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Effects of prenatal maternal stress on birth outcomes following tropical cyclone Yasi in Queensland, Australia (2011)

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ABSTRACT

Tropical cyclones cause widespread devastation while having a negative impact on human health and well-being. Maternal exposure to prenatal environmental stressors can lead to a shift in reproductive strategies. This study aims to statistically analyse maternal and infant health risks by studying birth outcomes following maternal prenatal exposure to tropical cyclone Yasi in Queensland, Australia. Queensland state birth records collected under the Australian National Perinatal Data Collection from January 2008 to December 2012 were analysed. A confounder controlled binary logistic regression model was used to statistically compare birth weight and gestation length in cyclone Yasi affected and unaffected Queensland local government areas (LGAs). Women in cyclone Yasi affected LGAs, had a significantly higher proportion (9.6%, $p = 0.008$) and significantly higher odds (OR = 1.26, 95% CI: 1.06 – 1.47) of having a preterm birth, compared to women in unaffected LGAs (7.9%). Women in affected LGAs during the year of cyclone Yasi (2011) also had a higher proportion of low birth weight births compared to women in the same LGAs during non-cyclone Yasi years (2008,2009,2010,2012). Our study supported a significant increase in the proportion of preterm births recorded for women pregnant in areas severely affected by cyclone Yasi. Our findings, and similar future research, will continue to inform the development of effective post-disaster perinatal health related policies and the continued improvement of disaster risk mitigation for vulnerable groups.

1. Introduction

On Thursday 3rd February 2011, tropical cyclone Yasi made landfall near Mission Beach, Queensland. A category five storm carrying heavy rains and damaging winds of up to 285 km/h, Yasi was one of the most powerful cyclones to hit the Australian east coast since 1899 and the second most costly cyclone to strike Queensland after Cyclone Tracey in 1974 [1]. An estimated 150 homes were lost and 650 were left uninhabitable [2] with total damage costs estimated at AU$3.5 billion [3,4]. Changes to disaster response protocol following cyclone Tracey lead to the early evacuation of over thirty thousand people before Yasi struck resulting in a single fatality [1]. Despite a reduction in the loss of lives directly linked to Yasi, experiencing an environmental disaster would still present widespread psychological and physical trauma due to financial losses, structural damage and widespread population displacement [5,6]. It is therefore crucial to understand the risks faced by affected groups, notably those with increased vulnerability due to pregnancy.

In addition to the physical pressures placed on the human body during and after a disaster, survivors can further experience an increase in psychological stressors associated with the loss of possessions and financial stability. Pregnant women are particularly vulnerable as they are already physiologically taxed supporting foetal development [7]. Constant fluxes of regulatory hormones throughout gestation make pregnant women highly susceptible to the effects of stress [8–11]. Disaster related prenatal maternal stress (PNMS) has been associated with negative health impacts on both the mother and child. Such impacts can present as low birth weight (LBW) babies born at less than 2500 g and preterm births born at less than 37 weeks gestation [12,13]. LBW has been long regarded as a strong indicator of infant health and has been frequently used as a predictor of mortality within the baby's first year [14], while both LBW and preterm births can result in increased morbidity throughout childhood [15,16]. With a predicted rise in the frequency and intensity of environmental disasters associated with climate change, research into the effects of PNMS following such events is becoming a crucial contribution to inform policy and support

Abbreviations: LBW, low birth weight; LGA, local government area; NPDC, National Perinatal Data Collection; OR, odds ratio; P-NMDS, Perinatal National Minimum Database; PNMS, prenatal maternal stress

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Table 1
Estimated trimester birth groupings by birth year, birth month and gestation age.

	Cyclone Yasi Year (2011)		Non-Cyclone Year (2008, 2009, 2010, 2012)	
Gestational age	**Trimester**	**Birth month (inclusive)**	**Group**	**Birth month (inclusive)**
0 weeks – 12 weeks	1	August –November (2011)	1	August – November (2008, 2009, 2010, 2012)
13 weeks – 26 weeks	2	May– July (2011)	2	May – July (2008, 2009, 2010, 2012)
27 weeks – 40 weeks	3	February– April (2011)	3	February – April (2008, 2009, 2010, 2012)

Note: Birth record groupings for analysis run on births during the year of cyclone Yasi (2011) and non-cyclone Yasi years (2008, 2009, 2010, 2012). Pregnancy trimester during month of cyclone Yasi, February 2011, estimated off recorded birth month. During non-cyclone years, births grouped based on estimated gestational age during February of each year as proxies for trimester exposure during 2011.

effective disaster response strategies.

PNMS has been supported as causing physiological changes to the intrauterine environment, preterm deliveries, and inhibiting foetal growth [17,18]. The negative impact of disasters on pregnancy outcomes has been widely reported following hurricanes in America, typhoons in the Philippines and the 2009 Black Saturday bushfires and the 2010 Queensland floods in Australia where an increase in early births and lighter babies was observed [19–22]. Tropical cyclones are further closely associated with heavy flooding which frequently affects Queensland's tropical regions. Flooding similarly presents stressors due to displacement, isolation from services and the introduction of infected flood waters. Significantly higher cases of both LBW and preterm births have been recorded in women affected by heavy flooding such as during the 2011 Thailand floods, the 1997 Red River flood in North Dakota, USA and the 1997 flooding of the Klodzko Region in Poland [23–25].

Between 1967 and 1999, over half of the environmental disasters experienced in Australia were severe tropical storms, yet no studies have explored their impact on reproductive outcomes. This is despite the first of seven long term objectives identified by Australian state and territory governments being that, "Australians are born healthy and remain healthy" [26]. Often organisations and governments fail to anticipate lasting effects of disasters and this can result in miscalculated decisions such as the premature withdrawal of support services [27]. As environmental disasters remain to be strongly considered a perinatal health risk, this study aims to support the negative impact of maternal prenatal exposure to cyclone Yasi through a statistical analysis of birth weight and gestation length.

2. Method

State legislation requires data on pregnancies and births in hospitals, birth centres and the community of each state and territory within Australia be collected under the National Perinatal Data Collection (NPDC) [28]. The NPDC incorporates the Perinatal National Minimum Data Set (P-NMDS) which is a standardised set of data elements agreed upon by the National Health Information Management Group for mandatory collection and reporting. We obtained perinatal data from the Queensland State Health Department with all births recorded within the Queensland perinatal data collection (PDC) from January 2008 to December 2012, inclusive ($n = 311,389$).

The Queensland PDC includes information on births, both live and stillborn, of at least 20 weeks gestation and 400 g birth weight [29]. All births recorded are irrespective of maternal characteristics such as age, ethnicity, disability and socioeconomic background. Miscarriages, medically defined as foetal loss at < 20 weeks gestation, were resultantly out of scope for this study due to P-NMDS data limitations. Stillbirths, defined in the P-NMDS as foetal death at > 20 weeks gestation or a > 400 g birthweight, were excluded from analysis. This was based on preliminary analysis supporting stillbirths having a significant association ($p < 0.001$) with LBW and preterm births but making up only less than 1% of sampled births.

As maternal residence was used to establish cyclone Yasi affectedness based on geography, and following O'Donnell and Behie, 2013, we removed women whose usual state of residence was not Queensland. We then divided the remaining births based on the mother's recorded area of usual residence, at the sub-state local government area (LGA) level, and then split LGAs into those affected or unaffected by cyclone Yasi in 2011. Literature supports the significance of when, during pregnancy, prenatal stressors are experienced [21,30]. To factor this, we further grouped births into cohorts based on the estimated pregnancy trimester during the month of the cyclone. As January births would occur prior to cyclone Yasi and December births would be over 9 months after Yasi they were excluded as there was a low chance their gestation period would have coincided with the cyclone. For non-cyclone Yasi years, we divided births based on the month groupings used for 2011 cohort analysis (Table 1).

Low birth weight (LBW) was defined using the World Health Organization's (WHO) classification of birth weights recorded at less than 2500 g. Preterm births were defined using the WHO classification of any live births recorded at less than 37 weeks gestation. As LBW and preterm births can occur for a variety of reasons, we screened our data and identified seven confounding variables, based on *a priori* analysis of literature, collected in the NPDC (Table 2). Confounders were controlled for using a binary logistic regression model. Regression analysis provides a statistical model commonly applied in relational studies such as those investigating disasters and pregnancy outcomes. The model effectively allows for the inclusion of known confounders of pregnancy independent of the disaster to better present disaster related outcomes [23,31]. A notable limitation of research into disasters and pregnancy outcomes is the use of inconsistent sampling and statistical methodologies across separate studies. Regression modelling selected for this study continues to be effectively applied in a number of causal studies including those investigating birth outcomes and disasters [30]. All analysis was run in IBM's Statistical Package for the Social Sciences (SPSS) version 22 with a set 95% confidence interval and an alpha of 0.05.

Statistical analysis included the conversion of all research variables into binary variables with 1 = condition present and 0 = condition not present or not reported as done by Zahran et. al, 2010. Maternal residence determined stress experienced based on geographic location therefore LGAs were categorised into binary variables based on cyclone Yasi impact (1 = affected and 0 = unaffected). Cases of LBW and preterm births were also entered as binary dependent variables with the odds of their occurrence in affected LGA's analysed while adjusting based on confounders.

A proxy for maternal cyclone Yasi exposure related stress was developed using an assessment of cyclone impact levels in different Queensland LGAs. Assessment was based on requests for disaster relief assistance under the Commonwealth/State Natural Disaster Relief Recovery Arrangements (NDRRAs). We identified 11 LGAs as severely affected by the cyclone based on an activation of over 90% of the available NDRRAs (Fig. 1) [43].

Studies support an association between geographic proximity to a disaster and adverse birth outcomes [44]. We analysed births recorded in 2011 by grouping them into affected and unaffected LGAs based on