Patterns of Pregnancy and Postpartum Depressive Symptoms: Latent Class Trajectories and Predictors

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This research was supported by grant #196156 from the Research Council of Norway.

There has been no prior dissemination of the data or ideas appearing in the manuscript.

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Abstract

Depressive symptoms among pregnant and postpartum women are common. However, recent studies indicate that depressive symptoms in the perinatal period do not follow a uniform course, and investigations of the heterogeneity of time courses and associated factors are needed. The aim of this study was to explore whether depressive symptoms in the perinatal period could be categorized into several distinct trajectories of symptom development among subgroups of perinatal women, and to identify predictors of these trajectory groups. The study used data from 1,036 Norwegian women participating in a community-based prospective study from mid-pregnancy until 12 months postpartum. Depressive symptoms were assessed with the Edinburgh Postnatal Depression Scale at seven time points (four during pregnancy). Partner-related attachment, stress, childhood adversities, pregnancy-related anxiety, previous psychopathology, and socioeconomic conditions were assessed at enrollment. By means of growth mixture modeling based on piecewise growth curves, four classes of depressive symptom trajectories were identified, including (a) *pregnancy only* (4.4%), (b) *postpartum only* (2.2%), (c) *moderate-persistent* (10.5%), and (d) *minimum symptoms* (82.9%) classes. Multinomial logistic regression analyses showed that membership in the pregnancy only and postpartum only classes primarily was associated with pregnancy-related anxiety and previous psychopathology, respectively, whereas the moderate-persistent class was associated with diverse psychosocial adversity factors. Findings suggest heterogeneity in temporal patterns of elevated depressive mood, relating specific trajectories of time courses with distinct adversity factors. Researchers and clinicians should be aware of possible multiple courses of elevated perinatal depressive mood, and inquire about possible diverse adversity factors, aberrant pathways, and prognoses.

General Scientific Summary

This study suggests that depressive symptoms during pregnancy and the postpartum period do not follow a uniform course, but rather supports a model of several distinct time courses of depressed mood associated with diverse psychosocial adversity factors.

Keywords: Postpartum depression, perinatal depression, maternal dysphoria, growth mixture modeling

Patterns of Pregnancy and Postpartum Depressive Symptoms: Latent Class Trajectories and Predictors

Postpartum depression (PPD) is one of the most common concomitants of childbirth, and with the accompanying risk of adverse consequences on maternal mental health, child development, and family functioning (Goodman et al., 2011; Meltzer-Brody & Stuebe, 2014), it has been of interest to both clinicians and researchers for decades. More recently, findings indicate that timing and duration of depressive symptoms in the perinatal period do not follow a uniform course, suggesting considerable heterogeneity in symptom trajectories as well as associated antecedents (Cents et al., 2013; Mora et al., 2009; PACT Consortium, 2015; Sutter-Dallay, Cosnefroy, Glatigny-Dallay, Verdoux, & Rasclé, 2012; Wisner et al., 2013). Investigating differential patterns of depressive symptomatology may enable efforts to develop more personalized approaches to treatment and prevention (Cuijpers et al., 2012). Exploring differential time courses and associated predictors may further provide a basis for investigating possible diverse etiologies, outcomes, and long-term prognoses.

This study employed a large, multisite community-based sample ($N = 1,036$) with seven data collection waves to examine trajectories of depressive symptoms from early pregnancy to one year postpartum with a dimensional approach. We examined whether subgroups of women following distinct trajectories of depressive symptoms can be identified, and whether a range of psychosocial adversity factors supposed to be risk factors for PPD can predict class membership.

Time Course of Depressive Symptoms Across Pregnancy and the Postpartum Period

There is an ongoing debate about the temporal definition of symptom onset in PPD (PACT Consortium, 2015; Wisner, Moses-Kolko, & Sit, 2010). Some emphasize the elevated incident rates during the first few weeks after birth, suggesting a narrowly defined period for symptom onset. This early elevated risk has been connected with physiological and

psychological changes in the first postpartum weeks and suggested to constitute a specific phenotype (Forty et al., 2006; Munk-Olsen, Laursen, Pedersen, Mors, & Mortensen, 2006). Others have expanded the time frame of PPD up to one year postpartum (O'Hara & McCabe, 2013). With a broadened time frame, PPD has been understood as a continuation of earlier mental health problems (Patton et al., 2015). Further, there is a growing number of reports highlighting the importance of investigating onset of depression during pregnancy, as well as depression limited to the pregnancy period (Pearson et al., 2013). For example, a study addressing the heterogeneity of PPD found that among women with the most severe subtype of PPD, the majority had a pregnancy onset (67%). In less severe subtypes of PPD, pregnancy onset was rarer (11% and 34%) (PACT Consortium, 2015). Moreover, in a study screening ten thousand women, Wisner et al. (2013) found that among screen-positive cases only 40% of women's depressive episodes began postpartum, while 33% had a pregnancy onset. There is also considerable variation regarding the duration of PPD; for most women diagnosed with PPD it seems to be a time-limited condition, whereas for a substantial subgroup (38%) depression develops into a persistent disorder (Vliegen, Casalin, & Luyten, 2014).

Only two studies have investigated heterogeneous time courses of depressive symptoms in a time frame limited to pregnancy and the postpartum period (Mora et al., 2009; Sutter-Dallay et al., 2012). Mora et al. (2009) found three groups with transient courses with high level symptoms predominantly (a) during pregnancy, (b) early postpartum, and (c) late postpartum, respectively. Additionally, they identified stable classes with (d) low symptom levels and (e) a chronic high trajectory. With a somewhat smaller sample Sutter-Dallay et al. (2012) described similar classes; however, they did not find specific postpartum classes reaching clinical levels. Several studies have investigated the heterogeneity of maternal depressive symptom trajectories from the perinatal period into childhood years (Campbell, Matestic, von Stauffenberg, Mohan, & Kirchner, 2007; Cents et al., 2013; Luoma, Korhonen,

Salmelin, Helminen, & Tamminen, 2015; Matijasevich et al., 2015; van der Waerden et al., 2015). All studies report several classes, ranging from four to six, with distinct trajectories, suggesting that a singular model of symptom onset and course is unwarranted. A robust finding across studies is that most women follow trajectories of minimal or mild symptoms. Further, all studies found a small class with a chronic high symptom burden. Stable trajectories (at different levels of severity) were common, whereas various transient trajectories tended to comprise relatively smaller class proportions. The findings are in accordance with research on heterogeneous courses in the transition to parenthood in concepts such as life satisfaction, where most participants report stable levels, although small subgroups show increasing or decreasing trajectories (Galatzer-Levy, Mazursky, Mancini, & Bonanno, 2011).

However, of studies spanning the perinatal period into childhood years, only one found a pregnancy only class (van der Waerden et al., 2015), and none reported specific postpartum classes. None of these studies had more than one measurement point during pregnancy, and several had none. In most of the studies, the majority of measurement points was after the postpartum period had passed. By including measurement points outside the postpartum period, there is a danger of missing mood changes specific for this period, because trends more typical of maternal mood at later stages may disguise fine grained developmental trends that may be found particularly in this period. To be able to capture the specific mood changes of the pregnancy and postpartum period, it is useful to apply a limited time frame with enough measurement points (Ram & Grimm, 2007). The present work extends extant studies by including several measurement points during pregnancy, by limiting the time period to pregnancy and one year postpartum, and building a statistical model suited to detect shorter-term changes in symptom levels in close proximity to childbirth.

Risk Factors of Depressive Symptoms in Pregnancy and the Postpartum Period

Reviews of risk factors for perinatal depression include previous psychopathology, domestic violence, history of abuse, life stress, lack of social or partner support, migration status, and anxiety during pregnancy as robust risk factors across studies. Pregnancy complications, neuroticism, family history of psychiatric illness, low socioeconomic status, substance misuse, and chronic illness are listed as risk factors with slightly less systematic evidence (Biaggi, Conroy, Pawlby, & Pariante, 2016; Howard et al., 2014; O'Hara & McCabe, 2013). The extent to which the same risk factors predict various trajectories of depressive symptoms in the perinatal period has received less attention. In studies investigating differential courses of depressive symptoms in this period sociodemographic variables, anxiety, stress, previous psychopathology, lack of social support, poor relationship quality, and minority status predicted class membership in subgroups with increased symptom burden relative to subgroups with minimal symptoms (Cents et al., 2013; Luoma et al., 2015; Mora et al., 2009; Sutter-Dallay et al., 2012; van der Waerden et al., 2015). Moreover, a review investigating differences between chronic and transient courses of PPD found that poor partner relationship, life stress, contextual risk, personality factors, and to some extent childhood abuse and low maternal care were associated with chronic time courses of PPD, relative to remitting time courses (Vliegen et al., 2014).

This study builds on and extends these findings in several ways. Measures of previous psychopathology, partner-related attachment patterns, life stress, pregnancy-related anxiety, childhood trauma, and sociodemographic variables are included as predictor variables. These constitute important risk factors across several contexts, however less is known of how these specific factors are related to various depressive symptom trajectories in the perinatal period. Specifically, this study extends earlier research on partner relations by including a measure of partner-related attachment patterns. Partner-related attachment has received little attention in research on perinatal depression; however, insecure attachment styles have been related to a

diagnosis of PDD (Ikeda, Hayashi, & Kamibeppu, 2014). Further, ambivalent attachment styles predicted increases in depressive symptoms from pregnancy to the postnatal period (Simpson, Rholes, Campbell, Tran, & Wilson, 2003). Moreover, instead of applying a general measure of anxiety; this study assessed pregnancy-related anxiety, because including features of the perinatal period is central to the idea of the study. Pregnancy-related anxiety is considered to constitute a distinct clinical entity with the capacity of predicting birth outcome independently of more generalized symptom measures, as well as explaining unique variance in postnatal mood disturbance (Blackmore, Gustafsson, Gilchrist, Wyman, & O'Connor, 2016; Huizink, Mulder, Robles de Medina, Visser, & Buitelaar, 2004). Finally, by including childhood trauma as a predictor, this study relates to research showing an increased risk of PPD among women with a history of abuse (Howard et al., 2014), and extends this literature by including a broad range of childhood adversities.

Study Aims and Hypotheses

In this study, we investigated maternal depressive symptoms with a dimensional approach within a large multisite community-based sample of women at seven time points from pregnancy through 12 months postpartum. The first aim was to explore whether maternal depressive symptoms throughout this period could be categorized into several distinct, empirically defined trajectories. Based on extant literature we expected (a) one trajectory characterizing women with elevated symptoms limited to the pregnancy period (Mora et al., 2009; Pearson et al., 2013); (b) one trajectory of early postpartum onset and a gradual recovery, based on findings of increased incidence early postpartum (Munk-Olsen et al., 2006) and studies of heterogeneous trajectories (Mora et al., 2009); (c) a stable trajectory at a moderate level with pregnancy onset in which symptoms continue into the postpartum period (PACT Consortium, 2015; Wisner et al., 2013); (d) a small group of women with a very high symptom level throughout the period of study, as this has been a consistent finding

in studies of heterogeneous courses (Cents et al., 2013; Mora et al., 2009; van der Waerden et al., 2015); (e) a majority of women presenting minimum symptoms (Cents et al., 2013; Mora et al., 2009; van der Waerden et al., 2015).

Second, we aimed to investigate whether potential psychosocial adversity factors, such as sociodemographic factors, previous psychopathology, stress, partner-related attachment patterns, pregnancy-related anxiety, and childhood trauma were differentially associated with the hypothesized trajectories. More specifically, we expected that higher levels of adversity predicted membership in trajectory classes with elevated symptom burden, relative to trajectories with low symptoms. Further, we expected stable courses with elevated symptoms to be predicted by more adversity factors than transient courses, as it has been shown that persistent courses of PPD are characterized by higher levels of adversities than time-limited courses (Vliegen et al., 2014).

Method

Procedure and Participants

This study is based on data from 1,036 women participating in the prospective multisite *Little in Norway* study (Moe & Smith, 2010). From September 2011 until October 2012, all pregnant women receiving routine prenatal care at nine public well-baby clinics in Norway were invited to participate in the study. Initially 1,041 women consented to participate; five women later withdrew their consent, leaving 1,036 (99.5%) women as participants. There were no exclusion criteria. At five clinics, the staff did not establish reliable routines to monitor rates of participation. At the remaining four clinics 50.7% of all women attending the clinic consented to participate. Participation rates were probably similar at the other five sites because recruitment strategies and resources allocated to the data collection were similar at all well-baby clinics. Comparisons of educational level of this sample with official national statistics of Norwegian women of similar age and residential

area showed that participants in the study had a significantly higher educational level (Statistics Norway, 2014). This study uses data from seven time points: at average gestational week 21 (range: weeks 8-34) (T1), week 28 (T2), week 32 (T3) and week 36 (T4), 6 weeks postpartum (T5), 6 months postpartum (T6), and 12 months postpartum (T7). Participants were recruited at their first prenatal care examination at the well-baby clinics. There is considerable variation in local and individual practices as to when pregnant women first receive prenatal care at a well-baby clinic (many choose to receive initial checkups at their general practitioner). As a result, the time frame for enrollment was rather large (i.e., between gestational week 8 and 34), and a comprehensive number of participants missed the early data collection points. Thus the recruited numbers of participants at T1 and T2 were $n = 659$ and 579 , respectively. Response rates at T2 were considerably lower than at other time points due to shortage of staff members to collect data. Response rates at T7 were also lower, reflecting the fact that paid parental leave ends one year after birth in Norway, and parents are returning to work. Information about recruitment and response rates is depicted in Figure 1.

Data were collected digitally by means of web-based questionnaires at all time points. Primarily, responses were submitted at designated computers at the well-baby clinics. However, at T3 and T4, respondents were asked to complete the questionnaire at their private computers at home. The nine well-baby clinics were located at geographically diverse sites across Norway.

Attrition analyses were conducted by means of univariate logistic regression analyses and showed that lower education (OR = 0.93, 95% CI [0.87, 0.99], $p = .02$), parity (OR = 0.75, 95% CI [0.57, 0.99], $p = .04$), and childhood trauma (OR = 1.20, 95% CI [1.06, 1.37], $p < .01$) predicted dropout at T7. Age, previous psychopathology, partner-related attachment, life stress, and pregnancy-related anxiety did not show any significant associations with missing status ($p > .05$). Further, high levels of depressive symptoms T1 to T5 significantly

predicted dropout (ORs = 1.06-1.10, $p < .05$), whereas depressive symptoms at T6 were not predictive (OR = 1.05, 95% CI [1.00, 1.10], $p = .06$).

At enrollment the mean age of the participants was 30.3 years (range: 17-43, $SD = 4.8$), 54.9% of the women were nulliparous. Most women were married (36.2%) or cohabitating (59.7%), with only a small fraction being single/divorced/separated (2.7%) or not specifying their marital status (1.4%). A large proportion of participants was educated at university level (77.1%), while the highest completed education of the remaining participants was high school level (19.8%) or lower (3.1%). At enrollment, 77.3% of the participants were full-time employed, 5.8% full-time students, 13.6% part-time students/part-time employed, while 3.0% reported being unemployed/on benefits/homemakers. Median annual personal income ranged from the equivalent of \$36,000 to \$55,000 (44.4%), while 31.1% had lower and 24.3% higher income. The ethnic majority was Norwegian (93.9%), with a few reporting a diversity of other ethnic backgrounds (6.1%).

Measures

With the exception of measures of depressive symptoms, which were assessed at all seven data collection points, all measures described below were collected at enrollment.

Depressive symptoms. Maternal depressive symptoms were assessed using the Edinburgh Postnatal Depression Scale (EPDS), originally developed to screen for depressive symptoms in women in the postpartum period (Cox, Holden, & Sagovsky, 1987), and later validated for antepartum use (Murray & Cox, 1990). The EPDS is a 10-item self-report questionnaire asking respondents to consider various depressive symptoms during the last seven days on a four-point scale (range: 0–30). Although developed with cut-off scores indicating probable depression, the EPDS composite score has also been used as a continuous variable for research purposes (Matijasevich et al., 2015), with the benefit of yielding a more detailed range of depressive symptomatology at both clinical and subclinical levels. The

EPDS composite score was used as a continuous variable in this study. Cronbach's alphas were high at each assessment (ranging from .80 to .85), indicating good internal consistency.

Sociodemographic factors. Education was stipulated in years of education. Parity was assessed by asking participants to state number of previous children, and was coded as a dichotomous variable (nulliparous / multiparous).

Previous psychopathology. Participants were asked the following question: "Have you ever experienced mental health problems earlier in life?" (yes/no). Similar single question measures have been shown to serve as acceptable screeners for mental health problems (Veldhuizen, Rush, & Urbanoski, 2014), and have previously been used extensively in research (van der Waerden et al., 2015).

Partner relationship. Characteristics of partner relationship were assessed by the Experiences in Close Relationships Scale (ECR), which is a 36-item self-report measure of adult romantic attachment styles rated on a 7-point scale. ECR yields two subscales of underlying attachment: anxiety (fear of interpersonal rejection or abandonment, an excessive need for approval from others, and distress when one's partner is unavailable or unresponsive), and avoidance (fear of dependence and interpersonal intimacy, an excessive need for self-reliance, and reluctance to self-disclose) (Brennan, Clark, & Shaver, 1998). Higher scores reflect greater levels of insecure attachment within each relationships domain (range 18-126 on each subscale). In this study Cronbach's alphas were .88 and .89 for anxiety and avoidance subscales, respectively, in accordance with the high level of internal consistency reported in other studies (Brennan et al., 1998).

Stressful life events. Stress was measured by the life stress subscale, which is part of The Parenting Stress Index (PSI) (Abidin, 1995). The Norwegian version of the subscale lists 22 major life events (Kaaresen, Ronning, Ulvund, & Dahl, 2006), such as serious illness in the family, changing school or work place (range 0-91). The respondents are asked to indicate

whether the family had experienced each of the life events during the last 12 months. Items were weighted according to the Professional Manual of the Parenting Stress Index (Abidin, 1995), and the composite score was used in this study.

Anxiety during pregnancy. Anxiety related to pregnancy and birth was assessed by the 10-item Pregnancy Related Anxiety Questionnaire-Revised (PRAQ-R) (Huizink et al., 2004). Each item is measured on a 5-point scale. PRAQ-R yields three subscales (fear of giving birth, fear of bearing a physically or mentally handicapped child and concerns about one's own appearance). In this study, mean scores across all 10 items were computed to obtain an indication of overall level of anxiety related to pregnancy and birth (Cronbach's $\alpha = .84$, range: 10-50).

Childhood trauma. Childhood traumas were assessed retrospectively by the Adverse Childhood Experiences Scale (ACE), a self-report measure of childhood abuse, neglect, and household dysfunction (Dong et al., 2004). It lists ten types of adverse childhood experiences and asks whether they have been experienced during their childhood. ACE has shown good test-retest reliability (Dong et al., 2004). Dong et al. (2004) showed that experiencing one type of adverse childhood event increased the odds of having additional adverse childhood experiences, and highlighted the importance of looking at the extent of such experiences rather than effects of a specific type. In this study we used the sum of reported types, ranging from 0 to 10.

Statistical Analysis

Statistical analyses were conducted in two steps. First, the time course of depressive symptoms from mid-pregnancy through one year postpartum was modeled, and subgroups of women with distinct longitudinal courses of depressive symptoms were identified. For this purpose, latent growth curves (LGC) were modeled based on EPDS composite scores at all seven time points (Bollen & Curran, 2006). To represent birth as a major event, a linear three-

piece piecewise growth curve model was estimated (Flora, 2008) with the first transition point at the end of the pregnancy period (i.e., T4) and the second six weeks after birth (i.e., T5). The three-piece model yielded three phases of symptom development: a pregnancy phase, a peripartum phase and a postpartum phase. By allowing for sharp transitions at these specific time points the statistical model was able to represent the theoretical expectation of differential change rates during these phases (Ram & Grimm, 2007), i.e. a pattern of rapid change in symptom levels during the peripartum phase and relatively slower change during the pregnancy and postpartum phases. Two-piece models with only one transition point at either T4 or T5 were also modelled to examine whether the three-piece model with its capacity of detecting slopes with rapid change in close proximity to birth in fact showed superior fit compared to growth models that did not allow for such patterns. Based on these growth curves, latent growth trajectory classes were estimated by means of growth mixture modeling (GMM) (Muthén, 2004). GMM can account for heterogeneity in longitudinal patterns of depressive symptomatology as latent classes correspond to qualitatively distinct trajectories. Variances were constrained to be equal across classes, as convergence issues emerged when models with unique variances across classes were estimated.

Second, class membership was regressed on the potential psychosocial adversity factors by estimating multinomial logistic regression models using the three-step modal ML approach accounting for class assignment uncertainties (Asparouhov & Muthén, 2014; Vermunt, 2010). This was done to examine the association of possible predictor variables with class probabilities. Such associations were initially investigated with a univariate approach and subsequently with a multivariate approach to reach the most robust set of predictor variables. Only significant predictors ($p < .05$) from the univariate analyses were entered in the multivariate model. The scales of the continuous predictor variables were z-

transformed, to make them more readily comparable (with the exception of age and education which were measured in years).

Model fit of basic growth models was evaluated by inspecting χ^2 -square statistics, Confirmatory Fit Index (CFI), Tucker–Lewis Index (TLI), and the root mean square error of approximation (RMSEA). According to recommendations in the literature, CFI and TLI values of .95 or greater and RMSEA values of .06 or lower are considered as indicating good fit (Hu & Bentler, 1999). To decide on number of classes, the bootstrapped likelihood ratio test (BLRT), the Lo–Mendell–Rubin adjusted likelihood ratio test (LMR-LRT), and the Bayesian information criteria (BIC) / sample size adjusted BIC (SABIC) were used (Nylund, Asparoutiov, & Muthen, 2007). Entropy values, which represent the quality of classification of individuals into latent classes, were also inspected. Finally, overall interpretability was evaluated, and we excluded models with classes comprising less than 20 women.

Missing data were handled by the full information maximum likelihood procedure (FIML) accounting for missing at random (MAR) assumptions. Moreover, because missing data due to dropout in longitudinal studies may not fulfill MAR assumptions, we additionally tested models handling dropout that is not missing at random (NMAR) (Muthen, Asparouhov, Hunter, & Leuchter, 2011). All data analyses were performed in Mplus 7.3, using maximum likelihood estimation with robust standard errors (Muthen & Muthen, 2015).

Results

Means, standard deviation and a correlation matrix of all variables used in the study are presented in Table 1. The table shows mean EPDS scores to range from 2.88 to 4.54, well below clinical cut-off, with generally higher EPDS mean levels during pregnancy compared to the postpartum period. Correlations between assessments were moderate to high ($.40 \leq r \leq .72$) and followed a pattern of stronger correlations among assessments closer in time. The means of life stress index (7.08), ECR anxiety and avoidance (44.23 and 30.05 respectively),

PRAQ (22.70), and ACE (0.75) were at the lower end of the scales, which would be expected in a community-based sample.

Latent Growth Curve Models

LGC models were fitted based on EPDS mean scores at all seven time points. Initially, a basic model allowing for linear development across all time points with an intercept (estimated initial status early in pregnancy) and a slope (estimated change in depressive symptoms) was estimated. The parameterization of the slope was coded as the number of weeks that had passed since the first measurement, thus reflecting the uneven time intervals between measurements. The basic LGC model had a mean intercept (I) of 4.65 ($p < .01$) and a mean slope (S) of -0.03 ($p < .01$), indicating an estimated mean score of depressive symptoms of 4.65 at T1 and a decrease of 0.03 scores each week. However, model fit was poor ($\chi^2[23] = 188.04$; CFI = 0.860; TLI = 0.872; RMSEA = 0.083, 90% CI: 0.072, 0.094). A linear three-piece LGC model with transition points at the end of the pregnancy period and six weeks postpartum was then estimated (Means: I = 4.38, $p < .01$; S1 [pregnancy slope] = 0.02, $p < .05$; S2 [peripartum slope] = -0.10, $p < .01$; S3 [postpartum slope] = -0.02, $p < .01$), yielding excellent fit ($\chi^2[14] = 27.00$; CFI = 0.989; TLI = 0.983; RMSEA = 0.030, 90% CI: 0.012, 0.047). Results indicate an estimated EPDS mean score of 4.38 at T1, with a slight symptom increase of 0.02 scores each week during pregnancy, a sharper weekly decrease of -0.10 scores in the peripartum phase, with a continued but small weekly decrease of -0.02 scores in the postpartum phase.

Two two-piece models with transition points at the end of pregnancy or six weeks postpartum respectively, were also estimated to investigate if more parsimonious models would yield equivalent fit. However, both models yielded a poor fit ($\chi^2[19] = 173.23$; CFI = 0.869; TLI = 0.855; RMSEA = 0.089, 90% CI: 0.077, 0.101 and $\chi^2[19] = 157.35$; CFI = 0.882; TLI = 0.870; RMSEA = 0.084, 90% CI: 0.072, 0.096). The linear three-piece model

was thus selected for further analyses as it was in accordance with the a priori theoretical model and yielded the best fit.

Growth Mixture Modeling

Next, a series of GMM models was fitted to the three-piece piecewise LGC model for assessment of the optimal number of classes. As Table 2 shows, the 2- and 3-class solutions were not optimal, as all the fit indices indicated that more classes yielded a better fit. Nor did the 6-class solution seem to be adequate as the LMR-LRT indicated fewer classes and the solution included two classes with less than 10 women in each. It was less clear whether a 4-class or a 5-class solution yielded the best fit, and as neither the BLRT nor the BIC/SABIC provided conclusive answers, we based our decision on LMR-LRT, overall interpretability, and entropy values. LMR-LRT and the entropy values both favored the 4-class solution. An inspection of these two solutions showed that the 5-class solution in most part reflected the 4-class solution, with the exception of one new class (6%) characterized by a high initial level, rapidly dropping to stable low levels. Taking all these aspects into consideration, a 4-class solution was finally decided upon. The entropy value was .89 for this model, which indicates good separation of latent classes (Celeux & Soromenho, 1996).

Estimated trajectories of the 4-class model are depicted in Figure 2, with corresponding parameters found in Table 3. As depicted in Figure 2, *the pregnancy only* class (4.4%) represents a heightened initial symptom level early in pregnancy with a steep increase of symptoms during pregnancy, peaking at the last time point before delivery. The symptom level then rapidly dropped during the peripartum period with a continued downward trend postpartum. *The postpartum only* class (2.2%) closely resembles the traditional PPD pattern, with low levels during pregnancy, a rapid peripartum onset of symptoms, followed by a gradual postpartum decrease, reaching low symptom levels at the end of the first postpartum year. A third class termed *moderate-persistent* (10.5%), showed elevated symptoms at a

subclinical level with a flat trend during pregnancy. The symptom level dropped slightly during the peripartum period; however, this pattern was reversed in the postpartum period with a steady increase of symptoms the first year after childbirth. The majority of women (82.9%) were categorized into a *minimum symptoms* class, characterized by low levels of depressive symptoms during pregnancy and with slight, but significant declines after birth.

Because conventional GMM models are based on MAR assumptions, additional analyses under NMAR assumptions were modeled as well. More specifically, we re-ran our models in the framework of Diggle-Kenward selection model, Roy latent dropout pattern mixture modeling, and Muthén-Roy modeling with latent subgroups of subjects with respect to the piecewise LGC model and the GMM model (Muthen et al., 2011). The estimated parameters, as well as number and proportions of classes did not differ substantially from those in the original models; thus only results from the GMM model under MAR assumptions are reported.

Predictors of Membership in Latent Trajectory Classes

In the next analytic step, the associations of sociodemographic factors, stress, partner attachment, pregnancy-related anxiety, and childhood adversity with class membership were investigated by regressing class membership on these factors in multinomial logistic regression analyses. First, each predictor was included one by one in separate regression models (see Table 4). Second, all significant predictors were included simultaneously in one multiple multinomial logistic regression analyses, to investigate their unique contributions. The minimum symptoms class was chosen as the reference class.

In the univariate models, membership in the pregnancy only class was predicted by several psychosocial factors, as fewer years of education, previous psychopathology, attachment-related anxiety and avoidance, pregnancy-related anxiety, and adverse childhood experiences all increased the odds of belonging to this class compared to the minimum

symptoms class. For the postpartum only class, only previous psychopathology showed a significant increase in odds ratios. Several psychosocial factors predicted class membership in the moderate-persistent class, including previous psychopathology, fewer years of education, increased scores on attachment-related anxiety and avoidance, stressful life events, pregnancy-related anxiety, and childhood adversities. Age and parity were unrelated to class membership.

In the multivariate model, only pregnancy-related anxiety remained a significant predictor of the pregnancy only class. However, the odds ratio for previous psychopathology remained elevated ($OR = 2.32, p = .09$), although not significant, possibly indicating low statistical power. For the postpartum only class results were similar to the univariate analysis, as only previous psychopathology significantly increased the odds of class membership as compared with the minimum symptoms class. Several predictors still distinguished the moderate-persistent class from the minimum symptoms class, as previous psychopathology, fewer years of education, as well as increases in partner-related anxiety and life stress showed significantly elevated odds ratios.

When comparing the three classes with elevated trajectories to one another by means of multinomial logistic regression analyses, some significant associations emerged (see supplementary Table 1). Individuals in the pregnancy only class reported higher pregnancy-related anxiety relative to both the postpartum only and the moderate increasing class in both univariate and multivariate analyses, even though the difference between the pregnancy only and the moderate increasing class was only marginally significant in the multivariate analysis ($p = .056$). The most notable finding for the for the postpartum only class was that it had significantly lower odds of both attachment anxiety and avoidance relative to the two other elevated trajectory classes in univariate analyses, as well as avoidance in multivariate

analyses. The postpartum only class thus resembled the minimum symptoms class with regard to partner-related attachment.

Discussion

In this study, a growth mixture model of four distinct latent piecewise trajectory classes accounted for the heterogeneity of depressive symptom course among women during pregnancy and 12 months postpartum. The four classes were labeled according to trajectory characteristics as pregnancy only (4.4%), postpartum only (2.2%), moderate-persistent (10.5%), and minimum symptoms (82.9%). Referring back to our initial hypothesis about trajectory features, we found: (a) One trajectory with elevated symptoms limited to the pregnancy period; (b) one trajectory with stable low symptoms during pregnancy, rapidly increasing after birth with a gradual recovery the first postpartum year, termed postpartum only; (c) a trajectory characterized with moderately elevated symptom levels during pregnancy, with a slight increase in symptom burden postpartum; (d) no class with a high chronic trajectory, contrary to our expectations; and (e) one trajectory including the majority of women without elevated depressive symptoms, as evident in the minimum symptoms class.

Thus, with the notable exception of not identifying a class characterized by persistent, severely elevated depressed mood, all expectations regarding class trajectories were met. Not finding a chronically elevated class with a high symptom burden has at least two possible explanations: Our sample did not include a sufficient number of participants with severe depressive symptoms. Alternatively, our statistical modeling choice of a 3-piece piecewise model facilitated a close mapping of symptom change, whereas other statistical models may overestimate the stability of symptoms in women reporting high levels of depressive symptoms at several, but not all occasions.

Regarding our second aim, all psychosocial adversity factors as well as education distinguished the elevated trajectory classes from the minimum symptoms class. Further, in

accordance with previous research distinguishing between remitting and chronic courses of PPD (Vliegen et al., 2014), the moderate-persistent class showed the highest number of associated psychosocial adversity factors. Overall, our findings were consistent with our hypothesis of heterogeneity in pathways of elevated depressive mood during pregnancy and the first postpartum year, connecting distinct trajectories of time courses with differential psychosocial adversity factors.

The pregnancy only class consisted of women with an elevated initial level of depressive symptoms that rises steeply throughout pregnancy. After birth, however, symptoms are ameliorated and the women did not report further elevated depressed mood. Pregnancy-related anxiety seemed to be of particular importance for this class, as anxiety was the only adversity factor differentiating between the pregnancy only class and all other classes, both in univariate and multivariate analyses. One potential explanation for this finding may be that depressive symptoms that are limited to pregnancy are a result of negative emotions and cognitions related to pregnancy and birth. This would fit the pattern of rapid symptom increase as the due date approaches followed by a quick amelioration of symptom burden after child delivery.

The second trajectory class follows a typical PPD-pattern (Wisner et al., 2010) comparable to Mora et al.'s (2009) early postpartum class and corresponds with studies of increased risk the first few weeks postpartum (Munk-Olsen et al., 2006). Surprisingly, the various measures associated with membership in the other trajectory classes did not increase odds of belonging to the postpartum only class. Of the psychosocial factors measured in this study, only previous psychopathology increased the odds - by a threefold. Further, higher partner-related attachment avoidance and anxiety decreased the odds of belonging to this group compared to the other two elevated trajectory classes. A tenable interpretation of this might be that this class represents a subgroup of women for whom the development of

depressive symptoms is associated with factors not belonging to the psychosocial domain, or alternatively that there are other psychosocial antecedents not covered in this study.

The moderate-persistent class is characterized by a consistently elevated symptom level, with increasing symptoms as time passes after birth. This is in line with Patton et al. (2015) finding that for a large proportion of women with PPD, it represents a continuation of earlier mental health problems, as well as studies identifying symptom onset during pregnancy (Wisner et al., 2013). A noteworthy finding is that the mean estimate trajectory for this group is close to the threshold between subclinical and clinical levels, and – as within-class variation is allowed in the analyses – individual trajectories included in this group will be located both above and below the clinical cut-offs. This emphasizes the importance of subclinical variance, and of including dimensional approaches in this area of research. Several psychosocial adversity factors increased the odds of belonging to this group, as fewer years of education, previous psychopathology, anxious attachment orientation and stress all increased the odds of following the moderate-persistent trajectory relative to the minimum symptoms class. Notably, stress further distinguished this class from the pregnancy only class in multivariate analysis, in accordance with Vliegen et al. (2014) who found life stress to be one of the factors distinguishing a persistent course of PPD from a remitting course.

About 83% of the women, belonging to the minimum symptoms class, reported consistently low levels or no symptoms of depression throughout the period of study. This is in accordance with most prevalence reports (Biaggi et al., 2016; Gavin et al., 2005), although direct comparisons are difficult due to differences in assessment periods, methods and populations (O'Hara & Wisner, 2014). The proportion of the minimum symptoms class in this study is also comparable with previous reports of heterogeneous time courses (Cents et al., 2013; Mora et al., 2009; Sutter-Dallay et al., 2012).

Limitations, Strengths and Conclusions

There are important limitations of this study. First, the representativeness of the sample can be questioned. Figures from Statistics Norway (2014) indicate that our sample has a higher educational level than the general population, and the response rate was 50.7%. As in any community-based research, there is a possibility of self-selection bias with an overrepresentation of healthy and resourceful participants; in this particular study there is a threat of underrepresentation of women with heightened levels of depressive symptoms as they might find participation in research too demanding. This might limit the generalizability of results.

A related concern is selective dropout, and analyses indeed showed that some demographic and psychosocial factors, including depressive symptoms, predicted attrition. However, by using contemporary missing data routines, including FIML and models not assuming MAR, we attempted to reduce the impact of such selective attrition. Yet another concern regarding representativeness is the specific cultural context. There is evidence of considerable variation of PPD prevalence rates across nations and cultures (Halbreich & Karkun, 2006), and it is possible that the relatively generous social welfare policies in Norway (i.e., free prenatal care, a year of paid parental leave) might have a preventive effect on PPD symptoms, thus potentially limiting generalizability in countries with less generous welfare policies. On the other hand, like many Western societies individualistic values are emphasized in Norway, whereas other societies may provide protective factors in endorsing cultural patterns that reinforce the maternal role and effectively relieve new mothers of burdens (Halbreich & Karkun, 2006).

Second, particularly the pregnancy only and the postpartum only classes were small in size, including $n = 41$ and $n = 20$ participants, respectively. Consequently, our study is limited by the resulting low statistical power to detect differences between these and other classes in multinomial logistic regression analyses. For example, the non-significant finding despite

relatively high odds ratios regarding previous psychopathology in the pregnancy only class may be due to low power.

Third, previous psychopathology was assessed by means of self-reports, based on a single item, including all kinds of psychopathology. The severity, timing and nature of earlier mental health problems thus remain unknown. Ideally, one ought to have objective measures of the participants' histories of affective disorders. Relatedly, depressive symptoms were measured by self-report only, and therefore provide no information about a clinical diagnosis of depression.

Fourth, stress exposure was measured by a self-reported life event checklist. Although there are reports of satisfying reliability and validity of the instrument we have used (Abidin, 1995), in general this assessment method has received criticism for having methodological limitations such as assuming that the life events listed have the same meaning across contexts and individuals (Harkness & Monroe, 2016). Some caution in the interpretation of stress is therefore warranted.

Fifth, we only included predictors at enrollment, and did not investigate the potential influence of time-varying covariates such as treatment received, birth complications, and infant health.

Despite these limitations, the present study has identified four trajectory classes of depressive symptom course in the pregnancy and postpartum period, as well as predicted class membership on the basis of psychosocial factors. Findings suggest that pregnancy and postpartum depressive symptom onset and development do not follow a uniform course, nor are predicted by a singular set of factors, but rather support a model of differential time courses associated with diverse psychosocial adversities.

Researchers and clinicians should be aware of possible heterogeneous symptom development trajectories, and subsequently inquire about diverse underlying mechanisms,

pathogenic pathways and prognosis, in order to refine theories and develop targeted prevention and intervention. Future research is needed to test differential diathesis-stress models for trajectory classes. An important next step would be to investigate the differential outcomes of trajectory classes on maternal health, child development and family functioning.

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Table 1

Means, Standard Deviations and Correlation Matrix of all Measures

Measure (range)	Time	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 EPDS (0-30)	T1	4.30	3.73	-														
2 EPDS (0-30)	T2	4.35	3.76	.69**	-													
3 EPDS (0-30)	T3	4.54	4.00	.61**	.69**	-												
4 EPDS (0-30)	T4	4.53	3.94	.56**	.61**	.72**	-											
5 EPDS (0-30)	T5	3.68	3.36	.41**	.49**	.49**	.48**	-										
6 EPDS (0-30)	T6	3.02	3.44	.40**	.45**	.47**	.45**	.54**	-									
7 EPDS (0-30)	T7	2.88	3.12	.48**	.52**	.54**	.54**	.48**	.55**	-								
8 Age (years)	T1	30.26	4.78	-.05	-.11**	-.07*	-.06	.02	-.02	-.03	-							
9 Education (years)	T1	15.05	2.13	-.16**	-.07	-.12**	-.10*	.01	-.05	.13**	.38**	-						
10 Life Stress Index (0-91)	T1	7.08	6.91	.19**	.22**	.14**	.15**	.16**	.14**	.22**	-.10**	-.06	-					
11 ECR Anxiety (18-126)	T1	44.23	17.18	.49**	.48**	.42**	.42**	.35**	.38**	.41**	-.12**	-.13**	.22**	-				
12 ECR Avoidance (18-126)	T1	30.05	12.68	.32**	.29**	.24**	.23**	.18**	.19**	.28**	.06*	-.18**	.07*	.33**	-			
13 PRAQ (10-50)	T1	22.70	7.77	.31**	.35**	.30**	.27**	.22**	.22**	.17**	-.20**	-.11**	.13**	.46**	.09**	-		
14 ACE (0-10)	T1	0.75	1.37	.16**	.27**	.18**	.18**	.12**	.20**	.21**	-.05	-.16**	.20**	.24**	.25**	.10**	-	
15 Previous Psychopathology ^a	T1	.22	0.41	.26**	.25**	.25**	.23**	.20**	.27**	.20**	-.03	-.05	.11**	.26**	.16**	.17**	.22**	
16 Parity: Nulliparous ^a	T1	.55	0.50	-.02	.03	-.01	-.03	.06	-.01	-.08*	-.32**	.01	.10**	.09**	-.12**	.32**	-.02	.02

Note. SD = Standard Deviation; EPDS = Edinburgh Postnatal Depression Scale; ECR = Experiences in Close Relationships; Pregnancy Related Anxiety Questionnaire; ACE = Adverse Childhood Experiences.

* $p < .05$. ** $p < .01$.

^aVariables are coded: 0=no, 1=yes; the mean indicates the proportion coded 1.

Table 2

Fit of Growth Mixture Models

No. of classes	Likelihood Ratio				Entropy
	Tests, <i>p</i> values		Information Criteria		
	<i>BLRT</i>	<i>LMR-LRT</i>	<i>BIC</i>	<i>SABIC</i>	
1-class			28012.97	27946.27	
2-classes	<.001	.002	27715.58	27633.00	.859
3-classes	<.001	.047	27592.64	27494.18	.895
4-classes	<.001	.008	27476.31	27361.97	.891
5-classes	<.001	.130	27411.59	27281.36	.872
6-classes ^a	<.001	.468	27358.97	27212.87	.878

Note. BLRT = Bootstrapped Likelihood Ratio Test; LMR-LRT = Lo-Mendell-Rubin Likelihood Ratio Test; BIC = Bayesian Information Criterion; SABIC = Sample size adjusted BIC.

^a2 classes with $n < 10$.

Table 3

Parameters of the 4-Class Growth Mixture Model

Classes	Class proportion ^a	Intercept		Pregnancy slope		Peripartum slope		Postpartum slope	
	%	Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance
Pregnancy only	4.4	8.66**	8.39**	0.42**	0.02**	-0.97**	0.03*	-0.04*	<0.01*
Postpartum only	2.2	3.12**	8.39**	0.05	0.02**	0.98**	0.03*	-0.26**	<0.01*
Moderate-persistent	10.5	7.35**	8.39**	0.05	0.02**	-0.17**	0.03*	0.08**	<0.01*
Minimum symptoms	82.9	3.81**	8.39**	-0.00	0.02**	-0.08**	0.03*	-0.02**	<0.01*

Note. Variances were constrained to be equal across classes.

^a Class proportions are based on post-hoc estimates of each individual's probability of class membership.

* $p < .05$. ** $p < .01$.

Table 4

Predictors of Class Membership: Results from Multinomial Logistic Regression Models

Predictors	Univariate models						Multivariate model					
	Pregnancy only		Postpartum only		Moderate-persistent		Pregnancy only		Postpartum only		Moderate-persistent	
	versus minimum		versus minimum		versus minimum		versus minimum		versus minimum		versus minimum	
	symptoms		symptoms		symptoms		symptoms		symptoms		symptoms.	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age	0.93	[0.86, 1.02]	1.02	[0.92, 1.13]	0.96	[0.90, 1.01]						
Education	0.85*	[0.72, 1.00]	1.07	[0.85, 1.34]	0.79**	[0.71, 0.88]	0.93	[0.78, 1.12]	1.07	[0.84, 1.35]	0.85*	[0.74, 0.97]
Parity ^a	1.74	[0.78, 3.84]	1.26	[0.47, 3.53]	0.81	[0.49, 1.36]						
PP ^a	4.28**	[2.03, 9.03]	3.45*	[1.30, 9.16]	3.82**	[2.23, 6.54]	2.32	[0.87, 6.22]	3.16*	[1.02, 9.82]	2.29*	[1.21, 4.31]
ECR anx ^b	2.76**	[2.01, 3.84]	1.30	[0.72, 2.34]	2.73**	[2.12, 3.50]	1.60	[0.99, 2.56]	1.21	[0.65, 2.25]	1.95**	[1.46, 2.59]
ECR avoid ^b	1.77**	[1.33, 2.38]	0.58	[0.24, 1.38]	1.73**	[1.38, 2.17]	1.40	[0.97, 2.02]	0.52	[0.24, 1.14]	1.27	[0.97, 1.67]
Stress ^b	1.19	[0.81, 1.74]	1.35	[0.90, 2.03]	1.74**	[1.41, 2.14]	0.91	[0.61, 1.36]	1.19	[0.71, 1.99]	1.39*	[1.07, 1.80]
PRAQ ^b	2.83**	[2.09, 3.85]	1.18	[0.67, 2.07]	1.71**	[1.30, 2.25]	2.22**	[1.49, 3.30]	1.00	[0.48, 2.11]	1.09	[0.79, 1.52]
ACE ^b	1.60**	[1.24, 2.06]	1.35	[0.83, 2.20]	1.57**	[1.25, 1.98]	1.30	[0.92, 1.82]	1.26	[0.73, 2.16]	1.09	[0.80, 1.48]

Note. $N = 1,035$. OR = odds ratio; 95% CI = 95% confidence intervals of OR; PP = Previous psychopathology; ECR = Experiences in Close Relationships; anx = anxiety subscale; avoid = avoidance subscale; Pregnancy-Related Anxiety Questionnaire; ACE = Adverse Childhood Experiences.

^adichotomous variables. ^bz-scores.

* $p < .05$. ** $p < .01$.

Figure 1

Recruitment and response rates ($N = 1,036$).

There is considerable variation in local and individual practices as to when pregnant women first receive prenatal care at a well-baby clinic and, consequently, were recruited to participate. As a result, the time frame for enrollment is wide (varying from gestational week 8 to 34), and a considerably number of participants missed the early data collection points.

This resulted in reduced participant numbers at T1 ($n = 659$) and T2 ($n = 579$).

Figure 2

Estimated mean trajectories of the GMM 4-class model of depressive symptoms from pregnancy to 12 months postpartum.