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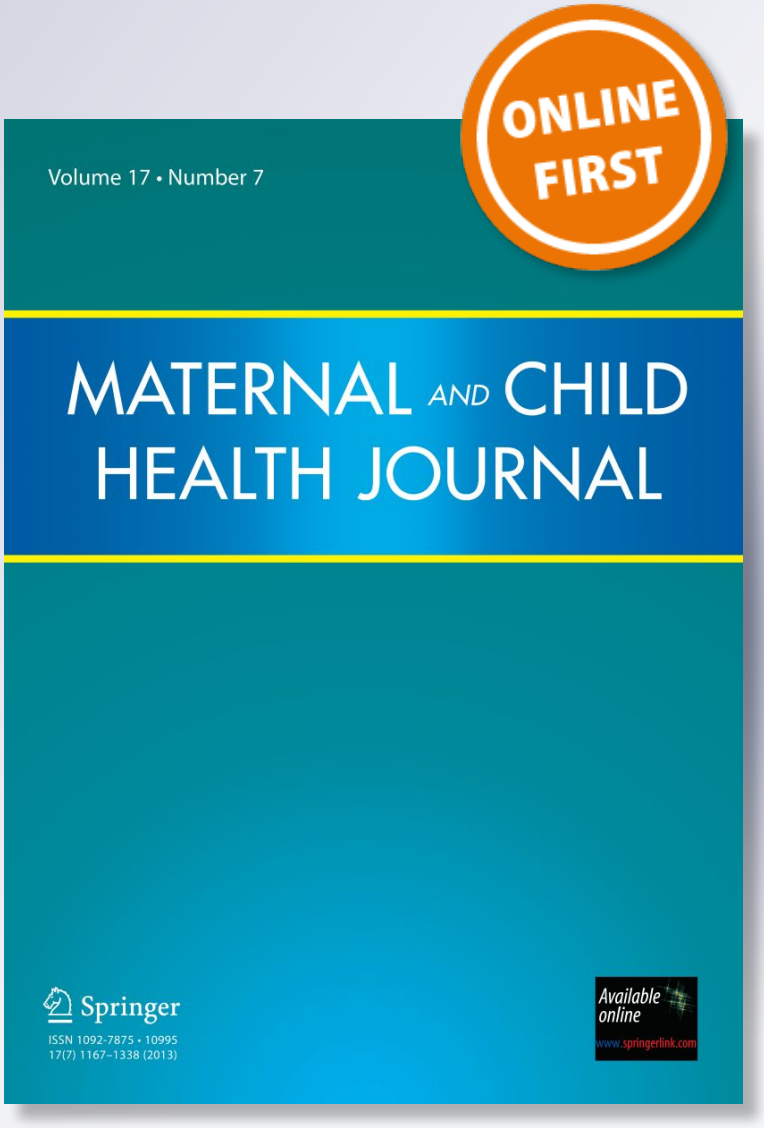

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Impact of Maternal Perinatal Anxiety on Social-Emotional Development of 2-Year-Olds, A Prospective Study of Norwegian Mothers and Their Offspring

The Impact of Perinatal Anxiety on Child Development

Carolin Polte[1] · Carolin Junge[1] · Tilmann von Soest[2] · Andreas Seidler[1] · Malin Eberhard-Gran[3,4,5,7] · Susan Garthus-Niegel[3,6]

Abstract
Introduction Anxiety in women is highly prevalent during pregnancy and in the postnatal period. Anxiety disorders in mothers have been linked to adverse outcomes in their children's development. However, large-scale prospective studies on this issue, covering both the prenatal and postnatal period with follow-up periods beyond the first year of life are scarce. *Method* In this prospective cohort study, data gathered from 1336 Norwegian women and their children were used. Maternal anxiety symptoms were measured at gestation week 17–19 and 32, as well as 8 weeks postpartum using the Symptom Check List. Child development problems were assessed at 2 years postpartum using the Ages & Stages Questionnaire: Social-Emotional. Logistic regressions were conducted to examine the association between maternal prenatal, postnatal, and perinatal anxiety and the risk of social-emotional development problems in 2-year-old children. *Results* Of all women, 8.2% experienced prenatal anxiety, 4.0% had postnatal anxiety, and 4.4% reported perinatal anxiety (i.e., anxiety in both the prenatal and postnatal period). 5.6% of the 2-year-olds showed problems in their social-emotional behavior. Child development problems were associated with maternal prenatal anxiety (Odds Ratio [OR] = 2.48, 95% CI 1.55–4.92), postnatal anxiety (OR 3.32, 95% CI 1.43–7.74), and anxiety both in the prenatal and postnatal period (OR 3.98, 95% CI 1.85–8.56). Adjusted for confounders, maternal anxiety continued to be a significant predictor of adverse child social-emotional development (postnatal anxiety: OR 2.46, 95% CI 1.01–5.97; perinatal anxiety: OR 2.40, 95% CI 1.03–5.59). *Discussion* Maternal postnatal anxiety and anxiety both during and after pregnancy are unique substantial predictors for problems in a 2-year-old's social-emotional development, even when controlled for confounders.

Keywords Maternal perinatal anxiety · Symptom Check List · Ages & Stages Questionnaire · Social-emotional development · Child development

Significance

What's known Maternal perinatal anxiety (PA) is a common condition but has been a neglected topic compared to postnatal depression. Several studies examined the association of anxiety only either during or after pregnancy and behavioral or mental problems in children. However, some studies did not account for relevant confounding factors on child development. As contradicting results have been found in previous studies, the effect of onset of pregnancy-related anxiety adjusted for confounders remains to be further examined. *What this study adds* Although adjustment for confounders

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reduced maternal PA's gradient, findings suggest an independent adverse effect of perinatal and postnatal maternal anxiety on 2-year-old's social-emotional development.

Introduction

The perinatal period is a time of transformation and related to physical, physiological, and psychological adjustments (Brunton et al. 2015; Punamäki et al. 2006). It triggers major life changes and might be accompanied by feelings of distress, insecurity, and anxiety (Brunton et al. 2015; Parfitt and Ayers 2014). Maternal perinatal anxiety (PA) has been identified as a common phenomenon (Kingston et al. 2012); however, reported estimates feature wide variation and are somewhat contradictory. Some sources describe PA as presenting a relatively stable and consistent course (Heron et al. 2004), some report higher prevalence of PA during pregnancy compared to the postnatal period (Figueiredo and Conde 2011; Parfitt and Ayers 2014), whereas others state the reverse case (Eberhard-Gran et al. 2003). Overall, the prevalence of maternal PA varies greatly between 1.6% and 24.7% in the prenatal period and 1.4% and 18.0% in the postnatal period (Eberhard-Gran et al. 2003; Figueiredo and Conde 2011; Heron et al. 2004; Ross and McLean 2006).

For children, the peripartum marks a period of comprehensive brain development and high parent dependency. Child development during this period is influenced by genetics and hormonal mechanisms in-utero activated by maternal stress responses concomitant with anxiety symptoms and postnatal care and experience (Glover 2014; Walker et al. 2011).

It has been suggested that children of women with PA are more likely to develop adverse health outcomes compared to children of healthy women (Glover 2014; Kingston et al. 2012). Specifically, maternal anxiety during pregnancy has been shown to be associated with increased risk for neurodevelopmental issues in offspring, such as lower mental development (Brouwers et al. 2001; Huizink et al. 2003) and behavioral disturbances (Hernández-Martínez et al. 2008; O'Connor et al. 2002).

Even though relationships between maternal anxiety and children's adverse development outcomes have been found (Brouwers et al. 2001; Hernández-Martínez et al. 2008; Huizink et al. 2003; O'Connor et al. 2002), some studies have reported opposing results. For instance, maternal anxiety failed to show significant associations with communication skills in 520 Finish 12-months-olds (Punamäki et al. 2006) and research on 94 American 2-year-olds unexpectedly found that high maternal prenatal anxiety was significantly associated with more advanced motor and mental development (DiPietro et al. 2006). Still, both studies suffer from methodological limitations, as the first study used unvalidated measurement instruments, and the sample size in the latter was rather small.

Although maternal PA is increasingly recognized as problematic, it has received scant research attention compared to the vast literature concerning maternal perinatal depression (Heron et al. 2004; Ross and McLean 2006), particularly concerning its health consequences for children (Austin et al. 2005). The existing research has been limited by small sample sizes (Brouwers et al. 2001; Hernández-Martínez et al. 2008; Huizink et al. 2003) or short follow-up periods (Huizink et al. 2003). Conclusive information about periods during which maternal anxiety could be particularly detrimental for the offspring's health is also missing, as only a few studies have examined both the prenatal and postnatal period (Kingston et al. 2012; O'Connor et al. 2002). Moreover, several studies have not accounted for important potential confounders of the relationship between PA and child development (Kingston et al. 2012). For example, child development is associated with maternal sociodemographic factors, such as age, socio-economic status, and parity (Brouwers et al. 2001; O'Connor et al. 2002; Stein et al. 2014; Thomson et al. 2014), and such factors may also influence PA (Kingston et al. 2012). Likewise, child development is influenced by alcohol consumption in pregnancy (Bingham 2015), social support from family and friends (Thomson et al. 2014; Walker et al. 2011), and child factors such as child gender (Brouwers et al. 2001; O'Connor et al. 2002; Stein et al. 2014), poor neonatal health (Huizink et al. 2003; Punamäki et al. 2006), and preterm birth (WHO 2015). It is therefore of importance to account for such potential covariates.

Considering the limitations of previous research, the objective of this prospective, 2-year-follow-up cohort study was to examine the relationship of maternal prenatal and postnatal anxiety with social-emotional development of 2-year old children while taking into account a comprehensive number of potential confounders. A secondary aim was to add evidence on the prevalence of maternal pre- and postnatal anxiety.

Methods

Study Population

Data were derived from the Norwegian Akershus Birth Cohort (ABC), a large population-based prospective cohort study. Between November 2008 and April 2010, women were recruited for the study during their routine fetal ultrasound examination at 17 weeks gestation and asked to complete questionnaires at 17 weeks gestation (Q1), 32 weeks gestation (Q2), 8 weeks postpartum (Q3) during an aftercare check-up, and 2 years postpartum (Q4)

during a well-child check-up. Additional data of participating women and children were derived from electronic patient and birth records. Of the eligible women (able to read, write, and understand Norwegian), 80% (n = 3752) provided written informed consent prior to study inclusion and returned the first questionnaire. Detailed information regarding the participation flow is presented in Fig. 1. Ethical approval in accordance with the ethical standards of the Declaration of Helsinki has been obtained by the Regional Committee for Medical and Health Research Ethics (approval number S-08013a).

As less than 50% of the original participants were included in the current sample, attrition analysis was performed. In a logistic regression analysis, relevant sociodemographic and mental health variables (i.e., maternal age, education, parity, social support, and anxiety symptoms in Q1) were included as predictors of drop-out within 2 years postpartum. The results showed that women with higher education (Odds Ratio [OR] = 0.61, 95% CI 0.50–0.75), with a partner (OR 0.70, 95% CI 0.57–0.85), and older age (OR 0.95, 95% CI 0.93–0.97) were less likely to drop out of the study, whereas women with symptoms of anxiety in Q1 (OR 1.43, 95% CI 1.10–1.86) were more likely to drop out. Of those women who dropped out at different time points, 19.7%, 18.0%, and 19.0% showed symptoms of prenatal anxiety in Q1 when dropping out at Q2, Q3, and Q4, respectively. In contrast, only 12.5% of women participating at all time points showed symptoms of prenatal anxiety.

Measures

Maternal Perinatal Anxiety

The 10-item anxiety scale of the Hopkins Symptom Checklist (SCL) was used to evaluate anxiety symptoms during the previous week in Q1, Q2, and Q3. The SCL is a widely used self-rating scale. Each item ranges from 'not at all' (1) to 'extremely' (4). Mean scores were computed, ranging from 1 to 4. Maternal PA was defined as ≥ 1.55, as this cut-off has been used in several studies (Mathiesen et al. 1999; Veijola et al. 2003). Persons scoring ≥ 1.55 are considered to be moderately affected by anxiety (Mathiesen et al. 1999) and may be seen as a possible clinical case (Veijola et al. 2003). Cronbach's alpha was 0.71, 0.77, and 0.79 in Q1, Q2, and Q3.

For regression analyses, Q1, Q2, and Q3 scores were aggregated into a single variable. The final variable consisted of four categories indicating the time points at which anxiety was present: 'prenatal anxiety' (score ≥ 1.55 in Q1 and/or Q2), 'postnatal anxiety' (score ≥ 1.55 in Q3), 'perinatal anxiety' (score ≥ 1.55 in Q1 and/or Q2 and Q3), and 'no anxiety' (score < 1.55 in Q1, Q2, and Q3).

Social-Emotional Child Development

Social-emotional child development was assessed by the Ages & Stages Questionnaire: Social-Emotional (ASQ:SE) (Squires et al. 2005). Using the ASQ:SE, mothers reported on their children's social-emotional competence (e.g., self-regulation, compliance, interaction with people). The ASQ:SE questions are rated on a three-point scale indicating if the child performs a behavior 'most of the time' (0), 'sometimes' (5), or 'never or rarely' (10). An additional check box allows for stating if a behavior is of concern to the parents; checked concerns score 5 additional points. Scores for each domain are totaled into an overall score: high total scores indicate possible developmental problems, while low scores suggest competent social-emotional behavior. With 26 questions to be answered, scores range from 0 to 390. Problems in social-emotional behavior were defined as sum score values ≥ 50. The ASQ:SE has been previously validated yielding an overall sensitivity of 82%, and an overall specificity of 92% (Salomonsson and Sleed 2010; Squires et al. 2005). Cronbach's alpha was 0.52.

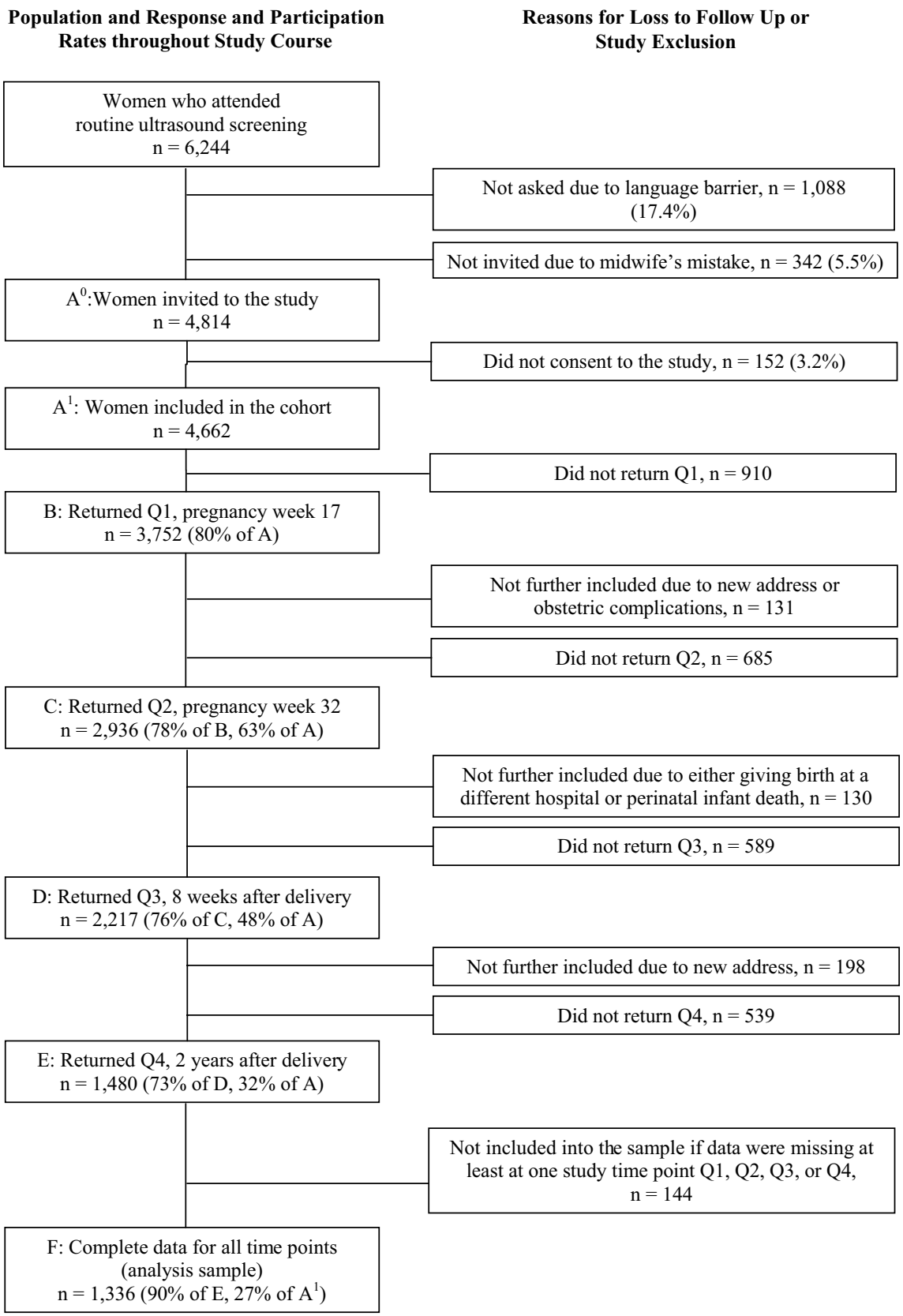
Potential Confounders

Maternal factors were assessed in Q3 and included age, education (≤ 12 years vs. >12 years), parity (parous vs. nulliparous), marital status (married/cohabitating vs. single), social support, and alcohol consumption during pregnancy. Social support was measured by the 3-item Oslo Support Scale with sum scores categorized as 'low' (3–8), 'moderate' (9–11), and 'high' (12–14) support (Dalgard et al. 2006). Alcohol consumption during pregnancy was dichotomized as 'yes' or 'no'.

Child factors assessed after delivery included gender, preterm birth, and health problems reported at 2 years postpartum. Preterm birth (preterm vs. term) was defined as being born before gestational week 37 according to WHO guidelines (WHO 2015). Child health problems including hearing problems, visual problems, eczemas, asthma, bronchitis, urinary tract infections, recurring ear infections, food allergies/intolerances, insufficient or excessive weight gain, diabetes, and injuries/accidents were counted and categorized as 'none', 'one', and '>1'.

Analyses

Analysis of Variance (ANOVA) combined with post-hoc t-tests using Bonferroni adjustment were used to examine mean differences in anxiety scores at different time points. Correlation analysis was used to investigate stability of anxiety symptoms across time. Associations between maternal PA and problems in children's social-emotional behavior were estimated by means of logistic regression



◂**Fig. 1** The left column depicts the numbers of the initial study population and response and participation rates in the longitudinal study course of the Norwegian Akershus Birth Cohort study during the recruitment phase (A^0: invited sample), the different study time points (A^1: inclusion, B: pregnancy week 17, C: pregnancy week 32, D: 8 weeks after delivery, and E: 2 years after delivery), and F: number of population as included into the current analysis. The right column depicts reasons for loss to follow up and study exclusion for mothers and their children

analysis. Regressions were adjusted for all potential confounders as all variables were entered simultaneously in one block.

In all analyses, women who participated at all four time points were included in our analysis ($n = 1336$). Multiple imputation based on 20 imputed datasets was used to handle missing data due to item non-response. Moreover, we conducted sensitivity analyses where all women who completed Q1 were included (n = 3752). Again, multiple imputation was used to handle missing data due to both drop-out and item non-response.

Results

In all, data from 1336 women and their children were eligible for analysis. Descriptive statistics are presented in Table 1.

The majority of the women had a cohabiting partner, more than 12 years of education, and reported moderate or high social support. Alcohol use in pregnancy was rare. A similarly high proportion of nulli-parous and parous women participated in the study. Moreover, slightly more boys than girls were born. The vast majority of the children were not born preterm. About one-third of the children experienced at least one health problem.

Table 2 displays characteristics of maternal PA.

On average, women scored rather low on the SCL in the perinatal period. Prevalence of anxiety at the two time points in the prenatal period (Q1, Q2) was similar and was reduced almost by half in the postnatal period (Q3). Of all women, 83.4% scored below the cut-off in all questionnaires, 8.2% had prenatal anxiety, 4.0% had postnatal anxiety, and 4.4% had perinatal anxiety (both, pre- and postnatal anxiety). SCL scores at different time points correlated significantly ($p < .01$) with strongest correlations between Q1 and Q2 and somewhat lower correlations between Q2 and Q3. ANOVA yielded a significant overall effect of time for mean SCL scores ($F(2, 1275) = 59.72$, $p \leq .001$). Post-hoc tests revealed that the mean SCL score was significantly higher in gestation weeks 17 and 32 compared to scores at 8 weeks postpartum ($p < .001$), with no significant differences between prenatal time points ($p > .05$).

Regarding social-emotional development at the age of 2 years, 5.6% of the children were rated to have problems. The average ASQ:SE score was 22.29 (SD = 14.98).

Table 3 displays the associations between maternal anxiety across the perinatal period and problems in children's social-emotional development by using logistic regressions with multiple imputation.

In crude logistic regressions, maternal prenatal anxiety, postnatal anxiety, and perinatal anxiety significantly increased the odds of social-emotional deficiencies in 2-year-olds by a factor about of 2.5, 3.3, and 4.0, respectively, when compared to children with asymptomatic mothers. In the crude models, four of the confounders proved to have a significant negative effect on the outcome: Maternal education ≤ 12 years posed a more than two-fold risk increase; moderate and low social support approximately doubled and quadrupled the odds for developmental problems; and having a single mother or suffering from more than one health problem posed an approximately three-fold risk increase each. Adjusted for all factors, the associations with maternal PA diminished somewhat, and prenatal anxiety was no longer a significant predictor. However, postnatal anxiety only and pre- and postnatal anxiety remained to show a significant increase of about 2.5 OR.

Sensitivity analyses were conducted by re-running multiple regression analyses using all participants who had participated in Q1 (n = 3752). A similar pattern of results were obtained, with no significant association of maternal prenatal anxiety (OR 1.74, p = .09) and a significant association of maternal postnatal anxiety (OR 2.72, p = .02) when all covariates were included together with maternal PA as predictors. However, even though maternal perinatal anxiety also showed an increased OR, this association with child development was non-significant (OR 2.09, p = .09).

Discussion

Main Findings

Results suggest that maternal PA is linked to adverse development of social-emotional behavior of 2-year-old children. Even after adjustment for confounders, children with mothers presenting with postnatal anxiety or perinatal anxiety were about 2.5 times more likely to develop problems in their social-emotional behavior at the age of 2 years than children with mothers scoring below the cut-off on all assessment time points. The prevalence of anxiety was about twice as high during, compared to after pregnancy, and mean anxiety scores significantly declined from the prenatal to the postnatal period. The declining prevalence of anxiety may indicate an anxiolytic effect of maternity during the early postnatal period (Brunton et al. 2015): it is conceivable that

Table 1 Demographic characteristics (n, %) of the Norwegian Akershus Birth Cohort study sample; total study sample for analyses n = 1336

Variables	n (%)	Missing values n (%)
Maternal factors		
Maternal age (mean, SD)	31.63 (4.53)	2 (0.1)
Parity		0 (0.0)
Nulli-parous	642 (48.1)	
Parous	694 (51.9)	
Marital status		10 (0.7)
Married/cohabitating	1298 (97.9)	
Single	28 (2.1)	
Education (years)		51 (3.8)
≤ 12	354 (27.5)	
> 12	931 (72.5)	
Social support[a]		1 (0.1)
High	549 (41.1)	
Moderate	648 (48.5)	
Low	138 (10.3)	
Alcohol consumption		3 (0.2)
No	1294 (97.1)	
Yes	39 (42.9)	
Child factors		
Child's sex		2 (0.1)
Girl	635 (47.5)	
Boy	699 (52.3)	
Preterm birth (weeks)[b]		2 (0.1)
< 37	81 (6.1)	
≥ 37	1253 (93.9)	
Child health problems (2 years postpartum)		0 (0.0)
None	917 (68.6)	
One	310 (23.2)	
> 1	109 (8.2)	

n number, % percentage, *SD* standard deviation

[a]Oslo Social Support Scale: score 3–8 = low social support, score 9–11 = moderate social support, score 12–14 = high social support

[b]Preterm birth: born before 37 weeks of gestation are completed

higher anxiety scores during gestation rather express insecurity about pregnancy and birth than a clinical abnormality that disintegrates after delivery. However, as pre-pregnancy conditions were not measured, the mechanism of the postnatal decline remains uncorroborated.

Maternal PA seems to have a unique association with child development and could be causally related to adverse outcomes. Still, longitudinal studies do not provide definite evidence for causal relations. Overall, postnatal anxiety might be a more important factor in this matter than prenatal anxiety, since prenatal anxiety alone was not significantly related to child development, whereas postnatal anxiety and perinatal anxiety were. One explanation might be that anxiety during pregnancy may primarily be a temporary expression of concern related to the delivery, the health of the child, and the ability to be a good mother rather than reflecting pathological anxiety (Brunton et al. 2015). Such temporary fear may not be strongly related to child development. The temporary alteration of the mental state of mothers towards the end of pregnancy up to the first few postnatal weeks has also been described by Winnicot in the concept of primary maternal preoccupation (Leckman et al. 2004).

Although prenatal anxiety showed to be a significant predictor in our main analyses, it failed to achieve significance when sensitivity analyses were conducted. However, perinatal anxiety presented as a significant predictor. Thus, some mechanisms in the prenatal period could possibly pose influential determinants. One explanatory approach is fetal programming as a growing body of evidence suggests (Austin et al. 2005; Glover 2014; O'Donnell et al. 2014). Triggered by stress response mechanisms based on the hypothalamus–pituitary–adrenal axis, high cortisol levels in mothers experiencing anxiety are passed to the child via the placenta due to stress-induced downregulation of the placental barrier enzyme 11β-hydroxy steroid dehydrogenase Type II. In the fetus' immature brain, cortisol impinges on the developing neuronal, somatic, and hormonal structures, thereby 'programming' the unborn for an increased risk of delay or problems in developmental areas (Austin et al. 2005; Glover 2014; O'Donnell et al. 2014). This mechanism may have long-term or permanent

Table 2 Correlation using Pearson's r, Analysis of Variance (ANOVA), and descriptive statistics for all three study time points; total study sample for analyses n = 1336

	Correlation Pearson's r			Mean SCL-anxiety score (SD)	SCL-anxiety ≥ 1.55[a] (%)
	1	2	3		
Maternal perinatal anxiety (PA)					
1 Q1—gestation week 17	1.00			1.28 (SD 0.27)	12.5
2 Q2—gestation week 32	0.63**	1.00		1.27 (SD 0.30)	13.6
3 Q3—8 weeks postpartum	0.48**	0.55**	1.00	1.20 (SD 0.27)	8.4

SCL-anxiety Symptom Check List, 10 items for anxiety; *SD* standard deviation, *n* number

**p < .01; ***p < .00

[a]Prevalence of anxiety symptoms according to SCL-anxiety cut-off

Table 3 Logistic regression with crude odds ratios (OR) for maternal perinatal anxiety (PA) alone and multivariable logistic regression with co-variable adjusted odds ratios (aOR) for problems in social-emotional development (ASQ:SE score ≥ 50) in 2-year-old children; total study sample for analyses n = 1336

	ASQ:SE score			Crude OR [95% CI]	aOR [95% CI]
	Low score: < 50, n (%)	High score: ≥ 50, n (%)	Total n		
Maternal perinatal anxiety (PA)[a]					
No anxiety (reference)	1060 (95.7)	48 (4.3)	1108	1.0	1.0
Prenatal anxiety	98 (89.9)	11 (10.1)	109	2.48* [1.55, 4.92]	1.88 [0.92, 3.84]
Postnatal anxiety	46 (86.8)	7 (13.2)	53	3.32** [1.43, 7.74]	2.46* [1.01, 5.97]
Perinatal anxiety	50 (84.7)	9 (15.3)	59	3.98*** [1.85, 8.56]	2.40* [1.03, 5.59]
Maternal age (mean, SD)	31.67 (4.52)	31.05 (4.59)	1332	0.97 [0.92, 1.02]	1.01 [0.95, 1.07]
Parity					
Nulli-parous (reference)	650 (93.8)	43 (6.2)	693	1.0	1.0
Parous	609 (95.0)	32 (5.0)	641	0.80 [0.51, 1.25]	0.87 [0.51, 1.47]
Marital status					
Married/cohabiting (reference)	1226 (94.6)	70 (5.4)	1296	1.0	1.0
Single	24 (85.7)	4 (14.3)	28	3.03* [1.03, 8.95]	1.68 [0.53, 5.32]
Education (years)					
>12 (reference)	889 (95.7)	40 (4.3)	929	1.0	1.0
≤12	321 (90.7)	33 (9.3)	354	2.30** [1.43, 3.71]	1.86* [1.10, 3.15]
Social support[b]					
High (reference)	530 (96.7)	18 (3.3)	548	1.0	1.0
Moderate	607 (93.8)	40 (6.2)	647	1.94* [1.10, 3.42]	1.82* [1.02, 3.26]
Low	121 (87.7)	17 (12.3)	138	4.14*** [2.07, 8.26]	2.69* [1.26, 5.73]
Alcohol consumption					
No (reference)	1220 (94.4)	72 (5.6)	1292	1.0	1.0
Yes	36 (92.3)	3 (7.7)	39	1.41 [0.42, 4.76]	1.67 [0.49, 5.88]
Child's sex					
Girl (reference)	604 (95.4)	29 (4.6)	633	1.0	1.0
Boy	653 (93.4)	46 (6.6)	699	1.47 [0.91, 2.37]	1.36 [0.83, 2.22]
Preterm birth (weeks)[c]					
≥ 37 (reference)	1184 (94.6)	67 (5.4)	1251	1.0	1.0
< 37	73 (90.1)	8 (9.9)	81	1.94 [0.90, 4.18]	2.08 [0.93, 4.65]
Child health problems (2 years postpartum)					
None (reference)	874 (95.5)	41 (4.5)	915	1.0	1.0
One	290 (93.5)	20 (6.5)	310	1.47 [0.85, 2.55]	1.42 [0.81, 2.50]
> 1	95 (87.2)	14 (12.8)	109	3.14*** [1.65, 5.97]	2.49** [1.26, 4.90]

n number, *OR* odds ratio, *aOR* odds ratio adjusted for all statistically significant confounders in the univariate logistic regression, *95% CI* 95 percent confidence interval, *ASQ-SE* ages & stages questionnaire-social-emotional

*p < .05, **p < .01, ***p < .001

[a]Presence of maternal anxiety according to SCL-anxiety cut-off: *Prenatal anxiety* SCL-anxiety score ≥ 1.55 in gestation week 17 and/or in gestation week 32, *Postnatal anxiety* SCL-anxiety score ≥ 1.55 8 weeks postpartum, *Perinatal anxiety* SCL-anxiety score ≥ 1.55 in gestation week 17 and/or in gestation week 32 and 8 weeks postpartum, *No anxiety* SCL-anxiety score < 1.55 in gestation week 17 and in gestation week 32 and 8 weeks postpartum;

[b]Oslo Social Support Scale: score 3–8 = low social support, score 9–11 = moderate social support, score 12–14 = high social support;

[c]Preterm birth: born before 37 weeks of gestation are completed

effects on subsequent child and adult physiology, behavior, and health. In addition, certain gene expressions that are modified by gene-environment interactions (epigenetic mechanisms) or are transmitted directly from the mother to the child during gestation might be the reason for a higher susceptibility of some children to developmental problems (Glover 2014; O'Donnell et al. 2014).

In contrast to in-utero mechanisms, a stronger focus ought to be set on postpartum determinants, i.e., social and environmental factors, as those may be of importance to understand associations of postnatal anxiety. Parenting self-efficacy has been recognized as an important contributor to competent parenting behavior and it has proven to be a strong and consistent predictor for subsequent social-emotional development of children (Belsky et al. 2007; Thomson et al. 2014; Wernard et al. 2014). Positive parenting skills such as parenting self-efficacy might be impaired as mothers experiencing anxiety might be less attentive or responsive to their children's needs (Walker et al. 2011). Maternal anxiety is also significantly linked to increased levels of parenting stress in the postnatal period (Misri et al. 2010) and is associated with feelings of parental unworthiness and anger toward the infant (Parfitt and Ayers 2014). These issues can lead to less-than-optimal parent–child bonding and less warm parenting behaviors and fewer positive mother–child interactions.

Low social support, lower education of women, having a single mother, and more than one child health problem were identified as significant risk predictors for problematic social-emotional development in 2-year old children. Associations for social support and single motherhood are plausible as previous studies have hypothesized that social support might counteract conditions of low resources, for example financial or child care related strains when being a single parent, and effects of maternal mental strain such as maternal disengagement and lack of stimulation by promoting positive and reducing negative parenting behaviors (Baydar et al. 2014). Also, health problems during infancy might restrict a child's ability to develop age-specific competencies in the first years of life. Furthermore, an increasing number of years of education was found to result in lower risk of problematic social-emotional behavior and higher mental developmental scores in 2-year-olds as shown in other studies (Brouwers et al. 2001; O'Connor et al. 2002). Still, the influence of a range of other biological and environmental factors remains unknown. For instance, information about the father could explain some additional variance in child outcome as fathers have acquired a greater role in the rearing of children in recent years (Reuben et al. 2015). There has been some evidence linking paternal postnatal depression to adverse emotional and behavioral problems in their children (Ramchandani et al. 2008). Hence, the father's influence in terms of child development should not be underestimated.

Strengths and Limitations

The present study is one of the few large scale studies to examine the effect of maternal perinatal mental health and its consequences for children. Due to its design, the importance of factors in the pre- and postnatal period could be investigated and the 2-year follow-up allowed for the assessment of child development beyond the postnatal period up to early childhood. Control for socio-demographic and health variables allowed evaluating the unique prospective association of maternal PA with child developmental problems. However, study limitations have to be taken into consideration.

Although the SCL is a widely used, validated instrument to screen for general anxiety, it is not specifically designed to assess perinatal anxiety. Such a use might have caused misclassification; still, internal consistency was rather high. Since the SCL is a self-reporting tool it does not suffice the requirements for a clinically valid diagnosis. The same applies for the ASQ:SE as this screening tool was developed to obtain a general sense of child development and may not go without professional evaluation. Clinical interviews with trained professionals remain the gold standard. However, such approaches are hardly implementable when large population-based cohorts are investigated. An alternative scientific approach to classify the developmental competence of under-5-year-olds is the Axis V of the latest "DC:0-5™ Diagnostic Classification of Mental Health and Developmental Disorders of Infancy and Early Childhood", which may be used as a comparative measures in future studies (Zeanah et al. 2016). In addition, Cronbach's alpha was of some concern for the ASQ:SE as it was found to be low. However, this finding might not be indicative of lack of reliability but might instead be due to ASQ:SE's multidimensionality. As the tool covers a wide range of characteristics that all measure important aspects of development in this field (Squires et al. 2005), internal consistency might have been lost due to maximization of construct comprehensiveness. The ASQ:SE is one of the few recommended universal screening tools for children's social-emotional development in infancy (American Academy of Pediatrics 2001) and a high proportion of children seem to be correctly identified by the ASQ:SE (Squires et al. 2005).

As data on exposure and outcome were based on mothers' reports only, common method bias possibly occurred and might explain parts of the relationship between maternal PA and child development. Anxiety-symptomatic mothers are more likely to be biased proxy-responders who incorrectly judge their child's problems due to their own psychological impairment (Najman et al. 2001). Other factors which might influence mothers' ratings are pre- and postnatal social determinants and socioeconomic status, which can affect the way mothers perceive their child's development (Najman et al. 2001).

Pregnancy and the postnatal period is a unique period of time when attachment and bonding systems are activated in the mother and in the newborn. Insecure attachment is related to issues of anxiety, and is as such an important potential covariate. Moreover, anxiety and depression are

highly comorbid (Glover 2014; Punamäki et al. 2006). Thus, some effects on child development which remain unexplained in this analysis might be due to maternal perinatal depression (Glover 2014), as a rich body of literature describes perinatal depression as an important factor for adverse child development (Kingston et al. 2012; Ross and McLean 2006). The present study is thus limited by not examining mother–child attachment and maternal perinatal depression as potential confounders.

It is conceivable that some analyses were restricted by lack of statistical power. As only few women could be identified with anxiety and prevalence of social-emotional problems in children was low, within-group samples might be too small to detect associations. This issue may be particularly the case for prenatal anxiety as no significant association was observed when adjusting for confounder.

Approaching mothers during a frequently used and free-of-charge routine pregnancy check-up examination allowed for unselective participant recruitment for a population-based cohort. However, comparisons with national data from the Medical Birth Registry of Norway revealed that women in the study were slightly older (31.6 vs. 30.2 years), more likely to be in a relationship (singles: 2.1% vs. 7.1%), and more often first time mothers (48.1% vs. 42.9%). These results suggest a slight social gradient associated with participation in the study. Selective attrition during the longitudinal course of the study, as demonstrated by attrition analyses, is a further threat to the representativeness of the sample and might indicate a bias. For example, it is likely that the study included women with healthier lifestyle behaviors, or women with a more positive attitude towards research, because such characteristics are associated with older age and higher education (Delgado-Rodriguez and Lloca 2004). Further, as pregnancy is a time of comprehensive physical and psychological change, some women may have felt vulnerable, insecure, or uncomfortable to participate. In particular, some women may have refused to participate due to clinical reasons such as high anxiety symptoms. Indeed, the percentage of women showing symptoms of anxiety among women who dropped out of the study at the different stages were higher than in women who completed the study. Generalizability of the results may also be limited since only Norwegian-speaking women were included. These limitations resulted in a relatively homogeneous, almost entirely Caucasian sample. However, selection bias does not necessarily influence results much when associations between variables are investigated (Nilsen et al. 2009). A subsequent loss-to-follow-up study could be valuable to understand the importance of data lost due to large drop out in order to re-evaluate the present findings and to clarify if anxiety scores of mothers who completed the study are similar to those who did not.

Conclusion

The findings highlight the importance of maternal anxiety across the perinatal period for children's social-emotional development. As the focus of routine pregnancy check-ups is mostly on somatic issues, psychological conditions are possibly overlooked in everyday obstetric practice. Since anxiety is a common condition in the perinatal period, awareness of maternal PA should be fostered both in women and in professionals who treat them. Thus, further research is needed in order to clarify patterns, physiology, and associations and to formulate clear definition criteria for maternal PA. Interventions should consider wider contexts with additional adversities, such as socially disadvantaged populations. Also, more research on mechanisms that may explain the associations between anxiety and child development are required. As child development is a complex multifactorial construct, other factors that trigger developmental problems should be considered.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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