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The BITTOC longitudinal cohort study

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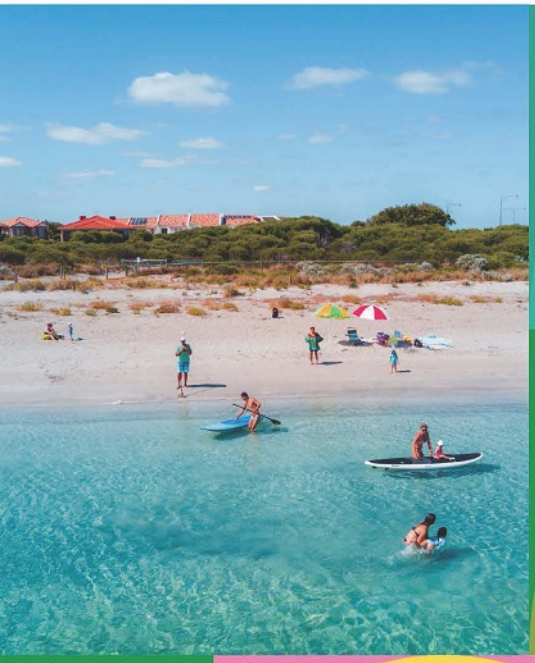

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ORIGINAL ARTICLE

Prenatal maternal stress was not associated with birthweight or gestational age at birth during COVID-19 restrictions in Australia: The BITTOC longitudinal cohort study

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ABSTRACT

Background: Various forms of prenatal maternal stress (PNMS) have been reported to increase risk for preterm birth and low birthweight. However, the associations between specific components of stress – namely objective hardship and subjective distress - and birth outcomes are not well understood.

Aims: Here, we aimed to determine the relationship between birthweight and gestational age at birth and specific prenatal factors (infant gender and COVID-19 pandemic-related objective hardship, subjective distress, change in diet), and to determine whether effects of hardship are moderated by maternal subjective distress, change in diet, or infant gender.

Materials and methods: As part of the Birth in the Time of COVID (BITTOC study), women (N = 2285) who delivered in Australia during the pandemic were recruited online between August 2020 and February 2021. We assessed objective hardship and subjective distress related to the COVID pandemic and restrictions, and birth outcomes through questionnaires that were completed at recruitment and two months post-partum. Analyses included hierarchical multiple regressions.

Results: No associations between maternal objective hardship or subjective distress and gestational age at birth or birthweight were identified. Lower birthweight was significantly associated with female gender (adjusted β = 0.083, $P < 0.001$) and with self-reported improvement in maternal diet (adjusted β = 0.059, P = 0.015).

Conclusions: In a socioeconomically advantaged sample, neither objective hardship nor subjective distress related to COVID-19 were associated with birth outcomes. Further research is warranted to understand how other individual factors influence susceptibility to PNMS and how these findings are applicable to women with lower socioeconomic status.

KEYWORDS

birth outcomes, birthweight, COVID-19 pandemic, gestational age, prenatal maternal stress

INTRODUCTION

Prenatal maternal stress (PNMS) has been identified as a risk factor for preterm birth (PTB) and low birthweight (LBW).[1–7] However, which aspects of PNMS are relevant to the association is not well understood. Objective hardship (the severity of events experienced) and subjective distress (one's reaction to these objective exposures) are two aspects of stress that are often conflated in research, yet they may have distinct or interacting associations with PTB and LBW.[8,9] Using more specific measures of PNMS, such as objective hardship as distinct from subjective stress, may yield more consistent findings. For instance, mothers' increased disaster-related subjective distress has been shown to independently predict a lower birthweight and also to moderate the association between objective hardship and birth outcomes.[2] Other factors, such as infant gender, may also moderate the relationship between PNMS and birth outcomes.[4,6,10,11] Furthermore, stress-associated behaviour change in the context of natural disasters, such as change in diet, has been associated with birth outcomes.[3]

Emerging literature from the COVID-19 pandemic shows mixed evidence of the impact of pandemic-related restrictions on birth outcomes, with some studies showing decreased incidence of preterm birth in the general population during the pandemic,[12,13] some showing no change,[14,15] and others showing an increased incidence of preterm birth associated with pandemic-related stress.[5] In the context of a population stressor such as a pandemic, not all pregnant women exposed to PNMS have the same experience of adversity. To improve risk stratification, it is therefore important to delineate how distinct aspects of PNMS, and interactions among maternal and fetal factors, shape the risk for PTB and LBW.

Birth in The Time of COVID-19 (BITTOC) is a longitudinal cohort study of women who were pregnant in Australia during the period of COVID-19-associated restrictions. Using the BITTOC cohort, we aimed to determine the association of prenatal factors – objective hardship, subjective distress, maternal diet, and infant gender – with gestational age at birth and birthweight. We also aimed to evaluate whether the relationship between objective hardship and birth outcomes is moderated by subjective distress, infant gender or change in diet.

MATERIALS AND METHODS

Study design

The BITTOC study was approved by the Research Ethics Board of Western Sydney University (#H13825) and the Charles Darwin University (#H13825). Participants provided implied informed consent by reading information about the study and selecting to proceed with the online survey.

Ethical standards

All procedures contributing to this work comply with the ethical standards of the relevant national guidelines on human experimentation (Canadian Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans – TCPS 2 2018, National Health and Medical Research Council National Statement on Ethical Conduct in Human Research) and with the Helsinki Declaration of 1975, as revised in 2008, and has been approved by the institutional committees.

Participants

Participants were eligible if they were pregnant, or had given birth to a live baby, since March 2020, lived in Australia, were at least 18 years old, had access to a computer or internet services, and spoke English. Pregnant women were recruited from 2 August to 29 November, 2020 through social media, mother and baby websites, and consumer organisations, such as Kidspot and Maternity Choices Australia. Recruited women then referred new participants to the study using snowball sampling. Eligible women completed an online survey through Qualtrics between August 2020 and February 2021 reporting on current pregnancy or a birth since March 2020 when the pandemic led to significant restrictions in Australia. Participants' responses were de-identified and stored with institutional-level data security protocols. Questionnaires were sent online to participants at recruitment and (if necessary) again at two months post-partum. Completed surveys were scrutinised to remove suspected bots and mischievous responders. Exposure variables were measured at two months post-partum, or at baseline if the mothers had already given birth before recruitment. Outcome variables were collected at two months post-partum.

Exposure variables

Objective hardship

Objective hardship related to the pandemic was measured with the BITTOC Assessment of Stress due to COVID-19 (BASC150), an instrument adapted from validated questionnaires of objective hardship from natural disasters.[16–19] Higher scores, for a maximum possible score of 150, indicate greater hardship. The items and their scoring can be found in the supplemental material of Di Paolo et al (2022).[20]

Subjective distress

As part of the BASC questionnaire, the subjective distress score was developed by the BITTOC team of researchers (psychologists and midwives) and has been shown to have predictive validity

with respect to post-partum maternal mental health.[20] It measures experiences of stress, isolation and worries due to the pandemic, both related and unrelated to pregnancy. Higher scores, for a maximum possible score of 200, indicate greater distress.[20] The internal consistency is good (Cronbach alpha = 0.89).

Other variables

Mothers reported their educational attainment (a commonly used indicator for socioeconomic status), age, parity, and their child's gender. Mothers also reported on how their diet changed due to the pandemic (one item; range: from one 'eating much worse' to five 'eating much better').

Outcome variables

Gestational age (in weeks) and birthweight (in grams) were reported by mothers at two months post-partum.

Data analysis

We performed analyses in SPSS version 26. Gestational age at birth and birthweight were treated as continuous variables and modelled with multiple hierarchical linear regressions. Objective hardship was added as the first predictor, followed by either subjective distress, infant gender, or change in diet (in separate models). We controlled for maternal age, education, and parity (nulliparous vs multiparous) in fully adjusted models. To evaluate moderation effects, we tested the following interaction terms: objective hardship × subjective stress, objective hardship × infant gender, and objective hardship × change in diet. Significance was defined as $P < 0.05$ (two-tailed).

RESULTS

Descriptive analysis

Table 1 presents characteristics of the sample. Of the 2285 women who completed the survey, all 2285 women reported gestational age at birth; 1906 reported birthweight, which had a minimum value of 686 g and a maximum value of 5330 g; and 3.1% of babies were born low birthweight (<2500 g) while 2.1% were born high birthweight (>4000 g). Both gestational age at birth and birthweight were approximately normally distributed. The most frequent maternal age category was 30–34 years. Most women (67%) reported having completed university education or higher. Also, 96.4% of the women reported having a current partner, and 43.3% were primiparous. Approximately 41% of women reported eating worse than before the pandemic, while ~49% reported no change, and ~10% were eating better. The sample included 1179 male infants (51.6%); gender was unreported for 11 infants (0.5%).

Associations between birthweight and prenatal factors

As presented in Table 2, in the unadjusted models there was no significant association between objective hardship and birthweight. When controlling for objective hardship, there was no association between subjective distress and birthweight. However, as expected, there were significant associations between infant gender and birthweight, indicating that female gender was associated with lower birthweight. A self-reported deterioration in diet was also associated with higher birthweight after controlling for objective hardship. The results were similar after further controlling for maternal education, parity and age (Table 2).

Associations between gestational age at birth and prenatal factors

There was no association between objective hardship and gestational age at birth (Table 2). When controlling for objective hardship, there was no association between subjective distress, infant gender or change in diet and gestational age at birth. The results were similar after further controlling for maternal education, parity, and age.

Moderation by subjective distress, infant gender and change in diet

Subjective distress, infant gender and change in diet did not moderate the association between objective hardship and birthweight, nor between objective hardship and gestational age at birth, in either the unadjusted or adjusted models (Table S1).

DISCUSSION

In this exceptionally high socioeconomic status cohort (30.0% of women in our sample had obtained a postgraduate degree vs 8.4% of all Australian women)[21] neither objective hardship nor subjective distress experienced by pregnant women during the COVID-19 pandemic explained significant amounts of variance in birthweight or gestational age. We instead found that infant gender and change in diet were significant predictors of birthweight over and above the non-significant influence of objective hardship.

Our results differ from some previous literature suggesting PNMS-associated adverse birth outcomes following natural disasters. For example, a population register study of births in Chile before and after a major earthquake suggests that significant effects of earthquake exposure on low birth weight are mediated by effects on shorter gestational age.[22] However, a study using administrative data in Quebec, Canada, failed to find any association between birth outcomes and prenatal exposure to a major ice storm that deprived 3 million people of electricity for as long as 45 days in the middle of winter.[23]

TABLE 1 Descriptive analysis of predictor and outcome variables (N = 2285)

Variable	*n*	Percentage of total data (*n*/*N*) (%)	Mean	Standard deviation	Median, interquartile range
Objective hardship (BASC 0–150)	2157	94.4	23.2	14.8	20.0, 20.0
Subjective distress (0–200)	2285	100	68.1	3.7	67.0, 44.0
Birthweight (g)	1906	83.4	3439.0	539.5	3460.0, 690.0
Gestational age at birth (weeks)	2285	100			

	n	Percentage of total data (*n*/*N*) (%)	Percentage of each variable (*n*/total) (%)
Maternal age (years)			
18–20	8	0.35	0.30
21–24	95	4.2	4.2
25–29	532	23.3	23.5
30–34	1010	44.2	44.6
35–39	534	23.4	23.6
40 or over	87	3.8	3.8
Total	2266	99.2	100
Education			
Less than year 12	66	2.9	2.9
Year 12 or high school certificate	194	8.5	8.6
TAFE or Diploma	476	20.8	21.0
Undergraduate or university	843	36.9	37.2
Postgraduate	687	30.0	30.3
Total	2266	99.2	100
Change in diet			
'I began eating much worse than before'	233	10.0	11.2
'I began eating somewhat worse than before'	627	27.4	30.0
'No change in diet'	1016	44.5	48.7
'I began eating better than before'	184	8.1	8.8
'I began eating much better than before'	27	1.2	1.3
Total	2087	91.3	100
Relationship status			
Have a current partner	2203	96.4	97.2
No current partner	63	1.9	2.8
Total	2266	98.3	100

Importantly, studies using administrative data cannot determine which aspects of the maternal experience account for any effects of prenatal maternal exposure to a disaster on birth outcomes. In a smaller study of the Quebec disaster, Project Ice Storm, researchers assessed the magnitude of pregnant women's experiences of disaster-related objective hardship and subjective distress. Although they failed to find main effects of the degree of stress on birth weight and gestational age, they did find effects on indicators of fetal growth such as head circumference.[2] Project Ice Storm may have been unable to uncover effects between objective hardship or subjective distress and birth outcomes because of the small sample size (n = 187). A recent meta-analysis of studies testing associations between the degrees of objective hardship or of subjective distress to a variety of child outcomes found, indeed, that the effect size of maternal hardship on birth outcomes was significant but small when combining 4474 data points (adjusted correlation r = 0.06);[24] interestingly, the positive correlation suggested that

TABLE 2 Results of individual regression analyses testing main effects of prenatal factors and birth outcomes

	Unadjusted[†]		Adjusted[‡]	
Prenatal factor	***β***	***P*-values**	***β***	***P*-values**
Birthweight (g) [*n* = 1906]				
Objective hardship	−0.010	0.67	−0.014	0.54
Subjective distress	−0.035	0.20	−0.034	0.22
Gender[§]	**−0.090**	**<0.001**	−0.083	**<0.001**
Change in diet[¶]	−0.069	0.005	−0.059	**0.015**
Gestational age at birth (weeks) (*n* = 2285)				
Objective hardship	0.011	0.62	0.012	0.57
Subjective distress	−0.025	0.31	−0.030	0.24
Gender	0.023	0.28	0.020	0.35
Change in diet	−0.032	0.15	−0.030	0.18

Each row presents a separate linear regression model evaluating the association between a prenatal factor and an outcome. Associations significant at $P<0.05$ are bolded.
[†]Adjusting only for objective hardship.
[‡]Adjusting for objective hardship, maternal education, parity, and age.
[§]Male = 1, female = 2.
[¶]A lower value corresponded to a deterioration in diet, and a higher value of 'change in diet' corresponded to an improvement in diet.

greater hardship was associated with larger, not smaller, babies at birth.

There has been mixed evidence of the association between pandemic exposure during gestation and birth outcomes in other high-income countries which may reflect heterogeneity and variance in PNMS objective hardship exposure (eg social gathering restrictions, changes to pregnancy care) across cohorts and measurement tools.[5,12–15] The current study is the first to separate out distinct aspects of PNMS (ie objective hardship and subjective stress) in examining associations with birth outcomes in the context of the COVID-19 pandemic.

Only a small percentage of the variance in birth outcomes following exposure to a natural disaster during pregnancy can be attributed to PNMS, suggesting that targeting PNMS may only have minimal effects at the population level.[2–4,7] Differences in birth outcomes may be better explained by other individual susceptibility factors. For instance, in the present study, female infant gender was found to be an independent predictor of lower birthweight, over and above the impact of objective hardship. Birthweight has consistently been shown to be lower in female infants than in male infants.[25] However, the lack of interaction between objective hardship and gender suggests that gender does not influence the offspring's vulnerability to prenatal maternal hardship. We also found that a woman's deterioration in diet during the pandemic was an independent predictor of higher birthweight over and above objective hardship. High-quality maternal diet during pregnancy has consistently been associated with better birth outcomes (higher birthweight and lower risk of preterm birth).[26] In addition, maternal diet, including higher intake of targeted nutrients, has actually been found to mitigate the effect of PNMS on infant development in other studies,[26,27] although we failed to show moderation by diet in the current study. Our sample had nearly double the proportion of babies born with high birthweight (2.1% vs 1.1%) and a lower proportion born with low birthweight (3.7% vs 6.6%) than in the 2019 Australian population.[28] It is possible that, in this study, mothers who indicated they began eating worse typically referred to overeating, rather than lacking access to nutritious food. For example, the increased proportion of high birthweight babies may indicate above average rates of gestational diabetes in our sample. Gestational diabetes, which was not measured in the current study, is independently associated with birthweight, such that poorer diet control of blood glucose levels would result in an increase in birthweight. Additional research is needed to understand how individual factors may modify the effects of PNMS on birth outcomes in the context of a populational stressor.

Our study has strengths. It is, thus far, the only longitudinal study in Australia which evaluates the separate effects of objective hardship and subjective distress during the COVID-19 pandemic on birth outcomes, and one of the first to do so worldwide. We also limited recruitment to a four-month period, which decreased the influence of variation in the duration of the pandemic at the time participants responded. Furthermore, our large sample size ensured power to detect associations and interactions among variables. Despite the large sample size, our study may have been underpowered to detect very small differences in outcomes associated with PNMS, as alluded to above. Other weaknesses of the study include that potential impacts of pandemic-related PNMS on offspring development may manifest later after birth, for example through developmental milestones.[29] Convenience recruitment through online platforms may have contributed to the sample being of exceptionally high income and not representative of women who are potentially more vulnerable to PNMS. Furthermore, we were not able to control for some potential confounders, such as medication use or medical conditions during pregnancy, as this information was not available. Given the absence of an association between PNMS and birth outcomes in the current models, it seems unlikely that controlling for additional confounders would have changed the results. Concerning the association between diet and birthweight, we cannot rule out the contribution of confounding factors; however, participants were invited to consider only *changes* in their diet during the pandemic, which may have mitigated the impact of confounding from pre-pandemic factors.

To capture the unique stress experiences related to the pandemic and pregnancy, we relied on *ad hoc* measures of objective hardship, subjective distress and change in diet. These tools build on previous work in natural disaster cohorts which demonstrates

their predictive validity for a range of maternal and offspring outcomes, including maternal mental health and birth outcomes, following sudden-onset acute stressors.[2,3,16] However, alternative measures emphasising other aspects of PNMS, such as post-traumatic stress symptoms, may yield distinct associations with birth outcomes.[30]

In conclusion, no associations between maternal objective hardship or subjective distress during the COVID-19 pandemic and birthweight or gestational age at birth were identified. Other factors, such as infant gender and maternal diet, appear to be independent predictors and do not moderate the association between objective hardship and birth outcomes. These findings may reassure mothers who have given birth during the pandemic. Extension of this work to other populations, including pregnant women with lower socioeconomic status, may help identify differential influences of PNMS on birth outcomes.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix S1