

Quick Response Research Report

QF2011: The effects of the Queensland Flood on pregnant women, their pregnancies, and their children's early development

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INTRODUCTION

Retrospective epidemiological studies suggest that maternal exposure to a severe stressor increases the fetus' risk for a variety of disorders in adulthood. Known as fetal programming, this hypothesis has been tested by randomly assigning pregnant animals to stressful conditions. Stress-induced maternal glucocorticoids (GCs) are believed to pass the placental barrier and disrupt fetal brain development, particularly the hypothalamic-pituitary-adrenal (HPA) axis and immune system. In humans, prenatal maternal stress (PNMS) at different time points during pregnancy has been found to influence the cognitive, behavioral and physical development of the offspring. To protect the developing fetus from disaster-related PNMS, we must increase understanding of the pathways by which women exposed to different levels of disaster-related hardship become distressed, thereby triggering biological reactions in the intra-uterine environment and possibly affecting postnatal development. Up until now, however, no longitudinal study of pregnant women has been able to elucidate the biopsychosocial mechanisms responsible for the wide variety of consequences of prenatal stress observed in offspring.

The 2011 January Floods in Brisbane, Australia, provided a unique opportunity to assess levels of PNMS in women exposed to the disaster at different stages of pregnancy, collect perishable biological specimens and determine the extent to which early child development was affected. In this context, a Quick Response Research Grant allowed me, the first author, to travel to Brisbane for 11 weeks to assist coordinating the implementation of this new study, known as the QF2011 Study. The purpose of this report is to describe the fieldwork conducted during this time and summarize the data collection process.

BACKGROUND

Preliminary study

Project Ice Storm: Based at the Douglas Hospital Center, Dr. King and Dr. Laplante initiated Project Ice Storm (<http://www.mcgill.ca/projetverglas/>) soon after a series of ice storms struck Southern Québec in January 1998 knocking out electricity for more than 3 million people for as long as 6 weeks during the coldest months of the year. The ice storm caused 27 deaths, and created financial and logistical hardship for everyone affected. The Insurance Bureau of Canada and Environment Canada count the ice storm as the worst and most costly natural disaster in Canadian history. Project Ice Storm, a prospective longitudinal study, was designed to investigate the role of prenatal maternal stress (PNMS) on child development. On June 1st, 1998, questionnaires were mailed to women in the affected region, whose doctors identified as being pregnant during the ice storm, or who became pregnant in the 3 months following the storm. A questionnaire (STORM32) was tailor-made to the disaster to assess 4 categories of objective exposure to the disaster: threat, loss, change, and scope. To estimate subjective stress reaction to the ice storm, the Impact of Events Scale – Revised (IES-R) [1, 2] which assesses Post-Traumatic Stress Disorder (PTSD) symptoms, was used. They determined the exact timing of disaster exposure during pregnancy. The 177 women in the initial sample spent an average of 15 days (0 - 42) without electricity. The wide range in objective exposure allows for comparisons among levels of PNMS.

Results from Project Ice Storm [3-8] suggest that greater PNMS in response to a natural disaster is related to poorer outcomes at different ages in children born to affected mothers. Depending upon the outcome measure, results implicate, either objective stress exposure (effects on intellectual abilities[6-9], language[6, 8], obesity[3]), subjective stress reaction (effects on externalizing and internalizing behavior problems[10], finger ridge counts[5]), or timing of the stressor (prematurity[4], low birth weight[4], neuromotor abilities[11]). The child's sex moderates some of these results[4, 10, 11]. Unfortunately, however, Project Ice Storm did not include the collection of biological samples at birth such as the placenta and cord blood. Thus, pathways by which PNMS affect the fetus and later development remain a mystery. There is an urgent need to collect such biological specimens in a cohort of pregnant women affected by a severe independent stressor, at varying levels of hardship and distress, and to replicate the longitudinal assessments conducted in Project Ice Storm.

Literature Review

Maternal depression. Between 12% and 15% of women experience depression in the first six months of the postnatal period, with a 9.3% 1-year period prevalence rate of major depression for postnatal women[12]. Perinatal depression has negative health consequences for the woman and her offspring [13-20]. The etiology of postnatal depression (PND) is not completely understood [21]. Risk factors include depression during pregnancy, history of psychiatric disorder, poor social support/marital distress, young age and lower socioeconomic status, and stressful life events[22-26]. However, "stressful life events" are often confounded with longstanding personality traits. To date, there have been no prospective studies on PND risk associated with "independent" life events such as a natural disaster.

Post-Traumatic Stress Disorder (PTSD). Exposure to disasters yields an overall conditional risk for PTSD of 4%[27], but up to 24% of disaster victims can develop PTSD[28], with rates being higher in women. Meta-analyses have shown that levels of distress and dissociation experienced around the time of trauma exposure (i.e., "peritraumatic") are among the most robust predictors of a diagnosis of enduring PTSD[29]. PTSD is consistently associated with altered Hypothalamus-Pituitary-Adrenal (HPA) axis activity, especially lower levels of basal diurnal cortisol, and especially in women [30-34].

Our co-investigator, Professor Alain Brunet, developed the Peritraumatic Distress Inventory (PDI[35]) which assesses, retrospectively, emotional distress and panic-like physical reactions that occurred around the time of a trauma. Peritraumatic dissociative-like experiences, measured by the Peritraumatic Dissociative Experiences Questionnaire (PDEQ[36]) are also informative. Brunet found that peritraumatic distress ($r=.58$, $p<.01$) and dissociation ($r=.50$, $p<.01$), and acute stress, assessed six months after a factory explosion explained 62% of the variance in PTSD symptoms[37], even when assessed 15 months later[38]. In Project Ice Storm, using the Impact of Events Scale-Revised (IES-R), Brunet found that 13% of women in the sample screened positive for possible PTSD 6 months after the ice storm. These women had significantly lower diurnal cortisol than women who scored below the IES-R cut off[39].

Behavioral functioning. Non-human primate research has found that either mild daily social stress [40] or 2 weeks of adrenocorticotrophic hormone (ACTH) treatment to the mother (stimulating GC response) at mid-gestation[41, 42] results in greater internalising behaviors in the infant monkeys. In Project Ice Storm, we recently analysed the mother-rated internalising and externalising problems for the five assessments at ages 4, 5½, 6½, 8½ and 9½ years[43]. Zero-order correlations between internalising problems and objective stress (Storm32) were low-to-moderate at each age, while correlations with subjective stress (IES-R) were strong and significant at every age (range: .348 to .512). Controlling for maternal depression and anxiety in June 1998 and at the time of the assessment, subjective stress still explains an additional 8% to 12% of unique variance in internalising problems at each age. Multilevel modeling (growth curves) results show, first, that the severity of internalising problems is increasing *relative to the norm group*. Second, that internalising at 4 years (the Y-intercept) is explained significantly by subjective maternal stress (estimate =

.503, $p < .05$) which explains 34% of the between-subjects variance in internalising.

Externalizing problems had low, positive correlations with objective maternal stress at all 5 ages, but stronger correlations with subjective stress (.28 to .558). Controlling for maternal mood, subjective stress explained an additional 8%-20% of additional variance in externalizing. Multilevel modeling of trajectories over time showed a significant interaction that parallels the results for internalizing above. Subjective maternal stress explains 35% of the between-subjects variance in externalizing.

Temperament: There is preliminary evidence suggesting that PNMS may impact infant temperament and later psychopathology [44, 45]. In a sample of 970 participants, Austin and colleagues [46] observed that pregnancy anxiety increased the odds of "difficult" infant temperament at 4 or 6 months. Similarly, results from *Project Ice Storm* suggest that after controlling for potential confounding variables, women who experienced higher levels of prenatal subjective stress reported their infant as being more fussy and difficult. This relation changed based on the timing of exposure to the storm. In a prospective study with 71 mothers, Van den Bergh [47] found that prenatal maternal anxiety explained 22%, 15%, and 9% of the variance in cross-situational attention deficit hyperactivity disorder symptoms, externalising problems, and self-report anxiety, respectively, even after controlling for child's gender, parents' educational level, smoking during pregnancy, birth weight, and postnatal maternal anxiety. Anxiety at 12-22 weeks gestational age turned out to be a significant independent predictor whereas anxiety at 32 to 40 weeks was not.

Cognitive functioning. Studies of non-human primates show that PNMS is associated with poorer cognitive development [40, 48, 49]. In *Project Ice Storm*, high objective PNMS exposure predicted lower intellectual abilities at 2 years [8], 5½ [50], 8½, and at 11½ years (males only), with a nearly 15-point (1 SD) difference in IQs between low and high objective stress groups. Children in the high objective PNMS group also had lower language abilities at 2 [8], 5½ [50], 8½ and 11½ years of age. At 2 years, 1st or 2nd trimester-exposed children of mothers exposed to high objective PNMS exhibited more immature, and less diversified, toy play [7], an indirect measure of intelligence. Effects are also seen on memory in boys.

Physical Development. PNMS has been linked to cardiovascular, endocrine, immune, metabolic (glucose/insulin) and respiratory disorders in children and adults, conditions which confer the major burden of disease in 'developed' countries. PNMS may lead to alterations in hypothalamic function, which, apart from HPA axis function, also regulates body weight through energy homeostasis (the balance between energy input (food) and energy expenditure). In *Project Ice Storm*, high objective PNMS exposure, regardless of timing, was associated with greater risk of obesity (Body Mass Index) and central obesity (waist to height ratios) at 5½ and 11½ (Dancause, in press) [3].

Research also suggests that stress and anxiety during pregnancy can influence brain lateralization in children, which can be reflected in handedness. Children exposed to maternal anxiety at 18 weeks gestation [51] and at 30 weeks gestation [52] are more likely to exhibit mixed-handedness compared to controls. These children are more likely to use both their left and right hands and their preference for one or the other is less strong. These effects are particularly pronounced among boys [51]. It has been suggested that the relationship between brain lateralization and handedness in children might be influenced by exposure to variations in fetal cortisol and testosterone levels, which are impacted by maternal stress and anxiety [51].

At 11½ years of age, *Project Ice Storm* children underwent structural brain MRIs. Preliminary results show that more severe objective stress (but not subjective) predicts smaller left hippocampus, but only in boys. In our "control" group, subjected to maternal stress hormones via breast milk intake, greater stress predicted smaller hippocampus, which was correlated with a smaller cortisol response to the MRI stressor, which was correlated with more severe internalising problems. Thus, effects of PNMS on hippocampus may cascade onto other outcomes.

Motor Development. Although most research on the effects of prenatal maternal stress focuses on cognitive and behavioral development, some animal and human research includes assessments of motor functioning. In infants, Buitelaar and colleagues [53] observed that increased fear of giving birth in expectant mothers, when assessed at mid-gestation, was related to lower motor development assessed using the

Psychomotor Index (PDI) of the Bayley Scales of Infant Development in infants at 8 months of age. The same study found that elevated maternal salivary cortisol levels during pregnancy predicted lower PDI scores in the babies at both 3 and 8 months. Finally, a recent study has shown that prenatal maternal work stress was negatively associated with motor development at 2 years of age, as assessed by the Comprehensive Developmental Inventory for Infants and Toddlers [54]. In *Project Ice Storm*, the earliest motor assessments took place at age 5 ½ years, and included evaluations of bilateral coordination, balance, and visual motor integration. Although prenatal stress did not explain variance in balance scores at that age, both objective and subjective stress explained significant amounts of variance in coordination and visual motor integration, the effects being moderated by child sex and the timing of the stress in pregnancy [11].

Study Context

The Queensland Flood Study (QF2011): Heavy rainfall in the Australian state of Queensland caused severe flooding in January 2011. At least 70 towns, including the state capital of Brisbane, and over 200,000 people were affected. Three-quarters of Queensland was declared a disaster zone. Residents of 2100 Brisbane streets were told to evacuate, and 20,000 homes were inundated. Thirty-five to forty deaths have been directly attributed to the floods. Damage initially was estimated at around \$1 billion Australian.

These floods happened *after* Dr. Sue Kildea's research team at the Mater Mothers' Hospital had already collected data on risk factors, including screening for depression, social support, and other psychosocial factors, in pregnant women in Brisbane, Queensland (n ≈ 300) for a Randomized Control Trial comparing midwifery group practice care with standard care: The M@NGO Study.

Quickly after the floods, Dr. Suzanne King and her research team from the Douglas Hospital Research Center initiated collaboration with Dr. Kildea. In order to save time in obtaining ethics approval, the QF2011's research protocol was superimposed onto the M@NGO study. Ethical approval was received on April 4th, 2011.

RESEARCH QUESTIONS

The overarching research question of the QF2011 study is: What are the bio-psychosocial mechanisms by which exposure to disaster-related PNMS, in different stages of pregnancy, affects maternal and pregnancy outcomes and the physical, cognitive and behavioral development of the children exposed *in utero*? As with any international longitudinal study, it will take a few years before the all the data is collected, analyzed and shared. In the meantime, this report will present my fieldwork and describe the data collection process. This is the first step in being able to answer larger questions on the effects of PNMS on early child development.

METHODS

Participants

There are 2 different groups of participants in this study. The first group consists of women already enrolled in the M@NGO study. These women were invited to participate by telephone or by e-mail. The second group consists of women not enrolled in the M@NGO study. These participants were recruited in the Mater Mother's Hospital's Antenatal clinic or through ads in the media. Both groups of women had to be pregnant at the time of the floods (peak between January 11th - 14th) 2011. At the time of recruitment to this study, women may have been pregnant or may have already given birth. Women also had to be 18 years of age or older. We excluded multiple pregnancies.

As of October 24, 2011, 173 women had provided a written consent form to participate in the QF2011 Study. A total of 147 placentas had been collected. In addition, 156 women had returned their recruitment questionnaire. Eighty-one women had returned the 6-12 weeks questionnaire and 23 women had returned the 6-months questionnaire. Research assistants continue to follow-up women on a daily basis.

Instruments

Table 1 (Appendix A) presents all assessments that have been or are to be conducted as part of the M@NGO research protocol and the QF2011 protocol. These have been added to the pre-existing M@NGO protocol. The section below summarizes the primary measures of interest in the QF2011 protocol.

QF2011 Data Collected During the First Author's Field Research:

Disaster Timeline:

Questionnaires at Recruitment (REC):

Objective flood stress exposure: Because disasters differ along many dimensions, we tailor-made a questionnaire for each disaster that reflects experiences related to 4 categories of exposure: Threat, Loss, Scope, and Change[55-60](Appendix B). From the information collect, we will create a single score to reflect total QF2011 objective hardship exposure.

Subjective Stress: The severity of current flood-related PTSD-like symptoms was assessed using the IES-R[2], which yields scores for intrusive thoughts, avoidance, and hyperarousal for the preceding 7 days. Subjects scoring above 22 on the IES-R (suggesting possible PTSD) will be followed up by telephone interview by clinical research staff supervised by collaborator, Brett McDermott, psychiatrist. Peritraumatic distress and dissociation, recalled from the time of the flood, were assessed using the PDI[35] and PDEQ[36], respectively.

Mental health: Maternal trait-state anxiety was assessed using the State-Trait Anxiety Inventory (STAI)[61]. Positive mental health was assessed by the Mental Health Continuum – Short Form (MHC-SF)[62].

Psychosocial factors: Coping abilities were assessed using the Brief COPE[63] and, for religious coping, the Brief RCOPE[64].

Diurnal cortisol (REC):

Subjects collected saliva samples over 2 days at the following times: waking (w), w+30 min, w+45 min, w+60 min, and before bed, taking note of all times, and times of breastfeeding before and during sampling[65].

Pregnancy Timeline:

Maternal blood samples during pregnancy (36WP):

We collected additional blood samples at the 36-week routine prenatal blood draw in order to assess biomarkers including CRH, pro-inflammatory cytokines, cortisol and catecholamines.

Biological samples at delivery:

Placenta: The placenta was obtained soon after expulsion, and was prepared using standardized methods[66, 67].

Umbilical cord: After measuring total length, 10-15 cm of cord (in the sterile area) was collected after birth.

Cord blood: Venous and arterial cord blood was collected by gravity drainage in heparinised tubes (10-15 mL).

Questionnaires: 6-12 weeks (6-12WPP) and 6-months postpartum (6MPP)

Questionnaires about the infant: Infant temperament will be assessed by mothers using the Short Temperament Scale for Infants (STSI)[68]. Mothers will complete the Ages and Stages Questionnaire[69] (ASQ-3) to indicate achievement of the child's developmental milestones in the areas of communication, gross motor, fine motor, problem solving, and personal-social. Maternal anxiety will be reassessed using the STAI.

QF2011 Data Collected After the First Author's Field Research:***Disaster timeline*** (12MPF):Questionnaires:

Objective flood stress exposure: The flood questionnaire will be re-administered in order to update the values of financial loss, damage to house and property, experiences dealing with insurance companies, etc.

Psychological assessments: We will reassess current PTSD symptoms with IES-R scale, maternal anxiety and maternal positive mental health. Because we found that childhood trauma is associated with lower diurnal cortisol values[70], women will complete the Childhood Trauma Questionnaire[71, 72]. Information concerning maternal major life events will be obtained using the Life Experiences Survey (LES).

Diurnal cortisol:

Subjects will repeat the cortisol procedures done at recruitment, and collect saliva samples over 2 days at the following times: waking (w), w+30 min, w+45 min, w+60 min, and before bed, taking note of all times, and times of breastfeeding before and during sampling[65].

Pregnancy timeline: Assessments at 16 month (16M), 2 ½ years (2½Y), and 4 years (4Y) of age

Questionnaires: Maternal Characteristics. Coping and life events will all be assessed with the same instruments as described above. Maternal anxiety, depression and Stress will be assessed using the short form of the Depression, Anxiety and Stress Scale. Levels of parenting stress will be assessed using the Parenting Stress Scale. The women's social support will be assessed using the short form of Sarason's Social Support Questionnaire (SSQ)[73]. Maternal depression will be assessed at 2½Y and 4Y only will be replaced with the Center for Epidemiologic Studies Depression Scale (CES-D)[74]. A short questionnaire will also assess maternal handedness.

Questionnaires: Child Characteristics: Global development will be assessed using the Ages and Stages Questionnaire[75] (ASQ) at all ages. Early language development will be assessed using the short form of the MacArthur-Bates Communicative Development Inventory[76] (16-M & 2½Y). At all ages, temperament will be assessed with the Short Temperament Scale for Toddlers[68] (STST). In order to respect the age ranges of the scales, internalizing and externalizing behaviour problems will be assessed with the Brief Infant Toddler Social Emotional Assessment[77] (BITSEA) at 16-M; and at 2½Y and 4Y using the Child Behavior Checklist[78]. Autistic-like traits will be assessed using the Autism Spectrum Rating Scales[79] at 2½Y and 4Y. Child handedness will also be assessed at 16-M & 2½Y.

Face-to-Face Assessments: Maternal: The mothers' intellectual functioning will be assessed using a short form of the Wechsler Adult Intelligence Scale[80] at 4Y. At 16-M & 2½Y, mothers who had breast fed their infants since the preceding assessment will be interviewed to estimate the amount of breast milk consumed by the child. Finally, mothers will be interviewed with the Mini-International Neuropsychiatric Interview[81] (MINI) at each assessment to determine any psychopathology diagnoses: current and lifetime; MINI interviews can be completed in as little as 15 minutes. Maternal sensitivity will be assessed using Emotional Availability Scales from videotape of 5 minutes of mother-infant semi-structured play as described below. Maternal height and weight will be measured at all assessments.

Face-to-Face Assessments: Child: The children's motor, cognitive and language development will be assessed using the Bayley Scales of Infant and Toddler Development[82] at 16-M & 2½Y, and by the Wechsler Preschool and Primary Scale of Intelligence[83] at 4Y. The children's play abilities, which are an indirect measure of cognitive development, will be assessed using a free play protocol at 16-M and 2½Y as per Laplante, et al.[7]. Language abilities will also be assessed by the Peabody Picture Vocabulary Test[84] at 4Y. Executive functioning abilities, such as visual attention, will be assessed using the NEPSY-II[85] at 4Y. Attention will be assessed using the computer-administered Kiddie Continuous Performance Test[86] at 4Y. Fine motor abilities will be assessed using the Beery-Buktenica Visual-Motor Integration[87] scale (2½Y and 4Y). We will collect the following anthropometric measures at all ages: head, waist, mid-upper-arm and calf circumference; and tricep, subscapular and suprailiac skinfolds. Fingerprints, finger lengths and

anthropometrics measures of faces will be taken at 4Y. Body composition by bio-electrical impedance (using a portable device, the BodyStat 1500) and height and weight (all ages), will be obtained. Finally, the children's attachment status and neuroendocrine development will be assessed using the Strange Situation protocol[88] (16-M & 2½Y): saliva samples will be obtained prior to and following the procedure as per protocol to assess hormonal reaction to stress. Video recordings of the Strange Situation Protocol will be coded to assess behavioral reaction to stress using the Braungart-Rieker Infant Negative Affect Scale.

Diurnal cortisol: Child: At 16M, Mothers will be asked to take a total of 6 saliva samples from their infant using a cheek swabs to measure diurnal patterns of cortisol. For two consecutive days, samples will be taken at waking, 30 minutes after waking and bedtime.

Data Analysis

A systematic plan for analysis of all data will be created based on the various hypotheses and the final sample size. We will test associations among cascades of variables from mother, to placenta, to cord blood and to the infant. These analyses lend themselves to structural equation modeling and hierarchical multiple regressions.

RESULTS

Fieldwork Description

I conducted 11 weeks of field research in Brisbane between April 21st and July 5th 2011. After meeting with Dr. Sue Kildea's team at the Mater Mother's Hospital, I became responsible for the data collection process. Time was of the essence as women pregnant during floods had already started giving birth and we needed to measure reactions the flood as early as possible. In this context, my responsibilities included recruiting participants, producing study documents, collecting biological samples, building partnerships with medical staff, conducting knowledge translation activities and training research staff.

Recruit Participants. The first priority was to recruit pregnant women exposed to the floods at different time points during their pregnancy into the expanded QF2011 Study. In this regard, I contacted participants of the M@NGO study by telephone to invite them in the QF2011 study. Arrangements with the hospital were also made to recruit new participants in the waiting room of the Mater Hospital's Antenatal Clinic. Before long, women were being recruited on a daily basis (see Figure 1 in Appendix C). I also keep track of women who, either declined to participate in the QF2011 Study, were not sure whether they would participate (i.e. wanted to think about it) or who did not meet inclusion criteria (were not pregnant at the time of the floods, had or expected twins, did not speak English, were not 18 years of age), in order to obtain an estimate the participation rate.

Produce Study Documents. A number of documents, essential for the implementation of this study, had to be produced quickly including instruction and information sheets for participants and medical staff as well an excel database to serve as a participant log. For every woman recruited, information was entered in the database and recruitment packs were prepared. Recruitment packs were composed of an introduction letter, a recruitment questionnaire, a mother saliva kit with individual labels on tubes, an instruction sheet for the blood sample at 36-weeks of pregnancy, two consent forms and a pre-addressed and prepaid envelop. Once packs were sent out, telephone follow-up was crucial to encourage the women to participate in the different phases of the study and to answer any questions or concerns the women might have had. Once the consent forms, questionnaires and saliva samples were returned, I processed the information and monitored the evolution of the study (see Figures 2 and 3 in Appendix C). Data collection summaries were produced and presented at weekly team meetings.

Assist the Collection of Biological Specimens at Birth. I supported the collection of biological specimens at birth (see Figure 4 in Appendix C) and was responsible for establishing mechanisms of communication between the midwives and the placentologist. For instance, purple alert sheets were placed in each of the participants' medical file in order to ask midwives and medical staff to contact the placentologist, who was on call 24 hours a day, 7 days a week, when women arrived in labor. I also dealt problems related to the collection of biological specimens at birth. For instance, I followed up cases in which midwives had failed to call the placentologist and helped create kits for midwives to collect the biological samples if the placentologist was unavailable be reached for any reason. Finally, I was in charge of visiting women who had not returned their written consent form in prenatal and postnatal ward.

Collect Samples After Birth. I also conducted trials to collect newborn footprints and saliva samples. Saliva was collected from infants before the 48-hour heel prick then 20 and 40 minutes after. These procedures were deemed too demanding for our limited resources and were ceased after a few weeks. Instead, saliva and footprints will be collected at a later age.

Build Partnership with Medical Staff and Conduct Knowledge Translation Activities. In order to cooperate effectively with midwives, I conducted information sessions, meetings and a conference with hospital staff. The main purpose of these activities was to review past research on the effects of PNMS, inform medical staff about the QF2011 study, request their collaboration, work out processes and answer remaining concerns and/or questions. Information folders were placed in the different departments of the hospital. Knowledge translation activities were also conducted outside of the research institution at the Mater Mother's Hospital. I was invited to speak at the the 4th Biennial Conference of the Australian Association of Maternal, Child and Family Health Nurses. Furthermore, I prepared a presentation for the co-principal investigator's (Dr. Sue Kildea) interview with the media. By publicly promoting the study, the QF2011 team was able to inform the population about the need to study the impact of stress during pregnancy, increase medical staff support and recruit more participants.

Train Research Staff. I was in charge of producing a detailed procedure manual and daily field notes to inform current and future staff about the QF2011 Study protocol. I also trained research staff as they joined the team. Knowledge transfer was gradually conducted to ensure that staff would have the capacity to take over the coordination of the study after my departure. I continue to help coordinate the QF2011 Study from Montreal.

CONCLUSION

Environmental scientists report that more frequent and severe weather events are likely to occur as a result of climate change. Terrorist threats and civil wars continue to be a global phenomena. Against this backdrop of uncertain and changing futures, families continue to bring children into the world. It is becoming increasingly evident that these unborn children are vulnerable to upsets in their mothers' environment. Yet, researchers have been unable, so far, to compile all of the pieces of the puzzle that will lead to the development of interventions that might limit the harm to mother and fetus.

QF2011 will enable us to collect the most comprehensive dataset ever obtained to study the effects of an independent stressor on pregnant women and risks for PTSD, postnatal depression, pregnancy outcomes and child development. By obtaining a multitude of maternal and child biomarkers form a sample of women exposed to the flood at different points during pregnancy, we can bring the entire human maternal-placental-fetal system into the laboratory, and test integrated biopsychosocoal models of prenatal stress for the first time. This is a unique opportunity to advance our understanding in this important field.

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