Journal of Affective Disorders 369 (2025) 276–287

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Research paper

Ten-year trajectories of postpartum depression of Japanese mothers and fathers

Takahiro Kubo [a,*], Yasumitsu Jikihara [b], Naoya Todo [c], Misako Aramaki [d], Naomi Shiozaki [e], Satoko Ando [f]

[a] College of Education, Yokohama National University, 79-1 Tokiwadai, Hodogaya-ku, Yokohama, Kanagawa, Japan
[b] Graduate School of Human Sciences, Osaka University, 1-2 Yamadaoka, Suita-shi, Osaka, Japan
[c] Faculty of Humanities and Social Sciences, Tokyo Metropolitan University, 1-1 Minami-Osawa, Hachioji, Tokyo, Japan
[d] Early Childhood Education Research Center, National Institute For Educational Policy Research, 3-2-2 Kasumigaseki, Chiyoda-ku, Tokyo, Japan
[e] Faculty of Integrated Arts and Social Sciences, Japan Women's University, 2-8-1 Mejirodai, Bunkyo, Tokyo, Japan
[f] Faculty of Human Sciences, University of Tsukuba, 3-29-1 Otsuka, Bunkyo, Tokyo, Japan

ARTICLE INFO

Keywords:
Perinatal depression
Postpartum depression
Maternal depression
Paternal depression
Depression trajectory
Parallel-process latent class growth analysis

ABSTRACT

Background: Perinatal depression is a significant concern affecting both women and men during pregnancy and postpartum periods. While maternal postpartum depression has been extensively studied, paternal depression remains under-researched despite its prevalence and impact on family well-being. This study aimed to estimate the trajectories of perinatal and postpartum depression in Japanese parents over ten years and to determine the details of the symptoms of postpartum depression for each trajectory group, considering reciprocal effects between maternal and paternal depression.

Methods: A total of 789 couples used the Edinburgh Postnatal Depression Scale to rate their depressive symptoms prenatally; at 5 weeks, 3 months, 6 months, and 1 year postpartum; and then yearly thereafter until the 10th year. Parallel-process latent class growth analysis was used to group participants according to their longitudinal patterns of depressive symptoms.

Results: For both mothers and fathers, four depressive symptom trajectories fit the data best and were most informative (escalating: 6.5 %; mothers low and fathers moderate: 17.2 %; mothers high and fathers low: 17.9 %; low: 58.4 %). A variance analysis showed significant class-parent interactions across anhedonia, anxiety, and depression subscales, indicating distinct patterns of depressive symptomatology.

Discussion: Tailored mental health programs and universal screening using the Edinburgh Postnatal Depression Scale are recommended to address the specific needs of each trajectory class. This study contributes to the understanding of long-term depressive symptom trajectories in parents and emphasizes the necessity of comprehensive support strategies to enhance family well-being and resilience.

1. Introduction

Perinatal depression is a significant concern that affects a considerable number of women during pregnancy and after childbirth, with prevalence rates ranging from 7 % to 20 % (Dadi et al., 2022). Similarly, postpartum depression was found to be prevalent in 14.3 % of Japanese women one month after childbirth (Tokumitsu et al., 2020a). However, both men and women are affected by postnatal depression. A meta-analysis of 74 studies with 41,480 participants found that paternal depression was present in 8 % of men in the included studies (Cameron et al., 2016). Approximately 10 % of Japanese men experience perinatal depression, highlighting that this condition is a concern for both sexes (Tokumitsu et al., 2020b). The mental health of both parents during the perinatal and postpartum periods is crucial, as it can significantly impact the overall well-being of children and families. A meta-analysis further revealed that 3.18 % of couples might experience perinatal depression simultaneously (Smythe et al., 2022). Longitudinal studies have also shown that depressive symptom trajectories can persist for up to 11 years postpartum (Mughal et al., 2023). Therefore, this study's primary objective was to estimate the trajectories of perinatal and postpartum

* Corresponding author at: Faculty of Education, Yokohama national University, Tokiwadai 79-8, Hodogaya-ku, Yokohama 240-8501, Japan.
E-mail address: kubo-takahiro-kc@ynu.ac.jp (T. Kubo).

https://doi.org/10.1016/j.jad.2024.09.154
Received 18 February 2024; Received in revised form 19 September 2024; Accepted 22 September 2024
Available online 30 September 2024

depression in Japanese parents and their associated risk factors, considering the reciprocal effects of postpartum depression on fathers and mothers.

It is crucial to understand the different trajectories of maternal perinatal and postpartum depression to identify at-risk individuals, provide appropriate support and interventions, and mitigate the potential negative impacts on both mothers and children. Previous studies have identified distinct trajectories of depressive symptoms during pregnancy and postpartum periods. These patterns vary and include low, medium, and highly stable symptoms (Ahmed et al., 2019; Putnick et al., 2020; Severo et al., 2023). These trajectories have been associated with various demographic and perinatal factors such as maternal age, education, history of mood disorders, and gestational diabetes (Putnick et al., 2020). Alcohol misuse and exposure to environmental toxins during pregnancy, especially active/passive smoke, significantly increase the risk of postpartum depression (Lobato et al., 2012; Mitchell et al., 2020). Postpartum depression is a common and serious mental health issue with risk factors including a history of depression, relationship issues, domestic violence, and lack of social support (Palumbo et al., 2017). These findings indicate that perinatal and postpartum depression are complex mental health conditions with varied presentations and numerous factors that influence their etiology. Understanding these aspects is crucial for early identification, providing appropriate support, and implementing effective interventions to mitigate the potential negative impact on mothers and their children.

Despite extensive research on maternal perinatal and postpartum depression, studies of paternal perinatal and postpartum depression remain limited. Molgora et al. (2016) identified three trajectories of depressive symptoms in first-time fathers, from late pregnancy to one year postpartum: a low, stable resilient trajectory; a moderate, stable distress trajectory; and a high, emergent depression trajectory. Factors contributing to paternal depression include partner relationship problems, low education, history of depression, stressful life events, and low partner support (Massoudi et al., 2016). When describing the most stressful aspects of postpartum depression, fathers often cite external requirements whereas mothers highlight internal requirements (Johansson et al., 2020). Factors such as age, poor sleep quality, and financial stress increase this risk (Costa et al., 2019). The trajectories of fathers' postpartum depressed mood can be categorized into three classes: high, moderate, and low (Nieh et al., 2022). Financial stress is also a potential contributor to the high-increase group (Nieh et al., 2022). Paternal postpartum depression limits men's capacity to provide emotional support to their partners and children (Melrose, 2010). It is associated with poor parenting environment, family functioning, and child health and development (Dennis et al., 2023). Available research indicates that age, relationship problems, low education, financial strain, and external pressures may lead to perinatal and postpartum depression in fathers, which, in turn, may affect child development and maternal postpartum depression.

Although existing research has suggested a strong correlation between paternal and maternal postpartum depression (Ierardi et al., 2019), not all couples exhibit the same postpartum depression symptoms and problems. The longest trajectory study of maternal and paternal depressive symptoms from prenatal to 24 months postpartum found that maternal and paternal trajectories were associated with each other, and that the strongest predictors (insomnia, previous depression, anxiety, stress, and poor family atmosphere) were common to both (Kiviruusu et al., 2020). Furthermore, the association between paternal and maternal depressive symptoms was found to be low-to-moderate during pregnancy, postpartum, and prospectively (Thiel et al., 2020). However, child, parental, and marital relationships were more problematic in families with high paternal depressive symptoms than in those with high maternal depressive symptoms, highlighting the crucial role of paternal support during the transition to siblinghood (Volling et al., 2018). Similarly, both paternal and maternal depressive symptoms have been observed to decrease over time, suggesting a similar pattern of parental depressive symptoms after the birth of a child; however, the decrease is more pronounced for mothers (Nath et al., 2016). These findings suggest that the trajectories of perinatal and postpartum depression for most couples are similar when considering paternal and maternal depression during the perinatal period. However, it is assumed that some couples may not show stable attenuation of postpartum depressive symptoms, and effective assessment and detailed examination of postpartum depression in these couples is needed.

Perinatal and postpartum depression in mothers is widely measured using the Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987), which has also been found to be a valid tool for measuring postpartum depression in fathers (Loscalzo et al., 2015; Nishigori et al., 2020). Many studies use the EPDS total score, which has a cutoff value for screening for perinatal and postpartum depression (Cox et al., 2014). Conversely, studies that have adopted subscales from the EPSD items have used three subscales: anhedonia, anxiety, and depression (Kubota et al., 2014). The subscales can be used to help identify anxious mothers missed during routine depression screening (Stasik-O'Brien et al., 2019), and comparing subscale characteristics can provide valuable insights into intervention strategies (Liu et al., 2022).

This study quantified the duration of postpartum depression in Japanese parents from gestation to 10 years postpartum, extending beyond the timeframe examined in a previous study (Kiviruusu et al., 2020). As our study considered long-term trajectories over 10 years, we did not have strong expectations of the specific number and type of trajectories; however, more than three trajectories can be assumed from previous studies, and the main trajectory is likely a stable one. The second objective was to conduct a detailed analysis of the types of postpartum depression trajectories identified using EPDS subscale scores and to characterize each trajectory type using EPDS cutoff points.

This study significantly advances both research and practice in understanding postpartum depression. By extending the observation period of postpartum depression in Japanese parents from pregnancy to 10 years postpartum, it provides a comprehensive understanding of long-term trajectories, exceeding the time frame of previous studies. The analysis and characterization of each trajectory type using EPDS subscale scores and cutoff points provides a nuanced perspective on the course of postpartum depression. This approach recognizes the complexity and variability of postpartum depression, identifying multiple trajectories and specific patterns of depressive symptoms. The findings have practical implications, informing targeted interventions and support strategies tailored to the diverse needs of parents experiencing postpartum depression, ultimately leading to more effective and personalized care.

2. Materials and methods

2.1. Participants

Participants were recruited from a perinatal center in the Kanto region of Japan; the center has approximately one thousand deliveries per year. All participants were couples, although their marital statuses were unknown when the survey responses were requested. Regarding marital status, both mothers and fathers were asked whether there had been a divorce 5 weeks, 3 months, 6 months, and 1 year after the birth. Based on the results, five couples reported having divorced 5 weeks after the birth. In total, 789 couples completed the first survey between August 2009 and December 2010. Of the participants, 12 couples, 21 mothers, and 14 fathers had complete data. The sociodemographic characteristics of the sample are presented in Tables 1 and 2. A comparison of complete and incomplete data is summarized in Supplementary Table 1.

2.2. Procedures

Women who had been pregnant for >24 weeks and their partners were asked to participate in the survey during prenatal check-ups. After

Table 1
Mothers and fathers' sociodemographic data during prenatal checkups.

	Mothers		Fathers	
Variable	Count	%	Count	%
Age				
~19	0	0.0 %	1	0.2 %
20–24	19	2.4 %	8	1.4 %
25–29	125	15.9 %	71	12.6 %
30–34	281	35.8 %	162	28.7 %
35–39	280	35.6 %	190	33.7 %
40–44	78	9.9 %	104	18.4 %
45–49	3	0.4 %	20	3.5 %
50~	0	0.0 %	8	1.4 %
Total	786		564	
Psychiatric history				
No	663	95.1 %		
Yes	34	4.9 %		
Total	697			
Childbirth experience				
No	417	52.9 %		
Yes	372	47.1 %		
Total	789			
Infertility treatment				
Natural pregnancy	550	70.1 %		
General fertility treatment	101	12.9 %		
Advanced assisted reproductive technology	133	16.9 %		
Other	1	0.1 %		
Total	785			
Education				
Junior high school	18	2.3 %	14	2.5 %
High School	195	24.9 %	161	28.6 %
Vocational and technical schools	199	25.4 %	97	17.2 %
Junior college	180	23.0 %	7	1.2 %
Four-year college and universities	180	23.0 %	246	43.7 %
Graduate school	10	1.3 %	38	6.7 %
Total	782		563	
Work conditions				
Full-time	192	24.5 %	544	97.1 %
Part-time	80	10.2 %	12	2.1 %
Unemployed	513	65.4 %	4	0.7 %
Total	785		560	
Resignation (or planned resignation) owing to childbirth				
Yes	410	63.8 %		
No	232	36.1 %		
Total	642			
Employment status				
Company	152	55.9 %	429	76.5 %
Government employee	41	15.1 %	51	9.1 %
Self-employed family employee	44	16.2 %	65	11.6 %
Other	35	12.9 %	16	2.9 %
Total	272		561	
Childcare leave system				
Use	165	69.3 %	37	6.9 %
Not used	24	10.1 %	233	43.2 %
Not decided	7	2.9 %	94	17.4 %
No system	42	17.6 %	175	32.5 %
Total	238		539	
Childcare shorter working hour system				
Used	71	29.1 %	8	1.5 %
Not used	35	14.3 %	227	41.3 %
Not decided	79	32.4 %	105	19.1 %
No system	59	24.2 %	210	38.2 %
Total	244		550	
Flextime system				
Used	23	9.3 %	67	12.3 %
Not used	77	31.0 %	230	42.3 %
Not decided	0	0.0 %	34	6.3 %
No system	148	59.7 %	213	39.2 %
Total	248		544	
Financial situation				
Fairly easy	27	3.5 %	15	2.7 %
Somewhat easy	393	50.6 %	255	45.5 %
Rather painful	310	39.9 %	253	45.2 %
Quite painful	47	6.0 %	37	0.1 %
Total	777		560	
Psychological domestic violence from partner				
No	372	48.0 %		
Yes	403	52.0 %		
Total	775			
Sexual domestic violence from partner				
No	708	91.0 %		
Yes	70	9.0 %		
Total	775			
Physical domestic violence from partner				
No	743	95.5 %		
Yes	35	4.5 %		
Total	778			

the prenatal checkups, questionnaires were sent to these parents by mail at 5 weeks, 3 months, 6 months, and 1 year postpartum. Questionnaires were subsequently mailed to them annually, from the child's birthday to the following month, until the child reached 10 years of age, except for parents who refused to continue the survey at 1 year. This study was reviewed and approved by the Ethics Committee of XXXX (approval number XXXXX). Written informed consent was obtained from all participants involved in this study. The percentages of missing data of the EPDS at each time point are shown in Table 2.

2.3. Measures

2.3.1. Outcomes

Mothers and fathers' depressive symptoms were measured prenatally and at 5 weeks, 3 months, 6 months, and 1 year postpartum, and then yearly thereafter until the 10th year using the Japanese version of the EPDS (Cox et al., 1987; Okano et al., 1996). The EPDS is a self-report

Table 2
Sociodemographic statistics on the children.

Variable	Count	%
Child		
Twins or singles		
Singles	697	88.3 %
Twins	92	11.7 %
Total	789	
Birth size		
Appropriate for gestational age	673	94.9 %
Heavy for gestational age	13	1.8 %
Light for gestational age	23	3.2 %
Total	709	
Gender of child		
Boy	249	50.3 %
Girl	246	49.7 %
Total	495	
Family members living together with the child		
Number of siblings		
One	276	75.4 %
Two	77	21.0 %
Three	10	2.7 %
Four	3	0.8 %
Total	366	
Maternal grandfather		
No	752	95.6 %
Yes	35	4.4 %
Total	787	
Paternal grandfather		
No	738	93.8 %
Yes	49	6.2 %
Total	787	
Maternal grandmother		
No	738	93.8 %
Yes	49	6.2 %
Total	787	
Paternal grandmother		
No	720	91.5 %
Yes	67	8.5 %
Total	787	
Father		
No	31	3.9 %
Yes	756	96.1 %
Total	787	

Note. Responses were collected from pregnant mothers.

questionnaire developed to assist health professionals in detecting mothers suffering from postpartum depression, a distressing disorder more prolonged than the "blues," which can begin in the first week after delivery (Cox et al., 1987). The EPDS comprises 10 short statements; the mother checks one of four possible answers that best represents how she felt during the past week. Responses are scored as 0, 1, 2, or 3 based on symptom severity. Items 3, 5, and 10 are reverse-scored (i.e., 3, 2, 1, and 0). The total score is determined by combining the scores of each of the 10 items. The Japanese version of the EPDS has been validated (Okano et al., 1996) and is widely used to assess perinatal depression. The EPDS subscales indicated by factor analysis using a sample of Japanese women were loss of pleasure (items 1 and 2), anxiety (items 3, 4, and 5), and depression (items 7, 8, and 9) (Kubota et al., 2014), which is similar to previous studies in other countries (King, 2012; Tuohy and McVey, 2008). The Japanese version of the EPDS has several recommended cutoff values. For mothers during pregnancy, a cutoff value of 12/13 points is suggested (Usuda et al., 2017). For postpartum depression in mothers, a cutoff value of ≥10 is recommended for the EPDS administered 4 days after delivery, and ≥ 13 for 1 month after delivery (Sasaki et al., 2019). A cutoff score of 8/9 has been found to identify probable postnatal depression in Japanese women, demonstrating a sensitivity of 75 % and a specificity of 93 % (Okano et al., 1996). For fathers at 4 weeks postpartum and 6 months, a cutoff value of 7/8 points is recommended (Nishigori et al., 2020; Nishimura and Ohashi, 2010). Despite these variations, we decided to use a cutoff score of 7/8 for fathers and 8/9 for mothers, as the latter choice is also supported by the EPDS manual (Cox et al., 2014). Means, standard deviations, coefficient alphas and omegas, and missing data percentage of the EPDS are presented in Table 3.

2.4. Data analysis

In the initial phase, a parallel-process latent class growth analysis (LCGA; Berlin et al., 2014) was employed to construct joint trajectories of depressive symptoms in both mothers and fathers. Parallel-process LCGA is a data-driven method that extends the typical univariate LCGA and permits the simultaneous examination of multiple growth trajectories via a limited number of classes. Trajectory classes are operationalized as groups of individuals who closely adhere to a consistent developmental trajectory (Andruff et al., 2009). Given that trajectories can be linear or quadratic, both growth models were employed, fitting models from one to six classes. The optimal classification solution was discerned by incrementally increasing the number of classes from one to six and evaluating each model using six indicators: the Bayesian information criterion (BIC), sample-size-adjusted BIC (aBIC), entropy, Lo-Mendell-Rubin adjusted ratio test (LMR-LRT), class size, model interpretability, and parsimony. The syntax for the selected model is presented in Supplementary Table 2.

In the following phase, an analysis of variance for the parents x group was conducted at each time point for the EPDS subscales of anhedonia, anxiety, and depression, to understand the characteristics of the groups indicated by the LCGA. In addition, the number and percentage of individuals exceeding the EPDS cutoff points were calculated for each point, parent, and group. In the parallel-process LCGA analysis, missing values were addressed using full information maximum likelihood (FIML) estimation and pairwise in other analyses. Parallel-process LCGA analysis was performed using Mplus 8.4, whereas other analyses were conducted using JASP (JASP Team, 2023).

3. Results

A four-class quadratic growth model was chosen based on the fit indices and the substantive interpretability of the trajectory classes. Table 4 presents the fit indices that supported this decision. For the linear growth models, BIC and aBIC decreased as class numbers increased, and this decline became notably less pronounced starting from the five-class model. Five- and six-class models were excluded owing to the insufficient size of the smallest class ($n < 5$ %). Although LMR-LRT and entropy did not support the four-class model, BIC and aBIC were best for four or fewer classes. Significantly, the model's selection was grounded not only in statistical indices but also in the discernibility and relevance of each class. Upon detailed examination of each class model, the "new class" in the four-class model evidently held significant distinction and relevance compared to the previous classes, especially when juxtaposed with the three-class model. Ultimately, owing to the superior fit of the quadratic model compared to the linear model, the four-class quadratic model was finally chosen.

Fig. 1 illustrates the four joint trajectory classes of depressive symptoms for mothers and fathers. The corresponding slopes and trajectory intercepts are listed in Table 5. The spaghetti plots for each class are shown in Supplementary Figs. 1–4, respectively. Class 1, constituting 58.42 % of the total sample ($n = 458$), was characterized by parents with consistently low EPDS scores throughout the period. Consequently, this class was termed the "mother and father's low depressive symptom trajectory." Class 2, accounting for 17.86 % of the total sample ($n = 140$), displayed a pattern in which mothers' EPDS scores remained persistently high, whereas fathers' scores were consistently low. Hence, this class was labeled the "mother's high and father's low depressive symptom trajectory." Class 3, representing 17.22 % of the total sample ($n = 135$), comprised fathers with moderate EPDS scores and mothers with low scores. Accordingly, it was designated as the "mother's low and father's moderate depressive symptom trajectory." Class 4,

Table 3
Descriptive statistics and reliability coefficients for the Edinburgh Postnatal Depression Scale.

	Mothers					Fathers				
Age of child	*Mean*	*SD*	*missing (%)*	*ω*	*α*	*Mean*	*SD*	*missing (%)*	*ω*	*α*
Prenatally	5.857	3.674	3.5 %	0.847	0.829	4.472	2.808	29.4 %	0.753	0.732
5 weeks	4.298	3.555	37.9 %	0.855	0.834	4.029	3.039	47.1 %	0.818	0.794
3 months	3.693	3.102	43.0 %	0.822	0.792	3.691	3.110	51.6 %	0.867	0.827
6 months	3.692	3.624	48.2 %	0.872	0.854	3.502	2.804	60.3 %	0.809	0.768
1 years	3.606	3.419	59.8 %	0.843	0.824	3.067	2.704	69.8 %	0.812	0.775
2 years	3.592	3.114	73.9 %	0.824	0.806	3.537	3.614	81.1 %	0.881	0.857
3 years	3.987	3.460	80.1 %	0.838	0.813	3.345	3.184	86.1 %	0.860	0.848
4 years	3.800	2.954	82.9 %	0.805	0.767	3.947	3.650	88.1 %	0.859	0.848
5 years	4.185	3.067	84.9 %	0.806	0.779	4.387	4.576	90.5 %	0.912	0.905
6 years	4.672	3.743	85.3 %	0.857	0.844	4.074	4.086	91.4 %	0.902	0.892
7 years	4.044	3.177	85.6 %	0.814	0.798	3.875	3.355	91.9 %	0.885	0.860
8 years	4.922	3.825	85.3 %	0.860	0.848	4.226	4.252	92.1 %	0.916	0.895
9 years	4.579	3.676	86.4 %	0.842	0.822	4.362	4.443	92.6 %	0.907	0.896
10 years	4.423	4.170	86.8 %	0.894	0.881	4.435	3.583	92.1 %	0.884	0.862

Table 4
Model fit indexes for linear growth and quadratic growth models of the Edinburgh Postnatal Depression Scale.

	BIC	Difference in BIC	aBIC	Difference in aBIC	Entropy	LMR-LRT	Smallest class (%)
Linear growth models							
1-class model	33,147.685	–	33,046.069	–	–	–	–
2-class model	31,839.808	1307.877	31,722.314	1323.755	0.754	0.162	24.2 %
3-class model	31,159.228	680.580	31,025.857	696.457	0.765	0.106	9.7 %
4-class model	30,836.339	322.889	30,687.090	338.767	0.666	0.359	6.8 %
5-class model	30,587.200	249.139	30,422.074	265.016	0.684	0.347	4.3 %
6-class model	30,433.452	153.748	30,252.448	169.626	0.678	0.495	3.7 %
Quadratic growth models							
1-class model	33,100.125	–	32,992.157	–	–	–	–
2-class model	31,791.870	1308.255	31,661.675	1330.482	0.780	0.012	22.6 %
3-class model	31,099.303	692.567	30,946.879	714.796	0.783	0.086	8.7 %
4-class model	30,785.497	313.806	30,610.844	336.035	0.681	0.699	6.5 %
5-class model	30,544.165	241.332	30,347.283	263.561	0.708	0.434	3.4 %
6-class model	30,408.978	135.187	30,189.868	157.415	0.713	0.241	2.2 %

Note. BIC: Bayesian information criterion; aBIC: sample-size-adjusted BIC; LMR-LRT: Lo-Mendell-Rubin adjusted ratio test.

encompassing 6.51 % of the total sample ($n = 51$), captured a trend in which the father's EPDS scores and mother's scores both increased progressively over time. This class was thus referred to as the "mothers and fathers' escalating depression symptom trajectory." Supplementary Table 3 shows the parameters of the four quadratic growth models of the EPDS when complete data are used. Additionally, the four trajectory classes of mothers and fathers' depressive symptoms using complete data are shown in Supplementary Fig. 5.

Based on the classification of the four types of classes, we examined the mean and SD on the subscales and the presence of class-parent interactions between the same time points. For anhedonia (Table 6), there was a class-parent interaction at all time points. For anxiety (Table 7), there was a class-parent interaction at all time points. For depression (Table 8), there was a class and parent interaction at all time points. In addition, the number and percentage of samples above the cutoff point of the EPDS at each time point based on the four types of class are shown in Table 9 for each class and parent. The overall trend was a prevalence of 19.05 % for women and 13.11 % for men during pregnancy, with a decrease in prevalence for both after 5 weeks postpartum. Individually, with the exception of class 1, mothers and fathers showed a decrease in prevalence from gestational age to 5 weeks postpartum, but then maintained a constant prevalence and also showed a trend toward an increase.

4. Discussion

This study examined the joint trajectories of mothers and fathers' depressive symptoms for the 10 years after childbirth. A model of paternal-maternal depressive quadratic curves revealed four joint trajectories: "Class 1. mother's and father's low depressive symptom trajectory," "Class 2. mother's high and father's low depressive symptom trajectory," "Class 3. mother's low and father's moderate depressive symptom trajectory," and "Class 4. mother's and father's escalating depressive symptom trajectory." For these four classes and parents, we compared the EPDS subscales of anhedonia, anxiety, and depression and found class-parent interactions on the subscales as well, continuing for 10 years. Some characteristics also revealed how the prevalence of postpartum depression decreased across classes using the cutoff points of the EPDS.

Our finding regarding four joint trajectories of mothers and fathers' depression is consistent with expectations based on prior research on maternal and paternal depressive trajectories. First, with respect to mothers, prior studies have reported low stability, low increasing, moderately decreasing, and high and stable as trajectories of depressive symptoms during pregnancy and the perinatal period (Ahmed et al., 2019; Putnick et al., 2020; Severo et al., 2023). The exact number of depressive trajectories probably depends on the characteristics of the sample, the methods used, and the statistical criteria applied; however, gradual increases and high stability are problematic. Research indicates that depressive symptoms tend to stabilize over time, with a gradual increase in severity (Tram and Cole, 2006). In this study, most participants had low-stability trajectories; however, some groups were characterized by gradual increases and high stability. These trajectories are consistent with a review of previous studies (Vliegen et al., 2014), which found that although most women recovered from postpartum depression, it became chronic in a relatively large subgroup. Research has shown that postpartum depression can last up to 6 months postpartum in both mothers and fathers (Paulson et al., 2016). Prior studies have also

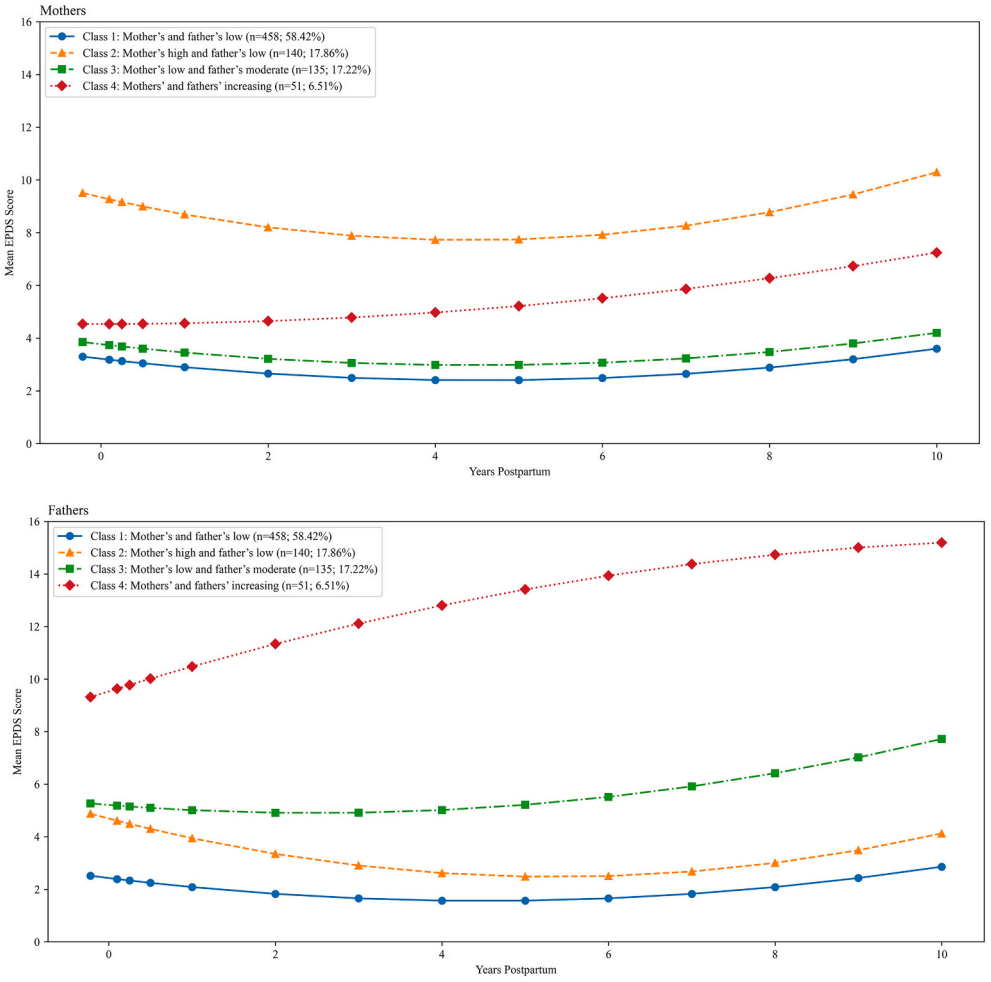

Fig. 1. Four joint trajectory classes of depressive symptoms for both mothers and fathers.

Table 5
Growth parameters for the selected fourth-order quadratic growth model of the Edinburgh Postnatal Depression Scale (EPDS).

			Mother's EPDS						Father's EPDS					
			Intercept		Linear		Quadratic		Intercept		Linear		Quadratic	
Class 1	Mother's and father's low depressive symptom trajectory	Estimate	3.218	***	−0.362	***	0.040	***	2.428	***	−0.387	***	0.043	***
		S.E.	0.164		0.074		0.008		0.120		0.077		0.009	
Class 2	Mother's high and father's low depressive symptom trajectory	Estimate	9.341	***	−0.735		0.083		4.692	***	−0.827	***	0.077	**
		S.E.	1.304		0.495		0.051		0.613		0.216		0.025	
Class 3	Mother's low and father's moderate depressive symptom trajectory	Estimate	3.769	***	−0.357	**	0.040	**	5.210	***	−0.249		0.050	*
		S.E.	0.469		0.127		0.014		0.224		0.167		0.019	
Class 4	Mothers' and fathers' escalating depression symptom trajectory	Estimate	4.535	**	0.001		0.027		9.534	***	0.986	*	−0.042	
		S.E.	1.572		1.239		0.145		0.778		0.458		0.051	

Note.
* $p < 0.05$;
** $p < 0.01$;
*** $p < 0.001$.

shown that depressive symptoms can persist for up to 11 years postpartum (Mughal et al., 2023). Previous studies have shown that prolonged perinatal depression can have significant negative effects on children, marriage, and other relationships (Hanington et al., 2012; Lee and Chung, 2007). Our findings align with those of Kiviruusu et al. (2020), who similarly reported that perinatal depression, whether mild or severe, often begins during pregnancy. However, our study extends this by examining postpartum depression over a longer period. This underscores the importance of early detection (even before pregnancy) and highlights the need for appropriate treatment efforts (Cuijpers et al., 2023; Stuart and Koleva, 2014).

Prior research on fathers has identified three depressive trajectories: high, medium, and low postpartum depression (Kiviruusu et al., 2020). However, studies of trajectories of postpartum depression in fathers are

Table 6
Descriptive statistics on anhedonia by class and parents.

		Class 1		Class 2		Class 3		Class 4		ANOVA					
		Mother's and father's low depressive symptom trajectory (N = 458)		Mother's high and father's low depressive symptom trajectory (*N* = 140)		Mother's low and father's moderate depressive symptom trajectory (*N* = 135)		Mothers' and fathers' escalating depression symptom trajectory (*N* = 51)		Class		Parents		Class×parents	
Age of child		Mothers	Fathers	Mothers	Fathers	Mothers	Fathers	Mothers	Fathers	*p*	η^2	*p*	η^2	*p*	η^2
Prenatally	mean	0.066	0.027	0.564	0.031	0.044	0.110	0.118	0.800	<0.001	0.065	0.185	0.001	<0.001	0.079
	SD	0.296	0.161	0.961	0.174	0.240	0.467	0.431	1.254						
5 weeks	mean	0.096	0.009	0.714	0.119	0.153	0.168	0.278	1.000	<0.001	0.107	0.753	0.000	<0.001	0.072
	SD	0.416	0.092	0.901	0.494	0.615	0.476	0.659	0.947						
3 months	mean	0.040	0.019	0.464	0.175	0.082	0.195	0.057	0.714	<0.001	0.080	0.002	0.010	<0.001	0.060
	SD	0.281	0.194	0.778	0.504	0.312	0.502	0.338	0.937						
6 months	mean	0.064	0.028	0.537	0.048	0.023	0.227	0.077	1.000	<0.001	0.061	0.003	0.010	<0.001	0.082
	SD	0.359	0.248	1.092	0.216	0.216	0.535	0.272	1.338						
1 years	mean	0.047	0.016	0.436	0.114	0.056	0.167	0.273	0.800	<0.001	0.079	0.172	0.003	<0.001	0.039
	SD	0.284	0.176	0.898	0.404	0.285	0.587	0.631	1.082						
2 years	mean	0.055	0.025	0.528	0.053	0.063	0.231	0.077	1.091	<0.001	0.078	0.013	0.015	<0.001	0.096
	SD	0.298	0.224	1.000	0.229	0.320	0.667	0.277	0.944						
3 years	mean	0.024	0.034	0.500	0.000	0.050	0.344	0.222	1.286	<0.001	0.102	0.011	0.020	<0.001	0.095
	SD	0.155	0.184	0.990	0.000	0.221	0.902	0.667	0.951						
4 years	mean	0.056	0.143	0.125	0.067	0.029	0.481	0.333	1.400	<0.001	0.078	<0.001	0.050	0.007	0.048
	SD	0.232	0.645	0.448	0.258	0.171	0.935	0.816	1.949						
5 years	mean	0.062	0.000	0.250	0.091	0.000	0.435	0.250	2.250	<0.001	0.190	<0.001	0.101	<0.001	0.156
	SD	0.300	0.000	0.639	0.302	0.000	1.037	0.707	2.062						
6 years	mean	0.085	0.027	0.591	0.000	0.129	0.368	0.400	2.000	<0.001	0.130	0.025	0.022	<0.001	0.099
	SD	0.337	0.164	1.182	0.000	0.499	0.761	0.894	1.633						
7 years	mean	0.034	0.097	0.364	0.000	0.000	0.300	0.500	0.667	0.027	0.049	0.686	0.000	0.019	0.053
	SD	0.183	0.396	0.727	0.000	0.000	0.733	1.000	1.155						
8 years	mean	0.150	0.000	0.833	0.000	0.000	0.294	0.000	1.667	0.002	0.067	0.084	0.014	<0.001	0.131
	SD	0.444	0.000	1.239	0.000	0.000	0.588	0.000	2.082						
9 years	mean	0.179	0.000	0.333	0.000	0.240	0.500	0.400	1.750	<0.001	0.118	0.048	0.021	0.002	0.080
	SD	0.543	0.000	0.658	0.000	0.663	0.966	0.894	1.708						
10 years	mean	0.088	0.000	0.591	0.143	0.136	0.474	0.500	2.000	<0.001	0.158	0.017	0.028	<0.001	0.094
	SD	0.434	0.000	0.854	0.378	0.468	0.697	1.000	0.000						

scarce. The four joint trajectories shown in this study suggest that the depression experienced by many fathers is similar to that experienced by mothers. However, the joint trajectory characterized by extremely depressed fathers was different from the other trajectory groups because of the fathers' chronically elevated depression and a different form of depression trajectory from that of the mothers. This father's trajectory also appears to be similar to the "emergent depression" and "high increasing" shown in previous studies (Molgora et al., 2016; Nieh et al., 2022). The gradual worsening of postpartum depression in fathers may be related to various social factors that follow fatherhood. For example, factors such as masculine socialization, which involves the internalization of societal expectations of male behavior, and self-efficacy, which is the belief in one's ability to achieve goals, significantly influence paternal mental health during the transition to fatherhood (Singley and Edwards, 2015). In addition, the stigma and taboos around male mental health issues, particularly expressing vulnerabilities, along with the pressure to conform to masculine norms, can significantly hinder fathers with postpartum depression from seeking help (Pedersen et al., 2021). Therefore, men may be more vulnerable to stress due to various life events after childbirth.

For the four classification-based subscales, i.e., anhedonia, anxiety, and depression, there was an interaction between parent and class at the same time point. This indicates that at no time during the 10-year period were the means of the parents' EPDS subscales for the four classes derived from the total EPDS score the same. Additionally, in this study, the prevalence rates of depressive symptoms at 24 weeks of pregnancy were 19.05 % for mothers and 13.11 % for fathers. At 5 weeks postpartum, the prevalence rates were 10.82 % for mothers and 10.79 % for fathers. In previous studies targeting Japanese populations (Tokumitsu et al., 2020a, 2020b), the period prevalence of maternal depression from late pregnancy (6 months) to childbirth was 14.9 % (95 % CI 11.1–20.0 %), and the paternal prenatal prevalence was 8.5 % (95 % CI 3.3–20.3 %). The period prevalence of maternal postpartum depression 1 to 3 months postpartum was 11.0 % (95 % CI 8.8–13.7 %), and the period prevalence of paternal postpartum depression 1 to 3 months postpartum was 8.6 % (95 % CI 5.5–13.3 %). The overall prevalence rates were consistent with previous studies. Below, we discuss each class in detail based on the EPDS subscales and prevalence rates.

Class 1 maintained low values consistently across all EPDS subscales compared to the other groups. In Class 1, mothers' anxiety and depression values were slightly higher during pregnancy but approximately halved postpartum. Fathers had lower anxiety and depression compared to mothers, but these values still slightly decreased postpartum. The trends in prevalence rates for mothers and fathers showed a slight presence of symptoms only during the mothers' pregnancy, but overall, it was minimal throughout the entire period. Thus, Class 1 had stable, low symptoms based on the subscales and prevalence rates.

Class 2 had a tendency for higher total EPDS scores in mothers. In Class 2, mothers' values for all subscales were the highest among all mothers in any class. Similar to Class 1, anxiety and depression decreased postpartum. However, anhedonia significantly increased at 5 weeks postpartum, which was observed for both mothers and fathers. Studies targeting Japanese populations have shown that anhedonia, depression, and anxiety increase from pregnancy to 2 weeks postpartum if there is no childbirth experience, and then decrease thereafter (Takehara et al., 2018). In this study, only anhedonia increased at 5 weeks postpartum, which may be related to the pregnant woman's tendency to have bipolar disorder, as women with bipolar disorder have been reported to experience twice as much postpartum anhedonia as those with unipolar depression (Gollan et al., 2021). Anxiety and depression in mothers remained at high levels for 10 years postpartum. Conversely, anhedonia in mothers decreased over 4–5 years but showed an increasing trend again after 6 years. In Class 2, fathers' subscale values were higher than those of Class 1 fathers and were at the same

Table 7
Descriptive statistics on anxiety by class and parents.

		Class 1		Class 2		Class 3		Class 4		ANOVA					
		Mother's and father's low depressive symptom trajectory (N = 458)		Mother's high and father's low depressive symptom trajectory (N = 140)		Mother's low and father's moderate depressive symptom trajectory (N = 135)		Mothers' and fathers' escalating depression symptom trajectory (N = 51)		Class		Parents		Class×parents	
Age of child		Mothers	Fathers	Mothers	Fathers	Mothers	Fathers	Mothers	Fathers	p	η^2	p	η^2	p	η^2
Prenatally	mean	2.829	1.828	5.386	3.143	3.207	3.744	3.471	4.913	<0.001	0.195	0.003	0.004	<0.001	0.079
	SD	1.634	1.301	1.786	1.478	1.603	1.274	1.617	1.029						
5 weeks	mean	1.425	1.470	4.610	2.881	2.273	3.316	2.528	4.967	<0.001	0.266	<0.001	0.009	<0.001	0.078
	SD	1.374	1.319	1.822	1.723	1.725	1.468	1.765	1.326						
3 months	mean	1.304	1.237	4.435	2.491	1.732	3.034	2.029	5.071	<0.001	0.248	<0.001	0.016	<0.001	0.120
	SD	1.366	1.254	1.631	1.649	1.558	1.579	1.706	1.538						
6 months	mean	1.215	1.017	4.561	2.429	1.581	3.533	1.880	4.650	<0.001	0.258	<0.001	0.014	<0.001	0.138
	SD	1.295	1.105	1.993	1.564	1.655	1.528	1.666	1.424						
1 years	mean	1.124	0.822	4.236	1.944	1.583	2.783	1.773	4.533	<0.001	0.235	0.034	0.005	<0.001	0.129
	SD	1.342	0.996	1.934	1.472	1.590	1.541	1.572	1.727						
2 years	mean	1.321	0.762	3.750	2.053	1.333	3.154	2.077	5.636	<0.001	0.247	<0.001	0.027	<0.001	0.169
	SD	1.367	0.903	1.857	1.508	1.226	1.548	1.754	1.748						
3 years	mean	1.366	1.000	4.423	1.538	2.225	2.719	2.000	5.000	<0.001	0.198	0.805	0.000	<0.001	0.127
	SD	1.291	1.155	2.003	1.266	1.747	1.486	1.732	1.291						
4 years	mean	1.394	1.313	4.000	1.600	2.147	2.962	2.500	5.200	<0.001	0.168	0.381	0.002	<0.001	0.109
	SD	1.293	1.371	1.978	1.502	1.654	1.732	2.168	1.924						
5 years	mean	1.631	1.308	4.000	2.000	2.308	3.217	3.875	7.000	<0.001	0.294	0.151	0.007	<0.001	0.100
	SD	1.318	1.398	1.376	1.789	1.463	1.622	2.357	1.826						
6 years	mean	1.864	1.216	4.455	2.000	1.903	3.421	2.200	6.000	<0.001	0.152	0.115	0.009	<0.001	0.148
	SD	1.766	1.250	1.945	1.852	1.326	1.710	1.304	1.633						
7 years	mean	1.678	1.290	3.955	1.636	1.448	3.200	3.500	6.000	<0.001	0.175	0.241	0.005	<0.001	0.164
	SD	1.479	1.553	1.253	1.502	1.352	1.436	0.577	0.000						
8 years	mean	1.950	1.273	4.375	2.111	2.036	3.471	4.250	8.000	<0.001	0.247	0.128	0.008	<0.001	0.126
	SD	1.672	1.442	1.663	1.764	1.290	1.736	0.957	1.000						
9 years	mean	1.607	1.100	4.667	1.625	2.240	4.125	2.200	5.250	<0.001	0.196	0.331	0.004	<0.001	0.166
	SD	1.734	1.213	1.528	1.598	1.786	1.310	1.483	2.872						
10 years	mean	1.456	1.382	4.727	2.286	2.091	3.737	2.000	6.000	<0.001	0.202	0.047	0.014	<0.001	0.127
	SD	1.501	1.498	1.518	1.799	1.477	1.284	2.309	0.000						

level or slightly lower than those of Class 3 fathers. Fathers' anhedonia increased around 3 months postpartum but decreased thereafter. The tendency for mothers to exceed the cutoff points was observed in 97 out of 139 mothers during pregnancy, with a certain percentage of prevalence thereafter. Class 2, with high subscale and prevalence rates for mothers, is considered to have a very high rate of postpartum depression, indicating that psychological support is most needed for mothers in this group.

Class 3 showed slightly higher total EPDS scores for fathers. Compared to other groups except Class 4, fathers in Class 3 consistently had higher values for all subscales from pregnancy to postpartum. Fathers' anxiety and depression decreased postpartum, but anhedonia increased. Fathers' anhedonia increased from pregnancy, began to decrease after 4–5 years, and increased again after 9–10 years. Mothers' subscale values were slightly higher than those of Class 1, but after one year, they maintained almost the same values as Class 1 mothers. The tendency for fathers to exceed the cutoff points was observed in 20 out of 117 fathers during pregnancy, gradually decreasing thereafter, but there were always a few with symptoms in any period. Class 3 highlights the need to observe postpartum depression from perspectives other than depression and anxiety, with slightly higher and long-lasting anhedonia in fathers.

Class 4 exhibited a gradual increase in total EPDS scores for both mothers and fathers over time. This group had higher subscale values for fathers compared to other groups. Fathers in this group did not show the postpartum decrease in subscale values seen in many other classes, maintaining high levels of anhedonia and anxiety, with increasing depression. For mothers, all subscale values were slightly higher during pregnancy compared to those of mothers in other classes, except for Class 2. These values decreased slightly over the first year but fluctuated thereafter. The tendency for mothers and fathers to exceed the cutoff points was observed in 13 out of 49 mothers and 36 out of 45 fathers during pregnancy, with particularly high prevalence in fathers. Mothers' prevalence decreased, but fathers' prevalence remained almost flat. Class 4 indicates that postpartum depression is particularly severe in fathers, maintaining high subscale values, highlighting the need for continuous psychological care for fathers in this group.

4.1. Implications of the study for research and practice

The findings of this study underscore the importance of early detection and intervention for depressive symptoms in both mothers and fathers, beginning during pregnancy or even pre-pregnancy. Healthcare providers should implement routine screening for both parents using tools like the EPDS throughout the perinatal period. Universal screening programs have been shown to increase detection and treatment, leading to improved maternal mental health outcomes (Avalos et al., 2016). Mental health support programs should be tailored to the specific needs of each trajectory class. For instance, mothers in Class 2 and fathers in Class 4, who exhibit higher and prolonged depressive symptoms, require more intensive and continuous psychological support (Field et al., 2000; Kieffer et al., 2013).

The study also highlights the need for extended longitudinal research to capture the full trajectory of depressive symptoms and their long-term impacts, as well as comparative studies across different cultural settings to identify universal versus culture-specific patterns in perinatal depression (Yu et al., 2020). Reducing the stigma around perinatal mental health issues, particularly for fathers, is crucial to encourage parents to seek help. Understanding interparental processes and the role of partner-related attachment can help in tailoring preventive and treatment efforts to address both parents' needs (Fredriksen et al., 2019). Integrated care models that involve collaboration between obstetricians, pediatricians, and mental health professionals can provide holistic care for families during the perinatal period, ultimately

Table 8
Descriptive statistics on depression by class and parents.

		Class 1		Class 2		Class 3		Class 4		ANOVA					
		Mother's and father's low depressive symptom trajectory (N = 458)		Mother's high and father's low depressive symptom trajectory (N = 140)		Mother's low and father's moderate depressive symptom trajectory (N = 135)		Mothers' and fathers' escalating depression symptom trajectory (N = 51)		Class		Parents		Class×parents	
Age of child		Mothers	Fathers	Mothers	Fathers	Mothers	Fathers	Mothers	Fathers	p	η^2	p	η^2	p	η^2
Prenatally	mean	0.394	0.139	2.321	0.735	0.481	0.678	0.922	2.196	<0.001	0.202	0.166	0.000	<0.001	0.094
	SD	0.774	0.439	1.859	0.914	0.761	0.815	1.074	1.439						
5 weeks	mean	0.221	0.068	1.974	0.644	0.424	0.600	0.750	2.467	<0.001	0.223	0.175	0.001	<0.001	0.104
	SD	0.536	0.269	1.754	1.242	0.927	0.721	1.079	1.814						
3 months	mean	0.216	0.094	1.580	0.421	0.278	0.580	0.714	2.179	<0.001	0.194	0.080	0.003	<0.001	0.112
	SD	0.524	0.378	1.519	0.755	0.573	0.893	1.073	1.634						
6 months	mean	0.189	0.051	1.970	0.286	0.209	0.440	0.385	2.050	<0.001	0.175	0.810	0.000	<0.001	0.155
	SD	0.499	0.244	1.834	0.554	0.463	0.775	0.898	1.234						
1 years	mean	0.225	0.031	1.927	0.417	0.181	0.400	0.591	1.933	<0.001	0.167	0.717	0.000	<0.001	0.106
	SD	0.670	0.215	2.017	0.806	0.613	0.694	0.908	1.280						
2 years	mean	0.200	0.136	2.000	0.421	0.271	0.590	0.462	3.000	<0.001	0.164	0.027	0.009	<0.001	0.143
	SD	0.485	0.494	2.111	0.838	0.676	0.910	0.660	2.366						
3 years	mean	0.244	0.034	2.077	0.154	0.525	0.469	0.667	2.857	<0.001	0.177	0.998	0.000	<0.001	0.154
	SD	0.600	0.184	1.742	0.555	0.960	0.671	1.323	1.676						
4 years	mean	0.169	0.265	1.417	0.200	0.353	0.815	2.000	3.400	<0.001	0.223	0.309	0.003	<0.001	0.076
	SD	0.478	0.700	1.767	0.561	0.812	1.145	2.098	1.673						
5 years	mean	0.108	0.079	2.100	0.364	0.444	1.318	2.125	5.000	<0.001	0.401	0.006	0.019	<0.001	0.158
	SD	0.312	0.487	1.619	0.674	0.892	1.211	1.885	1.414						
6 years	mean	0.424	0.108	2.045	0.250	0.677	0.789	1.200	4.250	<0.001	0.186	0.255	0.005	<0.001	0.128
	SD	0.932	0.315	1.889	0.463	1.045	1.084	1.304	1.708						
7 years	mean	0.220	0.097	2.136	0.273	0.483	1.350	1.250	3.000	<0.001	0.162	0.519	0.002	<0.001	0.137
	SD	0.696	0.539	2.031	0.467	0.949	1.268	1.500	1.000						
8 years	mean	0.350	0.152	2.500	0.333	0.679	1.176	2.000	4.667	<0.001	0.215	0.455	0.002	<0.001	0.120
	SD	0.685	0.566	2.207	0.707	1.056	0.951	1.414	2.887						
9 years	mean	0.350	0.152	2.500	0.333	0.679	1.176	2.000	4.667	<0.001	0.215	0.455	0.002	<0.001	0.120
	SD	0.685	0.566	2.207	0.707	1.056	0.951	1.414	2.887						
10 years	mean	0.304	0.176	2.682	0.000	0.227	1.632	1.750	3.000	<0.001	0.129	0.894	0.000	<0.001	0.180
	SD	0.658	0.576	2.169	0.000	0.528	1.535	2.062	0.000						

enhancing family well-being and resilience (Simas et al., 2019). Perinatal depression is not only a problem for mothers but also for fathers, and addressing these issues requires collaboration among various community professionals and families.

5. Limitations

While providing valuable insights into postpartum depression in parents for over a decade, this study has several limitations that must be acknowledged. The primary constraint is the reduction in sample size over time. As the study progressed, participant attrition led to a smaller sample size, which could have potentially affected the representativeness and generalizability of the findings. To address this issue, FIML estimation was employed. FIML is a statistical method used to handle missing data and estimate missing values based on available data. While FIML is a robust approach to dealing with incomplete data, it is important to note that it relies on assumptions and estimations, which may not fully compensate for the loss of data. Additionally, sample size reduction might have diminished the capacity to detect more nuanced or less common patterns of postpartum depression trends. Insufficient tracking of marital status is another issue to consider. Controlling for changes in marital status is important, as trajectories of depression may be affected by changes in relationship status. Another limitation is the inherent nature of longitudinal studies in which changes in societal norms, healthcare practices, and economic conditions over a decade could have influenced the results. To clarify, these changes may include shifts in cultural attitudes toward mental health, improvements in medical care and support systems for postpartum depression, and economic fluctuations that affect family stress levels and access to healthcare services. While these examples are relevant to the context of Japan, where this study was conducted, similar trends may also be observed in other countries with comparable economic development and healthcare systems. Furthermore, the focus of the study on a specific geographical area or demographics may limit the applicability of the findings to a broader population.

6. Conclusion

This 10-year longitudinal study identified four distinct joint trajectories of mothers and fathers' depressive symptoms from pregnancy to postpartum: low and stable for both parents, high for mothers and low for fathers, moderate for fathers and low for mothers, and escalating for both parents. The findings emphasize the importance of early detection and continuous monitoring of depressive symptoms, including anhedonia, anxiety, and depression, in both parents. Tailored mental health support programs are critical, especially for mothers in Class 2 and fathers in Class 4, who exhibit higher and prolonged symptoms. Despite limitations such as sample size reduction and external factors influencing results, the study adds to the growing body of knowledge on postpartum depression, underscoring the need for comprehensive and targeted approaches to support families and improve mental health outcomes through timely and appropriate interventions. Future research should include larger, more diverse populations to enhance generalizability and explore effective long-term intervention strategies.

Role of the funding source

This research was supported by Grants-in-Aid for Scientific Research (KAKENHI) from the Japan Society for the Promotion of Science (JSPS), Grant Numbers JP 22530731, JP25380869, JP16K04292, and JP19K03251.

Table 9
Number and percentage of samples above cutoff point for the Edinburgh Postnatal Depression Scale.

		Class 1		Class 2		Class 3		Class 4		Total	
		Mother's and father's low depressive symptom trajectory (N = 458)		Mother's high and father's low depressive symptom trajectory (N = 140)		Mother's low and father's moderate depressive symptom trajectory (N = 135)		Mothers' and fathers' escalating depression symptom trajectory (N = 51)			
Age of child	Above cutoff	Mothers	Fathers	Mothers	Fathers	Mothers	Fathers	Mothers	Fathers	Mothers	Fathers
Prenatally	no	414	296	42	82	124	97	36	9	616	484
	yes	26	2	97	15	9	20	13	36	145	73
	%	5.9 %	0.7 %	69.8 %	15.5 %	6.8 %	17.1 %	26.5 %	80.0 %	19.1 %	13.1 %
5 weeks	no	277	232	35	54	94	82	31	4	437	372
	yes	2	1	42	5	4	13	5	26	53	45
	%	0.7 %	0.4 %	54.5 %	8.5 %	4.1 %	13.7 %	13.9 %	86.7 %	10.8 %	10.8 %
3 months	no	246	209	46	52	96	73	31	5	419	339
	yes	3	1	23	5	1	14	4	23	31	43
	%	1.2 %	0.5 %	33.3 %	8.8 %	1.0 %	16.1 %	11.4 %	82.1 %	6.9 %	11.3 %
6 months	no	231	177	37	39	85	62	23	4	376	282
	yes	1	0	29	3	1	12	2	16	33	31
	%	0.4 %	0.0 %	43.9 %	7.1 %	1.2 %	16.2 %	8.0 %	80.0 %	8.1 %	9.9 %
1 years	no	166	128	33	33	70	54	20	5	289	220
	yes	2	0	22	2	2	6	2	10	28	18
	%	1.2 %	0.0 %	40.0 %	5.7 %	2.8 %	10.0 %	9.1 %	66.7 %	8.8 %	7.6 %
2 years	no	108	79	24	17	47	35	13	1	192	132
	yes	1	1	12	2	1	4	0	10	14	17
	%	0.9 %	1.3 %	33.3 %	10.5 %	2.1 %	10.3 %	0.0 %	90.9 %	6.8 %	11.4 %
3 years	no	82	58	15	13	38	29	8	2	143	102
	yes	0	0	11	0	2	3	1	5	14	8
	%	0.0 %	0.0 %	42.3 %	0.0 %	5.0 %	9.4 %	11.1 %	71.4 %	8.9 %	7.3 %
4 years	no	71	47	15	15	33	20	4	1	123	83
	yes	0	1	9	0	1	6	2	4	12	11
	%	0.0 %	2.1 %	37.5 %	0.0 %	2.9 %	23.1 %	33.3 %	80.0 %	8.9 %	11.7 %
5 years	no	64	37	8	11	25	18	4	0	101	66
	yes	1	1	12	0	1	4	4	4	18	9
	%	1.5 %	2.6 %	60.0 %	0.0 %	3.8 %	18.2 %	50.0 %	100.0 %	15.1 %	12.0 %
6 years	no	52	37	7	8	27	17	4	0	90	62
	yes	7	0	15	0	3	2	1	4	26	6
	%	11.9 %	0.0 %	68.2 %	0.0 %	10.0 %	10.5 %	20.0 %	100.0 %	22.4 %	8.8 %
7 years	no	58	30	13	11	29	15	3	0	103	56
	yes	1	1	9	0	0	4	1	3	11	8
	%	1.7 %	3.2 %	40.9 %	0.0 %	0.0 %	21.1 %	25.0 %	100.0 %	9.6 %	12.5 %
8 years	no	57	32	12	9	27	11	3	0	99	52
	yes	3	1	12	0	1	6	1	3	17	10
	%	5.0 %	3.0 %	50.0 %	0.0 %	3.6 %	35.3 %	25.0 %	100.0 %	14.7 %	16.1 %
9 years	no	54	30	12	8	24	11	4	0	94	49
	yes	2	0	9	0	1	5	1	4	13	9
	%	3.6 %	0.0 %	42.9 %	0.0 %	4.0 %	31.3 %	20.0 %	100.0 %	12.1 %	15.5 %
10 years	no	56	32	8	7	20	12	3	0	87	51
	yes	0	2	14	0	2	7	1	2	17	11
	%	0.0 %	5.9 %	63.6 %	0.0 %	9.1 %	36.8 %	25.0 %	100.0 %	16.3 %	17.7 %

CRediT authorship contribution statement

Takahiro Kubo: Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Yasumitsu Jikihara:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **Naoya Todo:** Writing – review & editing, Methodology. **Misako Aramaki:** Writing – review & editing. **Naomi Shiozaki:** Writing – review & editing. **Satoko Ando:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Data curation.

Declaration of competing interest

While the dataset analyzed in this study partially overlaps with a cross-lag analysis study by Jikihara et al. (2023) examining behavioral problem scores in children's aged 3–10 years, we deemed it suitable for publication because of the distinct research objectives.

The authors declare no conflict of interest.

During the preparation of this work the authors used ChatGPT in order to enhance the language and ensure that the paper conforms to the standards of scholarly journals. After using this tool/service, the authors reviewed and edited the content as needed and take(s) full responsibility for the content of the publication. The data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgement

We would like to thank Editage (www.editage.com) for English language editing.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2024.09.154.

References

Ahmed, A., Bowen, A., Feng, C.X., Muhajarine, N., 2019. Trajectories of maternal depressive and anxiety symptoms from pregnancy to five years postpartum and their prenatal predictors. BMC Pregnancy Childbirth 19 (1), 1–10. https://doi.org/10.1186/s12884-019-2177-y.

Andruff, H., Carraro, N., Thompson, A., Gaudreau, P., Louvet, B., 2009. Latent class growth modelling: a tutorial. Tutorials in quantitative methods for psychology 5 (1), 11–24. https://doi.org/10.20982/tqmp.05.1.p011.

Avalos, L., Raine-Bennett, T., Chen, H., Adams, A., Flanagan, T., 2016. Improved perinatal depression screening, treatment, and outcomes with a universal obstetric program. Obstet. Gynaecol. 127, 917–925. https://doi.org/10.1097/AOG.0000000000001403.

Berlin, K.S., Parra, G.R., Williams, N.A., 2014. An introduction to latent variable mixture modeling (part 2): longitudinal latent class growth analysis and growth mixture models. J. Pediatr. Psychol. 39 (2), 188–203. https://doi.org/10.1093/jpepsy/jst085.

Cameron, E.E., Sedov, I.D., Tomfohr-Madsen, L.M., 2016. Prevalence of paternal depression in pregnancy and the postpartum: an updated meta-analysis. J. Affect. Disord. 206, 189–203. https://doi.org/10.1016/j.jad.2016.07.044.

Costa, D., Danieli, C., Abrahamowicz, M., Dasgupta, K., Sewitch, M., Lowensteyn, I., Zelkowitz, P., 2019. A prospective study of postnatal depressive symptoms and associated risk factors in first-time fathers. J. Affect. Disord. 249, 371–377. https://doi.org/10.1016/j.jad.2019.02.033.

Cox, J., Holden, J., Henshaw, C., 2014. Perinatal Mental Health: The Edinburgh Postnatal Depression Scale (EPDS) Manual, 2nd edn. RCPsych Publications.

Cox, J.L., Holden, J.M., Sagovsky, R., 1987. Detection of postnatal depression: development of the 10-item Edinburgh postnatal depression scale. Br. J. Psychiatry 150, 782–786. https://doi.org/10.1192/bjp.150.6.782.

Cuijpers, P., Franco, P., Ciharova, M., Miguel, C., Segre, L., Quero, S., Karyotaki, E., 2023. Psychological treatment of perinatal depression: a meta-analysis. Psychol. Med. 53 (6), 2596–2608. https://doi.org/10.1017/S0033291721004529.

Dadi, A.F., Akalu, T.Y., Wolde, H.F., Baraki, A.G., 2022. Effect of perinatal depression on birth and infant health outcomes: a systematic review and meta-analysis of observational studies from Africa. Arch. Public Health 80 (1), 1–11. https://doi.org/10.1186/s13690-022-00792-8.

Dennis, C., Vigod, S., Grigoriadis, S., Brown, H., Brennenstuhl, S., Dol, J., Wade, M., Falah-Hassani, K., Shiri, R., Marini, F., 2023. Cohort profile: impact of maternal and paternal mental health – assessing concurrent depression, anxiety and comorbidity in the Canadian family (IMPACT study). BMJ Open 13. https://doi.org/10.1136/bmjopen-2023-071691.

Field, T., Pickens, J., Prodromidis, M., Malphurs, J., Fox, N., Bendell, D., Yando, R., Schanberg, S., Kuhn, C., 2000. Targeting adolescent mothers with depressive symptoms for early intervention. Adolescence 35 (138), 381–414.

Fredriksen, E., Soest, T., Smith, L., Moe, V., 2019. Depressive symptom contagion in the transition to parenthood: Interparental processes and the role of partner-related attachment. J. Abnorm. Psychol. 128 (5), 397–403. https://doi.org/10.1037/abn0000429.

Gollan, J.K., Yang, A., Ciolino, J.D., Sit, D., Wisner, K.L., 2021. Postpartum anhedonia: emergent patterns in bipolar and unipolar depression. Psychiatry Res. 306, 114274. https://doi.org/10.1016/j.psychres.2021.114274.

Hanington, L., Heron, J., Stein, A., Ramchandani, P., 2012. Parental depression and child outcomes–is marital conflict the missing link? Child Care Health Dev. 38 (4), 520–529. https://doi.org/10.1111/j.1365-2214.2011.01270.x.

Ierardi, J.A., Fantasia, H.C., Mawn, B., Watson Driscoll, J., 2019. The experience of men whose partners have postpartum depression. J. Am. Psychiatr. Nurses Assoc. 25 (6), 434–444. https://doi.org/10.1177/1078390319849102.

Jikihara, Y., Todo, N., Aramaki, M., Shiozaki, N., Kubo, T., Ando, S., 2023. The interrelationship between externalizing and internalizing problems over time and prosocial behaviors from late infancy to late childhood: A developmental cascade study using a cross-lagged panel model with eight years of longitudinal data. Jpn. J. Dev. Psychol. 34 (3), 208–218. https://doi.org/10.11201/jjdp.34.208.

Johansson, M., Benderix, Y., Svensson, I., 2020. Mothers' and fathers' lived experiences of postpartum depression and parental stress after childbirth: a qualitative study. International J. Qual. Stud. Health Well-being 15 (1), 1722564. https://doi.org/10.1080/17482631.2020.1722564.

Kieffer, E., Caldwell, C., Welmerink, D., Welch, K., Sinco, B., Guzmán, J., 2013. Effect of the healthy MOMs lifestyle intervention on reducing depressive symptoms among pregnant Latinas. Am. J. Community Psychol. 51, 76–89. https://doi.org/10.1007/s10464-012-9523-9.

King, P.A.L., 2012. Replicability of structural models of the Edinburgh postnatal depression scale (EPDS) in a community sample of postpartum African American women with low socioeconomic status. Arch. Womens Ment. Health 15 (2), 77–86. https://doi.org/10.1007/s00737-012-0260-8.

Kiviruusu, O., Pietikäinen, J., Kylliäinen, A., Pölkki, P., Saarenpää-Heikkilä, O., Marttunen, M., Paunio, T., Paavonen, E., 2020. Trajectories of mothers' and fathers' depressive symptoms from pregnancy to 24 months postpartum. J. Affect. Disord. 260, 629–637. https://doi.org/10.1016/j.jad.2019.09.038.

Kubota, C., Okada, T., Aleksic, B., Nakamura, Y., Kunimoto, S., Morikawa, M., Shiino, T., Tamaji, A., Ohoka, H., Banno, N., Morita, T., Murase, S., Goto, S., Kanai, A., Masuda, T., Ando, M., Ozaki, N., 2014. Factor structure of the Japanese version of the Edinburgh postnatal depression scale in the postpartum period. PloS One 9 (8), e103941. https://doi.org/10.1371/journal.pone.0103941.

Lee, D.T., Chung, T.K., 2007. Postnatal depression: an update. Best Pract. Res. Clin. Obstet. Gynaecol. 21 (2), 183–191. https://doi.org/10.1016/j.bpobgyn.2006.10.003.

Liu, L., Xu, D., Tong, Y., Shi, J., Zeng, Z., Gong, W., 2022. Symptomatology in 1,112 women screened positive and negative using the Edinburgh postnatal depression scale (EPDS): longitudinal observations from the first trimester to 6 weeks postpartum of a Chinese cohort. J. Psychosom. Obstet. Gynecol. 43 (4), 453–463. https://doi.org/10.1080/0167482X.2022.2052845.

Lobato, G., Moraes, C., Dias, A., Reichenheim, M., 2012. Alcohol misuse among partners: a potential effect modifier in the relationship between physical intimate partner violence and postpartum depression. Soc. Psychiatry Psychiatric Epidemiol. 47, 427–438. https://doi.org/10.1007/s00127-011-0346-z.

Loscalzo, Y., Giannini, M., Contena, B., Gori, A., Benvenuti, P., 2015. The Edinburgh postnatal depression scale for fathers: a contribution to the validation for an Italian sample. Gen. Hosp. Psychiatry 37 (3), 251–256. https://doi.org/10.1016/j.genhosppsych.2015.02.002.

Massoudi, P., Hwang, C., Wickberg, B., 2016. Fathers' depressive symptoms in the postnatal period: prevalence and correlates in a population-based Swedish study. Scand. J. Pub. Health 44, 688–694. https://doi.org/10.1177/1403494816661652.

Melrose, S., 2010. Paternal postpartum depression: how can nurses begin to help? Contemp. Nurse 34, 199–210. https://doi.org/10.5172/conu.2010.34.2.199.

Mitchell, H., Edali, S., Konkle, A., 2020. Considering xenobiotics as risk factors for postpartum depression: a qualitative systematic review. J. Health Med. Sci. 3 (1). https://doi.org/10.31014/aior.1994.03.01.105.

Molgora, S., Fenaroli, V., Malgaroli, M., Saita, E., 2016. Trajectories of postpartum depression in Italian first-time fathers. Am. J. Mens Health 11, 880–887. https://doi.org/10.1177/1557988316677692.

Mughal, M.K., Giallo, R., Arshad, M., Arnold, P.D., Bright, K., Charrois, E.M., Rai, B., Wajid, A., Kingston, D., 2023. Trajectories of maternal depressive symptoms from pregnancy to 11 years postpartum: findings from Avon longitudinal study of parents and children (ALSPAC) cohort. J. Affect. Disord. 328, 191–199. https://doi.org/10.1016/j.jad.2023.02.023.

Nath, S., Psychogiou, L., Kuyken, W., Ford, T., Ryan, E., Russell, G., 2016. The prevalence of depressive symptoms among fathers and associated risk factors during the first seven years of their child's life: findings from the millennium cohort study. BMC Public Health 16, 509. https://doi.org/10.1186/s12889-016-3168-9.

Nieh, H., Chang, C., Chou, L., 2022. Differential trajectories of fathers' postpartum depressed mood: a latent class growth analysis approach. Int. J. Environ. Res. Public Health 19 (3), 1891. https://doi.org/10.3390/ijerph19031891.

Nishigori, H., Obara, T., Nishigori, T., Metoki, H., Mizuno, S., Ishikuro, M., Sakurai, K., Hamada, H., Watanabe, Z., Hoshiai, T., Arima, T., Nakai, K., Kuriyama, S., Yaegashi, N., 2020. The prevalence and risk factors for postpartum depression symptoms of fathers at one and 6 months postpartum: an adjunct study of the Japan Environment & Children's study. J. Matern. Fetal Neonatal Med. 33, 2797–2804. https://doi.org/10.1080/14767058.2018.1560415.

Nishimura, A., Ohashi, K., 2010. Risk factors of paternal depression in the early postnatal period in Japan. Nurs. Health Sci. 12 (2), 170–176. https://doi.org/10.1111/j.1442-2018.2010.00513.x.

Okano, T., Murata, M., Masuji, F., Tamaki, R., Nomura, J., Miyaoka, H., Kitamura, T., 1996. Validation and reliability of a Japanese version of the EPDS. Arch. Psychiatr. Diagn. Clin. Eval. 7, 525–533.

Palumbo, G., Mirabella, F., Gigantesco, A., 2017. Positive screening and risk factors for postpartum depression. Eur. Psychiatry 42, 77–85. https://doi.org/10.1016/j.eurpsy.2016.11.009.

Paulson, J.F., Bazemore, S.D., Goodman, J.H., Leiferman, J.A., 2016. The course and interrelationship of maternal and paternal perinatal depression. Arch. Womens Ment. Health 19 (4), 655–663. https://doi.org/10.1007/s00737-016-0598-4.

Pedersen, S., Maindal, H., Ryom, K., 2021. "I wanted to be there as a father, but I couldn't": a qualitative study of fathers' experiences of postpartum depression and their help-seeking behavior. Am. J. Mens Health 15(3), 15579883211024375. doi: https://doi.org/10.1177/15579883211024375.

Putnick, D.L., Sundaram, R., Bell, E.M., Ghassabian, A., Goldstein, R.B., Robinson, S.L., Vafai, Y., Gilman, S.E., Yeung, E., 2020. Trajectories of maternal postpartum depressive symptoms. Pediatrics 146 (5), e20200857. https://doi.org/10.1542/peds.2020-0857.

Sasaki, Y., Baba, T., Oyama, R., Fukumoto, K., Haba, G., Sasaki, M., 2019. Re-evaluation of the Edinburgh postnatal depression scale as screening for post-partum depression in Iwate prefecture, Japan. J. Obstet. Gynaecol. Res. 45 (9), 1876–1883. https://doi.org/10.1111/jog.14042.

Severo, M., Ventriglio, A., Bellomo, A., Iuso, S., Petito, A., 2023. Maternal perinatal depression and child neurocognitive development: a relationship still to be clarified. Front. Psych. 14, 1151897. https://doi.org/10.3389/fpsyt.2023.1151897.

Simas, T., Brenckle, L., Sankaran, P., Masters, G., Person, S., Weinreb, L., Ko, J., Robbins, C., Allison, J., Byatt, N., 2019. The PRogram in support of Moms (PRISM): study protocol for a cluster randomized controlled trial of two active interventions addressing perinatal depression in obstetric settings. BMC Pregnancy Childbirth 19 (1), 256. https://doi.org/10.1186/s12884-019-2387-3.

Singley, D., Edwards, L., 2015. Men's perinatal mental health in the transition to fatherhood. Prof. Psychol. Res. Pract. 46, 309. https://doi.org/10.1037/PRO0000032.

Smythe, K.L., Petersen, I., Schartau, P., 2022. Prevalence of perinatal depression and anxiety in both parents: a systematic review and meta-analysis. JAMA Netw. Open 5 (6), e2218969. https://doi.org/10.1001/jamanetworkopen.2022.18969.

Stasik-O'Brien, S.M., McCabe-Beane, J.E., Segre, L.S., 2019. Using the EPDS to identify anxiety in mothers of infants on the neonatal intensive care unit. Clin. Nurs. Res. 28 (4), 473–487. https://doi.org/10.1177/1054773817740532.

Stuart, S., Koleva, H., 2014. Psychological treatments for perinatal depression. Best Pract. Res. Clin. Obstet. Gynaecol. 28 (1), 61–70. https://doi.org/10.1016/j.bpobgyn.2013.09.004.

Takehara, K., Tachibana, Y., Yoshida, K., Mori, R., Kakee, N., Kubo, T., 2018. Prevalence trends of pre-and postnatal depression in Japanese women: a population-based longitudinal study. J. Affect. Disord. 225, 389–394. https://doi.org/10.1016/j.jad.2017.08.008.

Team, J.A.S.P., 2023. JASP, Version 0.17.3. https://jasp-stats.org.

Thiel, F., Pittelkow, M., Wittchen, H., Garthus-Niegel, S., 2020. The relationship between paternal and maternal depression during the perinatal period: a systematic review and meta-analysis. Front. Psych. 11, 563287. https://doi.org/10.3389/fpsyt.2020.563287.

Tokumitsu, K., Sugawara, N., Maruo, K., Suzuki, T., Shimoda, K., Yasui-Furukori, N., 2020a. Prevalence of perinatal depression among Japanese women: a meta-analysis. Ann. Gen. Psychiatry 19 (1), 1–18. https://doi.org/10.1186/s12991-020-00290-7.

Tokumitsu, K., Sugawara, N., Maruo, K., Suzuki, T., Yasui-Furukori, N., Shimoda, K., 2020b. Prevalence of perinatal depression among Japanese men: a meta-analysis. Ann. Gen. Psychiatry 19 (1), 65. https://doi.org/10.1186/s12991-020-00316-0.

Tram, J.M., Cole, D.A., 2006. A multimethod examination of the stability of depressive symptoms in childhood and adolescence. J. Abnorm. Psychol. 115 (4), 674–686. https://doi.org/10.1037/0021-843X.115.4.674.

Tuohy, A., McVey, C., 2008. Subscales measuring symptoms of non-specific depression, anhedonia, and anxiety in the Edinburgh postnatal depression scale. Br. J. Clin. Psychol. 47 (2), 153–169. https://doi.org/10.1111/j.2044-8260.2008.tb00463.x.

Usuda, K., Nishi, D., Okazaki, E., Makino, M., Sano, Y., 2017. Optimal cut-off score of the Edinburgh postnatal depression scale for major depressive episode during pregnancy in Japan. Psychiatry Clin. Neurosci. 71 (12), 836–842. https://doi.org/10.1111/pcn.12562.

Vliegen, N., Casalin, S., Luyten, P., 2014. The course of postpartum depression: a review of longitudinal studies. Harv. Rev. Psychiatry 22 (1), 1–22. https://doi.org/10.1097/HRP.0000000000000013.

Volling, B., Yu, T., Gonzalez, R., Tengelitsch, E., Stevenson, M., 2018. Maternal and paternal trajectories of depressive symptoms predict family risk and children's emotional and behavioral problems after the birth of a sibling. Dev. Psychopathol. 31, 1307–1324. https://doi.org/10.1017/S0954579418000743.

Yu, M., Li, H., Xu, D., Wu, Y., Liu, H., Gong, W., 2020. Trajectories of perinatal depressive symptoms from early pregnancy to six weeks postpartum and their risk factors-a longitudinal study. J. Affect. Disord. 275, 149–156. https://doi.org/10.1016/j.jad.2020.07.005.