The Relationship Between Perinatal Stress and Newborn Food Allergy

A Somatic Experiencing Perspective

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ABSTRACT

An increasing body of evidence highlights the profound impact of maternal prenatal stress on the development and health of children. Investigations into the relationship between prenatal stress and the incidence of food allergies in newborns have, however, produced inconsistent findings. The specific mechanisms by which maternal prenatal stress contributes to food allergies in newborns remain largely uncharted. This study endeavors to clarify this relationship, introducing coupling dynamics as a viable explanatory mechanism. In a pioneering effort, it explores the association between various types of stress during pregnancy and infant food allergies. The study detailed the stress levels of 52 mothers and noted any food allergy symptoms in their children. Our analysis indicates a significant link between prenatal stress and the occurrence of food allergies in newborns during their first six months. Notably, work-related and physiological stress emerged as key factors in infant food allergies. These insights substantially advance our understanding of the adverse impact of prenatal stress on children's health and development, underscoring the imperative to devise interventions that reduce prenatal stress and enhance newborn immune function.

Keywords: pregnancy stress, prenatal stress, food allergy, Somatic Experiencing

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> ***By embracing a holistic methodology that encompasses both physiological and psychological aspects of food allergies in prenatal stress, this research sets the stage for substantial improvements in infant health and wellbeing.***

Intrauterine exposures can have long-lasting effects on children, significantly influencing their developmental trajectory both pre and postnatally (Szekeres-Bartho, 2002). Among these intrauterine exposures, maternal prenatal stress is increasingly recognized as a critical factor impacting both the physical and psychological development and health of the infant (Cookson et al., 2009; Mulder et al., 2002; Zijlmans et al., 2015). Recent studies have identified pregnancy-related stress as a potential contributor to the increased risk of food allergies in newborns (Phelan et al., 2015; Polloni et al., 2015; Smejda et

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al., 2018). Food allergies occur when the body's immune system erroneously identifies a harmless food as a threat (Sicherer & Sampson, 2010). However, the specific mechanisms underpinning the relationship between maternal prenatal stress and the development of food allergies in children have not been fully elucidated. The current study was conducted to clarify the association between maternal prenatal stress and offspring food allergy, proposing the coupling dynamics theory of Somatic Experiencing® as a possible explanatory mechanism. Additionally, this research pioneers an examination of how various types of pregnancy-related stress are associated with the development of food allergies in infants. This approach marks a significant advancement in understanding the complex interplay between prenatal environmental factors and early childhood health outcomes.

Infant Food Allergy

Food allergy constitutes an adverse health effect characterized by a specific immune response to dietary antigens, which can result in acute and potentially fatal reactions (Sicherer, 2002). In infants with food allergies, ingestion of the allergenic food triggers the immune system's release of chemicals like histamine, leading to symptoms such as rash, hives, vomiting, diarrhea, and respiratory difficulties (Chen et al., 2011). Food allergies are relatively prevalent, affecting approximately 2% of adults and 6-7% of children (Panel, 2010). The World Allergy Organization estimates that around 8% of infants and young children worldwide suffer from food allergies. Generally, the likelihood of developing food allergies is higher in infants and young children with a familial history of allergies, or other allergic conditions like eczema or asthma. Nonetheless, food allergies can develop at any age, regardless of family history (Tan et al., 2012). Several potential etiological factors for food allergies have been identified, including genetic predisposition, exposure to allergens, and the presence of other medical conditions (Ashley et al., 2015; Björksten, 2005; Patel & Volcheck, 2015). There is evidence to suggest that food allergies can be familial, with a higher incidence observed in infants with a close relative who has a food allergy. Genetic studies have unearthed associations between certain genes and the propensity for food allergies (Björksten, 2005). Early exposure to allergens, either through diet or environment, may increase children's risk of developing food allergies, and additionally, children with specific medical conditions, such as eczema or asthma, are at elevated risk of developing food allergies. However, it is crucial to recognize that the exact causation of food allergies is often multifactorial, and not always clearly understood. Recent research has implicated prenatal stress as a contributing factor to the risk of developing postnatal food allergies.

Stress During Pregnancy

Pregnancy represents a period of substantial hormonal and physiological alterations, rendering women particularly susceptible to stress (Kapoor et al., 2006; Mulder et al., 2002). This phase involves significant physical, emotional, and social transformations, often making it a challenging and stressful experience (Soma-Pillay et al., 2016). The hormonal fluctuations during pregnancy can influence a woman's mood and emotional state, thereby increasing her vulnerability to stress and anxiety (Bjelica et al., 2018; Ross et al., 2004). The pregnancy period can be demarcated into several critical stages, each associated with unique stress factors. The first trimester is often marked by physical and emotional symptoms such as nausea, fatigue, and mood swings, contributing to heightened stress levels (Rofe et al., 1993). While the second trimester may bring physical and emotional stability as the initial symptoms wane, it can also usher in increased stress and anxiety related to childbirth preparation and parenting decisions (Shapiro et al., 2017). The third trimester is typically the most physically demanding and stressful, characterized by continued significant bodily changes associated with the baby's growth, leading to discomfort, sleep difficulties, and concerns about childbirth and newborn care (Davis, 1996; Records & Rice, 2007; Nekoee & Zarei, 2015).

Pregnant women are exposed to a variety of external stressors, including financial strains, relationship stresses, work-related pressures, and social and cultural expectations (Cardwell, 2013; Katz, 2012; Palagini et al., 2014). Physical discomfort such as nausea, fatigue, and back pain, compounded by hormonal changes, can cause mood swings, anxiety, and depression (Lenz et al., 1997;

Palagini et al., 2014; Glazier et al., 2004). Relationship dynamics may also be strained due to differing expectations and concerns about parenthood (Khaled et al., 2021). Financial concerns, particularly the costs associated with pregnancy and childbirth, can be a significant stressor, especially for those with limited resources (Shishehgar et al., 2014). Work-related pressures may intensify as women balance job responsibilities with the demands of pregnancy (Katz, 2012). Additionally, societal and cultural norms regarding pregnancy, childbirth, and parenting can further contribute to stress (Thorpe et al., 1992). While some level of stress and anxiety is normal and expected during pregnancy (Soma-Pillay et al., 2016), excessive or chronic stress can adversely affect both the expectant mother and the developing fetus. Chronic stress during pregnancy has been associated with a heightened risk of preterm labor (Schetter, 2009), low birth weight (Lima et al., 2018), increased susceptibility to mental health issues like anxiety and depression (Rubertsson et al., 2014), and adverse pregnancy outcomes such as preeclampsia and placental abruption (de Paz et al., 2011; Yu et al., 2013). It can also impact newborn immune system function, and increase the risk of infections in newborns (Costello et al., 2003). Exposure to prenatal stress has been shown to alter the production of immune cells and activation of immune pathways in newborns (Gennaro & Fehder, 1996), potentially leading to long-term effects (Romero-Gonzalez et al., 2018). Additionally, evidence suggests that prenatal stress may elevate the risk of allergic diseases in newborns, including asthma and allergies (Andersson et al., 2016; Flanigan et al., 2018; von Hertzen, 2002).

Exposure to Stress during Pregnancy and Newborn Food Allergies

Emerging evidence suggests a potential association between stress during pregnancy and an increased risk of food allergies in infants. Studies by Phelan et al. (2015) and Polloni et al. (2015) have indicated that elevated stress levels in pregnant women may correlate with a higher incidence of food allergies in their offspring. Polloni et al. (2015) found that pregnant women reporting high stress levels had a greater likelihood of bearing infants with food allergies. Similarly, Phelan et al. (2015) identified high pregnancy stress as a significant predictor of gastrointestinal illness in newborns. A comprehensive review by Andersson et al. (2016) provided evidence supporting a positive relationship between prenatal grief and child asthma, and noted associations between prenatal stress and the prevalence of atopic dermatitis, allergic rhinitis, and elevated blood IgE levels. More recently, Flanigan et al. (2018) linked prenatal psychosocial stress to an increased risk of asthma and allergic outcomes in offspring. Complementing these review articles, empirical studies, such as those by Lukarinnen et al. (2021), have demonstrated a positive correlation between maternal mental health during pregnancy and the prevalence of postnatal food allergies. Specifically, Lukarinnen and colleagues (2021) showed that symptoms of depression and anxiety during pregnancy were predictive of food allergy diagnoses in infants at six months of age. However, Smejda et al. (2018) presented contrasting findings, failing to establish a significant link between perceived prenatal stress and infant food allergies at around one year of age. This discrepancy highlights the need for further research to conclusively determine the relationship between prenatal stress exposure and infant food allergies.

One hypothesis posits that stress during pregnancy may impact the immune system of the developing fetus, leading to changes in immune cell production and the activation of immune pathways (Schreier & Wright, 2014). Pregnancy stress can result in altered cortisol levels and delayed secretory immune globulin A (sIgA) production in both mothers and fetuses (Kang et al., 2018), potentially impairing infant immune function (Beijers et al., 2014; Veru et al., 2014). This alteration may affect T helper cell differentiation (Von Hertzen, 2002) and disrupt the hypothalamic-pituitary-adrenal (HPA) axis (Klinnert et al., 2001; Wright, 2007). Additionally, stress may exert effects on the neuroendocrine and immune systems (Morgan & Martinez, 1992; Van Lieshout & MacQueen, 2008; Wright et al., 1998), potentially elevating the risk of food allergies in infants. Another potential mechanism involves the impact of stress on the development of the gut microbiome – the complex community of microorganisms inhabiting the digestive system (Zijlmans et al., 2015) – which could influence the likelihood of food allergies in infants (Gao et al., 2021).

Somatic Experiencing Theory to Explain the Relation between Pregnancy Stress and Infant Food Allergy

In the realm of psychophysiological research, the framework of Somatic Experiencing and coupling dynamics presents a novel perspective in understanding the mechanisms underlying the relationship between pregnancy-related stress and infant food allergy. Somatic Experiencing, pioneered by Levine (1977), is an innovative therapeutic approach that addresses chronic stress and post-traumatic stress symptoms through focusing on internal bodily sensations, encompassing both visceral (interoception) and musculoskeletal (proprioception and kinesthesic) awareness. This method delves into the deeper regulatory functions of the nervous system, particularly targeting the autonomic nervous system (ANS), the emotional motor system, the reticular arousal systems, and the limbic system (Payne et al., 2015).

Somatic Experiencing posits a Core Response Network (CRN) comprising the autonomic nervous system, the limbic emotional system, the emotional motor system, and the reticular arousal systems. These systems are intricately interconnected through multiple feedback and feed-forward loops, forming a complex dynamical system capable of entering various discrete functional and dysfunctional states. Recent theories of stress emphasize cognitive appraisal mechanisms (Cohen, 2014); however, subcortical rapid emotional responses involving structures like the amygdala complex and hippocampus are gaining recognition. The understanding of the autonomic nervous system has evolved significantly, transitioning from a simplistic linear reciprocal model to a complex dynamical system with elaborate self-regulatory behaviors integrated with higher brain centers (Bernston & Cacioppo, 2007).

In mild stress scenarios, the sympathetic nervous system is activated with a corresponding decrease in vagal tone, leading to a reset of the central nervous system and resilient functioning (Payne et al., 2015; Porges, 2004). However, intense or prolonged stressors can elicit a more robust sympathetic response, and, in the absence of an adequate defensive response, can precipitate chronic stress conditions. Under extreme stress, paradoxical responses of the autonomic nervous system, including simultaneous activation of sympathetic and parasympathetic branches, have been observed (Gellhorn, 1968). Such phenomena are hypothesized to underlie "tonic immobility," observed in both animals and humans (Nijenhuis et al., 1998). Levine (1986) characterizes stress as a failure of the complex dynamical system of the ANS to return to normal functionality, with a fully functional CRN preventing the accumulation of allostatic load in challenging environments.

The concept of coupling dynamics, as developed by Levine et al. (2003), posits that the sensations, emotions, and behaviors experienced during stress may become linked (or "coupled") with the corresponding situation, leading to persistent dysregulation. This theory suggests that during traumatic or stressful events, physiological arousal becomes dysregulated, potentially causing individuals to become "stuck" in a heightened state of arousal, which manifests in physical, emotional, and psychological distress. In this framework, sensory stimuli accompanying dysregulation can become overcoupled with the experience, triggering stress responses in the absence of the original stressor.

Applying this perspective to the relationship between pregnancy stress and infant food allergies, we propose an overcoupling mechanism between maternal stress and food. When a pregnant woman experiences stress, the stress hormones, transmitted to the fetus via the umbilical cord, may become associated with the foods consumed during these periods of stress. Consequently, after birth, when the infant is exposed to these foods through breast milk, they might elicit stress responses, leading the baby to perceive these foods as harmful. This misidentification can trigger histamine release, a key chemical in allergic reactions (Averbeck et al., 2007), potentially causing the immune system to erroneously identify and react against these foods, which manifests as allergic reactions. This novel hypothesis offers a unique lens through which to examine the etiology of infant food allergies in the context of prenatal stress exposure.

The Present Study

The existing body of research robustly establishes that stress experienced during pregnancy is associated with adverse outcomes in newborn immune functioning (Ruiz & Avant, 2005). Additionally, emerging evidence suggests a potential correlation

between maternal stress during pregnancy and the incidence of food allergies in neonates (Phelan et al., 2015; Polloni et al., 2015). In light of these findings, the present study aims to replicate and extend this research within a non-WEIRD (Western, Educated, Industrialized, Rich, and Democratic) population, examining the relationship between pregnancy stress and the development of food allergies in infants.

A novel aspect of this study is its focus on how various types of stress experienced during pregnancy may differentially impact immune system function in infants. This approach is predicated on the hypothesis that stress during pregnancy is not only a potential factor in the development of food allergies in infants, but also a predictive indicator of an infant's risk of developing such allergies. The study seeks to comprehensively explore the connections between distinct forms of pregnancy stress and the manifestation of food allergies in infants.

Through this investigation, we aim to contribute to the nuanced understanding of how prenatal stress influences immune system development and the propensity for allergic reactions in early childhood. This research is particularly significant as it ventures into examining these relationships in diverse cultural and socioeconomic contexts, thereby offering a more global perspective on the impact of prenatal stress.

Method

Participants

Fifty-two mothers aged 25 to 45 participated in the study. Participants were from middle to high socioeconomic backgrounds. Nine infants (17%) were born preterm and 43 infants (83%) were born at full-term. The babies ranged in age from six to 30 months (M = 16.7, SD = 5.86) at the time of the assessment. Each participating mother was married to their baby's biological father. The educational attainment of mothers was as follows: 2% high school graduate, 42% undergraduate degree, 36.5% master's degree, 11.5% PhD degree, 2% specialization in medicine. Of the 52 mothers, 6% did not report their educational attainment.

Procedure

The data was collected online from 2021 to 2022. The mothers contacted the clinic to seek counseling on their infants' sleep disturbances, feeding difficulties, relational problems, as well as on healthy child development, and pre- and post-natal traumas. All mothers signed a consent form allowing the information they provided to be used for research purposes, and completed a questionnaire asking about their stress levels during pregnancy and their babies' health conditions (Appendix A). Mothers then participated in one-to-one interviews with the first author of this paper, a trained developmental psychologist.

Materials

Stress Assessment

The stress mothers experienced during pregnancy was assessed by asking mothers: "Was there a period during your pregnancy where you felt anxious/stressed for a month or longer?" They responded on a scale from 0 (not at all) to 5 (a lot). The type of stress mothers experienced during pregnancy was identified based on maternal reports during one-to-one interviews. The details about different stress types are provided in Appendix B.

Assessment of Infant Food Allergy

To assess whether infants experienced food allergies within the first three months of life, mothers were asked: "Did your child exhibit any food allergy symptoms in the first three months after birth?". Mothers were given the following response options: Yes, No, Other (please specify).

Results

Table 1 demonstrates frequencies of infant food allergy, preterm and cesarean birth rates, and frequency of stress types. Table 2 shows the correlations between variables of interest. As seen in Table 2, stress during pregnancy is related to having food allergies (r_S = .33, p = .02) in the first six months of the infant's life. Furthermore, mothers who experienced higher levels of stress during pregnancy were more likely to have preterm births (r_S = .43, p = .002), which was further positively associated with food allergy diagnoses (r_S = .29, p = .04). Although prenatal stress was positively linked to cesarean birth (r_S = .29, p = .02), it was not associated with newborn food allergies (r_S = .21, p = .11).

Table 1. *Descriptive Information*

	n	%
Food allergy	19	37
Preterm birth	9	17.3
Cesarean birth	37	71.2
Work-related stress	9	17.3
Physiological stress	17	33
Safe environment	11	21.2
Grief	1	2
Lack of inclusive relationship	12	23
Trauma	2	4
Fear of miscarriage	6	12
Stress about accepting the baby	13	25
Stress due to medicine use	12	23
Anxiety	1	2
Stress about nutrition	1	2
Stress due to medical intervention	1	2

Parenting Stress and Newborn's Food Allergy

A Mann-Whitney *U* test was conducted to determine whether mothers of newborns with food allergies experienced higher stress levels during pregnancy. The results were in the expected direction, and significant ($U = 192$, $p = .02$). Mothers of infants with food allergies ($M = 3.63$, $SE = .21$) experienced higher levels of stress during pregnancy compared to mothers of infants without food allergies ($M = 2.73$, $SE = .24$).

Logistic regression analyses were conducted to test whether stress during pregnancy predicts the risk of developing food allergies in infancy when controlling for preterm birth. Pregnancy stress significantly predicted the prevalence of food allergies in newborns, $b = .62$, $Z = 2.34$, $p = .02$. Preterm birth and stress during pregnancy explained the significant variance in newborns diagnosed with food allergies, $R^2 = .11$, $\chi^2(2) = 7.58$, $p = .02$.

Relations Between Different Types of Pregnancy Stress and Food Allergy

Table 3 demonstrated the relationship between different types of pregnancy-related stress and food allergies. As seen in Table 3, food allergies are positively related to work-related stress ($r_s = .29$, $p = .04$) and physiological stress ($r_s = .32$, $p = .02$). Furthermore, newborns whose mothers experienced higher levels of stress during pregnancy due to medication use were more likely to experience food allergies ($r_s = .25$, $p = .07$).

A Chi-square test of independence was performed to further investigate the relations between stress and infant food allergies. First, a significant relation was found between work-related stress and food allergies, $\chi^2(1, N = 52) = 4.26$, $p = .04$. Infants of mothers who experienced work-related stress during pregnancy are likelier to have food allergies. Next, physiological stress was related to infant food allergies ($\chi^2(1, N = 52) = 5.41$, $p = .02$), such that mothers who experienced higher physiological stress during pregnancy were more likely to have newborns with food allergies.

Table 2. *Correlations Between Study Variables*

	1.	2.	3.	4.
1. Maternal prenatal stress				
2. Infant food allergy	.33*			
3. Preterm birth	.43**	.29*		
4. Cesarean birth	.29*	.21	−.29*	
5. Infant age	−.16	.12	.07	.01

Note: * $p < .05$, ** $p < .01$

Table 3.
Correlations Between Different Types of Stress During Pregnancy and Food Allergy

Stress Type	Food allergy
Work-related stress	−.29*
Physiological stress	−.32*
Stress due to lack of a safe environment	.01
Stress due to grief	.11
Stress due to lack of inclusive relationship	.04
Stress due to transgenerational trauma	−.06
Stress due to fear of miscarriage	−.10
Stress about accepting the baby	−.21
Stress due to medicine use	−.25
Stress about anxiety	.11
Stress about nutrition	−.19
Stress due to medical intervention	.11

Note: * $p < .05$

Discussion

This study demonstrates a significant association between stress experienced during pregnancy and mothers' reports of food allergies in their babies during the first six months of life. Our finding that prenatal stress is associated with infant food allergies is in concordance with previous research associating exposure to stress during pregnancy with allergic diseases in newborns. Furthermore, for the first time, this study identified work-related and physiological stress as stressors related to infant food allergies.

The physiological association between prenatal stress and the development of food allergies in infants can be clarified through several distinct mechanisms. Initially, exposure to heightened stress during pregnancy, and the consequent increase in cortisol levels, may adversely affect immune system development and the hypothalamic-pituitary-adrenal (HPA) axis in the developing fetus. This disruption could potentially elevate infants' risk of developing food allergies, as Phelan et al. (2015) suggested. Furthermore, the gut microbiome, a crucial component for optimal immune system function, might be detrimentally impacted by increased stress levels, subsequently leading to a heightened risk of food allergies in infants (Gao et al., 2021). Additionally, an indirect mechanism may also play a significant role. Elevated stress levels during pregnancy are often associated with various lifestyle factors, including the consumption of caffeine, disrupted sleep patterns, smoking, and a tendency towards reduced physical activity, less use of vitamins, and unhealthy eating habits (Auerbach et al., 2014). Such behaviors, prevalent during periods of elevated stress, could potentially influence the physiological development of the fetus (Phelan et al., 2015). This indirect pathway highlights the multifaceted impact of maternal stress on fetal development, extending beyond direct physiological changes to encompass broader lifestyle factors that may collectively contribute to an increased risk of food allergies in infants. This complex interplay of direct and indirect influences underlines the importance of a comprehensive understanding of the various factors at play in the relationship between prenatal stress and infant health outcomes.

This article introduces a novel perspective to understand the relationship between prenatal stress and newborns' incidence of food allergies. We propose the integration of Somatic Experiencing and coupling dynamics, as conceptualized by Levine et al. (2003), as a potential underlying mechanism for this association. According to the theory of coupling dynamics, stressful situations activate the arousal system, leading to heightened arousal levels. In this process, stress may become intricately overcoupled with specific stimuli, such as particular food items. We posit that this overcoupling mechanism may extend to the development of food allergies in newborns. In scenarios of maternal prenatal stress, we hypothesize overcoupling between the mother's stress and the nutrients she consumes during these periods of heightened stress. Consequently, postpartum, infants may

perceive these foods, which are linked to maternal stress, as toxic, responding as if a stressful event is occurring. This suggests that infants might exhibit stress responses even without direct stressors upon encountering these overcoupled foods. However, it is important to note that the current study lacks the statistical power to test this hypothesis definitively. Nonetheless, anecdotal evidence from maternal reports offers preliminary support for this assumption. For instance, one mother, referred to as "Mother A," experienced significant nausea and work-related stress during her pregnancy. Interestingly, her newborn was later found to be allergic to eggs and dairy products, which she consumed in large quantities while pregnant. She had not previously consumed dairy products but began doing so because she believed they were necessary for healthy fetal development. This case illustrates a potential overcoupling between work-related stress, nutritional stress, and the consumption of dairy products. Similarly, "Mother I" reported an unplanned pregnancy and intense workplace stress in the early months. She consumed large amounts of walnuts, pomegranates, and tomatoes during that time, and her infant subsequently developed allergies to these same foods. Moreover, the baby showed resistance to supplementary foods, and the father's inability to regulate his emotions, stemming from his early childhood feeding experiences, suggests that the stress-food coupling that was initiated prenatally may have continued into the postnatal period.

These instances provide anecdotal evidence supporting the hypothesis of overcoupling between maternal stress and specific food consumption during pregnancy, potentially leading to the development of food allergies in infants. This novel approach underscores the complex interplay between maternal experiences during pregnancy and the subsequent health outcomes of their offspring, warranting further investigation into the mechanisms driving these associations. This study was the first to investigate the associations between different types of prenatal stress and infants' food allergies. We assessed different types of stress, such as work-related, partner-related, physiological, and others. Among different stressors, physiological and work-related stress correlated with newborn food allergies. Work-related stress has been identified as one of the significant sources of stress, and has been linked to increased stress levels and decreased quality of life (Moustaka & Constantinidis, 2010). Given that this type of stress is more chronic in nature, its adverse effects may be more prominent than other stress types, and allow more time for coupling to occur. During prolonged work-related stress, the foods the mother consumes may be matched with stress, and the infant may develop allergies to that particular food. Similar to work-related stress, physiological stressors may be more prolonged over time, and bind with certain foods consumed at that time. In agreement with our view, Flanigan et al. (2018) provided evidence for the adverse effects of cumulative stress during pregnancy on childhood allergic diseases.

Furthermore, stress due to the use of medicine tended to correlate with infant food allergies as well. One potential reason might be that certain medications may alter the microbiome of the mother and child, which may influence immune system function and allergic sensitization (Metzler et al., 2019). Another reason might be that mothers may take pills or medicine for longer durations of time and experience stress over the period. We did not find significant correlations between newborn food allergies and the lack of a safe environment, grief, absence of inclusive relationships, transgenerational trauma, the risk for miscarriage and preterm labor, difficulties accepting the newborn, anxiety, substance use, nutrition, and medical intervention. These stressors may be more short-term and less intense than other types of stress. Furthermore, the small sample size and low prevalence of some stress factors may explain the lack of a significant relationship.

Strengths and Limitations

This study's exploration of the various types of stress and their relationship to newborn food allergies significantly contributes to a nuanced understanding of this complex field. Additionally, the collection of maternal anecdotes regarding stress experiences and the inclusion of a non-WEIRD sample further augment the robustness of this research. Importantly, this study pioneers an attempt to explain the link between prenatal maternal stress and infant food allergies from a novel theoretical perspective, employing the coupling dynamics theory of Somatic Experiencing. Despite these strengths, a few notable limitations must be acknowledged. One primary limitation is the ret-

rospective nature of the stress assessments, which did not focus on specific periods during the pregnancy but rather on the overall experience of stress as reported by the mothers. This approach may obscure the nuances of stress experiences at different stages of pregnancy. Future research would benefit from a more detailed temporal assessment of stress levels and their correlation with the development of food allergies, ideally supplemented with medical confirmation by a pediatrician or allergist.

Additionally, the relatively small sample size and the specific socioeconomic background of the participants (middle- to high-level) may limit the generalizability of the findings. A more diverse sample in terms of size and socioeconomic status would enhance the applicability of the results across a broader population. Furthermore, it is critical to emphasize that this study, akin to previous research in this area, is observational. Consequently, it does not establish a causal relationship between prenatal stress and infants' subsequent development of food allergies. The study lays the groundwork for future research, which is essential to validate these findings and to delve deeper into the potential mechanisms through which stress during pregnancy might influence the development of food allergies in infants.

Future Directions

In sum, the current study represents a significant advancement in elucidating the complex relationship between prenatal stress and the development of food allergies in infants. However, further research in this area is paramount to validate and extend these findings. Such research would not only reinforce the existing body of knowledge. However, it could also crucially inform the creation of targeted interventions designed to alleviate the adverse effects of prenatal stress on infant health outcomes. The outcomes of this study pave the way for future investigations. It is essential to conduct additional research to establish the mechanisms and causal relationships that underlie the association between prenatal stress and food allergies. Longitudinal studies are needed to affirm the correlation between exposure to stress during pregnancy and the manifestation of food allergies in newborns. Future research could include statistical analysis to determine if the specific foods consumed by mothers under stress during pregnancy are the same as those to which infants show allergic reactions. That investigation could further explore whether the strength of this association is amplified if the mother continues to experience stress following childbirth. Future studies should also focus on assessing stress and cortisol levels during pregnancy in order to provide a more comprehensive understanding of the physiological impact of stress on both the mother and the developing fetus. In addition to relying on maternal reports, future research should incorporate medical evaluations of food allergies conducted by pediatricians or allergists to corroborate and validate the findings. Moreover, it is imperative to investigate other factors that may contribute to the development of food allergies in infancy. Such research would enable a broader understanding of the various elements at play, highlighting the distinct role of prenatal stress in this context.

The findings from this research provide pivotal insights crucial for directing future scholarly endeavors in prenatal stress and infant food allergies. This study underscores the need for a comprehensive, multifaceted approach to examining this relationship, necessitating the integration of psychological and physiological assessments. A deeper comprehension of these intricate dynamics is vital for developing more efficacious strategies to prevent and manage food allergies in infants, thereby enhancing health outcomes for this susceptible demographic. The data derived from this study hold significant potential for the formulation of targeted interventions designed to mitigate the detrimental impacts of prenatal stress on the development of food allergies in infants. These interventions could be structured from traditional medical practice to systematically desensitize infants to allergenic foods. This could be achieved by initially eliminating the triggering food stimulus entirely, followed by gradual reintroduction in progressively increasing, yet small, quantities. Crucial to this approach is the dissociation of the overcoupled stimuli. It is imperative to ensure a stress-free environment during these interventions, reassociating the previously stress-coupled food with positive experiences of pleasure and joy. To facilitate the establishment of new, positive associations with these foods, healthcare practitioners could offer guidance to caregivers on effective emotion regulation strategies and managing familial stress,

particularly during feeding interactions. Moreover, these interventions could be designed to foster increased synchrony and secure attachment between the parent and infant during feeding times. The overarching goal of these interventions should be to dissolve the existing overcoupling between the experience of stress and specific foods, aiming instead to foster an association of these foods with positive, pleasurable experiences.

Conclusion

In essence, applying the insights from this study holds significant promise in transforming clinical practice within pediatric allergy prevention and management. By embracing a holistic methodology that encompasses both physiological and psychological aspects of food allergies in prenatal stress, this research sets the stage for substantial improvements in infant health and wellbeing. Such advancements could lead to a more favorable start in life for this vulnerable population. Our study has successfully demonstrated a notable association between prenatal stress and the prevalence of food allergies in newborns during the initial six months of life. This finding enhances our existing understanding of the adverse consequences of prenatal stress. It contributes additional insights regarding the various types of stress implicated in developing food allergies in newborns. The significance of this study lies in its potential to inform the design of interventions aimed at reducing prenatal stress levels. Such interventions are essential for improving the overall pregnancy experience for mothers and optimizing newborn immune system function. Ultimately, the knowledge gained from this study represents a crucial step forward in our efforts to safeguard and promote the health of the youngest members of our society.

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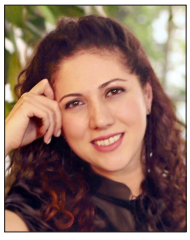

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Appendix A

Questionnaire Form Distributed to Parents

1. Infant age:
2. Did you give birth prematurely? If yes, at which month?
3. Did you experience difficulties during pregnancy? A. Yes B. No
4. Was there a period during pregnancy where you felt anxious/stressed for a month or longer?
   a. 1 (not at all) b. 2 c. 3 d. 4 e. 5 (all the time)
5. Did you have a cesarean birth? A. Yes B. No
6. Did your baby have allergies in the first trimester? A. Yes B. No C. Other

Appendix B

Table 1. *Detailed Explanation of Stress Type Categorizations*

Stress Type	Examples
Work-related stress	Mobbing, workload, long working hours, content-related
Physiological stress	Nausea and vomiting during pregnancy, narrowing of the feeding vessel, loss of vision, pregnancy cholestasis, physical fatigue, risk of fainting, gestational diabetes, constipation
Stress due to lack of a safe environment	Moving, fear of COVID-19
Stress due to grief	Loss of a family member
Stress due to lack of inclusive relationship	Loneliness, relationship problems, unsupportive spouse or family members, distance from social circle
Stress due to transgenerational trauma	Transmission of mother's experiences during pregnancy to newborn
Stress related to miscarriage risk	Fear of having a miscarriage
Stress about accepting the baby	Confused feelings in accepting the pregnancy and the baby, difficulty in accepting unhealthy baby, inability to accept the unplanned baby, difficulty in accepting the gender, not bonding with the baby during pregnancy
Stress about medication use	Use of medication other than supplements during pregnancy
Stress due to anxiety	Increased levels of anxiety
Stress due to use of toxic substances	Smoking during and before pregnancy