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Original Research

Risk Factor Analysis and Prediction Model Construction and Validation of Depression During Pregnancy

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Abstract

Background: Depression during pregnancy can have serious negative effects on the health of both the woman and the fetus. Therefore, studying the risk factors associated with depression in pregnancy is important for timely interventions and prevention. This study aimed to comprehensively identify the risk factors of depression during pregnancy and construct and verify the effectiveness of a prediction model to provide a basis for early prevention and intervention of depression during pregnancy. **Methods**: A total of 630 pregnant women who underwent regular prenatal checkups at Jinshan Central Hospital Affiliated to Shanghai University of Medicine & Health Sciences from January 2020 to October 2023 were included. The Edinburgh Postnatal Depression Scale (EPDS) and Generalized Anxiety Disorder (GAD-7) were utilized to assess the presence of depressive disorders in mid-pregnancy. A risk prediction nomogram model was constructed using the R program, and validation was performed using the Bootstrap method. The calibration curve chart was produced, and diagnostic efficacy was evaluated using the receiver operating characteristic (ROC) curve. **Results**: The prevalence of mid-pregnancy depression was found to be 19.37%. Moreover, no statistically significant differences were observed between the two groups in terms of age, gravidity, parity, pre-pregnancy body mass index (BMI), cultural level, smoking or drinking alcohol, and work cessation due to pregnancy ($p > 0.05$). However, statistically significant differences were noted in the incidence of spousal disharmony, discordant relations with parents, changes in sleep and diet, work-study stress, adverse maternal history, dissatisfactory living environments, assisted reproduction, unplanned pregnancy, adverse life events, lack of maternity knowledge, family income, and pregnancy comorbidities ($p < 0.05$). A nomogram model was developed based on the multifactor analysis, showing a mean absolute error of 0.011 in the calibration curve, indicating good predictive accuracy. The ROC analysis demonstrated an area under the curve (AUC) of 0.806 for the joint prediction model, with a sensitivity of 66.4% and a specificity of 83.5%, suggesting a strong clinical diagnostic value. The study sample was drawn from pregnant women in our hospital, which may have led to a limited representative sample. The timeframe of the study may also have led to the exclusion of specific periods of pregnant women. **Conclusions**: A nomogram model, which incorporates indicators such as spousal and parental disharmony, changes in sleep and dietary habits, work-study stress, adverse maternal history, unsatisfactory living environment, assisted reproduction, unplanned pregnancy, interference from adverse life events, and lack of maternity knowledge, can effectively predict depression during pregnancy.

Keywords: depression during pregnancy; risk factors; maternal mental health; social support

1. Introduction

Pregnancy and childbirth constitute crucial phases in the life cycle of a woman, yet these phases also present numerous physical and psychological challenges [1]. The occurrence of depression during pregnancy has been reported to be as high as 20.70% in 2020 [2], a rate significantly above that of the general population. According to the 2018 American College of Obstetricians and Gynecologists (ACOG) consensus, depressive episodes experienced by pregnant women, ranging from mild to severe, can be diagnosed as perinatal depression [3]. This condition not only poses risks for adverse pregnancy outcomes, such as fetal growth restriction, preterm labor, and increased cesarean section rates, but also elevates the likelihood of postpartum depression [4]. Furthermore, perinatal depression can impact the day-to-day functioning and overall quality of life for pregnant women and new mothers [5]. Research by Lebel *et al*. [6] has shown that maternal depression during mid-pregnancy can have lasting effects on neonatal brain structure and long-term emotional, behavioral, cognitive, physiological, and neurological development. Meanwhile, psychological factors play a significant role in labor and delivery, with approximately 10% of cesarean sections being attributed to elevated levels of maternal anxiety [7]. Notably, compared to postpartum mental health, mental health during pregnancy has not been adequately addressed in clinical practice. Moreover, depression screening is not routinely included in obstetric examinations, even though depression during pregnancy can lead to adverse birth outcomes such as smaller gestational age babies and reduced head circumference [8–10]. The reported detection rate of depression during pregnancy is 20.00% [11]. Research in-

dicates that depression and anxiety during pregnancy cannot only affect the health of the pregnant woman and fetus but also impact family dynamics and impose a significant economic burden on both the family and society [12]. Mellor *et al*. [13] highlighted that risk factors such as fear of childbirth, self-perceived stress, and exposure to stressful or negative events during pregnancy can contribute to the development of depressive symptoms in pregnant women. Thus, as the medical field transitions from the traditional biomedical model to the biopsychosocial medical model, there is a growing emphasis on recognizing and addressing the somatization of psychosocial stress symptoms in patients with mental illnesses stemming from psychosocial disorders.

Therefore, perinatal depression can result in a series of physical and psychological disorders in both mothers and children, imposing a certain burden on families and society. Australia recommends the application of the Prenatal Risk Factor Questionnaire (PRFQ) and the Postnatal Risk Questionnaire (PRQ) for maternal screening [14]. In the United States, it is recommended to ask about psychiatric history, medication use, and the presence of anxiety and depression at 6, 8, and 28 weeks of pregnancy and postpartum, and to use the Edinburgh Postnatal Depression Scale (EPDS) for screening [15]. Given the high prevalence of prenatal depression among perinatal women, coupled with the severity of adverse outcomes and low rates of mental health visits, the implementation of a rapid and convenient screening method could significantly enhance the mental well-being of perinatal women [16]. However, the current tools have limitations: The PRFQ and PRQ focus on risk factor questioning and lack consideration of complex multifactorial interactions; the EPDS is primarily used for postnatal depression screening and is not sufficiently targeted in the prediction of depression during pregnancy. Various risk factors contribute to depression during pregnancy, yet there remains a scarcity of studies examining the present state of depression and its risk factors in pregnant women [17–19]. Thus, this study aimed to explore the risk factors associated with the occurrence of depression in pregnant women, starting with the construction of a maternal handbook in mid-pregnancy. A column-line diagram model was constructed to quickly assess the risk of depression in pregnancy based on multidimensional information of pregnant women, which improved the diagnostic efficiency and made the operation more convenient. This study aimed to identify and explore risk factors associated with depression in pregnant women, focusing on the development of a maternity booklet during mid-pregnancy to enhance the detection and screening of prenatal depression.

2. Materials and Methods

2.1 Study Participants

A total of 630 pregnant women who had regular antenatal checkups in the Jinshan Central Hospital Affiliated to Shanghai University of Medicine & Health Sciences between January 2020 and October 2023 were selected for the prospective study. Inclusion criteria: (1) women with a first-time pregnancy booklet, weeks of pregnancy from 12 to 16; (2) pregnant women with normal intelligence; (3) those with voluntary participation and normal communication skills who were able to complete the questionnaire independently. Exclusion criteria: (1) any mental abnormalities before pregnancy; (2) receiving psychotherapy or participating in any psychological intervention. The patients were categorized into 122 cases in the occurrence group and 508 cases in the non-occurrence group according to whether or not depression occurred during pregnancy. This study was approved by the Ethics Committee of Jinshan Central Hospital Affiliated to Shanghai University of Medicine & Health Sciences (approval number: jszxyy202129), and the patients were informed and signed a consent form.

The sample size estimation in this study was based on two considerations: (1) this study was a prospective cohort design, and the sample size was derived from the data of 630 pregnant women collected in the clinic (122 cases in the depression group and 508 cases in the non-depression group), which meets the minimum criteria for the number of events/variable ratio $\geq$10 in predictive modeling studies (122 events *vs.* 12 variables). (2) Referring to the recommendations of the Tracking Reconstruction Informatics, Prevention, Observation, and Detection (TRIPOD) guidelines for predictive modeling studies, combined with the sample size range (usually 500–1000 cases) of similar studies (e.g., Pan *et al*. [20]), the sample size of the present study is representative. In addition, the model was downscaled by Least Absolute Shrinkage and Selection Operator (LASSO) regression to handle multivariate variables and validated using the bootstrap method (1000 times resampling) to ensure further robustness of the results.

2.2 Research Methodology

2.2.1 Questionnaire Survey

A self-administered questionnaire was used to investigate general demographic and clinical information. These included: age, gravidity, parity, pre-pregnancy body mass index (BMI), those who smoked or drank alcohol, literacy level, monthly family income, pregnancy comorbidities, sleep and dietary status, living conditions, husband and wife and parental relationships, marital satisfaction, work-study stress, adverse life events, adverse maternal history, unplanned pregnancy, assisted reproduction, lack of maternal knowledge, and work cessation due to pregnancy.

2.2.2 Assessment of Depression During Pregnancy

The EPDS [21] and the Generalized Anxiety Disorder (GAD-7) [22] were utilized to evaluate the occurrence of depression among pregnant women. Created by Cox *et al*. [23] in 1987 for postpartum depression screening, the EPDS demonstrates strong reliability and validity, making this scale suitable for depression screening during pregnancy. The EPDS consists of 10 entries, and the description of each entry is divided into four levels. The severity of each symptom is assigned a score of 0–3 according to the severity of each entry, from no symptoms to very severe symptoms, and lower total scores indicate fewer depression symptoms: A total EPDS score of $\geq$10 is considered positive for depression, and a score of $<$10 is considered negative for depression. The GAD-7 scale was developed by Spitzer *et al*. [22] for screening anxiety disorders and has good reliability and validity. The GAD-7 scale comprises seven items, each graded on a scale of 0–3. A score below 5 is within the normal range, while a score of 5 or higher suggests anxiety.

Pregnant women who showed abnormal results on both the EPDS and GAD-7 scales were classified as experiencing depression during pregnancy.

2.3 Data Collection

Uniformly trained investigators distributed all questionnaires to eligible pregnant women who had signed the informed consent form, and pregnant women were instructed to complete them alone and within the specified timeframe. The questionnaires were retrieved immediately after being verified and perfected by the investigators to ensure quality and authenticity.

2.4 Statistical Analysis

This study used SPSS 27.0 software developed by IBM (Armonk, NY, USA) for the database creation and analysis. Normality was tested for the measured variables using the Shapiro-Wilk test. Measured variables that followed a normal distribution are presented as the mean and standard deviation, with group comparisons conducted using an independent samples *t*-test. The median (lower and upper quartiles) was used for continuous variables that did not meet normal distribution, and independent samples rank sum test comparisons were performed. Categorical variables are expressed as the number of cases (percentage) (n (%)), and comparisons between groups were conducted using the Chi-square test or Fisher's exact probability method. Statistical analysis was performed to determine correlation indices with the occurrence of depression during pregnancy in patients. In terms of selecting appropriate risk factors to construct the model, this study first screened the potential factors associated with the occurrence of depression during pregnancy through one-way analysis of variance (ANOVA) ($p < 0.05$), and then included these factors in the LASSO regression model for further screening to avoid overfitting; finally, the independent risk factors were identified for constructing the model. Receiver operating characteristic (ROC) curve analysis was conducted to assess the sensitivity and specificity of the model in predicting depression during pregnancy in patients. Furthermore, by comparing the projected results from the model with the actual occurrence of depression during pregnancy, the true-positive rate was calculated as sensitivity, i.e., the proportion of those who were actually depressed and correctly predicted as depressed by the model, and the true-negative rate was calculated as specificity, i.e., the proportion of those who were not actually depressed and correctly predicted as not being depressed by the model. The R 4.2.1 software (R Foundation, Vienna, Austria) was used to create and evaluate the calibration curves based on the bootstrap method (1000 resamples) to assess the consistency of the predicted probabilities with the actual observed probabilities. Moreover, this study analyzed the quality of the calibration curves in terms of their slopes and intercepts; the closer the slope is to 1 and the closer the intercept is to 0, the better the agreement between the predicted and actual values of the model and the higher the quality of the calibration curves. In addition, the C index (consistency index) represents an indicator used to assess the discriminatory ability of the prediction model, with a value ranging from 0.5 to 1. The closer the C index is to 1, the stronger the discriminatory ability of the model is, i.e., it can better discriminate between individuals whose events occurred and those who did not, while a C index of 0.5 indicates that the predictive ability of the model is the same as that of a random guess.

3. Results

3.1 Research Groups

A total of 712 questionnaires were distributed to pregnant women, of which 652 were returned, resulting in 630 valid responses, indicating a valid response rate of 88.48% (Fig. 1). Among the respondents, 122 pregnant women, constituting 19.37% of the sample, were positively screened for depression with an EPDS score of $\geq$10 and a GAD-7 score of $\geq$5 at 12.32 $\pm$ 3.26 weeks of gestation, forming the occurrence group. The remaining 508 pregnant women who screened negative for depression, i.e., EPDS score $<$10 and GAD-7 score $<$5, constituted the non-occurrence group. In the present study, based on the screening criteria set, all pregnant women in the non-occurrence group met the negative criteria for both scales, and there were no cases where these women were positive on one scale and negative on the other.

3.2 Characteristics of the Study Population

The median age of patients in the occurrence group was 30 years old, with a mean pre-pregnancy BMI of 23.05 $\pm$ 2.34 kg/m^2. Similarly, the median age of patients in the non-occurrence group was also 30 years old, with a mean pre-pregnancy BMI of 22.68 $\pm$ 1.82 kg/m^2. No

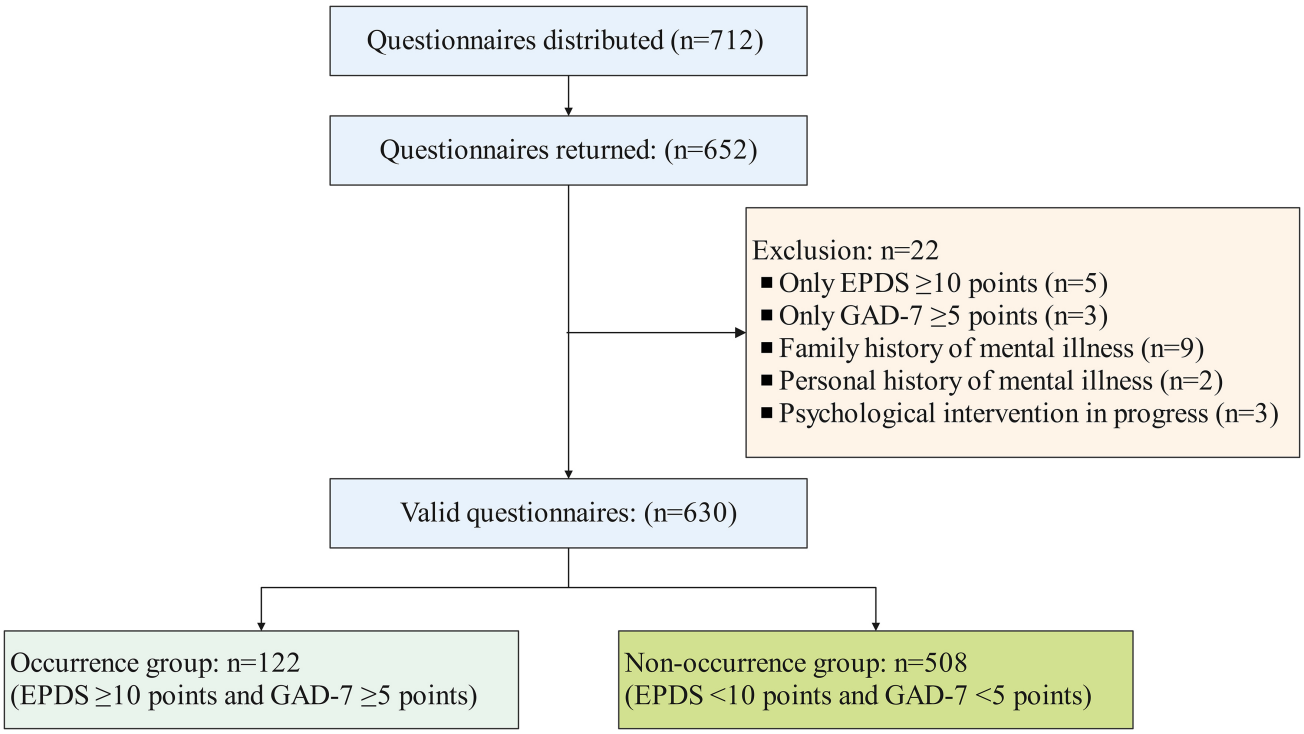

Fig. 1. Flowchart of the participation criteria in this study. EPDS, Edinburgh Postnatal Depression Scale; GAD-7, Generalized Anxiety Disorder.

statistically significant differences were observed between the two groups for age, gravidity, parity times, and pre-pregnancy BMI ($p > 0.05$). The occurrence group presented higher percentages in categories such as family incomes below 1400 USD, pregnancy complications, spousal disharmony, discordant relationship with parents, change in sleep and diet, work-study stress, adverse maternal history, unsatisfactory living environment, assisted reproduction, unplanned pregnancy, adverse life events, and lack of maternal knowledge compared to the non-occurrence group. These differences were all statistically significant ($p < 0.05$). For example, the percentage of pregnant women with spousal disharmony in the occurrence group was 30.3%, which was significantly higher than the 6.5% in the non-occurrence group. Further details are presented in Table 1.

3.3 LASSO Regression Model

A 10-fold cross-validated LASSO regression model was employed for screening independent variables and conducting regression analysis. Significant independent variables from the univariate analysis were incorporated into the regression equation. These findings indicated that various risk factors such as pregnancy comorbidities, discordant spousal and parental relationships, change in sleep and diet, work-study stress, adverse maternal history, family income, satisfaction with living environment, assisted reproduction, unplanned pregnancy, interference from adverse life events, and lack of maternal knowledge influenced the likelihood of experiencing depression during pregnancy. Specifically, planned pregnancy, interference from adverse life events, and lack of maternal knowledge were identified as key factors contributing to depression during pregnancy. The regression coefficients for each factor can be found in Table 2. Meanwhile, Figs. 2,3 display the deviation and partial regression coefficients plots generated by LASSO regression. Among them, Fig. 2 shows the deviation of the LASSO regression for different values of λ. The vertical dashed lines in the figure are used to identify specific λ-value reference points, and the bars represent the deviation data at the corresponding λ-values.

3.4 Logistic Regression Analysis

The independent variables were screened using LASSO regression and included in the logistic regression analysis. The regression model was established using the entry method. The Hosmer-Lemeshow test for the model ($\chi^2 = 6.143$, $p = 0.523$) indicated a good fit. The results revealed that spousal disharmony, discordant relations with both parents, change in sleep and diet, work-study stress, adverse maternal history, dissatisfactory living environment, assisted reproduction, unplanned pregnancy, interference from adverse life events, and lack of maternity knowledge were independent risk factors (odds ratio (OR) >1) for experiencing depression during pregnancy, as shown in Table 3.

Table 1. Analysis of general demographic and clinical data of patients in both groups.

Risk factors and conditions		Non-occurrence group (n = 508)	Occurrence group (n = 122)	$Z/t/\chi^2$	*p*-value
Age (years)		30.0 (27.0, 32.0)	30.0 (28.0, 33.0)	–1.836	0.066
Pre-pregnancy BMI (kg/m^2)		22.68 ± 1.82	23.05 ± 2.34	1.900	0.058
Education level	Junior high school and below	225 (44.3)	45 (36.9)	2.203	0.138
	High school and above	283 (55.7)	77 (63.1)		
Family income (USD)	<1400	71 (14.0)	35 (28.7)	20.657	<0.001
	1400–2800	249 (49.0)	62 (50.8)		
	>2800	188 (37.0)	25 (20.5)		
Smoked or consumed alcohol	No	496 (97.6)	120 (98.4)	0.021	0.885
	Yes	12 (2.4)	2 (1.6)		
Pregnancy comorbidities	No	485 (95.5)	110 (90.2)	5.284	0.022
	Yes	23 (4.5)	12 (9.8)		
Gravidity		2.0 (2.0, 3.0)	2.0 (2.0, 3.0)	–1.599	0.110
Parity		2.0 (2.0, 2.0)	2.0 (2.0, 2.0)	–1.026	0.305
Spousal disharmony	No	475 (93.5)	85 (69.7)	56.571	<0.001
	Yes	33 (6.5)	37 (30.3)		
Discordant relation with both parents	No	483 (95.1)	105 (86.1)	12.844	<0.001
	Yes	25 (4.9)	17 (13.9)		
Change in sleep and diet	No	446 (87.8)	93 (76.2)	10.648	0.001
	Yes	62 (12.2)	29 (23.8)		
Work-study stress	No	479 (94.3)	107 (87.7)	6.569	0.010
	Yes	29 (5.7)	15 (12.3)		
Work cessation due to pregnancy	No	432 (85.0)	100 (82.0)	0.707	0.400
	Yes	76 (15.0)	22 (18.0)		
Adverse maternal history	No	503 (99.0)	116 (95.1)	6.729	0.009
	Yes	5 (1.0)	6 (4.9)		
Living environment	Satisfactory	495 (97.4)	111 (91.0)	9.501	0.002
	Unsatisfactory	13 (2.6)	11 (9.0)		
Assisted reproduction	No	505 (99.4)	116 (95.1)	10.190	0.001
	Yes	3 (0.6)	6 (4.9)		
Unplanned pregnancy	No	429 (84.4)	87 (71.3)	11.456	0.001
	Yes	79 (15.6)	35 (28.7)		
Adverse life events	No	505 (99.4)	115 (94.3)	13.552	<0.001
	Yes	3 (0.6)	7 (5.7)		
Lack of maternity knowledge	No	454 (89.4)	96 (78.7)	10.125	0.001
	Yes	54 (10.6)	26 (21.3)		

Note: smoked or consumed alcohol and other categorical variables, except pre-pregnancy BMI, are reported in the table as number (%); pre-pregnancy BMI is presented as median (lower quartile, upper quartile) or mean ± standard deviation, respectively. BMI, body mass index.

3.5 Risk Prediction Model

Binary logistic regression was employed to identify independent factors influencing the construction of a risk prediction model depicted in a nomogram graph. Each position of the predictor on the scoring scale determined a score, which was then aggregated to calculate the total score. Mapping the total score on the probability axis allowed the predicted likelihood of pregnancy depression occurrence in patients to be ascertained, as illustrated in Fig. 4.

3.6 Nomogram Model

Validation of the nomogram model using the bootstrap method with 1000 samples presented a mean absolute error of 0.011 for the calibration curve, which shows that the predicted probability of the model is consistent with the actual value, reflecting the high quality of the calibration curve. In addition, the C index of the present model was 0.806, and the calibration C index was 0.791; these values show that the model has a good differentiation between whether or not a patient develops depression, as illustrated in Fig. 5.

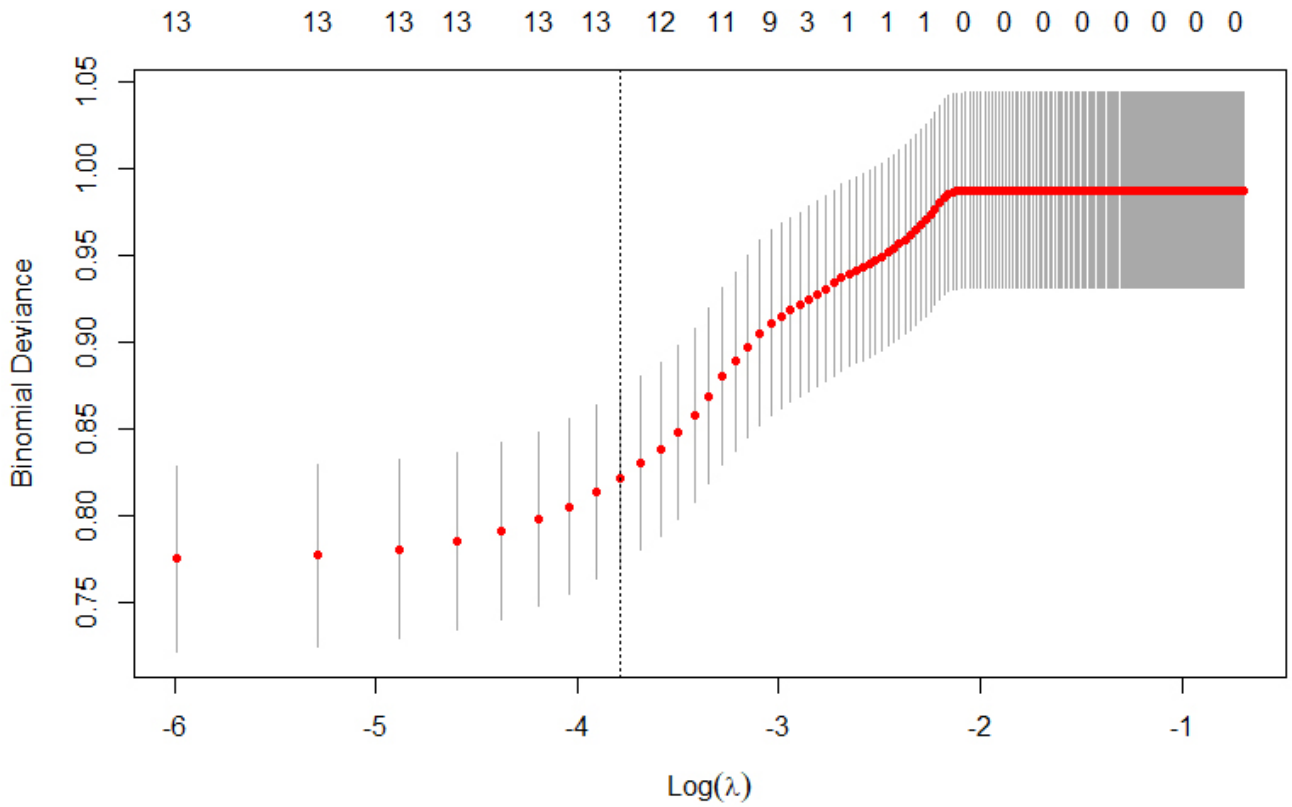

Fig. 2. Deviation in Least Absolute Shrinkage and Selection Operator (LASSO) regression with different λ values.

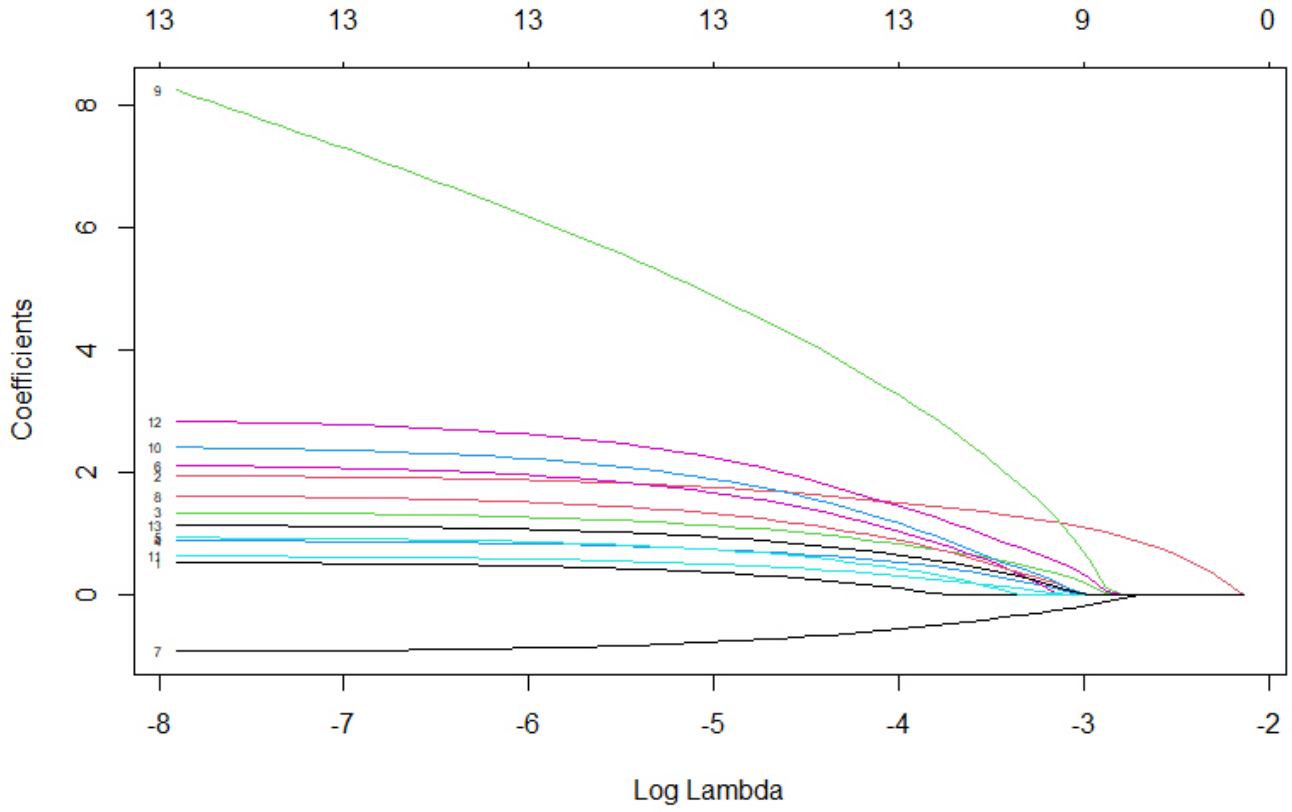

Fig. 3. Plot of λ *vs.* partial regression coefficients.

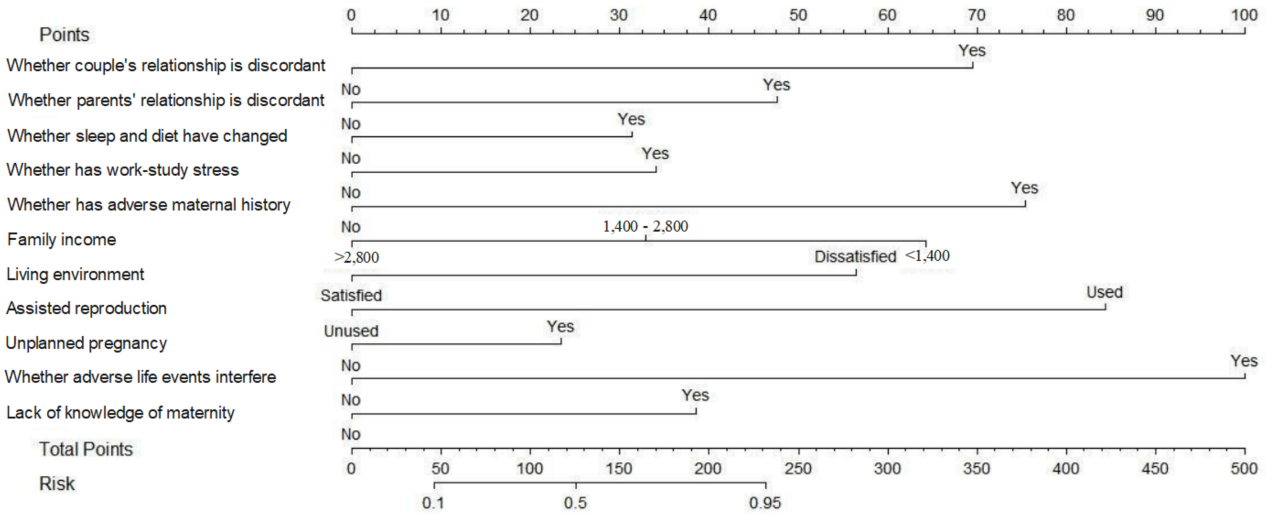

Fig. 4. Scores on the nomogram graph for each independent influential factor.

Table 2. Results of the 10-fold cross-validated LASSO regression model for the groups.

Risk factors	10-fold LASSO regression coefficient
Intercept	–1.006
Pregnancy comorbidities	0.013
Discordant spousal relationship	1.448
Inharmonious parental relationship	0.742
Alterations in sleep and dietary habits	0.456
Work-study stress	0.319
Adverse maternal history	0.849
Family income	–0.498
Living environment	0.742
Assisted reproduction	0.940
Unplanned pregnancy	0.254
Interference of adverse life events	1.251
Lack of maternal knowledge	0.559

LASSO, Least Absolute Shrinkage and Selection Operator.

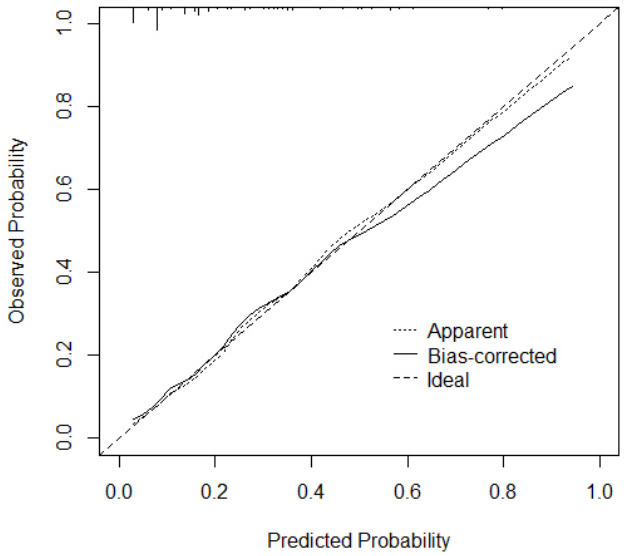

Fig. 5. Calibration curve of the bootstrap method of the prediction model.

3.7 ROC Curve

The ROC curve was utilized to establish the critical threshold of the prediction model for anticipating the onset of depression in pregnant patients. These findings indicated that the combined prediction model had an AUC of 0.806, with a sensitivity of 66.4% and a specificity of 83.5%. An AUC over 0.75 demonstrates promising clinical diagnostic utility, as presented in Table 4 and Fig. 6.

4. Discussion

Perinatal depression, also referred to as maternal depression, encompasses depressive symptoms that emerge during pregnancy, following childbirth, or after an abortion. Perinatal depression includes prenatal depression (PD) and postpartum depression (PPD), and is a prevalent complication during pregnancy and the postpartum period [24]. The various stressors experienced during pregnancy can have adverse effects on the mental health of women, potentially increasing the risk of depression due to hormonal changes and physical transformations [25]. Prior research has indicated that perinatal depression not only impacts the health and well-being of women but also extends to the entire family, influencing the emotional and psychological state of the mother, her ability to care for the baby, and the bonding process [26]. Moreover, perinatal depression can promote a significant decline in the mother's quality of life, an economic strain on the family, and may even result in family discord, self-harm, suicide, and other negative outcomes [27]. A study has shown a clear link between postpartum depression and depression during pregnancy, with approximately one-third of postpartum depression patients expe-

Table 3. Binary logistic regression analysis affecting the occurrence of depression during pregnancy in patients.

Risk factors	β	SE	χ^2	df	p-value	OR	95% CI	
							Lower	Upper
Pregnancy comorbidities	0.508	0.452	1.259	1	0.262	1.661	0.685	4.032
Discordant spousal relationship	1.885	0.308	37.568	1	<0.001	6.589	3.606	12.041
Inharmonious parental relationship	1.291	0.403	10.259	1	0.001	3.635	1.650	8.008
Alterations in sleep and dietary habits	0.838	0.290	8.378	1	0.004	2.312	1.311	4.078
Work-study stress	0.895	0.397	5.083	1	0.024	2.447	1.124	5.327
Adverse maternal history	2.061	0.751	7.525	1	0.006	7.855	1.801	34.252
Family income			25.530	2	<0.001			
1400–2800 USD	–0.888	0.285	9.687	1	0.002	0.412	0.235	0.720
>2800 USD	–1.774	0.352	25.345	1	<0.001	0.170	0.085	0.338
Living environment	1.563	0.507	9.482	1	0.002	4.771	1.765	12.899
Assisted reproduction	2.359	0.905	6.791	1	0.009	10.576	1.794	62.337
Unplanned pregnancy	0.658	0.281	5.473	1	0.019	1.931	1.113	3.350
Interference of adverse life events	2.748	0.909	9.129	1	0.003	15.608	2.626	92.780
Lack of maternal knowledge	1.079	0.302	12.746	1	<0.001	2.943	1.627	5.322
Constant	–1.698	0.260	42.692	1	<0.001	0.183	0.110	0.304

Note: df, degrees of freedom; OR, odds ratio.

Table 4. ROC curve analysis of the predictive model.

	AUC	SE	p-value	95% CI		Threshold value	Sensitivities	Specificities	Youden index
				Lower	Upper				
Joint prediction probability	0.806	0.023	<0.001	0.760	0.852	0.261	0.664	0.835	0.499

Note: ROC, receiver operating characteristic; AUC, area under the curve.

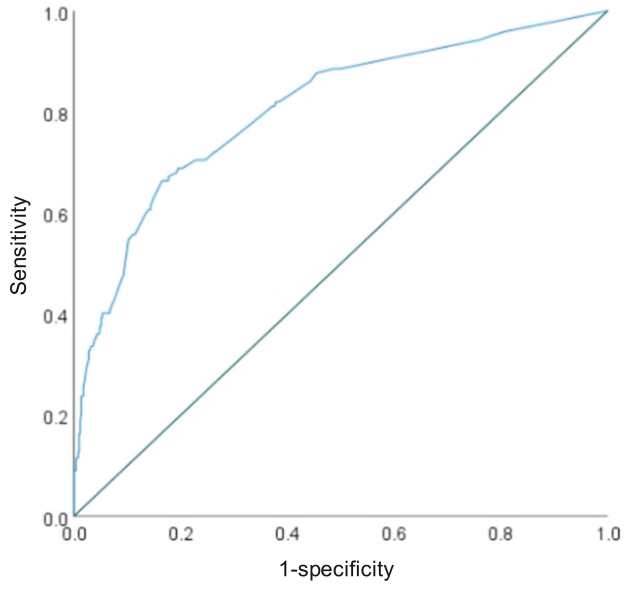

Fig. 6. ROC curve of the predictive model.

riencing depression during or before pregnancy [28]. Postpartum depression is characterized by persistent low mood, diminished self-esteem, lack of confidence in daily life, and heightened levels of anxiety or hypervigilance [29].

The current study found that 19.37% of pregnant women experienced mid-pregnancy depression. Meanwhile, general demographic and clinical data analysis revealed no statistically significant differences between the two groups of patients in terms of age, gravidity, parity, pre-pregnancy BMI, education level, smoking or alcohol consumption, and work cessation due to pregnancy ($p > 0.05$). However, factors such as family income, spousal disharmony, disharmony in relationships with parents, change in sleep and diet, work-study stress, adverse maternal history, low satisfaction with living environment, assisted reproduction, unplanned pregnancy, interference from adverse life events, and lack of maternal knowledge were identified as independent risk factors for depression during pregnancy (OR >1). Divney *et al.* [30] demonstrated that social support, family functioning, and intimate relationships can help mitigate the impact of stressful events on the mental health of pregnant women. Nonetheless, pregnant women with low marital satisfaction [31], poor interpersonal relationships, exposure to spousal physical violence [32], and high levels of social distrust [33] are more likely to experience depression or anxiety. Conflicts between the mother-in-law and daughter-in-law, as well as other family conflicts, are common during pregnancy and significantly increase the risk of developing depression [34]. Previous research has shown that low socioeconomic status is linked to prenatal depression [35], and unemployment may lead to a decrease in family income [36], particularly for low-income families [1].

Adverse pregnancy outcomes and insomnia can result in negative maternal emotions such as self-blame, guilt, and distress, and are significant risk factors for postpartum depression, as noted by Chung *et al*. [37]. Pregnant women who have experienced adverse pregnancy events, including miscarriage, preterm delivery, stillbirth, and other challenging experiences, are more prone to psychological issues during the next pregnancy. Gong *et al*. [38] found that pregnant women who had a history of miscarriage and short intervals between pregnancies were at a higher risk of experiencing depression and anxiety in early pregnancy compared to those without such a history. Additionally, Meijer *et al*. [39] discovered that life events during pregnancy were linked to prenatal depression and anxiety symptoms, with pregnancy-related events notably increasing the likelihood of anxiety symptoms.

In addition to social support and stressful life events, various social factors such as economic level, social status, marital status, non-native speakers, and housing status also play a role in the prenatal psychological state of pregnant women [40]. Morylowska-Topolska *et al*. [41] discovered that economic level and housing situations consistently impact the psychological well-being of pregnant women. Previous research [42] has indicated that favorable living conditions significantly contribute to enhancing maternal psychological recovery. Conversely, this study revealed that poor living conditions can be a risk factor for developing depression during pregnancy. Furthermore, women with lower marital satisfaction were more likely to experience heightened levels of stress during pregnancy [43]. The physiological changes and psychological needs that accompany pregnancy necessitate support and understanding within the marital relationship; thus, women with higher levels of marital satisfaction are less likely to experience postpartum depression [44].

This study successfully constructed a risk prediction model for depression during pregnancy. The mean absolute error of the calibration curve of the model was verified as 0.011, demonstrating good predictive accuracy, and the area under the working characteristic curve of the subjects reached 0.806, with a sensitivity of 66.4% and specificity of 83.5%. Compared with existing diagnostic methods and scales, the EPDS focuses on postnatal depression screening, and this model can integrate multidimensional risk factors at the stage of pregnancy to assess the risk of disease in pregnant women in advance; moreover, this model is more advantageous in terms of accuracy. Some traditional screening questionnaires focus on a single dimension of risk, whereas this model incorporates a combination of factors, which greatly improves the comprehensiveness of the prediction.

Compared with the existing literature, the advantage of this model is that it integrates multiple social, psychological, and physiological factors and is presented in the form of a visualized column-line graph, which facilitates clinicians in calculating the risk probability and identifying high-risk pregnant women quickly. However, the fact that the sample was from a single center may limit the generalizability of the model.

To summarize, the independent risk factors for depression during pregnancy include spousal disharmony, discordant parental relationships, changes in sleep and diet, work-study stress, adverse maternal history, dissatisfactory living environment, assisted reproduction, unplanned pregnancy, interference from adverse life events, and lack of maternal knowledge. The prediction model presented in this study can effectively calculate the occurrence of depression during pregnancy, which is helpful for clinical staff to identify high-risk groups, strengthen pregnancy health care for pregnant women with multiple risk factors, and conduct prenatal health education to alleviate nervousness and fear. Meanwhile, individualized psychological guidance and family intervention can be provided for depressed pregnant women to reduce the occurrence of depression during pregnancy, ensure that pregnant women receive sufficient social support, and minimize the probability of depression during pregnancy.

This study also has some limitations. First, this was a single-center retrospective study with a relatively small sample size (n = 630), and the subjects were all from the same region, which may result in an under-representative sample and affect the generalizability of the model. Second, although the EPDS and GAD-7 scales employed in the study are commonly used screening tools, these scales are mainly used for postpartum depression assessment, and their specificity in predicting depression during pregnancy still needs to be validated further. In addition, this study only explored the correlates of depression during pregnancy; thus, it did not clarify the causal relationships or consider potential influences such as cultural differences and social support systems. Future studies are needed to expand the sample size, conduct multicenter prospective studies, and include more dimensional assessment indicators to enhance the credibility of the research and the applicability of the model.

In addition, the model in this study was constructed and internally validated only on single-center data, meaning the model has not been externally validated, which limits its diagnostic generalizability. The follow-up study will expand the sample range, conduct a multicenter study, collect data from pregnant women in different regions, and externally validate the model by applying the same assessment scales and statistical methods to test the accuracy and applicability of the model further.

5. Conclusions

This study clarified the independent risk factors for depression during pregnancy through multifactorial analyses, including multidimensional indicators, such as spousal relationships, familial environments, changes in living habits,

work-study stress, and pregnancy and childbirth history. The column-line graph prediction model constructed based on these factors had good predictive efficacy (AUC = 0.806) and effectively identified a group of high-risk pregnant women. This study provides a visual and easy-to-use risk assessment tool for the clinic, which can help early intervention and personalized management to reduce the incidence of depression during pregnancy. Future multicenter studies are needed to validate the generalizability of the model further and explore its application value in different cultural contexts.

Availability of Data and Materials

Original data in this study are available from the corresponding author according to reasonable request.

Author Contributions

HQ and YZ designed the research study. HQ and YZ performed the research. YY performed verification and formal analysis. HQ analyzed the data. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Jinshan Central Hospital Affiliated to Shanghai University of Medicine & Health Sciences (Code number: jszxyy202129; Approval date: November 3, 2020). All subjects gave their informed consent for inclusion before they participated in the study.

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Conflict of Interest

The authors declare no conflict of interest.

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