Journal of Affective Disorders 248 (2019) 139–146

Contents lists available at ScienceDirect

Journal of Affective Disorders

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

Research paper

Different trajectories of depressive symptoms during pregnancy

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ARTICLE INFO

Keywords:
Maternal depressive symptoms
Pregnancy
Growth mixture modeling
Partner involvement
Course
Trajectories

ABSTRACT

Background: Up to 10–15% of women experience high levels of depressive symptoms during pregnancy. Since these levels of symptoms can vary greatly over time, the current study investigated the existence of possible longitudinal trajectories of depressive symptoms during pregnancy, and aimed to identify factors associated with these trajectories.

Methods: Depressive symptoms were assessed prospectively at each trimester in 1832 women, using the Edinburgh (Postnatal) Depression Scale (E(P)DS). Growth mixture modeling was used to identify trajectories of depressive symptoms during pregnancy.

Results: Three trajectories of depressive symptoms (E(P)DS scores) were identified: low stable (class 1, reference group, 83%), decreasing (class 2, 7%), and increasing (class 3, 10%). Classes 2 and 3 had significantly higher mean E(P)DS scores (7–13 throughout pregnancy) compared to the reference group (stable; E(P)DS < 4). Factors associated with trajectories 2 and 3 included previous depressive episodes, life events during pregnancy, and unplanned pregnancy. Notably, the only factor distinguishing classes 2 and 3 was the perception of partner involvement experienced by women during their pregnancies. Class 2 (with decreasing E(P)DS scores) reported high partner involvement, while class 3 (with increasing E(P)DS scores) reported poor partner involvement throughout pregnancy.

Limitations: Depressive symptoms were assessed by self-report rather than a diagnostic interview. The participants were more often both highly educated and of Caucasian ethnicity compared to the general Dutch population.

Conclusions: Poor partner involvement was associated with increasing depressive symptoms during pregnancy. Health professionals should focus on partner involvement during pregnancy in order to identify women who are potentially vulnerable for perinatal depression.

1. Introduction

Perinatal depression is a widespread problem affecting many women (Bennett et al., 2004; Gavin et al., 2005; Woody et al., 2017). There is sufficient evidence regarding the negative impact of perinatal depression on fetal and infant development, such as the increased risk of an adverse antenatal outcome (e.g., premature birth and low birth weight), as well as a negative impact on the child's emotional, behavioral, and developmental future (Lusskin et al., 2007; Grote et al., 2010; Field, 2011; Grigoriadis et al., 2013; Liu et al., 2017). Risk factors commonly associated with depressive symptoms during pregnancy and the postpartum period are, for example, unemployment, low educational level, unplanned pregnancy, history of depression, low levels of partner and social support, smoking, and negative life events (Beck, 2001; Robertson et al., 2004; Lancaster et al., 2010; Yim et al., 2015; Biaggi et al., 2016).

From clinical practice, it is known that depression is a heterogeneous syndrome (Chen et al., 2000; Nandi et al., 2009) of multifactorial origin, suggesting high variability in the symptom profiles of women, both between as well as within individuals over time. In the

Abbreviations: E(P)DS, Edinburgh (Postnatal) Depression Scale; TPDS, Tilburg Pregnancy Distress Scale

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https://doi.org/10.1016/j.jad.2019.01.021
Received 5 October 2018; Received in revised form 17 January 2019; Accepted 19 January 2019
Available online 26 January 2019
0165-0327/

current literature, most studies of perinatal depression measure this concept in a homogenous manner, thereby ignoring the natural variability of depressive symptoms over time (Baron et al., 2017; Santos et al., 2017). Growth mixture modeling is a statistical approach that can take into account individual differences in depressive symptom trajectories over time. This approach can be used to classify women into groups according to latent classes, based on similarities in the course of symptom profiles rather than differences (Jung and Wickrama, 2008; Leiby, 2012). Trajectory analyses could therefore be helpful in finding important factors associated with different groups of women, which could identify those who are most vulnerable for elevated symptoms of depression throughout the course of pregnancy, and who may also be at risk for elevated symptoms of depression in the postpartum period.

For this reason, various growth mixture models of different trajectories or classes of perinatal depressive symptoms have been described (Baron et al., 2017; Santos et al., 2017). However, innovative, previous studies using similar analytical techniques mainly examined depressive symptoms during the postpartum period, with typically only one or two measurements during pregnancy (e.g., Mora et al., 2009; Putnam et al., 2015; Van der Waerden et al., 2015). Moreover, factors that may identify an unfavorable course of symptoms during pregnancy have not been described (Baron et al., 2017).

For this reason, the current study followed a large sample of pregnant women prospectively, in whom depressive symptoms were assessed at each trimester during pregnancy. The primary outcome was to identify possible trajectories of depressive symptoms using growth mixture modeling, while the secondary outcome was to determine factors associated with the various depressive symptom trajectories.

2. Methods

2.1. Participants and procedure

The current study is part of the Holistic Approach to Pregnancy and the first Postpartum Year (HAPPY) study (Truijens et al., 2014), a large prospective cohort study. Women who visited one of 17 participating community midwifery practices in the south-east of the Netherlands, for their first antenatal appointment, were invited to participate. The midwifery practices approached 3160 Dutch-speaking Caucasian women who were eligible to participate during the period from January 2013 to September 2014. The following exclusion criteria were used: multiple pregnancy, a severe psychiatric disorder (*e.g.*, schizophrenia, borderline, bipolar disorder), and/or a documented history of chronic disease (*e.g.*, diabetes, thyroid dysfunction). Participants were asked to complete written or online questionnaires at three specific times during their pregnancies: at 12, 22 and 32 weeks. In total, 2269 (72%) agreed to participate. During pregnancy, 159 of these women did not return the questionnaire at the 12-week deadline. Of the remaining 2110 women, the window for completing the questionnaire to assess depressive symptoms was set at + / − four weeks of 12, 22 and 32 weeks' pregnant. However, these strict criteria were not met by 278 women, resulting in 1832 women being eligible for data analysis, the characteristics of whom are shown in Table 1. As can be seen from Table 1, up to 64% of the women were highly educated (a Bachelor or Master's degree). No data for comparison with the women included in the analysis were available in 159 of the 437 excluded women. The remaining 278 women excluded were less well educated (χ^2 (2) = 7.7, p = 0.021, low effect size: clinically not relevant) and more often reported an unplanned pregnancy (χ^2 (1) = 16.7, p < 0.001, low effect size). No differences were found in the other demographic characteristics, as shown in Table 1. Moreover, no difference was seen between the Edinburgh (Postnatal) Depression Scale E(P)DS scores of the two groups at baseline (t (2108) = −0.870, p = 0.384).

The study was approved by the Psychology Ethics Committee at Tilburg University (protocol number EC-2012.25) and reviewed by the Medical Ethics Committee at the Máxima Medical Centre, Veldhoven, the Netherlands. All women provided written informed consent.

Table 1
Characteristics of 1832 participating women.

Demographics	*N*	%	Mean (SD)	Range
Age			30.4 (3.6)	19–43
Educational level[a]				
Low	91	5		
Medium	564	30.8		
High	1177	64.2		
Paid job	1695	92.5		
Partner	1808	98.7		
Lifestyle habits				
BMI pre-pregnancy			23.9 (4.0)	16–42
Alcohol use during pregnancy	72	3.9		
Smoking during pregnancy	112	6.1		
Obstetrics				
Primiparous	915	49.9		
Previous miscarriage/abortion	489	26.7		
Unplanned pregnancy	105	5.7		
Psychiatric history				
Previous episode of depression	294	16		
Occurrence of a major life event				
Not pregnancy related	425	23.2		
Pregnancy related	82	4.5		

BMI: Body Mass Index; SD: standard deviation.
[a] High: bachelor or master's degree, medium: secondary education or vocational education, low: primary education or secondary pre-vocational education.

3. Measures

3.1. Depressive symptoms

Depressive symptoms over the preceding seven days were assessed at 12, 22, and 32 weeks of pregnancy using the Dutch version of the ten-item Edinburgh (Postnatal) Depression Scale (E(P)DS). The E(P)DS was originally developed by Cox et al. (1987) for assessing depressive symptoms during the postpartum period. Subsequently, it was validated by Cox et al. (1996) for use in non-postnatal women, and those authors proposed referring to the scale as the 'EDS' when using it in non-postnatal women. We have used the abbreviation E(P)DS throughout this paper. The E(P)DS has been validated for use in pregnancy (Kozinszky and Dudas, 2015; Lydsdottir et al., 2018). Based on their review, O'Connor et al. (2016) concluded that the E(P)DS is a frequently used and widely applicable instrument. It has also been validated in a Dutch population for use during the postpartum period (Pop et al., 1992) and during pregnancy (Bergink et al., 2011). Each item consists of a four-point scale ranging from 0 to 3. The total score ranged from 0 to 30, with higher scores indicating higher levels of depressive symptoms. The E(P)DS has been shown to be a reliable instrument for detecting women with syndromal depression at the various trimesters of pregnancy, using a cut-off of 11 during the first trimester and of 10 during the second and third trimesters (Bergink et al., 2011). In the current study, Cronbach's alphas of the E(P)DS at 12, 22 and 32 weeks of pregnancy were 0.82, 0.84 and 0.83, respectively. The E(P)DS consists of three subscales: anhedonia (items 1 and 2), anxiety (items 3, 4 and 5), and depression (items 7, 8, 9 and 10) (Pop et al., 1992; Tuohy and McVey, 2008).

3.2. Sample characteristics

3.2.1. Demographics

The demographic characteristics of the participating women were examined at 12 weeks of pregnancy; in particular: age (in years), educational level (high: a Bachelor or Master's degree, medium: secondary education or vocational education, low: primary education or secondary pre-vocational education), and employment (yes or no).

3.2.2. Lifestyle habits

At 12, 22 and 32 weeks of pregnancy, the women were repeatedly questioned about the quantity of alcohol intake during pregnancy. If, during any trimester, women indicated that they consumed alcohol during pregnancy, this was classified as alcohol use during pregnancy (yes or no). In addition, women who indicated having smoked cigarettes during any trimester of pregnancy (yes or no) were classified as smoking during pregnancy. The Body Mass Index (BMI) before pregnancy was also calculated.

3.2.3. Obstetrics

We also assessed obstetric factors, such as parity (primiparous or multiparous), a history of miscarriage or abortion, and an unplanned pregnancy.

3.2.4. Psychiatric history

At 12 weeks of pregnancy, women were asked whether they had ever been diagnosed with a depressive episode during their lifetime (yes or no).

3.2.5. Major life events

Women were asked whether they had experienced an event during pregnancy that affected them deeply. This question was asked at 12, 22 and 32 weeks of pregnancy, and the answers were recoded and categorized into two variables for each assessment: (1) negative life events related to pregnancy (e.g., vaginal blood loss, abnormal ultrasound results, poor fetal movements); and (2) negative life events unrelated to pregnancy (e.g., loss of a close friend or relative, problems at work). If the women reported such an event at least once during pregnancy, this was identified as a major life event.

3.2.6. Partner involvement in pregnancy

Partner involvement was assessed at 12, 22 and 32 weeks of pregnancy. The 16-item Tilburg Pregnancy Distress Scale (TPDS) (Pop et al., 2011) was developed by us previously. The TPDS mainly consists of two sub-scales: Partner Involvement (five items) and Negative Affect (11 items), and was developed after focus-group interviews. During these interviews, pregnancy-specific aspects emerged that were highly relevant to pregnant women, such as ‘my partner and I experience the pregnancy together’ and ‘the pregnancy has brought my partner and me closer together’ (Pop et al., 2011). This resulted in the five-item partner involvement sub-scale, and refers to a woman's perception of her partner's involvement during her pregnancy. Women could respond to each item on a four-point scale (0–3), creating total scores for partner involvement ranging from 0 to 15, with higher scores indicating poorer partner involvement. The partner involvement sub-scale had a Cronbach's alpha of 0.80 in the validation study (Pop et al., 2011). In the current study, this was 0.75 at 12 weeks of pregnancy and 0.80 at both 22 and 32 weeks. In a review, the TPDS was evaluated as excellent in terms of internal consistency and structural validity (Evans et al., 2015), while Morrell et al. (2013) highlighted the origin of the TPDS from pregnant women, new mothers and clinicians, rather than from existing generic measures (Morell et al., 2013). We defined a high score by a commonly used cut-off of self-rating scales: > 1 SD above the mean (assuming a normal distribution of the scores), which was categorized as 'poor partner involvement'.

3.3. Statistical analyses

3.3.1. Trajectories of depressive symptoms during pregnancy

Mplus version 7.4 (Muthén and Muthén, 1998–2015) was used to complete trajectory analyses. In order to define trajectories or classes of depressive symptoms during pregnancy, we fitted growth mixture models (Muthén and Shedden, 1999) with free but equal growth factor variances for the intercept, and the slope variances fixed to zero. The E(P)DS scores at 12, 22, and 32 weeks of pregnancy were used, and the spacing between measurement points was conform with the actual number of weeks between time points (Van de Schoot et al., 2017). Since three time points were included, only linear growth factors could be estimated. Missing data on the E(P)DS were handled in full information maximum-likelihood estimates (Muthén and Muthén, 1998–2015). Since the E(P)DS scores were positively skewed, with a large number of scores being equal to zero, we used the MLR option (i.e., maximum likelihood estimation with robust standard errors) in order to take non-normality into account. The starting point was a one-class model, after which we fitted models with increasing numbers of classes. In the current study, each class represented a specific trajectory of depressive symptoms during pregnancy. We considered the following fit indices for identifying the optimal number of classes: Bayesian Information Criterion, Lo-Mendell-Rubin Likelihood Ratio Test, and Bootstrapped Likelihood Ratio Test (Nylund et al., 2007; Jung and Wickrama, 2008). Better fitting models have lower Bayesian Information Criterion values (Collins and Lanza, 2010), and significant Lo-Mendell-Rubin Likelihood Ratio Test and Bootstrapped Likelihood Ratio Test values indicate that a model with an additional class improves model fit. Apart from these fit indices, we also considered entropy, with entropy values closer to 1 indicating clearer delineation of classes (Collins and Lanza, 2010). We also considered parsimony and interpretability of the models. Once the trajectory classes of depressive symptoms had been determined, women were assigned to their most likely class. The trajectory with the highest number of women was classified as the reference class.

3.3.2. Examining sample characteristics in relation to trajectories of depressive symptoms

The trajectory variable (containing the class membership of each participant) was subsequently entered into SPSS (version 24, IBM, Chicago, IL, USA) for further statistical analyses. Demographics, partner involvement, major life events, obstetrics, psychiatric history, and lifestyle habits were compared for each trajectory of depressive symptoms with descriptive statistics, using the χ^2-test for categorical variables and the *t*-test or Analysis of Variance (ANOVA) for continuous variables. We examined the relationship and change in partner involvement to the established depressive symptom trajectories over the course of pregnancy (at 12, 22 and 32 weeks of pregnancy) using the Generalized Linear Model (GLM) repeated measures ANOVA. We adjusted for several possible predefined confounders (history of depressive symptoms, parity, unplanned pregnancy, major life events, education, and age). Moreover, the number of women with E(P)DS scores above the cut-off in each trajectory were calculated for each trimester. Since large sample sizes easily result in statistically significant differences between groups, effect sizes of the differences were calculated. For the χ^2-test, the phi coefficient was calculated (0.10 small, 0.30 medium, 0.50 large; Cohen, 1988), for t-tests, the Cohen's *d* (0.2 small, 0.5 medium, 0.8 large; Cohen, 1988), and for ANOVA, the η^2 coefficient (0.01 small, 0.06 medium, 0.138 large; Cohen, 1988), were calculated.

4. Results

4.1. Different trajectories of depressive symptoms

In the total sample, 446 (24.3%) women showed at least one E(P)DS score above the trimester-specific cut-off (Table 2). According to the fit indices statistics (Bayesian Information Criterion, Lo-Mendell-Rubin Likelihood Ratio Test, and Bootstrapped Likelihood Ratio Test), the two-class growth mixture model was a significantly better fit than the one-class model and, in turn, the three-class model outperformed the two-class one. In the four-class model, the Bayesian Information Criterion and Lo–Mendell–Rubin Likelihood Ratio Test statistics remained significant. Although the Bayesian Information Criterion decreased from the three- to the four-class model, entropy also decreased slightly from the three-class model to the four-class. For this reason, and for the

Table 2
Characteristics of 1832 pregnant women according to different trajectories of E(P)DS symptoms.

	Class 1: Low stable, reference group (*n* = 1517, 83%)		Class 2: decreasing (*n* = 128, 7%)		Class 3: increasing (*N* = 187, 10%)		
	N (%)	Mean (SD)	*N* (%)	Mean (SD)	*N* (%)	Mean (SD)	*P*[a]
Demographics							
Age in years		30.5 (3.6)		29.9 (3.8)		30.0 (4.1)	0.064
Educational level							0.085
Low	67 (4.4)		8 (6.3)		16 (8.6)		
Medium	462 (30.5)		39 (30.5)		63 (33.7)		
High	988 (65.1)		81 (63.3)		108 (57.8)		
Paid job	1417 (93.4)		113 (88.3)		165 (88.2)		0.007
Lifestyle habits							
BMI pre-pregnancy		23.8 (3.9)		23.7 (4.1)		24.4 (4.6)	0.140
Alcohol use during pregnancy	56 (3.7)		6 (4.7)		10 (5.3)		0.492
Smoking during pregnancy	84 (5.5)		9 (7)		19 (10.2)		0.041
Obstetrics							
Multiparous	746 (49.2)		66 (51.6)		105 (56.1)		0.186
Previous miscarriage/abortion	398 (26.2)		37 (28.9)		54 (28.9)		0.626
Unplanned pregnancy	74 (4.9)		13 (10.2)		18 (9.6)		0.003
Psychiatric history							
Previous episode of depression	211 (13.9)		38 (29.7)		49 (26.2)		<0.001
Occurrence of a major life event							
Not pregnancy related	326 (21.5)		45 (35.2)		54 (28.9)		<0.001
Pregnancy related	63 (4.2)		10 (7.8)		9 (4.8)		0.153
Partner involvement score[b]							
12 weeks		4.0 (2.6)		6.0 (3.0)		5.3 (2.8)	<0.001
22 weeks		4.1 (2.7)		5.4 (3.0)		6.1 (3.2)	<0.001
32 weeks		4.2 (2.7)		5.2 (3.0)		6.3 (3.1)	<0.001
Score >1 SD > mean	294 (19.4)		54 (42.2)		92 (49.2)		<0.001
E(P)DS score							
12 weeks		3.1 (2.7)		13.6 (3.1)		8.7 (4.0)	<0.001
22 weeks		3.9 (3.1)		9.9 (4.7)		11.6 (4.1)	<0.001
32 weeks		3.8 (3.0)		6.8 (3.1)		13.2 (3.2)	<0.001
E(P)DS score > cut-off at least once during pregnancy	131 (8.6)		128 (100)		187 (100)		<0.001
12 weeks (>10)	30 (2.0)		122 (95.3)		79 (42.2)		<0.001
22 weeks (>9)	41 (2.7)		51 (39.8)		113 (60.4)		<0.001
32 weeks (>9)	63 (4.2)		23 (18.0)		158 (84.5)		<0.001
At all trimesters	0		13 (10.2)		47 (25.1)		<0.001
E(P)DS anxiety subscale score							
12 weeks		1.5 (1.6)		4.8 (1.7)		3.8 (2.1)	<0.001
22 weeks		2.0 (1.7)		4.1 (2.0)		4.7 (1.7)	<0.001
32 weeks		1.8 (1.6)		3.1 (1.8)		5.0 (1.6)	<0.001
E(P)DS depression subscale score							
12 weeks		0.6 (1.0)		4.5 (2.0)		2.3 (1.9)	<0.001
22 weeks		0.8 (1.2)		2.8 (2.1)		3.5 (2.1)	<0.001
32 weeks		0.8 (1.2)		1.5 (1.6)		4.2 (2.0)	<0.001

BMI, Body Mass Index; SD, Standard Deviation; E(P)DS, Edinburgh (Postnatal) Depression Scale.
[a] One-way ANOVA for continuous variables and $\chi 2$ test for categorical variables.
[b] High scores reflect poor partner involvement.

sake of model parsimony and interpretability, the three-class model was chosen to best represent the trajectories of depressive symptoms in our sample (see Supplementary Table). This three-class model had readily interpretable and clinically relevant trajectories, and adequate class sizes and entropy. Fig. 1 illustrates these three trajectories of depressive symptoms during pregnancy.

The first class (trajectory) represents the reference group of 1517 women (83%) who showed a stable and low intensity pattern of depressive symptoms with mean E(P)DS scores of less than 4 during pregnancy. The second class (n = 128, 7%) showed a pattern reflecting a high level of depressive symptoms in early pregnancy, which decreased over time: in short, the 'decreasing' pattern. At the first trimester, the mean E(P)DS score was 13.6, which decreased significantly to 6.8 at the last trimester (GLM- ANOVA: F (2) = 111, $p < 0.001$, $\eta^2 = 0.49$, large effect size). In the third class 187 (10%) women had a moderately high mean E(P)DS at first trimester (8.7) that increased significantly towards the end of pregnancy (13.2), (GLM- ANOVA: F (2) = 77, $p < 0.001$, $\eta^2 = 0.30$, large effect size): in short the 'increasing' pattern.

4.2. Sample characteristics in relation to trajectories of depressive symptoms

The characteristics of the women in each trajectory are presented in Table 2. The first class is referred to as the reference group.

When we compared the women in class 3 (increasing E(P)DS scores) to those in class 1 (low stable, reference group), they were less well educated (χ^2 (2) = 7.8, p = 0.02), had lower rates of employment (χ^2 (1) = 6.7, p = 0.010), and smoked more frequently (χ^2 (1) = 6.3, p = 0.012). However, the class 2 women (decreasing E(P)DS scores) did not differ from the reference group regarding these parameters. Women in classes 2 and 3 reported an unplanned pregnancy more often than those in the reference group (χ^2 (2) = 11.9, p = 0.003). Women in classes 2 and 3 reported a previous episode of depression significantly more often than the reference group (χ^2 (2) = 36.7, $p < 0.001$), as well as the occurrence of major life events during pregnancy that were unrelated to pregnancy (χ^2 (2) = 16.1, $p < 0.001$), but not of pregnancy-related life events.

We examined symptoms of anxiety in greater detail by analyzing the scores of the anxiety and depression sub-scales of the E(P)DS separately between the three trajectory classes. Results from a one-way ANOVA

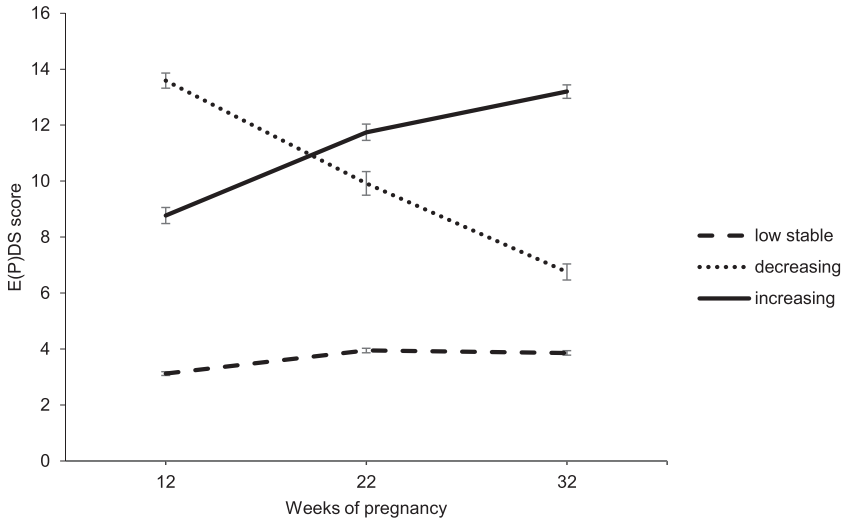

Fig. 1. Different trajectories of depressive symptoms during pregnancy in a sample of 1832 women.
E(P)DS, Edinburgh (Postnatal) Depression Scale.

showed that the three classes presented with significantly different scores for both symptoms of anxiety and depression at 12, 22 and 32 weeks of pregnancy (Table 2).

Furthermore, when comparing the increasing class with the decreasing class (*t* test), it was found that, at 12 weeks of pregnancy, the decreasing class reported significantly higher levels of anxiety (t (301.8) = 4.65, $p < 0.001$, medium effect size) and depression (t (313) = 10.09, $p < 0.001$, large effect size). Yet, at 22 and 32 weeks of pregnancy, it was found that the increasing class reported significantly higher levels of both anxiety and depression (anxiety: 22 weeks: t (227) = −2.68, $p = 0.008$, small to medium effect size; 32 weeks: t (291) = −9.16, $p < 0.001$, medium effect size. Depression: 22 weeks: t (300) = −2.81, $p = 0.005$, small to medium effect size; 32 weeks: t (286.4) = −12.67, $p < 0.001$, large effect size).

In the current study, 31 (1.7%) women reported that they visited their general practitioner or psychiatrist during their pregnancy due to mental health problems (including depression). Of these women, 22 (71%) were from classes 2 or 3, and 25 had an elevated E(P)DS score at least once during pregnancy. In total, 76 women had, at least once, a 'positive' score for item 10 of the E(P)DS (reflecting suicidal thoughts). Of these women, 54 were from classes 2 and 3 (17% of 315 women), and 22 from class 1 (1.5%).

Partner involvement was also examined. The total sample showed normally distributed partner involvement scores at all trimesters (skewness and kurtosis between −1 and 1). Partner involvement scores at 12 weeks correlated significantly with those at 22 and 32 weeks, $r = 0.68$ and $r = 0.64$, respectively, as did the scores at 22 weeks with those at 32 weeks, $r = 0.74$ (all $p < 0.001$, large effect sizes). A multivariate GLM repeated measure ANOVA (with a Mauchly W of 0.98, $p < 0.001$ indicating a violation of sphericity) showed a significant independent interaction effect between E(P)DS trajectories and partner involvement change over time (Greenhouse-Geisser correction for sphericity: F (3.9, 3189.0) = 12.1, $p < 0.001$, partial $\eta^2 = 0.014$). This interaction indicated that change in partner involvement over time differed between the women in the three E(P)DS classes. These differences are shown in Fig. 2: the level of partner involvement increases in the class with decreasing E(P)DS scores, but decreases in the class with increasing E(P)DS scores. Moreover, multiparous women showed a significant and independent increase in partner involvement scores over time (reflecting poorer partner involvement; Greenhouse-Geisser correction for sphericity: F (1.9, 3189.0) = 29.9, $p < 0.001$, partial $\eta^2 = 0.017$).

Other determinants such as unplanned pregnancy, previous episode of depression, occurrence of a major or pregnancy-related life event, education and age, were not significantly associated with changes in partner involvement scores over time (Table 3). Furthermore, contrasts related to the interaction of time and E(P)DS trajectory were examined with multivariate GLM repeated measures ANOVA, which showed that, between 12 and 22 weeks of pregnancy, a significant difference in partner involvement between the various E(P)DS trajectories was apparent (F (2, 1699) = 14.44, $p < 0.001$, partial $\eta^2 = 0.017$). This significant difference was also observed between 12 and 32 weeks of pregnancy (F (2, 1699) = 20.01, $p < 0.001$, partial $\eta^2 = 0.023$), but was not seen in the various trajectories between 22 and 32 weeks of pregnancy. In addition, at 12 weeks of pregnancy, the mean partner involvement scores for class 2 were slightly higher compared to those for class 3 (*t*-test, t (313) = 2.0, $p = 0.046$, small effect size) while, at 32 weeks, the partner involvement scores were significantly higher for class 3 than for class 2 (*t* test, t (295) = −3.3, $p = 0.001$, medium effect size).

5. Discussion

5.1. Main findings

We identified three different trajectories of depressive symptoms during pregnancy using growth mixture modeling: low stable (class 1, reference group, 83% of the total sample), decreasing (class 2, referring to 7% of the women) and increasing (class 3, 10% of the women). Well-known factors associated in general with heightened depressive symptoms during pregnancy were confirmed, and in particular poor partner involvement during pregnancy was found to distinguish between trajectories of elevated depressive symptoms.

5.2. E(P)DS scores of women in different trajectories

A stable level of minimal-to-no depressive symptoms during pregnancy was observed in 83% of the women (reference group). In particular, we identified two classes of women with elevated E(P)DS symptoms throughout pregnancy (classes 2 and 3). Even though the levels of depressive symptoms in class 2 women decreased towards the end of pregnancy, they remained significantly higher than those of the reference group throughout pregnancy, with a mean E(P)DS score of 6.8 (3.1) in the third trimester. Women with an increasing depressive symptomatology profile (class 3) had a mean E(P)DS score of 13.2 (3.2) during the last trimester. These findings are in accordance with

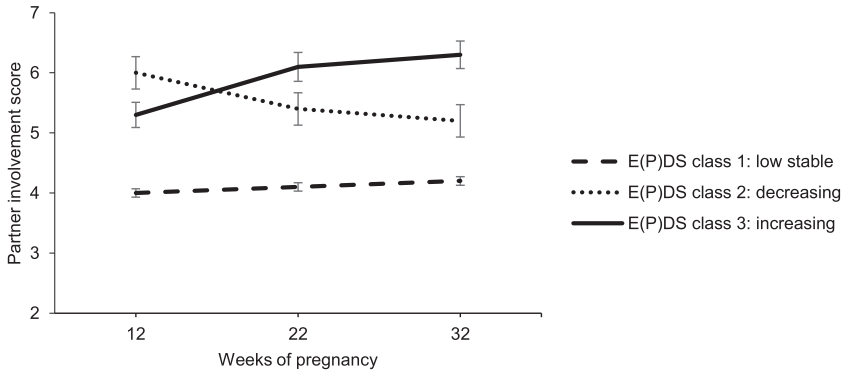

Fig. 2. Partner involvement scores in relation to different trajectories of depressive symptoms during pregnancy in a sample of 1832 women. Higher scores indicate poorer partner involvement.
E(P)DS, Edinburgh (Postnatal) Depression Scale.

Table 3
Multivariate GLM repeated measures ANOVA for trajectories of pregnancy depressive symptoms with partner involvement scores over time.

	SS	df	MS	F	*p* value
Time	3.73	1.97	1.90	0.78	0.46
Time * E(P)DS trajectory	114.92	3.93	29.24	12.10	< 0.001
Time * previous depressive episode(s)	3.78	1.97	1.92	0.79	0.45
Time * multiparity	142.77	1.97	72.65	26.96	< 0.001
Time * unplanned pregnancy	8.07	1.97	4.11	1.69	0.19
Time * MLE, not pregnancy related	0.94	1.97	0.47	0.20	0.82
Time * MLE, pregnancy related	3.65	1.97	1.86	0.77	0.46
Time * education	11.59	3.93	2.95	1.22	0.30
Time * age	6.97	1.97	3.55	1.46	0.23
Error (time)	8057.75	3323.18	2.43		

GLM, General Linear Model; ANOVA, Analysis of Variance; SS, sum of squares; df, degrees of freedom; MS, mean squares; E(P)DS, Edinburgh (Postnatal) Depression Scale, MLE, Major Life Event.

previous research on trajectories of depressive symptoms during the perinatal period, which also show that most women report few-to-no depressive symptoms (Baron et al., 2017; Santos et al., 2017). Marcus et al. (2011) also identified three trajectories during pregnancy: a low stable class, a class with increasing symptoms of depression, and a class of women with intermediate stable symptoms. However, they did not include the characteristics of the women allocated to their trajectories, making it difficult to compare their results in detail to those of the current study. Moreover, their study only included 103 participants, a different tool was used to measure depressive symptoms during pregnancy (Beck Depression Inventory), and the study did not assess women during all three trimesters (Marcus et al., 2011).

5.3. High depression and/or anxiety scores

Further sub-analyses using E(P)DS sub-scales showed that class 3 women scored significantly higher on both the E(P)DS anxiety and depression sub-scales during the second and third trimesters of pregnancy compared to the remaining women. As such, the increase in E(P)DS scores towards the end of pregnancy in this class could be explained by an increase in both anxiety and depressive symptoms combined, rather than by an increase in depression or anxiety symptoms separately. A recent systematic review and meta-analysis found a subset of 20–25% pregnant women who also reported high anxiety scores towards the end of pregnancy (Dennis et al., 2017). This is substantially higher than the 10% of class 3 women in the current study. However, all studies included in the meta-analysis used a cross-sectional design rather than the prospective design of the current study using latent class analysis.

5.4. Clinical relevance of different E(P)DS trajectories

During pregnancy, 31 women reported having sought help due to mental health problems. The majority of these women (up to 70%) were from class 2 (seven, i.e., 5.5% of 128) and class 3 (15, i.e., 8% of 187) compared to nine in class 1 (0.6% of 1517). This means that class 2 and 3 women are up to ten times more likely to seek help for mental health problems compared to the reference group. Similarly, class 2 and 3 women were up to ten times more likely to have a positive score on suicidal thoughts (item 10 of the E(P)DS). This underlines the clinical relevance of looking at depression symptoms prospectively during pregnancy.

5.5. Determinants of high E(P)DS scores: partner involvement

In the current study, the only variable that distinguished decreasing and increasing depressive symptomatology (classes 2 and 3) during pregnancy was partner involvement (small to medium effect size). Women in the decreasing depressive symptoms class reported increasing levels of partner involvement over the course of pregnancy, while women with increasing E(P)DS levels reported decreasing partner involvement levels. However, it is important to realize that the current study does not show causality: the perception of poor partner involvement could be considered to be a risk factor for depression or, alternatively, women with high depression scores may rate the involvement of their partner as insufficient due to their depressive symptoms and more negative perceptions in general.

Previous literature suggests that presence of a supportive partner strengthens a woman's coping mechanisms for pregnancy-related stressors (Jeong et al., 2013), and can help women during the transition period to parenthood (Bilszta et al., 2008; Røsand et al., 2011). Poor support from the partner is a commonly reported factor associated with increased levels of perinatal depressive symptoms (Lancaster et al., 2010; Biaggi et al., 2016). According to a systematic review and meta-analysis, communication, conflict, emotional support, instrumental support, relationship satisfaction, emotional closeness and global support are important partner-related protective factors associated with perinatal depression (Pilkington et al., 2015).

Partner involvement in the current study refers to aspects of the way in which a woman perceives that her partner was involved in her pregnancy. In the current study, partner involvement was assessed by means of the TPDS. A major strength of this is that it was constructed based on focus-group interviews, during which the concept of partner involvement throughout pregnancy spontaneously emerged during the interviews (Pop et al., 2011), and was not purely constructed by researchers (Morrell et al., 2013). Stapleton et al. (2012) found that

women who felt that their partner was more involved and supportive during pregnancy, showed less emotional distress (including lower levels of depressive symptoms) postnatally. Cheng et al. (2016) noted a relationship between partner support and involvement during pregnancy, and prenatal maternal anxiety and depression. However, these studies used cross-sectional designs that compared only one assessment during pregnancy with antenatal depressive symptoms (Cheng et al., 2016) or postnatal depressive symptoms (Stapleton et al., 2012). A recent review concluded that future research should incorporate levels of partner support in the assessment of perinatal depressive symptoms, using growth mixture modeling techniques (Baron et al., 2017). According to the Commission on Paternal Involvement in Pregnancy Outcomes, more research is needed in order to understand the effects of the underlying and distinct roles of partners in terms of their involvement during pregnancy (Bond, 2010).

5.6. Other factors associated with depression

In addition, well-known factors associated with heightened perinatal depressive symptomatology were also found in the current study, including lower levels of education, the occurrence of major life events (unrelated to pregnancy), unplanned pregnancy, and a previous episode of depression (Mora et al., 2009; Christensen et al., 2011; Cents et al., 2013; Glasheen et al., 2013; Giallo et al., 2014; van der Waerden *et al.*, 2015; Denckla et al., 2018).

5.7. Strengths and limitations

Our study has several strengths. Firstly, our sample size was large (n = 1832). Secondly, we assessed depressive symptoms at each trimester of pregnancy and analyzed our findings with growth mixture modeling techniques, which enabled us to study longitudinal trajectories. The following limitations must also be considered: firstly, depressive symptoms were assessed by self-reporting (Cox et al., 1987) and not by a diagnostic interview. Secondly, the participants were more often highly educated and of Caucasian ethnicity compared to the general Dutch population (Statistics Netherlands, the Netherlands 2018) and therefore generalization could be restricted. This could be explained by the location of the current study: the south-east of the Netherlands. This region has a more highly educated population compared to the Dutch general average, and was even named 'smartest area of the world' in 2011 by the international think-tank Intelligent Community Forum (ICF) in New York. Therefore, this difference in educational level compared to that of the general Dutch population was not due to attrition bias, but was representative of the population in this particular part of the country. A third limitation is that four instead of three consecutive assessments could have increased the power of the trajectory model and would have allowed us to include a quadratic term in the model, which might have identified other patterns of growth rather than linear growth alone (Berlin et al., 2014; Jung and Wickrama, 2008). Future studies could take this into account in their study design.

5.8. Clinical practice

The finding that perceived partner involvement is associated with the longitudinal course of depressive symptomatology is important in clinical practice. Future research should investigate whether women who perceived poor partner involvement during pregnancy are also at risk for poor partner involvement in parenting postnatally. Poor partner involvement during pregnancy is associated with high depressive symptoms, which, in turn, are associated with postpartum depression. Partner involvement during pregnancy should be included as a screening factor in psycho-social assessments during pregnancy, while it should be realized that perception and actual experiences could also differ. The clinical relevance of the current findings could be that partners, together with the pregnant women, should be educated explicitly in the provision of support, as well as in the resulting perception of supportive behaviors during pregnancy.

In conclusion, growth mixture modeling enabled us to discriminate three distinct trajectories of depressive symptoms during pregnancy. Poor partner involvement was clearly associated with the presence of consistently high and increasing levels of depressive symptoms during pregnancy. Adequate quality and perception of partner involvement seems to be very important to women during the perinatal period. We recommend that midwives and obstetricians pay sufficient attention to the intensity of partner involvement during pregnancy in order to improve the identification of those women who are potentially vulnerable for perinatal depression.

Conflict of interest

The authors declare no conflicts of interest.

Contributors

All contributors have approved the final article.

Role of funding source

This work was supported by Stichting de Weijerhorst. Stichting de Weijerhorst had no further role in the study design, the collection, analysis and interpretation of data, writing of the report, and the decision to submit the article for publication.

Acknowledgments

None.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jad.2019.01.021.

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