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Four Maternal Characteristics Determine the 12-Month Course of Chronic Severe Postpartum Depressive Symptoms

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Abstract

Background: Postpartum depression is a heterogeneous disorder in phenotype and etiology. Characterizing the longitudinal course of depressive symptoms over the first year after birth and identifying variables that predict distinct symptom trajectories will expedite efficient mental health treatment planning. The purpose was to determine 12-month trajectories of postpartum depressive symptoms, identify characteristics that predict the trajectories, and provide a computational algorithm that predicts trajectory membership.

Methods: A prospective cohort of women delivering at an academic medical center (2006–2011) was recruited from an urban women's hospital in Pittsburgh, PA. Women with a postpartum depressive disorder (n=507) participated and completed symptom severity assessments at 4–8 weeks (intake), 3 months, 6 months, and 12 months. Women were predominantly Caucasian (71.8%), married (53.3%), and college educated (38.7%). Clinician interviews of depressive symptom severity, medical and psychiatric history, assessment of function, obstetric experience, and infant status were conducted.

Results: Analyses resulted in identification of three distinct trajectories of depressive symptoms: 1) gradual remission (50.4%), 2) partial improvement (41.8%), and 3) chronic severe (7.8%). Key predictive characteristics of the chronic severe versus gradual remission and partial improvement trajectories included parity, education, and baseline global functioning and depression severity. We were able to predict trajectory membership in with 72.8% accuracy from these characteristics.

Conclusions: Four maternal characteristics predicted membership in the chronic severe versus gradual remission and partial improvement trajectories with 72.8% accuracy. The trajectory groups

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Clinical Trials Registration:

Identification and Therapy of Postpartum Depression Study (Wisner, PI; NCT 00282776, funding period 09/01/2006–07/31/2011). [Clinicaltrials.gov](https://clinicaltrials.gov/ct2/show/NCT00282776) Identifier: NCT00282776: <https://clinicaltrials.gov/ct2/show/NCT00282776>.

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comprise clinically relevant subgroups with the potential for tailored treatments to reduce the disease burden of postpartum depression.

Keywords

Postpartum depression; depression phenotype; primary care practice; women's mental health

Introduction

Depression is a heterogeneous disorder in phenotype and etiology (Klein and Kotov, 2016). Distinct phenotypes of depression impact the longitudinal course of the disorder and response to psychiatric treatment (Carter et al., 2012; Gaynes et al., 2009). Elucidation of the course of symptom severity, or trajectories, experienced by postpartum women is essential because the period prevalence of clinically significant depression is a striking 21.9% across the first postpartum year (Gaynes et al., 2005; Vesga-Lopez et al., 2008), with 800,000 women affected annually. A leading cause of maternal mortality is self-harm (Metz et al., 2016). The effectiveness of treatment approaches is limited and a paucity of translational research is available to match interventions with depression phenotypes. The Postpartum Depression: Action Towards Causes and Treatment Consortium (2015) pooled existing cross-sectional data from 19 sites across seven countries and demonstrated that women with postpartum depression comprise distinct phenotypes based on severity, onset timing, comorbid anxiety, and suicidality (Consortium, 2015). Other investigators have shown that subgroups of women have distinct long-term courses based on episode onset timing (e.g., chronic pre-pregnancy, during pregnancy, postpartum) (Stowe, Hostetter, and Newport, 2005; Beeghly et al., 2002).

Alongside biological and genetic contributions, a mother's psychosocial history and personal characteristics impact the course of postpartum depressive symptoms. Compared to non-depressed women, mothers with elevated depressive symptoms during pregnancy and the first year postpartum tend to be younger, have less than a high school education, a history of depressive episodes prior to pregnancy, higher parity, poor health status, inadequate social supports, more obstetric risk factors, and prenatal alcohol use (Giallo, Cooklin, and Nicholson, 2014; Rudy Bowen and Kazi Rahman, 2012; Sutter-Dallay et al., 2012; O'Hara, Neunaber, and Zekoski, 1984). A predictive model for determining the course would inform treatment selection and intensity.

Perinatal depression is usually comorbid with concurrent and lifetime anxiety disorders, which have shared psychosocial risk factors and exacerbate the course and severity of the depressive disorder (Ross et al., 2003). The course profiles of perinatal depression and anxiety symptoms from the third trimester to six months postpartum are highly associated ($p < .001$), and women with elevated levels of depression experience high levels of anxiety (Kuo, Chen, and Tzeng, 2014). The contemporaneous presentation of postpartum depressive and anxiety symptoms plays a role in defining the course of maternal psychopathology, including the risk of for relapse, response to treatments, and suicide (Kornstein and Schneider, 2001).

Children of mothers with sustained depressive symptoms are exposed to a chronic impaired parenting environment that adversely impacts development (Goodman et al., 2011). Women with chronic depression have newborns with elevated cortisol and norepinephrine levels, lower dopamine levels, and less optimal neurobehavioral performance compared to mothers with acute depression or without depression (Diego et al., 2004; Diego, Field, and Hernandez-Reif, 2005). Prolonged maternal depressive symptoms are associated with increased child behavioral problems, physiological reactivity to acute stress, poor social skills, cognitive impairment and poor academic performance (Campbell et al., 2007; Gump et al., 2009). Early identification of phenotypes and tailored treatments have potential to reduce the multi-generational risks of prolonged maternal depression on child and family outcomes.

The aims of this study were to: 1) identify subgroups of women with different courses of symptom evolution, or trajectories, across the first year after birth; 2) determine whether early postpartum (4–8 weeks) characteristics predict membership in definable trajectories; and 3) develop an algorithm to predict inclusion in the chronic depression trajectory. We hypothesized that one to four subgroups with distinct trajectories could be identified. To our knowledge, this is the first large-scale prospective study of depressed women derived from a general obstetrical hospital and whose symptoms were tracked with clinician-administered measures through the first year postpartum.

Materials and Methods

Participants and Procedures

This study was a secondary data analysis from a randomized clinical trial that involved case identification, diagnoses, and intervention for women with postpartum depression at a large urban medical center (Wisner, PI: NCT00282776, 09/01/2006–07/31/2011). The design, methods, and primary results of the screening study have been published (Wisner et al., 2013), and a brief summary follows. Mothers were evaluated at baseline (4–8 weeks), 3, 6, and 12 months postpartum (Wisner et al., 2017). All women were approached during their delivery hospitalization and assessed for eligibility for a postpartum screening study (n=27,504). Women were eligible if they were 18 years or older, English speakers, and delivered at the University of Pittsburgh Magee Women's Hospital (n=15,172). Subjects were recruited during the maternity hospitalization and offered a telephone screen for depression between 4–6 weeks postpartum. Trained college students contacted women who agreed to be screened. Women who screened positive for depression (n=628) on the Edinburgh Postnatal Depression Scale (EPDS 10) (Cox, Holden, and Sagovsky, 1987) were offered in-home diagnostic evaluations with the Structured Clinical Interview for DSM-IV (SCID) within two weeks of the screen. Women were ineligible if they had a diagnosis of bipolar or psychotic disorder, a suicide attempt within six months of pregnancy, or substance abuse/dependence during the index pregnancy (n=191). Blinded independent evaluators conducted assessments using the Structured Interview Guide for the Hamilton Depression Rating Scale-Atypical Depression Symptoms Version (SIGH-ADS₂₉) at the home visit and at all assessments (Williams, 2003; Wisner et al., 2017). Data from 507 women were included (see Supplementary eFigure 1). Ten women had more than one delivery and the

data from one postpartum period was selected at random for inclusion. The University of Pittsburgh Institutional Review Board approved this study, all participants provided written informed consent, and the study was compliant with the Code of Ethics of the World Medical Association.

Measures

Sociodemographic and perinatal information—The following information was collected from each participant: age, marital status, education, race, ethnicity, parity, lifetime history of physical and sexual abuse, preterm birth, type of delivery, and neonatal intensive care unit admission. The RAND Utilization of Care measure was used to collect maternal and infant health care utilization ('HCSUS Baseline Questionnaire Table of Contents,' 2015).

Psychiatric Diagnoses and Symptoms—The SCID was administered by master's level psychiatric clinicians. The SIGH-ADS₂₉ is a 29-item, clinician-administered depression assessment that was used to assess symptom severity (Williams, 2003). The SIGH-ADS₂₉ incorporates all versions of the widely-used Hamilton Rating Scale for Depression and includes atypical neurovegetative symptoms that are more common in women than men. The scores range from 0 to 90, with less than or equal to 8 indicative of remission. The Global Assessment of Function of the DSM-IV was used to assess postpartum psychosocial functioning. Maternal chronic illnesses were derived from the Medical Expenditures Panel Survey (Cohen et al., 1996).

Data Analyses

In the parent randomized clinical trial, no effect of the intervention on the mothers' mean depressive symptom or function scores was observed (Wisner et al., 2017). The intervention was telephone-based care management and the comparator condition was care as usual. All outcome measures improved significantly by greater than 50% across the first postpartum year. Therefore, no adjustment for treatment assignment was included in this trajectory analysis since our intervention was equivalent to the naturalistic condition.

The STATA plugin *traj* was used for estimating group-based trajectory models of SIGH-ADS₂₉ total score during the first year postpartum. The number of trajectories and the shape of the pattern of change for each over time were determined from the comparison of Bayesian Information Criterion (BIC), entropy, clinical meaning, and visual fit across all possible models. We expected one to four subgroups because we planned to avoid overfitting by controlling the number of women classified into each trajectory to be at least >5% of the total sample size. Greater than four subgroups would have resulted in too few women in at least one of the trajectories; therefore, this number of subgroups was used to ensure generalizability. After selecting a final model, we used the newly-created trajectory group membership variable to examine differences for demographic and other potential predictors across these categories. Since there were issues with model stability when including several predictive variables in the trajectory models themselves, we chose to examine potential predictors both individually and simultaneously using more "classical" statistical methods, whereby we assumed fixed trajectory group membership according to the chosen model

above. We note there are limitations to this approach as covariates have the potential to group membership; however, we use these simpler methods as a means of exploring these trajectories despite model instability and the small sample sizes in some trajectory groups. We employed Pearson's Chi-square test or Fisher's exact test for categorical variables and one-way ANOVA for continuous variables.

We created a multinomial logistic regression model with the trajectory group membership as the outcome to assess the capacity of baseline variables to predict one-year postpartum depression trajectories. We evaluated each demographic predictor in an unadjusted multinomial logistic regression model; those predictors individually statistically significant at the 10% level were assessed in the multivariable model. Development of a final predictive model for trajectory membership employed 10-fold cross validation techniques using a penalized multinomial regression model through the R package CARET (Classification and Regression Training). Variables that remained statistically significant at the 5% level were kept in the reduced model. A series of sensitivity analyses included (1) multiple imputation of missing covariate information, and (2) additional 10-fold cross validation coupled with resampling methods to explore predictors of the most sparse and most severely depressed trajectory group relative the remaining groups.

Post hoc analyses compared the two most severe trajectories with respect to the use of health services at baseline, month 6 and month 12 via a series of generalized linear mixed effect models (GLMMs). In each model, health service utilization served as an outcome and independent variables included trajectory group, time, and the trajectory-by-time interaction terms (assuming a 10% level of significance for interaction terms). The GLMMs included a random participant effect, which allowed us to account for within participant correlation. No adjustments made for multiple hypothesis tests because this was an exploratory study. Analyses were performed using STATA (StataCorp, 2015) and R 3.2.0 (Team, 2015). See the methods in the online supplement for more information.

Results

The 507 participants were predominantly Caucasian (71.8%) and married (53.3%). Less than half were college educated (38.7%) (Table 1). Slightly less than half reported postpartum onset of depression (46.4%), one third had onset during pregnancy (36.3%) and the remainder described chronic severe depression prior to the index pregnancy (17.4%). The most common diagnosis was recurrent major depressive disorder with a comorbid anxiety disorder (56.0%).

With cubic trajectories specified for all groups, BIC was minimized ($BIC_2 = 4955$, $BIC_3 = 4922$, $BIC_4 = 4928$, $BIC_5 = 4938$ in the two-, three-, four-, and five-trajectory models, respectively) in a three-trajectory model (Figure 1). Entropy for the three-trajectory model = 0.67 and the entropy for each of the two neighboring models (two- and four-trajectories) were lower (0.64 and 0.55, respectively).

The gradual remission trajectory (trajectory 1: $n=262$ [50.4%]) was optimally fit as quadratic. The SIGH-ADS₂₉ scores decreased from a mean of 18.0 (mild depression) at

baseline to 11.1 at 3 months postpartum, and gradually reached 7.8 (remission) at 12 months. Women in the partial improvement trajectory (trajectory 2: $n=211$ [41.8%]) experienced a consistent linear decrease in symptoms from an initial mean SIGH-ADS₂₉ score of 23.7 (moderate depression) to 15.1 (mild depression) at 12 months, which demonstrates improved but clinically significant symptoms. Women in the chronic severe depression trajectory (trajectory 3: $n=34$ [7.8%]), best fit as a cubic trajectory, had a similar mean SIGH-ADS₂₉ score of 23.5, but they experienced a worsening of symptoms at 3 months postpartum to an average of 34.1 (severe depression), which was sustained.

Table 1 presents summary statistics and potential predictors of the maternal characteristics examined across trajectories. Relative to trajectories 2 and 3, women with gradual remission (trajectory 1) were significantly more likely to be college-educated, have fewer children, and less likely to have an anxiety comorbidity, be physically abused or have a chronic illness.

The initial multinomial logistic regression analyses suggested the following candidate predictors based on the 10% level of significance criterion: anxiety comorbidity, education, child and adult physical abuse, number of chronic diseases, parity, EPDS and Global Assessment of Functioning (GAF) (Jones et al., 1995) scores. However, following the 10-fold cross validation model building procedure, all variables except child physical abuse, education, and EPDS score remained in the final predictive model. We assigned the gradual remission trajectory as the reference trajectory in all models because it was associated with the greatest improvement over time.

Five significant risk factors were found following the 10-fold cross validation modeling and model-estimated adjusted odds of trajectory membership (See supplementary eTable 1 and eFigure 2). The key comparison is between the reference trajectory with remitted depression and the other two trajectories: gradual remission trajectory 1 versus the partial improvement trajectory 2 and chronic severe depression trajectory 3. Compared to women with gradual remission, membership in the partial improvement trajectory (2 versus 1) and the chronic severe depression trajectory (3 versus 1) was associated with anxiety comorbidity (OR: 1.80 [1.16–2.78]; 2.13 [0.84–5.42]), having multiple children (OR for each additional child: 1.17 [0.96–1.42]; 1.86 [1.52–2.51]), physical abuse in adulthood (2.19 [1.39–3.45]; 1.82 [0.74–4.49]), number of chronic illnesses (OR for each additional illness: 1.61 [1.05–1.29]; 1.15 [0.95–1.40]), and global functioning (OR for one-point increase in GAF score: 0.92 [0.88–0.96]; 0.92 [0.85–0.99]).

The final model was used to calculate sensitivity analyses to distinguish the chronic severe depression (trajectory 3) from the combined gradual remission and partial improvement trajectories (trajectories 1 and 2). Women were classified into the trajectory with the highest model-estimated predicted probability. A sample of 485 women (95.7%) had complete data on all relevant variables to calculate the probabilities. Resampling and 10-fold cross validation modeling for trajectory 3 membership revealed four predictive variables that distinguished this trajectory from the other two: education, parity, EPDS, and GAF (see Table 2 and 3). Overall, the model correctly classified 353 out of the 485 women (72.8%).

$$\Pr(\text{Trajectory} = 3) = \frac{e^{\beta_2 * X_i}}{1 + e^{\beta_2 * X_i}}$$

Where $\beta_2 * X_i = 2.615 + 0.49 * (\text{parity}) - 0.077 * (\text{global functioning}) - 0.955 * (\text{education college and above}) + 0.091 * \text{EPDS}$

For example, if a woman presents at one month postpartum with two children, a global functioning score of 45, less than a college education, and an EPDS score of 22, the likelihood of membership in the chronic severe trajectory is 89.4% over the first postpartum year.

$$\text{Probability}(\text{Trajectory } 3) = \exp(2.132) / (1 + \exp(2.132)) = 0.8939 = 89.4\%$$

$$\text{Where } \beta_2 * X_i = 2.615 + 0.49 * (2) - 0.077 * (45) - 0.955 * (0) + 0.091 * (22) = 2.132$$

We explored whether different rates of engagement in treatment might explain the observation that women in the partial improvement and chronic severe depression trajectories had similar depression scores at baseline but a dramatic divergent course by three months postpartum. Women with chronic severe depression delayed contact with health care professionals. Despite being more likely to receive medication, they: 1) received less individual mental health counseling early in the post-birth period, but had more counseling visits later by six and 12 months, 2) initially visited the obstetrics clinic less frequently than women in the partial improvement trajectory over the first six months, but had a sudden increase in visits at 12 months, and 3) had more visits to the pediatric emergency room throughout the 12 months than women in the partial improvement trajectory (Tables 4 and 5).

Discussion

We were able to predict a woman's chronic severe depression trajectory by four key factors with 72.8% accuracy. The key predictive characteristics included parity, education, and current global functioning and baseline depression severity. Although approximately half of the participants in our sample experienced symptom remission, more than a third had clinically significant depressive symptoms and 7.8% suffered severe chronic symptoms across the first postpartum year. The latter trajectory equals approximately 68,000 women per year in the United States (based on 2015 US Census data). Prediction of a woman's depression trajectory based on her early postpartum characteristics paves the way for personalized interventions (Shelton, 2016) and promotes efficient use of healthcare resources by targeting women with high risk for a pernicious disease course. Personalized interventions are especially necessary for women in the chronic severe depression trajectory

because they are more difficult to engage in treatment. Targeted, efficient treatment plans are useful to produce positive results and increase patient engagement. If validated in other samples, the algorithm will support psychiatric stepped care approaches that provide individualized treatment based upon characteristics identified in the early postpartum period. The United States Preventive Services Task Force's recommendation (Force, 2014) to screen perinatal women for depression could be coupled with these models to match the level of care to her anticipated trajectory.

Each of the characteristics in the two models has an important role in defining the longitudinal depression phenotype. Women with fewer children and without a history of chronic illness or physical abuse have less stress taxing their emotional and financial resources. Low education is associated with unstable employment and fewer resources that increase the risk for a malignant course of depression (Fisher et al., 2016). The postpartum period is associated with a decline in global functioning in general, but postpartum depression adds additional strain on mothers' physical, social and emotional functioning (Boyce et al., 2000).

Our study revealed that women can have comparable early postpartum depression severity, but a divergent course of partial remission or escalation of severity. Residual symptoms of depression are associated with impairment at work, poor social adjustment, anxiety symptoms, chronic subthreshold depressive symptoms (Kennedy and Paykel, 2004). The risk for relapse for individuals with partial remission is four fold greater over 2 years than individuals with complete remission (Pintor et al., 2003). Remission of symptoms with full recovery is the goal of depression care (Keller, 2003).

Women in the partial improvement trajectory were more likely to consult with their obstetrician or a mental health clinician earlier than women with chronic severe depression despite having similar initial severity (see eTable 1). Early intervention shortens the course of depressive symptoms in perinatal women (Bittner et al., 2014), which may explain the divergence of symptoms for the gradual remission and chronic severe depression trajectories from 3 to 12 months. Women with postpartum depression prefer to receive treatment from their obstetrician (Goodman, 2009), which may account for the greater number of visits to obstetricians rather than mental health specialists. Women with chronic severe depression delayed contact until 12 months of worsening symptoms. Identifying and treating these women earlier in the postpartum period is supported by integrating mental health into obstetrical care via Collaborative Care clinics (Grote et al., 2004). The American College of Obstetricians and Gynecologists recommends that postpartum care extend beyond the traditional six weeks postpartum visit (American College of Obstetricians Gynecologists Committee on Obstetric Practice, 2016) and the American Academy of Pediatrics recommends postpartum screening during well-child visits (Siu et al., 2016).

Postpartum depression may have a similar course as in a non-perinatal population (Yaroslavsky et al., 2013), but it has unique predictors, differential rates of participants in each trajectory, and a divergence in course for individuals with elevated symptoms at baseline. Future research should incorporate additional factors that are potentially predictive

of perinatal depression trajectories (i.e., inter-parental relationship, partner and social support) (Kingsbury et al., 2015) to strengthen the predictive validity.

Strengths and Limitations

This study's strengths include the delineation of clinical subtypes of unipolar depression with careful exclusion of women with bipolar depression. All diagnoses were clinician-rated based on the DSM and the trajectory of depression severity was based on clinician ratings rather than a self-report measure. The focus on evaluating phenotypes of depression by examining the longitudinal course of symptoms is rare in perinatal depression research. The study included a large sample, with rates of Caucasian and African-American women similar to the 2015 US Census. However, limitations include representation of Latinas and Asians that was less than the general population, which limits generalizability; additionally, 17.8% did not provide complete data for use in the algorithm model of all of the groups and 4.3% in the model comparing the chronic severe depression trajectory 3 versus the gradual remission trajectory 1 and the partial improvement trajectory 2. Due to instability of trajectory models (i.e., small sample sizes in some of the resultant classes and relatively few follow-up time points), we were unable to build our predictive model using risk factors within the trajectory models, but we chose to use more classical statistical methods post hoc, after trajectory membership had been decided. This does not allow covariates to influence the shape and membership of classification in the truest form, but it does allow us to obtain an idea of which variables together may be influencing membership. We also note the small number of participants falling into the third trajectory (chronic severe). Comparing this small subset of women with the remainder of the sample lacks statistical efficiency and will have ramifications on power and precision in estimates. However, since the chronic severe trajectory was deemed the most clinically important group, we specifically sought to determine what characteristics may distinguish this group from the others. Finally, the exclusion criterion of women with a suicide attempt in the recent past may have resulted in a less severely ill sample of perinatal women.

Conclusion

Membership in the chronic severe trajectory versus the two better prognosis trajectories was predicted by four maternal characteristics with 72.8% accuracy. The trajectory groups comprise clinically relevant subgroups with the potential for tailored treatments to shorten the disease burden of postpartum depression.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

acknowledgements:

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Figure 1.

Trajectories of depressive symptoms across the 12 months postpartum in women with gradual remission (1), partial improvement (2), and chronic severe depression (3). Legend: SIGH-ADS score: Trajectory 1 = Gradual remission; Trajectory 2 = Partial improvement; Trajectory 3 = Chronic severe depression.

Table 1. Baseline characteristics of women at 4 to 8 weeks postpartum and the trajectory subgroup.

	All	Gradual remission (Trajectory 1)	Partial improvement (Trajectory 2)	Chronic severe depression (Trajectory 3)	p
N	507	262	211	34	
Age of mom (m(sd))	28.56 (6.00)	29.06 (6.00)	28.11 (6.04)	27.41 (5.52)	0.119
Race (%)					0.110
Caucasian	364 (71.79%)	196 (74.81%)	148 (70.14%)	20 (58.82%)	
African American	114 (22.49%)	49 (18.70%)	54 (25.59%)	11 (32.35%)	
Others	29 (5.72%)	17 (6.49%)	9 (4.27%)	3 (8.82%)	
Parity (m(sd))	1.10 (1.13)	1.00 (1.08)	1.14 (1.15)	1.65 (1.20)	0.006
Hispanic (%)	7 (1.48%)	1 (0.41%)	6 (3.02%)	0 (0.00%)	0.123
Education: College Degree or greater (%)	196 (38.66%)	114 (43.51%)	75 (35.55%)	7 (20.59%)	0.017
Married (%)	270 (53.25%)	150 (57.25%)	106 (50.24%)	14 (41.18%)	0.108
SIGH-ADS baseline (m(sd))	20.75 (5.63)	17.98 (4.96)	23.74 (4.67)	23.50 (5.15)	<0.001
SIGH-ADS 3months (m(sd))	16.87 (8.61)	11.13 (5.04)	21.33 (5.36)	34.09 (6.78)	<0.001
SIGH-ADS 9months (m(sd))	14.37 (8.41)	8.50 (4.47)	18.87 (5.89)	29.39 (7.83)	<0.001
SIGH-ADS 12months (m(sd))	11.58 (7.82)	7.33 (4.36)	15.11 (6.07)	30.47 (6.61)	<0.001
Onset (%)					0.145
Index Pregnancy	184 (36.29%)	85 (32.44%)	86 (40.76%)	13 (38.24%)	
Postpartum	235 (46.35%)	136 (51.91%)	85 (40.28%)	14 (41.18%)	
Prior to Index Pregnancy	88 (17.36%)	41 (15.65%)	40 (18.96%)	7 (20.59%)	
Endorsed self-harm ideation (%)	112 (22.09%)	50 (19.08%)	52 (24.64%)	10 (29.41%)	0.198
Anxiety Comorbidity (%)	284 (56.02%)	130 (49.62%)	132 (62.56%)	22 (64.71%)	0.011
Premature infant (%)	51 (11.06%)	26 (10.79%)	23 (12.11%)	2 (6.67%)	0.747
Delivery type (%)					0.216
Vaginal	344 (69.22%)	179 (69.65%)	140 (67.63%)	25 (75.76%)	
Planned C-section	74 (14.89%)	36 (14.01%)	31 (14.98%)	7 (21.21%)	
Emergency C-section	79 (15.90%)	42 (16.34%)	36 (17.39%)	1 (3.03%)	
NICU (%)	69 (13.94%)	35 (13.73%)	31 (14.98%)	3 (9.09%)	0.735

	All	Gradual remission (Trajectory 1)	Partial improvement (Trajectory 2)	Chronic severe depression (Trajectory 3)	p
Child Physical abuse (%)	97 (19.56%)	41 (15.95%)	47 (22.82%)	9 (27.27%)	0.093
Child sexual abuse (%)	113 (22.78%)	52 (20.23%)	52 (25.24%)	9 (27.27%)	0.361
Adult physical abuse (%)	160 (32.26%)	64 (24.90%)	84 (40.78%)	12 (36.36%)	0.001
Adult sexual abuse (%)	64 (12.90%)	29 (11.28%)	29 (14.08%)	6 (18.18%)	0.384
Number of chronic medical conditions (m(sd))	3.33 (2.13)	2.96 (1.85)	3.70 (2.32)	3.85 (2.46)	0.001
GAF score (m(sd))	59.50 (5.83)	61.42 (5.43)	57.45 (5.56)	57.21 (5.45)	<0.001

Note. Trajectory 1= gradual remission; Trajectory 2= partial improvement; trajectory 3=chronic severe depression; m=mean; sd=standard deviation; Planned C-section=planned cesarean section; Emergency C-section= Emergency cesarean section; NICU=Neonatal Intensive Care Unit; GAF=Global Assessment of Function; EPDS=Edinburgh Postnatal Depression Scale.

Table 2.

Baseline characteristics of women at 4 to 8 weeks postpartum and the trajectory subgroups: Trajectories 1 and 2 versus trajectory 3.

	All	Gradual remission (Trajectory 1) and Partial improvement (Trajectory 2)	Chronic severe depression (Trajectory 3)	p
N	507	473	34	
SIGH-ADS baseline (m(sd))	20.75 (5.63)	20.55 (5.62)	23.50 (5.15)	0.003
SIGH-ADS 3months (m(sd))	16.87 (8.61)	15.58 (7.24)	34.09 (6.78)	<0.001
SIGH-ADS 6months (m(sd))	14.37 (8.41)	13.25 (7.31)	29.39 (7.83)	<0.001
SIGH-ADS 12months (m(sd))	11.58 (7.82)	10.51 (6.39)	30.47 (6.61)	<0.001
Age of mom (m(sd))	28.56 (6.00)	28.64 (6.03)	27.41 (5.52)	0.22
Onset (%)				0.791
Index Pregnancy	184 (36.29%)	171 (36.15%)	13 (38.24%)	
Postpartum	235 (46.35%)	221 (46.72%)	14 (41.18%)	
Prior to Index Pregnancy	88 (17.36%)	81 (17.12%)	7 (20.59%)	
Endorsed self-harm ideation (%)	112 (22.09%)	102 (21.56%)	10 (29.41%)	0.395
Anxiety Comorbidity (%)	284 (56.02%)	262 (55.39%)	22 (64.71%)	0.38
Married (%)	270 (53.25%)	256 (54.12%)	14 (41.18%)	0.199
Education: College Degree or greater (%)	196 (38.66%)	189 (39.96%)	7 (20.59%)	0.04
Hispanic (%)	7 (1.48%)	7 (1.58%)	0 (0.00%)	>0.999
Race (%)				0.140
Caucasian	364 (71.79%)	344 (72.73%)	20 (58.82%)	
African American	114 (22.49%)	103 (21.78%)	11 (32.35%)	
Others	29 (5.72%)	26 (5.50%)	3 (8.82%)	
Parity (m(sd))	1.10 (1.13)	1.07 (1.11)	1.65 (1.20)	0.009
Premature infant (%)	51 (11.06%)	49 (11.37%)	2 (6.67%)	0.56
Delivery type (%)				0.058
Vaginal	344 (69.22%)	319 (68.75%)	25 (75.76%)	
Planned C-section	74 (14.89%)	67 (14.44%)	7 (21.21%)	
Emergency C-section	79 (15.90%)	78 (16.81%)	1 (3.03%)	

	All	Gradual remission (Trajectory 1) and Partial improvement (Trajectory 2)	Chronic severe depression (Trajectory 3)	p
NICU (%)	69 (13.94%)	66 (14.29%)	3 (9.09%)	0.602
Child Physical abuse (%)	97 (19.56%)	88 (19.01%)	9 (27.27%)	0.353
Child sexual abuse (%)	113 (22.78%)	104 (22.46%)	9 (27.27%)	0.673
Adult physical abuse (%)	160 (32.26%)	148 (31.97%)	12 (36.36%)	0.742
Adult sexual abuse (%)	64 (12.90%)	58 (12.53%)	6 (18.18%)	0.416
Number of chronic medical conditions (m(sd))	3.33 (2.13)	3.29 (2.10)	3.85 (2.46)	0.256
GAF score (m(sd))	59.50 (5.83)	59.64 (5.83)	57.21 (5.45)	0.027
EPDS total (m(sd))	14.27 (3.69)	14.13 (3.55)	16.21 (4.90)	0.021

Table 3.

Adjusted model odds of trajectory membership for four maternal predictive baseline characteristics of trajectories 1 and 2 versus trajectory 3.

	OR (95% CI) Trajectory 3 vs Trajectory 1,2
Education college and above	0.38(0.20–0.70)
Parity (number of pregnancies) ^a	1.63(1.26–2.23)
EPDS	1.1(1.03–1.17)
GAF at baseline ^a	0.93(0.87–0.98)

Note. The odds ratios between trajectory 1 (gradual remission), trajectory 2 (partial improvement), and trajectory 3 (chronic severe depression) during the first 12 postpartum months are displayed.

OR=odds ratio; CI=confidence interval; GAF= Global Assessment of Function.

OR and the 95% CI were estimated from 1000 resampling datasets

$$\Pr(Trajectory = 3) = \frac{1}{1 + e^{\beta * X_i}}$$
$$\Pr(Trajectory = 1or2) = \frac{e^{\beta * X_i}}{1 + e^{\beta * X_i}}$$

Where $\beta * X_i = 2.615 - 0.955 * (Education College or above) + 0.49 * (parity) + 0.091 * (EPDS) - 0.077 * (global functioning)$

Table 4.

Mother and infant health service utilization by time point (0, 6, 12 months) and trajectory membership.

Trajectory	Month 0			Month 6			Month 12		
	2	3		2	3		2	3	
Infant measures									
Visited emergency room (baby)	N 211	34		142	22		125	19	
Admitted to hospital (baby)	22 (10.7)	8 (25.8)		28 (20.3)	9 (42.9)		35 (28.2)	8 (42.1)	
Mother's rating of infant's health (Low)	10 (4.9)	4 (12.9)		10 (7.2)	5 (22.7)		9 (7.3)	2 (10.5)	
Exclusively breast feeding ⁺	22 (10.7)	7 (21.2)		20 (14.3)	5 (22.7)		22 (18.0)	3 (15.8)	
Maternal Measures									
Medical emergency room visit ⁺	40 (19.1)	5 (15.2)		20 (14.3)	5 (22.7)		13 (10.8)	0 (0.0)	
Regular emergency room									
Psychiatric emergency room ^{II}									
Visited primary care doctor ⁺	38 (18.2)	4 (12.1)		22 (15.5)	4 (18.2)		41 (33.3)	7 (36.8)	
Visited OB/GYN ^{*+}	35 (94.6)	4 (100.0)		19 (86.4)	3 (75.0)		37 (92.5)	5 (71.4)	
Visited psychiatrist ⁺	3 (8.1)	0 (0.0)		0 (0.0)	1 (25.0)		0 (0.0)	1 (14.3)	
Visited mental health professional ⁺	35 (17.0)	8 (25.0)		54 (38.3)	9 (40.9)		70 (56.5)	13 (68.4)	
Received help:	103 (49.5)	13 (39.4)		55 (38.7)	6 (27.3)		48 (39.0)	12 (63.2)	
Private counseling ^{*+}	15 (7.2)	2 (6.1)		21 (14.8)	3 (13.6)		24 (19.7)	6 (31.6)	
Medication ⁺	20 (9.6)	6 (18.2)		29 (20.4)	6 (27.3)		27 (22.0)	9 (47.4)	
Self-Help Group ^{II}									
Alternative Therapy ^{II}									

Note. Trajectory 2= partial improvement; trajectory 3=chronic severe depression.

^{II} Generalized mixed effect model was not performed due to small cell count

⁺ Significant time effect from generalized mixed effect model (p<0.05)

^{*} Significant time-by-trajectory group interaction from generalized mixed effect model (p<0.1)

Table 5.

Model coefficients from generalized mixed effect models of mother and infant health service utilization.

Fixed effect	Visited OB/GYN			Received private counseling		
	Estimate	SE	p	Estimate	SE	p
Trajectory 3 vs. Trajectory 2	−0.63	0.39	0.106	−0.51	0.47	0.277
Time	−0.04	0.02	0.039	−0.26	0.03	<0.001
Trajectory 3 X Time	0.12	0.05	0.034	0.17	0.06	0.008

Note. Only models with a significant trajectory group effect at the 5% level or a significant trajectory group-by-time interaction term at the 10% level are presented here.

Trajectory 2=partial improvement; trajectory 3=chronic severe depression.