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The Pandemial babies: effects of maternal stress on temperament of babies gestated and born during the pandemic

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Abstract
The COVID-19 pandemic may configure an adverse prenatal context for early development. The aim of this study was to analyze the effects of pandemic-related negative experiences, prenatal anxiety and depression on the temperament of six-month-old babies. The sample consisted of 105 mother–child dyads. A longitudinal evaluation was carried out using pre- and postnatal online surveys. Mothers completed the State-Trait Anxiety Inventory, the Beck Depression Inventory – II, the Pandemic Impact Questionnaire and the Infant Behavior Questionnaire Revised. Serial mediation models were tested, in which the pandemic-related negative experiences constituted the independent variable, the prenatal anxiety and depression were the mediators, and the children's temperament dimensions were the dependent variables. Pandemic-related negative experiences were indirectly associated with the offspring's negative affect and surgency through anxious symptomatology, which acted as a mediating variable. This was the first study to identify the effects of the COVID-19 pandemic on temperament. Such an adverse context implies risks for child development. Public health policies aiming to evaluate socioemotional variables during early childhood become necessary to allow on-time interventions for lessening these risks.

Keywords Temperament · Early development · Prenatal maternal stress · COVID-19

Introduction

Evidence suggests that current pandemic context could exacerbate the pre-existing vulnerability of certain population groups, such as pregnant women or young children, to suffer psychological distress (Holmes et al., 2020). This vulnerability could be further aggravated in low-and-middle-income countries (LMICs), since in environments characterized by inequity and disparity the pandemic is usually experienced as a chronic and extreme stressor (Gassman-Pines & Gennetian, 2020; Smith & Pollak, 2022).

The estimated prevalence of perinatal mental disorders in women in LMICs is 15.6% antenatally and 19.8% postnatally (Fisher et al., 2021), and it has been shown that these indicators increased during the COVID-19 pandemic, especially in LMICs (López-Morales et al., 2021). The pandemic context has introduced changes in medical routines and health assistance during pregnancy.

The vulnerability of pregnant women is given by the double impact of adversity. This means that negative impacts affect both them and their offspring (Madigan et al., 2018; Monk et al., 2021). Numerous studies have indicated that mental disorders during pregnancy increase preterm birth risk (Gemmill et al., 2019), generate a decrease in the birth weight of children and can cause intrauterine growth restriction (Grigoriadis et al., 2013), all of which increase the risks of infant mortality (D'Onofrio et al., 2013). On the other

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hand, depression and prenatal anxiety may also have negative effects on fetal and newborn development at physiological, cognitive, motor and emotional levels (Madigan et al., 2018); this generates greater predisposition to present future mental disorders, which could extend into childhood, adolescence and adulthood (Huizink et al., 2003; O'Donnell et al., 2014). Along these lines, the National Comorbidity Survey Replication Study estimated that exposure to adversity in early life could be associated with more than 30% of psychiatric disorders (Green et al., 2010), including depression and anxiety (Kingsbury et al., 2016; Wang et al., 2018). Other studies also suggest that early exposure to stress could be causally associated with underlying neural mechanisms that predispose to future psychopathologies (Lebel et al., 2016).

According to the *fetal programming hypothesis*, the prenatal period is a sensitive period for development, because the fetus has a physiological adaptation to the characteristics of the intrauterine environment in which it is developing (Barker & Osmond, 1986). The fetus responds to its uterine environment and to changes and disturbances in it, for example, those caused by prenatal maternal stress. Exposure to stressful physical and / or biological stimuli can have long-lasting effects on cognitive, emotional, neuroendocrine, and behavioral outcomes in humans (Lebel et al., 2016; Madigan et al., 2018; Monk et al., 2021). Since the central nervous system is developing during the gestational period, induced alterations in fetal physiology can modulate the programming of the developmental pattern of key tissues and organ systems (Gluckman et al., 2010). However, not all babies show developmental problems due to such exposure (Korja et al., 2017 Dec).

There are no studies to date that explore the effects of the pandemic context on offspring's early development, yet some previous experiences associated with health emergencies, catastrophes or natural disasters have shown that prenatal stress could have detrimental effects on mental health of pregnant women and on the well-being of their children (Cao-Lei et al., 2020). Historical events such as the Spanish flu during the 1918 pandemic (Almond, 2006), the Dutch Hunger Winter in 1944 or the Ice Storm in Quebec in 1998 (Yoshikawa et al., 2020), have shown that prenatal and early childhood stress associates with long-term consequences in cognitive and emotional development, such as lower cognitive, emotional and linguistic performance, decreased play abilities, and increased risk of developing psychopathological conditions—such as post-traumatic stress disorder, depression, anxiety and schizophrenia – (Monk et al., 2021; Yoshikawa et al., 2020).

Therefore, changes due to the current pandemic context could act as chronic stressors that increase the predisposition to suffer psychopathological symptoms, such as anxiety and depression during pregnancy. These symptoms could introduce changes in the trajectories of fetal development that, ultimately, could alter the adaptive behaviors of the offspring, among them, the processes related to the reactivity and stress regulation patterns of newborns.

In this sense, the study of early temperament is of special interest. Early temperament is defined as the particular differences in constitutional reaction and self-regulation that can be observed in children's emotionality, activity and attention (Rothbart, 2007). Reactivity refers to the tendency of an individual to exhibit arousal to stimuli, and self-regulation is the process by which this reactivity is modulated (Kohnstamm et al., 1989). Rothbart (Rothbart, 2007) proposes three dimensions of temperament: (1) *surgency*, which combines the disposition towards positive emotions, quick approach towards reinforcements and a high level of activity, referring to indicators such as activity, laughter and smiles, high intensity pleasure, impulsiveness, lack of shyness and positive anticipation; (2) *negative affect*, which includes indicators related to fear, anger, sadness, displeasure, and lack of ability to calm down; (3) *effortful control*, which refers to the ability to focus attention, inhibitory control, low intensity pleasure, and perceptual sensitivity.

Temperament reflects individual differences based on biology that arise in the first years of life and remain relatively stable thereafter (Gaias et al., 2012). However, its development also occurs in interaction with the environment (Putnam et al., 2002), and can be modulated by variables such as a child's social background, family characteristics, and caregivers' psychological functioning (Montirosso et al., 2011). In this sense, temperament is a valuable object of study due to characteristics related to neural plasticity, and has been strongly indicated as influenced by maternal factors (Braithwaite et al., 2013; Davis et al., 2004). Several studies have already highlighted the effects of maternal stress, mainly during the second and third trimesters on infant temperament (Zijlmans et al., 2015). For example, prenatal anxiety and depression have been associated with negative maternal report of child effortful control (Miller et al., 2021), greater infant negative affect (Pluess et al., 2011), difficult temperament (Della Vedova, 2014), lower consolation and higher excessive crying (Takegata et al., 2021) and greater irritability, reactivity and stress propensity (Gentile, 2017). Overall, maternal anxiety and depression during pregnancy serve to increase the risk of having an infant who is less likely to express joy (e.g., smiling and positive affect); is experienced as "difficult" (e.g., crying / fussing excessively); and is more dysregulated or fearful (Erickson et al., 2017; Takegata et al., 2021; Zijlmans et al., 2015).

In conclusion, this context of prenatal adversity could configure a negative stimulus that affects the trajectory of early development of children born during the pandemic in different conditions of isolation and social distancing (Pandemial Babies, for having been gestated and born in pandemic). Therefore, the aim of this study is to analyze the effects of negative pandemic experiences and prenatal anxiety and depression on the temperament of six-month-old babies.

Methods

Participants

The sample consisted of 105 mother–child dyads (mother's mean age = 32.49; SD = 4.71) with single, on term pregnancies who were recruited serially between March 2020 and May 2021. The dyads were evaluated longitudinally at different prenatal times (n = 105) -second trimester (mean gestational age = 21.68; SD = 2.58) and third trimester (mean gestational age = 30.8; SD = 1.37)- and one postnatal evaluation at 6 months (n = 103), both of the mother and her babies. All of them were part of the cohort of pregnant women of the Argentine project "Emotional impact of isolation by COVID-19", who were contacted through social networks and evaluated remotely. Sociodemographic characteristics (age, gestational age, educational level, parity, economic affectation due to the pandemic and presence of diseases or medical complications) are summarized in Table 1. The inclusion criteria were the following: age: 18–45 years old, residence: Argentina, absence of serious physical / psychological illnesses, absence of risk factors for COVID-19, single pregnancies between the second and third trimesters. Pregnant women who reported psychotropic drugs or steroids, and alcohol and / or illicit drugs consumption were excluded. With respect to the offspring, only newborns of single pregnancies and term (≥ 37 and < 42 weeks of gestational age) were included and those newborns with a higher risk of neurodevelopmental disorders (eg, birth weight < 2.5 kg; congenital abnormalities; neurological injury; diagnosis of intrauterine growth restriction) were excluded (Enlow et al., 2017).

Instruments

Pandemic-related negative experiences

The C-PIQ is a questionnaire that assesses the personal response to the COVID-19 pandemic in terms of its impact on mental health, growth and exposure to stressors (Lang, 2020). For the purposes of the current study, only the exposure subscale was used, which consists of eight dichotomous response items (yes–no) that assess whether or not certain pandemic-related negative experiences have happened to the respondent or to someone close. The Cronbach's α of the subscale in this study was 0.88.

Depression symptoms

The Spanish adaptation (Sanz & Vázquez, 2011) of the Beck Depression Inventory-II (BDI-II) (Beck et al., 1996) was administered. The BDI-II is a self-report questionnaire consisting of 21 items, each of which represents a symptom of depression (e.g. crying, appetite changes, sadness, pessimism, etc.). It is widely used for evaluating depression during pregnancy (Nast et al., 2013), since it has reported good internal consistency in studies with pregnant women (α = 0.87) (Nast et al., 2013). It has showed evidence of good reliability (α = 0.89) (Sanz et al., 2003) and validity in pregnant (Holcomb et al., 1996). In the present study, Cronbach's α for the BDI-II was 0.93. This scale is widely used for evaluating depression during pregnancy (Nast et al., 2013), since it has reported good internal consistency in studies with pregnant women (α = 0.87) (Carvalho Bos et al., 2009).

State anxiety

The Spanish adaptation (Spielberger et al., 1999) of the State-Trait Anxiety Inventory (STAI) was used (Spielberger et al., 1970). The STAI is a 40-item, self-report scale, which evaluates anxiety as a trait and as a state. Respondents answer about frequency of anxiety symptoms in a 4-point Likert scale, ranging from 0 to 3. Given the aim of the present study, only the 20 items of the state-anxiety subscale were applied. Previous studies have found evidence of adequate psychometric properties for the STAI, showing good reliability (α = 0.84 to 0.93) (Riquelme & Casal, 2011) and validity, in pregnant women (Gunning et al., 2010). It is widely used for research on pregnant women since it presents the best reliability (α = 0.83 to 0.72) (Delgado et al., 2016) and validity indicators for the assessment of anxiety in this population group (Nast et al., 2013). In the present study, Cronbach's α for the STAI was 0.86.

Temperament

The Spanish version of the *Infant Behavior Questionnaire Revised – Very Short Form* (IBQ-RVSF) (Farkas & Vallotton, 2016) for children 3 to 12 months of age was used (Putnam et al., 2013). The IBQ-RVSF measures a wide variety of children's behavior through parental report. By means of a seven-point Likert scale, each item (ranging from never to always). It includes 37 items, each of which assesses the frequency of different behaviors related to temperament during the seven days prior to the application. Items are responded according to a 7-point Likert Scale (ranging from "never" to "always"). The scale includes three factors: surgency, negative affect and effortful control. Factorial scores are obtained through the mean of its items, so each factor yields a score ranging from 1 to 7 points. The scale has shown adequate

Table 1 Sociodemographic variables and covariables

Variable			Pregnant women ($n = 105$)
Mother's age	*Mean*	32.49	
	SD	4.71	
Gestational age (weeks)	*Second trimester*	*Mean*	21.68
		SD	2.58
	Third trimester	*Mean*	32.8
		SD	2.37
Geographic region	*Pampeana region*		79.0%
	Cuyo region		8.6%
	Patagonia region		5.7%
	Northwest region		5.7%
	Northeast region		1.0%
Level of economic affectation due to the pandemic	*High*		17.1%
	Medium		23.8%
	Low		22.9%
	Null		36.2%
Educational level	*Postgraduate (complete & incomplete)*		34.3%
	First University Degree (complete)		34.3%
	First University Degree (incomplete)		31.4%
Parity	*Primiparous*		59.6%
	Multiparous		40.4%
Diseases or medical complications	*Heavy bleeding*		2.9%
	Fluid retention		9.8%
	Nausea or vomiting in excess		19.6%
	Drop of 5 kg or more		2.9%
	Increase of 12 kg or more		11.8%
	Infections		2.9%
	Hypertension		1.0%
	Thyroid problems		8.8%
	Gestational diabetes		2.0%
	Blood incompatibility		1.0%
	Other diseases		3.9%
Infant's sex	*Woman*		54.3%
	Male		45.7%
Birth weight (grams)	*Mean*		3307.53
	SD		218.40
Infant age (months)	*Mean*		6.12
	SD		0.42

reliability (Cronbach's α of 0.71 to 0.90), and convergent and predictive validity (Farkas & Vallotton, 2016). In the present study, Cronbach's α for the IBQ-RVSF was 0.91.

Covariables

Regarding mothers, closed-ended questions were applied to explore age, gestational age, educational level, parity, economic affectation due to the pandemic and presence of diseases or medical complications. As for babies, closed-ended questions were applied to explore sex, birthweight and age.

Procedure

The different surveys were administered through Google Forms. The sample was initially recluted on social networks through a snowball sampling procedure, and the links for follow-up were sent by email. Participants were asked to complete 4 surveys at different times during the pandemic: two prenatal evaluations, in the second and third trimesters respectively, and two evaluations at 6 months after birth, one of the mother and the other of her child.

Data analysis

Analyses were carried out using IBM SPSS 26 for Windows, with $p < 0.05$. Descriptive statistics were computed for socio-demographic characteristics and for all the variables reported in the measures section. Parametric indexes were obtained for continuous variables, whereas percentages were obtained for categorical variables. After that, the normality of the dependent variables was checked through skewness and kurtosis (values between ± 2 points are considered acceptable limits for normality) (George & Mallery, 2016). All variables presented acceptable values: *maternal anxiety* (2° trimester: $Sk = 0.56$; $Ku = -0.22$; 3° trimester: $Sk = -0.01$; $Ku = -0.17$; postnatal: $Sk = -0.61$; $Ku = -0.24$), *maternal depression* (2° trimester: $Sk = 0.80$; $Ku = 0.90$; 3° trimester: $Sk = 0.77$; $Ku = 0.29$; postnatal: $Sk = 0.87$; $Ku = 0.97$), *negative affect* ($Sk = 0.24$; $Ku = -0.54$), *effortful control* ($Sk = -0.77$; $Ku = 1.80$) and *surgency* ($Sk = -0.89$; $Ku = 1.75$). The repeated measures *ANOVA* statistic was used to test the effect of time (second/third trimester and postnatal measures) on depression and anxiety. The associations between the study variables were investigated with zero-order *Pearson* correlations.

Serial mediation models were estimated (Model 6) using PROCESS (Hayes, 2013). In these models, pandemic-related negative experiences constituted the independent variable, maternal anxiety and depression levels were tested as mediators, and child's temperament dimensions (negative affect, effortful control and surgency) were the dependent variables. To evaluate the indirect effect, a bootstraping procedure with 10,000 resamplings was conducted. This procedure creates accelerated and corrected 95% confidence intervals of indirect effects, which are considered significant when zero is not included in the high and low intervals. To limit the number of covariates included in these models given the relatively small sample size, potential covariates were evaluated in a preliminary correlational analysis. Variables that were correlated with any of the three IBQ- R-VSF subscales at $p < 0.05$ were included as a covariate in the mediation model that examined the temperament measure (surgency, negative affect and effortful control). The following variables Parity, infant sex and birth weight exhibited an association $p < 0.05$ with the predictor or the outcomes and so were included as covariates in all analyses.

Results

Characteristics of the sample and descriptive and inferential statistics of the psychopathological measures.

The demographic variables for the sample are shown in Table 1. The descriptive statistics of the administered tests are shown in Table 2. Regarding psychopathological measures, results of repeated measures ANOVA demonstrated a significant effect of time, both in depression [$F_{(1.91,\ 194.85)} = 10.91$, $p < 0.001$, $\eta_p^2 = 0.10$] and anxiety [$F_{(2,\ 208)} = 15.63$, $p < 0.001$, $\eta_p^2 = 0.13$]. Regarding anxiety measures, the post-hoc tests for paired comparisons with Bonferroni correction showed statistically significant

Table 2 Descriptive statistics of the administered tests and repeated measures ANOVA

Variable			Second trimester	Third trimester	Postnatal (6 months)	Repeated measures ANOVA
Maternal anxiety		*Mean*	23.56	23.86	19.25	$F = 15.63^{**}$
		SD	9.39	7.96	7.05	
Maternal depression		*Mean*	10.21	11.31	8.88	$F = 10.91^{**}$
		SD	5.97	6.93	4.39	
Negative experiences due to the pandemic	*Mean*	-	7.57	-	-	
	SD	-	2.71	-		
Infant temperament scales (IBQ-R-VSF)	Infant surgency	*Mean*	-	-	5.04	-
		SD	-	-	.52	
	Infant negative affect	*Mean*	-	-	3.96	-
		SD	-	-	1.18	
	Infant effortful control	*Mean*		-	5.49	-
		SD	-	-	.47	

* $p < .05$ / ** $p < .01$

differences between the second ($F_{(2, 208)} = 4.31$; $p < 0.01$) and third trimesters ($F_{(2, 208)} = 4.61$; $p < 0.01$) with respect to the postnatal measure (Fig. 1A). Respecting depression measures, the post-hoc tests for paired comparisons with Bonferroni correction showed similar results: postnatal scores were significantly lower in comparison to the ones registered at the second ($F_{(1.91, 194.85)} = 1.33$; $p = 0.03$) and third ($F_{(1.91, 194.85)} = 2.43$; $p < 0.01$) trimesters.

Associations between pandemic-related negative experiences, maternal anxiety symptoms and infant temperament

Three mediation models were tested. In these models, the pandemic-related negative experiences constituted the independent variable, the levels of maternal anxiety (during second and third trimester of pregnancy) acted as mediators, and the three dimensions of children's temperament (negative affect, effortful control and surgency) were the dependent variables. (Table 3) (Fig. 2A-C).

Overall, pandemic-related negative experiences were significantly associated with the anxiety levels observed at the second ($\beta = 0.23$, $p < 0.05$) and at the third trimester ($\beta = 0.55$, $p < 0.001$).

Regarding model A (COVID-19 experiences < maternal anxiety at second trimester < maternal anxiety at third trimester < negative affect) (Fig. 2A), maternal anxiety levels at the second ($\beta = 0.17$, $p < 0.05$) and at the third trimester ($\beta = 0.43$, $p < 0.001$) were significantly and positively associated with children's negative affect. No significant direct effect was observed between pandemic-related negative experiences and affectivity ($\beta = 0.05$, $p > 0.05$). At the

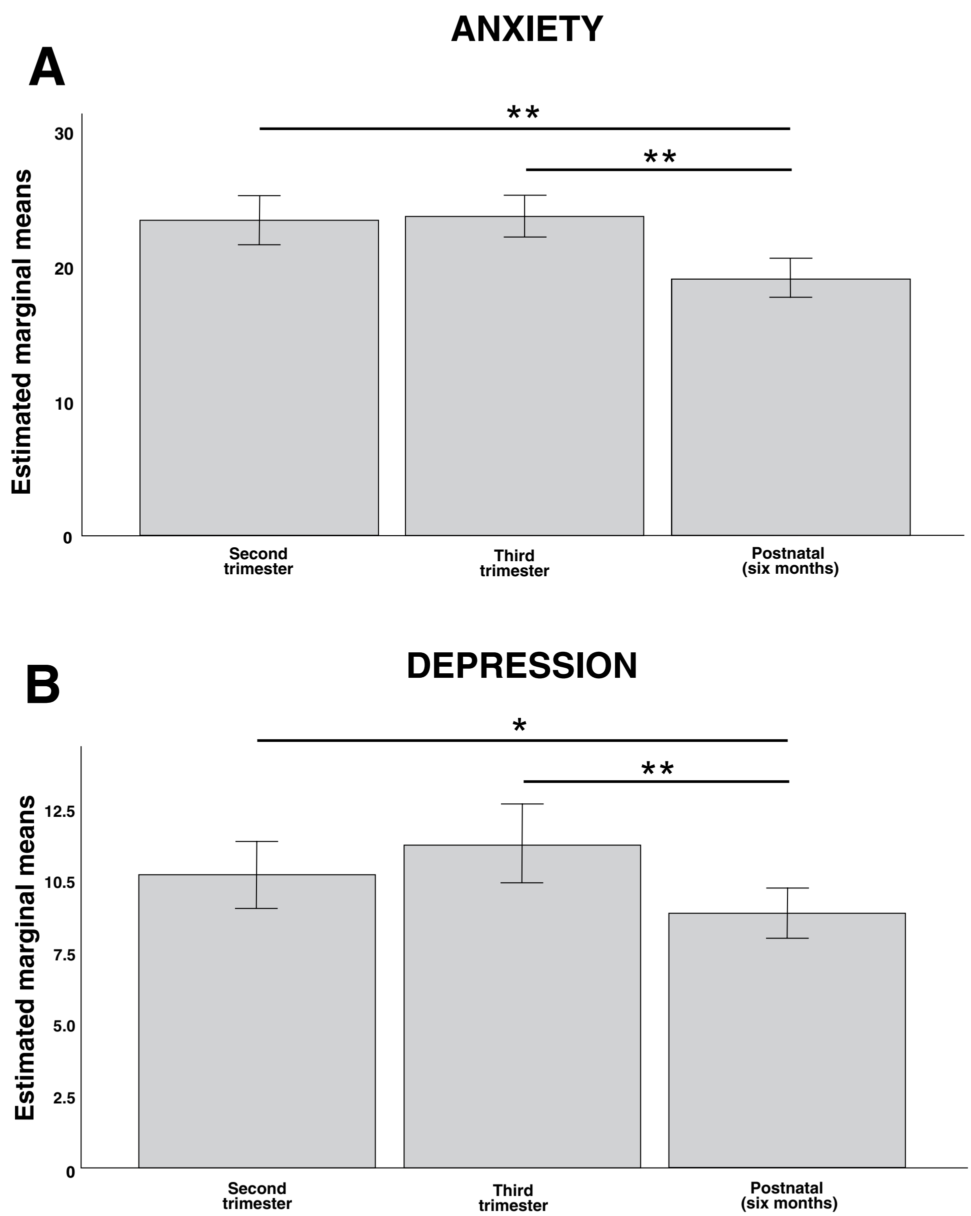

Fig. 1 Comparison of the adjusted mean of the psychopathological variables, during the three phases of the study. Figure 1 shows the adjusted means for (**A**) anxiety and (**B**) depression, during the three phases of the study (second trimester, third trimester and postnatal). $^{**}p < 0.01$; $^{*}p < 0.05$ / Error bars ± 2SD

Table 3 Total, direct and indirect effects of mediation models

Model	Effect	β	DE	P value	95% IC
Model A	Total	0.35	0.04	0.001	0.078 / 0.234
	Direct	0.05	0.04	0.629	-0.068 / 0.110
	Indirect (a_1b_1)	0.05	0.03	> 0.05	-0.055 / 0.109
	Indirect (a_1b_2) *	0.23	0.07	< 0.05	0.097 / 0.372
	Indirect ($a_1d_{21}b_2$)	0.03	0.02	< 0.05	0.001 / 0.066
Model B	Total	0.20	0.03	0.043	0.002/ 0.112
	Direct	-0.06	0.03	0.626	-0.082 / 0.050
	Indirect (a_1b_1)	-0.03	0.03	> 0.05	-0.119 / 0.010
	Indirect (a_1b_2) *	0.26	0.09	< 0.05	0.086 / 0.449
	Indirect ($a_1d_{21}b_2$)	0.03	0.01	< 0.05	0.001 / 0.078
Model C	Total	0.07	0.0035	0.465	-0.004 / 0.009
	Direct	0.01	0.0044	0.968	-0.009 / 0.009
	Indirect (a_1b_1)	-0.03	0.03	> 0.05	-0.100 / 0.026
	Indirect (a_1b_2)	0.08	0.08	> 0.05	-0.057 / 0.247
	Indirect ($a_1d_{21}b_2$)	0.01	0.01	> 0.05	-0.007 / 0.038
Model D	Total	0.35	0.0390	0.001	0.077 / 0.232
	Direct	0.29	0.0405	0.002	0.047 / 0.208
	Indirect (a_1b_1)	0.02	0.0351	> 0.05	-0.057 / 0.086
	Indirect (a_1b_2)	0.02	0.0255	> 0.05	-0.013 / 0.085
	Indirect ($a_1d_{21}b_2$)	0.02	0.0291	> 0.05	-0.018 / 0.096
Model E	Total	0.19	0.0277	0.052	-0.001 / 0.109
	Direct	0.20	0.0294	0.054	-0.001 / 0.116
	Indirect (a_1b_1)	0.0087	0.0393	> 0.05	-0.084 / 0.080
	Indirect (a_1b_2)	-0.0084	0.0290	> 0.05	-0.057 / 0.065
	Indirect ($a_1d_{21}b_2$)	-0.0105	0.0359	> 0.05	-0.070 / 0.074
Model F	Total	0.0229	0.0037	0.817	-0.006 / 0.008
	Direct	0.0760	0.0039	0.465	-0.005 / 0.011
	Indirect (a_1b_1)	-0.0025	0.0401	> 0.05	-0.091 / 0.074
	Indirect (a_1b_2)	-0.0225	0.0279	> 0.05	-0.079 / 0.035
	Indirect ($a_1d_{21}b_2$)	-0.0281	0.0345	> 0.05	-0.100 / 0.041

* *Top effect*

same time, there were significant indirect, mediation effects between pandemic-related negative experiences, maternal anxiety at the third trimester, and children's negative affect ($\beta = 0.23$, IC = 0.097 / 0.372), as well as between pandemic-related negative experiences, maternal anxiety during the second and third trimester, and negative affect ($\beta = 0.03$, IC = 0.001 / 0.066). The comparison between both indirect effects showed that the first one (a_2b_2) is greater than the second one ($a_1d_{21}b_2$) (Effect: 0.21; IC = 0.080 / 0.341).

Regarding model B (COVID-19 experiences < maternal anxiety at second trimester < maternal anxiety at third trimester < surgency) (Fig. 2B), it was also observed that maternal anxiety levels during the third trimester ($\beta = 0.48$, $p < 0.001$) were significantly and positively associated with children's surgency. There was no significant direct effect between these variables ($\beta = -0.05$, $p > 0.05$). However, significant indirect effects of mediation were observed between pandemic-related negative experiences, maternal anxiety at the third trimester and children's surgency ($\beta = 0.26$, IC = 0.086 / 0.449), as well as between pandemic-related negative experiences, maternal anxiety at the second and third trimester and children's negative affect ($\beta = 0.03$, IC = 0.001 / 0.078). The comparison between both indirect effects showed that the first one mentioned (a2b2) is greater than the second (a1d21b2) (Effect: 0.23; IC = 0.072 / 0.411).

Model C (COVID-19 experiences < maternal anxiety at second trimester < maternal anxiety at third trimester < effortful control) (Fig. 2C) did not show any total, direct or indirect significant effects ($p > 0.05$). However, the covariate postpartum anxiety showed significant effects ($p < 0.05$).

Associations between pandemic-related negative experiences, maternal depression symptoms and infant temperament

Three mediation models were tested, in which pandemic-related negative experiences were the independent variable, levels of maternal depression at second and third trimester acted as mediators and the three dimensions of children's temperament (negative affect, effortful control and surgency) were the dependent variables (Table 3) (Fig. 2D-F).

Overall, pandemic-related negative experiences were significantly associated with maternal anxiety levels at the second (β = 0.24, $p < 0.05$) and at the third trimester (β = 0.14, $p < 0.05$). None of the covariates showed significant effects ($p > 0.05$).

Only Model D (COVID-19 experiences < maternal depression at second trimester < maternal depression at third trimester < negative affect) (Fig. 2D) showed significant effects, both total (β = 0.35, $p < 0.001$) and direct (β = 0.29, $p < 0.01$). The rest of the models did not show significant total, direct or indirect effects ($p > 0.05$).

Discussion

The present study aimed to analyze the effects of prenatal and postnatal anxiety and depression on the temperament of 6-month-old babies born in the pandemic. The study is based on the hypothesis that the context of adversity due to the COVID-19 pandemic and its multiple associated variables could constitute an additional negative stimulus that affects future mothers and, consequently, the trajectory of early development of children gestated during confinement *-The Pandemials-*. Pregnancy is a transition period that includes

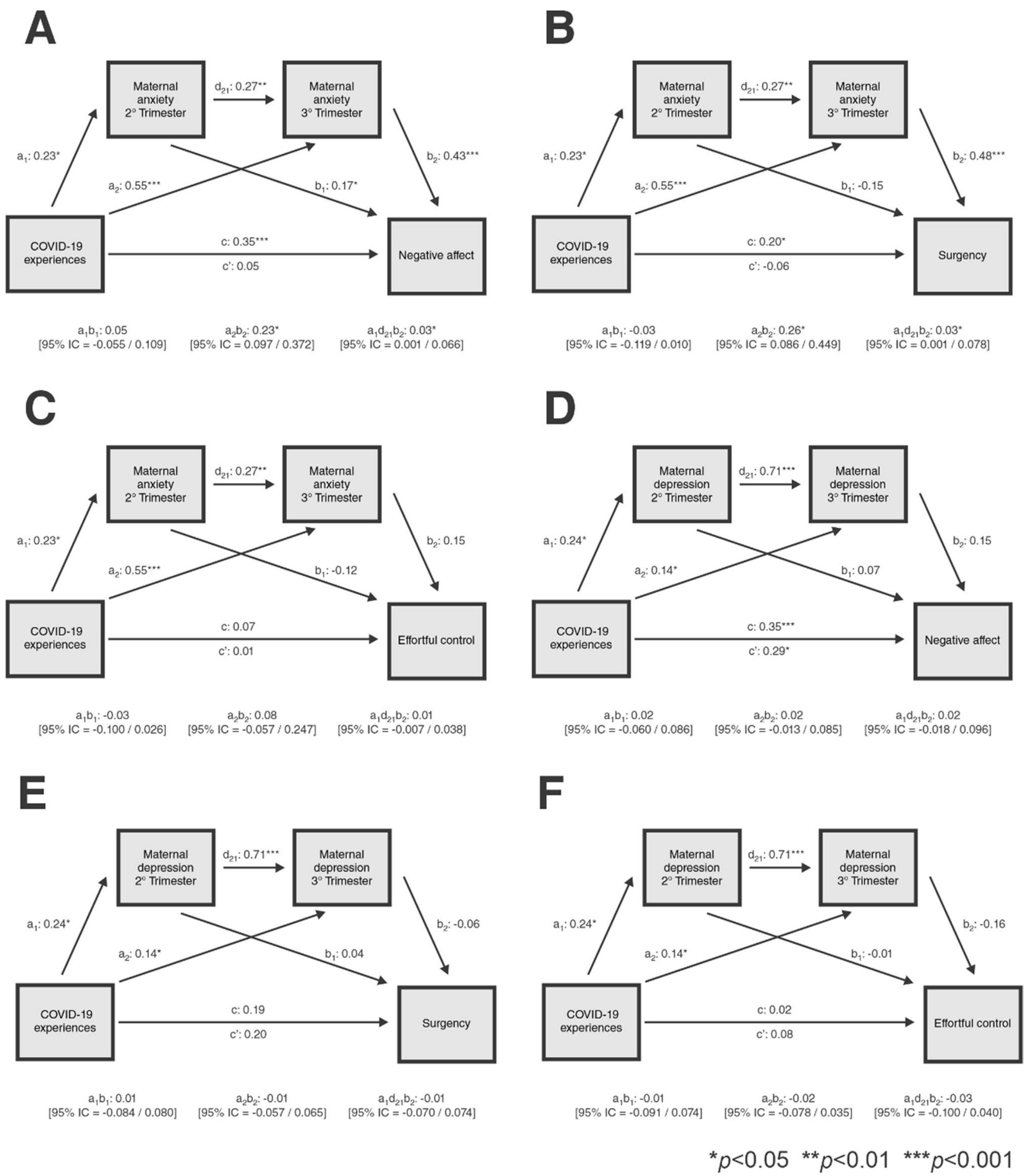

Fig. 2 Statistical diagram of serial mediation models used to test the influence of maternal anxiety (models **A**, **B**, **C**) and maternal depression (models **D**, **E**, **F**) on the association between negative pandemic experiences and the three dimensions of temperament. Note: The path values represent standardized regression coefficients (a_1, a_2, b_1, b_2, d_1 and d_2). The value c represents the total effect of the model. The c' value represents the direct effect of the initial analysis of pandemic negative experiences on the corresponding temperament dimension after mediator inclusion. The values a_1b_1, a_1b_2 and $a_1d_{21}b_2$ represent the indirect effects. Postnatal anxiety and depression, infant sex, and birth weight were introduced as covariates in the regression model. For simplicity, these covariates are not shown in the figure. * $p < 0.05$ / ** $p < 0.01$ / *** $p < 0.001$

changes on physiological, psychological and social dimensions. Exposure to situations of adversity that impact on any of these dimensions will increase the possibility that these women experience depression, anxiety or stress, and also that their children suffer negative consequences of a physiological, emotional or cognitive nature (King et al., 2021).

With regard to maternal mental health, the results indicated that levels of anxiety and depressive symptoms increased during the second and third trimesters of pregnancy, and decreased significantly during the postpartum period. On the other hand, a larger amount of pandemic-related negative experiences predicted higher levels of prenatal anxiety and depression, which highlights the adverse effect of the pandemic context over pregnant women's mental health. As mentioned above, the pandemic context introduced unpredictable changes in daily life, such as physical distancing, total or partial restriction to the freedom of movement, and significant difficulties in access to medical and social attention and care. Given that pregnant women have a special requirement for these practices and routines, the pandemic context accentuates the special vulnerability of this group (Matvienko-Sikar et al., 2020). In addition, studies have highlighted some of the special worries that pregnant women manifested in this context, such as fear of contagion and vertical transmission of the virus, concerns about the progress of the pregnancy or about the time of delivery, and difficulties in the distribution of time between work, childcare and housework (Khan et al., 2020; Saccone et al., 2020). All of these have predisposed women to the development of perinatal psychopathological indicators, as our study has also shown.

Regarding the relationship between maternal anxiety and children's temperament, our study demonstrated that pandemic-related negative experiences are indirectly associated with offspring's negative affect and surgency, mainly during the third trimester, through the mediation of prenatal anxious symptoms. In conclusion, a larger amount of pandemic-related negative experiences was related to higher levels of prenatal anxiety, which in turn predicted higher indicators of surgency and negative affect in 6-month-old babies.

In relation to prenatal anxiety, several studies have reported similar findings, in which maternal anxiety symptoms, after controlling for postnatal mood or stress, predicted higher levels of surgency (Lin et al., 2014) and negative affectivity (Braithwaite et al., 2013; Davis et al., 2004; McMahon et al., 2013; Miller et al., 2021; Werner et al., 2007). Regarding the pandemic context, only one study has published results on the relationships of pandemic-related negative experiences with socioemotional development. Provenzi et al. (Provenzi et al., 2021) reported that postnatal maternal anxiety was indirectly associated with babies' regulation capacities at 3 months old, through the mediation of parental stress and mother–child bonding. The aforementioned study gave the first evidence of the possible effects of the COVID-19 pandemic on maternal mental health and on the early development of socioemotional and behavioral variables. The present study shows additional evidence in the same line and contributes to deepen the knowledge on the subject.

Although the association between prenatal anxiety and negative affect has been widely reported, that is not the case with respect to the previous literature on surgency, since some studies have found that it shows a negative association with both prenatal anxiety and negative affect (Enlow et al., 2017; Takegata et al., 2021). Conversely, our study supports the explanatory models that positively associate negative affect and surgency (Lin et al., 2014) as dimensions of infant regulatory capacity: high levels of both variables could imply a risk for regulatory capacity (Gartstein & Rothbart, 2003). For example, negative affectivity—encompassing general negative mood, fear, and anger responses—predisposes these children to respond negatively to others and make them prone to a lasting distress response (Belsky, 1997). Along the same lines, children with high levels of arousal are more likely to be unable to regulate their behavior, and therefore use less effective regulatory strategies (e.g. kicking or hitting) and focus on distressing objects (Calkins et al., 2002). On the other hand, surgency includes components of both positive and negative affectivity, due to the fact that it consists of a disposition towards positive emotions, rapid approach towards reinforcements and high intensity pleasure, as well as high intensity activities, impulsiveness and lack of shyness. These last three components would be a risk factor for regulatory deficits (Gartstein et al., 2009). Additionally, the high levels of intensity associated with surgency could exaggerate expressions of negativity and promote negative interactions between the child and his / her caregiver (Rothbart et al., 2000).

Therefore, the reported association between prenatal anxiety on the development of self-regulation functions in children may have its origin in deficiencies associated with dimensions such as negative affect and surgency. Early identification of these indicators should be a priority, since difficulties in self-regulation have been associated with clinical forms of dysregulation in late childhood and adolescence, including depression, anxiety, and attention deficit / hyperactivity disorder (Erickson et al., 2017; Rosario et al., 2014; Sayal et al., 2014).

Regarding the relationship between maternal depression and temperament of the offspring, our model did not identify significant associations. Although most studies on the effects of prenatal psychopathology on temperament development have focused on anxiety indicators as predictors, there is currently a significant number of reports on childhood depression and temperament (Erickson et al., 2017; Takegata et al., 2021). While many investigations have pointed out significant associations between prenatal depression and some dimensions of temperament -mainly negative affect- (Babineau et al., 2015; Della Vedova, 2014), a considerable number of research papers have reported null effects (Nolvi et al., 2016; Rothenberger et al., 2010). This shows that, unlike prenatal anxiety, the association between prenatal depression and temperament development is still under discussion.

The mechanisms that mediate the influence of prenatal health on fetal development and early childhood have not yet been sufficiently clarified, although it is presumed that both genetic and environmental factors participate (Erickson et al., 2017). As previously mentioned, the fetal programming hypothesis (Gluckman et al., 2010) would suggest that the physical, behavioral and emotional characteristics in the offspring of mothers with prenatal stress are the result of sufficiently stable alterations in the structure and function of the offspring's brain and other organs (Demers et al., 2021). Currently, there is some consensus indicating that maternal influence on the fetus is mediated by the impact of maternal cortisol on the development of the hypothalamic–pituitary–adrenal (HPA) axis of the fetus. There is evidence (Cao-Lei et al., 2020) that adverse situations such as prenatal depression (Murgatroyd et al., 2015) or post-traumatic stress disorder (Perroud et al., 2014) can cause epigenetic modifications of the genes related to the functional adjustment of the HPA axis (such as FBPK5, NR3C1 and HSD11B2) (O'Donnell & Meaney, 2017). As a result, the regulatory mechanisms of the HPA axis are attenuated and, therefore, the neurotoxic effects of high cortisol concentrations are increased. This dysregulation has a very high cost on the neuroendocrine systems of the pregnant woman, which could directly influence the neuronal structures of the developing fetus and, if the stressful situation does not remit, of the child during the postnatal period (Rakers et al., 2017), altering cognitive, emotional and behavioral functions (Bergh et al., 2015). More precisely, the dysregulation of maternal cortisol levels could affect limbic brain structures (e.g., hippocampus and amygdala), generate an overproduction of neuronal connections, and alter the functioning of the prefrontal cortex, with fewer neuronal connections (Teicher & Samson, 2016). Limbic structures and the prefrontal cortex are involved in reactivity and stress regulation patterns, in emotional (e.g., anxiety and anger) and cognitive (e.g. learning and memory) processing and in temperamental variation of behavior (e.g. search for novelty, harm avoidance and reactive temperament). These structural changes can influence how an individual perceives, interprets and reacts to stressful situations (Hair et al., 2015).

Regarding the timing of exposure to stress, most studies have reported that prenatal anxiety and depression during the third trimester of pregnancy often show significant associations with the development of temperament. However, although with less evidence, it has also been indicated that exposure during the second and, to a lesser extent, the first trimester, can also generate effects on socio-emotional variables in children (Korja et al., 2017). This is probably due to the characteristics of fetal neurodevelopment during pregnancy: when exposure to the stressful stimulus occurs during the first trimester, it is expected to predict more severe effects on neurodevelopment, while exposure during the second and third trimesters has traditionally been identified as a window period for the later development of psychopathology or socio-emotional deficiencies.

Although the scope of our study is limited and results may not allow quick generalizations, the data suggest that factors predisposing to a phenotype with greater reactivity to stress (greater negative affect and surgency and less effortful control) are already present in very young children, which could be related to neuronal programming impairments mediated by maternal stress. In turn, the programming of the adversity response system could predispose these children to be hyper-reactive towards adverse events, activating the stress response system more frequently and for longer periods than necessary (Shonkoff, 2017). All these indicators of self-regulatory deficits lead to an increased risk of developing a wide range of psychopathological and neurodevelopmental disorders during childhood and adolescence (Erickson et al., 2017; Sayal et al., 2014). This special vulnerability of pregnant women and young children is aggravated by the current pandemic context in general terms, but, as exposed earlier, this susceptibility increases in LMICs., because the inequity and disparity in these countries could predispose population to experience the effects of the pandemic such as a chronic and extreme stressor (Smith & Pollak, 2022). Therefore, it is important to point out the need to implement public health policies that allow a timely evaluation of socio-emotional variables during early childhood, which will allow the creation of early interventions to reduce the risks associated with these deficits.

Several limitations of this study should be noted. First, the sample was relatively small and, given that an intentional sampling method was used, it cannot be considered representative of the population. Therefore, generalizability of the results is limited. Second, results are based exclusively on mothers' reports of their infants' temperament and of their own symptoms, so risk of response bias must be taken into consideration. For example, mothers with higher anxiety or depression levels may overestimate the negative characteristics of their children's temperament (Henrichs et al., 2009; Takegata et al., 2021). However, the longitudinal approach of the study may mitigate this risk (Nolvi et al., 2016). Moreover, parental reports have been found to be adequate indicators of infant emotional reactivity, across different contexts and situations (Nolvi et al., 2016). Future studies should complement this information with biological measures of maternal distress and infant temperament. Third, no specific method was implemented to avoid possible bias coming from remote completion of the surveys (e.g., trap question), which may have affected the quality of the results. Finally, there may be other confounding variables influencing temperament that have not been controlled for in this study. Since social maturation in infancy can modify temperamental expression, certain postnatal variables (such as the mother-baby bond) may be affecting the results (Takegata et al., 2021).

Summary

Our study is one of the few to identify the early effects of the psychosocial adversity context imposed by the COVID-19 pandemic on infant temperament. As reported, having been through a larger amount of pandemic-related negative experiences was related to higher levels of prenatal maternal anxiety, which in turn predicted higher surgency and negative affect in babies at 6 months of age. Overall, this creates a context of gestational and early childhood adversity, highlighting the possible developmental risks that the *Pandemial babies* may be under.

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Data availability The data that support the findings of this study are available from the author, upon reasonable request.

Declarations

Financial interests The authors declare they have no financial interests.

Non-financial interests None.

Ethical aspects Participation was voluntary and subject to the informed consent of the participants. Procedures to be implemented were submitted and approved by the Bioethics Committee of the National University of Mar del Plata. The study was carried out in compliance with the American Psychological Association recommended procedures, the Declaration of Helsinki principles and the International Convention on the Rights of the Child.

References

Almond, D. (2006). Is the 1918 influenza pandemic over? Long-term effects of in utero influenza exposure in the post-1940 US population. *J Political Economy, 114*, 672–712.

Babineau, V., Green, C. G., Jolicoeur-Martineau, A., Bouvette-Turcot, A. A., Minde, K., & Sassi, R. (2015). Prenatal depression and 5-HTTLPR interact to predict dysregulation from 3 to 36 months- a differential susceptibility model. *J Child Psychol Psychiatry, 56*, 21–29.

Barker, D. J., & Osmond, C. (1986). Infant mortality, childhood nutrition, and ischaemic heart disease in England and Wales. *Lancet, 1*, 1077–1081.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Beck Depression Inventory-II*. The Psychological Corporation.

Belsky, J. (1997). Variation in susceptibility to environmental influence: An evolutionary argument. *Psychol Inquiry, 8*, 82–186.

Braithwaite, E. C., Ramchandani, P. G., O'Connor, T. G., van Ijzendoorn, M. H., Bakermans-Kranenburg, M. J., Glover, V., Netsi, E., Evans, J., Meaney, M. J., & Murphy, S. E. (2013). No moderating effect of 5-HTTLPR on associations between antenatal anxiety and infant behavior. *Journal of the American Academy of Child and Adolescent Psychiatry, 52*, 519–526.

Calkins, S. D., Dedmon, S. E., Gill, K. L., Lomax, L. E., & Johnson, L. M. (2002). Frustration in Infancy: Implications for Emotion Regulation, Physiological Processes, and Temperament. *Infancy, 3*, 175–197.

Cao-Lei, L., de Rooij, S. R., King, S., Matthews, S. G., Metz, G. A. S., Roseboom, T. J., & Szyf, M. (2020). Prenatal stress and epigenetics. *Neuroscience and Biobehavioral Reviews, 117*, 198–210.

Carvalho Bos, S., Pereira, A. T., Marques, M., Maia, B., Soares, M. J., Valente, J., Gomes, A., Macedo, A., & Azevedo, M. H. (2009). The BDI-II factor structure in pregnancy and postpartum: Two or three factors? *European Psychiatry, 24*, 334–340.

Davis, E. P., Snidman, N., Wadhwa, P. D., Glynn, L. M., Schetter, C. D., & Sandman, C. A. (2004). Prenatal maternal anxiety and depression predict negative behavioral reactivity in infancy. *Infancy, 6*, 319–331.

Del Rosario, M., Gillespie-Lynch, K., Johnson, S., Sigman, M., & Hutman, T. (2014). Parent-reported temperament trajectories among infant siblings of children with autism. *Journal of Autism and Developmental Disorders, 44*, 381–393.

Delgado, A. M., Freire, A. D. B., Wanderley, E. L. S., & Lemos, A. (2016). Analysis of the construct validity and internal consistency of the state-trait anxiety inventory (STAI) state-anxiety (S-anxiety) scale for pregnant women during labor. *Revista Brasileira de Ginecologia e Obstetrícia, 38*, 531–537.

Della Vedova, A. M. (2014). Maternal psychological state and infant's temperament at three months. *Journal of Reproductive and Infant Psychology, 32*, 520–534.

Demers, C. H., Aran, Ö., Glynn, L. M., & Davis, E. P. (2021). Prenatal Programming of Neurodevelopment: Structural and Functional Changes. In A. Wazana, E. Székely, & T. F. Oberlander (Eds.), *Prenatal Stress and Child Development* (pp. 193–242). Springer International Publishing.

D'Onofrio, B. M., Class, Q. A., Rickert, M. E., Larsson, H., Långström, N., & Lichtenstein, P. (2013). Preterm birth and mortality and morbidity:A population-based quasi-experimental study. *JAMA Psychiatry, 70*, 1231–1240.

Enlow, M. B., Devick, K. L., Brunst, K. J., Lipton, L. R., Coull, B. A., & Wright, R. J. (2017). Maternal Lifetime Trauma Exposure, Prenatal Cortisol, and Infant Negative Affectivity. *Infancy, 22*, 492–513.

Erickson, N. L., Gartstein, M. A., & Dotson, J. A. W. (2017). Review of Prenatal Maternal Mental Health and the Development of Infant Temperament. *Journal of Obstetric, Gynecologic, and Neonatal Nursing, 46*, 588–600.

Farkas, C., & Vallotton, C. (2016). Differences in infant temperament between Chile and the US. *Infant Behavior & Development, 44*, 208–218.

Fisher, J., Cabral de Mello, M., Patel, V., Rahman, A., Tran, T., Holton, S., & Holmes, W. (2021). Prevalence and determinants of common perinatal mental disorders in women in low- and lower-middle-income countries:A systematic review. *Bulletin of the World Health Organization, 90*, 139G – 149.

Gaias, L. M., Räikkönen, K., Komsi, N., Gartstein, M. A., Fisher, P. A., & Putnam, S. P. (2012). Cross-cultural temperamental differences in infants, children, and adults in the United States of America and Finland. *Scandinavian Journal of Psychology, 53*, 119–128.

Gartstein, M. A., & Rothbart, M. K. (2003). Studying infant temperament via the revised infant behavior questionnaire. *Infant Behavior & Development, 26*, 64–86.

Gartstein, M. A., Slobodskaya, H. R., Putnam, S. P., & Kinsht, I. A. (2009). A cross-cultural study of infant temperament: Predicting preschool effortful control in the United States of America and Russia. *The European Journal of Developmental Psychology, 6*, 337–364.

Gassman-Pines, A., & Gennetian, L. A. (2020). *COVID-19 job and income loss jeopardize child well-being: Income support policies can help (Child Evidence Brief No 9)*. Society for Research in Child Development.

Gemmill, A., Catalano, R., Casey, J. A., Karasek, D., Alcalá, H. E., Elser, H., & Torres, J. M. (2019). Association of Preterm Births Among US Latina Women With the 2016 Presidential Election. *JAMA Network Open, 2*, e19708.

Gentile, S. (2017). Untreated depression during pregnancy:Short- and long-term effects in offspring A Systematic Review. *Neuroscience, 342*, 154–166.

George, D., & Mallery, P. (2016). *IBM SPSS Statistics 23 Step by Step: A Simple Guide and Reference* (14th ed.). Routledge.

Gluckman, P. D., Hanson, M. A., & Buklijas, T. (2010). A conceptual framework for the developmental origins of health and disease. *Journal of Developmental Origins of Health and Disease, 1*, 6–18.

Green, J. G., McLaughlin, K. A., Berglund, P. A., Gruber, M. J., Sampson, N. A., Zaslavsky, A. M., & Kessler, R. C. (2010). Childhood adversities and adult psychiatric disorders in the national comorbidity survey replication I:Associations with first onset of DSM-IV disorders. *Archives of General Psychiatry, 67*, 113–123.

Grigoriadis, S., VonderPorten, E. H., Mamisashvili, L., Tomlinson, G., Dennis, C. L., Koren, G., Steiner, M., Mousmanis, P., Cheung, A., Radford, K., Martinovic, J., & Ross, L. E. (2013). The impact of maternal depression during pregnancy on perinatal outcomes:A systematic review and meta-analysis. *Journal of Clinical Psychiatry, 74*, e321–e341.

Gunning, M. D., Denison, F. C., Stockley, C. J., Ho, S. P., Sandhu, H. K., & Reynolds, R. M. (2010). Assessing maternal anxiety in pregnancy with the State-Trait Anxiety Inventory (STAI): Issues of validity, location and participation. *Journal of Reproductive and Infant Psychology, 28*, 266–273.

Hair, N. L., Hanson, J. L., Wolfe, B. L., & Pollak, S. D. (2015). Association of Child Poverty, Brain Development, and Academic Achievement. *JAMA Pediatrics, 169*, 822–829.

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. The Guilford Press.

Henrichs, J., Schenk, J. J., Schmidt, H. G., Velders, F. P., Hofman, A., Jaddoe, V. W., Verhulst, F. C., & Tiemeier, H. (2009). Maternal pre-and postnatal anxiety and infant temperament. The generation R study. *Infant and Child Development, 18*, 556–572.

Holcomb, W. L., Jr., Stone, L. S., Lustman, P. J., Gavard, J. A., & Mostello, D. J. (1996). Screening for depression in pregnancy:Characteristics of the Beck Depression Inventory. *Obstetrics and Gynecology, 88*, 1021–1025.

Holmes, E. A., O'Connor, R. C., Perry, V. H., Tracey, I., Wessely, S., Arseneault, L., Ballard, C., Christensen, H., Cohen Silver, R., Everall, I., Ford, T., John, A., Kabir, T., King, K., Madan, I., Michie, S., Przybylski, A. K., Shafran, R., Sweeney, A., … Bullmore, E. (2020). Multidisciplinary research priorities for the COVID-19 pandemic:A call for action for mental health science. *Lancet Psychiatry, 7*, 547–560.

Huizink, A. C., Robles de Medina, P. G., Mulder, E. J., Visser, G. H., & Buitelaar, J. K. (2003). Stress during pregnancy is associated with developmental outcome in infancy. *Journal of Child Psychology and Psychiatry, 44*, 810–818.

Khan, S., Peng, L., Siddique, R., Nabi, G., Nawsherwan, X. M., Liu, J., & Han, G. (2020). Impact of COVID-19 infection on pregnancy outcomes and the risk of maternal-to-neonatal intrapartum transmission of COVID-19 during natural birth. *Infection Control and Hospital Epidemiology, 41*, 748–750.

King, S., Matvienko-Sikar, K. M., & Laplante, D. P. (2021). Natural Disasters and Pregnancy: Population-Level Stressors and Interventions. In A. Wazana, E. Székely, & T. F. Oberlander (Eds.), *Prenatal Stress and Child Development* (pp. 523–564). Springer Nature.

Kingsbury, M., Weeks, M., MacKinnon, N., Evans, J., Mahedy, L., Dykxhoorn, J., & Colman, I. (2016). Stressful Life Events During Pregnancy and Offspring Depression: Evidence From a Prospective Cohort Study. *Journal of the American Academy of Child and Adolescent Psychiatry, 55*, 709–716.

Kohnstamm, G., Bates, J., & Rothbart, M. K. (1989). *Temperament in childhood*. Wiley.

Korja, R., Nolvi, S., Grant, K. A., & McMahon, C. (2017). The Relations Between Maternal Prenatal Anxiety or Stress and Child's Early Negative Reactivity or Self-Regulation: A Systematic Review. *Child Psychiatry and Human Development, 48*(6), 851–869. https://doi.org/10.1007/s10578-017-0709-0

Lang, A. J. (2020). Complementary and integrative research (CAIR) lab. CAIR pandemic impact Questionnaire (C-piq). NIH public health emergency and disaster research response. Available from: https://www.phenxtoolkit.org/toolkit_content/PDF/CAIR_PIQ.pdf. Accessed 8 Nov 2022

Lebel, C., Walton, M., Letourneau, N., Giesbrecht, G. F., Kaplan, B. J., & Dewey, D. (2016). Prepartum and Postpartum Maternal Depressive Symptoms Are Related to Children's Brain Structure in Preschool. *Biological Psychiatry, 80*, 859–868.

Lin, B., Crnic, K. A., Luecken, L. J., & Gonzales, N. A. (2014). Maternal prenatal stress and infant regulatory capacity in Mexican Americans. *Infant Behavior & Development, 37*, 571–582.

López-Morales, H., & del-Valle, M.V., Andrés, M.L., Gelpi Trudo, R., Canet-Juric, L., & Urquijo, S. (2021). Longitudinal study on prenatal depression and anxiety during the COVID-19 pandemic. *Archives of Women's Mental Health, 24*(6), 1027–1036.

Madigan, S., Oatley, H., Racine, N., Fearon, R. M. P., Schumacher, L., Akbari, E., Cooke, J. E., & Tarabulsy, G. M. (2018). A Meta-Analysis of Maternal Prenatal Depression and Anxiety on Child Socioemotional Development. *Journal of the American Academy of Child and Adolescent Psychiatry, 57*, 645–657.

Matvienko-Sikar, K., Meedya, S., & Ravaldi, C. (2020). Perinatal mental health during the COVID-19 pandemic. *Women Birth, 33*, 309–310.

McMahon, C. A., Boivin, J., Gibson, F. L., Hammarberg, K., Wynter, K., Saunders, D., & Fisher, J. (2013). Pregnancy-specific anxiety, ART conception and infant temperament at 4 months post-partum. *Human Reproduction, 28*, 997–1005.

Miller, M. L., Williams, B. M., McCabe, J. E., Williamson, J. A., King, S., Laplante, D. P., Hart, K. J., & O'Hara, M. W. (2021). Perinatal anxiety and depressive symptoms and perception of child behavior and temperament in early motherhood. *Journal of Developmental Origins of Health and Disease, 12*, 513–522.

Monk, C., Spicer, J., & Champagne, F. A. (2021). Linking prenatal maternal adversity to developmental outcomes in infants:The role of epigenetic pathways. *Development and Psychopathology, 24*, 1361–1376.

Montirosso, R., Cozzi, P., Putnam, S. P., Gartstein, M. A., & Borgatti, R. (2011). Studying cross-cultural differences in temperament in the first year of life: United States and Italy. *International Journal of Behavioral Development, 35*, 27–37.

Murgatroyd, C., Quinn, J. P., Sharp, H. M., Pickles, A., & Hill, J. (2015). Effects of prenatal and postnatal depression, and maternal stroking, at the glucocorticoid receptor gene. *Translational Psychiatry, 5*, e560.

Nast, I., Bolten, M., Meinlschmidt, G., & Hellhammer, D. H. (2013). How to measure prenatal stress? A systematic review of psychometric instruments to assess psychosocial stress during pregnancy. *Paediatric and Perinatal Epidemiology, 27*, 313–322.

Nolvi, S., Karlsson, L., Bridgett, D. J., Korja, R., Huizink, A. C., Kataja, E. L., & Karlsson, H. (2016). Maternal prenatal stress and infant emotional reactivity six months postpartum. *Journal of Affective Disorders, 199*, 163–170.

O'Donnell, K. J., & Meaney, M. J. (2017). Fetal Origins of Mental Health: The Developmental Origins of Health and Disease Hypothesis. *American Journal of Psychiatry, 174*, 319–328.

O'Donnell, K. J., Glover, V., Barker, E. D., & O'Connor, T. G. (2014). The persisting effect of maternal mood in pregnancy on childhood psychopathology. *Development and Psychopathology, 26*, 393–403.

Perroud, N., Rutembesa, E., Paoloni-Giacobino, A., Mutabaruka, J., Mutesa, L., Stenz, L., Malafosse, A., & Karege, F. (2014). The Tutsi genocide and transgenerational transmission of maternal stress: Epigenetics and biology of the HPA axis. *The World Journal of Biological Psychiatry, 15*, 334–345.

Pluess, M., Velders, F. P., Belsky, J., & van IJzendoorn MH, Bakermans-Kranenburg MJ, Jaddoe VW, Hofman A, Arp PP, Verhulst FC, Tiemeier H,. (2011). Serotonin transporter polymorphism moderates effects of prenatal maternal anxiety on infant negative emotionality. *Biological Psychiatry, 69*, 520–525.

Provenzi, L., Grumi, S., Altieri, L., Bensi, G., Bertazzoli, E., & Biasucci, G. (2021). Prenatal maternal stress during the COVID-19 pandemic and infant regulatory capacity at 3 months: A longitudinal study. *Development and Psychopathology, 2*, 1–9.

Putnam, S. P., Sanson, A. V., & Rothbart, M. K. (2002). Child temperament and parenting. In M. H. Bornstein (Ed.), *Handbook of parenting: Children and parenting.* Lawrence Erlbaum Associates Publisher.

Putnam, S. P., Helbig, A. L., Gartstein, M. A., Rothbart, M. K., & Leerkes, E. (2013). Development and assessment of short and very short forms of the infant behavior questionnaire-revised. *Journal of Personality Assessment, 96*, 445–458.

Rakers, F., Rupprecht, S., Dreiling, M., Bergmeier, C., Witte, O. W., & Schwab, M. (2017). Transfer of maternal psychosocial stress to the fetus. *Neuroscience and Biobehavioral Reviews, S0149–7634*, 30719–30729.

Riquelme, A. G., & Casal, G. B. (2011). Actualización psicométrica y funcionamiento diferencial de los ítems en el State Trait Anxiety Inventory (STAI). *Psicothema, 23*, 510–515.

Rothbart, M. K. (2007). Temperament, development and personality. *Psychological Science, 16*, 207–212.

Rothbart, M. K., Derryberry, D., & Hershey, K. (2000). Stability of temperament in childhood: Laboratory infant assessment to parent report at seven years. In V. J. Molfese & D. L. Molfese (Eds.), *Temperament and personality development across the life span* (pp. 85–119). Lawrence Erlbaum Associates Publishers.

Rothenberger, S. E., Resch, F., Doszpod, N., & Moehler, E. (2010). Prenatal stress and infant affective reactivity at five months of age. *Early Human Development, 87*, 129–136.

Saccone, G., Florio, A., Aiello, F., Venturella, R., De Angelis, M. C., Locci, M., Bifulco, G., Zullo, F., & Di Spiezio, S. A. (2020). Psychological impact of coronavirus disease 2019 in pregnant women. *American Journal of Obstetrics and Gynecology, 223*, 293–295.

Sanz, J., & Vázquez, C. (2011). *Adaptación Española del Inventario para Depresión de Beck-II (BDI-II)*. Pearson.

Sanz, J., Perdigón, A. L., & Vázquez, C. (2003). Adaptación española del Inventario para la Depresión de Beck-II (BDI-II):2. Propiedades psicométricas en población general. *Clínica y Salud, 14*, 249–280.

Sayal, K., Heron, J., Maughan, B., Rowe, R., & Ramchandani, P. (2014). Infant temperament and childhood psychiatric disorder: Longitudinal study. *Child: Care, Health and Development, 40*, 292–297.

Shonkoff, J. P. (2017). Rethinking the Definition of Evidence-Based Interventions to Promote Early Childhood Development. *Pediatrics, 140*, e20173136.

Smith, K. E., & Pollak, S. D. (2022). Early life stress and neural development: Implications for understanding the developmental effects of COVID-19. *Cognitive, Affective, & Behavioral Neuroscience, 22*(4), 643–654.

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). *Manual for the State-Trait Anxiety Inventory*. Consulting Psychologists Press.

Spielberger, C. D., Gorsuch, R. L., Lushene, R. E., & Cubero, N. S. (1999). *STAI: Cuestionario de Ansiedad Estado-Rasgo*. TEA Ediciones.

Takegata, M., Matsunaga, A., Ohashi, Y., Toizumi, M., Yoshida, L. M., & Kitamura, T. (2021). Prenatal and Intrapartum Factors Associated With Infant Temperament: A Systematic Review. *Frontiers in Psychiatry, 12*, 609020.

Teicher, M. H., & Samson, J. A. (2016). Annual Research Review: Enduring neurobiological effects of childhood abuse and neglect. *Journal of Child Psychology and Psychiatry, 57*, 241–266.

Van den Bergh, B. R., Loomans, E. M., & Mennes, M. (2015). Early life influences on cognition, behavior, and emotion in humans: From birth to age 20. *Advances in Neurobiology, 10*, 315–331.

Wang, Q., Shelton, R. C., & Dwivedi, Y. (2018). Interaction between early-life stress and FKBP5 gene variants in major depressive disorder and post-traumatic stress disorder: A systematic review and meta-analysis. *Journal of Affective Disorders, 225*, 422–428.

Werner, E. A., Myers, M. M., Fifer, W. P., Cheng, B., Fang, Y., Allen, R., & Monk, C. (2007). Prenatal predictors of infant temperament. *Developmental Psychobiology, 49*, 474–484.

Yoshikawa, H., Wuermli, A. J., Britto, P. R., Dreyer, B., Leckman, J. F., Lye, S. J., Ponguta, L. A., Richter, L. M., & Stein, A. (2020). Effects of the Global Coronavirus Disease-2019 Pandemic on Early Childhood Development:Short- and Long-Term Risks and Mitigating Program and Policy Actions. *Journal of Pediatrics, 223*, 188–193.

Zijlmans, M. A., Riksen-Walraven, J. M., & de Weerth, C. (2015). Associations between maternal prenatal cortisol concentrations and child outcomes: A systematic review. *Neuroscience and Biobehavioral Reviews, 53*, 1–24.