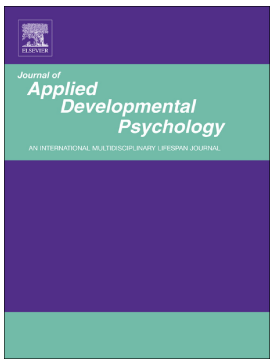
Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.



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Maternal anxiety, exposure to the COVID-19 pandemic and socioemotional development of offspring

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ABSTRACT

The COVID-19 pandemic context may predispose mothers to increased maternal psychopathology, which may be associated with offspring socioemotional development. The aim of this study is to analyze the relationships between prenatal anxiety and depression and exposure to the COVID-19 pandemic with offspring socioemotional development, controlling for postnatal anxiety and depression. A total of 105 mother-child dyads were assessed in pre- and postnatal periods. Questionnaires were used to assess the impact of the pandemic, indicators of psychopathology, and the socioemotional development of the offspring. Results suggest that negative pandemic experiences are indirectly associated with offspring socioemotional development via prenatal maternal anxiety symptomatology and after controlling for postnatal anxiety and depression. These indicators predispose to emotional deficits and increase the risks of psychopathological and neurodevelopmental disorders. It is important to adopt health policies that provide timely assessment of development in early childhood to reduce the risks associated with these deficits.

keywords:
prenatal anxiety; prenatal depression; socioemotional development; COVID-19

INTRODUCTION

The COVID-19 pandemic could present an adverse context for pregnant women, negatively affecting the early development of their offspring. As other disasters have shown, adverse circumstances lead to significant increases in stress, depression, and anxiety symptoms in pregnant women, which could have secondary psychological, cognitive, and motor effects on their prenatally exposed infants (Field, 2011; Madigan et al., 2018). Some studies have even suggested that exposure to adverse circumstances in early childhood could predict more than 30% of psychiatric disorders a posteriori (Green et al., 2010) and is causally associated with structural and functional changes in the nervous system that could affect the child's behavior and, thus, favor the development of a mental disorder (Babenko et al., 2015; Glover et al., 2011; Qiu et al., 2015). Therefore, the aim of this study is to analyze the relationships of prenatal anxiety and depression and exposure to the COVID-19 pandemic with the offspring socioemotional development, controlling for postnatal anxiety and depression. Gathering information about the behavioral and emotional changes children undergo in such situations is important to provide the public health system with tools for planning remedial actions and in light of possible future situations with similar characteristics (Canet-Juric et al., 2020).

Although the mechanisms involved in such a predisposition have not yet been fully described, it is already known that the prenatal period is particularly sensitive to environmental influences, as the fetus makes a physiological adaptation to the characteristics of the intrauterine environment, as proposed by the *fetal programming hypothesis* (Barker & Osmond, 1986). This hypothesis suggests that induced changes in fetal physiology may modulate the programming of developmental patterns in major tissues and organ systems

(Gluckman et al., 2010), which could explain how susceptibility to disease is maintained over time.

Several previous studies have addressed the effects of exposure of pregnant women to adverse circumstances or disasters and have provided important evidence for the fetal programming hypothesis. A disaster is an event that disrupts normal conditions of existence and causes a level of suffering beyond the adaptive capacity of the affected community (World Health Organization, 2002). Some events such as ice storms (Laplante et al., 2008), hurricanes (Nomura et al., 2019), floods (King et al., 2021; Moss et al., 2017), terrorist attacks (Brand et al., 2006) and war contexts (Qouta et al., 2021) have multiple negative consequences. High levels of maternal stress predicted lower cognitive development and language skills, poorer general intelligence and symbolic play ability, difficult temperament, distress towards novelty and lower levels of infant socioemotional development skills.

In Argentina, there were an average of 8498 daily COVID -19 infections and an average of 185 deaths per day during the period in which this study was conducted - March 2020 to November 2021. As in other countries, the COVID-19 pandemic forced governments to adopt restrictive measures that (despite the positive effect on containing viral circulation) had adverse social, economic and health consequences. Living conditions during the pandemic included confinement, social distancing, altered daily routines, reorganization of social life, restrictions on freedom, and concerns about health and the economy (Abel & McQueen, 2020). Several studies have shown that such health interventions have a negative impact on the mental health of the general population (Holmes et al., 2020), and these effects could be more severe for certain groups such as pregnant women or young children (Holmes et al., 2020). Regarding the mental health of pregnant women, studies have reported an increase in symptoms of depression (Dong et al., 2020; Durankuş & Aksu, 2020; López-

Morales et al., 2021a), anxiety (Kotabagi et al., 2020; Liu et al., 2020; López-Morales et al., 2021b), and perceived distress (Berthelot et al., 2020).

A significant increase in the prevalence of perinatal psychopathology in the pandemic context could be related to changes in fetal development that could ultimately alter adaptive behavior in the offspring. To date, few studies have examined the associations between prenatal stress during the pandemic and early development. They report lower motor and socio-personal development in six-month-old infants (Shuffrey et al., 2021), lower verbal, motor, and general cognitive performance (Deoni et al., 2021), lower regulatory abilities in three-month-old infants (Provenzi et al., 2021), and significant negative associations between days of maternal-infant separation and three developmental domains: Communication, gross motor skills, and personal-social skills (Wang et al., 2020).

However, less attention has been paid to the study of prenatal relationships between stress and socioemotional development. Socioemotional development is the child's developing ability to experience, regulate, and express emotions in socially and culturally appropriate ways, to explore the environment, and to learn (all within the context of family, community, and culture; Madigan et al., 2018). This definition includes *social and emotional competence* (e.g., understanding and selecting appropriate social or emotional responses), *temperament* (e.g., fussiness; negative affectivity), *behavioral problems* (e.g., internalizing, externalizing problems) and *self-regulation* (e.g., activating and inhibiting behavior as needed, and modulating behavior and emotional reactivity in social interactions) (Halle & Darling-Churchill, 2016).

The hypothesis that maternal stress during pregnancy is related to behavioral and emotional maladjustments in offspring is not new (Sontag & Wallace, 1934). In the socioemotional domain, although not all studies have demonstrated an association (Stein et

al., 2014), prenatal contexts of maternal stress have been linked to lower social and emotional competencies, such as less prosocial behavior (Rosenthal et al., 2018), lower responsiveness to faces and voices or less expression of interest and less effective interaction styles with others (Alder et al., 2007). Prenatal stress has also been associated with more temperament difficulties: more negative affect (Bekkhus, et al., 2018), longer periods of deep sleep, less time in states of peacefulness and active alertness (Field et al., 2003). Finally, prenatal stress has been linked to behavioral problems such as internalizing and externalizing difficulties (Barker et al., 2011), lower activity levels, increased irritability, disorientation (Field, 2011), and difficulties in self-regulation, such as lower consolation, higher excessive crying (Takegata et al., 2021) and greater reactivity and stress propensity (Gentile, 2017). It is worth noting that measures assessing these subdomains rely primarily on adult reports and, to a lesser extent, observational techniques by trained professionals (Halle & Darling-Churchill, 2016), while significantly fewer studies assess social-emotional development as a general domain.

To date, only one study has addressed the relationships between maternal stress during the COVID -19 pandemic and children's socioemotional development, a key variable in later emotional and behavioral adjustment (Rogers et al., 2020). The study conducted by Duguay et al. (2022) found that higher levels of maternal prenatal distress were significantly associated with poorer child socioemotional development. This important finding encourages further investigation of these possible associations with early development. Assessment of socioemotional competencies in early childhood is of great importance because they are an important predictor of later well-being and academic ability (Halle & Darling-Churchill, 2016). If dysregulation is prevalent or maladjustment occurs, delays and deficits in socioemotional development can lead to psychological problems later in life (Lewis et al., 2014; Madigan et al., 2018). Therefore, it is hypothesized that the prenatal context of

adversity could constitute a negative stimulus associated with an increase in psychopathological symptomatology in pregnant women and this in turn is related to the early development of children born during the pandemic. At the same time, controlling for the effects of postnatal indicators of anxiety and depression is suggested to underscore the importance of prenatal maternal stress as an influence on later child development.

MATERIALS AND METHODS

Participants

The sample consisted of 105 mother-child dyads (mean age = 32.49; *SD* = 4.71) with singleton and term pregnancies, recruited between March 2020 and November 2021. Mothers responded to surveys longitudinally during the second (*n* =137; mean gestational age = 21.68; *SD* = 2.58) and third trimesters of pregnancy (*n* =110; mean gestational age = 30.8; *SD* = 1.37) and postnatally at six months (*n* =105) (Figure 1). The sample was composed of only those mothers who participated in the three surveys of the study (*n* =105), excluding those who did not complete one or two of the surveys for various reasons (due to decline in participation: *n* = 31; due to pregnancy loss: *n* = 1). No missing data imputation methods were used because excluded participants had less than 80% of the data (Roth, 1994). Socioeconomic, demographic and health history characteristics (age, gestational age, educational level, parity, presence of disease or medical complications during pregnancy and COVID-19 infection during pregnancy or puerperium) are summarized in Table 1. The inclusion criteria were as follows: Age between 18 and 45 years, residence in Argentina, no severe physical/mental illness, absence of COVID-19 risk factors other than pregnancy, singleton pregnancy and being between the second and third trimesters of pregnancy. Pregnant women who reported taking psychotropic drugs or steroids during pregnancy and

who used alcohol and/or illicit drugs were excluded. As for the offspring, only newborns from singleton and term pregnancies (≥ 37 and < 42 weeks of gestation) were included and newborns with increased risk for neurodevelopmental disorders were excluded (birth weight < 2.5 kg; congenital anomalies, neurologic damage, and diagnosis of intrauterine growth restriction; Enlow et al., 2011; Minde, 2000). Women who did not participate in follow-up did not differ significantly from participating women in terms of prenatal anxiety (Z = -.049, p = .085), prenatal depressive symptoms (Z = -.350, p = .200), negative pandemic impact (Z = -.708, p = .059) and sociodemographic variables (Table 1).

Ethical Aspects

Participation was voluntary and subject to informed consent. For each survey conducted, mothers were required to read and consent to their own and their child's participation. The procedures to be performed were submitted to *[information omitted for anonymity]* and approved by *[information omitted for anonymity]*. The procedures recommended by the *American Psychological Association*, the principles of the Declaration of Helsinki, and the procedures set forth in the International Convention on the Rights of the Child were considered.

Procedure

Surveys were uploaded to *Google Forms* and disseminated through social networks using a snowballing sampling procedure. Figure 1 shows the design of the study.

[Figure 1 near here]

[Table 1 near here]

Assessment Tools

Assessment of pregnant women.

Negative pandemic experience: The Complementary and Integrative Research Pandemic Impact Questionnaire (C-PIQ) was used (Lang, 2020). This is a 28-item questionnaire that assesses response to the COVID-19 pandemic in terms of impact on mental health, growth, and exposure to stressors, either directly or through a loved one. This was an adaptation of the Coronavirus Health Impact Survey (CRISIS) volume 2.0, the Life Events Checklist (McLean & Cloitre, 2020) and the five dimensions of the Posttraumatic Growth Inventory (Taku et al., 2008). For the purposes of this study, only the *exposure* subscale was used, which consists of eight dichotomous response items (yes - no) that require the person to indicate whether they (*happened to me*) or someone close (*happened to someone close to me*) were exposed to different stressors generated by the pandemic (e.g., illness from the coronavirus, death of loved ones, loss of employment or income, difficulty obtaining food, medication, medical assistance, negative impact on relationships with family and friends, etc.). Scores are calculated by adding the "yes" responses from both columns ("it happened to me" and "it happened to someone close to me"), resulting in a final score for negative pandemic experiences. Scores range from 0 to 16 points (item 3, which refers to the death of a close person, can only be answered in the "happened to someone close to me" column, but contributes 2 points). The Cronbach's α in this study was .88.

Depression symptoms: The Spanish adaptation (Sanz et al., 2005; Sánz & Vázquez, 2011) of the Beck Depression Inventory-II was used (BDI-II; Beck et al., 1996). The BDI-II assesses the presence and severity of depressive symptoms through 21 items that indicate symptoms such as sadness, crying, loss of pleasure, guilt, pessimism, and so on. For each item, respondents are asked to choose the statement that best describes their feelings and thoughts in the past two weeks (to match the DSM-IV criteria for major depression). The statements (4-point scale) describe increasing severity of each symptom. The BDI-II has previously shown good reliability (α = .89, Sanz et al., 2003) and validity in pregnant women

(Holcomb et al., 1996). The scale has good internal consistency in studies with pregnant women (Cronbach's α was .87), indicating good reliability (Bos et al., 2009). Cronbach's α for the BDI in the present study were .93 (prenatal) and .91 (postnatal).

Anxiety symptoms: The state anxiety scale of the Spanish version (Spielberger et al., 1999) of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch & Lushene, 1970) was used. The STAI is a self-report instrument consisting of 40 items that separately assess anxiety as a state and as a trait. In this study, only the 20 items of the state anxiety subscale were administered. The items are answered on a Likert scale with a range from 0 to 3. The STAI has previously shown good reliability (α = .84 to .93, Riquelme & Casal, 2011) and validity in pregnant women (Gunning et al., 2010). The Cronbach's α in the present study were .86 (prenatal) and .88 (postnatal).

Covariates: Closed-ended questions were asked about age, gestational age, educational level, previous pregnancies, and prenatal illness or medical complications. For infants, closed-ended questions explored sex, birth weight, and age.

Assessment of infants

Socioemotional development problems: the *Ages & Stages: Socioemotional 2* (ASQ:SE2) scale was administered. The measure was designed by Squires, Bricker and Twombly (2015). It consists of nine parent questionnaires that examine the socioemotional development problems of children ages 1-72 months. For this project, the *3 months 0 days to 8 months 30 days* questionnaire was selected. It contains 23 items (e.g., *"Does your baby smile at you and other family members?"; "Do you and your baby enjoy feeding time together?"; "Does your baby make sounds and look at you while playing with you?"*). Questionnaires were completed by mothers on a 3-point scale (i.e., 0 = most of the time, 5 = sometimes, 10 = rarely or never). Mothers can also indicate whether the behavior addressed in

each item worries them. If so, 5 additional points are added to the total score. Higher scores indicate poorer socioemotional development. The scores obtained are added and the total is compared to the cut-off point established by age. This cut-off point delimits clinical categories: *Below the cut-off point* (score between 0 and 29), socioemotional development is within the expected range; *Close to the cut-off point* (score between 30 and 44), the child requires additional monitoring and follow-up actions; *Above the cut-off point* (score above 45), the child is at risk, requires further assessment and may require intervention.

Data Analysis

Analyses were performed using IBM SPSS 26 software for Windows, with a *p value* < .05. Descriptive statistics were calculated for socioeconomic and demographic characteristics and for all variables reported in the *assessment tools* section. Descriptive statistics (e.g., mean, standard deviation) were obtained for continuous variables and percentages for categorical variables. *Pearson's* correlations were used to assess associations between continuous variables; *Point-Biserial* correlations were used to assess associations between dichotomous and continuous variables; *Spearman's* correlations were used to assess associations between ordinal and continuous variables. The normality of the dependent variables was verified by analyzing skewness and kurtosis (values between ± 2 points were considered acceptable limits for normality; George & Mallery, 2016).

Hierarchical regression analysis models were used to examine whether prenatal anxiety/depression/ negative experiences due to the pandemic predicted socioemotional development problems at six months. In all models, predictors were gradually forced into regression in the following steps: 1) covariates were included to control for background factors; 2) postnatal anxiety/depression was added, accordingly, to control for the effects of maternal psychological context; 3) prenatal anxiety/depression or negative pandemic experiences were added to the model. The effect of the independent variables was estimated

using standardized β. The effect size was estimated through f^2 and Power (1-β) was also considered.

Finally, serial mediation models (Model 4) were estimated using PROCESS (Hayes, 2013) based on the data from the regression models. In these models, negative experiences due to the pandemic were the independent variable, prenatal anxiety (Model 1) or depression (Model 2) were the mediator, and socioemotional development problems were the dependent variable, as appropriate. The same covariates were used as in the linear regression analyses. A *bootstrapping* procedure with 10,000 resamples was used to assess the indirect effect. This procedure creates accelerated and bias-corrected 95% confidence intervals (CI of 95%) of the indirect effects, that are significant if the value of zero is not within the upper and lower CIs.

RESULTS

Characteristics of the Sample and Descriptive and Inferential Statistics of Psychopathological and Socioemotional Development Problems

The socioeconomic and demographic variables of the sample are presented in Table 1. The descriptive statistics for the tests are shown in Table 2. Regarding the clinical scale of the ASQ:SE2, socioemotional development was above expectations in 78.1% of the children, while 18.1% and 3.8% were just above and below expectations, respectively.

[Table 2 near here]

Correlations between Negative Pandemic Experiences, Maternal Psychopathology, Socioemotional development problems and covariables

Correlations among study variables are presented in Table 3. Socioemotional development problems showed positive correlations with prenatal psychopathology indicators and with negative pandemic experiences. It is important to clarify that higher socioemotional

development problems indicate more difficulties. On the other hand, prenatal anxiety showed significant correlations with prenatal and postnatal psychopathological indicators, negative pandemic experiences, parity, and maternal educational level ($p < .05$). Prenatal depression showed significant correlations with prenatal and postnatal psychopathological indicators, negative pandemic experiences and maternal educational level ($p < .05$). Finally, negative pandemic experiences showed significant associations with prenatal and postnatal anxiety and prenatal depression ($p < .05$). Considering that anxiety scores during the 2nd and 3rd trimesters showed a correlation above .50 ($r = .528$, $p < .01$), and the same was observed for depression during the 2nd and 3rd trimesters ($r = .775$, $p < .01$), we created a prenatal anxiety variable (mean= 23.71; SD=7.33) and a prenatal depression variable (mean= 10.76; SD=6.02) by averaging the second and third trimesters. These averaged scores are used in the regression and mediation analyses.

[Table 3 near here]

Associations Between Prenatal Anxiety and Infants' Socioemotional Development Problems

In all hierarchical regression models performed, only those variables that showed correlations ($p < .05$) with the socialemotional development scales and measures of prenatal anxiety and depression were included as covariates: maternal educational level (1 = up to university; 2 = university; 3 = postgraduate), postnatal anxiety, postnatal depression, and parity.

Table 4 (Predictor: Maternal anxiety) shows the results of the hierarchical regression (adjusted for covariates) performed to determine whether prenatal anxiety predicts offspring socioemotional development problems, after controlling for postnatal anxiety. In the final

model, socioemotional development problems are negatively predicted by prenatal anxiety only (β = .469, p < .01). The tested model explained 20% of the variance (R^2 = .200, p < .01).

[Table 4 near here]

Associations Between Prenatal Depression and Infants' Socioemotional Development Problems

Table 4 (Predictor: Maternal depression) also shows the results of the hierarchical regression (adjusted for covariates) performed to determine whether prenatal depression predicted offspring socioemotional development problems after controlling for postnatal depression. None of the steps showed significant results (p > .05). However, Step 2 showed a significant effect of postnatal depression (β = .268, p < .05). Thus, prenatal depression was not associated with infant socioemotional development problems.

Associations Between Negative Pandemic Experiences and Infants' Socioemotional Development Problems

Finally, Table 4 (Predictor: Negative pandemic experiences) describes the results of hierarchical regression (adjusted for covariates) performed to determine whether negative pandemic experiences predicted offspring socioemotional development problems, after controlling for postnatal anxiety and depression. Socioemotional development problems were associated with negative pandemic experiences (β = .237, p < .05). The model tested explained nearly 13% of the variance (R^2 = .130, p < .05).

For all hierarchical regression models performed, collinearity diagnostics showed values of the variance inflation factor below 1.24. In turn, the residuals of the model showed a normal distribution (*Sk* = .317; *Ku* = .252).

Mediation Model

In these models, negative experiences due to the pandemic were the independent variable, prenatal anxiety or depression were the mediators, and infants' socioemotional development problems were the dependent variable. Postpartum anxiety and depression, and maternal education and parity, were included as covariates in both models.

As shown in Figure 2 (Model 1), negative pandemic experiences were significantly and positively associated with prenatal anxiety ($\beta = 0.48$, $p < .01$) and, together with covariates, explained 40.51% of the variance ($R^2 = .40$; $p < .01$). Prenatal anxiety was significantly and positively associated with socioemotional development problems in six-month-old babies ($\beta = 0.43$, $p < .01$) and, together with covariates, explained 20.76% of the variance ($R^2 = .21$; $p < .01$). Although negative pandemic experiences and socioemotional development problems ($\beta = 0.07$, $p > .05$) were not significantly associated (direct effect), there was a significant *indirect mediation effect* between negative pandemic experiences, prenatal anxiety, and socioemotional development problems ($\beta = 0.21$, *IC* = 0.07/0.35, *SD* = .702). At the same time, it is worth mentioning that the total effect was significant ($\beta = 0.28$, $p < .01$).

On the other hand, Model 2 (Fig.2) showed a significant effect of negative experiences due to the pandemic on prenatal depression ($\beta = 0.16$, $p < .05$). No association was found between prenatal depression and infant socioemotional development problems ($p > .05$). In addition, there was no indirect mediation effect of negative pandemic experiences on infant socioemotion development problems through prenatal depression.

Nevertheless, a significant total effect of COVID-19 negative experiences on infant socioemotional development problems was found ($\beta = 0.25$, $p < .01$). In addition, postnatal depression as a covariate presents significant effects in the total model ($\beta = 0.22$, $p < .05$).

[Figure 2 near here]

DISCUSSION

The aim of this study was to analyze the relationships between prenatal anxiety and depression and exposure to the COVID-19 pandemic with the socioemotional development of offspring, controlling for postnatal anxiety and depression. It has been speculated that the current adverse context caused by the COVID-19 pandemic could be a negative stimulus that initially leads to an increase in maternal psychopathological symptoms, which could have a secondary effect on offspring's early developmental trajectories by exposing their children to potential negative consequences of a biological, affective, or cognitive nature (King et al., 2021). As mentioned above, the pandemic context brought unpredictable changes to daily life, including physical isolation, restricted mobility, loss of employment or lower income, and greater difficulty accessing medical and social care -dimensions that can be characterized as negative pandemic experiences-. Previous studies have already reported negative mental health outcomes caused by financial or work-related problems (Thayer & Gildner, 2020), increased COVID -19 infections or deaths (Zhou et al., 2020), disruption of prenatal care (Zhang & Ma, 2020), or maternal or fetal health concerns (Corbett et al., 2020; Thapa et al., 2020). Because pregnant women have special needs in these areas (Matvienko-Sikar et al., 2020), the pandemic context could have exacerbated the vulnerability of this group.

Regarding the socioemotional development of offspring, our study found that 3.8% of the children were below expectations, while 18.1% of the children were just above expectations for their age. Although the latter show normal socioemotional development, it is recommended that attention be paid to their later development and that the child be monitored in these developmental areas, as some children may show difficulties later (Squires et al., 2015). Unfortunately, there are currently no population-based data from previous studies describing norms in the region (i.e., Argentina). However, similar studies in other low- and

middle-income countries have reported rates like those in our study: 1.5%-2.5% (Poon et al., 2010), 3.3% (de Moura et al., 2010) and up to 12.5% (Potijk et al., 2013) of children fall below the expected performance for their age. Therefore, the results of the present study do not seem to be in great contrast to previous studies.

Consistent with the hypothesis, the results showed that prenatal anxiety and negative pandemic experiences were related to socioemotional development in six-month-old infants. Negative pandemic experiences, in turn, were indirectly associated with offspring socioemotional development problems via prenatal anxiety. These findings are also consistent with a substantial number of studies that have supported the hypothesis of the effects of prenatal adverse conditions and future consequences on development (Almond, 2006; Bátiz et al., 2021; Kamara et al., 2017; LaPlante et al., 2008; Spring & Silman, 2013), at cognitive, emotional, and social levels (Cao-Lei et al., 2020; Monk et al., 2012; Yoshikawa et al., 2020).

On this topic, there are few studies reporting the impact of the pandemic context on the early socioemotional development of infants gestated during the COVID-19 pandemic. Manning et al. (2022) showed that infants exposed to prenatal anxiety and depression in the COVID-19 pandemic context had different structural connections between their amygdala and prefrontal cortex. This finding suggests that brain structure is one mechanism through which prenatal maternal distress can impact children's behavioral development and predispose them to socioemotional difficulties, for example (Hay et al., 2020).

Because of considerable similarities in topic and methodology, the results of a study by Duguay et al. (2022) are worth noting. These authors reported that higher levels of maternal prenatal distress during the pandemic were significantly associated with poorer infant socioemotional development. The mediation model proposed by the authors showed that postnatal maternal distress during the pandemic acted as a mediator between prenatal

distress and infant socioemotional development, whereas (in contrast to our study) there was no significant direct effect of prenatal maternal distress.

Other studies conducted in this pandemic context have also reported similar findings on other socioemotional variables in offspring. The study by Provenzi et al. (2021) reported that maternal postnatal anxiety was indirectly related to infants' regulatory capacity at 3 months of age, mediated by parental stress and mother-child bonding. On the other hand, the study by Jeličić et al. (2022) reported a positive correlation between maternal trait anxiety and the infant socioemotional status at 12 months of age. As can be observed, our study shows additional evidence in this direction and deepens knowledge in this area.

Broadly, the results are also consistent with the theoretical model proposed by Madigan et al. (2018) in their meta-analysis of prenatal anxiety and offspring socioemotional difficulties. Specifically, the authors found that mothers who experienced prenatal anxiety were nearly 1.5 to 2 times more likely to have children with socioemotional difficulties than mothers who did not.

Although interest in this topic is increasing, the relationship between prenatal anxiety and socioemotional development in such young children needs further research. Some of the studies on this topic have also reported that prenatal anxiety is associated with excessive crying in one and a half month old babies (Bolten, Fink & Stadler, 2012), higher levels of choleric behavior in three-month-old babies (Escallier, 1995; Rautava, Helenius & Lehtonen, 1993), more negative affect responses of the infant at eight months (Grant et al., 2010), higher levels of infant activity, distress about limitations and sadness (Henrichs et al., 2009), greater infant negative affect (Pluess et al., 2010) and regulation problems (Agrati et al., 2015) and higher levels of crying and fussiness (Petzoldt et al., 2014).

Although the mechanisms mediating this relationship are not yet sufficiently understood (van den Bergh et al., 2020), there is currently a strong consensus that maternal

influence on the fetus is mediated by the effects of maternal cortisol on the development of the fetal hypothalamic-pituitary-adrenal (HPA) axis. It has been shown, although with limited research in human models (Cao-Lei et al., 2020), that adverse situations can lead to epigenetic changes (e.g., gene methylation) that can decrease gene expression (such as FBPK5, NR3C1 and HSD11B2) associated with HPA axis regulation (O'Donnell & Meaney, 2017). As a result, negative feedback mechanisms begin to fail, leaving cortisol concentrations at high levels, which amplifies its neurotoxic effects. This dysregulation has a very high cost on the neuroendocrine systems of pregnant women, which can directly influence the neural structures of the developing fetus (Rakers et al., 2017), potentially altering future cognitive, emotional, and behavioral functioning (van den Bergh et al., 2015). These changes could initially be explained by the effects of high cortisol concentrations on limbic brain structures (e.g., hippocampus and amygdala), which may lead to an overproduction of neural connections, and alter the prefrontal cortex functioning with a lower number of neural connections (Teicher & Samson, 2016). Both structures are involved in reactivity and stress regulation patterns, emotional (e.g., anxiety, anger) and cognitive (e.g., learning, memory) processing, and temperamental behavioral variations (e.g., novelty seeking, harm avoidance, reactive temperament). These structural changes can influence the way an individual perceives, interprets, and reacts to stressful situations (Hair et al., 2015). Thus, extreme exposure of the fetus to maternal anxiety could program its response system to adversity so that it is more susceptible to future responses to events that are not inherently stressful and therefore activates the stress response system more frequently and for longer than necessary (Shonkoff, 2017).

It is worth noting that a growing body of scientific evidence suggests that socioemotional problems observed in early development tend to be highly resistant to change and are likely to increase over time (Giannoni & Kass, 2012; Walker & Shinn, 2010).

Moreover, it has been previously reported that these delays or deficits can lead to psychological problems in adolescence and adulthood when socioemotional dysregulation is prevalent or poor social adjustment to context occurs (Bornstein et al., 2013). Consequently, early identification of socioemotional problems in infants is critical to help them build their socioemotional skills and reduce the likelihood of future difficulties, while allowing for earlier and thus more effective action plans (Squires et al., 2015).

On the other hand, most studies have focused on anxiety indicators as predictors of socioemotional development, but there are also some reports on the association between depression and infant socioemotional and behavioral variables (Erickson et al., 2017; Takegata et al., 2021). Although much research indicated the existence of significant associations between prenatal depression and some of these variables (e.g., greater presence of negative affectivity and problems regulating emotional states; Babineau et al., 2015; Della Vedova, 2014), a substantial number of articles report null effects (e.g., Nolvi et al., 2016; Rothenberger et al., 2011), which is consistent with the results of the present study. This indicates that the relationship between prenatal depression and socioemotional development, in contrast to prenatal anxiety, still poses major challenges and debates among scientists and researchers.

As mentioned above, the main interest of this study was to investigate the relationships between prenatal psychopathological and early childhood development. For this reason, we controlled for postnatal anxiety and depression, which did not show significant effects in the final statistical models. These results are consistent with the fetal programming hypothesis, which states that the prenatal period is a sensitive developmental period because the fetus makes a physiological adaptation to the characteristics of the intrauterine environment in which it is developing (Barker & Osmond, 1986). Because the central nervous system develops during the gestational period, induced changes in fetal physiology may modulate the

programming of developmental patterns of key tissues and organ systems (Gluckman et al., 2010). Consistent with this hypothesis, several papers have reported that postnatal maternal psychopathology is unrelated to infant socioemotional development. Oztop and Uslu (2007) found no association between maternal postnatal depression and children's social skills. In the cross-sectional study by Watts et al. (2018), no association was found between maternal postnatal anxiety and social-adaptive behavior. Similarly, it is worth noting that the present study did not focus on maternal postnatal psychopathology, but it nonetheless highlights the relevance of prenatal versus postnatal context in predicting early childhood social-emotional development.

It is necessary to point out some limitations of this study. First, the sample is relatively small and cannot be considered representative or generalizable due to the purposive selection method used. Nevertheless, this is the only study in Latin America and one of the few in the world that has attempted to investigate the effects of prenatal maternal distress on infant socioemotional development, which could be an incentive for subsequent studies with a larger number of participants and, therefore, greater generalizability. Second, the results were based only on mothers' reports of infant neurodevelopmental milestones and their own symptoms, so the risk of response bias and error had to be considered. For example, mothers with higher anxiety or depression scores might overestimate the negative features of their children's socioemotional characteristics (Della Vedova, 2014; Shonkoff, 2017). However, the longitudinal approach of the study may mitigate this risk (Babineau et al., 2015). In addition, parental reports across contexts and situations have been shown to be appropriate indicators of infant emotional reactivity (Babineau et al., 2015). Third, a limitation of this study was that mothers with a previous diagnosis of psychopathology were suggested as exclusion criteria. Because other studies have reported that individuals with a history of mental disorders may have been even more impaired in the pandemic context (Holmes et al., 2020), our study has

an important limitation. Fourth, because this study measured prenatal depression and anxiety and negative experiences of the pandemic at the same time, it is difficult to determine the true direction of the effects. Although less likely, it could be that preexisting depression or anxiety predisposes individuals to more negative pandemic experiences. Finally, there are many other variables that may affect infant neurodevelopment that were not controlled for or considered in this study. Because social maturation in infancy can alter cognitive, socioemotional, and behavioral functioning, certain postnatal variables, such as the mother-infant relationship, may have an impact on outcomes (Takegata, 2021).

CONCLUSIONS

In summary, this study provides evidence of relationships between exposure to contextual and psychological adversity during pregnancy and early socioemotional difficulties. These recorded indicators may predispose offspring to emotional deficits in childhood and adolescence and increase the risk for developing a wide range of psychopathological and neurodevelopmental disorders (Del Rosario et al., 2014; Erickson et al., 2017; Sayal et al., 2014). Therefore, it is important to warn of the need to adopt health policies that allow a more detailed assessment of variables linked to early childhood development, as well as the need to intervene early in pregnant women to reduce the risks associated with these deficits. Therefore, the emergence of early developmental difficulties related to the COVID -19 pandemic should be an incentive for the development of new strategies promoted by the state and its health systems. These could include assessments of psychopathological dimensions in mothers and socioemotional aspects in obstetric and pediatric check-up routines, respectively; interventions and training for early childhood professionals to identify socioemotional deficits and psychosocial stimulation at an early

stage; strategies driven by health professionals to improve parents' confidence and skills in psychosocial stimulation of their children.

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Figure 1.
Longitudinal design of the study

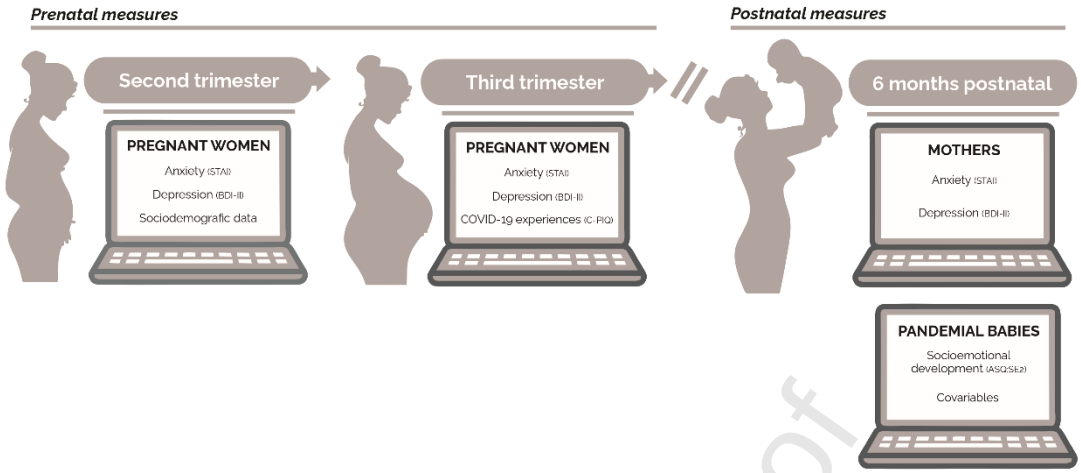
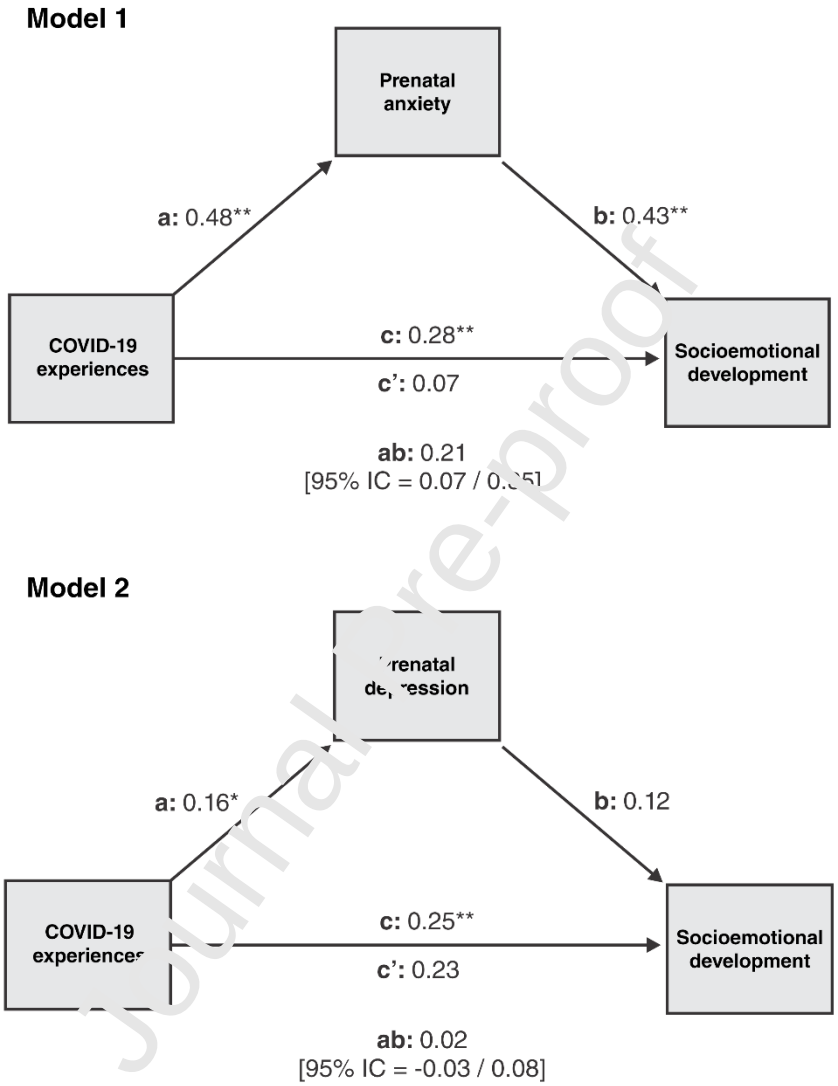


Figure 2.

Statistical diagram of the serial mediation models used to test the influence of prenatal anxiety (model 1) and prenatal depression (model 2) on the association between negative pandemic experiences and socioemotional development of six-month-old babies.



Note. Path values represent standardized regression coefficients. The ***c*** value corresponds to the total effect of COVID-19 negative experiences on child socioemotional development. The ***c'*** value represents the direct effect of negative pandemic experiences on socioemotional development. Postpartum anxiety and depression, as well as maternal education and parity were included as covariates in the models. For the sake of simplicity, these covariates are not shown in the figure. * $p < .05$ / ** $p < .01$.

Table 1
Socioeconomic and demographic variables and health covariates

Variable			Pregnant women (n = 105)	Excluded participants (n = 31)	X^2 / Z
Maternal age	*Mean*		32.49	32.6	-
	SD		4.71	5.01	0.031
Gestational age (weeks)	*Second trimester*	*Mean*	21.68	19.56	-
		SD	2.58	2.89	0.089
	Third trimester	*Mean*	32.8	-	-
		SD	2.37	-	
Educational level	*Postgraduate (complete and incomplete)*		34.3%	41.9%	4.18
	University (complete)		34.3%	45.5%	
	Up to university (incomplete)		31.4%	12.9%	
Parity	*Primiparity*		59.6%	66.7%	0.49
	Multiparity		40.4%	33.3%	
Diseases or medical complications	*Heavy bleeding*		2.9%	9.7%	-
	Fluid retention		9.8%	3.2%	
	Excessive nausea or vomiting		19.6%	16.1%	
	Weight loss of 5 kg or more		2.9%	3.2%	
	Weight gain of 12 kg or more		11.8%	6.5%	
	Infections		2.9%	0.0%	
	Hypertension		1.0%	0.0%	
	Thyroid problems		8.8%	6.5%	
	Gestational diabetes		2.0%	3.2%	
	Blood incompatibility		1.0%	3.2%	
	Other illnesses		3.9%	3.2%	
	Total medical complications	*Mean*	0.67	0.55	-
		SD	0.95	0.85	0.394
COVID-19 infection	*Yes, during labor*		1.9%	3.2%	0.68
	Yes, after labor		5.7%	-	
	No		92.4%	96.8%	
Sex of the baby	*Female*		54.3%	-	-
	Male		45.7%	-	
Birth weight (grams)	*Mean*		3307.53	-	-
	SD		218.40	-	

Table 2

Descriptive statistics of the tests administered.

Variable		Second trimester	Third trimester	Postnatal (6 months)
Negative pandemic experiences (C-PIQ)	*Mean*	-	7.57	-
	SD	-	2.71	-
Maternal anxiety (STAI)	*Mean*	23.74	23.86	20.97
	SD	9.25	7.96	10.72
Maternal depression (BDI-II)	*Mean*	10.39	11.31	9.54
	SD	6.37	6.93	5.43
Socioemotional development (ASQ:SE2)	*Mean*	-	-	25.43
	SD	-	-	11.83

Table 3
Correlations among STAI, the BDI-II, C-PIQ scores, ASQ:SE2 scale and covariables.

Variables[a]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Socioemocional development[b]	-																
2. Anxiety during 2° trimester	.358**	-															
3. Anxiety during 3° trimester	.444**	.528**	-														
4. Postnatal anxiety	.100	.397**	.306**	-													
5. Depression during 2° trimester	.301**	.418**	.398**	.251**	-												
6. Depression during 3° trimester	.227*	.451**	.409**	.274**	.776**	-											
7. Postnatal depression	.309**	.383**	.349**	.302**	.596**	.695**	-										
8. Negative pandemic experiences	.288**	.275**	.598**	.092	.214*	.230*	.135*	-									
9. Maternal age	.029	-.063	.043	.047	-.114	-.017	.011	-.190	-								
10. Gestational age (2° trimester)	.069	-.108	.091	.117	-.063	-.021	.121	.007	.203	-							
11. Gestational age (3° trimester)	-.060	-.075	.102	.238	.016	.048	.123	-.009	.180	1.00**	-						
12. Educational level	-.020	-.080	.171*	-.084	.176	.114*	.088	.114	.174	.012	-.086	-					
13. Parity[c]	.047	.322**	.110	.183	.046	.118	.101	.064	.184	.159	.135	-.126	-				
14. Total of diseases/medical complications	-.105	.000	.171	.003	.036	.054	.048	.182	.038	-.095	-.013	.099	-.028	-			
15. Sex of the baby[d]	-.168	.062	.174*	.067	-.069	.076	-.009	-.093	.097	.090	.015	-.030	.064	-.125	-		
16. Birth weight (grams)	.134	.119	.002	-.013	.128*	-.053	.032	-.007	-.006	.051	.100	-.106	-.043	-.049	.044	-	
17. Prenatal anxiety	.450**	.870**	.814**	.420**	.554**	.556**	.353**	.530**	-.024	-.022	.017	-.127*	.230*	.081	-.059	.174	-
18. Prenatal depression	.274**	.633**	.429**	.265**	.922**	.943**	.607**	.268**	-.034	-.029	.033	.162*	.091	.034	.005	-.091	.430**

Note. "prenatal anxiety" and "prenatal depression" refer to the average of the scores of the 2nd and 3rd trimesters.
** $p < .01$; * $p < .05$

(a) *Pearson's* correlations were used to assess associations between continuous variables; *Point-Biserial* correlations were used to assess associations between dichotomous and continuous variables; *Spearman's* correlations were used to assess associations between ordinal and continuous variable.
(b) Higher socioemotional developmental score is indicative of more difficulties.
(c) Primiparity = 1; Multiparity = 2.
(d) Female = 1; Male = 2.

Table 4.

Linear regression analyses examining the predictive roles of maternal anxiety, maternal depression, and negative pandemic experiences on infant socioemotional development problems

	Predictor: Maternal anxiety						Predictor: Maternal depression						Predictor: Negative pandemic experiences					
	R^2	ΔR^2	B	β	1 - β	f^2	R^2	ΔR^2	B	β	1 - β	f^2	R^2	ΔR^2	B	β	1 - β	f^2
Step 1	.002	.002			.066	.002	.002	.002			.066	.002	.002	.002			.066	.002
Educational level (mother)			-0.126	-.009					-0.126	-.009					-0.126	-.009		
Parity			1.135	.047					1.135	.047					1.135	.047		
Step 2	.023	.021			.223	.023	.073	.071			.719	.079	.077	.075			.679	.083
Educational level (mother)			0.004	.000					-0.481	-.023					-0.395	-.027		
Parity			0.256	.011					0.475	.020					0.138	.006		
Postnatal anxiety			0.256	.150					-	-					0.114	.067		
Postnatal depression			-	-					0.699	.268*					0.643	.247*		
Step 3	.200**	.177			.989	.250	.095	.021			.787	.105	.130*	.053			.890	.149
Educational level (mother)			-0.170	-.012					-0.810	-.056					-0.719	-.050		
Parity			-1.259	-.053					0.226	.009					-0.123	-.005		
Postnatal anxiety			-0.056	-.033					-	-					0.082	.048		
Postnatal depression			-	-					0.429	.165					0.547	.210		
Prenatal anxiety			0.756	.469**					-	-					-	-		
Prenatal depression			-	-					0.360	.183					-	-		
Negative experiences			-	-					-	-					1.037	.237*		

Note. * $p < .05$ / ** $p < .01$; $f^2 = .02$ (small); .15 (medium); .35 (large).

Author Statement Contributors
LMH: Conceptualization, Methodology, Formal analysis, Investigation, Writing - Original Draft. **US/LCJ:** Writing - Review & Editing, Resources, Supervision, Funding acquisition, Project administration, Funding acquisition. **DVMV/AML/GMJ:** Writing - Review & Editing. **LMC:** Project administration, Writing - Review & Editing.

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Highlights

- Negative experiences due to the COVID-19 pandemic predicted higher levels of maternal anxiety and depression.
- Prenatal maternal anxiety and the number of negative experiences due to the pandemic were negatively associated with the offspring's socioemotional development.
- Negative pandemic experiences are indirectly associated with the offspring's socioemotional development, mediated by the intensity of prenatal maternal anxious symptomatology.