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Emotion regulation is robustly associated with perinatal depressive symptoms in a Swedish national cohort

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Perinatal depression (PeriND) has serious consequences for mothers and children, yet early detection is challenging. Emotion regulation (ER) is increasingly recognized as a key factor for maternal mental health; however, associations with depressive symptoms during the perinatal period remain insufficiently understood. In this prospective, population-based Swedish cohort study ($N = 623$), we examined whether ER difficulties in the second trimester, assessed via the Difficulties in Emotion Regulation Scale-16 (DERS-16) were associated with depressive symptoms across seven perinatal time points (24–34 and 36–42 weeks antenatal; 1–4, 6–13, 14–23, 24–35 and 36–42 weeks postnatal) as measured by the Edinburgh Postnatal Depression Scale. Higher ER difficulties were significantly associated with elevated depressive symptoms during pregnancy to 14–23 weeks postnatal, independent of confounders. ER difficulties also differed between PeriND symptom trajectories, with higher scores in early and late postnatal-onset groups. These findings highlight ER assessed in the second trimester as a potential vulnerability marker for PeriND, with the DERS-16 offering promise for early risk detection. Targeting ER may provide a promising strategy for mitigating perinatal mental health risks.

Perinatal depression (PeriND), which includes depressive episodes occurring during pregnancy (antenatal depression, AnteND) or postnatally (postnatal depression, PostND), is a prevalent mental health condition with serious, long-term consequences for both the mother and the child[1–4]. In high-income countries, prevalence estimates of depression range from 9 to 11% during pregnancy and 9 to 13% after childbirth, with even higher rates reported in some low- and middle-income settings[5,6]. However, a recent meta-analysis estimates that up to 29% of women in high-income countries experience depressive symptoms during pregnancy, although numbers vary across trimesters[7]. In Sweden, these rates appear slightly lower, with 13–17% of women experiencing AnteND and 12–13% experiencing PostND[8–10]. Despite these figures, more than half of women with PeriND remain undiagnosed, and up to 85% receive no treatment[1,11]. Research has identified distinct PeriND trajectories, such as antenatal-only depression that resolves after childbirth, depression with onset in the early or late postnatal period, or persistent symptoms across the perinatal period[12–14]. These trajectories have been linked to different risk factors and may reflect distinct underlying causes, suggesting the need for tailored diagnostics and intervention approaches[14,15]. Although current clinical diagnostic criteria do not yet differentiate PeriND trajectories[16], recognizing this heterogeneity is crucial to improving maternal health outcomes[14].

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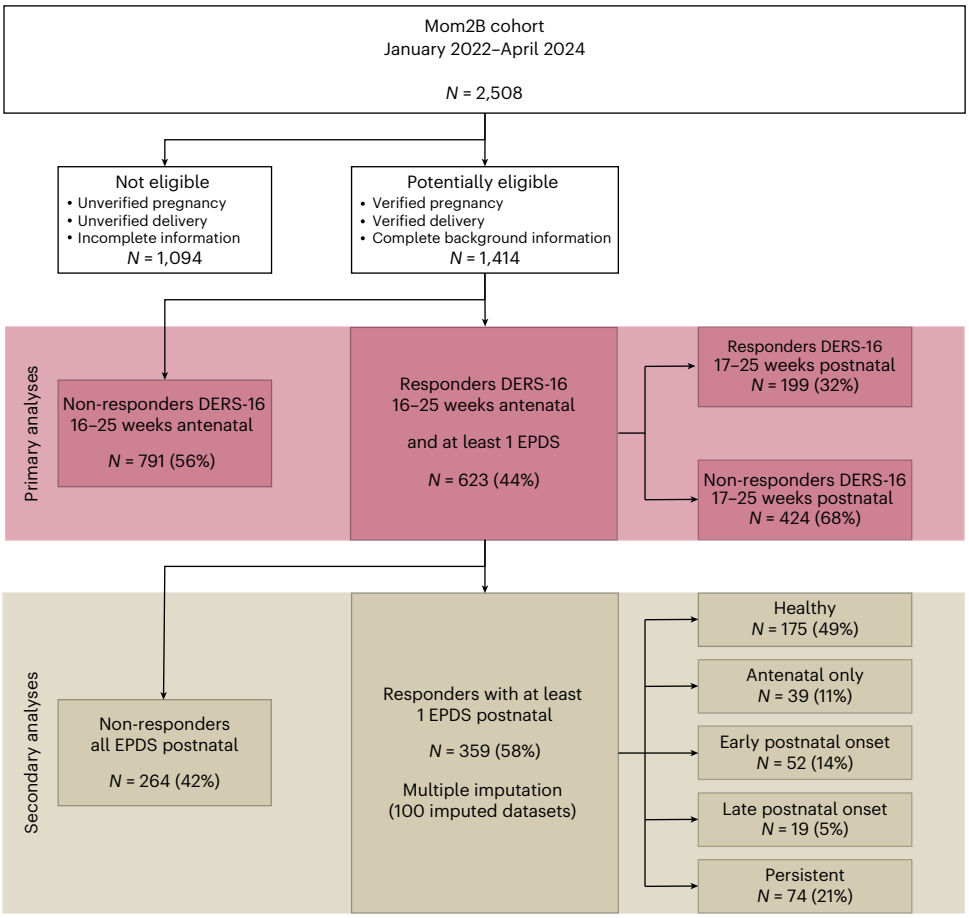

Fig. 1 | Flowchart of included participants in the study. Data for the present study were derived from January 2022 to April 2024 from the prospective Swedish national cohort study Mom2B[40] as the DERS-16[38] was introduced from May 2022 and was available for participants at 16–25 weeks antenatal.

Emotion regulation (ER), a key transdiagnostic factor in mental health, is the multidimensional ability to monitor, understand and modulate emotional experiences, beyond merely suppressing emotions[17–19]. ER is essential for social interactions, stress management and overall well-being[19,20], and difficulties in ER are associated with the development and persistence of various psychopathologies[17,21–23]. ER is increasingly recognized as crucial for maternal mental health during the perinatal period, a period marked by heightened vulnerability to emotional dysregulation, thus increasing the risk for adverse mental health outcomes[24–27]. Studies reveal that inadequate or maladaptive ER among pregnant women is associated with elevated hair cortisol levels indicating chronic stress[28], sleep disturbances[29], substance use[30] and increased rates of depression, anxiety and self-injurious thoughts[27,29,31]. While these associations are largely correlational and the directionality remains uncertain—given that chronic stress, sleep disruption and psychopathology may also impair ER—such findings underscore the possible bidirectional interplay between ER and perinatal mental health. This complexity highlights the importance of longitudinal study designs to disentangle temporal relationships and inform targeted interventions. Notably, higher ER difficulties have been specifically linked to heightened depressive and anxiety symptoms during pregnancy and after birth[32,33], reinforcing the central role of ER in maternal mental health. However, longitudinal associations of ER and depressive symptoms across the broader perinatal period remain insufficiently understood, as previous studies assessed either only single postnatal time points[33] or limited evaluations during late pregnancy and the early postnatal period[32]. Furthermore, ER is suggested to have long-term implications for parental health, caregiving behavior and the health and development of the child[27,28]. In shaping the parent–child relationship, parental ER capacity is especially important for the development of behavioral problems in children[34]. To assess ER, studies commonly use the Difficulties in Emotion Regulation Scale (DERS)[18], a validated self-report measure for clinical and non-clinical populations[18,32,35,36]. The DERS assesses key ER facets: emotional awareness, acceptance, impulse control, goal-directed behavior during negative emotions and access to effective strategies[18,37]. It shows strong internal consistency, construct validity and clinical utility, particularly in perinatal samples, where it correlates well with anxiety and depression measures[35]. There are several validated short forms, including the DERS-SF (18 items), the DERS-18 (18 items) and the DERS-16 (16 items), with previous research in adults with affective disorders and pregnant women showing comparable psychometric performance across all formats[36,37]. The DERS-16[38] has shown superior reliability compared with other short forms in a perinatal context, with item response theory analyses supporting stronger information retention on key subscales[36]. Thus, the DERS-16 demonstrates excellent psychometric properties and offers a brief yet reliable alternative to the original DERS for pregnant samples in time-constrained settings[36,38].

As a modifiable skill, ER is critical for assessing mental health risks and serves as a potential intervention target during the perinatal period[39]. However, research on the relationship between ER during pregnancy, perinatal depressive symptoms and distinct PeriND trajectories remains limited. To address this gap, we investigated ER using the DERS-16 during the second trimester of pregnancy and its association with depressive symptoms across the perinatal period, that is, across seven time points encompassing the second and third trimesters up to 1 year after birth. Data collected between January 2022 and April 2024 were drawn from the Mom2B cohort, a population-based, prospective

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Table 1 | Characteristics of study sample

Characteristics	*N* (%) Responders	Mean (s.d.)	Range (minimum–maximum)
Total	**623 (100%)**		
Age (years)	623 (100%)	31.66 (4.57)	19–44
Country of origin	623 (100%)		
Sweden	580 (93.1%)		
Nordic countries except Sweden	12 (1.9%)		
Europe except Nordic countries	15 (2.4%)		
Outside Europe	16 (2.6%)		
Pre-pregnancy BMI ($kg\,m^{-2}$)	616 (98.9%)	26.07 (6.04)	14–69
Education	623 (100%)		
University-level education	423 (67.9%)		
Relationship status	623 (100%)		
No partner	17 (2.7%)		
Partner, not cohabiting	21 (3.4%)		
Partner, cohabiting	585 (93.9%)		
Partner violence	596 (95.7%)		
Current partner violence	11 (1.8%)		
Previous partner violence	140 (23.5%)		
Mental health history	623 (100%)		
Depression history (self-reported)	340 (54.6%)		
Professional help (psychologist/psychiatrist/counselor)	276 (81.2%)		
Anxiety history (self-reported)	275 (44.2%)		
Professional help (psychologist/psychiatrist/counselor)	201 (73.1%)		
Female-specific mental health	618 (99.2%)		
Treatment for premenstrual disorders	62 (10%)		
Mood swings from oral contraceptives	308 (49.8%)		
Substance use	617 (99.2%)		
Alcohol, 3 months before pregnancy	478 (77.5%)		
Alcohol, ≥7 glasses per week 3 months before pregnancy	13 (2.7%)		
Smoking, 3 months before pregnancy	85 (13.8%)		
Snus, 3 months before pregnancy	112 (18.0%)		
Pregnancy-related variables			
Pregnancy week at registration to Mom2B study	603 (96.79%)	31.66 (4.57)	2–26
Parity	606 (97.3%)		
Primiparous	234 (38.6%)		
History of pregnancy loss	610 (97.9%)		
Previous pregnancy loss	206 (33.8%)		
Fear of Birth Scale (mean total score 13–42 weeks antenatal) (scale from 0 = low to 100 = high)	608 (97.6%)	38.31 (25.49)	0–100
Delivery-related variables			
Delivery experience 0–2 weeks postnatal (scale from 0 = negative to 100 = positive)	357 (57.3%)	76.6 (20.16)	0–100
Mode of delivery	357 (57.3%)		
Vaginal delivery	263 (73.7%)		
Assisted vacuum delivery	29 (8.1%)		
Planned cesarean section	29 (8.1%)		
Emergency cesarean section	36 (10.1%)		
Postnatal-related variables			
Neonatal issues	356 (57.1%)		
Reported neonatal issues up to 0–2 weeks postnatal	43 (12.1%)		
Breastfeeding	340 (54.6%)		
Full or partly	337 (99.1%)		
Psychometric scales			
Deficits in emotion regulation			
DERS-16 (total score) 16–25 weeks antenatal (scale from 16 = low to 80 = high)	623 (100%)	32.42 (13.03)	16–76
DERS-16 (total score) 17–25 weeks postnatal	199 (31.9%)	32.45 (13.67)	16–73
Sense of coherence antenatal SOC-13 (total score) 18–42 weeks antenatal (scale from 13 = low to 91 = high)	565 (90.7%)	55.61 (6.70)	31–78
Resilience antenatal RS-14 (total score) 20–42 weeks antenatal (scale from 14 = low to 98 = high)	550 (88.3%)	75.41 (12.36)	28–98
Vulnerable personality antenatal VPSQ (total score) 32–42 weeks antenatal (scale from 9 = low to 45 = high)	420 (67.4%)	26.95 (4.09)	19–41
Depressive symptoms			
EPDS (total score) 12–22 weeks antenatal (scale from 0 = low to 30 = high)	545 (87.5%)	7.45 (5.19)	0–27
EPDS (total score) 24–34 weeks antenatal	518 (83.1%)	7.50 (5.19)	0–26
EPDS (total score) 36–42 weeks antenatal	373 (59.9%)	6.82 (5.29)	0–24
EPDS (total score) 1–4 weeks postnatal	339 (54.4%)	7.99 (5.47)	0–26
EPDS (total score) 6–13 weeks postnatal	282 (45.23%)	6.34 (5.06)	0–24
EPDS (total score) 14–23 weeks postnatal	221 (35.5%)	6.38 (5.16)	0–25
EPDS (total score) 24–35 weeks postnatal	151 (24.2%)	5.37 (5.09)	0–21
EPDS (total score) 36–49 weeks postnatal	81 (13.0%)	5.61 (5.03)	0–19

Results are presented as frequencies and relative frequencies within the subset of survey responders and, if applicable, additionally means (s.d.). BMI, body mass index; RS-14, Resilience Scale-14; SOC-13, Sense of Coherence-13; VPSQ, Vulnerable Personality Style Questionnaire.

Swedish national study utilizing a smartphone app for data collection[40]. In addition, we analyzed ER differences across PeriND subgroups categorized by symptom onset and persistence. This study ultimately aims to assess the utility of the DERS-16 as a concise screening tool during pregnancy, enhancing PeriND risk assessment and guiding prevention and intervention strategies[35,37,38,41]. We hypothesized greater ER difficulties reported in the second trimester to be associated with elevated depressive symptoms across the perinatal period[32,35,36]. Moreover, given that distinct PeriND symptom trajectories are associated with diverse background characteristics (for example, age, education, partner violence, premenstrual mood symptoms, lack of sleep or fear of birth[14]), which may influence ER abilities, we expected to observe ER differences between PeriND symptom trajectories based on second trimester ER assessment.

Results

Sample characteristics

In total, 623 participants from the Mom2B cohort completed the DERS-16 at 16–25 weeks antenatal and were included in this study (Fig. 1). Sample characteristics are provided in Table 1. Due to varying availability of surveys across the perinatal period, sample sizes differ for each analysis (Table 1). PeriND symptoms were measured using the

Table 2 | Regression coefficients and 95% CI of DERS-16 16–25 weeks antenatal (exposure) in linear regression models on EPDS across the perinatal time points (outcome)

(Outcome) EPDS time points and mean total scores (95% CI) across the perinatal time points		(1) Unadjusted	(2) Adjusted for potential confounders – EPDS total score 12–22 weeks antenatal	(3) Adjusted for potential confounders + EPDS total score 12–22 weeks antenatal
Time points	**Mean (95% CI)**	**beta coefficients for DERS-16 total score 16–25 weeks antenatal**		
24–34 weeks antenatal	7.50 (7.05–7.94)	0.22 (0.19–0.25)*** *N*=518	0.15 (0.11–0.19)*** *N*=410	0.15 (0.11–0.19)*** *N*=410
36–42 weeks antenatal	6.82 (6.28–7.36)	0.23 (0.19–0.26)*** *N*=373	0.15 (0.11–0.20)*** *N*=352	0.15 (0.11–0.20) *** *N*=352
BIRTH				
1–4 weeks postnatal	7.99 (7.40–8.57)	0.17 (0.13–0.22)*** *N*=339	0.08 (0.03–0.13)*** *N*=317	0.06 (0–0.11)* *N*=296
6–13 weeks postnatal	6.34 (5.74–6.93)	0.18 (0.13–0.22)*** *N*=282	0.09 (0.04–0.14)*** *N*=267	0.06 (0–0.11)* *N*=246
14–23 weeks postnatal	6.38 (5.69–7.06)	0.21 (0.17–0.26)*** *N*=221	0.15 (0.09–0.20)*** *N*=209	0.10 (0.04–0.15)*** *N*=195
24–35 weeks postnatal	5.37 (4.55–6.19)	0.15 (0.10–0.21)*** *N*=151	0.06 (–0.01 to 0.13)[a] *N*=140	0.03 (–0.05 to 0.10)[b] *N*=133
36–49 weeks postnatal	5.61 (4.50–6.73)	0.22 (0.15–0.29)*** *N*=81	0.09 (0.02–0.16)* *N*=78	0.04 (–0.02 to 0.11)[b] *N*=76

EPDS mean total scores (95% CI) are provided for each assessment time point. Multiple linear regression models were fitted as described, with all tests two-sided. Models included (1) no potential confounders (2) potential confounders excluding EPDS total score 12–22 weeks antenatal and (3) potential confounders including EPDS total score 12–22 weeks antenatal. Results for all beta coefficients can be found in Supplementary Table 1. *P < 0.050; ***P ≤ 0.001. [a]P = 0.111. [b]P ≥ 0.196.

Edinburgh Postnatal Depression Scale (EPDS)[42–44] at eight time points: 12–22, 24–34 and 36–42 weeks antenatal and 1–4, 6–13, 14–23, 24–35 and 36–49 weeks postnatal.

Among those completing the EPDS, depressive symptoms above the antenatal cut-off (≥13) (refs. 43,44) were observed in 18.9% at 24–35 weeks and 15.5% at 36–42 weeks. Postnatally, symptoms above the cut-off (≥12) (refs. 43,44) were observed as follows: 23.6% at 1–4 weeks, 17.4% at 6–13 weeks, 16.7% at 14–23 weeks, 15.9% at 24–35 weeks and 14.8% at 36–49 weeks, with clinical cut-offs in line with Swedish clinical practice[43,44].

Emotion regulation remains stable over the perinatal period

For stability analysis, 199 participants filled in the DERS-16 for a second time at 17–25 weeks postnatal (Fig. 1). DERS-16 scores at 16–25 weeks antenatal (mean 31.08, s.d. 12.44, 95% confidence interval (CI) [29.34, 31.81]) were strongly correlated with scores at 17–25 weeks postnatal (mean 32.45, s.d. 13.67, 95% CI [30.54, 34.36]; r(197) 0.655, P < .001) with no significant mean differences between time points (P = 0.076; Supplementary Information).

Emotion regulation is robustly associated with perinatal depressive symptoms

Multiple linear regression models (Table 2) showed that DERS-16 score at 16–25 weeks antenatal (exposure) is significantly associated with perinatal EPDS scores (outcome). DERS-16 was significantly associated with EPDS scores until 14–23 weeks postnatal in all three regression models (Table 2; crude model, P values < 0.001; adjusting for potential confounders excluding EPDS at 12–22 weeks antenatal, P values < 0.017; adjusting for potential confounders including EPDS at 12–22 weeks antenatal, P values < 0.05). While DERS-16 was significantly associated with EPDS assessed at 24–35 weeks postnatal in the crude model, this association became non-significant with the coefficients attenuated toward the null when adjusting for potential confounders (excluding EPDS antenatally, P = 0.111; including EPDS antenatally, P = 0.517). For EPDS scores at 36–49 weeks postnatal, the association was significant in the crude model (P < 0.001) and the confounder-adjusted model (excluding EPDS antenatally, P = 0.018) but non-significant after adjusting for EPDS antenatally (P = 0.196). Figure 2 shows all included regression coefficients (exposure and potential confounders) and color-codes their significant positive or negative association with perinatal EPDS total score. All regression coefficients and associated statistics for potential confounders are reported for the different multiple regression models in Supplementary Table 1. Variance inflation factors were examined for all models and remained below 2.0, indicating no evidence of multicollinearity.

Emotion regulation differs across perinatal depression trajectories

Of the 623 participants, 359 provided at least 1 antenatal and 1 postnatal EPDS assessment and were thus included in the secondary analysis, followed by classification into 5 PeriND trajectories based on Swedish clinical cut-offs (≥13 antenatally, ≥12 postnatally; Methods)[14]. PeriND symptom trajectories referred to healthy (49%), antenatal-only depression symptoms (11%), early postnatal-onset depression symptoms (14%), late postnatal-onset depression symptoms (5%) and persistent depression symptoms (21%; Fig. 1). Significant differences in antenatal DERS-16 scores were observed between the PeriND symptom trajectory groups (P < 0.001; Fig. 3). Bonferroni-adjusted pairwise comparison revealed higher antenatal DERS-16 scores in early and late postnatal-onset trajectories compared with the healthy group (P = 0.006 and P = 0.004, respectively). After Bonferroni correction, the persistent depression symptoms trajectory had significantly higher DERS-16 scores than both the healthy group and the early postnatal-onset trajectory (both P < 0.001) and showed borderline significantly higher scores compared to the antenatal-only group (P = 0.056). Supplementary Tables 2 and 3 provide descriptive information.

Discussion

This Swedish national app-based cohort study showed that self-reported ER remained relatively stable from pregnancy through the postnatal period. Difficulties in ER, assessed in the second trimester via the DERS-16, were strongly associated with PeriND symptoms up to 14–23 weeks postnatal, even after adjusting for potential confounders, including second trimester EPDS scores. This association, however, did not extend

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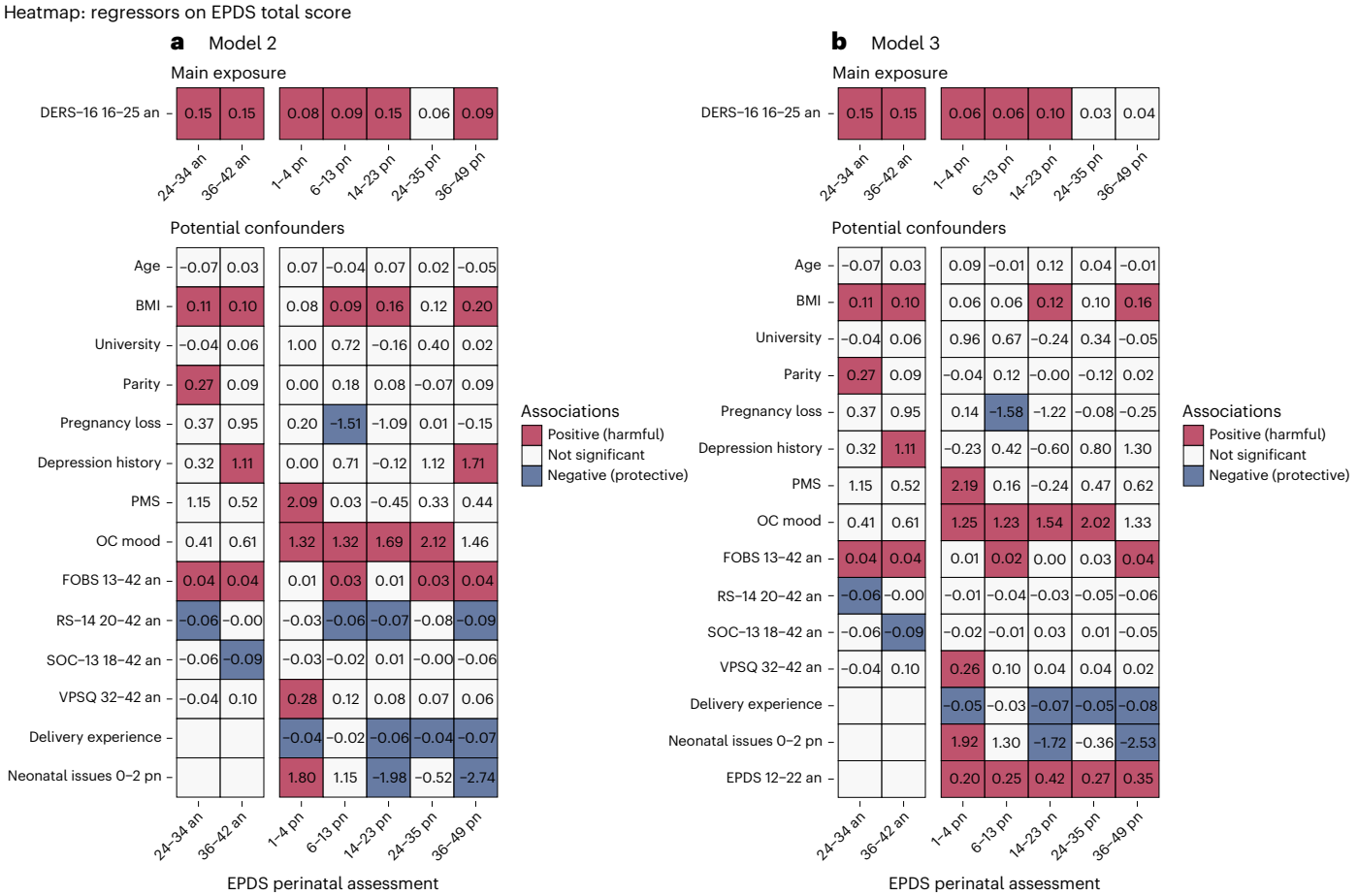

Fig. 2 | Regression coefficients in linear regression models on EPDS total score across the perinatal time points (outcome). a, Model 2 with DERS-16 16–25 weeks antenatal (exposure) and other potential confounders excluding EPDS total score 12–22 weeks antenatal. **b**, Model 3 with DERS-16 16–25 weeks antenatal (exposure) and other potential confounders including EPDS total score 12–22 weeks antenatal. Heatmaps show regressors and their respective coefficient values on EPDS total scores across the perinatal time points in tiles. The colors of the tiles are dependent on the regressors' significance and direction of association (positive or negative). DERS-16 16–25 an, Deficits of Emotion Regulation Scale-16 total score at 16–25 weeks antenatal; BMI, pre-pregnancy BMI; University, university-level education (versus less); Pregnancy loss, pregnancy loss history (versus never); Depression history, self-reported depression history with professional help (versus no); PMS, past treatment for premenstrual disorder (versus never); OC mood, mental health issues due to oral contraceptives (versus never); FOBS 13–42 an, Fear of Birth Scale, mean total score at 13–42 weeks antenatal; RS-14 20–42 an, RS-14 total score at 20–42 weeks antenatal; SOC-13 18–42 an, SOC-13 total score 18–42 weeks antenatal; VPSQ 32–42 an, VPSQ total score at 32–42 weeks antenatal; Delivery experience, delivery experience at 0–2 weeks postnatal; Neonatal issues 0–2 pn, neonatal issues up to 2 weeks postnatal (versus none); EPDS 12–22 an, EPDS total score at 12–22 weeks antenatal.

robustly beyond 6 months postnatal when accounting for AnteND scores. Notably, women who would later meet the EPDS threshold for PostND already displayed increased ER difficulties as early as the second trimester, pinpointing a possibility for early identification of high-risk individuals.

Reinforcing previous evidence linking ER to psychopathology and mental health vulnerability[17,45], our core findings demonstrated that ER difficulties assessed in the second trimester were strongly associated with depressive symptoms throughout the perinatal period and up to 6 months postnatal, even after controlling for potential confounders. Furthermore, our results are in line with previous studies showing an association between emotion dysregulation and higher levels of AnteND and PostND symptoms[25,29,31,32,46,47]. Unlike previous studies that found no significant link between antenatal ER and PostND[32], our data show a robust association across multiple postnatal time points. This association, however, weakened beyond 6 months postnatal, suggesting that the DERS-16's sensitivity for depressive risk might be limited after this period. Our results underscore ER as an important factor in identifying PeriND risk and support the clinical utility of the DERS-16 as a prognostic tool during pregnancy.

Remarkably, the early and late postnatal-onset depression symptom trajectories reported significantly more ER difficulties during the second trimester, even while still below the threshold for depression during the time of the ER assessment. This finding aligns with ref. 14, who identified distinct characteristics among PeriND trajectories before childbirth, yet extends this work by demonstrating that these trajectories may differ in psychological abilities such as ER. Recognizing emotion dysregulation as an early vulnerability marker for PostND is particularly relevant for the late postnatal-onset trajectory, where many cases go undiagnosed, partly due to diagnostic criteria not acknowledging symptom onset beyond 6 weeks postnatal[16,48]. Thus, assessing ER difficulties during pregnancy with the 16-item self-report scale could be of considerable value for healthcare providers. Contrary to our expectations, the antenatal-only depression symptoms trajectory showed no significant differences in DERS-16 scores compared with the healthy group, suggesting that women in the antenatal-only trajectory may have had adaptive ER skills, limiting symptoms to pregnancy only. Moreover, our data imply that the antenatal-only trajectory might not be linked primarily to emotion dysregulation. Instead, previous research suggests that other factors, such as younger

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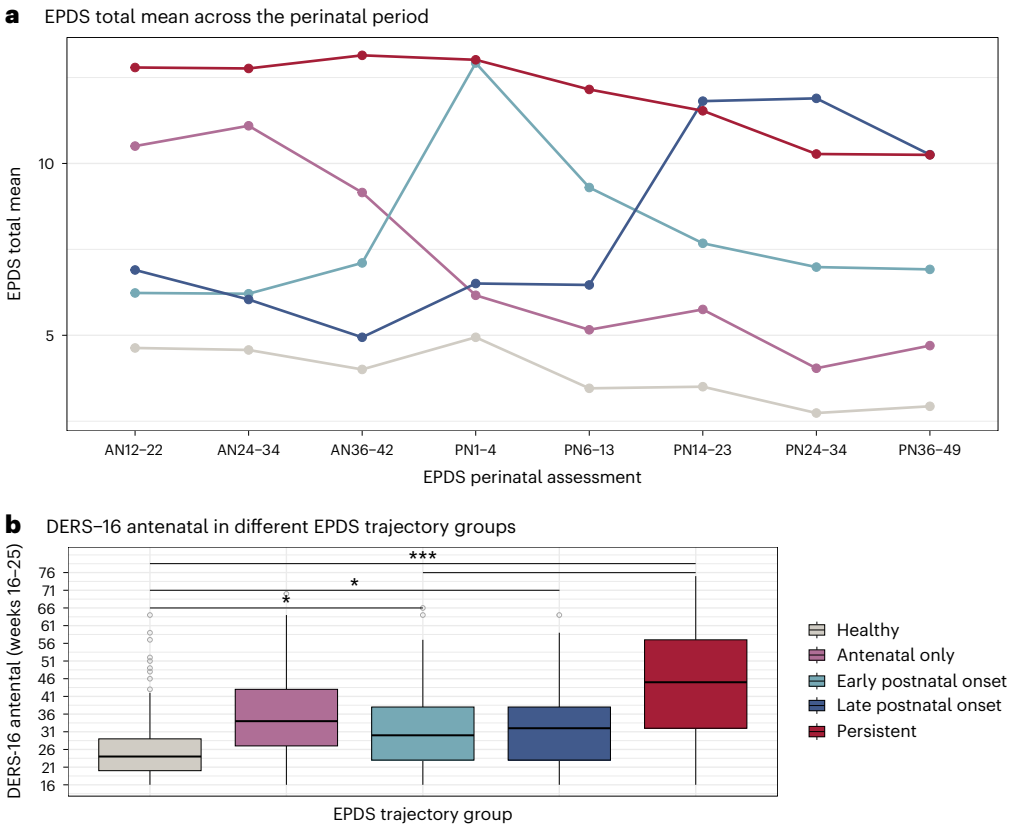

Fig. 3 | Perinatal depression symptom trajectories and differences in DERS-16 total score. a, Mean total scores of the EPDS across five distinct perinatal depression symptom trajectory groups, assessed across the perinatal time points. **b**, Mean total scores of the DERS-16 at 16–25 weeks antenatal between the 5 distinct perinatal depression symptom trajectory groups. Overall differences were assessed using a pooled likelihood ratio test across imputed datasets; pairwise comparisons were performed using two-sided pooled Wald tests with Bonferroni correction. Data represent the mean scores for each perinatal depression symptom trajectory group on the basis of a sample $N = 359$ (provided at least 1 antenatal and 1 postnatal EPDS), with multiple imputation applied to account for missing data. Perinatal depression symptom trajectories were categorized as follows: (1) healthy: EPDS scores remained below the clinical cut-off during both the antenatal and postnatal assessments; (2) antenatal-only depression symptoms: EPDS scores were at or above the cut-off during the antenatal assessments (12–22, 24–34 or 36–42 weeks) but below the cut-off postnatally; (3) early postnatal-onset depression symptoms: EPDS scores were below the cut-off antenatally but rose to or above the cut-off during the early postnatal assessment (1–4 and/or 6–13 weeks); (4) late postnatal-onset depression symptoms: EPDS scores remained below the cut-off antenatally and during the early postnatal assessments (1–13 weeks) but reached or exceeded the cut-off during later postnatal weeks (14–23 and/or 24–35 weeks); (5) persistent depression symptoms: EPDS scores were at or above the cut-off during at least one time point in the antenatal, early postnatal and/or late postnatal assessments. Boxes show upper and lower quartile values with the median indicated as a bold line. Whiskers show minimum and maximum scores. $^{*}P \leq 0.006$; $^{***}P < 0.001$.

age, lower educational status, socioeconomic disadvantage, trauma exposure or increased psychosocial stress, may play a more prominent role in the emergence of antenatal depression[14]. However, the absence of a difference in self-reported ER should be replicated in larger samples. Future work should also examine ER stability from antenatal to postnatal periods within trajectory groups to test whether antenatal-onset symptoms reflect transient or variable ER difficulties, and thus whether ER contributes to this trajectory. By contrast, the persistent trajectory was characterized by significantly higher ER difficulties compared with the healthy group during pregnancy, with depressive symptoms continuing throughout the perinatal period. In this group, pronounced ER difficulties may reflect a persistent and reciprocal vulnerability to stress that is particularly elevated during the perinatal period due to neurobiological, physiological and psychological transitions[27]. An increased vulnerability may lower the threshold for the onset of depressive symptoms throughout the perinatal period. While the EPDS remains essential for screening for current PeriND symptoms, antenatal ER assessment may complement screening by capturing risk for later-onset depression and offering a modifiable target for early intervention, even among those with persistent symptomatology. Collectively, our study highlights the heterogeneity of PeriND, challenging the traditional dichotomous view of this condition. A nuanced understanding is vital for identifying trajectory or subgroup-specific causes and risk factors[14]. Ultimately, effectively communicating the distinct mental health risks and needs associated with different PeriND trajectories, such as ER, to healthcare providers is essential[14], paving the way for personalized medical approaches to prevention and treatment.

In addition to these primary and clinically relevant results, the DERS-16 demonstrated a strong correlation and no significant mean changes between antenatal and postnatal scores. This supports its reliability for assessing ER across the perinatal period, consistent with previous evidence of ER stability[27,32,38,49]. Although Coo et al.[32] reported overall ER stability alongside subscale improvements, we observed a non-significant trend toward slightly elevated, that is, worse, DERS-16 scores 4–6 months postnatally. Differences in assessment timing (third versus second trimester) and the ER assessment versions (only subscales of adapted DERS[50] versus DERS-16 total score) may account for these discrepancies. Together, these findings highlight the utility of the DERS-16 as a reliable tool for assessing ER difficulties across the perinatal period, while underscoring that subtle ER variability may be amenable to targeted interventions.

Although this study features a large, population-based and well-characterized prospective sample, some limitations should be noted. First, the cohort's overrepresentation of Swedish-born women with higher education may limit generalizability of findings, particularly given the higher prevalence of PeriND among women from lower socioeconomic or minority backgrounds[8,51]. As the collection of ethnicity data is commonly not approved for research in Swedish ethics protocols, we reported country of birth as a proxy in the sample description; however, this limitation precluded further subgroup analyses by ethnicity, which may be relevant for understanding disparities in PeriND risk. Second, high rates of self-reported history of mental health illness for which they sought professional care potentially introduces a level of selection bias, as individuals more attuned to mental health concerns may be more likely to participate in a study on maternal mental health. Third, missing data and non-response at different time points, a common challenge of mobile health research[52], led to variable sample size in our regression analyses, which could be linked to how well or poorly participants felt during the perinatal period. In addition, dropout rates during later postnatal time points increased. These issues, however, were mitigated by maintaining a fairly large sample size in the primary regression analyses alongside multiple imputation (100 imputed datasets) applied in secondary analyses across PeriND symptom trajectory groups. Nonetheless, the relatively small size of the late postnatal-onset depression symptoms group ($N = 19$; Fig. 1) may have limited statistical power, for example, in detecting differences relative to the persistent trajectory. The EPDS, although a widely used screening tool, is not a diagnostic instrument and has been discussed to capture general psychological distress rather than specifically just depressive symptoms[53–55]. We did not evaluate symptom severity in relation to clinically diagnosed depression, nor did we account for potential treatment effects that might have altered symptom trajectories. Instead, our goal was to examine the association between ER and the EPDS as a measure of perinatal mental health symptomatology and overall well-being. Our results underscore the role of ER as a transdiagnostic factor for mental health, highlighting it as a tangible target for prevention and intervention efforts. Finally, PeriND is a multifactorial disorder[13,56,57], with ER probably representing just one part of its complex etiology. While future research should approach PeriND from multiple perspectives, our study's strength lies in addressing this complexity by controlling for diverse known and available confounders in the Mom2B dataset. For example, a robust association was shown for previous mood symptoms linked to oral contraceptive (OC) use with PostND symptoms. This supports previous evidence of a subgroup of women who are particularly sensitive to hormonal transitions across the female lifespan[58]. Assessing ER in a hormone-sensitive subgroup of women might improve risk prediction and inform preventive strategies, positioning ER as a potential protective factor.

Building on these limitations, future research should establish clinically meaningful DERS-16 cut-offs for early PeriND risk detection, ideally leveraging machine learning and receiver operating characteristic analyses. Furthermore, to enhance generalizability, the DERS–perinatal depressive symptom association should be validated across culturally and socioeconomically diverse populations, particularly in low- and middle-income countries[6,8]. Finally, targeted intervention studies are warranted to assess whether enhancing ER during the perinatal period can mitigate risk and support both prevention and early treatment efforts[27]. Together, these directions could advance a globally relevant, precision-based approach to maternal mental health.

Conclusions

In conclusion, this study emphasizes the significance of ER difficulties during the second trimester of pregnancy as an early and robust vulnerability marker for PeriND symptoms, particularly for cases progressing to PostND. The findings endorse the DERS-16 as a practical screening tool for identifying perinatal mental health risks and guiding timely interventions[35,36]. Given that effective ER skills can be trained and strengthened during pregnancy[27,59,60], enhancing ER during pregnancy presents a promising avenue for prevention and intervention as well as for optimizing parental behaviors. Future research should evaluate the clinical utility of DERS-16 screenings and explore which PeriND trajectories benefit most from ER-centered interventions. As a resilience factor, strengthened ER abilities can buffer stress, improve maternal mental health and ultimately support positive parent–child relationships and child development[25,31,32,41].

Methods

Participants and procedure

Data were obtained from the Mom2B cohort (www.mom2b.se), an ongoing, prospective Swedish national study using a smartphone app for data collection[40]. All Swedish-speaking women over 18 living in Sweden who are pregnant or within 3 months postnatal can participate by downloading the Mom2B app. Recruitment occurs via healthcare facilities, social media and print advertisements. After providing informed consent, participants complete online surveys accessible at designated perinatal periods and distributed approximately one to two times per week via the Mom2B app.[40]. Pregnancy and delivery are confirmed via the Swedish national birth registry. The study complies with General Data Protection Regulations and has ethical approval from the Swedish Ethical Review Committee (dnr: 2019/01170, with amendments). Compared with Sweden's general pregnant population, the Mom2B cohort has a higher proportion of highly educated individuals and a lower proportion of participants born outside Sweden[40,61,62]. This study used data collected between January 2022 and April 2024, specifically including responses to the DERS-16[38], which was included from May 2022 on and was available for participants at 16–25 weeks antenatal. The DERS-16 was administered in the Mom2B app during the second trimester to optimize feasibility and participant responsiveness as the first trimester was already survey-intensive and focused on time-sensitive assessments, and the third trimester was characterized by increased symptom burden and reduced participant availability. Eligibility criteria for this study included verified pregnancy and delivery, complete background information ($N = 1{,}414$) and a completed DERS-16 ($N = 623$) during the specified period. The Mom2B app allows users to join at any stage of pregnancy, but survey access is limited to specific time windows, and participants may discontinue at any point without providing reasons, both of which can result in missing data—a common issue in mobile health research[52].

Sociodemographic information. In the background questionnaire, provided in the Mom2B app, participants reported on country of birth, age at registration, highest education level ('no schooling', 'primary school', 'high school', 'polytechnic/vocational training', 'university or college'), mental health history ('no', 'yes, with professional help (psychologist/psychiatrist/counselor)', 'yes, without professional help') and parity. Additional information included pre-pregnancy BMI, relationship status ('no partner', 'partner, cohabiting', 'with a partner, no cohabiting'), partner violence history, substance use 3 months before pregnancy (alcohol, cigarettes, snus), mental health issues due to OCs, past treatment for premenstrual disorders and pregnancy loss history (all 'yes'/'no'). After birth, participants reported mode of delivery ('vaginal delivery', 'assisted vacuum delivery', 'planned cesarean section', 'emergency cesarean section') and neonatal issues up to 2 weeks postnatal ('yes'/'no'). Breastfeeding was tracked up to 42 weeks postnatal ('yes, full/partly', 'no').

DERS-16. Emotion regulation was measured with the DERS-16[37], a 16-item short form of the DERS[13], at 16–25 weeks antenatal and 17–25 weeks postnatal. The DERS-16 assesses trait-level emotion dysregulation using 5 subscales: (1) lack of emotional clarity, for example,

"I have difficulty making sense out of my feelings"; (2) non-acceptance of emotional responses, for example, "When I'm upset, I become angry at myself for feeling that way"; (3) impulse control difficulties, for example, "When I'm upset, I become out of control"; (4) difficulty in engaging in goal-directed behavior, for example, "When I'm upset, I have difficulty getting work done"; (5) limited access to emotion regulation strategies, for example, "When I'm upset, I believe there is nothing I can do to feel better"[36–38]. Scores range from 16 to 80, with higher scores indicating greater emotion dysregulation[18,38]. The DERS-16 has shown strong psychometric properties, including high internal consistency, test-retest reliability and convergent and discriminant validity[38], also in perinatal samples[36].

EPDS. PeriND symptoms were measured using the Swedish version of the EPDS[42–44] at 8 time points: 12–22, 24–34 and 36–42 weeks antenatal and 1–4, 6–13, 14–23, 24–35 and 36–49 weeks postnatal. The EPDS is a validated 10-item self-report screening tool assessing depressive symptoms over the past 7 days, with higher scores indicating greater severity[43,44]. Scores of ≥13 antenatally and ≥12 postnatally indicate clinically relevant symptoms, as validated and recommended in Swedish clinical practice[43,44]. These cut-off scores were also used for the present secondary analyses in the PeriND symptom trajectories[14] (see the following). If respondents completed nine of ten items, the missing score was imputed with the mean of the other items; with fewer than nine completed items, the total score was set to missing.

Additional psychometric surveys. On the basis of a study using data from a population-based prospective cohort study and machine learning methods to predict depressive symptoms 6 weeks after birth[63], we included additional psychometric scales assessed during pregnancy via the Mom2B app as potential confounders for our primary analyses (see the following). These included the FOBS[64]; the RS-14, measuring the ability to recover from stress and adapt to adversity[65,66]; the SOC-13, assessing the extent to which individuals perceive life as comprehensible, manageable and meaningful[67,68]; and the VPSQ, capturing personality dimensions linked to elevated risk for PostND, including sensitivity, worry, perfectionism and obsessiveness[69,70]. In addition, delivery experience was included, which was assessed via a visual analog scale with low values indicating a negative and high values indicating a positive delivery experience. These constructs have been identified as predictive of PostND[14,63] and associated with ER[71–73]; thus, they are assumed to be associated with both EPDS and DERS scores. To estimate the effect of ER on depressive symptoms independently of these related factors, we adjusted for them by including them as potential confounders in our regression analyses.

Statistical analyses

Descriptive statistics and primary statistical analyses were conducted using IBM SPSS Statistics (v28.0), while multiple imputation and secondary analyses were performed in R (v4.4.3) via RStudio (2024.12.1 + 563). A two-sided alpha level of $P \leq 0.05$ was applied throughout.

Emotion regulation across the perinatal period. To assess perinatal emotion regulation, we performed a Pearson correlation analysis of DERS-16 total score at 16–25 weeks antenatal with scores at 17–25 weeks postnatal. A paired samples *t* test was conducted to test whether DERS-16 total scores were different in the postnatal compared with the antenatal assessment time points.

Primary analyses. To assess the association of ER and depressive symptoms, we performed multiple linear regression models with the DERS-16 total score at 16–25 weeks antenatal as the exposure and perinatal EPDS total score (24–34 and 36–42 weeks antenatal and 1–4, 6–23, 14–23, 24–35 and 36–42 weeks postnatal) as outcomes, respectively. Model 1 was unadjusted for any other potential confounders; Model 2 was adjusted for potential confounders including age, pre-pregnancy BMI, university-level education, parity, pregnancy loss history, self-reported history of depression, treatment for premenstrual disorder, mental health issues from OC use and mean FOBS, RS-14, SOC-13 and VPSQ scores (all assessed antenatally). Postnatal EPDS outcomes were additionally adjusted for delivery experience, neonatal issues (0–2 weeks postnatal) and in Model 3 also adjusted for EPDS score at 12–22 weeks antenatal. Participants with missing data for a specific survey variable were excluded from the corresponding regression analysis.

Secondary analyses. To examine ER differences across PeriND symptom trajectories, we performed multiple imputation using the R package mice[74] (100 imputed datasets), restricting imputation to participants with at least one antenatal and one postnatal EPDS response ($N = 359$) to avoid imputing data from cases of pregnancy loss or stillbirth. Subsequently, we categorized participants into five groups on the basis of seven EPDS assessments, using clinically established cut-offs (≥13 antenatally, ≥12 postnatally) in accordance with Swedish practice[43,44]) and ref. 14: (1) healthy (EPDS scores remained below the clinical cut-off during both the antenatal and postnatal assessments), (2) antenatal-only depression symptoms (EPDS scores were at or above the cut-off during the antenatal assessments, 12–22, 24–34 or 36–42 weeks, but below the cut-off postnatally), (3) early postnatal-onset depression symptoms (EPDS scores were below the cut-off antenatally but rose to or above the cut-off during the early postnatal assessment, 1–4 and/or 6–13 weeks), (4) late postnatal-onset depression symptoms (EPDS scores remained below the cut-off antenatally and during the early postnatal period, 1–13 weeks, but reached or exceeded the cut-off during later postnatal weeks, 14–23 and/or 24–35 weeks), (5) persistent depression symptoms (EPDS scores were at or above the cut-off during at least one time point in the antenatal, early postnatal and/or late postnatal assessments). A pooled likelihood ratio test across the imputed datasets was used to test whether DERS-16 scores were significantly different across PeriND symptom trajectories. Pooled post hoc Wald tests across the imputed datasets, followed by Bonferroni adjustments, were used to identify which PeriND symptom trajectories differed significantly from each other.

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Data availability

All relevant data are presented within this Article and its Supplementary Information. Due to legal and ethical restrictions, the individual data are not publicly accessible. The individual data presented in this report contain sensitive information, and deductive disclosure cannot be completely excluded due to the nature of the sample. The individual data are available on reasonable request, subject to the necessary agreements being signed by the involved parties. Requests should be directed to the local Data Access Committee of the Obstetrics and Reproductive Health Research Group at the Department of Women's and Children's Health, Uppsala University (kbh-orhf-datarequest@uu.se).

Code availability

The analytical code used in this study is available from the corresponding author Franziska Weinmar (franziska.weinmar@med.uni-tuebingen.de) on request.

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Author contributions

F.W. undertook conceptualization, methodology, formal analysis, investigation, visualization and writing of the original paper. E.F. performed conceptualization, validation and writing (review and editing). B.D. undertook conceptualization, methodology, funding acquisition, supervision, validation and writing (review and editing). A.S. performed project administration, conceptualization, data acquisition, methodology, investigation, funding acquisition, resources, supervision, validation and writing (review and editing).

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Competing interests

The authors declare no competing interests.

Additional information

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Policy information about availability of computer code

Data collection	Data for this study were collected using the Mom2B mobile application, which was developed based on the open-source Beiwe research platform, originally created by the Harvard T.H. Chan School of Public Health.
Data analysis	Descriptive statistics and primary statistical analyses were conducted using IBM SPSS Statistics (v28.0), while multiple imputation and secondary analyses were performed in R (v4.4.3) via RStudio (2024.12.1+563).

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Reporting on sex and gender	The sample consisted only of female participants.
Reporting on race, ethnicity, or other socially relevant groupings	No information on ethnicity/race was collected in the study, as this is not often accepted by the Review Board in Sweden to include in a study. For our sample we reported information on country of birth.
Population characteristics	The sample consits of Swedish-speaking women over 18 (age range in present sample 19-44 years) living in Sweden, who are pregnant or within three months postnatal who can participate by downloading the Mom2B app.
Recruitment	Recruitment occurs via healthcare facilities, social media, and print advertisements. After providing informed consent, participants complete online surveys accessible at designated perinatal periods and distributed approximately 1-2 times per week via the Mom2B app.
Ethics oversight	The study complies with General Data Protection Regulations and has ethical approval from the Swedish Ethical Review Committee (dnr: 2019/01170, with amendments).

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Study description	Longitudinal quantitative data
Research sample	The sample consits of Swedish-speaking women over 18 living in Sweden, who are pregnant or within three months postnatal who can participate by downloading the Mom2B app (for information on the Mom2B cohort, see www.mom2b.se). The sample is representative of other perinatal population-based cohorts in Sweden.
Sampling strategy	We included all participant who fulfilled our eligbility criteria (see below), which resulted in a sample of N = 623.
Data collection	Data were obtained from the Mom2B cohort (www.mom2b.se), an ongoing, prospective Swedish national study using a smartphone-app for survey data collection.
Timing	This study used data collected between January 2022 to April 2024.
Data exclusions	Eligibility criteria for this study included verified pregnancy and delivery, complete background information and a completed the DERS-16 questionnaire (our variable of interest)
Non-participation	The Mom2B app allows users to join at any stage of pregnancy, but survey access is limited to specific time windows, and participants may discontinue at any point without providing reasons, both of which can result in missing data – a common issue in mobile health research. We provide a detailed flowchart of the response rates at the included timepoints.
Randomization	Participants were not allocated to groups.

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