.
43. Melville JL, et al. Depressive disorders during pregnancy: prevalence and risk factors in a large urban sample. Obstet Gynecol. 2010;116(5):1064.
44. Evans CD, et al. Recovery from acidification in European surface waters. Hydrol Earth Syst Sci. 2001;5(3):283–98.
45. Faisal-Cury A, et al. Common mental disorders during pregnancy: prevalence and associated factors among low-income women in São paulo, Brazil. Arch Womens Ment Health. 2009;12(5):335–43.
46. Friedman LE, et al. Association of migraine headaches with suicidal ideation among pregnant women in Lima, Peru. Headache. 2016;56(4):741–9.
47. Golbasi Z, et al. Prevalence and correlates of depression in pregnancy among Turkish women. Matern Child Health J. 2010;14(4):485–91.
48. Husain N, et al. Social stress and depression during pregnancy and in the postnatal period in British Pakistani mothers: a cohort study. J Affect Disord. 2012;140(3):268–76.
49. Husain N, et al. Prevalence and psychosocial correlates of perinatal depression: a cohort study from urban Pakistan. Arch Womens Ment Health. 2011;14(5):395–403.
50. Bennett HA, et al. Prevalence of depression during pregnancy: systematic review. Obstet Gynecol. 2004;103(4):698–709.
51. Mo Y, et al. The association between the use of antenatal care smartphone apps in pregnant women and antenatal depression: cross-sectional study. JMIR mHealth UHealth. 2018;6(11):e11508.
52. Zeng Y, Cui Y, Li J. Prevalence and predictors of antenatal depressive symptoms among Chinese women in their third trimester: a cross-sectional survey. BMC Psychiatry. 2015;15:1–7.
53. Nisar A, et al. Prevalence of perinatal depression and its determinants in mainland China: a systematic review and meta-analysis. J Affect Disord. 2020;277:1022–37.
54. Zeng Y, Cui Y, Li J. Prevalence and predictors of antenatal depressive symptoms among Chinese women in their third trimester: a cross-sectional survey. BMC Psychiatry. 2015;15:66.
55. Zhang L, et al. Prevalence of prenatal depression among pregnant women and the importance of resilience: a multi-site questionnaire-based survey in Mainland China. Front Psychiatry. 2020;11:374.
56. Bunevicius R, et al. Psychosocial risk factors for depression during pregnancy. Acta Obstet Gynecol Scand. 2009;88(5):599–605.
57. Bayrampour H, McDonald S, Tough S. Risk factors of transient and persistent anxiety during pregnancy. Midwifery. 2015;31(6):582–9.
58. Ginsburg GS, et al. Depressive symptoms among reservation-based pregnant American Indian adolescents. Matern Child Health J. 2008;12:110–8.
59. Martini J, et al. Risk factors and course patterns of anxiety and depressive disorders during pregnancy and after delivery: a prospective-longitudinal study. J Affect Disord. 2015;175:385–95.
60. Mohammad KI, Gamble J, Creedy DK. Prevalence and factors associated with the development of antenatal and postnatal depression among Jordanian women. Midwifery. 2011;27(6):e238–45.
61. Edwards B, et al. Antenatal psychosocial risk factors and depression among women living in socioeconomically disadvantaged suburbs in adelaide, South Australia. New Z J Psychiatry. 2008;42(1):45–50. Australian.
62. Rahman A. Challenges and opportunities in developing a psychological intervention for perinatal depression in rural Pakistan–a multi-method study. Arch Womens Ment Health. 2007;10:211–9.
63. O'Mahen H, et al. Modifying CBT for perinatal depression: what do women want? A qualitative study. Cogn Behav Pract. 2012;19(2):359–71.
64. Wang Y, et al. Negative life events and antenatal depression among pregnant women in rural China: the role of negative automatic thoughts. PLoS ONE. 2016. https://doi.org/10.1371/journal.pone.0167597.
65. Verreault N, et al. Rates and risk factors associated with depressive symptoms during pregnancy and with postpartum onset. J Psychosom Obstet Gynaecol. 2014;35(3):84–91.

66. Mohamad Yusuff AS, et al. Prevalence of antenatal depressive symptoms among women in Sabah, Malaysia. The Journal of Maternal-Fetal & Neonatal Medicine. 2016;29(7):1170–4.
67. Zelalem ED, Asaye MM, Mihret MS. Antenatal depression and its correlates on Northwestern Ethiopian women: community-based cross-sectional study. Pan Afr Med J, 2020. 36(1).
68. Du SN, Wang J. Mental health services of supply and utilization in rural China. Chin J Soc Med. 2011;28(4):284–6.
69. Klainin P, Arthur DG. Postpartum depression in Asian cultures: a literature review. Int J Nurs Stud. 2009;46(10):1355–73.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.