



Childhood Anxiety: Prenatal Maternal Stress and Parenting in the QF2011 Cohort

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Abstract

In this study we examine whether specific ‘anxiety-maintaining’ parenting behaviors (i.e., overinvolvement and/or negativity) exacerbate the effects of disaster-related prenatal maternal stress (PNMS) on school-age anxiety symptoms. Women (N = 230), pregnant at the time of the 2011 Queensland Floods, reported on their experience of flood-related PNMS (objective hardship, cognitive appraisal, subjective distress). At 4-years, mother–child dyads were coded for maternal overinvolvement and negativity during a challenging task; at 6-years mothers reported on their children’s anxiety symptoms and their own mood, N = 83. Results showed no associations between PNMS and 6-year anxiety, nor did parenting moderate these effects. Poorer maternal concurrent mood was associated with greater anxiety symptoms at 6 years ($\beta = 0.52$). Findings suggest maternal concurrent mood, but not exposure to disaster-related PNMS nor ‘anxiety-maintaining’ parenting behaviors at preschool age, is related to school-age anxiety symptoms.

Keywords Childhood anxiety · Natural disasters · Prenatal stress · Parenting behaviors

Maternal distress in pregnancy (PNMS; anxiety, depression, stress) has been associated with the development of childhood emotional problems including anxiety symptoms [1]. According to the fetal programming hypothesis [2], intrauterine exposure to maternal distress during gestation alters fetal biological systems, including stress-regulatory systems (hypothalamic pituitary adrenal axis, HPA) which

may then enhance susceptibility to anxiety. Consistent with this hypothesis, our group recently established a link between a mothers’ experience of hardship (e.g., financial burden, property damage, personal danger) due to a random and independently occurring natural disaster that occurred in pregnancy—the 2011 Queensland Floods—and heightened anxiety symptoms for boys and girls at age 4-years [3]. Importantly, by using a ‘natural experiment’ design, we disentangled the unique effects of different aspects of PNMS (hardship, subjective reactions, cognitive appraisal) on childhood anxiety [4]. That is, experiencing a natural disaster in pregnancy influences childhood anxiety, independent of mother–child heritability factors (e.g., genetics, personality) and other co-occurring risk factors (e.g., maternal age, education) [5].

Unique to disaster-related PNMS studies, we determined the specific timing of the onset of stress exposure during gestation due to the random nature and sudden onset of the event. Interestingly, the earlier in pregnancy the mother experienced the flood, the greater her child’s anxiety symptoms at age 4-years [3]. Processes underlying fetal programming may be sex-specific [6]. While we did not establish sex differences, in line with etiological work suggesting an increased prevalence of anxiety symptoms in girls [7, 8],

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associations between greater PNMS exposure and internalizing behaviors during late childhood through adolescence, seem to be stronger among girls [9].

There is much more to be understood about the development of childhood anxiety symptoms following PNMS exposure. In order to establish an evidence base to inform and promote targeted intervention, it is necessary to identify for whom and how PNMS leads to the development of anxiety symptoms. Here we build upon our prior findings to examine longitudinally whether parenting behaviors in the early childhood rearing environment, as observed by unbiased raters, predict the development of school-age anxiety following exposure to disaster-related PNMS.

Maternal Parenting Behaviors in the Context of PNMS-Programming

To date, little research has examined the contribution of the postnatal parenting environment in the development of PNMS-related childhood anxiety. When examining the effects of PNMS on child outcomes, researchers typically account for effects of the postnatal parenting environment by statistically controlling for aspects of maternal mood and parenting stress [3, 10, 11]. However, in line with the fetal programming hypothesis [2], PNMS may program biological systems such that they are more stress-reactive [10, 12] increasing the impact of future stressors, including parenting environments, on the child. In one study girls aged 2–5 years who were exposed to high maternal prenatal distress and poorer observed maternal interaction quality (sensitivity, intrusiveness, structuring and non-hostility) displayed increased paternal reported internalizing behaviors (i.e., depressive, somatic, and anxiety symptoms) compared to girls whose mothers experienced prenatal distress but parented with higher maternal interaction quality [13]. When prenatal maternal distress was low, child internalizing behaviors were also low, regardless of maternal postnatal sensitivity. This study suggests that PNMS effects on child anxiety symptomatology may only be expressed in the context of poorer quality parenting behavior.

‘Anxiety-Maintaining’ Parenting Behaviors

A large body of research has demonstrated that parenting as an environmental factor contributes to the development of childhood anxiety symptoms [14]. Researchers studying development and maintenance of childhood anxiety have typically examined the role of two broad parenting constructs: parental overinvolvement and negativity [15]. Herein we refer to these behaviors as ‘anxiety-maintaining’ parenting behaviors. Overinvolved parents may protect their

children from distressing or anxiety-provoking situations, depriving them of opportunities to face their fears and cope. This reinforces anxious, avoidant behaviors and increases the child’s risk of developing and maintaining clinical levels of anxiety. Rejecting or negative parenting behaviors may put children at increased risk for developing anxiety by limiting the development of children’s emotion regulation skills. In this novel study we explore whether anxiety maintaining parenting behaviors at age 4 years predict more severe anxiety symptoms in children at age 6 years who were exposed to disaster-related PNMS.

The Current Study

The current study is part of an ongoing prospective longitudinal study: the QF2011 Queensland Flood study [4]. In 2011, Queensland (Australia) experienced its worst flooding in 35 years. QF2011 examines the biopsychosocial mechanisms through which disaster-related PNMS impacts maternal wellbeing and child development. Here, we extend upon our previous work [3] with the following aims and hypotheses:

Aim 1

Examining the additive effects of aspects of disaster-related PNMS (objective, subjective PNMS) on childhood anxiety symptoms at 6 years; and whether these effects are dependent upon child sex and timing of flood-exposure.

Hypothesis 1 Greater maternal objective hardship due to the floods would predict greater childhood anxiety symptoms at 6 years.

Hypothesis 2 Children exposed to the floods earlier in gestation would display greater childhood anxiety symptoms at 6 years.

Hypothesis 3 Girls would display greater anxiety symptoms following PNMS exposure than boys.

Aim 2

Examining whether anxiety symptoms at 6-years following PNMS exposure are moderated by maternal anxiety maintaining parenting behaviors (overinvolvement and negativity) at age 4 years.

Hypothesis 4 The negative association of objective hardship on anxiety symptoms at 6 years will be stronger for children who also experience higher levels of maternal (a) involvement and (b) negativity at 4 years, with a weaker association at lower levels of maternal overinvolvement and negativity.

Method

Participants and Procedures

The QF2011 Queensland Flood study team recruited women who were pregnant at the time of the flood, were 18 years of age or older, had a singleton pregnancy, and were fluent in English. Recruitment began once ethical approval was received in April 2011 and continued until January 2012 (1-year post-flood). The QF2011 Study received ethical approval from the Mater Research Institute (1709M, 1844M) and The University of Queensland (2013001236).

A total of 230 women responded to a questionnaire detailing their demographics, and flood experience. At 4 years, mother–child dyads were invited to attend lab-based developmental assessments, with 109 dyads completing the mother–child interaction task (91 mothers also reported on their own mood at this age). At 6 years, 124 mothers returned surveys detailing their children’s anxiety, and of these 122 women also reported on their own mood. We excluded two children born < 37 weeks’ gestation. A total of 120 participants had complete data at recruitment and 6-year follow-up. A subsample of these also had complete 4-year observational parenting data ($n = 83$). Informed written consent was provided by all participants at each phase of the study.

Participants received a \$30 shopping voucher for their participation in the 4-year assessments and again at the 6-year questionnaires to thank them for their time. At the 4-year assessment, children were also gifted a small toy of their choice.

Measures

Prenatal Stress Variables

Objective Hardship The four dimensions of maternal exposure (threat, loss, scope, and change) to the 2011 Queensland Flood were assessed using the Queensland Flood Objective Stress Scale (QFOSS). This questionnaire was similar to those used in previous disaster-related PNMS studies [16, 17]; all items are presented along with the scoring in the supplemental material of [4]. Scores for each item were attributed according to severity of exposure. Items within each dimension were scored such that the maximum score for each dimension ranged from 0 (*no impact*) to a possible maximum of 50 (*extreme impact*). The sum of dimensions was used to create an overall score of objective hardship from the floods, ranging from 0 (no hardship) to 200 (extreme hardship).

Subjective Distress Subjective distress in response to the floods was assessed using three measures. The 10-item Peritraumatic Dissociative Experiences Questionnaire (PDI-Q) [17] and the Peritraumatic Distress Inventory (PDI-Q) [18] assessed maternal peritraumatic responses to the event. The questionnaires assessed a mother’s severity of emotional distress and physical reactions (PDI-Q) and dissociative-like experiences (PDEQ) [19] at the time of the flood as recalled later at study recruitment. Current post-traumatic stress (PTS) symptoms (intrusive thoughts, avoidance/numbing, and hyperarousal) at recruitment were assessed using the 22-item Impact of Event Scale-Revised (IES-R) [20]. Mothers responded to the questionnaires using a 5-point Likert scale from 0 (*not at all true*) to 4 (*extremely true*). All measures show good internal consistency and good test–retest reliability [4].

Using scores of all 230 participants who provided PNMS data, a Composite Score for Mothers’ Subjective Stress (COSMOSS) was computed to reflect subjective distress. This was done via Principal Component Analysis (PCA) on the three measures of subjective distress. The PCA-derived algorithm ($\text{COSMOSS}_q = 0.359 \cdot \text{IESR} + 0.396 \cdot \text{PDI} + 0.389 \cdot \text{PDEQ}$) resulted in one factor explaining 76.27% of the overall subjective stress variance. Scores are centered around zero ($M = 0$, $SD = 1$): positive scores represent levels of maternal subjective stress above the mean, while negative scores indicate maternal subjective stress levels below the mean.

Cognitive Appraisal Mothers were asked to rate their appraisal of the flood experience. The single item asked mothers: “If you think about all of the consequences of the 2011 Queensland flood on you and your household, would you say the flood has been...?” Possible responses were on a 5-point Likert scale: very negative (– 2) to neutral (0) to very positive (+2). Scores were dichotomized to Negative (0) and Neutral/Positive (1), due to the few very negative evaluations.

Anxiety Symptoms at Age 6

The Spence Preschool Anxiety Scale (SPAS) [21] provides an overall maternal-report measure of specific anxiety symptoms, as well as six childhood anxiety disorder subscale scores, in accordance with DSM-IV criteria [22]. Mothers reported the frequency at which an item is true for their child on a Likert scale from 1 (*not at all*) to 5 (*very often true*) across 28 items. The overall total score of anxiety symptoms was calculated and used for the analyses. Children are classified as within Normal (total score ≤ 33) and Elevated (total score ≥ 34) symptom ranges using established clinical cut-off scores. The SPAS total anxiety score shows good construct validity with the CBCL-Internalizing scale [21].

Postnatal Maternal Variables

Parent–Child Interaction Task Mother–child interactions were coded using a puzzle task adapted from a study conducted by [23]. The task was completed as one part of a two-hour developmental protocol at 4 years, conducted by the first author (see [4] for full protocol assessment details), who was blind to the mothers' flood stress levels and all other study variables. The puzzle task was administered approximately 30 min from the commencement of the assessment.

The mother and her child were seated side-by-side at the assessment table and their interaction was observed while the child completed a challenging jigsaw puzzle. This puzzle was deliberately chosen to be challenging, suitable for 5- to 6-year-old children rather than 4-year-olds. After being shown the jigsaw puzzle pieces and completed picture on the box, the child was asked to complete the task within a five-minute period. The experimenter read out the below instructions and left the room for the allocated time and, upon returning, asked the child to display their work. The task was videotaped for later coding.

Children's instructions "Now I'm going to get you to complete a puzzle! Here are all the puzzle pieces. This is to show me how good you are at putting jigsaws together. I'm going to leave the room for five minutes and when I come back, you can show me what you've done."

Mother's instructions "This is a test of (child's) ability to reason and solve problems. Most 4-year-olds have no trouble completing this puzzle in a five-minute period. I want to see how well (child) performs. You can help him/her if you think s/he needs it. You're here for support."

Observation coding scheme The 5-min puzzle task interactions between the mother and child were rated on a nine-scale puzzle coding system adapted from [23]. The nine scales load onto two factors: negativity and involvement. For a detailed explanation of the principal factor extraction see [23]. The negativity factor includes four scales that assess the degree of parental warmth/negativity during the interaction: (1) general mood of the interaction; (2) mother's degree of positive affect; (3) mother's tension; and (4) mother's degree of verbal and nonverbal encouragement and criticism. An average of the four scales was calculated as an overall score of negativity for each participant, with higher scores indicating increased negativity.

The involvement factor has five scales: (1) general degree of involvement in the task; (2) degree of unsolicited help; (3) touching of the puzzle pieces; (4) mother's focus during the interaction; and (5) mother's posture. These scales represent the mother's involvement and help during the task, with higher average scores on the five scales representing increased intrusiveness. Both scales were coded from 0 to 8. Scores below 4.0 reflect less intrusive/more warm interactions, and scores above 4.0 code more negative/overinvolved

interactions. A rating of 4.0 was scored if the interaction was neutral.

Reliability All puzzle tasks were coded by a research assistant (RA) trained by the first author, who provided reliability coding for approximately 30% of the videos. The primary coder was blind to all variables for each mother–child dyad. The first author had conducted the assessments and the puzzle protocol; however, significant time had elapsed between testing and coding (3 to 10 months). The RA watched the entire video of each puzzle task before coding the interaction. Both factors had high inter-rater reliability scorings: Involvement, ICC (2,1)=0.95, $p < 0.001$; Negativity, ICC (2,1)=0.89, $p < 0.001$.

Covariates To control for maternal reporter bias of child behaviors [24], and the effects of current maternal mood on anxiety-related parenting behaviors [25], maternal mood scores at 4 and 6 years were included in statistical models. A composite score of maternal mood was calculated using the Depression, Anxiety, and Stress Scale short-form (DASS-21) [26]. Higher scores indicate poorer maternal mood.

Demographics At recruitment, maternal socio-economic status was estimated via the Australian Bureau of Statistics' Socio-Economic Indexes for Areas (SEIFA). SEIFA scores are based on census data regarding postcode. Scores have a mean of 1000 (SD = 100), with higher scores indicating greater socio-economic advantage of the neighborhood of residence. Mothers reported their date of birth, marital status, and household income. Child birth date, birth weight, sex, and gestational age were collected from medical records taken at birth.

Statistical Analyses

Statistical analyses were conducted using SPSS version 25. Prior to conducting the main analyses one outlier on the SPAS outcome was winsorized [27].

To explore Hypothesis 1, we tested a hierarchical regression model of child anxiety symptoms (SPAS) at age 6 years. PNMS variables were entered first: Objective hardship, followed by the composite score for subjective stress, and then cognitive appraisal. We next entered infant sex and timing of flood exposure during gestation. Next, maternal concurrent mood at 6-years entered the model. Final models were trimmed of non-significant covariates and re-run.

To explore Hypotheses 2–4, about child anxiety symptoms at age 6, a series of moderation models were run using the PROCESS Macro v3.2 [28]. For Hypotheses 2 and 3, we examined the interaction between each aspect of flood-related PNMS (objective hardship, cognitive appraisal and subjective

stress) and child sex and timing of flood exposure. Here we included 6-year concurrent maternal mood as a covariate.

For Hypothesis 4, we investigated interactions between each aspect of flood-related PNMS (objective hardship, cognitive appraisal and subjective stress) and parenting behaviors at age 4 years (involvement and negativity) in predicting 6-year anxiety symptoms. For parent behavior interactions, maternal mood at both 4- and 6-years were included in the models.

Results

Attrition Analyses

Participation varied at different time points. There were no differences between the overall samples at 4 years and 6 years on any flood-related variable. Participants who completed the 6-year child anxiety measure were exposed to the flood later in gestation (prior to exclusions; $N = 124$, $M = 125.30$ days; $SD = 73.88$) than those who did not complete the 6-year child anxiety report ($N = 106$, $M = 106.11$ days; $SD = 73.01$), $t(228) = 1.97$, $p = 0.05$.

Descriptive Statistics

As shown in Table 1 child anxiety scores were largely within the normal range (i.e., ≤ 33). A total of 10 children (8.1% of the sample) displayed elevated or clinical levels of anxiety at 6 years. Mothers similarly experienced largely normative levels of PTS symptoms, with only five of 120 mothers (3.3%) experiencing clinically diagnosable symptoms (IES-R scores ≥ 33).

Preliminary Analyses

Table 2 displays the correlations between PNMS, predictor, and outcome variables for the subsample of participants with recruitment and 4- and 6-year outcome data. Objective hardship, subjective stress, and cognitive appraisal measures were moderately correlated (r 's range 0.38–0.52). Maternal subjective distress due to the floods was positively marginally associated with maternal involvement ($r = 0.22$, $p = 0.055$), but not negativity. Maternal negativity and involvement were significantly, positively correlated ($r = 0.30$).

Study Analyses

Aim 1

Hypothesis 1 and 2 Results of hierarchical multiple regression analyses (Table 3) for the full sample of participants

Table 1 Descriptive statistics

Measure	Descriptive	
	N	M (SD) or n (%)
6-year SPAS ^a	120	14.78 (12.72)
Objective hardship	120	20.26 (16.93)
Post-traumatic stress ^b	120	6.11 (9.92)
Peritraumatic distress ^c	120	11.52 (10.00)
Peritraumatic dissociation ^d	120	5.94 (3.58)
Composite subjective stress ^e	120	– 0.02 (0.29)
Cognitive appraisal: neg	120	43 (35.8%)
Timing of exposure (days)	120	126.59 (117.98)
Parental Involvement	83	5.26 (1.34)
Parental negativity	83	2.98 (2.75)
Infant sex (boys)	120	63 (52.5%)
Socio-economic index ^f	120	1054.87 (54.28)
Schooling level (years)	92	14.57 (1.86)
Maternal age at recruitment (years)	120	31.06 (4.60)
4-year maternal mood ^g	90	19.58 (19.99)
6-year maternal mood ^g	120	16.90 (28.54)
Gestational age at birth (weeks)	120	39.41 (1.17)
Birthweight (g)	120	3547.38 (479.28)

Untransformed scores are used for the descriptive measures of maternal stress

^aSPAS Spence Preschool Anxiety Scale

^bIESR

^cPDI

^dPDEQ

^eCOSMOSS (IES-R, PDI, PDEQ)

^fSEIFA

^gDASS (depression, anxiety, stress) composite score

with 6-year SPAS data ($N = 123$) showed no effect of disaster-related PNMS (objective, subjective, or cognitive appraisal) or gestational timing of exposure on childhood anxiety symptoms. More severe concurrent maternal mood was significantly associated with greater child anxiety symptoms ($\beta = 0.515$, $p < 0.001$), accounting for 26% of variance in 6-year SPAS. The total model accounted for 27.2% of the variance in 6-year anxiety symptoms.

Hypothesis 3 The effects of PNMS (objective hardship, subjective stress, cognitive appraisal) on child anxiety at age 6 were not moderated by child sex (data available on request).

Aim 2

Hypothesis 4 The association between objective hardship and childhood anxiety symptoms at 6 years was not moderated by parental overinvolvement, $F(1, 77) = 0.001$,

Table 2 Pearsons correlations between study variables

Variables	1	2	3	4	5	6	7	8	9	10
1. 6-year SPAS ^a total score	–	–	–	–	–	–	–	–	–	–
2. Objective hardship	0.07	–	–	–	–	–	–	–	–	–
3. Composite subjective stress ^b	0.13	0.48**	–	–	–	–	–	–	–	–
4. Cognitive appraisal ^c	– 0.02	– 0.52**	– 0.35**	–	–	–	–	–	–	–
5. Child sex	– 0.04	– 0.07	– 0.14	0.05	–	–	–	–	–	–
6. Timing of exposure (days)	– 0.08	0.06	0.01	0.00	0.04	–	–	–	–	–
7. 4-year maternal mood ^d	0.19 [^]	0.00	0.11	0.09	0.02	0.04	–	–	–	–
8. 6-year maternal mood ^d	0.51**	0.15 [^]	0.22*	– 0.11	– 0.13	0.01	0.60**	–	–	–
9. Parental involvement	– 0.10	.04	0.22 [^]	– 0.13	– 0.07	– 0.02	0.10	0.10	–	–
10. Parental negativity	– 0.02	– 0.10	– 0.14	.03	– 0.09	– 0.08	.25*	0.11	0.30*	–

Transformed scores are used for the measures of maternal stress. N=120 other than correlations with parental negativity and involvement, where N=83

^aSPAS Spence Preschool Anxiety Scale

^bCOSMOSS (IES-R,PDI,PDEQ)

^cCoding for cognitive appraisal: 0=negative/very negative; 1=neutral/ positive/very positive

^dDASS (depression, anxiety, stress) composite score at 4 and 6 years

** $p < 0.001$, * $p < 0.05$, [^] $p = 0.051–0.99$

Table 3 Summary of hierarchical regression analyses, trimmed of all non-significant variables for 6-year anxiety symptoms

Predictor variables	β	B	Std. error	R	R^2	ΔR^2	F	ΔF
Step 1				0.067	0.004	0.004	0.532	0.532
Objective hardship	0.067	1.080	1.482					
Step 2				0.110	0.012	0.008	0.719	0.113
Objective hardship	0.073	1.170	1.485					
Gestational timing of exposure	– 0.088	– 0.015	0.016					
Step 3				0.521**	0.272	0.260**	14.414	14.301
Objective hardship	– 0.005	– 0.0861	0.296					
Gestational timing of exposure	– 0.089	– 0.015	0.014					
6-year maternal mood	0.515**	0.388**	0.060					

** $p < 0.001$, * $p < 0.05$, [^] $p = 0.051–0.99$

$p = 0.981$, $\Delta R^2 = 0.000$, nor by negativity, $F(1, 77) = 0.275$, $p = 0.601$, $\Delta R^2 = 0.003$. Results were similarly non-significant when considering subjective stress and cognitive appraisal as predictors, controlling for level of objective hardship (data not shown).

Discussion

Understanding how anxiety develops in childhood can aid in the development of targeted, timely, and efficacious intervention. In the current study, we examined whether PNMS and parenting behaviors exacerbate the development of anxiety symptoms in early childhood. Unexpectedly, the results provided no support for the effect of disaster-related aspects of PNMS on the development of anxiety at 6 years

nor were there associations with anxiety-maintaining parenting behaviors. Finally, worse concurrent maternal mood was associated with higher maternal ratings of child anxiety at 6 years, after controlling for disaster-related PNMS exposure.

PNMS, 'Anxiety Maintaining' Parenting Behaviors and Childhood Anxiety

None of the three aspects of disaster-related PNMS, nor gestational timing of flood exposure, predicted child anxiety symptoms at 6 years. Previously, our team established a direct effect of objective hardship on anxiety symptoms at 4 years in this same QF2011 cohort, and found that children who were exposed earlier in gestation showed greater

anxiety symptoms [3]. In line with our prior finding, sex did not moderate PNMS effects.

The attenuation of the PNMS effect on anxiety symptoms across development within the QF2011 cohort is in contrast to Project Ice Storm, which found that the effects of maternal objective and subjective disaster-related PNMS on child internalizing problems persisted from childhood through adolescence [29]. Still, discontinuity and change of maternal mood in pregnancy effects on internalizing behaviors across development have been reported [30]. Differences in results across studies could be due to different types and severities of stressor; for example, the magnitude of effects of PNMS from the Quebec ice storm may be larger than those from flooding—the severity of maternal PTSD symptoms, as measured by the IES-R in both studies, was significantly higher in Project Ice Storm than in QF2011. As well, the effects of prenatal exposure to maternal mood problems differ from those arising from exposure to independent events, such as disasters. Finally, findings may vary when considering specific anxiety symptoms to that of broader internalizing behaviors (anxiety/depressive).

Prenatal programming may contribute uniquely to anxiety symptom development in early childhood. As the child develops, postnatal factors may contribute to symptom severity in conjunction with, or above and beyond, prenatal factors. However, we did not find a direct effect of PNMS on childhood anxiety, or a moderating role of maternal involvement and/or negativity. Prior studies using the same puzzle task with mothers of children between 7 and 15 years [23, 31, 32] found that maternal involvement and negativity were significantly associated with children's internalizing behaviors and anxiety symptoms [15]. It is possible that the protocol used in the current study may be more appropriate for school-aged children, when an understanding of the task is greater. During preschool years, mothers and children are likely to complete puzzles together rather than a child completing such a task autonomously. Autonomy of task at school age be more likely to elicit maternal overinvolvement. Finally, the current study examined parenting behaviors and child anxiety longitudinally. Many studies use cross-sectional data to examine parent–child interactions in relation to childhood internalizing behaviors [15]. Maternal parenting behaviors and child vulnerability factors may interact to predict concurrent child anxiety but may not predict symptom severity across time.

However, the current findings are consistent with other studies with the QF2011 cohort that failed to find associations between PNMS and maternal parenting style. Here, we did not find associations between maternal objective hardship or subjective stress with maternal over-involvement or negativity. Similarly, maternal mind-mindedness at 16-months was not associated with aspects of prenatal maternal stress [33]. Finally, maternal subjective stress

accounted for only ~4% of variance in maternal sensitivity at 16 months [34]. Taken together, results from the QF2011 study suggest that flood-related PNMS is not associated with parenting behaviors during early childhood, suggesting that parenting behaviors are not likely to mediate any associations between PNMS and child anxiety or other child developmental outcomes. In line with other research [13, 34], it is possible that in the current study, the effects of PNMS on 4-year anxiety attenuated at 6-years due to the role of unmeasured positive parenting behaviors. More challenging parenting behaviors, whereby parents expose children to safe risk environments buffer anxiety symptom development by increasing child confidence and bravery in unfamiliar situations [35]. Further research within QF2011 could look to verify whether the use of positive parenting behaviors at 4-years, such as maternal sensitivity, aids explanation of the attenuation of objective hardship effects on anxiety symptom development from 4 to 6 years.

The Development of Anxiety Following PNMS Exposure: Maternal Mood

In the current study, poorer maternal concurrent mood was associated with increased anxiety symptoms at 6 years. We initially included maternal mood in the proposed models to account for the effects of maternal mood on parenting behaviors at 4 years [25, 36] and potential maternal reporter bias of child anxiety symptoms at 6 years [24]. While prenatal effects may be evident in early life, developmental programming continues beyond birth, guided by early environmental factors including maternal anxiety and depression [37, 38]. Maternal mood during pregnancy has been found to be relatively stable across the postnatal and toddler period [39]. Moreover, prior research has found that associations between aspects of maternal mood (anxiety, depression) during pregnancy and child social emotional outcomes are at least partially accounted for by postnatal and concurrent maternal mood [40, 41]. In the current study however, subjective distress in relation to the 2011 floods did not lead to enduring poor maternal mood across early childhood: maternal subjective distress was not associated with maternal mood at the 4 year assessments and only accounted for roughly 4% of variance in maternal mood at the 6 year assessments ($r=0.22$). This pathway is therefore unlikely to account for PNMS effects on anxiety at 6-years in the current prenatal disaster-exposed cohort.

Mechanisms of transmission of maternal mood to child anxiety symptoms are likely to be environmental and genetic in nature [42, 43]. Maternal mood may impact the development of anxiety via alterations to parenting behaviors [25, 36, 44]. However, in the current study, maternal mood at 4 years accounted for only 6% of the variance in maternal negative parenting behaviors but was not associated with

maternal behaviors of overinvolvement. This suggests that the effects of maternal mood on child anxiety development are largely independent of, or may act parallel to, the effects of anxiety-maintaining parenting behaviors [45, 46]. Intervention studies similarly find changes in parental control and negativity, independent of parent anxiety disorder diagnosis [47].

Our finding that children of mothers with poor mood are vulnerable to developing anxiety symptoms early in life highlights the importance of considering maternal mood as an etiological influence and in the context of intervention. Children of parents with anxiety tend to respond less favorably to child-focused therapy, with improved efficacy established when parental anxiety is also targeted during treatment [48]. Given that symptoms of anxiety in childhood often continue into adolescence and adulthood [49], our results support the necessity for early and targeted intervention.

Strengths and Limitations

By examining PNMS within a natural disaster quasi-experimental study design, we were able to provide a detailed assessment of various aspects of a mother's stress response during pregnancy; not only her subjective distress in response to a random onset, independent stressor, but the objective hardship she experienced and her cognitive appraisal of the event [4, 29]. However, the well-resourced and healthy sample limits the generalizability of these findings to clinical populations, which may also account for why we failed to attain significant results. While it is a clear strength of the current study that maternal parenting behaviors were examined via observational measures, the role of paternal parenting behaviors in development of anxiety symptoms were not examined [14]. Moreover, the observational measure of child anxiety for the puzzle task had not been developed [31] when this study was conducted, so only maternal behaviors were coded. Prior studies using this coding scheme [23, 32] have used both maternal report of symptoms (SPAS) and clinical diagnosis of anxiety to examine child anxiety, whereas we only utilized parent-report. However, the validity of the SPAS is well-established [21, 50]. Arguably, observational tools while valid, lack standardized norms as well as predictive validity [51] with refinement of tools needed.

Conclusions

In the current study, we did not establish an interactive role of PNMS and early parenting behaviors in the development of anxiety symptoms at school age. The examination of how

prenatal and postnatal environments jointly influence the development of anxiety symptoms and indeed, other child psychopathology, is an emerging field of research. More work is needed to understand how PNMS influences on infant neurodevelopment interact with established postnatal factors in the development of anxiety symptoms. A better understanding of the longitudinal and possibly transient nature of PNMS effects on anxiety symptomatology across early and mid-childhood is needed. In conjunction with the current findings, future research within this field can only lead us to a more complete understanding of the biopsychosocial mechanisms underlying anxiety development within PNMS-exposed cohorts.

Summary

Emerging research suggests early childhood parenting behaviors may ameliorate or exacerbate effects of prenatal maternal stress (PNMS) on later child psychopathology. We have previously shown that greater hardship due to a natural disaster, the 2011 Queensland Floods, is related to greater anxiety symptoms at age 4 years. Here, we examine whether specific parenting behaviors, traditionally regarded as 'anxiety-maintaining' (i.e., overinvolvement and/or negativity), exacerbate the effects of disaster-related PNMS on anxiety symptom development at 6 years of age. Pregnant women at the time of the 2011 Queensland Floods ($N=230$) were recruited shortly after the flood and reported on their experience of various aspects of flood-related PNMS (objective hardship, cognitive appraisal, subjective distress). At 4-years, we coded 109 mother-child dyads for maternal overinvolvement and negativity during a challenging task. Mothers reported on their children's anxiety symptoms at 6 years of age ($n=124$; Spence Preschool Anxiety Scale) and on their own mood. A total of 83 mother-child dyads had valid data at recruitment, 4 and 6-year follow-up. Regression analyses showed that no aspect of PNMS was associated with later anxiety symptoms in the children. PNMS—anxiety pathways were not moderated by maternal parenting behaviors (overinvolvement, negativity), child sex or timing of exposure to the floods. Poorer maternal concurrent mood was associated with greater child anxiety symptoms at 6 years, accounting for 26% of variance in symptoms. The current findings raise questions as to the role of PNMS in programming a child's vulnerability towards experiencing anxiety at school-age. Findings support the continued investigation of the mechanisms underlying the role of maternal psychopathology in the development of childhood anxiety symptoms.

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Compliance with Ethical Standards

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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