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REVIEW ARTICLE

The impact of prenatal maternal stress due to potentially traumatic events on child temperament: A systematic review

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Abstract

The objective of the current study was to complete a systematic review of the relationship between prenatal maternal stress due to potentially traumatic events (PTEs) and child temperament. Eligible studies through June 2020 were identified utilizing a search strategy in PubMed and PsycInfo. Included studies examined associations between prenatal maternal stress due to PTE and child temperament. Two independent coders extracted study characteristics and three coders assessed study quality. Of the 1969 identified studies, 20 met full inclusion criteria. Studies were classified on two dimensions: (1) disaster-related stress and (2) intimate partner violence during pregnancy. For disaster-related prenatal maternal stress, 75% (nine out of 12) of published reports found associations with increased child negative affectivity, 50% (five out of 10) also noted associations with lower effortful control/regulation, and 38% (three out of eight) found associations with lower positive affectivity. When considering prenatal intimate partner violence stress, 80% (four out of five) of published reports found associations with higher child negative affectivity, 67% (four out of six) found associations with lower effortful control/regulation, and 33% (one out of three) found associations with lower positive affectivity. Prenatal maternal stress due to PTEs may impact the offspring's temperament, especially negative affectivity. Mitigating the effects of maternal stress in pregnancy is needed in order to prevent adverse outcomes on the infant's socioemotional development.

KEYWORDS
maternal stress, pregnancy, psychological trauma, systematic review, temperament

1 | INTRODUCTION

The fetal programming hypothesis, as described in the Developmental Origins of Health and Disease (DOHaD) model, states that prenatal adversity can influence human behavior and mental health by shaping neurodevelopmental processes (Barker, 2007). Fetal programming theories suggest that prenatal adversity, in turn, is reflected in an expectant mother's mental and physical health (Gluckman et al., 2008). Furthermore, DOHaD postulates that exposure to prenatal maternal stress might alter fetal neurodevelopment as reflected in an offspring's temperament, specifically in reactivity and regulation (Van den Bergh et al., 2017). This relationship with temperament provides one possible mechanism for the established associations between prenatal maternal stress exposure and adverse child outcomes (Gartstein & Skinner, 2018). As a result, the risk for adverse emotional and behavioral outcomes can be increased even before birth.

Potentially traumatic events (PTEs) are life experiences that pose a significant threat to a person's physical or psychological well-being (American Psychiatric Association, 2013). PTEs can be classified into individually experienced events and collectively experienced events (McFarlane & Norris, 2006). Individually experienced events include interpersonal violence, sudden bereavement, and life-threatening illness. In contrast, collectively experienced events include chronic threats (e.g., threat of terrorism), escalating threats (e.g., war and epidemics), and acute threats (e.g., natural disasters). PTEs can also be classified as chronic, escalating, and acute threats according to the time-course of the events. Individually experienced events and interpersonal PTEs (e.g., intimate partner violence, physical assault, or sexual assault) have been shown to be more harmful in comparison with collectively experienced events or accidental exposures to PTEs (e.g., natural disaster or serious accident), war-related trauma, and unexpected death of a loved one (e.g., bereavement) and to have the highest risk to post-PTE psychopathology (Kessler et al., 2017; Schwerdtfeger & Goff, 2007).

Pregnant women are highly affected by the stress of PTEs (Levey et al., 2018). Among the most studied PTEs during pregnancy are natural and man-made disasters, intimate partner violence, and bereavement. Pregnant women exposed to trauma are twice as likely than non-pregnant women to die after the adverse exposure (Deshpande et al., 2017). Exposure to PTEs during pregnancy poses multiple threats to mental health. First, women exposed to intimate partner violence during pregnancy are at increased risk for depression, anxiety, perceived stress, alcohol or drug use, and posttraumatic stress disorders (PTSD; Kastello, Jacobsen, Gaffney, Kodadek, Bullock, et al., 2016; Kastello, Jacobsen, Gaffney, Kodadek, Sharps, et al., 2016; Murugan et al., 2020). Second, women who experienced a natural disaster during pregnancy report elevated depression and PTSD symptoms at 2 months postpartum (Harville et al., 2009). Some aspects of natural disasters, such as illness/injury, loss, or danger due to a hurricane, storm, flood or earthquake, may increase prenatal psychopathology. Pregnant women who experience traumatic war events, such as human and material losses, witnessing war events, and threat to life, also report higher PTSD and prenatal stress (Isosävi et al., 2017). To our knowledge, no studies have explored consequences of maternal bereavement (a core PTE) during pregnancy on maternal perinatal mental health. Studies examining PTEs may help us better understand the proximal mechanisms that may influence maternal mental health and aid targeted interventions. This approach is underutilized in the field.

Maternal adversity during pregnancy can lead to short and long-lasting outcomes in the offspring's neurodevelopment. Women who were pregnant during the Tutsi genocide (Perroud et al., 2014) or the Holocaust (Yehuda et al., 2016) and their offspring had higher levels of PTSD and depression in comparison with nonexposed dyads. These authors suggested that children born from mothers exposed to a traumatic experience were at higher risk of adverse mental health outcomes (Perroud et al., 2014; Yehuda et al., 2016). Given that maternal stress has been associated with increased maternal glucocorticoid concentrations and subsequent increase in fetal exposure, glucocorticoid-sensitive brain regions, such as the amygdala and the hippocampus of the offspring, are the most affected (McGowan & Matthews, 2018). The amygdala plays a central role in threat and fear and defensive responses to external stimuli (LeDoux & Pine, 2016) and has an activating influence on the hypothalamic–adrenal (HPA) axis. The hippocampus, on the other hand, plays a major role in regulating the HPA axis and response to stress. In studies examining the developmental consequences of child adversity, the amygdala and hippocampus appear to be the brain regions the most affected (McLaughlin et al., 2019).

The current study focuses on the effect of prenatal stress due to PTEs on temperament, which is one of the core early indicators of socioemotional functioning in children (Pérez-Edgar, 2019). Temperament is an umbrella term for constitutionally based characteristics associated with differences in reactivity and self-regulation (Rothbart et al., 2000). Within this conceptualization in psychobiological models, constitutional refers to the biological basis of temperament, which includes genetic, epigenetic, and specific microbiome mother-to-fetus transmission and programming (Gartstein & Skinner, 2018). According to Rothbart, Evans, and Ahadi (Rothbart et al., 2000), reactivity refers to excitability, responsibility, and arousability, whereas self-regulation refers to processes functioning to modulate this reactivity. Behavioral and parent-report measures suggest that temperament profiles are relatively stable (Beekman et al., 2015), and researchers often rely on a three-factor model of temperament including extraversion/surgency, negative affectivity, and regulation/effortful control evident across cultures (Rothbart et al., 2001). Merging the reactivity and regulation components, Thomas and Chess (Thomas & Chess, 1989) proposed three child temperament types: easy, difficult, and slow to warm up.

As noted above, temperament models suggest that multiple biological mechanisms contribute to observed socioemotional and behavioral profiles. Furthermore, temperament is modified over time via child maturation and experience. Traditionally, however, temperament traits are treated largely as genetically based, such that the biological substrate is assumed to be set prior to birth (Rothbart & Bates, 2007). In this formulation, the environmental impact on the *expression* of temperament is thought to arise postnatally. However, recent work has captured more nuanced biological mechanisms of temperament, noting that prenatal stressors might activate a biological cascade effect during fetal development, generating epigenetic changes in temperament in utero (Ostlund et al., in press).

Prior research examining fetal programming of children's temperament has focused on expectant mother's stress, depression, anxiety, pregnancy-specific anxiety, and substance exposure (or combinations of these sources of stress) (Austin et al., 2005; Baibazarova et al., 2013; Davis et al., 2007; Haselbeck et al., 2017; Lin et al., 2018; Locke et al., 2016). Most of these studies have relied on a data-driven three-factor model of offspring temperament that includes *Surgency/Positive Affectivity*, *Negative Affect*, and *Regulatory Capacity/Effortful Control*. *Positive Affectivity* includes sociability, sensation seeking, and activity. *Negative Affectivity* includes discomfort, fear, anger, sadness, and low soothability. *Regulation/Effortful Control* includes processes, such as attention, that can modulate the expression of emotionality and reactivity. In general, researchers suggest that prenatal substance exposures and prenatal stress may heighten infant's emotional reactivity and dampen

regulation (Nolvi et al., 2016; Ostlund et al., in press, 2019; Werner et al., 2013).

Exploring specific PTEs during pregnancy may give an opportunity to understand their unique effects on child temperament, which has in turn been associated with psychopathology risk. Specifically, intimate partner violence as an individual experienced event and interpersonal PTE, natural disaster as a collectively experienced event or an accidental exposure PTE, and bereavement as an unexpected loss PTE were chosen for potential unique effects on temperament. In the case of natural disaster survivors, prenatal maternal stress offers an opportunity to explore the unique effects of wide-spread population level events on child development (King et al., 2012). This can be contrasted with the impact of intimate partner violence and unexpected loss, which, while also a source of prenatal stress, do not typically occur at a population level (Chisholm et al., 2017).

Maternal traumatic stress increases or magnifies sensitivity to emotional distress (e.g., stress, anxiety, depression) during the perinatal period (Tung et al., 2020). Rather than differentiate the types of stressors, studies that focus on traumatic stress combine a list of exposures into a cumulative risk score, commonly as a count of negative life events (Austin et al., 2005; Baibazarova et al., 2013; Davis et al., 2007; Haselbeck et al., 2017). Nonetheless, this strategy hindered clarification of the specific mechanisms and the type, chronicity, or severity of the adversity that could help us better understand the processes underlying the intergenerational transmission of trauma and temperament. Building on the stress neurobiology literature, McLaughlin and colleagues characterized early childhood adversity into two groups: threat (e.g., violence in the community, intimate partner violence) and deprivation (e.g., support, socioeconomic status) (McLaughlin et al., 2014, 2019). According to this model, threat and deprivation have distinct influences on neural development. Controlling for cooccurring exposures (e.g., prenatal substance use) or possible consequences, such as maternal perinatal psychological distress, is needed to isolate potential effects on offspring.

Although researchers have conceptualized and measured prenatal maternal stress and distress in a number of different ways, maternal depression during pregnancy has been the most common stressor studied. To date, there are two systematic reviews suggesting links between prenatal maternal anxiety and depression and an infant's temperament reflected in increased negative reactivity or decreased self-regulation (Erickson et al., 2017; Korja et al., 2017). There are still multiple gaps in understanding the unique effects that other traumatic prenatal experiences (e.g., acute, prolonged or chronic threats) may have on child temperament.

The overarching objective of the current study is to perform a comprehensive synthesis of the literature in order to provide a more precise determination of the associations between prenatal maternal stress due to PTEs, and its possible consequences on prenatal and early perinatal stress and distress, and subsequent child temperament. This systematic review encompasses all studies on prenatal maternal stress due to PTEs published through June 2020, including the specific onset of the stress exposure during gestation due to sudden events. Specific objectives of this review include (a) to examine the associations of prenatal maternal stress due to PTEs on children temperament; (b) to describe similarities and differences across studies of in the pattern of child temperament effects as a function of specific prenatal maternal stress due to unique PTEs; and (c) to identify methodological strengths and weaknesses among studies. Understanding prenatal origins of newborn temperament may also help to identifying mechanistic pathways by which prenatal adversity is transmitted from mother to child. This systematic review will help structure and appraise our knowledge on the prenatal origins of temperament, while also identifying specific targets for marking risk and intervening.

2 | METHODS

The research question was formulated according to the PECO format as follows: "Are mothers exposed to PTEs during pregnancy more likely to have children with altered temperament compared to mothers who are not exposed to such events?" This systematic review protocol was not registered previously in PROSPERO.

2.1 | Definitional criteria

2.1.1 | Definition of exposure

Potentially traumatic events (PTEs) are defined as "powerful and upsetting incidents that intrude into daily life". They are usually experiences which are life threatening, or pose a significant threat to a person's physical or psychological wellbeing" (American Psychiatric Association, 2013). PTEs include natural disasters, fire or explosion, serious transportation accident, physical assault, assault with a weapon, sexual assault, life threatening illness or injury, sudden violent death, severe human suffering, and sudden accidental death. For the purpose of this study, PTEs were limited to events that occurred during pregnancy to capture prenatal maternal stress and were categorized as individual experienced events and interpersonal (e.g., intimate partner violence, physical assault, or sexual assault), collectively experienced or accidental exposures (e.g., natural disaster or serious accident), and unexpected death of a loved one (e.g., bereavement).

2.1.2 | Definition of outcome

The definition of temperament in the current systematic review is "individual differences that can be seen early in life, shaping our reaction to events in the social and physical environment, and the environment's reaction to us. Temperament includes the child's dispositions toward emotionality, activity and orienting, along with their attention based effortful control" (Rothbart, 2019). Child temperament includes an individual's affect and behavior, regularity of biological functioning, response to new stimuli, adaptability to new situations, intensity of reaction, and quality of mood (Thomas & Chess, 1989). According to Thomas and Chess (1989) proposed temperament styles, the

difficult child has irregular sleep and feeding schedules, is slow to accept new people and situations, and responds to frustration with tantrums (Thomas & Chess, 1989).

2.2 | Search strategy

This systematic review was performed according to the standard reporting recommendations by PRISMA (Moher et al., 2015). Searches were conducted in PubMed and PsycINFO between (April 2020 and June 2020) for published studies. A librarian suggested the text word fields searched. Relevant database specific subject heading and text word fields were searched. The search included the three concept strings related to: (1) stress, (2) pregnancy, and (3) temperament. For the first string, searches included "stress," "adversity," "adverse event," "adverse life event," "anxiety," and "depression." For the second string, searches included "pregnancy," "prenatal," and "antenatal." For the third string, searches included "temperament," "surgency," "reactivity," "regulation," and "effortful control." Synonymous terms were combined with the Boolean operator "OR," and then these three strings were combined using the Boolean operator "AND." As recommended by a research librarian, truncation symbols were used in searches when appropriate (i.e., pregnan*, prenatal*). A systematic database search from 1980 up to June 2020 was performed. The search was limited to English and Spanish language articles.

2.3 | Study inclusion and exclusion criteria

Inclusion criteria for the systematic review were: (1) exposure: PTE experiences (sexual abuse, interpersonal partner violence, war, bereavement, and natural and man-made disasters) experienced by the mother during pregnancy and, if included, the possible consequences on prenatal maternal distress: maternal depression, trauma, and/or distress; (2) outcome: offspring's temperament assessed prior to the age of 12 years; (3) the full-text article was available and written in English or Spanish. We excluded review articles, editorials, commentaries, and animal studies. An upper limit of 12 years was selected in light of the multiple changes in social relationships, biological maturation, and cognitive development seen in early adolescence (Vijayakumar et al., 2018). We excluded studies where the stress exposure was not restricted to pregnancy. Although negative life events during pregnancy are extremely stressful, we excluded them because they may fail to detect the effects of specific traumatic events.

2.4 | Data screening, extraction, and analysis

Articles that were related to prenatal PTEs, and its possible consequences of prenatal and early perinatal stress and distress, and their effects on child temperament were extracted. A protocol was developed so that each sample of participants was presented in the systematic review. First, if a study presented more than one predictor (e.g., PTSD and depression) or outcome (e.g., effortful control and negative affect), each result was presented and entered into the tables separately. Second, if more than one time point of exposure or child outcomes were provided, each indicator was presented and entered into the tables.

After duplicate citations were removed, the remaining articles was assessed for eligibility by three independent reviewers (N.R.-S., I.O.-Q., M.S.-G.). Studies meeting inclusion criteria were coded using a detailed coding system for recording sample, design, and measurement. Sample characteristics were prenatal stress factor (PTEs, and PTSD or depression), time of assessment during pregnancy, child gender, family socioeconomic status, and mean age of the children at the time of assessment. The design and measurement characteristics included: study designs (case–control, cross-sectional, or cohort studies), temperament dimensions (negative affect, positive affect, or effortful control/regulation), type of temperament (easy, difficult, or slow to warm-up), and sample size. Potential covariates accounted for included: medical risk (e.g., maternal age of pregnancy), sociodemographic risk (e.g., low income, low education, single parent, child age and sex, number of children, and gestational age), and behavior risk (e.g., smoking and alcohol use during pregnancy, and postnatal depression).

Finally, an assessment of study quality was conducted based on a quality assessment tool adapted from previous published meta-analyses and systematic reviews (Accortt et al., 2015; Madigan et al., 2018) (see Table 1). This tool considers elements of study quality recommended by the Cochrane collaboration group (Downes et al., 2016). Data extraction was conducted by first author (N.R.-S.) and coauthors (I.O.-Q. and M.S.-G.). Two independent coders extracted study characteristics and three independent coders performed the study quality. Consensus was achieved among three data extractors and reported accordingly. Two experts (K.P.-E and C.J.B.) then reviewed and revised data extraction results.

3 | RESULTS

3.1 | Studies selected

The PRISMA flow diagram detailing the search strategy is presented in Figure 1 (Moher et al., 2009). Our search of two databases yielded 1969 articles. Upon review of the titles and abstracts, 58 articles were identified as potentially meeting study inclusion criteria. Three additional articles were identified through backward citation (Laplante et al., 2016; McLean et al., 2019; Tees et al., 2010). After review of full text articles, 20 studies met full inclusion criteria.

3.2 | Study characteristics and quality

Study quality is reported in Table 2. Sample sizes ranged from 82 to 12,151 mother–child dyads (Med = 299). At the outcome assessment, child age averaged ranged from 2 to 24 months (mean: 8 months). Studies were found from multiple nations and territories, as labeled

TABLE 1 Study quality criteria evaluations

1. Defined sample	Study has a defined eligibility and exclusion criteria for their sample; and time period (dates) and location (s) of recruitment and assessment.	0 = No
	–If the study includes all four criteria, it receives a 1.	1 = Yes
2. Demographic information	Does the study report complete demographic data for parents and children included in the study?	
	0 = No demographic information specified	0 = Not specified
	1 = data for only child or parent (e.g., child gender, birthweight, gestational age, infant's age). At least two indicators.	1 = specified for parent or child
	2 = demographic data for child and parent	2 = specified for parent and child
3. Representative sample	Is the sample representative of a defined population? (i.e., was everyone included who should be and is this sample generalizable), for example, only selecting mothers of children with disabilities = 0.	
	1 = Cohorts recruited from the general population or from multi-site (e.g., cities or clinics) studies or large databases.	0 = No
	0 = Single site clinical studies (e.g., one clinic or hospital)	1 = Yes
4. Valid instrument (trauma/stress)	Does the study use a validated instrument for the assessment of potentially traumatic event or stress?	
	0 = Nonvalidated (made up by researcher)	0 = Nonvalidated
	1 = Validated measure (e.g., BDI, EPDS)	1 = Validated
5. Valid instrument (Child temperament)	Does the study use a validated instrument for the assessment of child outcome?	
	0 = Nonvalidated (made up by researcher)	0 = Nonvalidated
	1 = Validated measure (e.g., IBQ, ECBQ)	1 = Validated
6. Subjective versus objective measures (trauma/stress)	Does the study use different reporters or multiple methods to measure potentially traumatic events and stress?	
	0 = Maternal self-report (e.g., EPDS)	0 = Self-report
	1 = Objective measure = physician or clinical evaluation, cortisol levels or biological data.	1 = Objective measure
	2 = Multiple methods = self-report *and* biological data or clinical/physician diagnosis.	2 = Multiple methods
7. Subjective versus objective measures (child temperament)	Does the study use different reporters or methods to measure child outcome?	
	0 = Maternal report (IBQ, ECBQ)	0 = Maternal report
	1 = Objective measure = observation protocol or cortisol	1 = Objective measure
	2 = Multiple methods = self-report *and* biological data/multiple informants/observation protocol (Lab-TAB)	2 = Multiple methods (e.g., two reporters, maternal report, and observational data)
8. Confounding variables	Were confounding variables taken into account in the analysis? (consider exclusion criteria, covariates, and control in statistical analyses)	
	– Medical? (e.g., mother' age, HIV infection, GDM/preeclampsia)	0 = No control
	– Sociodemographic? (e.g., maternal education, marital status, maternal race)	1 = Limiting the sample, treating key variable as effect modifier or statistically controlling for three or more key variables from at least two categories out of three (e.g., medical, sociodemographic, and behavior).
	– Behavior? (e.g., smoking and alcohol use, postnatal depression), for example, in modeling or regression did they control or adjust for confounding factors?	2 = Control for at least one variable from each category and a total of four or more variables.

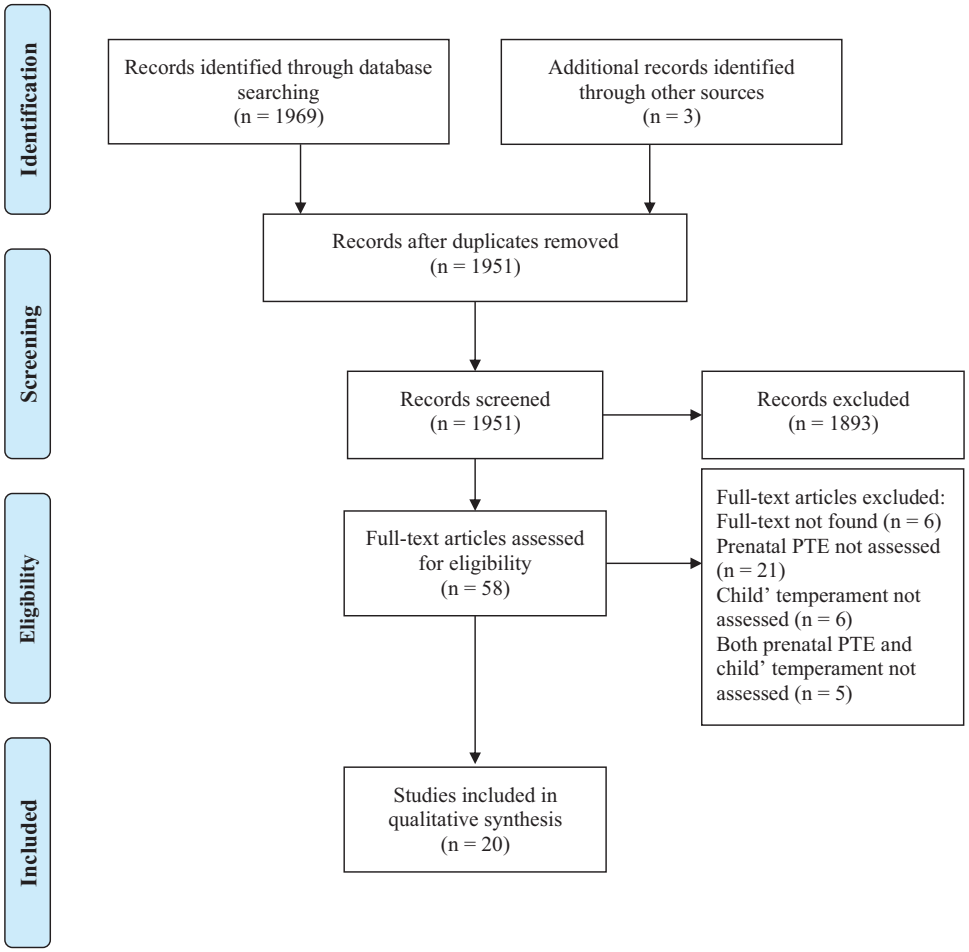

FIGURE 1 PRISMA flow diagram

in the original study, including the United States (n = 12), Australia (n = 3), Israel (Gaza) (n = 3), England (n = 1), and Canada (n = 1). A detailed study quality is reported in Table 3. For study quality, the mean score across all studies was 6 (SD = 1.30; range 4–8). Included studies were classified on two dimensions: (1) collectively experienced event or accidental-related exposure (natural and man-made disasters), and (2) individual experienced event and interpersonal exposure (intimate partner violence). Studies related to unexpected loss (bereavement) were not identified in the search.

Twelve published studies examined disaster-related prenatal maternal stress and temperament (Table 4). Most studies (n = 8) were related to natural disasters (Buthmann et al., 2019; Laplante et al., 2016; McLean et al., 2019; Nomura et al., 2019; Pehme et al., 2018; Simcock et al., 2017; Tees et al., 2010; Zhang et al., 2018), including the Queensland Floods in Australia, the Quebec Ice Storm in Canada, and superstorm Sandy and hurricane Katrina in the United States. Man-made disasters included the World Trade Center collapse on 9/11 (Brand et al., 2006) in New York City and the Gaza War (2008–2009 and 2014) in Israel (Diab et al., 2018; Isosävi et al., 2017; Vänskä et al., 2019). Eight published findings examining prenatal intimate partner violence and temperament were identified from 20 studies (see Table 5) (Ahlfs-Dunn & Huth-Bocks, 2014; Barker, 2013; Burke et al., 2008; Gibson et al., 2015; Martinez-Torteya et al., 2018; McMahon et al., 2011; Miller-Graff & Scheid, 2020; Quinlivan & Evans, 2005).

3.3 | Studies methodologies

Most studies were prospective cohort designs (n = 18), except for one retrospective cohort design (Laplante et al., 2016) and one cross-sectional study (Martinez-Torteya et al., 2018). To measure infant or child temperament, most studies administered maternal self-reported questionnaires (n = 19), such as the Infant Behavior Questionnaire (IBQ) (Rothbart, 1981). Very few studies included biological measures (n = 1) or multiple reporters (n = 1) (Gibson et al., 2015; Martinez-Torteya et al., 2018). To measure maternal stress, many studies measured maternal depression (n = 10) or maternal PTSD (n = 5) with self-reported questionnaires, such as the Edinburgh Postnatal Depression Scale (EDPS) (Murray & Carothers, 1990) or PTSD Checklist (PCL-C) (Blanchard et al., 1996). Only one study collected maternal biological measures during pregnancy (n = 1) (Brand et al., 2006). Furthermore, few studies assessed maternal subjective distress (n = 4) (Buthmann et al., 2019; Laplante et al., 2016; McLean et al., 2019; Simcock et al., 2017). To assess prenatal exposure to disasters, most studies included

TABLE 2 Study quality criteria and characteristics

Criteria		N (%)
1. Defined sample	Yes	11 (55%)
	No	9 (45%)
2. Demographic information	Specified for parent and child	8 (40%)
	Specified for parent or child	9 (45%)
	Not specified	3 (15%)
3. Representative sample	Yes	15 (75%)
	No	5 (25%)
4. Valid instrument (trauma/stress)	Validated	16 (80%)
	Nonvalidated	4 (20%)
5. Valid instrument (child temperament)	Validated	19 (95%)
	Nonvalidated	1 (5%)
6. Subjective versus objective measure (trauma/stress)	Multiple methods	1 (5%)
	Objective measure	2 (10%)
	Self-report	17 (85%)
7. Subjective versus objective measure (child temperament)	Multiple methods	2 (10%)
	Objective measure	0
	Maternal report	18 (90%)
8. Confounding variables	Adequate control	7 (35%)
	Limited control	12 (60%)
	No control	1 (5%)

self-reported questionnaires to understand objective hardships due to disasters ($n = 7$), such as Storm32 (King & Laplante, 2005) or war checklist (Qouta et al., 2005). To assess prenatal exposure to intimate partner violence, most studies administered self-reported measures ($n = 5$), such as the Conflict Tactics Scale (CTS2) (Straus et al., 1996).

Of the 12 disaster reports, most were prospective cohort studies ($n = 11$). Of these 12 reports, five studies did not identify at least a not exposed group (Diab et al., 2018; Isosävi et al., 2017; Laplante et al., 2016; McLean et al., 2019; Vänskä et al., 2019). Five included adequate postnatal control for known temperamental risk factors (Buthmann et al., 2019; Nomura et al., 2019; Pehme et al., 2018; Tees et al., 2010; Zhang et al., 2018). For example, Zhang et al. (2018) controlled for seven medical (i.e., GDM/preeclampsia), sociodemographic (i.e., maternal education and infant's sex), and behavioral factors (i.e., substance use and trauma) and excluded women with HIV infection, maternal psychosis, maternal age < 15 years, life-threatening maternal medical complications, and congenital or chromosomal abnormalities in the fetus. Furthermore, temperament was assessed longitudinally at 6, 12, 18, and 24 months with the IBQ-R (Gartstein & Rothbart, 2003) and ECBQ (Putnam et al., 2006).

Of the eight reports using intimate partner violence as an exposure, most were prospective cohort studies ($n = 7$). Only two studies identified unexposed groups of mothers for comparison (Ahlfs-Dunn & Huth-Bocks, 2014; Quinlivan & Evans, 2005). Of eight reports, two included adequate postnatal covariates for known temperamental risk factors, such as postnatal intimate partner violence and postnatal depression (Martinez-Torteya et al., 2018; Quinlivan & Evans, 2005). For example, Quinlivan and Evans (2005) controlled for 10 sociodemographic (i.e., social class and homelessness) and behavioral factors (i.e., breastfeeding and postnatal depression).

3.4 | Timing of exposures and outcomes

Baseline assessments were conducted in most studies during second trimester ($n = 6$). In regard to natural disasters, most studies assessed prenatal consequences in the second trimester ($n = 5$), whereas others waited 5–7 months after the disaster to collect data (Buthmann et al., 2019; Diab et al., 2018; Isosävi et al., 2017; Pehme et al., 2018; Zhang et al., 2018). In regard to intimate partner violence, most assessments were conducted during second or third trimester ($n = 3$) (Ahlfs-Dunn & Huth-Bocks, 2014; Barker, 2013) or after giving birth ($n = 2$) (Burke et al., 2008; McMahon et al., 2011).

In studies that explored associations between prenatal disaster stress and temperament, children's assessment varied from 4 months to 24 months postnatally. In most reports ($n = 10$), temperament was only measured once. In the studies using exposure to intimate partner violence, the timing of temperament assessment varied from 4 months to 48 months postnatally. In most studies, temperament was measured at one time point ($n = 6$). Most studies used maternal self-reported measures of their child's temperament and only two studies utilized multiple methods of assessments (Gibson et al., 2015; Martinez-Torteya et al., 2018). One report included measures that had not been independently validated (McMahon et al., 2011).

3.5 | Summary of findings: prenatal disaster stress and child temperament

Not all studies assessed each temperament dimension: all evaluated negative affect (or an indicator), whereas only 10 looked at effortful control/regulation and eight considered positive affectivity. When combining all possible prenatal disaster stress exposures (maternal depression or PTSD, objective hardships due to disasters, and subjective distress), 75% (nine out of 12) of published reports noted associations with higher negative affectivity, 50% (five out of 10) noted associations with decreased effortful control/regulation, and 38% (three out of eight) noted some associations with positive affectivity.

3.5.1 | Negative affectivity

In the seven studies that explore prenatal depression or perinatal PTSD symptoms, five studies suggested positive associations with children's negative affectivity (Brand et al., 2006; Buthmann et al., 2019; McLean et al., 2019; Nomura et al., 2019; Tees et al., 2010). In the four studies where subjective distress was included, four studies found

TABLE 3 Study quality

	Defined sample	Demographics	Representative Sample	Valid scale (trauma/stress)	Valid scale (temperament)	Subjective versus objective measure (trauma/stress)	Subjective versus objective measure (temperament)	Confounders' variables	Total
Ahlfs-Dunn & Huth-Bocks (2014)	0	1	1	1	1	0	0	1	5
Barker (2013)	1	0	1	1	1	0	0	1	5
Brand et al. (2006)	0	0	0	1	1	2	0	1	5
Burke et al. (2008)	1	1	1	0	1	1	0	1	6
Buthmann et al. (2019)	1	2	1	1	1	0	0	2	8
Diab et al. (2018)	0	2	1	1	1	0	0	1	6
Gibson et al. (2015)	1	1	1	1	1	0	2	1	8
Isosävi et al. (2017)	0	1	1	1	1	0	0	1	5
Laplante et al. (2016)	1	0	1	1	1	0	0	1	5
Martinez-Torteya et al. (2018)	0	1	1	1	1	0	2	2	8
McLean et al. (2019)	1	2	1	1	1	0	0	1	7
McMahon et al. (2011)	1	2	1	0	0	0	0	1	5
Miller-Graff & Scheid (2019)	0	1	0	1	1	0	0	1	4
Nomura et al. (2019)	1	1	1	1	1	0	0	2	7
Pehme (2018)	0	1	0	0	1	0	0	1	4
Quinlivan (2005)	0	2	0	0	1	1	0	2	6
Simcock et al. (2017)	1	2	0	1	1	0	0	1	6
Tees et al. (2010)	1	1	1	1	1	0	0	2	7
Vänskä (2019)	0	2	1	1	1	0	0	0	5
Zhang et al. (2018)	1	2	1	1	1	0	0	2	8

TABLE 4 Studies examining prenatal maternal stress due to disasters and child temperament

Reference	Sample country	Methods	Prenatal stress exposure measure	Confounders	Outcome measure	Outcome			Quality
						Negative affectivity	Surgency/ positive affectivity	Effortful control/ regulation	
Brand et al. (2006)	*$n = 98$	Prospective cohort study	PCL (Blanchard et al., 1996) Pregnancy (Sept. 11, 2002) 9/11 World Trade Center	Medical	IBQ (Rothbart, 1981)	PTSD and infant's distress to novelty ($r = .450$, $p < .01$).			5
	USA	Exposed PTSD: $n = 47$	One week postnatally		9 months	Maternal morning cortisol and infant distress to novelty ($r = -.274$, $p < .05$).			
		Not exposed to PTSD: $n = 55$	Maternal salivary cortisol (morning and night)						
Buthmann et al. (2019)	$n = 380$	Prospective cohort study	Storm32 (King & Laplante, 2005) Pregnancy (second trimester) superstorm Sandy	Medical	IBQ-R (Gartstein & Rothbart, 2003)	ns	ns	ns	8
	USA	Prenatal: $n = 169$; postnatal: $n = 175$	EPDS (Murray & Carothers, 1990)	Sociodemographic	6 months	Prenatal depression and infants' negative affectivity ($r = .18$, $p < .01$).	ns	Prenatal depression and infant's regulation ($r = -.15, p < .01$)	
		Preconception: $n = 36$	IES-R (Weiss & Marmar, 1997)	Behavior		Prenatal subjective distress and infant's negative affectivity ($r = .11, p < .05$)	ns	ns	
Diab et al. (2018)	$n = 511$	Prospective cohort study	War trauma (Qouta et al., 2005) Pregnancy (second trimester) War of Gaza	Medical	IBQ-R (Gartstein & Rothbart, 2003)	ns	ns	ns	6
	Israel (Gaza)		HTQ (Mollica et al., 1992)	Sociodemographic	4 months	ns	ns	ns	
			EPDS (Cox et al.,1987)			ns	ns	ns	
Isosävi et al. (2017)	$n = 511$	Prospective cohort study	War trauma (Qouta et al., 2005) Pregnancy (second trimester) War of Gaza	Medical	IBQ-R (Gartstein & Rothbart, 2003)	ns (In mothers with low levels of war trauma, high childhood emotional abuse was associated with higher negative affectivity ($\beta = -.21, p = .002$).		ns	5
	Israel (Gaza)		HTQ (Mollica et al., 1992)	Sociodemographic	4 month	ns (Prenatal hypervigilance and infant's sadness ($r = -.10, p < .05$)		ns	
			EPDS (Cox et al., 1987)			ns		ns	

(Continues)

TABLE 4 (Continued)

Reference	Sample country	Methods	Prenatal stress exposure measure	Confounders	Outcome measure	Outcome			Quality
						Negative affectivity	Surgency/ positive affectivity	Effortful control/ regulation	
Laplante et al. (2016)	$n = 121$	Retrospective cohort study/cross-sectional	Storm32 (King & Laplante, 2005)	Medical	ICQ (Bates et al.,)	ns	ns	ns	5
	Canada		Pregnancy Quebec Ice Storm	Sociodemographic	6 months	Prenatal subjective distress and infants' difficulty/fussy ($r = .24$, $p < .01$).	ns	Prenatal subjective distress and infant's needs attention ($r = .31$, $p < .001$).	
			IES-R (Weiss & Marmar, 1997)	Behavior					
McLean et al. (2019)	$n = 104$	Prospective cohort study	QFOSS (Brock et al., 2014) Pregnancy Queensland floods	Medical	STST (Prior et al., 1989)	ns		ns	7
	Australia		IES-R (Weiss & Marmar, 1997)	Behavior	16 months	Maternal subjective distress and toddler's negative reactivity ($r = .23$, $p < .05$).		ns	
			PDI (Brunet et al.,)			ns		Peritraumatic distress and toddler's persistence ($r = -.23$, $p < .05$).	
			EPDS (Cox et al., 1987) (6 months postpartum)			Perinatal depression at 6 months and toddler's negative reactivity ($r = .28$, $p < .05$).		ns	
Nomura et al. (2019)	$n = 310$	Prospective cohort study	Pregnancy during superstorm Sandy	Medical	IBQ-R (Gartstein & Rothbart, 2003)	Infants exposed prenatally to superstorm Sandy and to maternal depression had greater sadness ($M = 3.74$, $p = .05$) and greater distress ($M = 4.50$, $p = .03$) than those exposed to superstorm Sandy (without depression).	Infants exposed prenatally to superstorm Sandy and to maternal depression had greater activity ($M = 4.87$, $p = .02$) and greater approach ($M = 6.03$, $p = .05$) than those exposed to superstorm Sandy (without depression).	ns	7

(Continues)

TABLE 4 (Continued)

Reference	Sample country	Methods	Prenatal stress exposure measure	Confounders	Outcome measure	Outcome			Quality
						Negative affectivity	Surgency/ positive affectivity	Effortful control/ regulation	
	USA	Exposed: $n = 110$; not exposed: $n = 200$ (pregnant before Sandy)	EPDS (Murray & Carothers, 1990)	Sociodemographic behavior	6 months	Prenatal depression and infant's sadness ($b = .05$, $p < .001$) and distress ($b = .25$, $p < .05$) and less recovering from distress ($b = -.031$, $p < 0.01$).	Prenatal depression and infant's less smiling and laughter ($b = -.043$, $p < .01$) and less high pleasure seeking ($b = -.20$, $p = .05$).	Prenatal depression and less infant's soothability ($b = -.030$, $p < .01$) and cuddliness ($b = -.034$, $p < .01$).	
Pehme et al. (2018)	$n = 95$	Prospective cohort study	Pregnancy during superstorm Sandy (second trimester)	Medical	IBQ-R (Gartstein & Rothbart, 2003)	ns	Infants whose mothers were exposed ($M = 5.59$) compared with those who were not exposed in utero to Sandy ($M = 6.12$) had lower smiling/laughter scores, $t(93) = 2.96$, $p = .004$.	ns	4
	USA	Exposed: $n = 43$; not exposed: $n = 52$ (44 gave birth before Sandy and 8 became pregnant after Sandy)	EPDS (Cox et al., 1987) (6 months postpartum)	Sociodemographic behavior	12 months		ns		
Simcock et al. (2017)	*$n = 121$	Prospective cohort study	QFOSS (Brock et al., 2014): 7 months after disaster Queensland floods	Medical	STSI (Sanson et al., 1987) 6 months	ns	ns	ns	6
	Australia	Exposed: $n = 38$	PDI (Brunet et al., 2001)	Sociodemographic		ns	Peritraumatic distress and higher activity-reactivity ($r = .21$, $p < .01$).	ns	
		Not exposed: $n = 88$ (not pregnant during floods)	IES-R (Weiss & Marmar, 1997) 12 months after floods	Behavior		Maternal subjective distress and higher irritability ($r = .27$, $p < .01$).	ns	ns	
Tees et al. (2010)	*$n = 288$	Prospective cohort study	EDS (Norris et al.,) Pregnancy hurricane Katrina: 2 months postpartum	Medical	EITQ (Medoff-Cooper et al., 1993)	Flooding in the house and 3 difficult temperaments among those pregnant during the storm (OR = 11.25).			7

(Continues)

TABLE 4 (Continued)

Reference	Sample country	Methods	Prenatal stress exposure measure	Confounders	Outcome measure	Outcome			Quality
						Negative affectivity	Surgency/ positive affectivity	Effortful control/ regulation	
	USA	Prenatal (exposed): $n = 68$	PTSD Checklist (DeSalvo et al., 2007)	Sociodemographic	2 months	Perinatal PTSD increased odds of difficult temperament at 12 months (OR = 2.27).			
		Precon-ception (not exposed): $n = 216$	EPDS (Cox et al., 1987)	Behavior	TTS (Fullard et al., 1984) 12 months	Perinatal depression increased odds of difficult temperament at 12 months (OR = 3.16).			
Vänskä et al. (2019)	$n = 502$	Prospective cohort study	HTQ (Mollica et al., 1992	Medical	IBQ-R (Gartstein & Rothbart, 2003)	ns	ns	ns	5
	Israel (Gaza)		Pregnancy (first trimester) 2014 War of Gaza		6-7 months				
Zhang et al. (2018)	$n = 318$	Prospective cohort study	Pregnancy during	Medical	IBQ-R (Gartstein & Rothbart, 2003)	At 6 months, children exposed to Sandy in utero were rated higher on fearfulness, and perceptual sensitivity as compared to no-exposed.	At 6 months, children exposed to Sandy in utero were rated higher on high-intensity pleasure, and approach as compared to no-exposed.	At 6 months, children exposed to Sandy in utero were rated lower on cuddliness and duration of orientation as compared with no-exposed.	8
	USA	Exposed: $n = 183$	superstorm Sandy (second trimester)	Sociodemographic	6 months	Fearfulness decreased overtime.	Approach and high-intensity pleasure decreased overtime		
		Not exposed: $n = 135$ (pregnant before or after Sandy)		Behavior	12 months				
					ECBQ (Putnam et al., 2006) 18 months 24 months				

*It is not clear from which groups participants were excluded.

Questionnaires' abbreviations. Depression: EPDS, Edinburgh Postnatal Depression Scale; PTE: *Objective hardship*: EDS, Exposure to Disaster Scale; QFOSS, Queensland Flood Objective Stress Scale; Storm32, objective stress due to a storm; *Subjective distress*: IES-R, impact of event scale-revised; *Peritraumatic Distress*: PDI, Peritraumatic Distress Inventory; PTSD, PCL, PTSD checklist; *Temperament*: CITS, Carey Infant Temperament Scale; ECBQ, Early Childhood Behavior Questionnaire; EITQ, Early Infancy Temperament Questionnaire; IBQ, Infant Behavior Questionnaire; IBQ-R, Infant Behavior Questionnaire-Revised; ICQ, Infant Characteristics Questionnaire; STS, Short Temperament Scale; STSI, Short Temperament Scale for Infants; STST, Short Temperament Scale for Toddlers; TTS, Toddler Temperament Scale; *Trauma*: HTQ, Harvard Trauma Questionnaire.

TABLE 5 Studies examining prenatal intimate partner violence (IPV) and child temperament

Reference	Sample country	Methods	Prenatal stress exposure	Confounders	Outcome measure	Outcome Results			Quality
						Negative affectivity	Surgency/positive affectivity	Effortful control/regulation	
Ahlfs-Dunn & Huth-Bocks (2014)	*$n = 120$	Prospective Cohort Study	CTS-2 (Straus et al., 1996)	Behavior	CFSI (McDonough et al., 1998)			ns, Prenatal IPV and infant's regulatory difficulties was moderated by prenatal PTSD avoidance symptoms ($\beta = .39$, $p < .05$).	5
	USA	Presence (exposed): $n = 90$	Pregnancy (third trimester)		3 months				
		Absence (not exposed): $n = 25$	PCL-C (Blanchard et al., 1996)						
Barker (2013)	$n = 12{,}151$	Prospective Cohort Study	DIS (dependent interpersonal stress) Pregnancy (12–18 wk) (second trimester)	Sociodemogr	CIT (Carey & McDevitt, 1978) 24 months			Prenatal DIS and child's dysregulation at 2 years ($r = .08$, $p < .05$) and child' dysregulation at 4 years ($r = .10$, $p < .05$).	5
	UK		EPDS (Cox et al., 1987) (32 wk prenatal)	Behavior	CIT (Carey & McDevitt, 1978) 48 months			Children of mothers who experienced prenatal DIS and chronic depression ($r = .20$, $p < .05$) showed continuity in dysregulation.	
Burke et al. (2008)	$n = 4141$	Prospective Cohort Study	IPV interview	Medical	EAS (Buss & Plomin, 1984)	Infants of mothers who had experienced psychological IPV during pregnancy reported difficult temperaments ($\beta = .13$, $p < .001$).			6
	USA		After giving birth	Sociodemographic	12 months				
Gibson et al. (2015)	$n = 592$	Prospective Cohort Study	CTS-2 (Straus et al., 1996)	Medical	CIT (Carey & McDevitt, 1978)	Once controlling for confounders, prenatal IPV was associated with poorer infant's temperament (B = -2.925, $p < .01$).			8
	USA		Pregnancy (second or third trimester)	Sociodemogr	6 months	Perinatal depression mediated the association between prenatal IPV and poorer infant temperament (B = −2.130, $p < .01$).			
			CES-D (Radloff, 1977) (6 months postpartum)		12 months				

(Continues)

TABLE 5 (Continued)

Reference	Sample country	Methods	Prenatal stress exposure	Confounders	Outcome measure	Outcome Results			Quality
						Negative affectivity	Surgency/positive affectivity	Effortful control/regulation	
Martinez-Torteya et al. (2018)	$n = 99$	Cross-sectional with retrospective report	CTS-2 (Straus et al., 1996)	Medical	Cortisol (infant)			ns	8
	USA		Pregnancy	Sociodemographic behavior	IBQ (Rothbart, 1981) 12 months			ns, (For infants with Met allele, more physical IPV predicted less orienting ($b = -.29$, $p = .009$).	
McMahon et al. (2011)	$n = 3961$	Prospective Cohort Study	IPV questions about pregnancy	Medical	Temperament questions	Prenatal emotional IPV significantly affected toddler's more difficult temperament (OR = 0.15, $p < .001$).			5
	USA		After baby's birth	Sociodemogr	15 months				
Miller-Graff & Scheid (2020)	$n = 82$	Prospective Cohort Study	CTS-2 (Straus et al., 1996)	Behavior	IBQ-R-VS (Putnam et al., 2014)	ns, once adjusted for confounders	Once adjusted for confounders, prenatal IPV was associated with infant's positive affectivity ($ß = -1.27$, $p < .001$).	ns, Once adjusted for confounders, prenatal IPV was associated with infant's regulatory capacity ($ß = -1.10$, $p < .001$).	4
	USA	Not exposed: $n = *18$	Pregnancy CES-D (Radloff, 1977)		4 months	ns	ns	ns	
Quinlivan & Evans (2005)	$n = 117$	Prospective Cohort Study	Interviews	Medical	STS (Prior et al., 1989) 6 months	Adolescent mothers who had been exposed to IPV had infants with more irritability than the nonabused ($p < .01$).	ns	ns	6
	Australia	Exposed: $n = 33$	Pregnancy	Sociodemogr					
		Not exposed: $n = 84$		Behavior					

*It is not clear from which groups participants were excluded.

Questionnaires' abbreviations. *Depression*: CES-D, Center for Epidemiological Studies Depression Scale; EPDS, Edinburgh Postnatal Depression Scale; PTE: *Intimate Partner Violence*: CTS-2, Conflict Tactics Scale 2; DIS, Dependent Interpersonal Stress; PTSD, PCL-C: PTSD Checklist; *Temperament*: CFSI, Cry-Feed-Sleep Interview; CIT, Carey Infant Temperament Scale; IBQ, Infant Behavior Questionnaire; IBQ-R-VS, Infant Behavior Questionnaire-Revised: Very Short Form; EAS, Emotionality, Activity, Sociability Inventory; STS, Short Temperament Scale.

positive associations (Buthmann et al., 2019; Laplante et al., 2016; McLean et al., 2019; Simcock et al., 2017). When objective hardships due to the disaster experience were considered in 10 of the studies, only four studies showed associations with negative affectivity (Isosävi et al., 2017; Nomura et al., 2019; Tees et al., 2010; Zhang et al., 2018).

3.5.2 | Positive affectivity

In the four studies that explores prenatal depression or perinatal PTSD, only one study suggested a negative association with children' positive affectivity (Miller-Graff & Scheid, 2020). No associations between subjective distress and positive affectivity were found out of three studies. When objective hardships due to the disaster experience were considered, associations were inconsistent in most studies. At least three out of seven suggested some type of association between those infants prenatally exposed to the disaster in comparison with those not exposed (Nomura et al., 2019; Pehme et al., 2018; Zhang et al., 2018).

3.5.3 | Effortful control/regulation

Only two studies suggested negative associations between prenatal depression or perinatal PTSD and effortful control/regulation in the five studies that evaluated this relationship (Buthmann et al., 2019; Nomura et al., 2019). In four studies that included subjective distress, only one study suggested a negative association with effortful control (Laplante et al., 2016). In nine studies that considered objective hardships due to the disaster experience, associations were not found in most studies, with only one showing negative association between those infants prenatally exposed to the disaster in comparison to those not exposed (Zhang et al., 2018).

3.6 | Summary of findings: prenatal intimate partner violence and child temperament

Not all studies assessed each temperamental dimension: studies looked at indicators of negative affect, positive affectivity, and effortful control. When considering both maternal prenatal psychological symptoms and objective intimate partner experience, 80% (four out of five) of published reports noted associations with higher negative affectivity, 67% (four out of six) found associations with lower effortful control/regulation, and 33% (one out of three) noted associations with lower positive affectivity.

3.6.1 | Negative affectivity

In a study that explored prenatal depression as a consequence of prenatal intimate partner violence exposure, no association was found between prenatal depression and toddler negative affectivity (Miller-Graff & Scheid, 2020). However, in a different study, perinatal depression at 6 month postpartum mediated the association between prenatal intimate partner violence and poorer infant's temperament (Gibson et al., 2015). Prenatal intimate partner violence showed associations with difficult temperament or irritability ($n = 4$ out of 5) (Burke et al., 2008; Gibson et al., 2015; McMahon et al., 2011; Quinlivan & Evans, 2005).

3.6.2 | Positive affectivity

In a study that explored prenatal depression as a consequence of prenatal intimate partner violence exposure, no association was found between prenatal depression and infant's positive affectivity (Miller-Graff & Scheid, 2020). Only one study (one out of two) suggested a negative association between prenatal intimate partner violence and infant's positive affectivity (Miller-Graff & Scheid, 2020).

3.6.3 | Effortful control/regulation

Only one study suggested a positive association between prenatal chronic depression and prenatal intimate partner violence and child's dysregulation ($n = 1$ out of 1) (Barker, 2013). When objective experience was considered, four studies suggested associations with indicators of child's effortful control/regulatory capacity ($n = 4$ out of 5) (Ahlfs-Dunn & Huth-Bocks, 2014; Barker, 2013; Martinez-Torteya et al., 2018; Miller-Graff & Cheng, 2017).

4 | DISCUSSION

This systematic review presented a descriptive assessment of the relatively small number of published reports that have examined the associations between unique prenatal PTE's and children's temperament. The three-factor model of temperament including extraversion/surgency, negative affectivity, and regulation/effortful control has been among the most studies formulation of temperament (Buthmann et al., 2019; Diab et al., 2018; Isosävi et al., 2017; Miller-Graff & Scheid, 2020; Nomura et al., 2019; Pehme et al., 2018; Vänskä et al., 2019). Not surprisingly, most researchers selected this model in their respective studies. Results suggest that clear patterns emerged showing that prenatal PTE's were associated most strongly with indicators of increased negative affectivity and decreased effortful control/regulation (Erickson et al., 2017; Korja et al., 2017). Specifically, 75% ($n = 9$ out of 12) of published reports found significant associations between any prenatal disaster-related stress and child temperament, and 67% ($n = 6$ out of 9) of published results found significant associations between prenatal intimate partner violence stress and child temperament. The majority of studies used validated self-report measures to evaluate PTEs and mother's perceptions of their child's temperament. As covariates, short screening tools to evaluate levels of perinatal depression or PTSD and cutoff scores for identifying clinically significant symptoms were

included. However, very few studies used a confirmed clinical diagnosis as a measure.

To our knowledge, this is the first systematic review that explores the associations between prenatal PTEs and children' temperament. We used a systematic method (i.e., PRISMA guidelines) (Moher et al., 2015) and covered a fairly long time period (1980–2020). Although the search engine considered studies from 1980 to 2020, the first published reports in this area were evident in 2005. Given that, it is notable that 20 studies met inclusion criteria. We included retrospective assessments ($n = 1$) of prenatal exposure to any PTE. We also added studies that combined maternal perinatal mental health (i.e., depression and PTSD) as secondary variables or as covariates. We found that the evidence favors broad associations between PTEs during pregnancy and patterns of child temperament. In more specific terms, exposure to prenatal disaster and prenatal intimate partner violence were more closely associated with higher negative affect in the child.

The effects of prenatal stress on offspring temperament due to a disaster were unique to the developmental window observed. At 2 months of age, infants exposed in utero to a natural disaster and PTSD and depression had increased odds of having an infant with three characteristics of difficult temperament (Tees et al., 2010). At 4 months of age, we found no associations with any temperament dimensions, with the exception of prenatal hypervigilance and infant sadness (Diab et al., 2018; Isosävi et al., 2017). At 6 months, infant exposure to prenatal depression due to a natural disaster was associated with increase negative affectivity, decreased effortful control, and less positive affect (Buthmann et al., 2019; Nomura et al., 2019; Simcock et al., 2017; Zhang et al., 2018), but prenatal trauma was not associated with any of these temperamental traits (Vänskä et al., 2019). At 12 months of age, infants exposed in utero to a natural disaster and PTSD had three characteristics of difficult temperament and lower Smiling and Laughter scores (Pehme et al., 2018; Tees et al., 2010). At 16 months, prenatal depression due to a natural disaster was associated with toddler's negative reactivity but not persistence, whereas peritraumatic distress was associated with toddler's persistence, but not negative reactivity (McLean et al., 2019). Of course, a more comprehensive longitudinal study capturing temperament in the same children across the time windows would be needed to fully test any developmentally related outcomes.

The effects of prenatal stress due to intimate partner violence on offspring temperament were also unique to child development. At 3 months of age, infants exposed to prenatal intimate partner violence was associated with infant's regulatory difficulties (Ahlfs-Dunn & Huth-Bocks, 2014). At 4 months of age, infants' prenatal intimate partner violence was associated with lower positive affectivity and regulatory capacity, but not with negative affectivity (Miller-Graff & Scheid, 2019). At 6 months of age, infants exposed to intimate partner violence were more irritable than those nonexposed (Quinlivan & Evans, 2005). However, temperament trajectories associated with prenatal intimate partner violence are not clear. Due to this, disentangling the biological dimensions of prenatal aspects from the social-contextual are complex.

Studies about prenatal disaster-related stress and temperament had the most controls in the designs. Most studies about natural disaster stress included some type of control (prenatal exposure or unexposed group), whereas studies about war-related stress did not include controls to explore differential effects on offspring temperament. Multiple methods of assessing prenatal maternal stress (i.e., self-report and biological data) noted differential associations (Brand et al., 2006). In terms of child outcome, studies with at least two time points suggested that longitudinal changes in offspring temperament due to disaster-related prenatal stress are characterized by pattern of changes in temperament (Tees et al., 2010; Zhang et al., 2018). Unfortunately, none of these studies provided multiple-informant or observational methods to assess child temperament, which again could reduce the maternal report bias and provide more fruitful data.

Studies regarding prenatal intimate partner violence and temperament had fewer controls in the designs. Lack of control group in most studies prevented us from examining differences in temperament outcomes among exposed and nonexposed groups. Results suggest associations with negative affectivity even when controlling with a nonexposed group (Burke et al., 2008; Quinlivan & Evans, 2005). Unlike disaster-related studies, two studies had multiple methods to assess child temperament (Gibson et al., 2015; Martinez-Torteya et al., 2018). The addition of observational assessment, particularly when coupled with longitudinal measures of child temperament, will allow for multidimensional assessment of long-term impacts. For example, the child maltreatment and neglect literature (Blaisdell et al., 2019) suggests that early experiences may have long-term implications for biological regulatory mechanisms. For example, blunted HPA-axis responses often follow early hyperreactivity, providing a mechanistic understanding of observed changes in emotional reactivity and regulation (Reilly & Gunnar, 2019).

Although both prenatal disaster-related stress and prenatal intimate partner violence are PTEs, vulnerabilities to these exposures during pregnancy varies substantially. On the one hand, intimate partner violence is an interpersonal exposure and an individually experienced event with chronic and prolonged stress. A history of childhood sexual or physical abuse was associated with threefold increase of experiencing intimate partner violence during pregnancy (Gartland et al., 2016). In this case, women with a history of childhood abuse may be at high risk of revictimization in adulthood. Pointing to a precise day where the stressor occurs in this case is problematic. Moreover, women who reported intimate partner violence are more likely to report maternal depression, thoughts of self-harm, and smoking (Dahlen et al., 2018). Due to this constellation of effects, these pregnant women are more likely to be admitted for preterm labor (Dahlen et al., 2018). Prematurity is a major risk factor for adverse neurodevelopmental outcomes. In comparison, there is little evidence to support the effects of disaster on premature birth (Harville et al., 2010). On the other hand, disasters, by definition, are collectively experienced events, accidental exposures, and acute stressors (McFarlane & Norris, 2006). Although natural disasters are promising quasi-experimental designs where we can point the day it happened, post-disaster stressors have lingering effects. Furthermore, the magnitude of the effects varies as a function of unique

issues experienced by the women (i.e., education and socioeconomic status), and characteristics of the environment (i.e., disaster preparedness and community support).

As noted above, human studies do not allow us to fully understand the unique effects of PTE on childhood outcomes. Animal studies provide a valuable opportunity to control both the timing and severity of prenatal stress exposure and to better understand its mechanisms and specific impact. Even among the adequately controlled studies, many scored lower in methodological quality due to few control variables and exclusion criteria, lack of multiple methods to assess temperament (e.g., two reporters, maternal report, and observational data), and only relying on maternal self-report measures to assess her PTE or psychological symptoms. Additionally, the timing of PTE assessment or mental health screening differed between studies. As such, we lack a robust and replicated evidence base to note how the specific timing of an event, and the impact on the mother, can systematically shape child temperament. Thus, the available data are suggestive of broader patterns of socioemotional functioning. In addition, the pattern and specific instruments of assessment differed with the category of PTE examined. We observed that in prenatal intimate partner violence stress, some studies assessed the experience after the baby's birth, whereas in prenatal disaster-related stress exposure was assessed at 5–7 months after the disaster. As a systematic error, recall bias can decrease or increase the strength of associations.

4.1 | Strengths, limitations, and research directions

One of the main strengths of this systematic review is that it builds on the methodological quality and characteristics of the individual research designs. Studies included women from varied and diverse countries, including the United States, England, Canada, Israel (Gaza), and Australia. Mothers were from many ethnicities and races (Buthmann et al., 2019; Martinez-Torteya et al., 2018; Miller-Graff & Scheid, 2020; Nomura et al., 2019; Zhang et al., 2018) and sociodemographic backgrounds (Martinez-Torteya et al., 2018; Miller-Graff & Scheid, 2020; Nomura et al., 2019; Quinlivan & Evans, 2005; Tees et al., 2010).

However, most studies were self-contained and specific to one specific pool of recruited participants. Multisite studies were scarce. The types of PTEs examined were also limited. Despite predicted relations that would have been of interest, we found no studies exploring the effects of prenatal bereavement, systemic violence, or pandemics on child temperament. With respect to our approach to the study, limitations include the fact that we did not register the protocol prospectively and studies were from only two databases.

Several additional steps would be needed in order to better understand the relations noted here. Distinguishing types of maternal adversity following the framework from McLaughlin and colleagues to separate threat and deprivation exposures during pregnancy is necessary (McLaughlin et al., 2014). Among the intimate partner violence studies, few divided prenatal intimate partner violence exposures into emotional intimate partner violence and physical intimate partner violence. Among the disaster studies, findings used the cumulative risk score or a general exposure metric, which hindered our ability to examine the type (e.g., food deprivation vs. fear of death), chronicity (during and/or after the disaster), or severity of the adversity.

Furthermore, a meta-analysis could compare perinatal mood and PTEs to explore their unique effects on child temperament. However, there would be an imbalance in the evidence base as most studies have focused on prenatal depression and anxiety as unique sources of adverse prenatal and postnatal exposure with community samples (Madigan et al., 2018). Well-designed randomized control trials, carefully noting the timing, type, and severity of exposure could be used to assess the impact on child outcomes as well as explore if a psychological intervention targeting the maternal stress response can reduce the evident negative effects on child socioemotional functioning.

5 | CONCLUSIONS

There is evidence supporting the associations between prenatal PTE and child temperament, particularly increased levels of negative affectivity, and decreased levels of effortful control/regulation. This evidence arises mostly from prospective cohort studies relying on self-reported measures. PTEs, such as disasters and intimate partner violence, may increase maternal distress during pregnancy, which in turn has an impact on the fetal development of the offspring, including brain structures associated with HPA axis activity. These relations are also noted in neural development. For example, high negative affect is associated with alterations in amygdala activity and connectivity (Kann et al., 2017). Thus, the review shows that exposure to stress during the prenatal period can result in changes in early indicators for socioemotional development, such as temperament. Future work can build on these largely observational studies to examine potential mechanisms and points of intervention or prevention.

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AUTHOR CONTRIBUTIONS

N. C. R.-S., C. J. B., E. M.-B., and K. G. M. contributed to the study concept. N. C. R.-S., C. J. B., I. T. O.-Q., M. B. S.-G., and K. P.-E. contributed to data extraction. N. C. R.-S., I. T. O.-Q., and M. B. S.-G. contributed to quality assessment. N. C. R.-S. performed data analysis. N. C. R.-S. performed data interpretation under the supervision of C. J. B., E. M.-B., K. P.-E., and K. G. M. All authors contributed to drafting and revising the manuscript. All authors approved the final version of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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