Maternal prenatal stress and postnatal depressive symptoms: discrepancy between mother and teacher reports of toddler psychological problems

R Wesselhoeft[1,2], **K Davidsen**[1,3], **C Sibbersen**[4], **H Kyhl**[5], **A Talati**[6], **MS Andersen**[7], **N Bilenberg**[1]

[1]Research Unit of Child and Adolescent Mental Health, Mental Health Services in the Region of Southern Denmark, Institute for Clinical Research, University of Southern Denmark

[2]Clinical Pharmacology and Pharmacy, Department of Public Health, University of Southern Denmark

[3]Department of Psychology, University of Southern Denmark

[4]Research Unit of E-mental Health, Mental Health Services in the Region of Southern Denmark

[5]Hans Christian Andersen Children's Hospital, University of Southern Denmark and Odense Patient data Explorative Network (OPEN)

[6]Department of Psychiatry, Columbia University, Division of Epidemiology, New York State Psychiatric Institute

[7]Department of Endocrinology, Odense University Hospital

Abstract

Purpose—Maternal prenatal stress and postnatal depression are reported to increase the risk for early offspring psychological problems. We examined whether these two stressors predicted toddler emotional or behavioral problems based on mother and teacher reports, respectively.

Methods—A longitudinal study within the Odense Child Cohort (OCC). Prenatal stress was assessed (gestation week 28) using Cohen's Perceived Stress Scale (PSS). Depressive symptoms were assessed (3 months after birth) using the Edinburgh Postnatal Depression Scale (EPDS). Behavioral and emotional problems were assessed by mothers using the preschool version of Child Behaviour Checklist (CBCL) and by teachers using the caregiver-teacher report form (CTR-F).

Results—N=1,302 mother-child dyads were included. CBCL (N=1,302) was collected at 29 months (SD 5.3) and C-TRF (N=989) at 32.6 months (SD 6.9). N=70 mothers (5.4%) were at high

risk for postnatal depression (EPDS score>12). Generalized additive models showed that prenatal stress (increase of +1 on PSS-10 total score) predicted an increase on CBCL (+0.011) and C-TRF (+0.015) total scores. Postnatal depressive symptoms (increase of +1 on EPDS total score) only predicted an increase on CBCL total score (+0.026).

Conclusion—Prenatal maternal stress was a significant predictor of both mother and teacher reported toddler emotional and behavioral problems, although effect sizes were small. Postnatal depressive symptoms were associated with increased maternal (but not teacher) reporting of toddler problems. Mothers reported more toddler psychological problems than teachers, and the mother-teacher discrepancy was positively correlated to maternal postnatal depressive symptoms.

Introduction

Prenatal maternal stress and anxiety is associated with offspring emotional, behavioral and cognitive problems in childhood and beyond [1–5]. Maternal stress hormone (cortisol) passes the placenta and affects fetal development in various ways [6,7]. Excessive cortisol levels in fetal life may induce lasting imbalance of the Hypothalamic-Pituitary-Adrenal (HPA) axis, which plays a crucial role in the biological stress response [8]. Patients with anxiety and depressive disorders exhibit altered cortisol stress responses to psychosocial stressors [9,10] and prolonged activation of the HPA axis in early life may increase the risk for development of psychiatric disorders [11,12]. Prenatal maternal depression has also been linked to offspring internalizing and externalizing problems in early childhood, but recent studies suggest that this association is mainly due to shared genetic factors [13,14]. In addition, maternal distress after child birth has consequences for the developing offspring. Postnatal depression is a common and severe complication to giving birth [15]. Depressed mothers tend to display irritability, hostility and disengagement when interacting with their offspring [16,17] and this affects mother-infant interaction and is likely to impair the socioemotional development of the child [18,19].

Hence, several studies have found that maternal prenatal and postnatal anxious-depressive symptoms are frequent and associated with early offspring emotional and behavioral problems [20–26]. However, these studies are limited by the use of maternal reports of offspring psychological problems only, which gives a risk for reporting bias influenced by the maternal mental state [27,28]. Studies are needed that examine the association between prenatal and postnatal maternal distress and multi-informant reported offspring problems. The use of multiple informant reports is known to outweigh single informant data in accurate description of child psychopathology [29] and some even argue that reports from various informants should be weighted differently [30].

We provide longitudinal birth cohort data with the overall aim to examine the association between maternal perinatal distress and subsequent toddler psychological problems reported by two informants. The specific objectives were:

1. To determine the extent of maternal perinatal distress (prenatal stress and postnatal depressive symptoms) and toddler behavioral and emotional problems in a Danish birth cohort

2. To examine the association between 1) maternal prenatal stress and 2) postnatal depressive symptoms and toddler behavioral and emotional problems as reported by mothers and teachers

3. To determine the level of agreement between mothers and teachers regarding toddler emotional and behavioral problems

Methods

Study design

This is a prospective cohort study including data collected during pregnancy and in toddlerhood.

Study population

Odense Child Cohort (OCC) is a prospective birth cohort based in the Municipality of Odense in the Region of Southern Denmark [31]. The citizens of the Region of Southern Denmark have a social distribution similar to the full Danish population. The OCC inclusion period was 2010–2012, and a total of 2,874 pregnant women were recruited at midwife visits or at their general practitioner (see Kyhl et al. 2015 for details). Study participants filled in questionnaires from pregnancy onwards providing information about their own physical and mental health, and that of their child. The OCC offspring were examined several times from birth and will be so continuously up until the age of 18 years.

Inclusion criteria for this study were fulfillment of one of the maternal self-report questionnaires regarding prenatal stress (see below) as well as maternal report of offspring behavioural and emotional problems in toddlerhood (see Table 2 for further details). A power calculation was conducted prior to the study based on the numbers of the data already collected (EPDS and CBCL or C-TRF collected). This post hoc analysis showed that with a number of 9 predictors and a power of 90% and a 0.05 significance level, we would be able to detect effects with small effect sizes (Cohens's $f^2 = 0.012$ or more).

Measures

Exposure variables—Information on maternal stress was collected in pregnancy week 28 using the 14-item Cohen's Perceived Stress Scale (PSS-14) [32]. The PSS-14 is scored using a 5-point Likert scale (some items scored reversely) ranging from 0 ('never') to 4 ('always') (total score range 0–56). Occasionally, studies restrict reports to ten items (PSS-10) (total score range 0–40) [33] and we therefore used both measures. Information regarding the mother's experience of stressful life events was also collected in pregnancy week 28 using a 12-item modified version of the Social Readjustment Rating Scale (SRRS) [34]. The SRRS is scored on a 4-point Likert scale ranging from 0 ('no') to 3 ('yes, and I was very affected by it') (total score range 0–36).

Maternal depressive symptoms at child age 3 months were measured using the 10-item self-report Edinburgh Postnatal Depression Scale (EPDS) [35]. The items are rated on a 4-point Likert scale ranging from 0 ('No, not at all'/'No, never') to 3 ('Yes, all the time'/'Yes, most of the time') providing a total score range of 0–30. An EPDS cut-off score above 12 is often

used to identify women at risk for postnatal depression [35,36]. The internal reliability of the EPDS was 0.84 in the OCC sample [37].

Outcome variables—Offspring psychological problems were measured using the Danish version of the Achenbach System of Empirically Based Assessment (ASEBA) preschool forms (www.aseba.com) [38,39]. The ASEBA preschool forms include a parent report form Child Behaviour Checklist 1.5–5 (CBCL/1½–5, from now on referred to as CBCL) and a caregiver-teacher report form collected from daycare or kindergarten teachers (from now on referred to as teacher report or C-TRF). Each report consists of 99 items rated on a 3-point Likert scale (total score range 0–198) and one open-ended question. The CBCL and C-TRF questionnaires have 82 items in common, and 17 items vary. Both questionnaires comprise an internalizing symptom subscale covering emotional problems (emotional reactivity, anxiety/depression and somatic complaints), and an externalizing symptom subscale covering behavioral problems (attention problems and aggressive behavior). A total problem score is created by adding the internalizing and externalizing subscale scores and the sum scores of items covering 'other problems' (fi. speech problems, strange behavior, gets teased etc.).

Information on maternal and paternal psychopathology prior to child birth was obtained from the Danish Psychiatric Central Research Register (PCR) [40]. The PCR contains information on all psychiatric disorder diagnoses assigned at inpatient or outpatient mental health services from 1995 onwards.

Data analyses

Descriptive statistics are reported using means and standard deviations (SD). According to the previous literature, categories of a depression high-risk group and a low-risk group were created based on an EPDS cut-off score of 12. Subgroup scores were compared using t-tests, Wilcoxon rank sum tests and chi-squared tests.

Furthermore, exposure variables (PSS-14, PSS-10, SRRS and EPDS total scores) and outcome variables (CBCL and C-TRF total scores, internalizing subscale scores, and externalizing subscale scores) were treated as continuous variables. Linear regression models for the C-TRF and CBCL total scores were fitted and examined and Q-Q plots showed that the residuals were not normally distributed, meaning that the assumptions for linear regressions were not met. Therefore we fit generalized additive models (GAMs) that account for outcomes sampled from non-normal distributions. The outcome scores were fitted to a range of different count data distributions and model fits were compared using Akaike Information Criterion (AIC). Generalized additive models were then fitted for the predictor variables [maternal self-reported stress (PSS) during pregnancy, stressful life events (SRRS) during pregnancy, maternal postnatal depressive symptoms (EPDS)], using the best fitting count distribution. The following covariates were included in the analyses: Ethnicity (Western/non-Western), maternal age (years), parity (0/ 1), pre-gestational BMI (kg/m^2), maternal education (lower, intermediate, higher), maternal smoking during pregnancy (yes/no), offspring sex (male/female), pre-birth maternal psychopathology (yes/

no), pre-birth paternal psychopathology (yes/no), maternal psychotropic treatment during pregnancy (yes/no) and child age at CBCL and C-TRF assessment (months).

Data analysis was conducted using R 3.5.0 with package gamlss 5.0–8 (for general additive models and fitting of distributions).

Results

A total of N=1,302 study participants (mother-child dyads) fulfilled inclusion criteria (CBCL and PSS *or* SRRS reports available), equivalent to 46% of those originally recruited to OCC. Participants did not differ from non-participants on parity, offspring gender, birth weight, gestation week, BMI, civil status, parental psychopathology, psychotropic use, EPDS, CBCL or C-TRF total scores (Supplement Table 1). Non-participating mothers were however more likely to be younger, smokers, of non-Western origin and with lower education level, and they also tended to report more prenatal stress (measured by PSS and SRRS) and postnatal depressive symptoms (measured by EPDS). Descriptive data of study participants are presented in Table 1. Initially, categories of depression high-risk and low-risk groups were created and N=70 women (5.4%) had an EPDS total score >12 (mean 15.43 SD 2.61). The two groups did not differ on a range of baseline characteristics, except that maternal psychiatric disorder was more likely in the high-risk group (chi-squared = 32.92, df = 1, p<0.001) as was psychotropic use during pregnancy (chi-squared = 14.03, df = 1, p<0.001) (Table 1).

Perinatal maternal distress

The prenatal stress questionnaires PSS (perceived stress) and SRRS (experienced stressors) were completed by 1,253 and 1,286 mothers, respectively. The EPDS (postnatal depressive symptoms) was completed by N=1,212 mothers. The mean scores of these measurements in the total study sample and the depression high- and low risk subgroups are presented in Table 2. Compared to the depression low-risk group, women at high risk for postnatal depression had experienced significantly more stress (Wilcoxon W = 16144, p<0.001) and stressful life events (Wilcoxon W = 22822, p<0.001) during pregnancy (Table 2).

Toddler emotional and behavior problems

The CBCL was filled out by N=1,302 mothers at mean child age 29 months (SD 5.3) and C-TRF was filled out by N=989 teachers (mean age 32.6 months, SD 6.9). The mean duration between completion of CBCL and C-TRF was 4.1 months (SD 5.7), with C-TRF usually completed later. As expected, the CBCL and C-TRF scores were not normally distributed. The mean CBCL and C-TRF total scores in the OCC total sample were 19.1 (SD 13.4) and 12.1 (SD 14.2), respectively. Mothers and teachers reported significantly more psychological problems on behalf of boys than girls: CBCL total score means 19.8 vs. 18.3 (Wilcoxon W = 197050, p=0.047) and C-TRF total score means 13.3 vs. 10.8 (W = 111030, p=0.028).

Mothers who had been at risk for postnatal depression generally reported more offspring emotional and behavioral problems (CBCL total, internalizing and externalizing scores) compared to low-risk mothers (p=0.009) (Table 2). Although it did not reach statistical significance, teacher reports of toddler emotional and behavioral problems were higher for

children, whose mothers were at risk for depression after birth (C-TRF mean total score 16.5) compared to those with no risk for depression (C-TRF mean total score 11.8).

The association between perinatal maternal distress and offspring psychological problems

Table 3 shows the associations between various predictor variables (including perinatal stressors) (specified in Supplement Table 1) and offspring psychological problems reported by mothers (CBCL) and teachers (C-TRF). Maternal stress during pregnancy (measured by PSS-10) was statistically significantly associated with toddler psychological problems reported by mothers, meaning that for every increase in PSS-10 total score of +1, CBCL total and externalizing scores increased with 0.011 and CBCL internalizing score increased with 0.016 (Table 3). The same pattern was seen for teacher reports, where C-TRF total score increased with 0.015 and C-TRF externalizing score increased with 0.021 for every PSS-10 score increase of +1. Maternal experience of stressful life events during pregnancy (measured by SRRS) was statistically significantly associated with mother-reported offspring psychological problems (CBCL total and externalizing scores), but not with teacher-reported problems. Similarly, an increased EPDS total score at child age three months was statistically significantly associated with mother reported emotional and behavioral problems (CBCL total, internalizing and externalizing scores) but not with teacher reported psychological problems (C-TRF scores).

Increasing maternal age was associated with toddler behavioral and emotional problems according to the mother, in the sense that for every increase of maternal age by one year, CBCL total, externalizing and internalizing scores decreased by 0.022, 0.023 and 0.027, respectively. Increasing child age at assessment was also associated with both increased CBCL and C-TRF scores at a statistically significant level. Finally, the predominance of psychological problems in boys compared to girls was driven by behavioral problems according to both mothers and teachers ($p<0.001$).

Mother/teacher reporting discrepancy

Given that postnatal depressive symptoms were only correlated to mother-reported offspring psychological problems, we posthoc examined if the mother/teacher reporting discrepancy was related to postnatal EPDS score. We found that the higher the EPDS score, the higher the discrepancy between CBCL and C-TRF total scores (Spearman's rho = 0.13, $p < 0.001$). The correlation persisted after adjusting for child age at assessments (beta = 0.33, SE = 0.14, $p = 0.02$). We also found crude associations between prenatal PSS/SRRS scores and the mother/teacher reporting discrepancy, but these were eliminated, when adjusting for child age at assessment.

Discussion

We carried out a longitudinal birth cohort study with the overall aim to examine the association between perinatal maternal distress and mother and teacher reported toddler psychological problems. Our main findings were that prenatal maternal stress predicted toddler psychological problems as reported by both mothers and teachers, whereas postnatal depressive symptoms only predicted offspring problems as reported by mothers. The

mother-teacher reporting discrepancy was accentuated if the mother had experienced postnatal depressive symptoms.

Maternal prenatal stress was measured using the full Cohen's Perceived Stress Scale (PSS-14). We did not identify studies that used PSS-14 to assess perceived stress during pregnancy, but the mean of PSS-14 in our sample of pregnant women was similar to that of female student samples in the US (mean 23.6–25.6, SD 7.6–6.2) [32]. For comparison reasons, we also used the PSS-10, and the mean value for PSS-10 in our sample was similar to that of Polish pregnant women (mean 17.5, SD 5.6) [22] and higher than German community sample women aged 20–39 years (mean 13.3, SD 6.8) [41]. We did not identify studies that used the exact same items from the Social Readjustment Rating Scale (SRRS) to assess prenatal exposure to stressful life events and comparisons were therefore not possible.

One out of 20 OCC mothers (5.4%) were at risk for postnatal depression (defined as EPDS total score >12), which is consistent with a previous Danish study of postpartum women (5.5%) [42]. Still, the frequency was lower than that of a small Swedish study (N=258), which found 13% of women to be at risk for postnatal depression [43] and somewhat lower than reports from a Canadian study [44]. A study from Greenland (an autonomous constitutent country within the Kingdom of Denmark) found that 8.6% of post partum women had an EPDS total score >12 [45]. Greenland is characterized by a mainly Inuit population and a high level of social and psychological problems. We therefore expect our finding of an even lower frequency in Danish women to be a valid result. Women at high risk for postnatal depression in our study had experienced significantly more stress and stressful life events during pregnancy than low-risk women. This is also in line with a previous Danish study showing that women at risk for postnatal depression experienced less social support and more distress during pregnancy [42].

The magnitude of toddler emotional and behavioral problems measured by the ASEBA questionnaires in our sample was in line with a previous Danish population-based study [39], although the mean CBCL and C-TRF externalizing scores were slightly higher in our study (7.7 vs. 6.7 and 5.7 vs. 4.8, respectively). A study of N=19,850 preschoolers from 24 countries found the means of all three CBCL scores to be significantly lower for Danish preschoolers in comparison to other nationalities, which is in line with our results [46].

The literature indicates that maternal prenatal stress increases the risk for offspring psychopathology [4] and that psychological problems may be present at a very early age [1,47]. Our study of Danish toddlers supports these findings even though effect sizes were small. Mothers and teachers reported significantly more psychological problems on toddlers, who had been exposed to maternal stress (measured by Cohen's Perceived Stress Scale) in utero, also when a range of predictor variables were accounted for. However, our study does not explain, whether this association was caused by in utero environmental exposure to prenatal maternal stress and/or shared genetic or environmental factors. A recent large-scale study assessing prenatal maternal anxiety using a four-item questionnaire suggests that the latter is the main component [48]. In our study, prenatal maternal exposure to stressful life events was related to increased toddler psychological problems as reported by the mother, but not the teacher. This could indicate that maternal exposure to stressful life events per se,

does not affect the offspring, but rather the maternal perception of these events. This is supported by the original literature, where PSS is found to be superior in predicting health outcomes for the respondent as compared to stressful life event scores [32]. However, it is also possible that maternal stressful life events during pregnancy lead to subtle effects on the toddler detectable only to mothers. Rater bias is discussed in more detail below.

The literature shows that maternal postnatal depression is associated with an increased risk of mother-reported offspring psychopathology [26,49,50,23]. Our study added to the existing knowledge by providing teacher reports of toddler psychological emotional and behavioral problems in addition to mother reports. We found that maternal postnatal depressive symptoms at a continuous level were associated with toddler emotional and behavioral problems as reported by the mother, but not the teacher. We also examined, at a categorical level, how severe maternal postnatal depressive symptoms (EPDS total score >12, corresponding to risk for depression) affected the offspring. This analysis confirmed an association between severe postnatal depressive symptoms and toddler emotional and behavioral problems according to mother reports, whereas it did not reach statistical significance for teacher reports. Reporting discrepancy of child psychological problems, with parents generally reporting more psychological problems than teachers, has been described in many countries using the ASEBA measures [51]. In 1999, a study including CBCL and C-TRF data from seven countries found that the internal construct validity of the scales was very low [52]. In a Dutch study, low-moderate reporter agreement was found, with the lowest agreement concerning children aged 4–5 years [53]. A study of primarily African-American preschoolers found pronounced discrepancy in 51 out of the 82 shared CBCL and C-TRF items, with parents generally scoring higher than teachers [54]. The same pattern was found for Belgian preschoolers, where the mother-teacher dyad showed the lowest agreement (Grietens 2004). In a US study of preschoolers, there was simply no correlation between mother and teacher reports of externalizing symptoms [55]. Similarly, teachers rated 4-year-olds considerably lower than their parents, particularly on internalizing problems in Norway, a country comparable to Denmark in terms of economy, health care and social support [56]. The tendency for parents to report more psychological problems than teachers is also demonstrated in studies using other assessment methods [57,58] and across countries [59], indicating that this finding is not restricted to a specific measure or culture.

In line with these studies, we found that teachers generally reported lower levels of toddler psychological problems compared to mothers. This could partly be explained by the mother spending more time with the toddler. A study showed that time spent with the child is a major factor for recognizing especially emotional problems, and it is suggested to be the reason why mothers report more offspring emotional problems than fathers do [60]. The study also found mother-father reporting discrepancy to be even higher, when the mother had experienced postnatal depressive symptoms. This is supported by our study. We found the reporting discrepancy between mother and teacher to be positively correlated with maternal postnatal EPDS score. However, our study does not delineate the potential mechanisms behind this important finding. The *depression-distortion hypothesis* suggests that maternal depressive symptoms might bias reporting of psychiatric symptoms in the offspring [61,62]. Some studies have found that depressed mothers generally overreport

offspring psychopathology [63], and other studies find the bias to be gender-specific with an increased report of daughters' internalizing [64–66] and of sons' externalizing symptoms [65,66]. However, another study suggested maternal depression to be associated with maternal overreporting of behavioral problems but also truly raised levels of offspring behavioral problems [67]. Hence, it is argued that the reporting discrepancy might be due to depressed individuals being more accurate in their perceptions and judgements (*the depressive realism hypothesis*) [68]. Finally, it is also possible that children act differently when together with a depressed parent or that psychological problems of children are more likely to manifest at home [61,69]. This is supported by a study finding that in a laboratory setting, child behavior is context-specific, meaning that it depends on the individual with whom the child is interacting (parent or a teacher) (*attribution bias context model*) [70]. We recommend that future studies address the important question of the validity of parent vs. teacher reports.

Limitations

This study has several strengths including the prospective longitudinal design of a data-rich birth cohort, the thorough assessment of emotional and behavioral problems using two independent respondents, and available information about parental psychopathology before child birth. Still, there are limitations. Recent studies indicate that maternal anxiety or depressive symptoms in toddlerhood (and not prenatally) could be the main contributors to offspring behavioral and emotional problems at this age [48,13]. We did not collect information on maternal anxiety or depressive symptoms concurrently with data collection on toddler problems and are therefore not able to take this into consideration.

The many questionnaires provided for OCC study participants were filled out online in order to ensure high compliance and response rate (study participants in Denmark receive no reimbursements for their participation). Still, some questionnaires were left unfilled and about half of the OCC sample was not included in this study, because inclusion required filled CBCL and PSS/SRRS questionnaires for a given study participant. Therefore, our sample might not be representative of all OCC participants. In addition, cohort study participants usually differ from non-participants by representing a higher health status and socio-economic status [71,72] and loss to follow up has been observed in OCC [31]. This poses a risk for selection bias and our sample is expected to represent a subgroup of the total Danish population characterized by better health and higher socio-economic status. Still, we have no reason to believe that our main findings of an association between prenatal stress and offspring psychological problems would only exist in this privileged sample. In fact, we would expect that our findings would tend to underestimate any given association in the background population, where prenatal stress is likely to be more pronounced.

Conclusion

Our study demonstrates that offspring exposed to maternal stress in utero develop psychological problems recognizable to mothers and teachers already in toddlerhood. In spite of the harmful effects of prenatal maternal stress on the offspring, the maternal conditions are often left untreated [73]. Our findings encourage that health care systems

prioritize the assessment and treatment of maternal perinatal stress and depression as previously suggested [74,75].

Our study also showed an association between postnatal maternal depressive symptoms and mother-reported offspring emotional and behavioral problems. This observation was however not supported by teacher reports, although there was a trend for teachers to report more psychological problems on behalf of toddlers, whose mothers had been at risk for depression after birth. There was a general discrepancy between mothers and teachers regarding the severity of toddler psychological problems, and maternal depressive symptoms three months postpartum accentuated this discrepancy.

We need to know more about the the mother/teacher reporting discrepancy regarding toddler psychological problems and how informants may be affected by their personal condition. Our study supports the recommendations by Vidair et al. that screening of parents during child assessments should be common practice in child and adolescent psychiatry [76]. This would optimize information about family stressors, and more importantly, it would increase the knowledge of the potential bias the provided parental information might hold.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Table 1.

Descriptive statistics for the Odense Child Cohort study participants.

	Total sample (N=1,302)	Depression high-risk (EPDS >12) (N=70)	Depression low-risk (EPDS ≤ 12) (N=1,142)	EPDS data missing (N=90)	Comparison low-risk vs. high-risk (p-value)
Maternal age (years) mean (SD)	30.4 (4.4)	30.9 (4.7)	30.4 (4.4)	30.1 (4.6)	0.402 (t)
Ethnicity (%)					
Western	97	95.7	97.5	92.2	
Non-Western	3	4.3	2.5	7.8	0.617 (c)
Parity (%)					
0	55	51.4	55.5	51.7	
> 1	45	48.6	44.5	48.3	0.491 (c)
Offspring sex (%)					
Male	47	41.4	47.3	47.2	
Female	53	58.6	52.7	52.8	0.403 (c)
Birth weight (g) mean (SD)	3517 (524.1)	3549 (661.3)	3517 (517.2)	3482 (494.2)	0.695 (t)
Gestation weeks (%)					
Preterm (<37)	4	8.6	3.7	4.5	
Term (37–41)	93.2	88.6	93.5	92.1	
Postterm (42)	2.9	2.9	2.8	3.4	0.125 (c)
Pre-gestational BMI (kg/m2) mean (SD)	24.4 (4.48)	25.1 (6.72)	24.4 (4.39)	23.6 (3.27)	0.397 (w)
Maternal education level (%)					
Lower (high school or less)	52.1	51.5	51.9	55.2	
Intermediate (high school + 1–3 years)	20.9	14.7	21.7	16.1	
Higher (high school + 4 years)	27.0	33.8	26.4	28.7	0.248 (c)
Civil status (%)					
Married	39.7	47.4	39.0	43.8	
Living together	56.5	47.4	57.3	53.1	
Registered partnership	1.4	0	1.4	3.1	
Separated	0.1	0	0.1	0	
Single	1.9	5.3	1.8	0	0.289 (c)
Smoking during pregnancy (%)					
Yes	3.5	1.4	3.6	4.5	
No	96.5	98.6	96.4	95.5	0.532 (c)
Maternal psychopathology (PCR) (%)					
Yes	10.6	31.4	9.1	13.3	
No	89.4	68.6	90.9	86.7	**<0.001 (c)**
Paternal psychopathology (PCR) (%)					
Yes	5.6	8.6	5.5	4.4	
No	94.4	91.4	94.5	95.6	0.421 (c)

	Total sample (N=1,302)	Depression high-risk (EPDS >12) (N=70)	Depression low-risk (EPDS 12) (N=1,142)	EPDS data missing (N=90)	Comparison low-risk vs. high-risk (p-value)
Psychotropic use during pregnancy (%)					
Yes	3.3	11.4	2.6	5.6	
No	96.7	88.6	97.4	94.4	**<0.001** (c)

Comparisons between high-risk and low-risk groups are conducted using t-tests (t), Wilcoxon rank sum tests (w), or chi squared tests (c). Statistically significant levels (p<0.05) are marked in bold.

Table 2.

Questionnaire mean values and standard deviations (SD) for maternal perinatal distress (exposure variables) and toddler psychological problems (outcome variables).

	Total sample	Postnatal depression high-risk group (EPDS>12) (N=70)	Postnatal depression low-risk group (EPDS 12) (N=1,142)	EPDS data missing (N=90)	Comparison low-risk vs. high-risk (p-value)
Maternal perinatal distress	**Mean score (SD)**	**Mean score (SD)**	**Mean score (SD)**	**Mean score (SD)**	
PSS-14 total score (N=1,244)	27.1 (7.8)	34.9 (8.0)	26.5 (7.5)	28.8 (7.7)	**<0.001 (w)**
PSS-10 total score (N=1,253)	17.4 (5.5)	22.7 (5.9)	17.0 (5.4)	18.3 (5.4)	**<0.001 (w)**
SRRS total score (N=1,286)	13.8 (2.4)	15.9 (3.5)	13.6 (2.3)	13.8 (2.2)	**<0.001 (w)**
EPDS total score (N=1,212)	5.1 (4.0)	15.4 (2.6)	4.5 (3.2)	NA	**<0.001 (w)**
Toddler behavioral and emotional problems	**Mean score (SD)**	**Mean score (SD)**	**Mean score (SD)**	**Mean score (SD)**	
Age (months) at CBCL assessment	29.2 (5.3)	29.6 (5.5)	29.1 (5.3)	30.3 (5.7)	0.436 (t)
Age (months) at C-TRF assessment	32.7 (6.8)	32.7 (6.0)	32.6 (6.9)	33.8 (6.4)	0.912 (t)
CBCL total score (N=1,302)	19.1 (13.4)	25.5 (19.3)	18.7 (12.8)	20.1 (13.6)	**0.009 (w)**
CBCL int. score (N=1,302)	3.7 (4.0)	5.7 (5.8)	3.6 (3.9)	4.0 (4.0)	**0.003 (w)**
CBCL ext. score (N=1,302)	7.7 (5. 6)	9.9 (7.5)	7.6 (5.4)	7.9 (5.5)	**0.016 (w)**
C-TRF total score (N=989)	12.1 (14.2)	16.5 (20.5)	11.8 (13.8)	12.4 (12.0)	0.098 (w)
C-TRF int. score (N=989)	3.0 (4.2)	3.8 (5.0)	3.0 (4.2)	3.0 (3.6)	0.266 (w)
C-TRF ext. score (N=989)	5.7 (7.9)	8.3 (11.4)	5.5 (7.6)	6.3 (7.5)	0.127 (w)

Comparisons are conducted using t-tests (t) and Wilcoxon rank sum tests (w). Statistically significant levels (p<0.05) are marked in bold.

Abbreviations: PSS-14: Cohen's Perceived Stress Scale (14 items), PSS-10: Cohen's Perceived Stress Scale (10 items), SRRS: Social Readjustment Rating Scale, CBCL: Child Behaviour Checklist 1.5–5, C-TRF: Caregiver-teacher report form.

Note: All 1,302 study participants completed CBCL. However, the remaining questionnaires were only completed by subgroups of the total study sample (numbers listed in brackets).

Table 3.

Generalized additive models of the association between various predictor variables and mother and teacher reported offspring total problems, emotional problems (internalizing), and behavioral problems (externalizing). The model distribution is indicated in parenthesis. Statistically significant levels (p<0.05) are marked in bold.

Predictor variable	CBCL (mother report)												C-TRF (teacher report)					
	Total (Z)			Internalizing (N)			Externalizing (D)			Total (B)			Internalizing (B)			Externalizing (N)		
	Estimate	SE	p-value	Estimate	SE	p-value	Estimate	SE	p-value	Estimate	SE	p-value	Estimate	SE	p-value	Estimate	SE	p-value
Child age at assessment	0.012	0.004	**0.003**	0.026	0.006	**0.000**	0.006	0.004	0.115	−0.024	0.005	**0.000**	−0.023	0.006	**0.000**	−0.023	0.007	**0.001**
EPDS total score	0.026	0.006	**0.000**	0.040	0.008	**0.000**	0.022	0.005	**0.000**	0.005	0.009	0.583	0.017	0.011	0.136	0.011	0.013	0.405
Prenatal SLE (SRRS)	0.023	0.009	**0.016**	0.021	0.013	0.109	0.024	0.008	**0.003**	−0.014	0.013	0.283	−0.026	0.018	0.141	0.002	0.022	0.933
Maternal stress (PSS-10)	0.011	0.004	**0.010**	0.016	0.006	**0.010**	0.011	0.004	**0.006**	0.015	0.007	**0.032**	0.006	0.008	0.472	0.021	0.010	**0.038**
Maternal age	−0.022	0.005	**0.000**	−0.027	0.008	**0.001**	−0.023	0.006	**0.000**	−0.015	0.009	0.091	−0.007	0.010	0.498	−0.023	0.013	0.074
Smoking	−0.104	0.135	0.439	−0.171	0.171	0.317	−0.120	0.127	0.345	−0.105	0.220	0.632	−0.337	0.270	0.211	−0.199	0.286	0.487
Ethnicity (Western)	0.015	0.142	0.917	−0.025	0.204	0.900	0.102	0.130	0.433	0.101	0.211	0.632	0.233	0.293	0.428	−0.004	0.335	0.991
Child gender (male)	0.051	0.042	0.229	−0.028	0.059	0.631	0.123	0.041	**0.003**	0.090	0.064	0.157	0.106	0.078	0.176	0.281	0.095	**0.003**
Parity	−0.041	0.031	0.182	−0.140	0.046	**0.003**	0.019	0.032	0.546	0.040	0.048	0.407	−0.002	0.059	0.980	0.135	0.073	0.065
Maternal education (high)	−0.050	0.054	0.355	−0.089	0.078	0.253	−0.039	0.057	0.496	0.041	0.080	0.608	0.137	0.098	0.165	0.041	0.120	0.731
Maternal education (low)	0.072	0.053	0.176	0.122	0.072	0.089	0.051	0.049	0.295	−0.053	0.078	0.496	0.043	0.097	0.660	−0.003	0.121	0.983
Maternal psychopathology (PCR)	−0.055	0.077	0.479	−0.207	0.105	**0.049**	0.020	0.067	0.764	0.181	0.126	0.151	0.049	0.139	0.723	0.097	0.172	0.573
Paternal psychopathology (PCR)	0.016	0.085	0.849	0.155	0.124	0.213	−0.016	0.087	0.855	0.028	0.135	0.834	0.083	0.172	0.628	0.102	0.214	0.635
Psychotro pics during pregnancy	0.111	0.177	0.531	0.273	0.177	0.124	−0.074	0.148	0.616	−0.103	0.202	0.610	0.064	0.224	0.775	−0.533	0.299	0.075

Abbreviations:

SE: Standard error, Z: Zero-inflated negative binomial type I distribution, N: Negative binomial type I distribution, D: Double Poisson distribution, B: Beta negative binomial distribution, CBCL: Child Behaviour Checklist 1.5–5, C-TRF: Caregiver-teacher report form, EPDS: Edinburgh Postnatal Depression Scale, SLE: Stressful Life Events, SRRS: Social Readjustment Rating Scale, PSS-10: Cohen's Perceived Stress Scale (10 items), PCR: Psychiatric Central Research Register.