



# Maternal postpartum depression literacy subtypes: A latent profile analysis

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## ABSTRACT

**Aim:** To explore the potential categories and characteristic differences of maternal postpartum depression literacy.

**Design:** Cross-sectional survey.

**Methods:** From February 2023 to April 2023, convenience sampling was used to survey 278 women attending postnatal visits to three tertiary level A hospitals. The study included general demographic characteristics, postpartum depression literacy scale, and family caring index scale. Latent profile analysis was performed to identify the categories of maternal postpartum depression literacy, and multiple disordered logistic regression was used to analyze the influencing factors of different categories.

**Results:** Maternal postpartum depression literacy was divided into three categories: low literacy (41.0 %), moderate literacy (32.4 %), and high literacy (26.6 %). The results showed that work status, education level, whether the pregnancy was planned, whether or not they had participated in mental health-related courses, and family functioning status were factors influencing the category of maternal postpartum depression literacy ( $P < 0.05$ ).

**Conclusion:** There was heterogeneity in postpartum depression literacy among mothers. Medical staff should implement targeted interventions according to potential category characteristics and influencing factors to improve the level of postpartum depression literacy.

## 1. Introduction

Perinatal women experience both physical and psychological stress during pregnancy and childbirth and are at a high risk for developing mental health illness [1]. Maternal mental illness not only causes adverse pregnancy outcomes [2], but also leads to cognitive developmental delays in children, a high incidence of behavioral problems, and insecure attachment [3], and even suicide or

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infanticide in severe cases, resulting in adverse social impacts [4,5]. The prevention and treatment of maternal mental health problems not only requires the participation of medical personnel, but also the mothers themselves should learn to actively cope with psychological problems. Earlier surveys show that the proportion of mothers who take the initiative to seek professional psychological help or mental health services when they encounter psychological problems is very low [6,7]. Additionally, the results of the 2021 China Mental Health Survey showed that treatment rates for depression are low, with only a small percentage of the population receiving adequate treatment [8]. Mental health literacy may be one of the significant influencing factors contributing to low rates of help-seeking and treatment utilization [9,10].

Mental health literacy refers to the knowledge and beliefs that help individuals identify, cope with, and prevent mental health problems or diseases [11]. Individuals with higher mental health literacy can identify their mental health problems on time and have a more positive attitude toward seeking professional psychological help and services, which is of great significance for improving their mental health [12]. However, low levels of mental health literacy can affect an individual's state of awareness of the recognition of symptoms of psychological problems and their treatment, among other things [13]. This may cause individuals to normalize or minimize psychological problems, prevent them from seeking mental health services, and interfere with the improvements in their mental health [14]. As a branch of mental health literacy, postpartum depression literacy can help perinatal women identify, cope with, and prevent postpartum depression [15]. Improving postpartum depression literacy in perinatal women may help improve their perceptions of postpartum depression, enhance their trust in maternal mental health services, and help maintain maternal mental health. Therefore, it is also necessary to pay attention to maternal postpartum depression literacy [16,17].

Early studies have shown that the factors affecting maternal postpartum depression literacy are complex and not-uniform. For example, the relationship between education level and postpartum depression literacy is still controversial [15,18]. In addition, studies from China, Iran, Portugal, and the United States indicate that age, working status, family economic level, birth time, whether to plan pregnancy, and whether to receive mental health knowledge training may also be influencing factors for maternal postpartum depression literacy [15,17,19,20]. In addition, existing studies have shown that family functioning is closely related to the level of maternal mental health literacy and affects positive attitudes towards professional psychological help [21]. Although improving postpartum depression literacy is important to maintain maternal mental health, research on postpartum depression literacy among perinatal women in China is relatively limited. Previous studies have primarily focused on validating the reliability and validity of research tools, along with a limited number of cross-sectional studies [16,22]. Existing research evaluates only total scores without considering heterogeneity among individuals.

Latent profile analysis (LPA) has been widely used in psychology for model fitting with indicators to better demonstrate heterogeneity and for more accurate and objective classification [23]. This study intends to use potential profile analysis to explore the potential classification of postpartum depression literacy of puerpera, analyze whether there is heterogeneity in postpartum depression literacy of puerpera, and explore the impact of demographic data and family function status on different potential profiles to provide targeted intervention measures for perinatal women with different potential literacy profiles and a more reasonable basis for improving postpartum depression literacy. We hypothesized that there are multiple categories of maternal postpartum depression literacy, and assumed that general demographic characteristics and family functioning status are the influencing factors of multiple potential categories of maternal postpartum depression literacy.

## 2. Materials and methods

### 2.1. Aim

The aims of this study were as follows: (a) to analyze potential categories of maternal postpartum depressive literacy, and (b) to explore whether general demographic characteristics and family functioning status are associated with potential categories of maternal postnatal depressive literacy.

### 2.2. Sampling and participants

The study was conducted using a convenience sampling method, and women who had postnatal visits to three tertiary level A hospitals from February to April 2023 were selected as respondents for the survey. The authors first explained the purpose of the study to the participants and asked them to sign an informed consent form before completing the paper questionnaire. Questionnaires were collected as soon as they were completed. The inclusion criteria were as follows: (1) age >18 years, (2) postpartum 42–90 days, (3) no communication barriers or voluntary participation. The exclusion criteria were as follows: (1) history of depression, (2) Serious comorbidities or complications. The termination criteria were withdrawal during questionnaire completion and inability to cooperate with the researcher for various reasons. According to the requirements of multifactor analysis on sample size, the sample size should be at least five to ten times the number of variables. A total of 21 variables were included in this study, with a sample size of at least 105–210 cases. Considering 20 % invalid questionnaires, the sample size was 126–252 cases. A total of 300 questionnaires were sent out in this study, of which 5 people refused to fill out the questionnaires for various reasons. A total of 295 questionnaires were collected, of which 278 were valid, with an effective recovery rate of 94.23 %. All participants provided informed consent and was approved by the hospital Ethics Committee (KY2023093).

## 2.3. Measures

### 2.3.1. General demographic characteristics

They were designed by the researchers themselves and included age, postpartum days, working status, education level, per capita monthly family income (¥), number of births, mode of delivery, planned pregnancy, and whether they had received mental health-related training courses and contact with patients with mental problems.

### 2.3.2. Postpartum depression literacy scale

The Postpartum Depression Literacy Scale is a reliable and effective tool to measure postpartum depression literacy. It was compiled by the Iranian scholar Mirsalimi [15] and translated and revised by Chinese scholars in 2022 [22]. Prior to conducting the survey, permission was obtained from the author of the Chinese version of the scale. The revised scale included six dimensions (ability to identify postpartum depression, risk factors and causes, knowledge, and beliefs about self-care activities, knowledge and beliefs about available professional help, attitudes toward promoting postpartum depression cognition or appropriate seeking behavior, and ability to query and judge information related to postpartum depression), with a total of 27 items in the Chinese version. These items were scored on a Likert 5 scale (from 1 = strongly disagree/not likely at all to 5 = strongly agree/very likely). The total score ranged from 27 to 135 points, and the higher the score, the higher the maternal postpartum depression literacy level. The total Cronbach's  $\alpha$  coefficient of the scale was 0.862. The Cronbach's  $\alpha$  coefficient of each dimension ranged from 0.679 to 0.880. The content validity index was between 0.833 and 1. These findings indicate strong reliability and validity.

### 2.3.3. The family caring index scale

The family caring index [24] scale is used to measure family function. The questionnaire included five dimensions: fitness, cooperation, growth, emotion, and intimacy, and adopts the Likert 3 scoring method. The total score ranges from 0 to 10, with higher scores indicating better family functioning. Total score of 0–3, 4–6, and 7–10 represented serious, moderate, and good family dysfunction, respectively. Its reliability is 0.86, validity is 0.80, indicating good reliability and validity. The scale has been widely used in China [25,26]. In this study, they were divided into family dysfunction (0–6 points) and family functioning well (7–10 points), with a Cronbach's  $\alpha$  coefficient of 0.893.

## 2.4. Methods of data analysis

Mplus8.3 was used for potential profile analysis, and the scores of six dimensions of postpartum depression literacy were taken as explicit variables, and 1–4 categories were selected for model fitting estimation of potential profile analysis. The Akaike information criterion (AIC), Bayesian information criterion (BIC), adjusted Bayesian information criterion (aBIC), entropy index, Lo–Mendell–Rubin adjusted likelihood ratio test (LMR-A), and bootstrapped likelihood ratio test (BLRT) were used as model fitting index; the smaller the AIC, BIC, and aBIC values, the better the model fitting [27]. An entropy index was used to evaluate classification accuracy. The values range from 0 to 1. The closer the value is to 1, the more accurate the classification is, and a value greater than 0.8 is considered acceptable [28]. The P values of LMR-A and BLRT were significant level ( $P < 0.05$ ), indicating that the fitting effect of the K-class model was better than that of the K-1 class model [29]. In addition, the attribution probability matrix for each category was examined. If the values on the diagonal were all higher than 0.7, the classification result of the model was acceptable [30].

SPSS26.0 was used for data analysis, and the measurement data were presented as mean  $\pm$  standard deviation. Counting data were expressed as frequencies and percentages, and the Chi-square test was used for comparison between groups. General information and family functional grouping were used as independent variables, and the results of the latent profile analysis of postpartum depression literacy were used as dependent variables. After calculating the parallel line test with a significance level of  $P < 0.05$ , multiple disordered logistic regression was employed to analyze the influencing factors influencing various categories of postpartum depression literacy in puerpera, with a significance level set at  $\alpha = 0.05$  for the test.

## 3. Results

### 3.1. Participant characteristics

A total of 278 women who underwent postpartum visits completed the questionnaire. The average age of the participants was 29.89  $\pm$  3.62 years old, of which 231 (83.1 %) were 25–34 years old. The postpartum days were 49.16  $\pm$  6.49 days. The majority of participants were employed 205 (73.7 %), College or undergraduate students (186; 66.9 %), with household incomes per capita (¥):  $\leq$ 5000

**Table 1**  
Latent profile model fitting index (N = 278).

Model	AIC	BIC	aBIC	LMR-A(P)	BLRT(P)	Entropy	Class probability (%)
1	7812.841	7856.373	7818.322	–	–	–	–
2	7057.677	7126.602	7066.355	<0.001	<0.001	0.911	0.493/0.507
3	6902.091	6996.409	6913.966	<0.001	<0.001	0.897	0.410/0.324/0.266
4	6856.774	6976.486	6871.847	0.280	<0.001	0.920	0.032/0.396/0.295/0.277

RMB (147; 52.9 %), primigravida (192; 69.1 %), spontaneous delivery (191; 68.7 %), or planned pregnancy (177; 63.7 %). One hundred and sixty eight (60.4 %) had no training history (mental health related training courses), 178 (64.0 %) had no contact history (had contact with patients with psychological problems), and 161 (57.9 %) had good family functioning. Additionally, the mean ( $\pm$ SD) values of postpartum depression literacy was  $100.55 \pm 12.97$ .

### 3.2. Latent profile analysis

Four models were established, and the specific indicators are listed in Table 1. With an increase in the number of categories, the values of AIC, BIC, and aBIC gradually decreased, and entropy values were all greater than 0.8. When divided into four categories, the values of AIC, BIC, and aBIC were the smallest, but LMR did not reach significance ( $P > 0.05$ ), and the number of people in one category was too small, accounting for only 3.2 %. After comprehensive consideration, postpartum depression literacy was divided into three categories. The attribution probability matrix of each category is presented in Table 2, the diagonal values of which are all greater than 0.7, indicating that the results of the three potential category models are credible. The potential profiles were drawn based on these results (see Fig. 1). There were 114 cases (41.0 %) in class 1, whose scores in all dimensions were lower than those in other groups, so they were classified as low literacy type; 90 cases (32.4 %) in class 2, whose scores in all dimensions were at the medium level, so they were named as medium literacy type; and 74 cases (26.6 %) in class 3, whose scores in all dimensions were higher than those in other categories. Thus, it is referred to as the high-literacy type.

### 3.3. Single-factor and multi-factor analyses of potential categories of maternal postpartum depression literacy

The results of the univariate analysis showed that there were statistically significant differences among the three potential categories of postpartum depression literacy in working status, educational level, monthly per capita family income, planned pregnancy, training history, contact history, and family function status ( $P < 0.05$ ; see Table 3).

Variables with statistical significance in the univariate analysis were considered as independent variables, the three potential categories of maternal postpartum depression literacy were considered dependent variables, and a multiple disordered logistic regression analysis was conducted. The regression results are presented in Table 4. Class1 compared with the class 2 group, unplanned pregnancy, non-working or full-time homemakers, and family dysfunction were more likely to be in the class1 group. Compared with the class 3 group, those with unplanned pregnancies, no job or full-time homemakers, no mental health training courses, an education level below secondary school or high school, and family dysfunction were more likely to enter class 1. When comparing class 2 with class 3, those who had not received mental health-related training courses and had an education level of less than secondary or high school were more likely to belong to class 2.

## 4. Discussion

### 4.1. Potential category characteristics of maternal postpartum depression literacy

In this study, the potential profile of postpartum depression literacy in puerpera was analyzed, and the results showed that clear classification characteristics. The study revealed three potential categories: low literacy (41.0 %), medium literacy (32.4 %), and high literacy (26.6 %), reflecting the heterogeneity in maternal postpartum depression literacy. In the dimension of "attitude towards promoting postpartum depression cognition or appropriate help behavior", medium and high literacy puerpera scored the highest, which indicates that individuals with higher mental health literacy are more likely to seek professional psychological help to improve and maintain their mental health. Therefore, mental health care services during pregnancy and childbirth should be continuously improved, the level and ability of mental health services of medical staff should be improved, and the literacy level of postpartum depression in mothers should be improved through various forms of education and mental health first aid [12]. The sum of the proportion of low and medium literacy was more than two-thirds of the total, indicating that maternal postpartum depression literacy was in the lower-middle level, which is consistent with the results of previous studies [18,31]. This suggests that clinicians should differentiate categories of maternal postpartum depression literacy as early as possible and develop targeted interventions.

### 4.2. Analysis of influencing factors of potential categories of maternal postpartum depression literacy

#### 4.2.1. Maternal without jobs or full-time housewives have a higher probability of belonging to the low-literacy group

The results of this study show that mothers without jobs or full-time homemakers were more likely to be classified as having low literacy (OR = 0.262,  $P = 0.020$ ), which is consistent with the findings of an earlier study [18]. This may be because unemployed or

**Table 2**  
The probability of the three potential classes.

Project	Class 1	Class 2	Class 3
Class 1	0.975	0.025	0.000
Class 2	0.047	0.925	0.028
Class 3	0.000	0.040	0.960

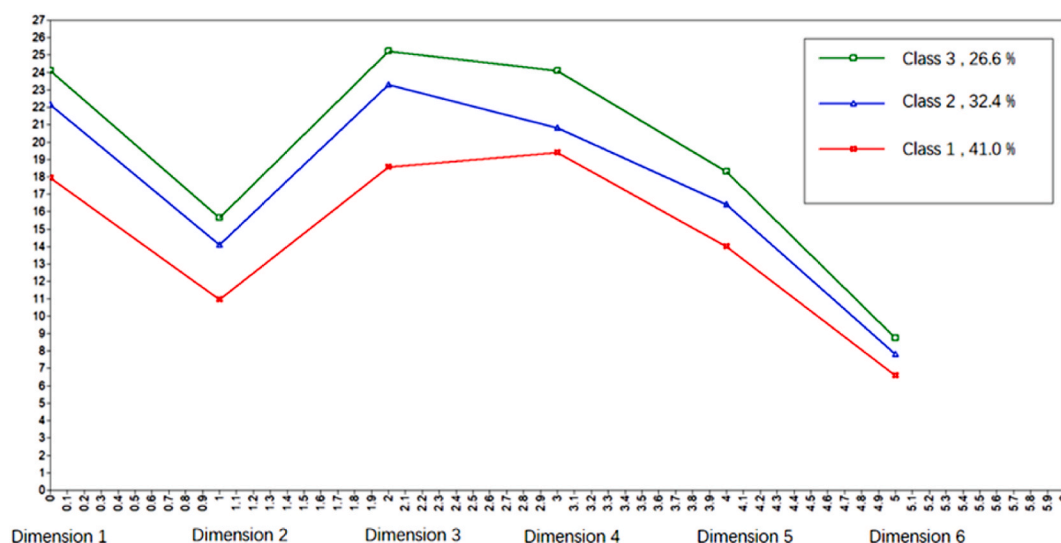


Fig. 1. The distribution of the three potential classes with postpartum depression literacy levels.

full-time homemakers are more likely to focus on their children after childbirth, communicate less with the outside world, and have limited access to sources of mental health information [32]. Medical workers should encourage puerpera to communicate more with their peers, and provide more professional mental health resources by strengthening communication with perinatal women to provide appropriate guidance on how to obtain mental health care and choose appropriate management strategies.

#### 4.2.2. Women with unplanned pregnancies are more likely to be classified as belonging to the low literacy group

The results showed that women with unplanned pregnancies were more likely to be classified as having low literacy (OR = 0.126,  $P < 0.001$ ), which is consistent with previous findings [19]. This may be because women with unplanned pregnancies are not adequately prepared for the arrival of a new life and compared with planned pregnancies, coping with problems after child birth is more difficult, thus resulting in ignoring the maintenance of maternal mental health [33]. Studies have shown a correlation between unplanned pregnancies and an increased incidence of perinatal depression [34]. Women who have unplanned pregnancies, unlike those who plan their pregnancies, are more likely to suffer from mental illness and experience negative consequences, thus affecting the child and the family unit [35]. It has been suggested that medical staff should pay more attention to women with unplanned pregnancies, enhance mental health screening, understand their awareness of mental health knowledge, and provide mental health referral services promptly.

#### 4.2.3. Perinatal women with family dysfunction have a higher probability of belonging to the low literacy group

Regression analysis showed that perinatal women with family dysfunction were more likely to be classified as having low literacy (OR = 0.035,  $P < 0.001$ ), which is consistent with the results of an earlier study [36]. Family function is closely related to individual mental health levels and is an important index for evaluating family relationships. People with good family functions are more likely to get resources, help, and mental health guidance from their families [37,38]. Many perinatal women are reminded by family members to realize their mental state problems, and mothers who receive more family care are more likely to receive professional psychological help [39]. Medical staff should encourage family members to receive mental health education and maintain their maternal mental health education [14]. In addition, it is necessary to pay close attention to maternal women with family dysfunction and help improve their family function status to improve the mental health level of the mother's postpartum depression literacy.

#### 4.2.4. Perinatal women with high school or technical secondary school education or below are more likely to be classified as belonging to the low or medium literacy groups

The results of this study showed that perinatal women with an education level below high school or technical secondary school were more likely to be classified as having low or medium literacy (OR = 0.077/0.037,  $P = 0.005/0.037$ ), which is consistent with the results of an earlier study [17]. When the maternal literacy level is low, the maternal postpartum depression literacy level is lower [15]. This may be related to a low level of maternal ability to acquire mental health knowledge and an inadequate awareness of mental health issues. However, some studies have shown that there is no significant relationship between educational level and maternal mental health literacy [18,40]. This may be because the main objective of their study was mothers with a low education level, and the distribution was relatively balanced. The participants in this and other studies were mainly women with higher education levels. Future literature integration should be considered to further explore the relationship between education level and postpartum depression literacy. It is suggested that medical staff conduct mental health literacy interventions according to different categories of educational levels to improve the ability of mothers to maintain their mental health.

**Table 3**  
Univariate analysis of potential categories of maternal postpartum depression literacy (N = 278).

Variable		Total cases ( n = 278 )	Potential profile class			$\chi^2$	p-value
			Class 1 ( n = 114 )	Class 2 ( n = 90 )	Class 3 ( n = 74 )		
Age	≤24	16 (5.8 %)	7 (6.1 %)	6 (6.7 %)	3 (4.1 %)	3.223	0.521
	25–34	231 (83.1 %)	94 (82.5 %)	71 (78.9 %)	66 (89.2 %)		
	≥35	31 (11.2 %)	13 (11.4 %)	12 (14.4 %)	5 (6.8 %)		
Working conditions	employed	205 (73.7 %)	60 (52.6 %)	79 (87.8 %)	66 (89.2 %)	44.512	<0.001
	Non-employed or full-time homemaker	73 (26.3 %)	54 (47.4 %)	11 (12.2 %)	8 (10.8 %)		
Education	Junior high school or below	16 (5.8 %)	15 (13.2 %)	1 (1.1 %)	0	66.067	<0.001
	Technical secondary school/ high school	47 (16.9 %)	36 (31.6 %)	9 (10.0 %)	2 (2.7 %)		
	College/Undergraduate	186 (66.9 %)	60 (52.6 %)	70 (77.8 %)	56 (75.7 %)		
per capita monthly family income (¥)	Postgraduate and above	29 (10.4 %)	3 (2.6 %)	10 (11.1 %)	16 (21.6 %)	51.744	<0.001
	≤5000	147 (52.9 %)	89 (78.1 %)	28 (31.1 %)	30 (40.5 %)		
	5001–10,000	97 (34.9 %)	21 (18.4 %)	45 (50.0 %)	31 (41.9 %)		
Number of births	≥10001	34 (12.2 %)	4 (3.5 %)	17 (18.9 %)	13 (17.6 %)	1.335	0.513
	1 time	192 (69.1 %)	76 (66.7 %)	61 (67.8 %)	55 (74.3 %)		
Delivery mode	≥2 times	86 (30.9 %)	38 (33.3 %)	29 (32.2 %)	19 (25.7 %)	1.167	0.558
	Spontaneous delivery	191 (68.7 %)	80 (70.2 %)	58 (64.4 %)	53 (71.6 %)		
Whether the pregnancy was planned	Cesarean section	87 (31.3 %)	34 (29.8 %)	32 (35.6 %)	21 (28.4 %)	74.881	<0.001
	Yes	177 (63.7 %)	39 (34.2 %)	71 (78.9 %)	67 (90.5 %)		
Training history	No	101 (36.3 %)	75 (65.8 %)	19 (21.1 %)	7 (9.5 %)	31.850	<0.001
	Yes	110 (39.6 %)	27 (23.7 %)	35 (38.9 %)	48 (64.9 %)		
Contact history	No	168 (60.4 %)	87 (76.3 %)	55 (61.1 %)	26 (35.1 %)	23.484	<0.001
	Yes	100 (36.0 %)	24 (21.1 %)	35 (38.9 %)	41 (55.4 %)		
Family function status	No	178 (64.0 %)	90 (78.9 %)	55 (61.1 %)	33 (44.6 %)	129.402	<0.001
	Yes	117 (42.1 %)	94 (82.5 %)	14 (15.6 %)	9 (12.2 %)		
Family function status	Family dysfunction	117 (42.1 %)	94 (82.5 %)	14 (15.6 %)	9 (12.2 %)	129.402	<0.001
	Good family functioning	161 (57.9 %)	20 (17.5 %)	76 (84.4 %)	65 (87.8 %)		

**Table 4**  
Multivariate disordered logistic regression analysis of factors influencing maternal postnatal depression literacy.

Project	$\beta$	SE	Wald	P-value	OR	95%CI
Class1 and class2 are compared						
working condition(Non-employed or full-time homemaker)	-1.341	0.577	5.401	0.020	0.262	0.084–0.811
Whether the pregnancy was planned (No)	-2.068	0.488	17.942	< 0.001	0.126	0.049–0.329
Family function status (Family dysfunction)	-3.365	0.512	43.195	< 0.001	0.035	0.013–0.094
Class1 and class 3 are compared						
working condition (Non-employed or full-time homemaker)	-1.369	0.680	4.048	0.044	0.254	0.067–0.965
Education (high school, technical secondary school, below)	-2.570	0.920	7.812	0.005	0.077	0.013–0.464
Whether the pregnancy was planned (No)	-2.843	0.591	23.130	< 0.001	0.058	0.018–0.186
Training history (No)	-1.559	0.553	7.936	0.005	0.210	0.071–0.622
Family functioning status (Family dysfunction)	-3.510	0.584	36.103	< 0.001	0.030	0.010–0.094
Class2 and class3 are compared						
Education (high school, technical secondary school, or below)	-1.783	0.853	4.373	0.037	0.168	0.032–0.894
Training history (No)	-0.981	0.352	7.772	0.005	0.375	0.188–0.747

**4.2.5. Mothers who have not received mental health-related training courses are more likely to be classified as having low or medium literacy**

The research results show that those who have not received mental health training courses are more likely to be classified as having low or medium literacy (OR = 0.210/0.375, P = 0.005/0.005), which is consistent with Jones’s [41] conclusion that maternal

education is encouraged to improve their mental health literacy. This is because some hospitals have already conducted education workshops on the identification and prevention of mental illnesses during pregnancy and childbirth when conducting maternal health education activities; therefore, the level of knowledge of postpartum depression among this group of puerpera is relatively high [42]. However, there is still a lack of dissemination of mental health knowledge and the improvement in related content, and there is room for improvement in mental health promotion [43]. The maternal mental health service system should be improved at the national level, and the screening methods used for maternal mental health problems should be clarified [44]. Based on the practical implementation of national policies at the medical and nursing level, training on the early mental health knowledge of puerpera is conducted through pregnant women's schools, public accounts, and educational manuals to improve their awareness of psychological problems and the need for attention.

#### 4.3. Limitations

The samples for this study were drawn from the same region and were all from the same level of hospital. Differences in economic levels and cultures in different regions, as well as differences in hospitals at different levels, may have led to bias in the sample. In the future, we will consider conducting a large-sample survey of hospitals in different regions and at different levels. The convenience sampling method used in this study also limited the extrapolation of the results. In addition, this study was a cross-sectional survey and did not observe the dynamics of maternal depressive literacy in the postnatal period, nor did it explain the causal relationship. Therefore, longitudinal studies should be conducted in the future to explore the changes in maternal postpartum depression literacy and explain the causal relationship to provide a basis and direction for future interventional studies.

#### 5. Conclusion

In this study, the literacy level of mothers with postpartum depression was divided into three categories: low, medium, and high literacy, through latent profile analysis. Healthcare workers need to identify different types of puerpera and take intervention measures, especially for unplanned pregnancies, non-working or full-time homemakers, and where there is evidence of family dysfunction, Pregnant women who have not received mental health-related training courses and have low education levels, need more robust intervention to improve their postpartum depression literacy.

#### Ethics Declarations

This study was reviewed and approved by the Ethics Review Committee of Affiliated Hospital of Southwest Medical University (approval number: KY2023093). All participants provided informed consent to participate in the study.

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#### Data Availability

The data used or analyzed in this study may be obtained from the corresponding author upon reasonable request.

#### CRediT authorship contribution statement

**Kangfen Li:** Writing – original draft, Project administration, Data curation. **Jie Lu:** Methodology, Investigation, Data curation. **Yan Pang:** Writing – review & editing, Methodology. **Xinlie Zheng:** Data curation. **Ran Liu:** Data curation. **Min Ren:** Writing – review & editing, Funding acquisition. **Suhua Tu:** Writing – review & editing, Writing – original draft, Project administration.

#### Declaration of competing interest

There are no conflicts of interest in this study.

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