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Developing and Validating Optional EPDS Short Form for Multi-ethnic Areas in China Based on machine learning method of RiskSLIM algorithm

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May, 19, 2026

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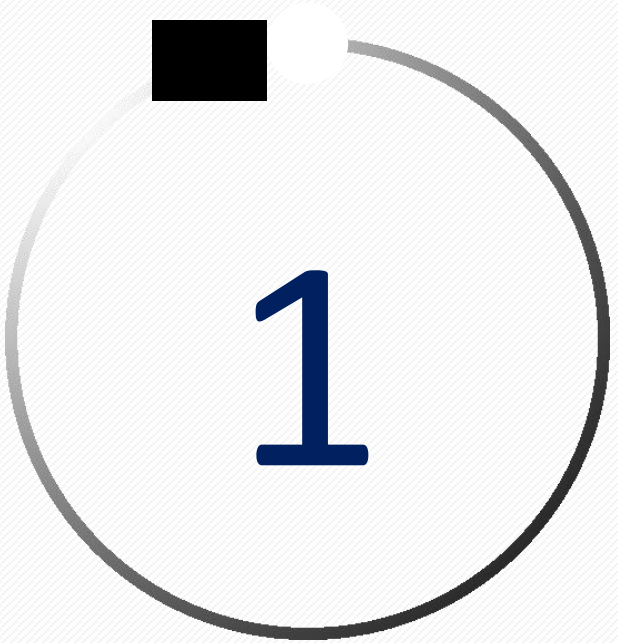


1 Background & Aims

Background

- Perinatal depression is defined as depressive disorders that occur during pregnancy and up to one year after childbirth. Perinatal depression of global incidence was 26.30%[1], and with 16.30%[2] in China.

- The Edinburgh Postnatal Depression Scale (EPDS) is the most commonly used tool for screening perinatal depression.

Table 1 the Edinburgh Postnatal Depression Scale (EPDS)

Please read each item carefully. There are four response options for each question. Check (√) the option that best describes how you have felt over the past 7 days.

Item of EPDS	Score (points)			
	Never (0)	Sometimes (1)	Often (2)	Always (3)
EPDS1-unable to laugh				
EPDS2-can not look forward with enjoyment to things				
EPDS3-blame myself and worried				
EPDS4-anxious or worried				
EPDS5-scared or panicky				
EPDS6-things getting to me				
EPDS7-sleep difficulties				
EPDS8-sad or miserable				
EPDS9-crying				
EPDS10-self-harming				

[1]Al-Abri K, Edge D, Armitage C J. Prevalence and correlates of perinatal depression [J]. Social psychiatry and psychiatric epidemiology, 2023, 58(11): 1581-1590.
[2]Nisar A, Yin J, Waqas A, et al. Prevalence of perinatal depression and its determinants in Mainland China: A systematic review and meta-analysis [J]. Journal of affective disorders, 2020, 277: 1022-1037.

Background

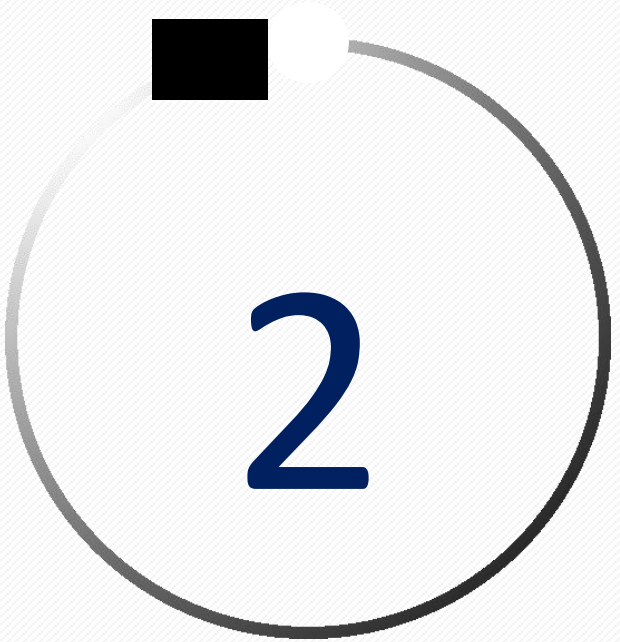
- Government guidelines recommend incorporating perinatal depression screening into routine maternal healthcare, so it is necessary to develop a brief tool for obstetric clinical settings.

- Simplification is typically achieved through quantitative or qualitative methods. RiskSLIM, as a machine learning algorithm, offers the most comprehensive and efficient solution, which has been used to develop brief scales such as the Generalized Anxiety Disorder-7, the Cognitive Distortions Questionnaire, the Geriatric Depression Scale-30.

[1]Albuquerque M R, Corrêa H, Couto T C, et al. A proposal for a new Brazilian six-item version of the Edinburgh Postnatal Depression Scale [J]. Trends psychiatr psy, 2017, 39(1): 29-33.
[2]Harel D, Levis B, Ishihara M, et al. Shortening the Edinburgh postnatal depression scale using optimal test assembly methods: Development of the EPDS-Dep-5 [J]. Acta psychiat scand, 2021, 143(4): 348-362.
[3]Martínez P, Magaña I, Vöhringer P A, et al. Development and validation of a three-item version of the Edinburgh Postnatal Depression Scale [J]. Journal of clinical psychology, 2020, 76(12): 2198-2211.

Aims

1. To develop multiple brief versions of the EPDS using the RiskSLIM and datasets from multiple ethnic groups to determine the optimal items combination
2. To evaluate the reliability and validity of the optimal items combination by comparing it against previously developed brief EPDS scales.
3. To perform external validation of the optimal items combination across different age groups, ethnicities, and hospitals.
4. To determine the optimal screening cutoff values using restricted cubic spline (RCS) models.



2 Materials & Methods

Data Sources

Location	• Ethnic minority autonomous county in Yunnan Province • Hospitals, maternal and child health centers, and township health centers
Screening participants	• A total of 1,191 pregnant and postpartum women were screened • Across seven perinatal stages • Including multi-ethnicities(Han: 478,Zhuang: 517, Miao: 77, Yao: 22,Other : 97)

➢ The detection rate of perinatal depressive symptoms (EPDS > 9) was 12.93% (154/1,191).

Study Design

Screening 1,191 pregnant and postpartum women with full EPDS

Randomly split dataset into training(n=840) and testing sets in a 7:3 ratio (n=357)

Using RiskSLIM based on the test set to develop multiple brief EPDS models

Validated the brief EPDS across the test set, Han, Zhuang, Miao, Yao, and other ethnic minority datasets.The optimal brief EPDS was selected for multi-faceted validation.

External data were used to separately validate the screening performance of the best short-form EPDS across age groups, ethnicities, and hospitals.

Compared the detection performance of different short-form EPDS versions, including 3, 5, and 6-item scales.

3 Results

RiskSLIM-Derived Short-Form EPDS Models

Table 2 Selected 1 to 9 selected EPDS items in the RiskSLIM models

Item of EPDS	Number of items containing EPDS in models								
	1	2	3	4	5	6	7	8	9
EPDS1-unable to laugh							✓	✓	✓
EPDS2-can not look forward with enjoyment to things			✓	✓	✓	✓	✓	✓	✓
EPDS3-blame myself and worried					✓	✓	✓		✓
EPDS4-anxious or worried								✓	✓
EPDS5-scared or panicky		✓	✓	✓	✓	✓	✓	✓	✓
EPDS6-things getting to me						✓	✓	✓	✓
EPDS7-sleep difficulties				✓	✓	✓	✓	✓	✓
EPDS8-sad or miserable	✓	✓	✓	✓	✓	✓	✓	✓	✓
EPDS9-crying								✓	✓
EPDS10-self-harming									

Validation with Multi-ethnic minorities

Table 3 Model Accuracy (AUC) of EPDS-R4

Test samples	Number of Items in the EPDS Model (AUC)								
	1	2	3	4	5	6	7	8	9
30% of all participants	0.913	0.955	0.978	0.988	0.989	0.993	0.994	0.997	0.997
Han majority	0.898	0.963	0.981	0.985	0.984	0.986	0.987	0.996	0.995
Zhuang minority	0.895	0.949	0.974	0.989	0.990	0.992	0.992	0.996	0.997
Miao minority	0.848	0.908	0.947	0.980	0.984	0.980	0.996	1.000	1.000
Yao minority	0.930	0.965	0.982	0.991	1.000	1.000	1.000	1.000	1.000
Other minority	0.933	0.983	0.991	0.998	1.000	1.000	1.000	1.000	1.000

- The 4-items short EPDS model demonstrated high and stable screening accuracy in the multi-ethnic validation sample.

Validation with Multi-ethnic minorities

Table 4 Model Goodness-of-Fit (R^2) of EPDS-R4

Test samples	Number of Items in the EPDS Model (R^2)								
	1	2	3	4	5	6	7	8	9
30% of all participants	0.384	0.506	0.702	0.800	0.813	0.881	0.905	0.982	0.986
Han majority	0.415	0.584	0.679	0.721	0.735	0.798	0.880	0.951	0.962
Zhuang minority	0.371	0.542	0.616	0.728	0.754	0.786	0.800	0.880	0.930
Miao minority	0.169	0.211	0.388	0.834	0.895	1.000	1.000	1.000	1.000
Yao minority	0.485	0.691	0.743	0.807	1.000	1.000	1.000	1.000	1.000
Other minority	0.526	0.763	0.858	0.921	1.000	1.000	1.000	1.000	1.000

- The 4-item brief EPDS model was identified as the optimal short-form scale, showing high and stable goodness-of-fit with the full EPDS model in the multi-ethnic validation sample.

RiskSLIM-Based Differentiated Integer Scoring

Table 5 EPDS-R composite score and positive probabilities of each short form model

Model	Item	Scoring range	EPDS-N composite score	Positive probability
1-item model	Item 8	0-12	Score=4×item8	$P = 1/\{1 + \exp[-(-5+ \text{score})]\}$
2-item model	Item 5 and 8	0-21	Score=3×item5+4×item8	$P = 1/\{1 + \exp[-(-7+ \text{score})]\}$
3-item model	Item 2, 5 and 8	0-27	Score=2×item2+3×item5+4×item8	$P = 1/\{1 + \exp[-(-11+ \text{score})]\}$
4-item model	Item 2, 5,7 and 8	0-36	Score=4×item8+3×item5+2×item2+3×item7	$P = 1/\{1 + \exp[-(-11+ \text{score})]\}$
5-item model	Item 2, 3, 5,7 and 8	0-60	Score=3×item2+3×item3+5×item5+4×item7+5×item8	$P = 1/\{1 + \exp[-(-16+ \text{score})]\}$
6-item model	Item 2, 3, 5, 6, 7and 8	0-63	Score=3×item2+3×item3+4×item5+3×item6+3×item7+5×item8	$P = 1/\{1 + \exp[-(-20+ \text{score})]\}$
7-item model	Item 1, 2, 3, 5, 6, 7 and 8	0-93	Score=4×item1+3×item2+4×item3+4×item5+5×item6+5×item7+5×item8	$P = 1/\{1 + \exp[-(-26+ \text{score})]\}$
8-item model	Item 1, 2, 4, 5, 6, 7, 8 and 9	0-99	Score=3×item1+4×item2+5×item4+5×item5+4×item6+5×item7+5×item8+2×item9	$P = 1/\{1 + \exp[-(-30+ \text{score})]\}$
9-item model	Item 1, 2, 3, 4, 5, 6, 7, 8 and 9	0-129	Score=4×item1+5×item2+5×item3+5×item4+5×item5+5×item6+5×item7+5×item8+4×item9	$P = 1/\{1 + \exp[-(-40+ \text{score})]\}$

Note: The numbers preceding the items represent the integer weights assigned by RiskSLIM. For example, in the 4-item model, item 2 has a weight of 2, and item 5 has a weight of 3.

EPDS-R4 Cutoff Score for Perinatal Depression Screening Using RCS

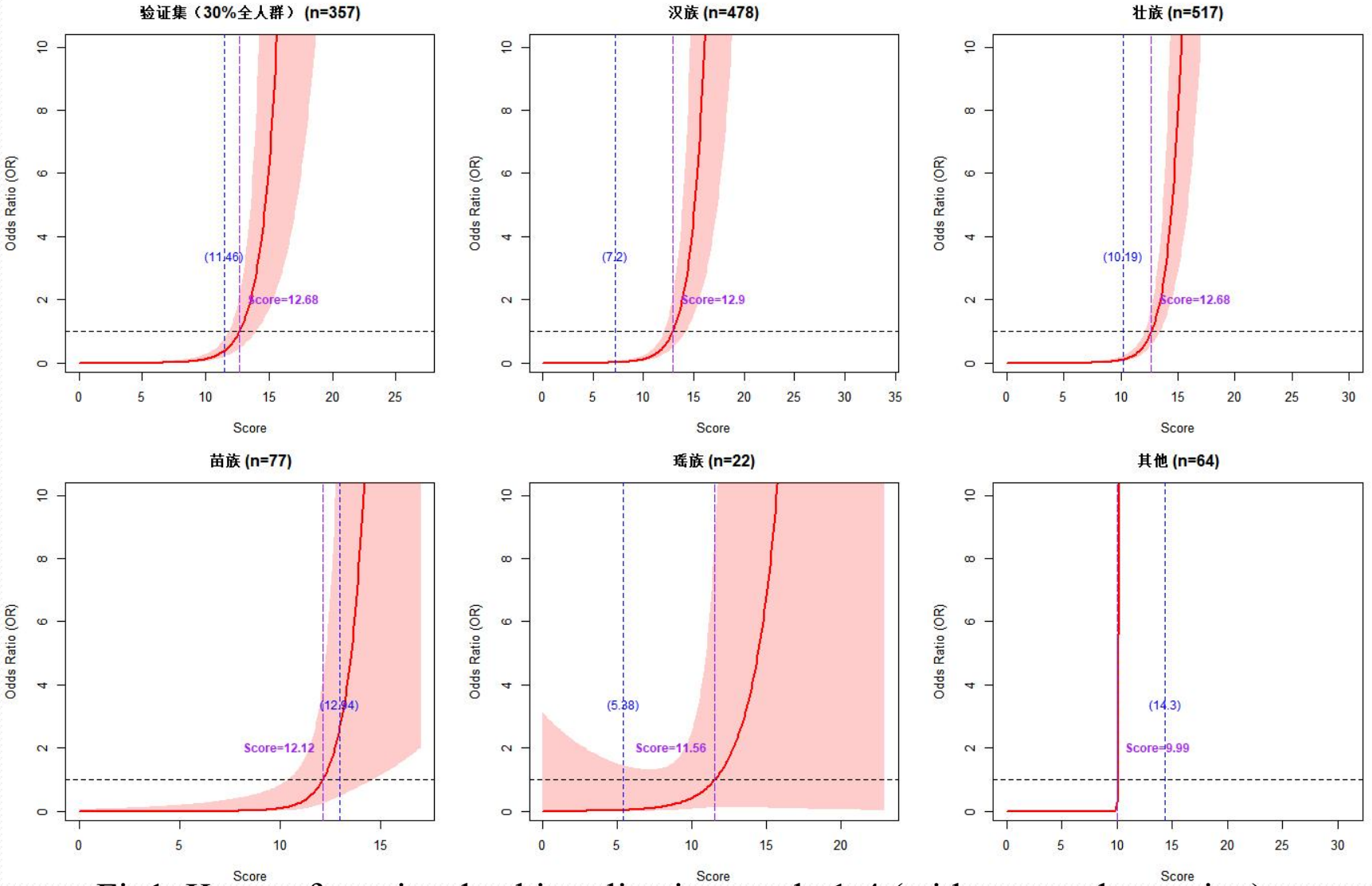
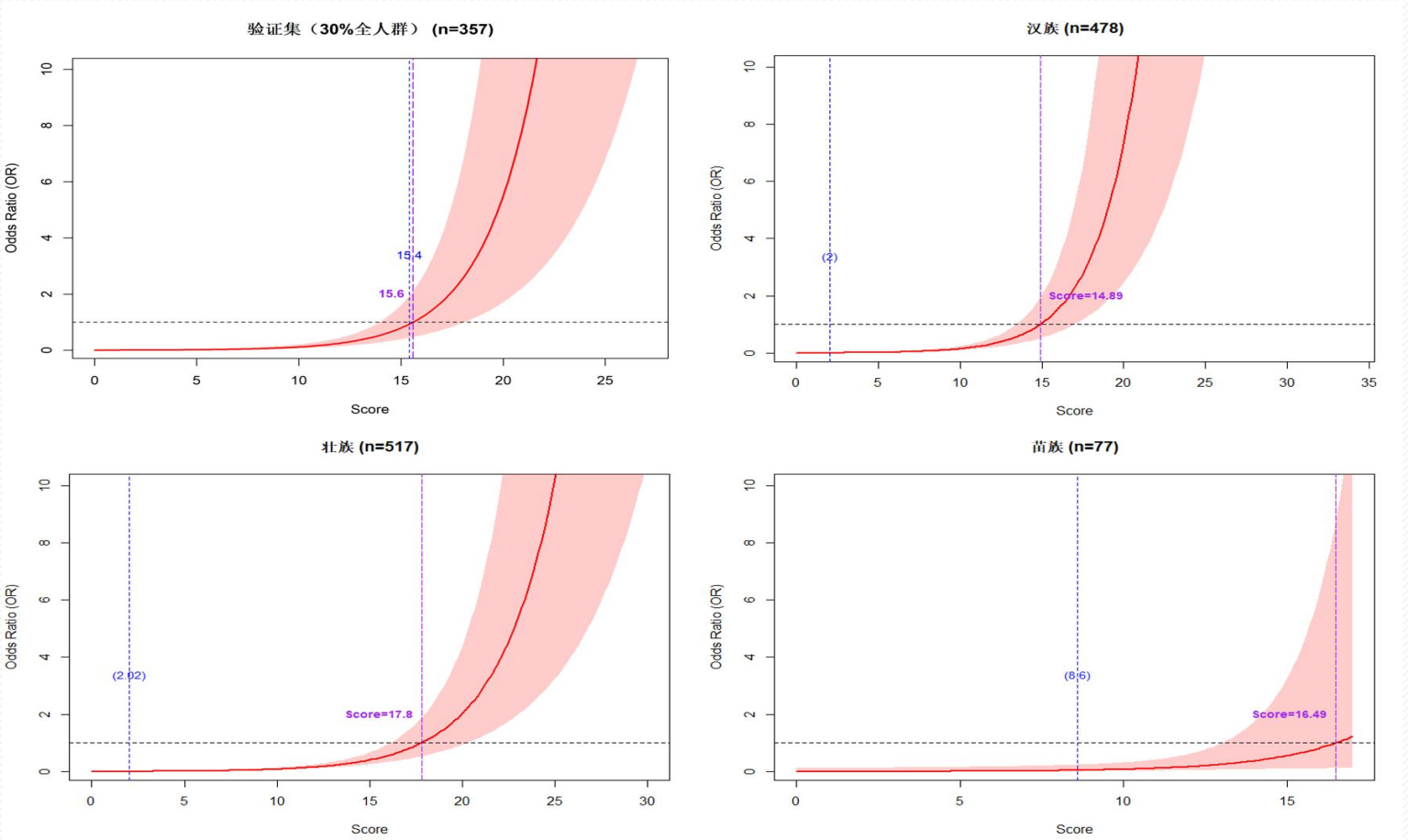


Fig1 Knots of restricted cubic spline in sample 1-4 (with severe depression)

- Based on the restricted cubic spline (RCS) analysis, the screening cutoff for perinatal depression using EPDS-R4 composite scores was determined to be relatively stable within the range of 10–13 points.

Cutoff Score for Severe Perinatal Depression Screening Using RCS



- The cutoff for severe perinatal depression was stable within 15 to 18 point.

Note:The Score value corresponds to the intersection of the restricted cubic spline (RCS) curve with OR = 1 on the vertical axis, representing the first statistically significant inflection point.

Fig2 Knots of restricted cubic spline in sample 1-4 (with severe depression)

Table 6 The Selection Results of EPDS Items by EPDS-R4

Please read each item carefully. There are four response options for each question. Check (√) the option that best describes how you have felt over the past 7 days.

Item of EPDS	Score			
	0=Not at all	1=Several days	2=More than half the days	3=Nearly every day
2*Can not look forward with enjoyment to things (item2)		✓		
3*Scared or panicky (item5)			✓	
3*Sleep difficulties (item7)				✓
4*Sad or miserable (item8)	✓			

Composite score of EPDS-R4： score=**2×item 2+3×item 5+3×item 7+4×item 8**

Positive probabilities of EPDS-R4： $P = 1/\{1 + \exp[-(-11+ \text{score})]\}$

Note: If a participant's EPDS-R4 composite score is 2×1+2×3+3×3+4×0=17, then the probability of a positive result is 95.85%.

- A cutoff of 10 points is recommended for screening perinatal depressive symptoms, while 15 points is recommended as the cutoff for screening severe perinatal depression.

Validation of Reliability and Validity Across Different Brief EPDS Versions

Table 7 Reliability and Validity of 3, 4, 5, and 6-Item EPDS Versions

Brief EPDS	TP	FN	FP	TN	Sensitivity	Specificity	PPV	NPV	Accuracy
EPDS-R4	115	4	44	1,028	0.966	0.959	0.723	0.996	0.960
EPDS-3(≥9)	75	44	15	1,057	0.630	0.986	0.833	0.960	0.950
EPDS-5(>4)	87	32	9	1,063	0.731	0.992	0.906	0.971	0.966
EPDS-6(≥6)	49	70	4	1,068	0.412	0.996	0.925	0.938	0.938

Note: TP is True Positive; FN is False Negative; FP is False Positive; TN is True Negative; PPV is Positive Predictive Value; NPV is Negative Predictive Value.

- The three short EPDS versions showed acceptable applicability in dataset of this study, with favorable performance on other indicators; however, its sensitivity was relatively low.

External Validation Results of EPDS-R4

Table 8 External validation results of EPDS-R4

Subgroup	TP	FN	FP	TN	Sensitivity	Specificity	PPV	NPV	Accuracy
Overall	5,958	497	1,127	6,745	0.923	0.857	0.841	0.931	0.887
Antenatal	4,890	390	883	4,776	0.926	0.844	0.847	0.925	0.884
Postpartum	236	24	37	332	0.908	0.900	0.864	0.933	0.903
≤19 years	50	10	4	58	0.833	0.935	0.926	0.853	0.885
20–34 years	5,268	422	983	5,838	0.926	0.856	0.843	0.933	0.888
≥35 years	640	65	140	849	0.908	0.858	0.821	0.929	0.879
Han majority	4,506	387	876	5,255	0.921	0.857	0.837	0.931	0.885
Minority ethnicity	1,101	93	202	1,267	0.922	0.862	0.845	0.932	0.889
The first affiliated hospital of Kunming medical university	2,108	135	344	1,542	0.940	0.818	0.860	0.919	0.884
Qujing first people's hospital	2,873	265	596	3,678	0.916	0.861	0.828	0.925	0.884
Gejiu people's hospital	976	97	187	1,524	0.910	0.891	0.839	0.940	0.898

Note: There are missing data in the information provided above.

- Using external datasets from Yunnan Province to conduct external validation across subgroups stratified by pregnancy stage, postpartum period, age group, ethnicity, and hospital. Results showed that EPDS-R4 exhibited excellent screening performance, with sensitivity, specificity, and positive and negative predictive values all approaching or exceeding 0.900.

4 Strengths & Limitations

Strengths

1 This study paied attention to the accessibility of perinatal mental health services for women in muti-ethnic minority regions of China.

2 Using the RiskSLIM model as the central framework, also this study incorporated previously developed short-form scales and conducted internal and external validation to examine the stability and cross-cultural adaptability of the optional brief EPDS.

3 Study population covered seven perinatal stages, and EPDS-R4 is applicable for depression screening at any stage of the perinatal period.

Limitations

- Firstly, Diagnostic and Statistical Manual of Mental Disorders (DSM) were not used.
- Secondly, the data on perinatal depression among ethnic minorities were limited, with fewer data on Miao and Yao ethnic groups.
- All items of EPDS in this study are positively worded; however, items 1-3 in the other short scales and external data used for validation are reverse-scored.

Conclusions & Recommendations

Conslusions

1 The RiskSLIM-derived EPDS-R4 retains core symptom items reflecting depressed mood, fear/anxiety, insomnia, and lack of positive anticipation. Results from both internal and external validation demonstrated that it possesses excellent cross-cultural appropriateness and stability.

2 A cutoff of 10 points is recommended for screening perinatal depressive symptoms, while 15 points is recommended as the cutoff for screening severe perinatal depression.

Recommendations

1 EPDS-R4 as the first-line rapid screening tool for perinatal depressive symptoms in routine screening practice, and routinely implemented in prenatal examinations, postpartum home visits, and public health follow-ups to improve both screening coverage and efficiency.

2 Pregnant and postpartum women who screen positive with EPDS-R4 further rescreen and diagnostic confirmation using the full EPDS and DSM to reduce missed and misdiagnoses, forming a two-stage screening strategy to ensure precision in intervention and referral.

3 Future research may explore digital screening tools based on EPDS-R4, such as brief dialogue programs or AI-assisted tools, to reduce the workload of primary care staff.

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