

Research paper

Positive cognitive appraisal “buffers” the long-term effect of peritraumatic distress on maternal anxiety: The Queensland Flood Study

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ABSTRACT

Background: Limited research has evaluated distinct aspects of disaster experience as predictors of affective symptoms. In this study, we examined the extent to which maternal depression and anxiety over time were predicted by (1) objective hardship from a flood during pregnancy, (2) peritraumatic distress and (3) cognitive appraisal of the flood's consequences.

Methods: Data were drawn from the 2011 Queensland Flood Study, a prospective, longitudinal study of pregnancy ($n = 183$). Mothers' disaster experience was measured within 1 year after the flood. Their levels of depression, anxiety and stress were measured at 16 months, 30 months, 4 years and 6 years after childbirth. Linear mixed models were employed to evaluate symptom trajectories.

Results: There were no time-dependent effects of disaster-related variables. Objective hardship did not predict outcomes. Peritraumatic distress significantly predicted depression and anxiety symptoms when cognitive appraisal was negative. Conversely, when cognitive appraisal was neutral or positive, the effect of peritraumatic distress was “buffered”. For anxiety, but not depression, this interaction survived Bonferroni correction. Neutral/positive cognitive appraisal similarly moderated the effect of peritraumatic dissociation.

Limitations: The generalizability of our findings is limited by overall low levels of depression and anxiety, along with a predominantly Caucasian, higher socioeconomic status sample. Potential confounders such as pre-disaster anxiety were not controlled for.

Conclusion: In line with previous evidence, this study supports the predictive validity of peritraumatic distress for post-disaster depression and anxiety. Our findings suggest that cognitive appraisal could be a relevant target for interventions aimed at fostering maternal resilience.

1. Introduction

Experience of a natural disaster can increase the long-term risk for depression and anxiety (Bonde et al., 2016; Tang et al., 2014; Thoresen et al., 2018). In pregnant women, these enduring consequences represent a particular risk (Brock et al., 2014; O'Hara and Wisner, 2014). In the years after childbirth, maternal depression has been associated with child internalizing and externalizing behaviors, and psychopathology (Goodman et al., 2011). Similarly, maternal anxiety has been associated with adverse effects on child development

(Reck et al., 2018; Rees et al., 2019) and with less positive parenting behaviors (Seymour et al., 2015).

What is experienced during a disaster is an important predictor of subsequent depression and anxiety (Bonanno et al., 2010). The objective severity of hardship from a disaster is probably the most studied, and has been associated with later depressive symptoms in various populations (Goenjian et al., 2020; Paul et al., 2014; Tang et al., 2014), including in pregnant women (Brock et al., 2015; Harville et al., 2009; Qu et al., 2012; Xiong et al., 2010). It is unclear if objective hardship can predict the trajectory of depressive symptoms over time. In one

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study by Meewisse et al. (2011), objective hardship was associated with different patterns of change in depressive symptoms between two and four years following a fireworks accident. However, in Brock et al. (2015), objective hardship from a flood was not associated with rates of change in depressive symptoms over time. As for the risk of post-disaster anxiety, some studies conducted in youth found an association with objective hardship (e.g. Brown et al., 2019), while others did not (e.g. Derivois et al., 2017). To our knowledge, no study has tested associations between the objective severity of hardship from a disaster and trajectories of anxiety symptoms.

Subjective reactions of an individual at the very time of a disaster, that is, “peritraumatic” reactions, are also predictive. Growing evidence suggests that peritraumatic distress could be as strong a predictor of post-disaster depression and anxiety as objective hardship. Peritraumatic distress has been associated with post-disaster depression in various studies (Bell et al., 2017; Derivois et al., 2017; Wilson-Genderson et al., 2018), including one in pregnant women (Brock et al., 2015). Peritraumatic distress in children also predicted their future anxiety (Derivois et al., 2017). In Wilson-Genderson et al. (2018), objective hardship was no longer associated with depression when peritraumatic distress was controlled for. Guo et al. (2017) observed that fear during an earthquake, but not objective hardship, was associated with depressive symptoms 8 years after the event. In Brock et al. (2015), objective hardship interacted with peritraumatic distress to predict the level of maternal depression. To our knowledge, no study has yet evaluated if peritraumatic distress is associated with trajectories of depressive and anxiety symptoms over time.

Following the immediate experience of the disaster, cognitive appraisal of the disaster's consequences could also influence affective symptoms. According to the appraisal theory of emotion, cognitive appraisal is a “process that detects and assesses the significance of the environment for well-being” (Moors et al., 2013). Cognitive appraisal is thought to determine one's emotional response to negative life events such as disasters (Levine et al., 2005; Moors et al., 2013). Appraisals of harm and threat were associated with depressive and anxiety symptoms 3 months after an earthquake and tsunami (Kyutoku et al., 2012). Negative attitudes about an earthquake during pregnancy were associated with more perinatal distress in a study by Chang et al. (2002). Other elements of appraisal such as self-efficacy (Wadsworth et al., 2009) and self-esteem (Adams and Boscarino, 2006) were found to predict trajectories of psychological problems after natural disasters. Following prenatal exposure to a natural disaster, maternal cognitive appraisal of the disaster's impacts has been associated with altered fetal development (Cao-Lei et al., 2016; L. 2018; Laplante et al., 2019; G. Simcock et al., 2019). Considering its associations with outcomes in offspring, it appears worthwhile examining whether this particular domain of cognitive appraisal also predicts maternal depression and anxiety, and how it interacts with objective hardship and peritraumatic distress.

Despite a growing literature on post-disaster outcomes, a number of gaps limit our ability to assess long-term risks in pregnant women. While specific aspects of disaster experience can interact together and differentially predict outcomes (e.g. Brock et al., 2015), they are rarely studied in tandem. Further, most studies are cross-sectional, and thus cannot examine the trajectories of symptoms over time (Bonanno et al., 2010; Tang et al., 2014; Wilson-Genderson et al., 2018). This is problematic considering that such symptoms can have a delayed onset (Bonanno et al., 2010; Meewisse et al., 2011; Nandi et al., 2009). Lastly, anxiety symptoms have not been frequently studied as a distinct outcome (Bonanno et al., 2010; Kyutoku et al., 2012), and only a few studies have focused on pregnant women (e.g. Brock et al., 2014, 2015; Qu et al., 2012).

A prospective study of prenatal maternal stress, such as the Queensland Flood Study (QF2011) (King et al., 2015), can jointly examine these objective, subjective and cognitive aspects of disaster experience as predictors of long-term depression and anxiety in mothers.

Floods hit the state of Queensland, Australia on January 10, 2011. It was the worst flood in 30 years, affecting over 200,000 people in more than 70 towns and causing 30–45 deaths.

The current paper draws on data from QF2011. Our goal was to determine the extent to which objective hardship from the flood during pregnancy, peritraumatic distress and cognitive appraisal predicted the trajectory of depression and anxiety symptoms in mothers between 16 months and 6 years after childbirth, and whether these disaster-related variables interacted together.

2. Methods

2.1. Participants and procedure

Women were recruited between 3 and 12 months after the event ($n = 230$). Participants were eligible if they were over 18 years old, fluent in English, had a singleton pregnancy, and were pregnant at the time of the flood. Written informed consent was obtained from all study participants. The study received ethical approval from the Mater Hospital and from the University of Queensland Human Research Ethics Committees. A detailed description of the sample composition of QF2011 and of its protocol can be found elsewhere (King et al., 2015). Measures of mothers' experience of the flood were collected at recruitment. Mental health outcomes were measured at 16 months, 30 months, 4 years and 6 years after childbirth.

2.2. Measures

2.2.1. Depression, anxiety and stress

Maternal affective symptoms were assessed at each timepoint using the 21-item Depression, Anxiety and Stress Scales (DASS; Antony et al., 1998; Lovibond and Lovibond, 1995). It comprises three scales (detailed below) with seven items each. Agreement is marked on a 3-point Likert scale. Points are multiplied by two to obtain the same denominator as the original 42-item DASS (Lovibond, 1995).

The Depression scale (DASS-D) assesses feelings of sadness, hopelessness, loss of interest and lack of enthusiasm. The Anxiety scale (DASS-A) assesses somatic symptoms of anxiety, non-directed fear, near-panic feeling and performance worry. The Stress scale (DASS-S) assesses irritability, tension, agitation and reactivity.

In a normative sample of Australian women, mean scores were 6.14 for DASS-D (SD = 6.92; proposed lower cut-off for moderate severity = 14), 4.80 for DASS-A (SD = 5.03; cut-off = 10.00), and 10.29 for DASS-S (SD = 8.16; cut-off = 19) (S. H. Lovibond et al., 1995).

DASS is commonly used for assessing maternal depression and distress (e.g. Das et al., 2019; Symon et al., 2012; Tran et al., 2013). It has good internal consistency and predictivity validity (Antony et al., 1998).

2.2.2. Objective hardship

The participants' severity of flood-related objective hardship was assessed using the Queensland Flood Objective Stress Scale (QFOSS). QFOSS builds on a questionnaire developed for another flood study (i.e., IF100, for the Iowa Flood Study; Brock et al., 2014), to which items were added to more fully represent the women's flood-related experiences in the present study. Its items focus on factual elements rather than subjective experiences.

As did IF100, the scale covers four domains: Threat (e.g. “Were you physically hurt?”), Loss (e.g. “Was your home damaged?”), Scope (e.g. “To what extent was your neighbourhood affected?”), and Change (e.g. “How many times were you required to change residence because of the flood?”). Each domain amounts to a maximum of 50 points, with a total maximum possible score of 200 points. A higher score indicates more severe objective hardship. The scale is described in more details in King et al. (2015).

QFOSS has good test-retest reliability ($r = 0.84$). Previous QF2011

publications demonstrated its predictive validity for developmental outcomes in prenatally-stressed offspring (McLean et al., 2018; M.A. 2019; Simcock et al., 2017; G. 2018; G. 2019).

2.2.3. Peritraumatic experiences

Peritraumatic distress. Participants recalled their reactions during and immediately after the flood using the Peritraumatic Distress Inventory (PDI; Brunet et al., 2001). The PDI is comprised of 13 statements, such as “I felt helpless to do more”, “I was horrified by what happened”, “I felt I might pass out”, etc. The instructions are to read each statement and mark agreement on a 4-point Likert scale: 0 = not at all, 1 = slightly, 2 = somewhat, 3 = very, and 4 = extremely true. The PDI has good internal consistency, test-retest reliability, and convergent and divergent validity (Brunet et al., 2001).

Peritraumatic dissociation. Participants also completed the Peritraumatic Dissociative Experiences Questionnaire (PDEQ; Marmar et al., 1997). The self-report questionnaire comprises 10 items, such as “My sense of time changed” and “I had moments of losing track of what was going on”, each scored on a 5-point Likert scale from 1 = not at all, to 5 = extremely true. The total score can range between 10 and 50. A higher score indicates more peritraumatic dissociative symptoms. In a sample of earthquake victims, PDEQ and PDI were strongly correlated ($r = 0.699$) and were both associated with depressive symptoms (Blanc et al., 2016).

2.2.4. Cognitive appraisal

Cognitive appraisal of the disaster's consequences (Conseq) was assessed using a single question: “Overall, what were the consequences of the flood on you and your family?”. Response options were coded as the following: -2 = very negative, -1 = negative, 0 = neutral, 1 = positive, 2 = very positive. Because of substantial positive skew, responses were dichotomized as 0 = negative (score = -2 or -1) or 1 = neutral/positive (score ≥ 0). Across three cohort studies, we have found that this single item has predictive validity for several outcomes in the unborn children of women exposed to disasters prenatally; notably their birth weight (Kroska et al., 2018), DNA methylation (Cao-Lei et al., 2018) and future autistic traits (Laplante et al., 2019). However, the item's predictive validity and reliability with respect to maternal mental health have yet to be evaluated.

2.2.5. Covariates

Maternal age at childbirth, years of education, and socioeconomic status were included as covariates in a sensitivity analysis. Socioeconomic status was measured using the Socio-Economic Indexes for Areas (SEIFA) – Index of Relative Socio-Economic Advantage and Disadvantage, which is based on postcode and Australian census data in the general population ($M = 1000$; $SD = 100$) (Pink, 2011).

2.3. Statistical analysis

Analyses were performed with R version 3.6.1. Descriptive analyses were conducted. Recruitment peritraumatic distress and peritraumatic dissociation were missing for 55 (23.9%) and 54 (23.5%) participants, respectively. Multiple regressions were performed to impute missing values, using objective hardship, 12-month post-flood measures of peritraumatic distress and peritraumatic dissociation, Impact of Event Scale-Revised, and State-Trait Anxiety Inventory (State) as predictors (described in King et al., 2015). Participants who did not have affective symptom scores for at least one timepoint were excluded (see Results); attrition analyses were conducted using two-tailed Welch's t -tests for continuous variables and Fisher's exact test for categorical variables. Spearman correlations were calculated between disaster-related variables and outcomes.

Linear mixed models with random intercepts and random slopes were used to evaluate the effects of time and disaster-related variables on depression, anxiety and stress. Irrespective of the timing of

assessments relative to the delivery of the baby, the timing of each outcome for the current analyses was calculated in months since the flood (January 10, 2011). Models were fitted using REML. The “DHARMA” package was used to interpret scaled residuals (Hartig, 2020). Following identification of heteroscedasticity in our initial models, the following variables were log-transformed: objective hardship, peritraumatic distress, peritraumatic dissociation, depression, anxiety and stress.

Outcomes were investigated in separate models (depression, anxiety, and for exploratory purposes, stress). Repeated measures of outcomes over time were nested in individuals. First, an intercept-only model was tested. Then, at block 1, time of outcome was allowed in a level 1-only fixed model. After, random effects of time were tested. All three models failed to converge at this step, and random effects of time were thus removed. At block 2, objective hardship was allowed in the models, followed by peritraumatic distress at block 3 and cognitive appraisal at block 4.

2.3.1. Interactions

To determine whether objective hardship, peritraumatic distress or cognitive appraisal had time-dependent effects on outcomes, we investigated interactions between those three measures and time of outcome. Three interaction terms were tested separately: time \times objective hardship, time \times peritraumatic distress and time \times cognitive appraisal.

We also tested for interactions within disaster-related variables: objective hardship \times peritraumatic distress, objective hardship \times cognitive appraisal, peritraumatic distress \times cognitive appraisal, and objective hardship \times peritraumatic distress \times cognitive appraisal.

Significant two-way interactions, which all involved one continuous predictor (peritraumatic distress or peritraumatic dissociation) and one dichotomized predictor (cognitive appraisal), were explored using conditional effects and plots. The conditional effects, i.e. the coefficient for the effects of the first variable conditional on the levels of the second variable, were computed. Their significance was examined with a t -test, where the standard error was computed using the variance-covariance matrix of the effect. We estimated the effect of the continuous predictor at both levels of the dichotomous predictor, and the effect of the dichotomous predictor at different levels of the continuous predictors, as well as their significance. Lastly, to examine whether interactions involving peritraumatic distress could be generalized to other measures of peritraumatic experiences, models using peritraumatic dissociation as a substitute for peritraumatic distress were tested.

2.3.2. Sensitivity analysis

P -values were derived from Satterthwaite approximations and were considered significant if below 0.05. In the primary models, Bonferroni corrections were applied to account for multiple tests of time-disaster interactions (critical P -value = $0.05/3 = 0.0167$) and disaster-disaster interactions (critical P -value = $0.05/4 = 0.0125$) per outcome. To test the stability of significant interactions, a sensitivity analysis was conducted by adding maternal age, years of education and socioeconomic status as covariates.

3. Results

3.1. Descriptive and attrition analyses

Descriptive findings and attrition analyses are presented in Table 1. In total, 183 participants had outcome scores for at least one timepoint while 47 participants had none. On average, participants retained for analysis had significantly more years of education compared to participants lost to follow-up. They did not differ significantly on disaster-related variables and other characteristics.

Correlations are presented in Table 2. Disaster-related variables

Table 1
Sample characteristics, affective symptoms after childbirth, and comparison of sample characteristics in included vs. excluded participants.

| | Included participants (total N = 183) | | | | Excluded participants (total N = 47) | | | | t | df | p |
|----------------------------------|---------------------------------------|---------|-------|------------------------|--------------------------------------|---------|-------|-------|-------|-------|-------------------|
| | N | Mean | SD | % | N | Mean | SD | % | | | |
| Age (years) | 183 | 31.44 | 4.88 | | 47 | 29.57 | 6.51 | | 1.85 | 59.95 | 0.07 |
| Ethnicity (% Caucasian) | 176 | | | 96.59 | 45 | | | 95.56 | | | 0.67 [#] |
| Married or cohabiting (%) | 160 | | | 88.13 | 43 | | | 76.74 | | | 0.08 [#] |
| Years of education | 182 | 14.15 | 1.89 | | 46 | 13.22 | 2.17 | | 2.68 | 63.25 | 0.009 |
| Annual household income (%) | 135 | | | | 31 | | | | | | 0.11 [#] |
| < \$34,000 AUD | 11 | | | 8.15 | 7 | | | 22.58 | | | |
| \$34,001 to \$52,000 AUD | 19 | | | 14.07 | 5 | | | 16.13 | | | |
| \$52,001 to \$73,000 AUD | 26 | | | 19.26 | 8 | | | 25.81 | | | |
| \$73,001 to \$104,000 AUD | 35 | | | 25.93 | 5 | | | 16.13 | | | |
| > \$104,000 AUD | 44 | | | 32.59 | 6 | | | 19.35 | | | |
| SEIFA | 183 | 1052.80 | 55.83 | | 47 | 1038.66 | 70.96 | | 1.27 | 61.39 | 0.21 |
| Objective hardship | 183 | 19.55 | 15.92 | | 47 | 21.81 | 18.47 | | -0.77 | 64.64 | 0.45 |
| Peritraumatic distress | 183 | 11.65 | 8.48 | | 47 | 11.77 | 8.53 | | -0.08 | 71.14 | 0.93 |
| Peritraumatic dissociation | 183 | 5.96 | 7.25 | | 47 | 5.64 | 6.86 | | 0.28 | 74.64 | 0.78 |
| Cognitive appraisal (% negative) | 183 | -0.27 | 0.76 | 34.43 | 45 | -0.64 | 0.77 | 40.00 | 0.65 | 64.95 | 0.52 |
| Depression | | | | % mod. severity | | | | | | | |
| 16 months after childbirth | 155 | 4.91 | 6.04 | 9.03 | 0 | | | | | | |
| 30 months after childbirth | 150 | 4.75 | 6.25 | 8.67 | 0 | | | | | | |
| 4 years after childbirth | 118 | 5.35 | 7.63 | 12.71 | 0 | | | | | | |
| 6 years after childbirth | 122 | 4.64 | 6.05 | 11.48 | 0 | | | | | | |
| Anxiety | | | | | | | | | | | |
| 16 months after childbirth | 155 | 3.61 | 5.19 | 12.26 | 0 | | | | | | |
| 30 months after childbirth | 150 | 3.65 | 5.18 | 13.33 | 0 | | | | | | |
| 4 years after childbirth | 118 | 3.53 | 5.36 | 12.71 | 0 | | | | | | |
| 6 years after childbirth | 122 | 3.25 | 4.56 | 9.84 | 0 | | | | | | |
| Stress | | | | | | | | | | | |
| 16 months after childbirth | 155 | 11.05 | 8.07 | 14.84 | 0 | | | | | | |
| 30 months after childbirth | 150 | 10.77 | 8.16 | 13.33 | 0 | | | | | | |
| 4 years after childbirth | 118 | 10.74 | 8.95 | 16.10 | 0 | | | | | | |
| 6 years after childbirth | 122 | 9.93 | 8.03 | 13.11 | 0 | | | | | | |

Note: #: Fisher's exact test. % mod. severity: percentage of scores above the lower cut-off for moderate severity (21-item Depression Anxiety Stress Scales). SEIFA: Socio-Economic Indexes for Areas.

were overall moderately intercorrelated, with the exception of a particularly strong correlation between peritraumatic distress and peritraumatic dissociation. Objective hardship was not significantly correlated with any outcome except depression at 6 years after childbirth. There were several significant, if small, correlations between the other disaster-related variables (peritraumatic distress, peritraumatic dissociation, cognitive appraisal) and outcomes at different timepoints, although all correlations were $r_s < 0.30$. Peritraumatic distress was positively correlated with many outcome variables, and stronger correlations emerged at 6 years between peritraumatic distress and both depression and anxiety. As expected, all significant correlations

involving cognitive appraisal were negative, suggesting that negative appraisal was associated with more severe affective symptoms.

3.2. Linear mixed models

Linear mixed models with depression, anxiety and stress as outcomes are presented in Table 3 (all blocks, including non-significant interactions, are detailed in Tables S1-S6). Time since the flood was not a significant predictor in any model. Objective hardship and cognitive appraisal had no main effects on outcomes. Peritraumatic distress had significant, positive main effects on depression, anxiety and stress.

Table 2
Spearman correlation coefficients between disaster-related variables and affective symptoms at 16 months (16 m), 30 months (30 m), 4 years (4y) and 6 years (6y) after childbirth.

| | QFOSS | PDI | PDEQ | Conseq | D 16m | D 30m | D 4y | D 6y | A 16m | A 30m | A 4y | A 6y | S 16m | S 30m | S 4y | S 6y |
|--------|----------|----------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|------|
| PDI | 0.47*** | | | | | | | | | | | | | | | |
| PDEQ | 0.39*** | 0.71*** | | | | | | | | | | | | | | |
| Conseq | -0.35*** | -0.25*** | -0.15* | | | | | | | | | | | | | |
| D 16m | 0.14 | 0.10 | 0.17* | -0.12 | | | | | | | | | | | | |
| D 30m | 0.05 | 0.13 | 0.17* | -0.20* | 0.47*** | | | | | | | | | | | |
| D 4y | 0.03 | 0.12 | 0.17 | 0.09 | 0.47*** | 0.37*** | | | | | | | | | | |
| D 6y | 0.18* | 0.21* | 0.12 | -0.10 | 0.44*** | 0.51*** | 0.56*** | | | | | | | | | |
| A 16m | 0.10 | 0.15 | 0.18* | -0.11 | 0.54*** | 0.24** | 0.33*** | 0.32*** | | | | | | | | |
| A 30m | 0.13 | 0.13 | 0.16* | -0.24** | 0.36*** | 0.55*** | 0.16 | 0.39*** | 0.38*** | | | | | | | |
| A 4y | 0.02 | 0.12 | 0.15 | 0.05 | 0.45*** | 0.26** | 0.45*** | 0.32** | 0.33*** | 0.38*** | | | | | | |
| A 6y | 0.12 | 0.26** | 0.12 | -0.04 | 0.29** | 0.23* | 0.39*** | 0.60*** | 0.28** | 0.46*** | 0.45*** | | | | | |
| S 16m | 0.13 | 0.24** | 0.26** | -0.04 | 0.69*** | 0.34*** | 0.46*** | 0.31** | 0.60*** | 0.38*** | 0.41*** | 0.33*** | | | | |
| S 30m | 0.09 | 0.15 | 0.16 | -0.10 | 0.43*** | 0.64*** | 0.31** | 0.41*** | 0.24** | 0.53*** | 0.31** | 0.34*** | 0.44*** | | | |
| S 4y | 0.02 | 0.17 | 0.21* | 0.07 | 0.44*** | 0.32*** | 0.76*** | 0.54*** | 0.40*** | 0.20* | 0.56*** | 0.50*** | 0.55*** | 0.45*** | | |
| S 6y | 0.17 | 0.24** | 0.16 | -0.08 | 0.35*** | 0.34*** | 0.50*** | 0.74*** | 0.23* | 0.30** | 0.36*** | 0.61*** | 0.33*** | 0.38*** | 0.55*** | |

Note: Statistical significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. A: Anxiety scale of the 21-item Depression Anxiety Stress Scales (DASS). Conseq: Cognitive appraisal of the disaster's consequences. D: DASS Depression scale. PDEQ: Peritraumatic Dissociative Experiences Questionnaire. PDI: Peritraumatic Distress Inventory. QFOSS: Queensland Flood Objective Stress Scale (i.e. objective hardship). S: DASS Stress scale.

Table 3
Linear mixed models with affective symptoms as outcomes and disaster variables as predictors.

| Outcome: Depression | | |
|--|-------------|------|
| Term | Coefficient | SE |
| Time since flood (months) | -0.00 | 0.00 |
| Objective hardship | -0.01 | 0.11 |
| Peritraumatic distress | 0.55** | 0.17 |
| Cognitive appraisal | 0.98* | 0.50 |
| Peritraumatic distress × cognitive appraisal | -0.44* | 0.19 |
| Constant | 0.030 | 0.50 |
| Outcome: Anxiety | | |
| Term | Coefficient | SE |
| Time since flood (months) | -0.00 | 0.44 |
| Objective hardship | 0.00 | 0.09 |
| Peritraumatic distress | 0.52*** | 0.15 |
| Cognitive appraisal | 1.03* | 0.44 |
| Peritraumatic distress × cognitive appraisal | -0.45** | 0.17 |
| Constant | -0.16 | 0.44 |
| Outcome: Stress | | |
| Term | Coefficient | SE |
| Time since flood (months) | -0.00 | 0.00 |
| Objective hardship | 0.05 | 0.09 |
| Peritraumatic distress | 0.27*** | 0.08 |
| Cognitive appraisal | 0.14 | 0.14 |
| Constant | 1.37*** | 0.32 |

Note: Statistical significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. In bold: interaction significant after Bonferroni correction.

Peritraumatic distress × cognitive appraisal had a significant effect on depression (Table 3). As illustrated in Fig. 1, the effect of peritraumatic distress on depression was significant when cognitive appraisal was negative ($B = 0.55$; $SE = 0.17$; $p < 0.01$), such that higher peritraumatic distress was associated with higher depression, but was not significant when cognitive appraisal was neutral/positive ($B = 0.11$; $SE = 0.11$; $p = 0.29$). There was no region of significance between the 16th and 84th percentiles of peritraumatic distress. This interaction did not, however, survive Bonferroni correction.

There was also a significant peritraumatic distress × cognitive appraisal interaction on anxiety, which remained significant after Bonferroni correction (Table 3; Fig. 2). The effect of peritraumatic

distress on anxiety was significant when cognitive appraisal was negative ($B = 0.52$; $SE = 0.15$; $p < 0.001$), such that higher peritraumatic distress was associated with higher anxiety, but not when cognitive appraisal was neutral/positive ($B = 0.07$; $SE = 0.09$; $p = 0.48$). There was no region of significance between the 16th and 84th percentiles of peritraumatic distress.

The peritraumatic distress × cognitive appraisal interaction on stress was not significant ($B = -0.21$; $SE = 0.17$; $p = 0.20$). There was no significant interaction between time and any of the disaster-related variables for depression, anxiety or stress (Tables S1, S3 and S5). Other interactions between disaster-related variables were not significant (objective hardship × peritraumatic distress, objective hardship × cognitive appraisal, and objective hardship × peritraumatic distress × cognitive appraisal; Tables S2, S4, S6). In *post hoc* analyses, we tested time × peritraumatic distress × cognitive appraisal interactions, which were not significant.

After adding maternal age, schooling years and socioeconomic status as covariates, peritraumatic distress × cognitive appraisal retained a significant effect on depression ($B = -0.43$; $SE = 0.19$; $p < 0.05$) and anxiety ($B = -0.45$; $SE = 0.17$; $p < 0.05$).

Lastly, we substituted peritraumatic dissociation for peritraumatic distress in the primary models (Tables S7-S9). Similarly, there were significant peritraumatic dissociation × cognitive appraisal interaction effects on depression and anxiety, but not on stress. The effects of peritraumatic dissociation on depression and anxiety were significant when cognitive appraisal was negative (on depression: $B = 0.30$; $SE = 0.11$; $p < 0.01$; and on anxiety: $B = 0.29$, $SE = 0.09$, $p < 0.01$) (Fig. S1-S2); when cognitive appraisal was neutral/positive, there was no effect of peritraumatic dissociation on either outcome. There was no boundary of significance between the 16th and 84th percentiles of peritraumatic dissociation. Peritraumatic dissociation had a significant main effect on stress ($B = 0.23$, $SE = 0.09$, $p < 0.05$).

4. Discussion

The goal of this study was to determine the extent to which disaster-related objective hardship, peritraumatic distress and cognitive appraisal predicted the trajectory of maternal depression and anxiety during the 6 years after childbirth. We found that greater peritraumatic distress at the time of the flood predicted more severe symptoms of depression and anxiety over time, but only when the woman's cognitive appraisal of the disaster was negative, and not when it was neutral or

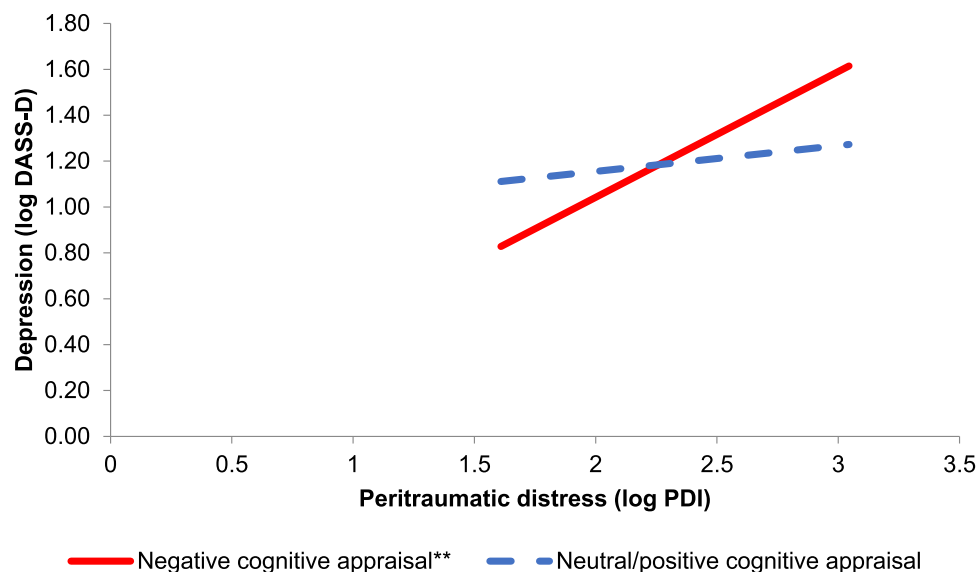


Fig. 1. Predicted values of depression by peritraumatic distress, across dichotomous levels of cognitive appraisal (linear mixed model). The effect of peritraumatic distress on depression is only significant when cognitive appraisal is negative. Statistical significance: ** $p < 0.01$.

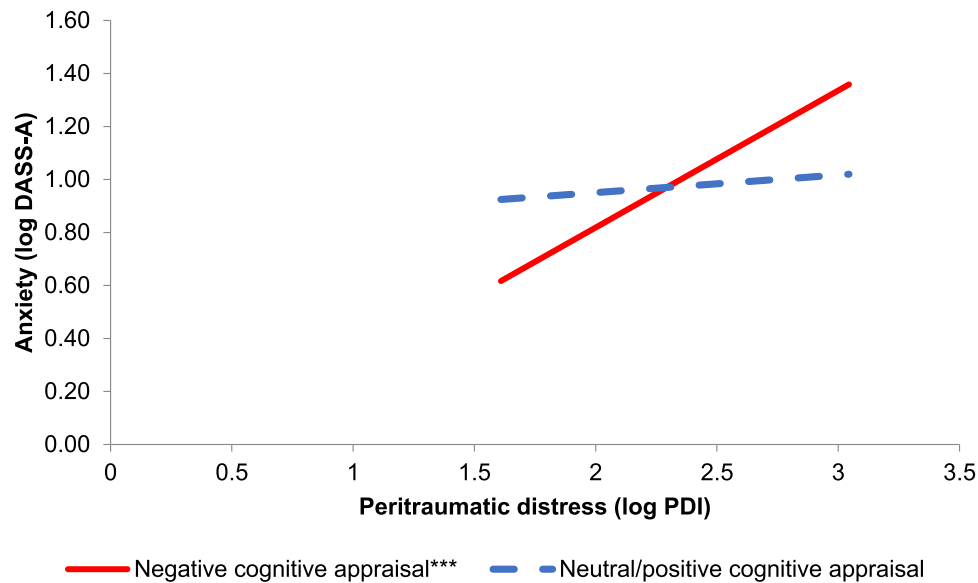


Fig. 2. Predicted values of anxiety by peritraumatic distress, across dichotomous levels of cognitive appraisal (linear mixed model). The effect of peritraumatic distress on anxiety is only significant when cognitive appraisal is negative. Statistical significance: *** $p < 0.001$.

positive. Overall, symptom levels did not significantly improve or worsen over time, and the effect of disaster-related variables was stable across timepoints.

First, univariate correlations suggested a pattern of stronger associations between peritraumatic distress and affective symptoms emerging at 6 years after childbirth. These apparent time-dependent effects were not supported by linear mixed models; there were no main effects of time since the flood, and none of the three disaster-related variables interacted with time (fixed effects) to predict maternal affective outcomes. Further, models including random effects of time failed to converge. This was probably due to a very small random effect of time and/or covariance between time and intercept random effects, preventing reliable estimations of model parameters. While another study of flood exposure during pregnancy found a decrease in depressive symptoms over time (Brock et al., 2015), there is evidence that post-disaster depression, like PTSD, can have either a delayed, refractory or resilient trajectory (Bonanno et al., 2010; Meewisse et al., 2011; Nandi et al., 2009). Hence, although we did not identify time-dependent variations in symptomatology, our linear mixed models might have failed to capture heterogeneous trajectories within subgroups of participants. In a larger sample, latent growth curve analysis could be better suited to identify such patterns.

We expected peritraumatic distress and cognitive appraisal to predict post-disaster depression and anxiety. We found that the effects of peritraumatic distress were significantly moderated by cognitive appraisal, such that higher peritraumatic distress predicted higher depression and anxiety only among women whose cognitive appraisal of the flood was negative. This suggests that a more positive cognitive appraisal of the flood's consequences “buffered” the noxious effects of peritraumatic distress on later maternal affective symptoms. After Bonferroni corrections, the effect of peritraumatic distress \times cognitive appraisal remained significant for anxiety, but not for depression, suggesting that the buffering effects of cognitive appraisal are especially strong for anxiety. In a sensitivity analysis, results were stable after adding maternal age, education and socioeconomic status as covariates. Further, cognitive appraisal similarly moderated the effect of peritraumatic dissociation on depression and anxiety.

In our models, we found no association between objective hardship from the flood and levels of depression, anxiety or stress between 16 months and 6 years after childbirth. This came as a surprise because objective hardship predicted several outcomes in the offspring of

QF2011 mothers (e.g. McLean et al., 2018, M.A. 2019). It is possible that the association between objective hardship and maternal affective symptoms is non-linear, such that an effect emerges only when objective hardship meets a certain (yet undefined) level of severity. However, considering mixed evidence linking disaster-related objective hardship to depression (Brock et al., 2015; Guo et al., 2017; Wilson-Genderson et al., 2018), this finding strengthens our view that peritraumatic distress (moderated by cognitive appraisal) is a better predictor of affective symptoms in women affected by a flood during pregnancy.

Lastly, we explored the extent to which objective hardship, peritraumatic experiences and cognitive appraisal predicted stress levels between 16 months and 6 years post-partum as measured by the DASS-S. We found that peritraumatic experiences (either peritraumatic distress or peritraumatic dissociation) were the only significant predictors. There was no interaction with time since the flood. Unlike for depression and anxiety, there was also no interaction with cognitive appraisal. The fact that peritraumatic distress and peritraumatic dissociation were consistently associated with all three outcomes supports their predictive validity with regards to post-disaster affective symptoms. It is unclear why cognitive appraisal did not moderate the effect of peritraumatic distress or peritraumatic dissociation on stress. Unfortunately, the lack of literature on DASS-S as a post-disaster outcome limits our ability to interpret this finding. DASS-S has been shown to correlate with other depression and anxiety scales and was associated with diagnoses of depression and anxiety disorders in clinical and nonclinical samples unaffected by disasters (Antony et al., 1998). One possible explanation is that this scale could reflect traits more than states, thus being less amenable to moderation by cognitive appraisal than temporary states of distress following a population-level disaster.

The current study has limitations. Like nearly all studies of post-disaster outcomes, it relies on retrospective assessments of disaster experience (Tang et al., 2014; Wilson-Genderson et al., 2018). The initial assessments in our sample were conducted relatively shortly after the flood: more than half were done between 4 and 7 months post-disaster. Further, the Peritraumatic Distress Inventory has been shown to have a good temporal stability, with a modest decrease in mean scores over time (Brunet et al., 2001). However, time elapsed between the disaster and the assessment of cognitive appraisal can potentially influence appraisal, as more consequences of the disaster can be felt later (Forbes et al., 2015; Lock et al., 2012). Despite this, cognitive

appraisal was not significantly correlated with time since the flood in our sample ($r_s = -0.05$, $p = 0.52$). More research is needed to establish the predictive validity and reliability of this self-reported, single-item measure of cognitive appraisal with respect to maternal mental health. Another limitation is that overall, our participants reported low levels of depression, anxiety and stress. On one hand, scores of peritraumatic distress were substantial: 32.2% of participants had a score equal to or greater than the proposed cut-off of 14 for predicting trauma-related disorders (Guardia et al., 2013). On the other hand, across the four timepoints, only a small proportion (8–16%) of affective symptom levels were in the moderate-to-severe range. Perhaps underlying these favourable outcomes, our sample was characterized by high socioeconomic status and education levels. This, in addition to a largely Caucasian sample, limits the generalizability of our findings. Future studies could explore the connections between cognitive appraisal, other determinants of resilience, and mental health outcomes in disaster-stricken populations from low- and middle-income countries (e.g. Nicolas et al., 2010; Rahill et al., 2016).

Of note, the associations between disaster-related variables and affective symptoms do not allow us to distinguish the relative contributions of two possible mechanisms: (1) higher peritraumatic distress was causally responsible for increasing affective symptoms, and/or (2) the associations observed in this study were confounded, to some extent, by pre-disaster factors. In a study with motor vehicle collision victims, prior anxiety predicted peritraumatic distress (Lewis et al., 2014). Likewise, in our study, it is possible that peritraumatic distress and cognitive appraisal acted as proxy variables for prior anxiety, or even personality traits, which could partially confound their associations with post-disaster affective symptoms.

Our study holds important strengths. It is the first prospective longitudinal study to jointly examine these three aspects of disaster experience (objective, peritraumatic and cognitive) as predictors of post-disaster depression and anxiety. In addition, we were able to replicate the association between peritraumatic distress and affective symptoms previously identified in a similar population of pregnant women affected by major flooding (Brock et al., 2015). We also found that cognitive appraisal moderated the effect of peritraumatic experiences, an interaction pattern that was consistent across two predictors (peritraumatic distress and peritraumatic dissociation) and two outcomes (depression and anxiety). Finally, our results have implications for policy and clinical care. Pregnant women and their offspring are vulnerable to the stress of natural disasters. Maternal distress and negative cognitive appraisal have been associated with various adverse outcomes relative to the offspring's development and physical health (e.g. Cao-Lei et al., 2016, L. 2018; Laplante et al., 2019). Cognitive appraisal (1 item) and the Peritraumatic Distress Inventory (13 items) can be easily administered to victims of natural disasters to assess their long-term risk for depression and anxiety. Thus, if future research confirms the external validity of current findings, it is foreseeable that peritraumatic distress and cognitive appraisal could be targets of interest for risk estimation and interventions aimed at fostering resilience in vulnerable groups such as pregnant women.

5. Conclusion

The goal of this study was to determine the extent to which the trajectories of maternal depression and anxiety were predicted by three disaster-related variables: objective hardship from the flood, peritraumatic distress and cognitive appraisal of the flood's consequences. Although there were no time-dependent effects, we found that higher peritraumatic distress predicted higher levels of depression and anxiety in the 6 years following childbirth, an effect that was “buffered” by a neutral or positive cognitive appraisal of the flood.

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Contributors

SKing, SKildea and DPL conceived the QF2011 study and were responsible for project supervision. VP conceived the current project, performed the statistical analyses and wrote the manuscript draft. GE was responsible for data curation and supervised statistical analyses. All authors contributed to reviewing and editing the manuscript and have approved the final article.

Declaration of Competing Interest

All authors declare no conflict of interest.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.jad.2020.09.041](https://doi.org/10.1016/j.jad.2020.09.041).

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