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ORIGINAL PAPER

Antenatal maternal mental health as determinant of postpartum depression in a population based mother–child cohort (Rhea Study) in Crete, Greece

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Abstract
Purpose Antenatal maternal mental health has been identified as an important determinant of postpartum depression (PPD). We investigated the occurrence of depression both antenatally and postnatally and examined whether maternal trait anxiety and depression during pregnancy were associated with PPD at 8 weeks postpartum in a prospective mother–child cohort (Rhea Study) in Crete, Greece.
Methods 438 women completed the Edinburgh Postnatal Depression Scale (EPDS) and the Trait subscale of the State-Trait Anxiety Inventory (STAI-Trait) questionnaires assessing antenatal depression and anxiety, respectively, during the third trimester of pregnancy as well as the EPDS at 8 weeks postpartum.
Results The prevalence of women with probable depression (EPDS score $\geq$13) was 16.7 % at 28–32 weeks of pregnancy and 13.0 % at 8 weeks postpartum. A per 5 unit increase in the STAI-Trait subscale increased the odds for PPD by 70 % (OR = 1.70, 95 % CI 1.41, 2.05), whereas a per unit increase in EPDS during pregnancy increased the odds for PPD by 27 % (OR = 1.27, 95 % CI 1.19, 1.36).
Conclusions Our findings suggest that antenatal maternal psychological well-being has a significant effect on PPD, which might have important implications for early detection during pregnancy of women at risk for postpartum depression.

Keywords Antenatal anxiety · Antenatal depression · Postpartum depression

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Introduction

Maternal mental health across the transition from pregnancy to the postnatal period has been the focus of both research and clinical attention during the last decades. Most existing research has focused on depression antenatally or postnatally, whereas less is known about anxiety symptoms during pregnancy. The prevalence of antenatal and postpartum depression (PPD) is similar and ranges from 10 to 15 % [1–6]. Community-based studies—many of which used the Edinburgh Postnatal Depression Scale (EPDS) [7]—indicate that rates of PPD seem to be relatively consistent across countries, although estimates tend to vary when other assessment tools were employed and depending on how the postpartum period time frame was defined. The prevalence of PPD [8, 9] in Greece is similar to that reported in other countries [10, 11].

PPD is considered to be a systemic illness affecting a woman's functioning and sense of well-being as well as her

relationship with her infant and family [12]. Symptoms of PPD occur in the first 6 months after delivery, with onset usually within 2 weeks of childbirth [6, 13]. A range of biological, psychological, socio-demographic and obstetric risk factors have been identified as important determinants of PPD with antenatal maternal mental health being a clearly crucial predictor [6, 14, 15]. Empirical evidence suggests that the strongest predictor of PPD is depression during pregnancy [6, 13, 16–19]. Moreover, antenatal anxiety has been identified as a significant determinant of PPD in a number of community-based studies [16, 19–21] and meta-analyses [6, 15, 21].

Most research into PPD has been conducted in Western industrialised countries [6, 13] and has not taken into account the range of different socio-demographic factors in addition to psychosocial experiences likely to be involved in childbirth, i.e. differences in rates of lone motherhood, the nature of marriage, family and kinship, and variations in the support new mothers receive in different countries and cultures [22]. In an early cross-cultural study conducted in Britain and Greece [23], social support, life events, and emotional well-being during pregnancy were found to predict PPD 4–6 weeks postpartum, whereas history of depression and stressful life events during pregnancy were estimated to have a stronger association with the development of PPD [8, 9, 23].

Antenatal anxiety and depression are powerful predictors of PPD, although it is not clear at which point during pregnancy these psychological states are most predictive of PPD. Antenatal depression increases in severity from the first to the second and the third trimester of pregnancy [25]. A recent meta-analysis found that the rate of depression in the first trimester was similar to rates seen in the general female population, while rates in the second and the third trimester were double as compared to those observed in the general population [1]. Unfortunately, data on prevalence and course of antenatal anxiety during pregnancy are inadequate. In a very recent study, Lee et al. [19] found a U-shaped relationship between stage of pregnancy and anxiety and depressive symptoms during pregnancy, suggesting that both antenatal anxiety and depression decreased from early to mid-pregnancy, but increased again in late pregnancy. The researchers also found that both antenatal anxiety and depressive symptoms predicted PPD. The association between antenatal anxiety symptoms and PPD was found to be increased as pregnancy progressed, with anxiety symptoms in late pregnancy being most strongly associated with PPD, whereas the association between antenatal depressive symptoms and PPD was found to be decreased as pregnancy progressed, with depressive symptoms in early pregnancy being most strongly associated with PPD [19].

Even though symptoms of anxiety and depression during pregnancy often present together indicating high rates of comorbidity [25], empirical evidence suggests that anxiety and depression during pregnancy may have differential effects on PPD. Closing the gap in the evidence regarding the associations between antenatal maternal mental health and PPD has important implications for both families and health-care practitioners. Within the context of a population-based mother–child cohort study in Crete, Greece (Rhea Study), we evaluated whether antenatal maternal mental health—evaluated by means of trait anxiety and depression psychological measures during the third trimester of pregnancy—was associated with PPD at 8 weeks postpartum.

Methods

The mother–child cohort in crete (Rhea Study)

The Rhea Study is a prospective cohort examining a population sample of pregnant women and their children at the prefecture of Heraklion, Crete [26]. Female residents (Greek and immigrants) who had become pregnant during the 12-month period starting in February 2007 were contacted at four maternity clinics in Heraklion and asked to participate in the study. To be eligible for inclusion in the study, women had to have a good understanding of the Greek language and be older than 16 years of age. The first contact was made before week 15 of gestation, at the time of the first major ultrasound examination. Women were then contacted again at 28th–32nd week of gestation, at birth, at 8 weeks, 6 and 18 months postpartum and currently the children are being followed up at 4 years of age. Face-to-face structured interviews, together with self-administered questionnaires and medical records, were used to obtain information on several psychosocial, dietary, and environmental exposures during pregnancy and early childhood. The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the ethical committee of the University Hospital in Heraklion, Crete, Greece. Written informed consent was obtained from all women participating in the study. Detailed characteristics of the study population have been described elsewhere [26].

During the study period, 1,765 eligible women were approached, 1,610 (91 %) agreed to participate, and 1,388 (86 %) were followed up until delivery. A total of 578 participants completed self-administered questionnaires assessing antenatal trait anxiety and depressive symptoms at 28–32 weeks of gestation, and 1,079 women completed the depression scale at 8 weeks postpartum. A total of 460

women had all three aforementioned questionnaires on anxiety, and antenatal and postnatal EPDS completed. Finally, eight women with a history of past psychiatric disorder and those with twin pregnancies ($n = 14$) were excluded from the sample, resulting in a cohort of 438 women with no reported previous psychiatric disorder (i.e. indicating new onset of anxiety and depression) available for analyses, resulting in a participation rate of 75.8 % among women with available questionnaires on antenatal maternal mental health who constitute the base population of women with assessed antenatal maternal mental health followed up postnatally with the EPDS.

Measures

Socio-demographic characteristics

Socio-demographic characteristics were collected through questionnaires administered to pregnant women by trained interviewers during the first trimester of pregnancy, such as maternal age, education and origin, marital status, parity, maternal employment status, smoking during pregnancy, and physical activity before and during pregnancy. Infant sex, gestational age, type of delivery, and anthropometric measures at birth were collected from clinical records. Gestational age was based on the interval between the last menstrual period and the date of delivery. When the menstrual estimate of gestational age was inconsistent by seven or more days with the ultrasound measurement taken in the first trimester of pregnancy, a quadratic regression formula describing the relation between crown rump length and gestational age was used instead [26, 27]. Maternal education was divided into three categories: low level: $\leq$9 years of school, medium level: higher than 9 years of schooling but $\leq$12 years, and high level: some years in university or university degree. Maternal employment status during pregnancy was categorised as working vs. not working, parity as primiparous vs. multiparous, smoking during pregnancy as yes vs. no, physical activity before and during pregnancy as yes vs. no, planned pregnancy as yes vs. no, and delivery type as vaginal delivery vs. caesarean section.

Psychological assessment both antenatally and postnatally

Women were asked to complete self-reported instruments for antenatal psychological assessment at 28–32 weeks of gestation at home and asked to return them by mail, while postnatal assessment (at 8 weeks postpartum) took place by telephone interview.

Maternal anxiety was measured at 28–32 weeks of gestation using the State-Trait Anxiety Inventory (STAI) [28]. It is a 40-item scale made up of two 20-item subscales (one state and one trait) and has been widely used to asses anxiety not only in clinical, but in non-clinical samples. Only the STAI-Trait subscale was used for the purposes of the present study. Trait anxiety reflects relatively stable individual differences in anxiety proneness. Each item of the trait subscale is scored on a 4-point scale ranging from 1 (almost never) to 4 (almost always). The STAI is a widely used index of anxiety symptoms and has considerable validity, reliability, and clinical utility. The STAI has been translated and validated in Greek [29] and has been found to have satisfactory psychometric properties.

(Cronbach's a for STAI-State subscale $\alpha = 0.92$ and for STAI-Trait subscale $\alpha = 0.89$).

Maternal depressive symptoms were assessed—antenatally at 28–32 weeks of gestation and postnatally at 8 weeks postpartum—using the Edinburgh Postnatal Depression Scale (EPDS) [7]. The EPDS is a widely used 10-item self-report questionnaire providing an indication of the severity of mother's mood during the past 7 days. Items are rated on a 4-point Likert scale ranging from 0 (not at all) to 3 (most of the time) and refers to depressed mood, anhedonia, guilt, anxiety, and suicidal ideation. The EPDS is the only rating scale for depression validated during both the antenatal and the postnatal period [30]. A cutoff score of 13 or greater on the EPDS has been found to identify probable clinical postnatal depression with a sensitivity of 86 % and a specificity of 78 % [7, 31]. The EPDS has been translated and validated for the Greek population by two research groups [9, 32] and showed a very high overall internal consistency. Cronbach's alpha for the total scale was equal to 0.90 in the validation study of Leonardou et al. [9] and 0.80 in the validation study of Vivilaki et al. [32].

Potential confounders

Potential confounders included characteristics that have an established or potential association with antenatal maternal mental health and PPD including: maternal age at delivery; maternal education (low level: $\leq$9 years of school, medium level: higher than 9 years of school but $\leq$12 years, and high level: some years in university or university degree, ref: low level); maternal employment status during pregnancy (working vs. not-working); parity (primiparous/multiparous); smoking during pregnancy (yes vs. no); physical activity before and during pregnancy (yes vs. no); planned pregnancy (yes vs. no); child's gender (boy vs. girl); delivery type (caesarean vs. vaginal delivery).

Statistical analyses

The primary outcome variable of interest was the EPDS score at 8 weeks postpartum. The primary exposures of

interest were antenatal STAI-Trait and EPDS scores. Scores entered the analyses as continuous or categorical variables. EPDS was used as a continuous (both antenatal and postnatal EPDS scores) and as a categorical variable with a cutoff score of 13 (only postnatal EPDS scores) or greater as recommended by Cox et al. [7], which appeared to be an effective screening for probable clinical depression indicating high levels of postpartum depressive symptoms. No clinical cutoff has been established for the STAI-Trait subscale. To obtain a cutoff score for STAI-Trait, the sample mean plus one standard deviation was used. Thus, those who scored above 48 on the STAI-Trait were categorised as "high" in trait anxiety. Antenatal and postpartum EPDS failed the normality test (Kolmogorov–Smirnov with Lilliefors significance correction); hence, nonparametric statistical tests were applied in univariate analyses.

Bivariate associations between categorical dependent and independent variables were studied using Pearson's Chi-square test for categorical variables (with Fisher correction for groups with <5 subjects). Bivariate associations between continuous dependent and categorical independent variables were studied using either Student's t test (normally distributed continuous dependent variables) or nonparametric statistical methods (Mann–Whitney, Kruskal–Wallis) for non-normally distributed continuous dependent variables. Pearson's or Spearman's rho correlation coefficient was used to estimate the strength of the association between continuous dependent and independent variables.

Multivariable linear and logistic regression models were fit to estimate the association between trait anxiety and depression during pregnancy with maternal depressive symptoms at 8 weeks postpartum. Variables related with either the outcome or the exposure of interest in the bivariate associations with a $p < 0.2$ were included in the multivariable models as potential confounders, as well as *a priori* selected potential confounders such as maternal age and maternal education. Estimated associations are described in terms of odds ratios (OR) with 95 % confidence intervals (CIs) (logistic regression models) or β coefficients and 95 % CIs (linear regressions models). Antenatal STAI-Trait and EPDS scores were highly correlated, so as to avoid multicollinearity which increases the standard errors of the coefficients; antenatal EPDS and STAI-Trait scores were entered as independent variables into separate models. To account for the possibility of residual confounding by antenatal EPDS, the association between maternal trait anxiety and postnatal EPDS also were estimated excluding women with high scores of antenatal EPDS. In addition, to account for the possibility of residual confounding by antenatal STAI-Trait, the association between maternal antenatal EPDS and postnatal EPDS were estimated also excluding women with high scores of antenatal STAI-Trait. All association testing was conducted assuming a 0.05 significance level and a two-sided alternative hypothesis. Additionally, we applied generalised additive models (GAMs) to explore the shape of the relationships between antenatal EPDS and STAI-Trait scores with postnatal EPDS [33]. These models indicated linear relationships with postnatal EPDS and antenatal EPDS and STAI-Trait scores, after adjusting for confounders. Restricted quadratic spline models, as well as Lowess smooth were used to plot the observed associations.

All statistical analyses were performed using PASW Statistics 19 software (SPSS Inc, Chicago, IL, USA).

Results

Table 1 presents the socio-demographic characteristics of the study participants. 418 (95.4 %) of the participants were of Greek origin, 242 (57.2 %) were multiparous, 396 (91.2 %) were married or cohabiting, with a mean age at delivery of 29.77 years (SD = 4.68). Among newborns, 48 (11.0 %) were born prematurely (<37 weeks of gestation) and 216 (49.4 %) of the deliveries were caesarean. 252 (58.9 %) of the pregnancies were planned pregnancies. The comparison between the 438 participants and the 140 non-participants (i.e. women with complete antenatal maternal mental health questionnaires who did not participate in the postpartum study) revealed few significant differences between the two groups. Mothers who participated in postnatal psychological assessment were more likely to have high levels of education and to be non-smokers as compared to non-participants.

STAI-Trait was positively correlated with antenatal EPDS ($\rho = 0.694$, $p < 0.001$), while postnatal EPDS was found to be positively related with STAI-Trait ($r = 0.459$, $p < 0.001$) and antenatal EPDS ($r = 0.454$, $p < 0.001$). Mean scores for depression were higher in pregnancy than postnatally. Specifically, the antenatal mean EPDS was 7.71 (SD = 4.95), while the mean EPDS score at 8 weeks postpartum was 6.48 (SD = 4.90). The proportion of women with probable depression (EPDS score ≥13) was 16.7 % at 28–32 weeks of pregnancy ($n = 73$) and 13.0 % at 8 weeks postpartum ($n = 57$), with 29 women scoring high on the EDPS scale indicating clinical depression in both periods. The proportion of women with high levels of anxiety (STAI-Trait score ≥48) was 17.8 % at 28–32 weeks of pregnancy ($n = 78$). Finally, 11.4 % of the women had high levels of both anxiety and depression during pregnancy ($n = 50$).

Table 2 presents the associations of maternal mental health both antenatally and postnatally with infant's and maternal socio-demographic characteristics. Women with

Table 1 Socio-demographic characteristics of participants and non-participants in the present study (Rhea Study, Crete, Greece, 2007–2013)

	Participants ($n = 438$)	
	Mean	SD
Maternal age (years)*	29.77	4.68
Gestational age (completed weeks)	38.31	1.55
	N	%
Maternal origin*		
Greek	418	95.4
Non-Greek	20	4.6
Maternal educational level*		
Low	63	14.5
Medium	216	49.7
High	156	35.9
Marital status*		
Married	396	91.2
Other	38	8.8
Working during pregnancy*		
Yes	235	53.9
No	201	46.1
Parity		
Primiparous	181	42.8
Multiparous	242	57.2
Infant sex		
Boy	236	53.9
Girl	202	46.1
Preterm		
Yes	48	11.0
No	387	89.0
Delivery type		
Vaginal	221	50.6
Caesarean	216	49.4
Planned pregnancy		
Yes	252	58.9
No	176	41.1
Smoking during pregnancy		
Ever	175	40.3
Never	259	59.7
Physical activity before pregnancy*		
Yes	107	24.9
No	322	75.1
Physical activity during pregnancy*		
Yes	39	9.0
No	392	91.0

* Statistically significant differences ($p < 0.05$); Mann–Whitney tests for two independent samples; Pearson's Chi-squared tests (χ^2 tests)

low levels of education and those who did not work during pregnancy had significantly higher scores on antenatal EPDS. Moreover, women who did not plan their pregnancies and those who did not exercise before or during pregnancy tended to report higher symptoms of antenatal trait anxiety and depression. Higher rates of PPD were reported by mothers who gave birth to boys and those who had a caesarean section delivery.

Table 3 presents the crude and adjusted associations between antenatal maternal mental health and PPD as a continuous variable at 8 weeks postpartum. In the multivariable analysis, it was estimated that for every 1 unit increase in the antenatal maternal depressive score there was a 0.51 unit increase in PPD (β coefficient 0.51, 95 % CI 0.42, 0.59), while for every 5 units increase in the antenatal maternal anxiety scale there was 1.25 units increase in PPD (β coefficient 1.25, 95 % CI 1.00, 1.51). The relationship between antenatal EPDS and PPD proved remarkably robust when sensitivity analysis was conducted following the exclusion of 78 women with higher anxiety levels (STAI-Trait score $\geq$48) (β coefficient 0.38, 95 % CI −0.42, 0.59). The same was true for the association between antenatal trait anxiety and PPD following the exclusion of 73 women with antenatal EPDS score $\geq$ 13 (β coefficient 0.92, 95 % CI 0.63, 1.20).

Table 4 summarises the associations between antenatal depression and anxiety and high levels of postpartum depressive symptoms (EPDS $\geq$ 13). Specifically, a per 5 unit increase in the STAI-Trait subscale was associated with a 70 % increase in the odds for PPD (OR = 1.70, 95 % CI 1.41, 2.05), whereas a per unit increase in antenatal EPDS was associated with a 27 % increase in the odds for PPD (OR = 1.27, 95 % CI 1.19, 1.36). These associations were supported by sensitivity analyses as well. After exclusion of 78 women with STAI-Trait score $\geq$48, a per unit increase in antenatal EPDS increased the odds for PPD by 18 % (OR = 1.18, 95 % CI 1.07, 1.29); whereas after the exclusion of 73 women with antenatal EPDS score $\geq$13, a per 5 unit increase in the STAI-Trait subscale increased the odds for PPD by 36 % (OR = 1.18, 95 % CI 1.03, 1.79).

GAMs examining the shape of the relationships between postnatal EPDS with antenatal EPDS and STAI-Trait scores showed no significant departures from linearity, both for antenatal EPDS (P-gain = 0.536) and STAI-Trait (P-gain = 0.621) scores (Fig. 1).

Discussion

The present study was carried out to provide insight into the early assessment of PPD by exploring the association of antenatal maternal mental health with maternal mood in the postpartum period in Crete, Greece. The results of our study suggest that maternal trait anxiety and depressive symptoms during pregnancy are significantly associated

Table 2 Associations of both infants' and maternal socio-demographic characteristics with antenatal maternal mental health and postpartum depression, univariate analysis (Rhea Study, Crete, Greece, 2007–2013)

	STAI-Trait Mean (SD)	EPDS-antenatal Mean (SD)	EPDS-postnatal Mean (SD)
Marital status			
Married/engaged	39.58 (8.78)	7.55 (4.77)	6.32 (4.87)
Other	40.76 (7.77)	9.47 (6.30)	7.37 (4.92)
Maternal origin			
Greek	39.76 (8.65)	7.75 (4.96)	6.48 (4.84)
Non Greek	38.05 (9.60)	6.85 (4.79)	6.50 (6.30)
Maternal educational level			
Low	41.60 (8.55)	8.67 (5.01)	6.59 (4.74)
Medium	39.64 (8.23)	7.93 (5.01)	6.36 (5.00)
High	38.98 (9.23)	6.99 (4.78) *	6.53 (4.80)
Working during pregnancy			
Yes	39.23 (9.07)	7.20 (4.94)	6.09 (4.60)
No	40.15 (8.22)	8.29 (4.89) *	6.85 (5.16)
Working after pregnancy			
Employment	40.28 (8.60)	7.82 (5.00)	6.50 (4.81)
Employment with leave	38.53 (9.78)	6.86 (4.74)	6.29 (5.00)
Unemployment	39.78 (8.29)	7.92 (5.03)	6.59 (4.90)
Parity			
Primiparous	39.18 (7.96)	7.47 (4.90)	6.51 (4.73)
Multiparous	40.10 (8.92)	7.78 (4.93)	6.53 (5.05)
Infant sex			
Boy	40.17 (9.07)	8.05 (4.98)	6.93 (4.98)
Girl	39.10 (8.22)	7.31 (4.89)	5.95 (4.77)*
Preterm			
Yes	39.00 (8.26)	7.06 (4.22)	7.17 (4.95)
No	39.81 (8.76)	7.82 (5.03)	6.41 (4.91)
Delivery type			
Vaginal	39.57 (8.92)	7.61 (5.14)	6.06 (4.81)
Caesarean	39.81 (8.49)	7.79 (4.77)	6.92 (4.97)*
Planned pregnancy			
Yes	38.45 (8.48)	7.12 (4.60)	6.18 (4.92)
No	41.32 (8.88)*	8.51 (5.34)*	6.82 (4.86)
Smoking during pregnancy			
Yes	40.58 (8.15)	8.45 (5.17)	6.53 (4.92)
No	39.05 (9.01)	7.21 (4.75)*	6.39 (4.87)
Physical activity before pregnancy			
Yes	37.46 (8.04)	6.34 (4.66)	6.26 (5.12)
No	40.43 (8.82)*	8.16 (4.97)*	6.54 (4.85)
Physical activity during pregnancy			
Yes	37.05 (7.30)	6.13 (4.73)	6.31 (4.99)
No	39.99 (8.82)*	7.89 (4.98)*	6.49 (4.90)
Maternal age	$r = 0.020$	$\rho = -0.052$	$\rho = -0.001$
Gestational age (completed weeks)	$\rho = -0.007$	$\rho = -0.011$	$\rho = -0.019$
Duration of breastfeeding (months)	$\rho = -0.088$	$\rho = -0.097$*	$\rho = -0.079$

Table 2 continued

	STAI-Trait Mean (SD)	EPDS-antenatal Mean (SD)	EPDS-postnatal Mean (SD)
BMI before pregnancy (kg/m^2)	$\rho = 0.071$	$\rho = 0.062$	$\rho = 0.028$

EPDS Edinburgh Postnatal Depression Scale, *STAI Trait* State-Trait Anxiety Inventory, Trait subscale

* Statistically significant differences at $p < 0.05$, based on t test or Mann–Whitney U test for two independent samples, analysis of variance (ANOVA) or Kruskal–Wallis one-way analysis of variance by ranks and Pearson's or Spearman's rho correlation coefficient

Table 3 Associations between antenatal depression and anxiety and postpartum depression (Rhea Study, Crete, Greece, 2007–2013)

	EPDS-postnatal			
	Crude		Adjusted‡	
	β-coefficient	(95 % CI)	β-coefficient	(95 % CI)
EPDS-antenatal[a]	0.48	(0.40, 0.57)*	0.51	(0.42, 0.59)*
EPDS-antenatal[a‡‡]	0.37	(0.27, 0.48)*	0.38	(0.42, 0.59)*
STAI-Trait[b] (per 5 unit increase)	1.24	(1.00, 1.48)*	1.25	(1.00, 1.51)*
STAI-Trait[b‡‡‡] (per 5 unit increase)	0.95	(0.68, 1.23)*	0.92	(0.63, 1.20)*

EPDS Edinburgh Postnatal Depression Scale, *STAI-Trait* State-Trait Anxiety Inventory, Trait subscale

* $p < 0.05$

‡ β-coefficients and 95 % CI of β retained from linear regression. All models adjusted for maternal age and maternal education

‡‡ After excluding women with STAI-Trait score ≥48 ($n = 78$)

‡‡‡ After excluding women with antenatal EPDS scores ≥13 ($n = 73$)

[a] Also adjusted for delivery type, infant sex, working during pregnancy, smoking during pregnancy, physical activity before pregnancy, and planned pregnancy

[b] Also adjusted for delivery type, infant sex, physical activity before pregnancy, and planned pregnancy

Table 4 Associations between antenatal depression and anxiety and high levels of postpartum depressive symptoms (RHEA Study, Crete, Greece, 2007–2013)

	High levels of postpartum depressive symptoms (EPDS-postnatal ≥13)			
	Crude		Adjusted‡	
	β-coefficient	OR (95 % CI)	β-coefficient	OR (95 % CI)
EPDS-antenatal[a]	0.21	1.24 (1.16, 1.32)*	0.24	1.27 (1.19, 1.36)*
EPDS-antenatal[a‡‡]	0.14	1.15 (1.06,1.26)*	0.16	1.18 (1.07, 1.29)*
Stai_Trait[b] (per 5 unit increase)	0.50	1.65 (1.39, 1.97)*	0.53	1.70 (1.41, 2.05)*
Stai_Trait[b‡‡‡] (per 5 unit increase)	0.28	1.33 (1.02,1.72)*	0.31	1.36 (1.03, 1.79)*

EPDS Edinburgh Postnatal Depression Scale, *STAI-Trait* State-Trait Anxiety Inventory, Trait subscale

* $p < 0.05$

‡ β-coefficient, Odds Ratio (OR) and 95 % CI of OR retained from logistic regression. All models adjusted for maternal age and maternal education

‡‡ After excluding women with STAI-Trait score ≥48 ($n = 78$)

‡‡‡ After excluding women with antenatal EPDS scores ≥13 ($n = 73$)

[a] Also adjusted for delivery type, infant sex, working during pregnancy, smoking during pregnancy, physical activity before pregnancy and planned pregnancy

[b] Also adjusted for delivery type, infant sex, physical activity before pregnancy and planned pregnancy

with PPD at 8 weeks postpartum, a finding that is consistent with previous research [6, 13, 15–21] The findings also indicated that the effect of antenatal maternal anxiety or depressive symptoms on postpartum depressive symptoms are not likely to be a result of residual confounding due to antenatal EPDS or STAI-Trait, respectively, although replication of such analyses in other population samples would be desirable.

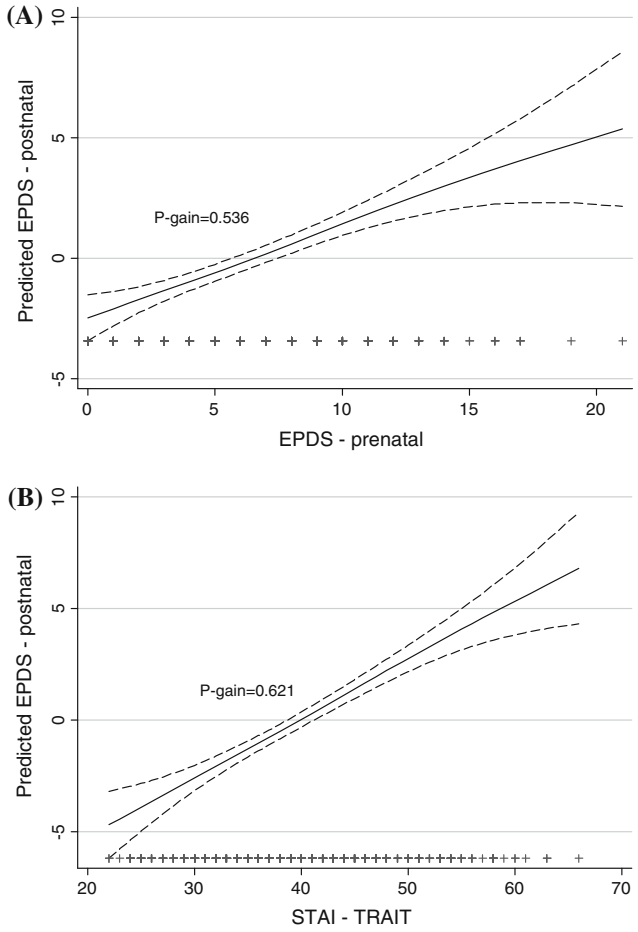

Fig. 1 Lowess smooth of the adjusted association between **a** EPDS-postnatal and EPDS-prenatal, and **b** EPDS-postnatal and STAI-Trait. Predicted values were estimated by restricted quadratic spline models

By excluding women with a history of past psychiatric disorder, the present study examined new onset of antenatal anxiety and depression, as well as PPD. Depressive symptoms were found to be higher in pregnancy than in the postnatal period. Antenatal psychological states appear to be dynamic and changing in nature, with most studies demonstrating a generally increasing trend of depressive symptoms and anxiety during pregnancy followed by a decline after childbirth [2, 16], thus highlighting the significance of antenatal mental health problems. It is not clear at which point during pregnancy symptoms of anxiety and depression are most predictive of PPD. Antenatal depressive symptoms may occur during any trimester, but increases in depressive symptoms seem to be most likely between 18 and 32 weeks of pregnancy [2], with symptoms being more prevalent and severe during the third trimester [19]. It seems that women who are anxious in the final trimester are those with most difficulty in adjusting to the maternal role and least confident in meeting the demands of motherhood [19].

Given the high prevalence and serious consequences of both antenatal and postnatal depression, efforts have been made to identify risk factors to assist in prevention, identification, and treatment. In our sample, findings in the univariate analysis indicated that low level of mother's education and unemployment were associated with antenatal depression in univariate analysis similarly to previous findings [34]. Moreover, unplanned pregnancy was related to both antenatal depression and anxiety. Consistent with other study findings [18, 35], an unplanned or unwanted pregnancy, and the accompanying feelings, might be trigger for antenatal anxiety and depression. Preliminary evidence in the literature showed that unwanted or unplanned pregnancy places women under great psychological risks [36]; however these studies did not examine its varying importance across different stages of pregnancy [19].

In our study, women who had no physical activity before or during pregnancy tended to report higher symptoms of anxiety and depression during pregnancy. In a number of studies, participation in physical activity was associated with lower levels of depressive symptoms [37, 38], even though in other studies no associations between total or recreational physical activity and depressive symptoms were found [39, 40]. Physical exercise has long been thought to benefit mental health and is an attractive, low-risk and low-cost approach to the management of depression and anxiety during pregnancy and postnatally.

Our results indicated that higher rates of PPD were reported by mothers who gave birth to boys and those who had a caesarean section delivery, although the mean scores in EPDS postpartum compared for both variables were still quite low, thus the differences might not seem to be clinically meaningful in our sample. However, as far as infant sex is concerned, our findings supported the results of previous studies that women who gave birth to boys were significantly more likely to suffer from severe PPD than women who gave birth to girls [41]. Interestingly, the same research group found that even if women did not have PPD, giving birth to a boy was significantly more likely to reduce their quality of life than delivering a girl. However, our findings were in contrast with the finding of previous studies in China [42], Turkey [43], and India [44], which found that rates of PPD were higher among women who had given birth to girls. This could be explained by the fact that women who live in cultures where greater value is placed on sons are more likely to suffer from PPD if they give birth to a girl. In a similar vein, some research has linked caesarean section delivery with higher rates of PPD compared to vaginal delivery [45–47], and this may be due to the discrepancies in oxytocin release and the time it takes to recover from the procedure, as well. However, the link between caesarean section and depression is still unclear [48]. As previously described [45–47], the

proportion of caesarean sections is very high in this population and this high percentage is not believed to be due to medical conditions.

In the current study, the prevalence of depressive symptoms in late pregnancy was 16.7 and 13.0 % at 8 weeks postpartum and is similar to other reported prevalence rates in Western countries. However, comparisons are compromised by varying follow-up data in relation to delivery, variation in EPDS thresholds, and selection problems when samples are on specified populations [2, 5, 49–51]. In Greece, research on PPD has yielded similar findings to those reported in the literature. A recent study found that PPD had an overall prevalence of 19.8 % and a point prevalence of 12.5 % at the end of the 1 month after delivery [8]. Leonardou et al. [9], using the non-patient version of the structured clinical interview for DSM-III-R (SCID), found that 12.4 % of the participants suffered from depression at 2 months postpartum.

The strengths of the present study include the population-based, prospective follow-up design, reasonable numbers of women with PPD symptoms, and detailed data for maternal mental health in terms of trait anxiety and depressive symptoms during pregnancy. The study population included women followed up since early pregnancy, providing us the opportunity to account prospectively for the effect of exposures during pregnancy. Furthermore, the exclusion of women who gave birth to twins and women with a previous history of psychiatric disorder as well as adjustment for several socio-demographic variables reduced the likelihood of confounding. We did not observe any substantial differences between the crude and adjusted models. Thus, it is unlikely that over-adjustment affected our findings. Participants were unaware of the hypothesis being tested, so, misclassification of mental health scores estimated by the questionnaires is likely to be random with respect to PPD scores.

There are, however, some limitations in the present study that deserve acknowledgement. A possible limitation is the participation rate (75.8 %) together with the differences found between participants and non-participants. We could hypothesise that due to the non-participants' profile, they might have been women with higher levels of anxiety and/or prenatal depressive symptoms. If however our hypothesis, which is supported by current findings, is correct then even stronger associations between antenatal maternal mental health and PPD might have been detected. In addition, as the lower response rate was not due to loss to follow-up which can also produce selection bias in a cohort study, biasing estimates toward unknown direction, we are quite confident that the direction of the association is most probably toward the null. Although we consider that these differences observed at baseline are not likely to have affected appreciably the present results, this limitation should be taken into account when considering study findings; it is difficult to understand the direction of bias, which depends on what the association between antenatal maternal health and PPD would be for non-participants, which cannot be tested. Furthermore, we assessed antenatal and postpartum depressive symptoms with the self-reported EPDS scale and trait anxiety with the self-reported STAI-Trait subscale, rather than definite cases of depression and anxiety based on clinician-administered structured diagnostic interview. However, this is an epidemiological study assessing the prevalence of antenatal/postpartum depression and trait anxiety, and EPDS and STAI-Trait scores are established and widely used screening tools with high specificity and sensitivity [52, 53]. Furthermore, a setback of our study was that we did not use a questionnaire to evaluate marital satisfaction and perceived social support, which have been identified as protective factors for maternal mental health both antenatally and postnatally. Finally, no questions were asked about stressful life events and a history of abuse. Research suggests that stressful life events, such as the death of a loved one, relationship breakdowns or divorce, losing a job or moving away from home, as well as low social support during pregnancy and early puerperium, have been shown to contribute to the onset of PPD [6, 15, 54]. Furthermore, although the present study examined the relationship of new onset of anxiety and depression during pregnancy and PPD by excluding women with a history of past psychiatric disorder, there still may be the possibility of residual confounding due to past history of adversity or mental health problems not captured in this study or due to other unknown social and lifestyle variables. The exclusion criteria of only eight women with a history of past psychiatric disorder might render some overinterpretation of newly onset anxiety and depression, although the results would likely not change if these participants were included. Further research therefore is needed to replicate findings for newly onset mental health conditions in pregnancy and the postpartum.

Notwithstanding these limitations, our study serves as an important step toward recognising the dynamic nature of anxiety and depression across pregnancy and the postpartum period. Antenatal depression and anxiety are found to be strongly associated with PPD at 8 weeks postpartum in a sample of Greek mothers. With the exclusion of women with a history of past psychiatric disorder, the present study highlights the contribution of newly onset anxiety and depressive symptoms in late pregnancy to PPD. Future research should encourage the longitudinal assessment of both anxiety and depression across all three trimesters and during the first postnatal year as well, for examining how these psychological states change across pregnancy and at the postpartum period. Research findings have shown that antenatal anxiety and depression are not

static, but instead show a changing course, both in prevalence rates and in intra-individual anxiety and depression levels [19]. Clinicians should be vigilant of potential cases of anxiety and depression emerging in different stages of pregnancy, with ongoing screening being done throughout.

Worldwide research has been accumulated over the last two decades, emphasising the need for special care of women during pregnancy and the postpartum period. Antenatal and postnatal maternal mental health might have a significant adverse impact, not just on the affected woman, but on her family as a whole. Our group has recently shown that both antenatal and postnatal maternal psychological well-being have important consequences on early child neurodevelopment [55]. The findings of the present study suggest that antenatal maternal psychological well-being has a significant effect on PPD, which might have important implications for early detection during pregnancy of women at risk for PPD. Consequently, a longitudinal analysis of antenatal anxiety and depression across different stages of pregnancy is of great value for developing effective prevention and early intervention strategies.

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Conflict of interest The authors have no conflicts of interest to declare.

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