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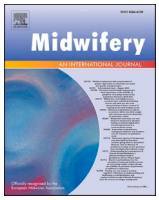

Experience of continuity of care mitigates poorer infant temperament for women reporting elevated hardship during pregnancy: Birth In The Time of COVID (BITTOC) study

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ABSTRACT

Problem: It is unknown whether unborn infants exposed to their mothers' uncontrollable stressful life events could benefit from the continuity of their mothers' prenatal carer.
Background: Maternal stress in pregnancy predicts poorer child outcomes. Continuity of care improves maternal mental health.
Aim: Determine whether continuity of care moderates association between prenatal maternal stress due to COVID-19 and infant negative emotionality at age 6 months.
Methods: Australian women, pregnant during the pandemic, completed a survey detailing their level of continuity of maternity care, pandemic-related difficulties (objective hardship), cognitive appraisal of, and subjective distress related to, COVID-19. Six months post-birth, they reported on their mental health, COVID-19 related stress and their infants' negative emotionality (n = 903).
Findings: Hierarchical multiple regression analysis showed that higher prenatal pandemic-related subjective distress was associated with greater infant negative emotionality. Interaction analyses determined that, for women exposed to higher levels of objective hardship in pregnancy, the more they experienced continuity of carer, the lower their child's negative emotionality at age 6 months. This relationship was not evident for dyads exposed to lower objective hardship. However, actual model of maternity care did not moderate the relationships between COVID-19-related prenatal maternal stress and infant negative emotionality. All models accounted for 6-month maternal COVID-19 objective hardship and subjective stress as well as depressive symptoms.
Discussion: We found that the protective effect of experienced continuity of care, small but potentially consequential, was most evident among women exposed to high COVID-19-related hardship. This finding supports the roll-out of maternity care models that foster relational continuity for at-risk pregnant women with additional medical and psychological needs.
Conclusion: For women most exposed to uncontrollable stressful events, such as pandemic-related restrictions and threat, their experience of high continuity of care may predict long-term benefits for their infant's temperament.

Midwifery continuity of care (MCOC) is a style of prenatal care that favours continuity of care provider throughout pregnancy, birth, and the postpartum, often by providing care from a small group of midwives. MCOC has been shown to improve outcomes for women and their babies (Sandall et al., 2024). This relationship-based model builds trust, supports the biopsychosocial process, and improves the chance of positive birth experiences (Kuipers, 2024). Australia offers diverse maternity care models through public and private systems, varying in their ability to deliver relational continuity. Only 28 % of models provide continuity of carer across the full maternity continuum (antenatal to

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postnatal), and most women receive standard fragmented care (Australian Institute of Health Welfare 2023). Midwife-led models (private midwifery or through midwifery group practices in public hospitals) extending postnatal care in the home for 2 to 6 weeks. These models typically offer greater continuity than doctor-led models, unless in the private system (Australian Institute of Health Welfare 2023; Perdok et al., 2018). . By contrast, Standard care, is fragmented and involves multiple professionals—often unfamiliar to the woman during labour and birth (Donnolley et al., 2016). Research has shown that women receiving MCOC models are less likely to have a caesarean section, instrumental birth or an episiotomy and are more likely to have a spontaneous vaginal birth and have a positive experience. MCOC also costs less than comparable models of care (Sandall et al., 2024). Less is known, however, about the impact of these models on women at higher risk of complications or with social risk factors, such as stressful life events. Moreover, benefits of MCOC could have an ongoing ripple effect into the postnatal period, with potential to improve infant development. However, studies examining the effects of models of care on infant development remain scant.

The enduring associations between exposure to maternal distress in pregnancy (stress, anxiety, depression) on infant neurodevelopment and behaviour are well-established (van den Bergh et al., 2017). One behavioural outcome has been extensively investigated and linked to prenatal maternal distress: infant negative emotionality, a temperament trait observable very early in life, marked by fear, distress, and sadness. High negative emotionality increases risk three-to seven-fold for clinical anxiety, the most common mental health problem for children (Clauss and Blackford, 2012; Muris and Ollendick, 2006). Beyond maternal anxiety, depression and stress of significant life events (e.g. bereavement), previous research has demonstrated associations between severity of exposure to, and distress from, natural disasters in pregnancy, and infant and aspects of toddler negative emotionality (Lipschutz et al., 2024; Zhang et al., 2018; McLean et al., 2019). In contrast, research to date has demonstrated mixed support for a direct relationship between COVID-19 distress and infant negative emotionality (Buthmann et al., 2022; Sacchi et al., 2023). This may reflect failure to account for the quality and continuity of maternity care during the pandemic.

The protective role of MCOC models during situations of high environmental stress for both mother and infant has been previously demonstrated by researchers in Australia (Kildea et al., 2018; Simcock et al., 2018). Following the 2011 Queensland floods, women enrolled in a large randomised controlled study of the benefits of MCOC (M@NGO, Tracy et al., 2013) were invited to participate in a prospective cohort examining the effects of the flood on their wellbeing and that of their unborn infant. For women in standard care that has little continuity, the greater the prenatal maternal hardship (i.e., greater severity of exposure to threat, loss, scope and change due to the flood) or subjective distress (peri- and post-traumatic response to flood hardship), the more severe their postpartum depression. Yet, no such association was found among women receiving MCOC (Kildea et al., 2018). Moreover, infants of women enrolled in MCOC displayed better socio-emotional outcomes than those in standard care (Simcock et al., 2018). MCOC buffered postnatal depression and improved infant neurodevelopment for women pregnant at the time of a large-scale, random stressor.

In our recent work, private midwifery, compared with standard care, was linked to better postpartum mental health and infant birth outcomes in the context of pandemic-related stress (Lequertier et al., 2024; McLean et al., 2024). Still, variation in carer-woman relationships, for example, how well the carer knows and shows commitment towards the woman, affect how she experiences continuity (Perdock et al., 2018). Given that social support buffers the effects of PNMS (e.g. Kroska et al., 2018), and that continuous midwifery models foster emotional support (Allen et al., 2019; Forster et al., 2016) and trust (Boyle et al., 2016), a woman's subjective experience of continuity of care may provide additional insights as to the benefits of continuity of care in relation to PNMS and child outcomes. This may be especially so in the context of the pandemic, where pandemic restrictions varied across different models.

There is a dearth of research examining whether continuity of maternity care models and experience benefit infant outcomes, as well the impact of these models on women with social risk factors such as perinatal stressors. The COVID-19 Pandemic represents a rare opportunity to address these knowledge gaps. The COVID-19 Pandemic was a global disaster. The outbreak of COVID-19 sudden, globally pervasive, and largely beyond individuals' ability to predict, prevent, or personally control exposure or its societal consequences. Such uncontrollable stressors affect large numbers of women of all sociodemographic backgrounds and heritable traits (e.g. anxiety and depression). That is, extent of stress exposure is random. This quasi-experimental study design affords researchers the ability to examine the unique effects of maternal disaster-related objective hardship (level of exposure to the event, e.g. financial loss, threat to self and family) and distress, independent of these well-established contributors to child outcomes (King et al., 2021; McLean et al., 2018; King et al., 2012).

Consistent with this framing, the COVID-19 pandemic disproportionately affected vulnerable populations including pregnant women (Berthelot et al., 2020; Lebel et al., 2020). In Australia, despite low infection rates, social restrictions were tightly enforced. Consistent with other findings (Davis et al., 2023), our group showed that 40 % of women pregnant at commencement of the first lockdown on March 22, 2020 experienced clinical levels of depression in the perinatal period (Lequertier et al., 2022).

Here, we examine whether actual models of care provided, and/or women's perceived experience of continuity, buffer the relationship between PNMS during the COVID-19 pandemic and infant negative emotionality at age 6-months. We hypothesized that:

1) greater PNMS (Objective Hardship, Subjective Distress, negative Cognitive Appraisal) would predict higher infant negative emotionality at age 6 months;,
2) The relationship between greater PNMS (Objective Hardship, Subjective Distress, negative Cognitive Appraisal) and infant negative emotionality at age 6 months would be moderated by (a) model of maternity care and/or (b) experienced continuity of care. Specifically, any adverse association(s) between PNMS and infant negative emotionality will be attenuated for pregnant women (a) enrolled in continuous models of midwifery care (private midwifery, public midwifery) but not standard care, GP shared care or continuity of care with a private doctor, and (b) who reported experiencing greater continuity of care (being known by/commitment from care provider).
3) Enrolment in continuous models of care, and/or greater experienced continuity of care, would be most beneficial for infants of mothers who reported greater COVID-19 related PNMS.

This natural experiment offers insights into the potential benefits of continuity of care (COC) in the face of uncontrollable stressors during pregnancy that could predict infant development, independent of heritable traits like maternal anxiety or depression. As such, the findings of this study may generalise to other personal or population-level sudden-onset stressors.

Methods

Participants and procedures

The current study is part of the Birth in the Time of COVID (BITTOC) study. The BITTOC study is a longitudinal, prospective cohort study of child-bearing women from across Australia recruited during the pandemic. Recruitment through social media and Australian maternity and parenting websites occurred: August 2020-February 2021. Women were included in the study if they were pregnant or had given birth to a

singleton live baby since the start of the pandemic in Australia (March 20, 2020), lived in Australia at the time of reporting, spoke English and were over 18 years old. Surveys were scrutinized to remove bots and probable fraudulent respondents based on several criteria (DeSimone et al., 2015; Storozuk et al., 2020), including time of survey completion, univariate outliers, discrepancy between measures that assessed similar constructs at the same time point (e.g. scores on the Edinburgh Postnatal Depression Scale and the Depression, Anxiety and Stress Scale), and male sounding names. Participants had to meet 3 or more criteria to be excluded.

Of 3048 who completed an online survey via Qualtrics, an online survey platform, at recruitment, a total of 991 responded with data on COVID-19 related hardship again at 6 months post-partum. Given study aims centred on models of care, and that women do not typically meet their care provider prior to 20 weeks gestation, pregnant women in their first trimester were excluded leaving 907 participants. Four mother-infant dyads were excluded due to the infant being born extremely preterm (<29 weeks gestation), resulting in a final sample of $N = 903$ (278 pregnant at recruitment). A flowchart of participation is detailed in Supplementary, Figure 1. Participant consent was obtained at both recruitment and 6-month postpartum surveys. Ethical approval was received from Western Sydney University (#H13825) and Charles Darwin University (#H21052).

Measures

Pregnancy PNMS

Objective hardship. At recruitment, objective hardship was measured by '*The BITTOC Assessment of Stress due to COVID-19 150*', hereafter referred to as the *BASC150*. We developed this scale by modelling it on instruments our team has previously created to capture objective exposures during environmental disasters (www.mcgill.ca/spiral), including the 1998 Québec ice storm (Laplante et al., 2007), the 2008 Iowa floods (Brock et al., 2014), the 2011 Queensland flooding (King et al., 2015), the 2016 Fort McMurray wildfires in Alberta (Olson et al., 2019), and the 2017 Houston floods following Hurricane Harvey (Paquin et al., 2022). Each iteration is custom-built to reflect the characteristic experiences associated with the specific event. Item content is designed to capture at least three domains of disaster-related hardship—threat, loss, and change (Bromet and Dew, 1995)—and items are pre-tested to strengthen face validity where necessary. A multidisciplinary team then collaboratively assigns weights to item responses to reflect the relative severity of hardship and to ensure that each hardship domain contributes an equivalent possible maximum score. Consistent with earlier developed measures of objective hardship (Brock et al., 2014Kildea et al., 2018), BASC150 predicts maternal postpartum mood (Lequertier et al., 2024Di Paolo et al., 2022).

Tailored specifically to the BITTOC study, the *BASC150*, assesses the levels of Threat (e.g. COVID-19 symptoms of self, family or friends), Loss (e.g. financial loss), and Change (e.g. change in daily routines, employment) due to the pandemic, with a maximum score of 50 points per category (for the full list of items and their scoring see McLean et al., 2024; Di Paolo et al., 2022). The 50 points allocated to Change were separated into pregnancy-related changes (35 points) and non-pregnancy-related changes (15 points). This resulted in two measures: Pregnancy-related Change (e.g. change to pregnancy plans; maximum 35 points) and *The BITTOC Assessment of Stress due to COVID-19 115 (*BASC115) which included the remainder of the BASC150 items (maximum 115 points, i.e., 150 minus 35). Possible Pregnancy-related change scores range from −3 to 35, with higher scores indicating greater change. BASC115 scores range from −3 to 115; a higher score on BASC115 indicates greater objective hardship and a negative score indicates improvement of situation during the pandemic.

Subjective distress. The BITTOC SubjectiveDistress200 scale assessed the mothers' subjective distress during pregnancy due to the COVID-19 pandemic, including Non-Pregnancy Subjective Distress and Pregnancy-related Subjective Distress. Higher scores reflect a greater level of subjective distress, with a maximum score of 200 points (Di Paolo et al., 2022). This total scale has good internal consistency (Cronbach alpha = 0.89).

Cognitive appraisal. At recruitment, we assessed the women's cognitive appraisal of the pandemic: "Overall, what would you say have been the consequences of COVID-19 on you and your household?" Response options ranged from a score of 1 (*extremely positive*) to a score of 7 (*extremely negative*). As in prior natural disaster PNMS studies from our group that have used this measure (for a review see King et al., 2021), the scores were categorised into negative and neutral/positive categories. Scores 1 to 4 were recoded as 0 (*neutral/positive*) and scores 5 to 7 were recoded as 1 (*negative*).

Model of maternity care

At recruitment, women reported on their maternity care provider and model of maternity care. Models of maternity care were categorised into 6 groups according to the Maternity Care Classification System (Donnolley et al., 2016) (see Table 1).

Experience of continuity of care

At recruitment, women completed the Nijmegen Continuity Questionnaire (NCQ; Uijen et al., 2011) which measures a woman's experienced continuity of maternity care. We included two "Personal Continuity" subscales: "Care provider knows me" and "Care provider shows commitment". Women responded to 5 items for each subscale on a Likert scale of 1 (*strongly disagree*) to 5 (*strongly agree*) with 3 indicating *neutral*. Greater level of experienced continuity of care is indicated by higher mean ratings for each subscale.The NCQ was found to be reliable at development α=0.82–.89 and demonstrates good construct and discriminative validity (Uijen et al., 2011). Follow-up validation of the measure demonstrated strong test-retest intercorrelation coefficients = 0.71–0.82 (Uijen et al., 2012). In our sample, "Care provider knows me" and "Care provider shows commitment" demonstrated good internal consistency (Cronbach's alpha 0.88, 0.82).

Maternal COVID-19 related stress and mood at 6 months postpartum

Objective Hardship. Effects of hardship (Change, Loss, Threat) related to the pandemic since the birth of the baby were captured by BASC150 6 Months. Items regarding pandemic Loss matched those included in BASC150, however, items on the Change subscale differed to those in the recruitment survey to capture change since the birth: Non-baby-related change (15 points) and Baby-related (35 points). The BASC150 6 months included an additional item on the Threat subscale asking women if their baby had been tested for COVID-19 (yes = 5). Possible BASC150 6 Months scores ranged from −3 to 150, with higher scores indicating greater hardship since the birth of the baby. Items and scoring are detailed in Supplementary Table 1.

Subjective Distress. We adapted the SubjectiveDistress200 scale to measure a woman's overall experience of subjective distress due to the pandemic since the birth of her baby. The scale, SubjectiveDistress200 6 Months, included two subscales: Non-baby Subjective Distress and Baby-related Subjective Distress. Non-baby Subjective Distress items were identical to those in SubjectiveDistress200 while Baby-related Subjective Distress items captured stress related to care of the infant during COVID-19. Each subscale had a maximum score of 100 (Supplemental Table 2) summed for a total possible score of 200 on SubjectiveDistress200 6 Months. Higher scores indicated greater COVID-19 related subjective distress at 6 months postpartum. Cronbach's alpha of 0.90 demonstrates the good internal consistency of this measure.

Maternal depression. Maternal 6-month depression was assessed via the Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987).

Table 1
Description of models of maternity care in Australia (key differences in bold).

	Model of maternity care	Antenatal care	Intrapartum/Early postnatal care	Postnatal care
Fragmented Care	Standard care	Provided in hospital outpatient clinics by midwives and/or doctors. Care could also be provided by a multidisciplinary team.	Provided in a private or public hospital by rostered hospital midwives and doctors (likely to have never met the woman).	Provided in the hospital by rostered hospital midwives and doctors, and may continue in the home or community (likely by unknown care providers and possibly by phone/ telehealth, rarely past 2-weeks).
	General practitioner (GP) shared care	Provided by a community maternity service provider with hospital medical and midwifery staff. Care occurs in the community and in outpatient clinics.	Intrapartum (labour and birth) and postnatal care are provided in the hospital by rostered hospital midwives and doctors, not known providers.	
Continuous Care	Continuity of care with a doctor	Provided by a private specialist obstetrician. Midwives may work in the obstetrician's practice but rarely are available to provide care in labour and birth.	Provided in a private or public hospital by the private specialist obstetrician or his back up (often work in teams) in collaboration with hospital midwives who may not have met the woman (known doctor usually attends the birth and may attend during labour but not for the duration).	Occurs in the hospital by the private specialist obstetrician and hospital midwives and may continue in the obstetrician's rooms after discharge at 6 weeks postnatally.
	Private midwifery care	Antenatal, intrapartum, and postnatal care provided by a private midwife/s, with doctors in the event of identified risk factors. Care, including antenatal, labour and birth, could be provided in a range of locations, including the home, by a known provider. Postnatal care is usually provided up to 6-weeks in the home by a known provider.		
	Continuity of care with a public midwife	Antenatal, intrapartum (labour and birth), and postnatal care are provided within a publicly-funded caseload model by a known primary midwife with secondary backup midwives (team of 4–6) to assist. Midwives work in collaboration with doctors when risk factors are present. Care is provided in the hospital, community, or home. Intrapartum care may be provided in birthing centers and should be by known care providers. Postnatal care is usually provided up to 6-weeks in the home by the known midwife.		

Note: Table adapted from (Donnolley et al., 2016).

The EPDS is a self-reported 10-item gold-standard questionnaire rating the experience of symptoms over the past week, with each question being scored on a 0–3 point scale for a maximum of 30 points. EPDS scores ≥13 reflect clinically significant depressive symptoms. The EPDS has strong criterion validity, broad cross-cultural use and is highly reliable (Levis et al., 2020); Cronbach's alpha 0.88 in our sample.

Infant temperament at 6 months

At 6 months postpartum, mothers reported on their infants' temperament via the Infant Behaviour Questionnaire–Revised Very Short Form (IBQ-R VSRF; Putnam et al., 2014). This widely used questionnaire includes 37 items on a Likert scale of 1 (*never*) to 7 (*always*). The measure assesses three domains of infant temperament: Positive Affectivity/Surgency, Negative Emotionality, and Orienting/Regulatory Capacity. Scale scores were calculated as the mean of scale items, after reverse-scoring items as outlined in Putnam et al. (2014). The three domains have shown acceptable internal consistencies (α's ≥ 0.75) and convergent/predictive validity. Here, we used the Negative Emotionality subscale, analogous to the personality trait of Neuroticism. The Negative Emotionality score is the mean of 12 items that ask questions such as "At the end of an exciting day, how often did your baby become tearful?" Higher scores on this subscale represent a more "difficult" temperament and are generally thought to be maladaptive. Cronbach's alpha for this subscale within the current sample was 0.82.

Demographic variables

At recruitment, women reported on their level of education, combined household income and language spoken at home. Maternal age and baby gestational age at birth were reported at 6 months postpartum. These demographic variables were coded as described in Table 2.

Statistical analysis

Analyses run in R studio version 4.2.2. Data were not imputed, as only two variables, 'Care Provider knows me' and 'Care Provider shows commitment' had missing data (4.9 % and 4.4 % respectively). Because missingness was low (<5 %) and unlikely to meaningfully influence parameter estimates (Allison, 2010; Little and Rubin, 2002), participants with missing data on these variables were excluded from relevant analyses and no sensitivity analyses run. Descriptive analyses and associations among study variables using Pearson correlation and ANOVA were run. A hierarchical linear regression was run via R package *lme* to examine relationships between infant negative emotionality at age 6 months and each predictor (BASC115, Pregnancy-related Change, Subjective Distress, Cognitive Appraisal). Interaction analyses tested product terms between PNMS and (a) model of maternity care and (b) experienced continuity of care (Hypothesis 2, 3). To test Hypothesis 2, we determined whether relationships between PNMS variables and infant negative emotionality at 6 months were moderated by (a) model of maternity care and/or (b) experienced continuity of care. Under a buffering/attenuation pattern, the PNMS–negative emotionality slope is expected to be smaller (attenuation; less positive) or show no relationship (buffering; non-significant effect) in models characterized by greater relationship-based support and at higher continuity. For significant interactions, we used the Johnson–Neyman (J–N) procedure, conditioning on PNMS, to locate the PNMS threshold(s) at which the

Table 2
Sample characteristics.

Study Variables	N (%)
Level of education	
High school certificate and below	70 (8)
Technical And Further Education (TAFE) or diploma	143 (16)
Undergraduate degree	365 (40)
Graduate degree	325 (36)
Maternal age at birth (years)	
<24	19 (2)
25–34	609 (67)
35+	275 (31)
Relationship status	
Married/De-facto	
Single/Separated/Divorced/Other	884 (98)
19 (2)	
Combined household income	
< $ 100 000	189 (22)
> = 100 000	665 (78)
Language spoken at home	
English	836 (93)
Other	67 (7)

care-context effect on infant negative emotionality was statistically significant. We did this for continuity of care (treating continuity as the focal predictor across PNMS) and for the model of maternity care, estimating the PNMS values where the between-model difference was significant. To test Hypothesis 3, whether continuity/model of care is most beneficial at higher PNMS (greater hardship, distress), we applied the J-N procedure to the interaction analysis: PNMS was the moderator variable, enabling estimation of the PNMS value(s) at which the conditional effect of continuity of care (and the difference between maternity care models) on infant negative emotionality becomes statistically significant. Simple slopes of the predictor trend at each level of the factor were probed using R packages *interactions* and *emmeans*. Models controlled for covariates that were $p < .10$ correlated with the outcome variable, resulting in models controlling for BASC150 6 months, Subjective Distress and Depressive symptoms at 6 months. See Supplementary Table 3 and Results for full list of covariates tested for inclusion in current study.

Statistical significance was defined as alpha < 0.05. Models met all assumptions. Analyses were exploratory and therefore we did not control for multiple comparisons.

Results

Participant sample characteristics are reported in Table 2 and descriptives of study variables in Table 3. Women were well educated, and mostly English speakers. Women receiving private midwifery care represented the smallest group, while roughly one-third-received continuity of care with a private doctor and another third, standard hospital care. Most women had positive experiences of continuity in their maternity care, with 70 % of women reporting NCQ scores above 3 (neutral). During pregnancy, 20% of women reported clinically significant depressive symptoms, while at 6 months this number decreased to 16%.

In Supplementary Table 3 we present correlations among study variables. Women who were exposed to greater objective hardship reported greater COVID-related subjective distress. Measures of BASC115 and SubjectiveDistress200, but not Pregnancy-related Change or Cognitive Appraisal, were related to infant negative emotionality at age 6 months such that greater maternal COVID-19 related objective hardship and subjective distress in pregnancy predicted greater infant negative emotionality at age 6 months. Neither of the two continuity of care variables nor model of maternity care were significantly related to infant negative emotionality at age 6 months. At 6 months, maternal objective hardship, subjective distress and depressive symptoms were positively correlated with concurrent infant negative emotionality. While demographic variables were associated with predictor variables, none were related to infant negative emotionality.

Importantly, BASC115, reflecting the degree of non-baby-related objective hardship, did not differ by maternity care provider, F(4, 899) = 1.07, $p = .369$. Scores on NCQ subscales "Care provide knows me" (F(4, 855) = [86.51], $p < .001$, R2 = 0.29) and "Care provider shows commitment" (F(4, 859) = [90.48], $p < .001$, R2 = 0.30) significantly differed by care provider group. Across both NCQ subscales, continuous models of care (Private midwife, Continuity of care with a public midwife, Continuity of care with a private doctor) reported higher continuity than those in non-continuous models (GP shared care and standard care); see Supplement for complete reporting.

Table 3
Descriptive statistics of study variables.

	M (SD)	Range (min, max)
Pregnancy		
BASC115	16.82 (12.30)	−3, 63
Pregnancy-related change	6.30 (4.46)	−1, 26
SubjectiveDistress200	68.17 (30.45)	1, 164
Cognitive Appraisal, negative, n (%)	564 (63)	
6-months		
Infant Negative emotionality	3.74 (0.99)	1.25, 6.91
Objective Hardship	22.83 (14.91)	−3, 82
Subjective Distress	53.21 (31.54)	0, 180
Maternal depression	6.74 (5.27)	0, 25
Model and experience of care		
Model of maternity care (n (%))		
Standard care	312 (35)	
Continuity of care with a public midwife	162 (18)	
Continuity of care with a private doctor	313 (35)	
GP shared care	67 (7)	
Private midwifery care	50 (5)	
Personal Continuity (M (SD))		
Care provider knows me, n = 860	3.77 (1.16)	1–5
Care provider shows commitment, n = 864	3.76 (1.15)	1–5

Hypothesis 1: PNMS and infant temperament

As reported in Models 1, 2 and 3 of Table 4, BASC115, but not Pregnancy-related Change nor Cognitive Appraisal, significantly predicted infant negative emotionality at 6 months. Once SubjectiveDistress200 was added (Model 4), it remained the only significant predictor of the outcome, with greater subjective distress in pregnancy predicting greater infant negative emotionality at 6 months (3.7 % variance explained). BASC150 6 Months was unrelated to the outcome (Model 5). Marginal effects of greater maternal subjective distress and depressive symptoms at 6 months in relation to concurrent infant negative emotionality were evident (Model 7). The final model was significant (F(7, 894) = 6.22, $p < .001$) and accounted for 4.6 % of the variance in outcome. In summary, controlling for objective hardship, greater subjective distress in pregnancy is related to greater infant negative emotionality.

Model 1:

Hypothesis 2a: PNMS, model of care and infant temperament

In predicting infant negative emotionality, there were no significant interactions between care provider and BASC115 ($F(4, 886) = 0.59$, $p = .673$, 95 % CI [−0.03, 0.01]), Pregnancy-related Change ($F(4, 886) = 1.96$, $p = .098$, 95 % CI [−0.09, 0.47]), Subjective Distress in Pregnancy, ($F(4, 886) = 1.76$, $p = .134$) or Cognitive Appraisal ($F(4, 886) = 2.37$, $p = .051$, 95 % CI [−1.13, −0.01]).

Hypothesis 2b: PNMS, experienced continuity of care and infant temperament

Care provider knows me. No significant interactions were found between Care provider knows me and Pregnancy-related Change (F(9, 848) = 0.02, $\beta = 0.004$, $B = 0.0008$, SE = 0.006, $t = 0.129$, $p = .898$), Cognitive Appraisal (F(9, 848) = 0.33, $\beta = -0.019$, $B = -0.34$, SE = 0.058, $t = -0.58$, $p = .563$), or SubjectiveDistress200, (F(9, 848) = 0.17, $\beta = -0.014$, $B = -0.0004$, SE = 0.001, $t = -0.42$, $p = .674$).

Results demonstrated a significant interaction between scores on Care provider knows me and BASC115 in relation to infant negative emotionality, F(9, 848) = 4.49, $p = .034$; Table 5, Fig. 1. At all values of Care provider knows me, BASC115 was not significantly related to infant negative emotionality. Region of significance testing identified that at higher levels of BASC115 (scores of 30.79 and greater), greater scores on Care provider knows me significantly predicted lower scores on infant negative emotionality at 6 months, ($B = -0.086$, SE = 0.04, 95 %CI [−0.171, −0.000]). In contrast, at lower levels of BASC115, the relationship between Care provider knows me and infant negative emotionality at 6 months was not significant. The full model accounted for 5.2 % of the variance in the outcome and was significant, F(9, 848) = 5.29, $p = <0.001$.

Care Provider shows commitment. There were no significant interactions between Care Provider shows commitment and BASC115 (F(9, 852) = 1.82, $\beta = -0.046$, $B = -0.003$, SE = 0.002, $t = -1.35$, $p = .178$), Pregnancy-related Change (F(9, 852) = 0.01, $\beta = 0.002$, $B = 0.0004$, SE = 0.006, $t = 0.08$, $p = .939$), Cognitive Appraisal (F(9, 852) = 0.05, $\beta = -0.007$, $B = -0.01$, SE = 0.06, $t = -0.213$, $p = .831$), or

Table 4
PNMS in relation to infant negative emotionality at 6 months.

Negative emotionality at age 6 months							
	β	B[a]	SE[b]	t-value	p-value	R-square	R-square change
	Model 1: BASC115						
Intercept	0	3.602	0.055	65.488	0		
BASC115	0.089	0.007	0.003	2.692	0.007	.008	.008
			Model 2: Pregnancy-related Change added				
Intercept	0	3.578	0.066	54.209	0		
BASC115	0.084	0.007	0.003	2.46	0.014		
Pregnancy-related Change	0.023	0.005	0.007	0.661	0.509	.009	.001
			Model 3: Cognitive Appraisal added				
Intercept	0	3.544	0.073	48.537	0		
BASC115	0.079	0.006	0.003	2.308	0.021		
Pregnancy-related Change	0.018	0.004	0.008	0.528	0.598		
Cognitive Appraisal	0.036	0.074	0.068	1.076	0.282	.01	.001
			Model 4: Subjective Distress in Pregnancy added				
Intercept	0	3.334	0.083	40.001	0		
BASC115	0.009	0.001	0.003	0.245	0.806		
Pregnancy-related Change	−0.047	−0.01	0.008	−1.303	0.193		
Cognitive Appraisal	−0.007	−0.014	0.07	−0.207	0.836		
Subjective Distress in pregnancy	0.205	0.007	0.001	5.024	<0.0001	.037	.027
			Model 5: BASC150 6 months added				
Intercept	0	3.323	0.085	39.195	0		
BASC115	−0.002	−0.0002	0.003	−0.054	0.957		
Pregnancy-related Change	−0.047	−0.01	0.008	−1.299	0.194		
Cognitive Appraisal	−0.009	−0.018	0.07	−0.25	0.802		
Subjective Distress in pregnancy	0.198	0.006	0.001	4.697	<0.001		
BASC150 6 months	0.03	0.002	0.003	0.75	0.453	.037	.000
			Model 6: Subjective Distress 6 months added				
Intercept	0	3.312	0.085	39.113	0		
BASC115	0.01	0.001	0.003	0.259	0.796		
Pregnancy-related Change	−0.045	−0.01	0.008	−1.228	0.220		
Cognitive Appraisal	−0.019	−0.039	0.07	−0.554	0.58		
Subjective Distress in pregnancy	0.147	0.005	0.002	3.139	0.002		
BASC150 6 months	−0.018	−0.001	0.003	−0.405	0.685		
Subjective Distress 6 months	0.113	0.003	0.001	2.428	0.015	.044	.006
			Model 7: Depressive symptoms 6 months added				
Intercept	0	3.288	0.085	38.559	0		
BASC115	0.007	0.001	0.003	0.178	0.858		
Pregnancy-related Change	−0.042	−0.009	0.008	−1.162	0.246		
Cognitive Appraisal	−0.014	−0.029	0.07	−0.414	0.679		
Subjective Distress in pregnancy	0.133	0.004	0.002	2.801	0.005		
BASC150 6 months	−0.02	−0.001	0.003	−0.446	0.656		
Subjective Distress 6 months	0.092	0.003	0.001	1.938	0.053		
Depressive symptoms 6 months	0.068	0.013	0.007	1.858	0.063	.046	.002

[a] Unstandardised β, unstandardized regression coefficient;.
[b] Standard Error of B.

Table 5
Model summary for interaction between care provider knows me and BASC115 in relation to infant negative emotionality at age 6 months.

	B	SE	t-value	p-value
Intercept	3.041	0.216	14.09	0
BASC115	0.018	0.010	1.877	.061
Pregnancy-related Change	−0.009	0.009	−1.018	.309
Cognitive Appraisal	−0.055	0.072	−0.767	.443
Subjective Distress in pregnancy	0.005	0.002	2.883	.004
BASC150 6 months	−0.001	0.003	−0.246	.806
Subjective Distress 6 months	0.002	1.835	0.067	.003
Depressive symptoms 6 months	0.012	0.007	1.686	.092
Care provider knows me	0.069	0.051	1.364	.173
BASC115 * Care provider knows me	−0.005	0.002	−2.118	.034

SubjectiveDistress200 ($F(9, 852) = 1.23$, $\beta = 0.039$, $B = 0.001$, SE = 0.001, $t = 1.11$, $p = .268$) in relation to infant negative emotionality at age 6 months.

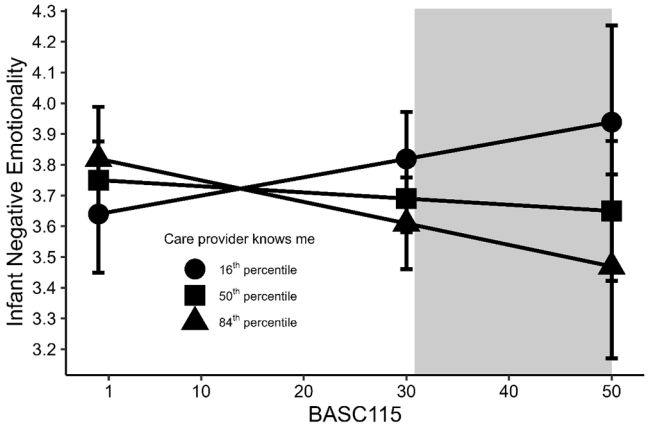

Fig. 1. The significant interaction between Care provider knows me and BASC115 in relation to infant negative emotionality.
Note: Care provider knows me 16th percentile = 2.4, 50th percentile = 4, 84th percentile = 5, error bars represent standard error (SE).

Discussion

We demonstrate the benefits of women's experience of continuity of care from their care provider for infants exposed to high levels of in-utero maternal hardship related to a random, independent stressor,

using data from a prospective, longitudinal cohort of women pregnant during the COVID-19 pandemic in Australia. Our novel study demonstrates that benefits of continuity in maternity care models extend well beyond pregnancy and early postpartum, and are associated with a key child outcome, particularly in the context of stressful life events in pregnancy. Greater prenatal subjective maternal distress was also related to greater infant negative emotionality. While final models accounted for only 4–5 % of variance in infant negative emotionality, effects are comparable to the broader prenatal stress literature (McLean et al., 2019). Despite modest variance explained, such early effects can be consequential at scale through cumulative and interactive processes, particularly given that our outcome captures the earliest expression of temperament in infancy. Moreover, while the clinical significance of this magnitude is uncertain in the absence of a minimally clinically important difference for infant temperament, Our results are important for women, children, and society at large, given that infant negative emotionality is a key etiological risk-factor of anxiety and depressive symptoms (Muris and Ollendick, 2006) - prevalent mental health problems that come with considerable economic cost (Pollard et al., 2023). Our finding supports the roll-out of maternity care models that foster relational continuity for at-risk pregnant women with both additional medical (Fox et al., 2023) and psychological needs (Cummins et al., 2023). Our results could, as well, generalise to any major life event during pregnancy: being well known by the maternity care provider appears to buffer the effects of such effects on the developing fetus.

Our most important finding suggests that dyads exposed to greater COVID-19 objective hardship in pregnancy may benefit most from a positive experience of continuity of care. Specifically, for women exposed to greater COVID-19 related hardship during pregnancy, a greater sense that their care provider knew them across the perinatal period was related to fewer displays of infant negative emotionality at age 6-months. However, women who reported less COVID-19 related hardship during pregnancy did not have the same benefits from experienced continuity of care. Rather, infants born of these mothers displayed less negative emotionality (albeit not statistically different), regardless of their experience of continuity of care.

This work extends that of studies examining PNMS resulting from the 2011 Queensland floods (QF2011) (Kildea et al., 2018; Simcock et al., 2018). Benefits of midwifery continuity of care for postnatal maternal mental health (Kildea et al., 2018; Lequertier et al., 2024) extend to infant development (Simcock et al., 2018) across large-scale, random life stressors or ‘disasters’. In addition, research demonstrates that women enrolled in midwifery continuity of care had positive experiences during the pandemic (Kluwgant et al., 2022), had higher levels of experienced continuity of care (McLean et al., 2024) and better immediate birth outcomes relative to other models of care (McLean et al., 2024).

Here, we demonstrate that the quality of experienced continuity of care, not only the model of care, is important for infant development. Together with Australian and International research examining demographic risk factors (e.g., maternal age, ethnicity, social risk), our work demonstrates that provision of continuity of care may be particularly beneficial for women who are most at risk (Allen et al., 2015; Kildea et al., 2019; McLachlan et al., 2022; Rayment-Jones et al., 2021; Tracy et al., 2013). Given that women enrolled in continuous models of care reported experiencing greater continuity than standard care, our finding supports qualitative work (Allen et al., 2015) and quantitative work (Kildea et al., 2021) in Australia as well as the most recent Cochrane review (Sandall et al., 2024). This prior work suggest that the benefits of continuity of care for those most at-risk are primarily due to the relational component of the partnership that develops between women and their care provider.

For a woman exposed to significant hardship during the pandemic, feeling “known” and remembered such that their care provider knows of their daily activities, medical history and relevant medical data and familial circumstances, may increase advocacy and engagement in health services as well as ensure the woman feels supported and safe to disclose important information that increases relevant health care support (Fernandez Turienzo et al., 2021; Perriman et al., 2018). A trusting relationship and engagement in services were likely particularly important for maternal wellbeing at the time of recruitment for this study, during the first major lockdown in Australia. At this time, social restrictions were widely enforced, and maternity care service delivery was disrupted. This proposed mechanism is consistent with UK findings in specialist continuity teams for women with social risk. Continuity reduced anxiety, fostered trust and built a supportive network. Woman-midwife partnerships were shown to facilitate timely help-seeking, with women reporting that known midwives understood their medical and social history, which enhanced perceived safety (Rayment-Jones et al., 2023). This supported engagement with services and create opportunities for earlier prevention and management. Cross-country systematic review evidence also highlights processes consistent with the pathway we propose here: targeted models that embed continuity of carer appear to reduce inequities by activating trust, advocacy, and timely help-seeking within accessible, culturally attuned services (Khan et al., 2023).

Although research is sparse, greater perceived social support has been demonstrated to buffer the negative associations between PNMS and infant birthweight (Kroska et al., 2018), infant physiological stress (Luecken et al., 2013), unpredictability (Takács et al., 2021), and ADHD symptoms (Zhu et al., 2015). Here, we demonstrate that a formal source of social support, experienced continuity of maternity care, may reduce displays of infant negative emotionality, a key vulnerability factor for childhood emotional disorders (Clauss and Blackford, 2012; Muris and Ollendick, 2006), in the face of elevated maternal pandemic-related hardship. Prenatal distress may reduce mother-infant bonding and caregiving sensitivity, with meta-analytic evidence linking antenatal distress to postpartum bonding problems (O’Dea et al., 2023; Vega-Sanz et al., 2025). These effects could be long-lasting. In prior disaster PNMS research, McLean et al. (2021) demonstrated that greater maternal subjective stress in pregnancy was related to more parent over-involvement at age 4-years, a maladaptive parenting behaviour associated with the development and maintenance of childhood anxiety (Möller et al., 2016). Care models that help women feel trusted and supported may plausibly enhance early mother-infant bonding, caregiving sensitivity and attachment. This offers a plausible pathway to lower infant negative emotionality and more adaptive socio-emotional trajectories. Population-based evidence from Australia shows that changes in caregiving sensitivity are associated with shifts in attachment security across 1–4 years, indicating a modifiable relational route to early socio-emotional adaptation (McIntosh et al., 2024). Meta-analytic work further positions early attachment to later socio-emotional outcomes (Groh et al., 2012), supporting the plausibility of this pathway. Even small gains in relational support during pregnancy may translate into meaningful early socio-emotional benefits.

Moreover, despite infant temperament being related to the mother’s sense of being known by the care provider, this finding did not extend to the level of commitment shown by the care provider or model of maternity care. Knowing a patient/client well is theorised to be a prerequisite for a care provider to demonstrate commitment (Uijen et al., 2011). However, given changes to how care was provided and the increased workload of care providers during COVID-19, demonstrations of commitment, such as unsolicited contact, may have been more difficult to engage in. Continuous models of care provide maternity care providers with more flexibility, autonomy and time than standard care, and therefore enable carers to go above and beyond to meet the needs of the individual (Allen et al., 2019) fostering a stronger therapeutic relationship. Midwifery-led models typically deliver greater continuity than doctor-led care (Perdok et al., 2018) and provide extended postnatal care through 6-weeks postpartum. However, the variability in changes to service provision across models of care during the pandemic may explain why our analyses of models of care did not show benefits of

continuous midwifery-led models (particularly public models) for infant outcomes relative to standard care as were found in the Queensland Flood Study (Simcock et al., 2018). Evident from qualitative analysis of women and care provider experiences, fewer changes to service provision due to COVID-19 government restrictions were evident for private midwifery and obstetrician models than continuity of care with a midwife in the public system. Restrictions, including increased use of telehealth and use of personal protective equipment (PPE), impacted care providers' ability to provide relationship-based care (Collins et al., 2024; Keedle et al., 2023). As well, women enrolled in continuity of care with a private midwife or obstetrician reported the greatest experienced continuity of care, suggesting continuous models of care in the private system were able to continue to deliver "above and beyond" care as usual. This may be due to the greater autonomy and control these providers had over the care they gave and ability to moderate some of the system changes enforced in public health. For public safety, changes to access and provision of maternity care services in future pandemics is inevitable. These data suggest that solutions are needed to ensure optimal continuity of care is provided while protecting care providers and women in the face of such disruptions for the benefit of women and their infants.

After controlling for the significant effect of objective hardship, greater subjective COVID-19 related PNMS was associated with poorer infant negative emotionality at age 6-months. Findings are consistent with literature which has established relationships between prenatal maternal stress, anxiety and depression during COVID-19 and dimensions of infant temperament (Buthmann et al., 2022; López-Morales et al., 2022; Provenzi et al., 2021; Sacchi et al., 2023; Saxbe et al., 2018). By comprehensively assessing and studying associations among child outcomes and various aspects of the maternal stress experience (Lazarus and Folkman, 1984) during pregnancy and at 6-months postpartum, our study contributes substantially to literature examining child outcomes associated with COVID-related PNMS. Given the specificity of our stress measures, and that subjective distress during pregnancy and not postnatal mood, contributed uniquely and most substantially to infant negative emotionality, we argue that this finding is not likely indicative of heritability potentially via shared neuroticism/negative emotionality mother-infant interactions (Dix and Yan, 2014; Weiss et al., 2023). We argue that our finding provides the strongest evidence to-date of in-utero programming of fetal neurodevelopment associated with maternal stress during the COVID-19 pandemic. Our current work is unable to determine the specific biological mechanism(s) through which prenatal maternal stress may alter fetal neurodevelopment; we direct the interested reader to van den Bergh (2017).

Finally, while greater experience of being known by continuity of care was associated with lower infant negative emotionality at age 6 months for those with the greatest hardship, the negative association between pregnancy subjective distress and infant negative emotionality was not buffered by continuity of care (neither model of care, nor experienced). Research suggests social support may dampen the relationship between exposure to a stressor and the subjective response (Brock et al., 2014; Li et al., 2021). It is plausible that experienced continuity of care acts in a similar fashion, dampening but not ameliorating the long-term effects of subjective distress on infant negative emotionality evident. Continuity of maternity care, as it was delivered during the pandemic, may not be sufficient to help buffer the negative effects of maternal subjective distress on infant negative emotionality. Psychological therapy is beyond the scope of maternity care providers. It is important to note that continuous models of care, including public and private midwifery, were not designed to counteract the long-term effects of traumatic events. Our findings highlight the importance of screening for pandemic-related distress amongst perinatal women to ensure women are offered specialised services where needed.

Our study is not without limitations. Potential selection bias cannot be ruled out due to recruitment online of a convenience sample of women who were relatively advantaged, white, and lived in urban settings. We chose to include both pregnant and postnatal women in the study cohort to maximise sample size of women pregnant and reporting during the first wave of COVID-19 in Australia. Randomized controlled trials are needed to extend on conclusions of the current study to rule out alternative explanations due to residual confounding and increase generalizability beyond the advantaged sample studied here. Due to the exploratory nature of analysis, findings require replication. Finally, although our parent-report measure of negative emotionality, IBQ-R VSF, is psychometrically robust and efficient for large, dispersed samples, parent-report and observational assessments (e.g., Infant Version of the Laboratory Temperament Assessment Battery [Lab-TAB]) correlate only modestly (Planalp et al., 2017). This indicates method-specific variance (accumulated behavior across everyday contexts vs standardized, elicited behaviour in the lab); future work could triangulate with observational paradigms to strengthen inferences about infant negative emotionality.

The strengths of this study are many, including the large longitudinal sample, focus on continuity of care during COVID-19 and the scrutiny of the data to eliminate bots and fraudsters. The assessment of both what happened to the women during the pandemic using relatively objective items reflecting hardship, and the women's subjective distress, allows the parsing of the effects of different aspects of their stress experience. The use of validated self-report instruments for maternal symptoms (EPDS) and experienced continuity of care (NCQ) is a strength of this study. Self-report is the recommended approach for perinatal mental health screening in routine obstetric and midwifery care in Australia, and these tools have established psychometric validity in perinatal populations. Such measures are particularly appropriate in a community sample without clinical diagnoses, enabling dimensional assessment of symptom severity and patient-experienced care processes that cannot be captured by administrative proxies.

Conclusion

Our findings support the potential for a woman's experience of continuity of care to positively impact infant behaviour for those who are exposed to the greatest level of hardship in the context of highly stressful life events such as a pandemic. Also, findings open an exciting and important research agenda: future longitudinal and pragmatic trials could test mechanistic pathways linking relational continuity to infant socio-emotional outcomes in at-risk dyads. Experiences of continuity of maternity care should be enabled and promoted for the maximal benefit of mothers and children, particularly when most vulnerable.

Data statement

Survey respondents were assured raw data would remain confidential and would not be shared.

Data not available / The data that has been used is confidential

CRediT authorship contribution statement

Mia A. McLean: Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization. **Belinda Lequertier:** Writing – review & editing, Methodology, Data curation. **Suzanne King:** Writing – review & editing, Validation, Methodology, Funding acquisition. **Sue Kildea:** Writing – review & editing, Methodology, Funding acquisition. **Hazel Keedle:** Writing – original draft, Methodology, Investigation, Funding acquisition, Data curation. **Hannah G Dahlen:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition.

Declaration of competing interest

The authors have no conflict of interests to declare

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Supplementary materials

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