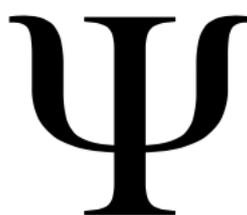


UNIVERSITY OF BERGEN  
*Faculty of Psychology*



***THE 2015 NEPAL EARTHQUAKES: MATERNAL PTSD AND INFANTS'  
SOCIOEMOTIONAL DEVELOPMENT AND SOCIAL BEHAVIOR***

THESIS

*Professional studies in psychology*

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### **Preface and acknowledgements**

Post-traumatic stress symptoms not only impact on the earthquake-affected, but also seem to have a substantial impact on the affected person's day-to-day life and immediate family. Based on an aspiration to promote good upbringing conditions for children and an interest in how traumatic events may interrupt these conditions, my thesis seeks to contribute to the understanding of how maternal PTSD and subsequent child adjustment are associated when examining the youngest children. With only a thin knowledge base on how the youngest children are affected by the mother's mental health in the traumatic event of earthquakes, this study may contribute to the field of health consequences after natural disaster. Working with this master thesis has been both educational and enlightening. Through writing the thesis, I now have a better knowledge on the devastating aftermaths of earthquakes and a widened insight into the lives of earthquake-affected mothers and infants. The thesis also has provided me with the opportunity to challenge myself and learn more about statistics. Ultimately, I want to acknowledge my supervisors, professor Mari Hysing and researcher Ingrid Kvestad. Thank you for all the encouraging words and the valuable guidance throughout this year. Your time and effort have been of invaluable help. I also want to thank my family, friends and fellow students for all their support and motivational conversations. In addition, I want to express my fullest appreciation to the research group in Nepal for the opportunity to use their collected data and research findings as the basis for our study.

### **Abstract**

On 25<sup>th</sup> of April 2015, Nepal suffered from major earthquakes resulting in great damage to the Nepalese society. An earthquake is considered one of the most destructive and frequently occurring natural disaster, a traumatic event that include an increase in the survivors' risk of developing post-traumatic stress disorder (PTSD). Disaster-survivors with PTSD symptoms do not seem to experience their symptoms in isolation, which is especially relevant for parental PTSD and subsequent child adjustment as parents and children are considered an interdependent unit. The objective of the current study was to examine the associations between maternal PTSD symptoms and the infants' social behavior and socioemotional development. A population-based randomized controlled trial (RCT) was carried out in Bhaktapur district, Nepal, in the aftermaths of the 2015 earthquakes. The current study included 555 mothers and infants, accounting for 92.5 % of the 600 participants from the original sample. Maternal PTSD was assessed with scores on the Impact of Event Scale-Revised (IES-R). Infants' socioemotional development was assessed with scores on the Bayley Socio-Emotional scale (Bayley SE) and infants' social behavior with scores on the modified Alarm Distress Baby scale (m-ADBB). Linear regression, ANCOVA and logistic regression were conducted to examine associations between mothers' scores on IES-R and infants scores on Bayley SE. Poisson regression and logistic regression were carried out for associations between mothers' scores on IES-R and infants scores on m-ADBB. Of the 555 mothers, 27 % had IES-R scores indicating PTSD as a clinical concern or probable PTSD diagnosis. No associations were found between maternal PTSD and infant socioemotional development, nor between maternal PTSD and socially withdrawn behavior in the infant. To conclude, the current findings do not suggest associations between maternal PTSD symptoms and infant social and emotional development in the aftermaths of major earthquakes in Nepal.

*Keywords:* earthquakes, maternal post-traumatic stress disorder, infant socioemotional development, social withdrawal behavior.

### **Sammendrag**

Den 25. april 2015 ble Nepal rammet av kraftige jordskjelv som resulterte i store ødeleggelser i det nepalske samfunnet. Et jordskjelv er ansett som en av de mest destruktive og hyppigst forekommende naturkatastrofene, og er en traumatisk hendelse som involverer økt risiko blant overlevende for utvikling av post-traumatisk stresslidelse (PTSD). Katastrofeoverlevende

med PTSD-symptomer synes ikke å oppleve symptomene sine isolert, noe som spesielt er relevant for foreldre med PTSD og barnas påfølgende tilpasning, med tanke på at foreldre og barn er ansett som gjensidig avhengige av hverandre. Formålet med denne studien var å undersøke assosiasjonene mellom mødre med PTSD-symptomer og spedbarns sosiale atferd og sosioemosjonelle utvikling. En populasjonsbasert randomisert kontrollert studie ble utført i Bhaktapur-distriktet i etterkant av de nepalske jordskjelvene i 2015. Denne studien har inkludert 555 mødre og deres spedbarn, noe som utgjør 92,5 % av de 600 deltakerne fra det opprinnelige utvalget. PTSD symptomer hos mødre ble kartlagt med skårer på Impact of Event Scale-Revised (IES-R). Spedbarns sosioemosjonelle utvikling ble vurdert med skårer på den sosioemosjonelle skalaen i Bayley III og spedbarns sosiale atferd med skårer på en modifisert versjon av Alarm Distress Baby Scale (m-ADBB). Lineær regresjon, ANCOVA og logistisk regresjon mellom mødres skårer på IES-R og spedbarns skårer på Bayley SE. Poisson regresjon og logistisk regresjon ble utført mellom mødres skårer på IES-R og spedbarns skårer på m-ADBB. Av de 555 mødrene hadde 27 % IES-R skårer som indikert PTSD-symptomer som klinisk betydningsfulle eller PTSD som sannsynlig diagnose. Ingen assosiasjoner ble funnet mellom mødre med PTSD og spedbarns sosioemosjonelle utvikling, og heller ikke mellom mødre med PTSD og spedbarns sosiale tilbaketrekkingssatferd. Funnene tyder på at det ikke er assosiasjoner mellom mødre med PTSD og spedbarns sosiale og emosjonelle utvikling i etterkant av katastrofale jordskjelv i Nepal.

*Nøkkelord:* jordskjelv, post-traumatisk stresslidelse, spedbarns sosioemosjonelle utvikling, sosial tilbaketrekkingssatferd.

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A disaster is defined as a potentially traumatic event that is collectively experienced, has an acute onset and is time-delimited (McFarlane & Norris, 2006). Earthquakes are considered one of the most destructive and frequently occurring natural disasters, with low to middle income countries seen as the hardest-hit regions, and women and children often the most vulnerable and severely affected (Nour, 2011; Kousky, 2016). Disaster-survivors with post-traumatic stress disorder (PTSD) do not seem to experience their symptoms in isolation, which is relevant for maternal PTSD and subsequent child adjustment as mothers and children are considered an interdependent unit (Juth et al., 2015). The potential impact of earthquakes on maternal mental health, and subsequent impact on developmental outcomes among young children, will be the focus of concern in the present study.

### **The Nepalese context**

Nepal is considered the 11<sup>th</sup> most earthquake prone country in the world (Dahal, Kumar & Thapa, 2017). On 25<sup>th</sup> of April 2015, Nepal suffered from major earthquakes resulting in great damage to the Nepalese society. With an earthquake of magnitude 7.8 followed by several aftershocks and an epicenter 77 kilometers northwest of Kathmandu in the Gorkha district, millions of people were affected. About 9000 died, at least 23 000 were injured and more than two million people were displaced due to the destructions (Basnyat et al. 2015). The consequences of the Gorkha earthquakes included substantial damage to building structures and lifelines, including road networks, water supply and sanitation systems. These damages also resulted in an increased risk of spread of disease epidemics and represented a significant threat of negative consequences on mental health (Khanal, Khanal & Lee, 2015). The disruption of the existing health system affected the whole population, but especially pregnant women, new mothers and their babies (Dhital et al., 2019).

### **PTSD in the aftermath of earthquakes**

PTSD is considered the most common negative psychological reaction among disaster-survivors (Tang et al., 2017) and is also the most studied post-disaster psychiatric disorder (Neria, Nandi & Galea, 2008).

#### **The PTSD diagnosis**

PTSD refers to delayed and lasting psychological reactions caused by exposure to trauma (Tang et al., 2017). According to DSM-5, criteria for PTSD is A) exposure to traumatic event, either directly or indirectly, B) intrusion symptoms, C), avoidance of stimuli, D) negative alterations in cognitions and mood, and E) marked alterations in arousal and reactivity. Duration of the disturbance must be more than one month and the disturbance must cause clinically significant distress or impairment in functioning as well as not be attributable to psychological effects of a substance or another medical condition (American Psychiatric Association [APA], 2013).

#### **Prevalence of earthquake related PTSD**

The prevalence of PTSD in the aftermath of earthquakes is widely ranging. A systematic review on the mental health consequences after earthquakes presents incidence of PTSD from 1.2 to 82.6 % with a combined incidence of 23.7 % (Dai et al., 2016). A more recent meta-analysis identified the prevalence of PTSD ranging from 4.1 to 67.1 % in adults and from 2.5 to 60.0 % in children (Tang et al., 2017).

On a world basis, men are considered at a slightly greater risk of being exposed to stressful events than women (Hu et al., 2017). However, lifetime prevalence of PTSD seems to occur about twice the rate among women compared to men (Olf, 2017). Prevalence of PTSD and gender differences also seem to differ across types of trauma with the highest

gender difference found in the aftermath of disasters and accidents (Ditlevsen & Elkit, 2012). Particularly earthquakes as natural disasters have been associated with significantly higher rates of PTSD among women compared to men (Carmassi & Dell'Osso, 2016).

### **Pre-, peri- and post-disaster factors**

The impact of disasters on mental health depends upon several pre-, peri- and post-disaster factors (Tang et al., 2017; Tortella-Feliu et al., 2019; Dahal, Kumar & Thapa, 2017). The pre-, peri- and post-disaster factors seems likely to be grounds for the high degree of heterogeneity and widely ranging prevalence observed in studies on PTSD after earthquakes (Dai et al., 2016; Tang et al., 2017). These factors also seem to contribute to the explanation for the prevalence of PTSD in the aftermath of the Nepal earthquakes.

Nepal is in addition to being the 11<sup>th</sup> most earthquake prone country in the world (Dahal, Kumar & Thapa, 2017), also among the world's least developed countries with one third of the population living below the poverty line (Central Bureau of Statistics, Government of Nepal, 2018). The country is a low to middle income country with need for major improvements in their mental health care systems (Luitel et al., 2015). With one third below the poverty line, many of the Nepalese families live in low socioeconomic situations. A study on the same sample of 600 Nepalese mothers used in the present study, reported that about 24 % of the mothers in the aftermath of the earthquakes showed scores on Impact of Event Scale-Revised (IES-R) indicating PTSD symptoms of clinical concern or a probable PTSD diagnosis (Kvestad et al., 2019). In the study, questions on exposure were collected and an association between severity of exposure to the disaster and the risk of developing PTSD symptoms was found. Mothers with family members who were killed had a higher risk of PTSD, based on the mothers' total IES-R scores, than those with no family members who died (Kvestad et al., 2019). Post-disaster risk factors were also addressed within this study, with questions on family life in the aftermath of the earthquakes. For instance, 98 % of the

mothers reported to have moved twice or more after the earthquakes and 83.8 % reported on having property conflicts as a result of the earthquakes (Kvestad et al., 2019). Over 60 % of the mothers reported that the earthquakes had a negative impact on their family life. The mothers who reported negative impact on family's daily life had higher total IES-R scores compared to mothers who reported no negative impact (Kvestad et al., 2019).

A meta-analysis on risk factors, or predictors, for development of PTSD reported that several previous studies have found PTSD symptoms following earthquakes to be more prevalent in people from low socioeconomic situations, in people with low social support and in females, relevant to the Nepalese setting (Tang et al., 2017; Kvestad et al. 2019). Furthermore, the meta-analysis reported that a number of studies have found an association between the risk of PTSD and the severity of exposure to the disaster, with direct survivors at utmost risk, as reported in the study on 600 Nepalese mothers after the earthquakes in 2015 (Tang et al., 2017; Kvestad et al., 2019). Lastly, the meta-analysis reported on several post-earthquake characteristics, such as loss of houses and property conflicts, increasing the risk of PTSD, also reported by the study on the current sample (Tang et al., 2017, Kvestad et al., 2019). Other previous studies have described that prior personal or family history of psychiatric disorders, history of exposure to distressing events and life stresses in general have been found to be potential pre-disaster factors increasing the risk of developing earthquake related PTSD symptoms (Tortella-Feliu et al., 2019). Further, perceived social support resources as a post-disaster factor have been found to predict risk of developing PTSD (Dahal et al., 2017). Typically, initial disaster relief efforts are time consuming and resource demanding, leaving social support somewhat compromised and limited (Substance Abuse and Mental Health Services Administration [SAMHSA], 2014).

### **Associations between parental disaster-related PTSD and child outcomes**

Disaster survivors do not seem to experience their PTSD symptoms in isolation as the symptoms also are considered to have an impact on their closest relatives. This is especially relevant for parents and children who, because of the required physical proximity to provide and receive care, need to adjust together as an interdependent unit (Juth et al., 2015). As a result, maternal PTSD in the aftermath of disasters such as earthquakes, may have a negatively impact on child mental health and development.

### **Parental PTSD and child psychological distress**

The passing of trauma-related symptoms from parent to child have been a topic of research for decades (e.g. Rosenheck & Nathan, 1985). A cross-sectional study in the aftermath of the 2015 Nepal earthquakes aimed at identifying the association between parental PTSD symptoms and PTSD symptoms in their children (Achary, Bhatta & Assannangkornchai, 2017). With a sample of 800 earthquake-affected parents and children, aged 7-16 years, the study found that children with both parents having PTSD symptoms were seven times more likely to have PTSD symptoms than children with parents without PTSD symptoms (Achary, Bhatta & Assannangkornchai, 2017). Further, with a dyadic approach, a study on post-disaster mental health among 397 parent-child dyads in the aftermath of the 2006 Indonesian earthquake reported the degree of PTSD symptoms in the parent to be a strong predictor of general psychological distress in the child (Juth et al., 2015). The children's PTSD symptoms were, however, not associated with their parents' general psychological distress (Juth et al., 2015). These previous studies indicate that parents' post-disaster and earthquake related mental health might be negatively associated with children's psychological adjustment. However, both the parents and the children were exposed to the earthquakes in both studies, which makes it important to question whether the children's

psychological maladjustment should be attributed to being directly affected or affected through their parent's mental health.

### **Parental PTSD and child behavioral problems**

In addition to studies on transmission of PTSD symptoms and general distress, previous studies have also found children's behavioral problems to be associated with parental earthquake related PTSD (Honda et al., 2019; Jang, Lee & Kim, 2020).

In a longitudinal study with repeated measures on long-term psychological impact of the Great East Japan earthquake (GEJE), researchers aimed at monitoring parental PTSD symptoms using the IES-R and total, externalizing and internalizing problems in their children over time using the Child Behavior Checklist (CBCL) (Honda et al., 2019). The children were 4-6 years old and assessed both at baseline and a follow-up. A significant negative association between parental PTSD symptoms and children's behavioral problems was found in the follow-up (2014), but not at baseline (2012). Furthermore, the study found a strong association between parental PTSD symptoms at baseline and the children's behavioral problems in the follow-up, indicating that parental PTSD symptoms could be negatively associated with children's behavioral problems, long-term lasting for at least 3 years (Honda et al., 2019). Parental PTSD symptoms at baseline was also found to be significantly associated with the children's internalizing behavioral problems in the follow up. Parental PTSD symptoms in the follow up was significantly associated with the children's externalizing behavioral problems and moderately, but not significantly, associated with internalizing behavioral problems in the follow up (Honda et al., 2019). These findings could suggest that externalizing symptoms such as aggressive and rule-breaking behavior are more responsive to current parental stress while internalizing symptoms such as anxiety, depression and social withdrawal are more long-term affected by parental PTSD symptoms.

A study on associations between parental and child PTSD symptoms and parents' and children's behavioral problems have also been conducted in the aftermath of the 2015 Nepal earthquakes (Jang, Lee & Kim, 2020). In this sample, the children, aged 6-17 years, and their families were residing in refugee camps for 24 months following the earthquakes. The study reported a relatively strong relationship between PTSD symptoms and behavioral problems for both parents and children (Jang, Lee & Kim, 2020). Parental PTSD was measured with the IES-R, traumatic symptoms in the children with child and parental reports, and behavioral problems with Adult Self-Report based on Aschenbach's scale for the parents and with CBCL for the children. The more severe the parental PTSD symptoms were, the more internalizing problems were reported in the children. Severity of parental PTSD symptoms was further, in combination with the parents' externalizing problems, associated with more externalizing problems in the children (Jang, Lee & Kim, 2020).

### **Maternal PTSD and infant socioemotional development**

The interrelationship between maternal PTSD parent-child interaction measured by emotional availability and infants' psychosocial functioning and development was investigated in a study of 49 asylum-seekers and refugee mothers and their infants, aged 18-42 months (van Ee et al., 2012). They found maternal PTSD to be positively associated with infants' total psychosocial problems (van Ee et al., 2012). The children's psychosocial functioning was based on parent-reported CBCL. Due to the use of parental report, the study acknowledges the possibility that the findings could be explained by maternal PTSD associated with a more negative perception of the child, as well as by actual delays in child development (van Ee et al., 2012). Further, the study included a measure of the parent's emotional availability and the children's emotional availability to determine the quality of the parent-child interactions (van Ee et al., 2012). Emotional availability was defined as the degree to which the parent and child expressed emotions and were responsive to the emotions

of the other by using the Emotional Availability scales (the EA scales). The EA scales include four dimensions to determine the parent's availability; sensitivity, structuring, non-intrusiveness and non-hostility, and two dimensions to determine the children's availability; responsiveness and involvement to the parent. Mothers with PTSD symptoms scored lower on all dimensions of the EA scales, and significantly lower on sensitivity, structuring and non-hostility (van Ee et al., 2012). The study also showed that maternal PTSD symptoms were associated with a combination of less sensitivity of the mother and less responsiveness of the child (van Ee et al., 2012). The researchers explain how the parent's lack of sensitivity seems to include impaired ability to regulate the child's affects and arousal which in turn could lead to impaired child development of ability to self-regulate. Consequently, because of impaired self-regulation strategies, the child may show negative behavioral adaptations. A mediation model could not be inferred in this study (van Ee et al., 2012), and the study was not earthquake related.

Still-face is as an observational method that has been used to study associations between maternal PTSD symptoms and infant emotional reactivity and emotion regulation during their first year of life (Enlow et al., 2011). In a study of 52 mother-infant dyads, maternal PTSD (not earthquake related) predicted infants emotion regulation at six months. Infant regulation was assessed by the infant's ability to recover from distress during a still-face paradigm episode and assessed by maternal report of the infant's recovery from distress in the daily life (Enlow et al., 2011). The study also found maternal PTSD to predict maternal reported externalizing, internalizing and dysregulation symptoms in the infant at 13 months (Enlow et al., 2011). These findings support an association between maternal PTSD and offspring emotion regulation difficulties. However, maternal PTSD was not found to be associated with measures of infant emotional reactivity (Enlow et al., 2011). An explanation for these findings could be that emotional reactivity is more determined by the child's

temperament style, while emotion regulation refers to the ability to adapt to a situation, an ability more prone to be affected by stress, including maternal PTSD.

Another method to examine infant socioemotional development is through infant social withdrawal behavior. Social withdrawal is a broad concept (Rubin, Coplan & Bowker, 2009). One way to understand the concept of withdrawal behavior in infants is as a sign of reluctance to participate in social interaction (Guedeney & Fermanian, 2001). Brief withdrawal is seen as a normal mechanism in the mother-infant interaction (Guedeney & Fermanian, 2001). Short periods of withdrawal behavior may be seen as a way for the infant to regulate the amount of stimuli in interactions with their mother, as well as a way to regulate their emotions (Feldman, 2007). In fact, some lack of synchronization in the interaction is considered important for the infant's development of self-regulatory abilities. Too much asynchronization is, however, related to more sustained social withdrawal behavior, and understood as an important alarm signal for organic or relational disorders (Guedeney & Fermanian, 2001).

Social withdrawal in the infant could be considered a product of an inhibited temperament, an insecure parent-child-relationship or shared genetic vulnerability with the parent (Rubin et al., 2009). Some cases of withdrawal behavior in the infant are associated with organic causes such as fever, dehydration, intoxication, post-critical state after seizure, diseases of the central nervous system or visually and auditory sensory impairments (Guedeney & Fermanian, 2001). Withdrawal behavior is also a typical trait in relation to diagnoses such as autism (Guedeney & Fermanian, 2001)

Although no studies have examined the link between maternal PTSD and infant social withdrawal behavior, there are studies linking social withdrawal behavior with maternal mental health such as postpartum depression (PPD) (Braarud et al., 2013; Smith-Nielsen et al., 2019). A longitudinal study has been conducted to examine the prevalence of social

withdrawal in both full-term and premature born infants in association with maternal PPD (Braarud et al., 2013). The study used the Alarm Distress Baby scale (the ADBB) to assess social withdrawal behavior and the Edinburgh Postnatal Depression scale (EPDS) to measure maternal depressive symptoms at three-, six- and nine-months' post-partum. The results showed a significantly higher ADBB score among premature infants at three and six months compared to full-term infants (Braarud et al., 2013). The results also revealed a significantly higher EPDS score among premature infants at three months compared to full-term infants (Braarud et al., 2013). Validation of the study is required before the results can be generalized to the population, however, results indicate an important association between maternal PPD and social withdrawal behavior in infants. Another study examining social withdrawal in the context of maternal PPD also found more maternal depressive symptoms related to more infant social withdrawal, when using the ADBB scale (Smith-Nielsen et al., 2019). In addition, this study on 28 dyads of mothers with PPD and 41 control dyads without depressive symptoms further examined whether infant social withdrawal could mediate an association between maternal depression and cognitive development of the infant, measured at four months of age using the Bayley Scales of Infant and Toddler Development, 3<sup>rd</sup> edition (the Bayley III). Their findings suggested that social withdrawal only partly mediated the association (Smith-Nielsen et al., 2019).

### **Parental PTSD and general child development**

Previous studies have proposed and reported parental PTSD symptoms in general, but also after earthquakes, to be a risk factor for child development (Cai et al., 2017; van Ee, Kleber & Mooren, 2012). Given the limited research and literature on maternal PTSD and infant mental health outcomes, the reported associations with developmental domains can be informative.

With a selection of women being pregnant during or after an earthquake, a study on earthquake related maternal PTSD in the aftermath of the 2008 Wenchuan earthquake explored the association between maternal PTSD and development of the children, including social adaptability, motor ability and intellectual development (Cai et al., 2017). Among the 86 mothers included, 20.9 % had scores indicating PTSD symptoms, measured with a PTSD Checklist-Civilian scale (PCL-C). Among the 86 children, 25.6 % had a development quotient (DQ) score and 29.8 % had a mental index (MI) score under the cut-off value of 85 measured with the Mental Developmental Screening Test (DST) (Cai et al., 2017). A significant association between maternal earthquake related PTSD during pregnancy and relatively lower intellectual development in the children aged 0-3 years was reported. This finding suggests a negative association between the severity of maternal PTSD and the stage of neurodevelopment in the children. Regarding the trimester of gestation when the earthquake occurred, the study did not find occurrence in one trimester to be more influential on the children's development than the other trimesters (Cai et al., 2017). The study is limited by a small sample size and did not take into account how persistent the association would be over time.

As opposed to results from the study on mental development in the aftermath of the 2008 Wenchuan earthquake, a study based on other types of trauma than earthquakes, did not find delays in the infants' mental and psychomotor development measured by the Bayley Scales of Infant Development, 2<sup>nd</sup> edition (the Bayley II) to be associated with maternal PTSD (van Ee et al., 2012). However, only a limited number of studies have been conducted on the youngest children, and further research is needed on general child development in the aftermath of earthquakes.

### **Mechanisms**

There are several understandings of how parental PTSD symptoms are associated with child outcomes including hereditary and environmental pathways, and through parenting factors, emotional availability and responsiveness. The children's age and stage of development is also important to consider.

#### **Hereditary and environmental pathways**

Genetically, parents with PTSD may transmit their vulnerability to stress to their offspring through inheritance of similar genetic risks, for instance heritability of cortisol levels (Bartels et al., 2003). Environmental pathways relate to both the immediate environment, such as family, and the larger surroundings, including the community and culture the child and family lives in (Bronfenbrenner, 1977). One environmental pathway is that parents with PTSD may transmit vulnerability to stress through behavioral alterations due to development of stress-related psychopathology. Such alterations could for instance be in their parenting style and family functioning (Juth et al., 2015; Christie et al., 2019). A third pathway explored in more recent years is how epigenetic mechanisms can explain the intergenerational transmission of trauma-related symptoms (Yehuda & Bierer, 2009). Epigenetically, parents with PTSD may transmit vulnerability to stress through enduring epigenetic changes in the parent's biological systems which arises in response to stress exposure (Yehuda & Lehrner, 2018).

Finally, it is important to consider a fourth explanation for the understanding of the associations between parental PTSD and child outcomes, namely that children born prior to the disaster such as earthquakes have been directly exposed to the same traumatic event as their parent and thus directly affected.

**Parenting, emotional availability and responsiveness**

In general, one of the most important factors for young children to achieve their developmental potential is the parent's provision of nurturing care and protection (Britto et al., 2017). Several reviews on trauma in general have examined the associations between parental PTSD and parenting practices, including relational patterns in parent-child interactions and the parent's emotional availability and responsiveness to their children (Christie et al., 2019; Lambert, Holzer & Hasbun, 2014; Scheeringa & Zeanah, 2001; van Ee, Kleber & Jongmans, 2015; van Ee et al., 2012).

**Parenting.** A systematic review of parental PTSD and parenting suggested an association between parental PTSD and impaired functioning on several parenting domains (Christie et al., 2019). These findings were related to increased levels of parenting stress, lower parenting satisfaction, less optimal parent-child relationships, and more frequent use of negative parenting practices (Christie et al., 2019). The 27 quantitative studies in this systematic review were based on traumas such as traumatic birth experiences, military trauma and intimate partner violence, and did not account for natural disasters. The review concludes with a need for further research on the impact of different trauma types to better understand the potential consequences of PTSD on parental functioning (Christie et al., 2019). The need for more specific research on natural disasters is emphasized, since trauma inflicted upon us by others will significantly differ from more coincidental trauma due to for instance natural disasters.

A meta-analysis of studies on the association between severity of parental PTSD and children's psychological distress, including parenting factors, has also been conducted (Lambert, Holzer & Hasbun, 2014). Across 42 studies, with different types of traumatic events including natural disaster, the results yielded a moderate overall effect size ( $r=.35$ ). The severity of parental PTSD symptoms on the children's psychological distress was

reported to be negatively correlated with parental functioning and positively correlated with parenting stress (Lambert, Holzer & Hasbun, 2014).

**Relational patterns.** A review of studies assessing parental and child functioning following trauma has proposed three distinctive relational patterns describing traumatized mothers and the influence of maternal PTSD symptoms on their children; (1) the withdrawn, unresponsive and unavailable pattern with the mothers' sensitivity and emotional availability being compromised, (2) the overprotective and constricting pattern with the mothers' fear and guilt preventing sense of security in the relationship, and (3) the reenacting, endangering and frightening pattern with the mothers' preoccupation of the traumatic reminders preventing protection of the child (Scheeringa & Zeanah, 2001). Another, more recent review of parental PTSD and child functioning also have referred to relational patterns, including traumatized parents observed to be emotionally less available and children at a young age to be easily deregulated and distressed by their traumatized parents (van Ee et al., 2015). These relational patterns examined in the literature are related to other types of trauma than earthquake related trauma. As with parental functioning, to better understand the potential consequences of earthquake related PTSD on relational parent-child patterns, the need for trauma-specific research is of importance.

**Availability and responsiveness.** Parental PTSD has been associated with inadequate parental support and care, including emotional unavailability and unresponsiveness, and poor parenting behaviors, such as dismissive, avoidant and distant behaviors (Hafstad et al., 2010; Kelley et al., 2010). In turn, inadequate parenting is thought to leave children feeling unsafe, insecure and with heightened distress (Bowlby, 1988). In other words, parenting functioning as a result of parental PTSD will potentially affect how the children respond and adapt, in relation to the parents' lack of capacity to be emotionally available to give adequate support and care. Findings from the earlier mentioned study on asylum-seekers and refugee mothers

and their infants, emphasized the importance of maternal sensitivity and of how maternal PTSD can impede the mother's ability and capacity to be emotionally available through lack of sensitivity (van Ee et al., 2012).

To summarize, regardless of type of trauma, parenting, parental emotional availability and parental responsiveness alone seem to only partly explain the relationship between maternal PTSD and child outcomes. Other variables can be equally or more important explanatory variables (van Ee et al., 2012).

### **The children's age and gender**

Children's age and stage of development may moderate the susceptibility to be affected by parental PTSD (Salmon & Bryant, 2002). Younger children, compared to older children and adolescents, seem to be at a greater risk of adverse outcomes when their parent develop PTSD symptoms (De Young, Kenardy & Cobham, 2011).

Infants, toddlers and preschoolers are thought to be high-risk groups for exposure to trauma based on their limited coping skills, developmental limitations and dependency on primary caregiver (De Young, Kenardy & Cobham, 2011). The studies that do exist have yielded inconsistent findings on age as a predictor of outcomes following trauma (De Young, Kenardy & Cobham, 2011). Most of the studies on parental earthquake related PTSD and child outcomes do not take into account age differences. However, it is acknowledged that age differences and stage of development seem to have an impact on the outcomes and is encouraged to be explored in further research (Juth et al., 2015). Less developed cognitive skills in younger children may lead to difficulties in expressing their psychological distress verbally and they will rather express their distress through behavioral alterations (Salmon & Bryant, 2002).

Child gender as a risk factor for health outcomes has shown mixed and inconclusive findings following trauma (De Young, Kenardy & Cobham, 2011). A study on the association

between parental PTSD and children's general distress, aged 8-17 years, found no moderating effect of gender on the association (Juth et al., 2015). Another study, moderating for gender when examining maternal PTSD and mental development of the child, reported that boys obtained lower scores compared to girls on The Mental Developmental Screening Test (DST) (Cai et al., 2017). However, the study did not find an association between maternal PTSD and child development (Cai et al., 2017).

### **Theoretical models and perspectives**

Infants are born to be social, and from the very beginning of life, they are actively communicating with their surroundings (Pelaez & Monlux, 2018). At an early age, the social infants show capacity to take initiatives using gaze, facial expressions, gesticulation, vocalization and imitation. With such initiatives, infants aim at arousing reactions from their caregiver (Pelaez & Monlux, 2018). The relationship with the caregiver provides the context in which the infant's psychological functions and learned emotional responses develop (Sullivan et al., 2011), leaving the youngest infants highly dependent on their caregiver (Bowlby, 1988; Qouta et al., 2021).

### **Attachment theory**

The infant's and parent's need to adjust together as an interdependent unit (Juth et al., 2015), is well explained by the attachment theory by John Bowlby (1988), which consider the children dependent on their caregiver from the moment they are born. The attachment theory assumes that children are born with a need to belong and feel attached, and with a motivation to engage in social interactions with their surroundings to fulfill these needs (Bretherton, 1994). The theory further emphasizes how children and parents both desire emotional proximity to ensure survival (Bowlby, 1988). Such emotional proximity is thought to provide

a sense of security for the child and fulfill the parents inherent need to care for their child (Bowlby, 1988).

According to attachment theory, a secure attachment is associated with parents more likely to actively provide care, provide substantial support and love, and build a safe family atmosphere with the family as a safe harbor (Bowlby, 1969). An insecure attachment is in contrast associated with parents being more inconsistent or unavailable caregivers who promote the formation of ineffective emotion regulation strategies (Dagan et al., 2021).

In interaction with their caregiver, the infant develops attachment behavior, e.g. crying or reaching, that serves to increase the proximity between the infant and the caregiver (Bretherton, 1994). Attachment behavior is thought to be activated in the infant when the caregiver is out of reach, or unavailable to the infant's needs, and when the infant need to evoke a reaction from the caregiver (Bretherton, 1994). It is assumed that children by their second year of life are cognitively able to create a representation of their caregiver, even when the caregiver is not present or reachable (Bretherton, 1994).

Prior to being able to create a representation of their caregiver, an infant is fully dependent on a caregiver to be responsive to its physical, social and emotional needs (Bowlby, 1969). A caregiver could be physically unavailable to the infant due to separation or bereavement (Bowlby, 1988), e.g. within the aftermaths of earthquakes where families are being separated and family members lost. Also, a caregiver could be emotionally unavailable due to deprivation (Bowlby, 1988). While the childrens need for attention is likely to increase in the aftermath of a disaster, the parent's ability to provide that attention may decrease or be deprived, for instance due to time spent on re-establishment of resources and managing their own adjustment, e.g. their PTSD symptoms (Bowlby, 1988).

PTSD symptoms have previously been associated with consequences that might disrupt attachment, including increased risk of emotional lability, difficulties in modulating

anger, appropriately expressing emotions and interpreting other's emotions, as well as disruptions in attention, memory and consciousness (van der Kolk, 2000). However, secure attachment has also been directly associated with post-traumatic growth, defined as positive changes following traumatic events, in a study on 872 adolescents, nine and a half years after the 2008 Wenchuan earthquake (Zhou, Zhen & Wu, 2019). This direct association was found to be mediated by feelings of safety, justice beliefs and cognitive reappraisal in adolescents (Zhou et al., 2019). It is suggested that the quality of early attachment determines the infants later internal working models of self and others (Bowlby, 1969), and that these working models influence emotion regulation and how to cope with stressors later in life (Bartholomew & Horowitz, 1991).

### **The transactional perspective**

Another theoretical model to support an association between parental PTSD and child outcomes is the transaction model, a systematic developmental model (Sameroff, 2009). The transaction model is based on an assumption that a child's development is a product of a reciprocal, dynamic and continuous interaction between the child and the contextual conditions that constitute the child's surroundings, including their interaction with their mother (Sameroff, 2009). The transactional model proposes that both the parent and the child play crucial roles in contribution to the parent-child interaction (van Ee et al., 2015). Above the assumption of dependency, the transactional perspective view parents and children as interdependent and builds on relational perspectives such as in the attachment theory by adding more aspects of the child into the interaction (Sameroff, 2009). The transactional model also emphasizes how the child is influenced by interplay with different processes in the individual's context over time (Sameroff, 2009). While the relationship between a child and their mother is considered reciprocal, it is not considered symmetrical since it is not mutually

binding. The child is, however, considered an important contributor to this relationship in its own development (Sameroff, 2009).

The transactional model includes the concepts of proximal and distal influences (Sameroff, 2009). Proximal influences refer to factors such as parents and family that influence the child closely, due to their time spent together. Distal influences affect the child less directly, for instance through socioeconomic status of the family or type of community. In the context of earthquakes, both proximal and distal influences could explain adverse outcomes in the children. For the youngest children, proximal factors, for instance the parents' mental health, is assumed to influence the most, while distal factors may be more influential for older children (Sameroff, 2009; Bornstein, 2012). The consequences in the aftermath of earthquakes could be considered distal factors that impact on the caregiver's ability to provide for their children and support their development, for instance due to unemployment, lack of housing, or having to move.

With more child characteristics, as well as other ecological settings, accounted for when examining the interaction between a mother and child and the associations between maternal PTSD and child outcomes, a transactional perspective would likely offer a better understanding of, and an explanation for the development of adverse outcomes in the aftermath of earthquakes. Such a transactional view may also contribute to potential resilience among the infants.

### **The present study**

A clinical trial in Bhaktapur, Nepal, started only one week before the earthquakes struck the area in 2015. Originally, the study was a randomized controlled trial (RCT) designed to measure the effect of daily supplementation of vitamin B12 for one year in marginally stunted children on neurodevelopment and growth (Strand et al., 2017; Strand et al., 2020). At enrollment, data on infant social development through the Bayley III and social

behavior through the ADBB scale was collected. As a result of the earthquakes, data on earthquake exposure, perceived impact of the earthquakes on the family's daily life, and maternal PTSD symptoms were also collected in the study follow ups. The associations between earthquake exposure and post-traumatic stress among these Nepalese mothers after the earthquakes have previously been described (Kvestad et al., 2019) and the present study examines the associations between maternal PTSD symptoms after experiencing major earthquakes and infant socioemotional development and social behavior.

### **Hypotheses, aims and objectives**

Overall, the aim of the study is to contribute to the understanding of the impact of natural disasters on women with caregiving responsibilities and their children in vulnerable populations such as Nepal, an earthquake prone country. In light of empirical studies and the theoretical setting presented above, it is expected that the current study will find associations between maternal PTSD and infants' socioemotional development and social behavior. We hypothesize that maternal PTSD symptoms will be negatively associated with the infants' socioemotional development, and positively associated with infants' socially withdrawn behavior. In addition, we hypothesize that infants of mothers with PTSD symptoms considered to be of clinical concern or a probable diagnosis, will have a higher probability of inadequate socioemotional development and showing socially withdrawn behavior compared to infants of mothers with no or under cut-off PTSD symptoms.

Based on these hypotheses, a first objective of the study is to determine whether there is a relationship between maternal PTSD symptoms, measured with the IES-R, and the infants' socioemotional development, measured with the Bayley Socio-Emotional scale (the Bayley SE), and the infants' social withdrawal behavior, measured with the modified-Alarm Distress Baby scale (the m-ADBB). In examining these potential associations, a second objective is to assess whether the results will differ between different core symptoms of

PTSD; intrusion, avoidance and hyperarousal. Furthermore, a third objective is to compare mothers below and above the criteria for clinically significant PTSD symptoms with infants below and above cut-off for normal socioemotional development and below and above cut-off for socially withdrawn behavior.

## **Materials and methods**

### **Study design**

The present study uses an observational cohort design, with data collected within a large population-based RCT on infant nutrition, growth and neurodevelopment (Strand et al., 2017; Strand et al., 2020).

### **Study setting**

The study was conducted in the Bhaktapur area of Nepal. The Bhaktapur municipality is a small district in the nearby area to Kathmandu, the capital of Nepal, with a high-density population. As per the last census conducted in 2011, Bhaktapur is one of the most densely populated municipalities in Nepal (Central Bureau of Statistics, Government of Nepal, 2011, p. 40). The main livelihood is agriculture, with small-scale self-owned businesses and daily wage labor also being important sources of income, and one in every second family are living in joint families (Central Bureau of Statistics, Government of Nepal, 2018).

Although Nepal is among the world's least developed countries, and one third of the population lives below the poverty line (Central Bureau of Statistics, Government of Nepal, 2018), the country has made substantial progress in improvement of maternal and child health services the last decades (Khanal, Khanal & Lee, 2015). However, earthquakes have been a considerable threat to this progress, and the earthquakes in 2015 made substantial damages and represented a major setback in health facilities available in the country (Khanal, Khanal & Lee, 2015). A situation analysis of mental health services was conducted prior to the 2015

earthquakes in Nepal referring to existing gaps, especially within district mental health care plans (Luitel et al., 2015). The analysis reported a clear progress in strengthening the mental health care system since a mental health policy was adopted in Nepal in 1997. Nevertheless, the analysis also showed that major improvements are still required (Luitel et al., 2015).

### **Participants**

The original study targeted 600 infants considered mildly to moderately stunted (defined as length-for-age <1 z-scores) (WHO, 2006) and their families. Infants were from six to 11 months old at enrollment. Enrollment for the study started in April 2015 and the last infant was enrolled in February 2017. At the time of the earthquakes, some of the mothers were not yet pregnant, some were pregnant, and some had already given birth. In the present study, participants with data on socioemotional development and social withdrawal behavior from the enrollment procedures, as well as on maternal PTSD symptoms during the follow ups were included, giving a total sample size of 555 infants and their mothers.

### **Procedure**

The clinical trial was originally carried out with an aim to examine the effect of daily vitamin B12 supplementation on growth and development. Only one week after the study had started enrollment of infants, Nepal was struck by large earthquakes and the district of Bhaktapur was severely affected (Subedi & Chhetri, 2019). The clinical trial managed to continue the enrollment with a short delay and reach the total sample size of 600 infants by February 2017.

As part of the enrollment process, information on demographics and socioeconomic status of the families were collected and the infants were assessed with the Bayley III, including the Bayley SE scale to measure socioemotional development (Strand et al., 2020). The infants were video recorded during examination and interaction with a study supervisor

or physician in the presence of a caregiver (Ulak et al., 2020). These videos were used to measure the social withdrawal behavior with the m-ADBB scale.

In addition to the original study protocol, questionnaires regarding the impact of the earthquakes both on the family's practical life and mental health were collected approximately 20 months after the earthquakes. This data collection included measures on IES-R for PTSD symptoms (Kvestad et al., 2019).

### **Variables and measurements**

**Background variables.** Baseline demographic features on child, maternal and family characteristics were collected at baseline in the original study, including information on the infants' age (months), gender, gestational status, and birthweight. Further, weight and length of the infants were measured during the enrollment procedures with portable electronic scales (Salter/HoMedics Group, UK and seca. Germany) and infantometers. All anthropometric measurements were converted to z-scores with reference to the WHO Child Growth Standards (WHO, 2006). Parents were asked on their educational background (illiterate or primary complete, secondary complete, intermediate complete, or bachelor or above), maternal age (year), and their family living arrangement (joint/nuclear). Socioeconomic status in the family was assessed by a composite WAMI-index (range 0-1) using variables for water and sanitation access, household assets, and maternal education and income (Psaki et al., 2014).

**Maternal PTSD – Impact of Event Scale-Revised (IES-R).** Maternal PTSD symptoms were measured with the IES-R (Weiss, 2007), approximately 20 months after the earthquakes (Kvestad et al., 2019). A group of trained field workers visited the homes of the enrolled infants and asked the mothers questions on earthquake related PTSD symptoms experiences by the mothers (Kvestad et al., 2019).

The IES-R scale is a 22-item self-report measure of subjective distress and symptomatic status of PTSD after specific traumatic events in the past seven days (Weiss,

2007). IES-R is a revised version of IES which includes seven items related to hyperarousal symptoms of PTSD in addition to the 15 items related to intrusion and avoidance included in the original IES. The items are rated on a 5-point scale with a score of 0-4 ranging from not at all to extremely and yields a total score from 0-88 and subscale scores for intrusion (range 0-32), avoidance (range 0-32) and hyperarousal (range 0-24).

The IES-R was translated from English to Nepalese according to official recommendations (Weiss, 2007), and the original version was compared with the back-translated version as well as piloted on a sample of 12 women in the study population (Kvestad et al., 2019). The standardized alpha for the total scale was 0.87, and ranged from 0.50 to 0.80 in the subscales, indicating acceptable internal consistency (Kvestad et al., 2019). A score of 24 or more has been used to indicate that PTSD should be a clinical concern and above 33 to indicate a probable PTSD diagnosis (Weiss, 2007; Kvestad et al., 2019). For the present study, the mothers were considered either below cut-off and with no PTSD (<24) or above cut-off and with PTSD as clinical concern or a probable diagnosis ( $\geq 24$ ).

**Socioemotional development in the infants – Bayley Socio-Emotional Scale (Bayley SE).** Infants' socioemotional development was measured using the Bayley SE scale. The Bayley SE assessment was administered as a questionnaire with the caregiver at the study research office by one of three trained psychologists (Strand et al., 2020).

The Bayley III is a widely used developmental assessment tool (Leaders project, 2013). Bayley III consists of five scales, and while the cognitive, language and motor scales are administered by a clinician, the socioemotional and adaptive behavior scales are completed as an interview to the primary caregiver.

Bayley SE is a sub-scale in the Bayley III that aim to measure socioemotional development in infants and toddlers 1-42 months of age by identifying socioemotional milestones that are typically achieved at certain ages (Leaders Project, 2013). The

socioemotional scale assesses social and emotional functioning as well as sensory processing. The total score ranges from 0-200 (Leaders Project, 2013). Raw scores were converted to composite scores with a mean (*SD*) score of 100 (15) based on American norms.

The Bayley SE includes 35 items to identify normal social and emotional developmental milestones of infants, toddlers and preschoolers derived from the Greenspan Social-Emotional Growth Chart (Greenspan, 2004). The Greenspan chart have identified six stages of socioemotional growth from birth to 42 months (Weiss, Oakland & Aylward, 2010). During stage 1, from birth to three months, the scale assesses development of self-regulated behaviors and interest in the world. Entering stage 2, with infants being four to five months, they start engaging in relationship with others and exhibit positive emotions with their caregiver. For the infants included in this study, stage 3, from six to nine months, and stage 4, from 10-14 months, laid guidelines for what to expect of socioemotional development in the sample of six to 11 months old infants. Stage 3 refers to when infants use emotional expressions and motor actions with their caregiver, including smiling, reaching out to the parent and pointing. In the transition from stage 3 to stage 4 the infants interactive communication develops, and by stage 4 infants use emotional signals and gestures to communicate and organize their behavior to form interactions of socially meaningful communication. The infants are in stage 4 able to respond in a back-and-forth manner to indicate their wants and needs (Weiss et al., 2010).

In the study, standardization exercises were performed with 20 infants prior to enrollment with assessments by two raters. About 7 % of the assessments during the main study were double scored by the expert rater to ensure appropriate inter-observer agreement throughout the study (Strand et al., 2020).

**Social withdrawal in the infants – Alarm Distress Baby Scale (ADBB).** The ADBB scale was used to evaluate infant social withdrawal behavior. Video recordings were

conducted during examination and interaction with a study supervisor or physician in the presence of a caregiver (Ulak et al., 2020). During the examination, infants were engaged in social interactions with the examiner, the caregivers received information on the study, and length and weight of the infants were taken (Ulak et al., 2020).

AADB is an observational tool designed to assess sustained withdrawal reactions in infants aged two to 24 months (Guedeney & Fermanian, 2001). The scale is used during interaction between the infant and an unfamiliar person such as a doctor, nurse, psychologist or other health professionals during routine consultations. An observation of 10-15 minutes is required to score the AADB, usually based on videorecording. The AADB scale examines social withdrawal through eight items: facial expression, eye contact, general level of activity, self-stimulating gestures, vocalizations, briskness of response to stimulation, relationship with the observer and the capacity to attract and maintain attention with the observer. The items are rated on a 5-point scale with a score of 0-4: normal behavior (0), slight abnormal behavior (1), clearly abnormal behavior (2), frankly abnormal behavior (3) and massively obvious abnormal behavior (4). The total possible score of the AADB is 32 with a minimum score of 0. A higher score indicates more social withdrawal behavior. The cutoff score is suggested to be greater than or equal to five based on a sample of French infants (Guedeney & Fermanian, 2001).

The modified AADB (m-AADB) is a shorter and revised version of the AADB scale, developed to obtain more sufficient interrater reliability in an Australian sample (Matthey et al., 2013). The m-AADB examines social withdrawal through five items: facial expression, eye contact, general level of activity, vocalization and relationship to observer. These items are rated on a 3-category scale as satisfactory (0), possible problem (1) or definite problem (2), except for the vocalization item which is rated as satisfactory (0) or possible problem (1) due to the fact that many infants may be quiet in unfamiliar settings (Matthey et al., 2013).

The total possible score of the m-ADBB is nine with a minimum score of 0. A higher score indicates more social withdrawal behavior and the cut-off score is suggested to be one definite problem, or two possible problems (i.e. score of  $\geq 2$ ) based on the sample of Australian infants (Matthey et al., 2005).

While there is a lack of measures on the psychometric properties of m-ADBB, we know more about psychometrics for the full-ADBB scale. The validity of the ADDBB-items is considered good and satisfactory in assessing withdrawal reactions in infants (Guedeney & Fermanian, 2001). Interrater reliability, based on nurses and pediatricians scores immediately after consultation, have been described as very good (0.84). Test-retest reliability, based on assessment of 60 videos by two psychology students trained to use the ADDBB and repeated assessment of the same videos six months later, have been assessed to be high for both students (0.90 and 0.84). Internal consistency, based on Cronbachs alpha to evaluate the ADDBB as a global scale, have also been assessed as high (0.83) (Guedeney & Fermanian, 2001).

The ADDBB scorings for the current study have been thoroughly described previously (Ulak et al., 2020). The recording of the examination in the present study lasted over 10 minutes. Guidelines on how to structure the examination, including making sure the infants were well fed, not feeling sick or sleepy, using well-lit room for all assessments and having examiners seated in the same position and at eye level of the infants, were used to make the situation as uniform as possible. Four examiners were, prior to enrollment, trained and standardized to perform the ADDBB observations according to existing standards of the ADDBB scale and by the developer of the scale, Antoine Guedeney (Ulak et al., 2020). Of these, three examiners scored the m-ADBB based on the video recordings, with one examiner performing double scores for quality control. The interrater agreement from the quality control reached an acceptable agreement with a concordance correlation coefficient of 0.81 (Ulak et al., 2020).

### **Ethical approvals**

The original study was approved by the Nepal Health Research Council (Reg 233/2014) and the Norwegian Regional Committee for Medical and Health Research Ethics (REC # 2014/1528). All participating parents signed a written informed consent form or used thumbprint (if illiterate) prior to enrollment and the videorecording. New informed consent from the mothers were gathered when including assessment of PTSD symptoms.

### **Statistical methods**

JASP version 0.10.2 and Stata17 were used to analyze the data. Data are presented as numbers (*N*)/percentage (%) and as mean/standard deviation (*SD*).

First, descriptive analyses were conducted on demographic features of the 555 infants, including age, gender, prematurity, birthweight, height-for-age and weight-for-age z-scores, and their mothers, including age and level of education. Descriptive statistics were also reported for the husbands' level of education and the families' socioeconomic status to provide important background information on the surrounding factors. Descriptive analyses were conducted on the IES-R variables, to report total average score, average scores for the core symptoms intrusion, avoidance and hyperarousal, and number of mothers below and above criteria for PTSD symptoms (cut-off of 24). Furthermore, descriptive analyses were conducted on the outcome variables, Bayley SE and m-AIDB, to report total average scores and number of infants with inadequate socioemotional development (scores less than  $-1SD$  of the sample mean) and considered socially withdrawn (cut -off of two).

Second, linear regressions were used to check for potentially confounding variables that should be included as covariates in the regression analyses (**Supplementary 1**). Possibly confounding variables examined were child characteristics; time of inclusion, age, gender, birthweight, height-for-age z-scores and weight-for-age z-scores, maternal characteristics;

age, level of education and occupation, environmental characteristics; level of education of the father, father's occupation, wealth index (WAMI-score) and family type.

Third, the association between IES-R and Bayley SE was measured with linear regressions in JASP. We also used the ANCOVA to estimate the marginal means of the Bayley SE scores dichotomized on the IES-R with a cut-off of 24. Finally, using logistic regression, we assessed the odds ratio (OR) for having Bayley SE scores below 1SD of the sample mean for infants with mothers with IES-R scores  $\geq 24$  compared to mothers with IES-R scores  $< 24$ . These regression analyses are done in unadjusted analysis only. No significant covariates were found for both the exposure (IES-R) and Bayley SE as outcome variable and therefore no adjusted models were performed.

The association between IES-R and m-ADBB was measured using poisson regression in STATA. Poisson regression was used due to the skewed distribution of the outcome variable. Poisson regression was also used to calculate the marginal means of the m-ADBB scores for IES-R above and below the cut-off of 24. Finally, in logistic regression, the OR for being socially withdrawn in infants of mothers with IES-R scores  $\geq 24$  compared with infants of mothers with IES-R scores  $< 24$  was calculated. For all three regression models, the analyses were done in crude models. When examining for potentially confounding variables, no significant covariates were found for both the exposure (IES-R) and m-ADBB as outcome variable and thereby no adjusted models were conducted.

## Results

A total of 555 mothers and infants were included from the original sample of 600 (92.5 %) participants. All 600 infants were scored on the Bayley SE scale. Of the 600 enrolled infants, 597 were video-recorded and further included for m-ADBB scoring. Of the 600 mothers, 555 reported on the PTSD assessment scale IES-R. The included 555 participants

had valid data from the mothers on the exposure variable, as well as valid data from the infants' outcome variables.

### **Characteristics of the sample**

Demographic features of the 555 mothers and their infants are listed in **Table 1**. The age of the infants ranged from six to 11 months of age, one third were six months and the mean age was eight months. In terms of gender, 51.9 % of the infants were boys and 48.1 % were girls. Of the 555 infants, 59 were born premature (<37 weeks). The mean birthweight of the infants was 3040.9 gram. In total, 32.8 % were considered stunted and 18.7 % were considered underweight. The age of the mothers ranged from 17 to 43 years, with a mean age of 28. Considering the level of education, about 37 % of the mothers were illiterate or had completed primary school up to grade five. About 20 % of the mothers had a bachelor or higher level of education. About 35 % of the husbands were illiterate or had completed primary school up to grade five, while about 19 % had a bachelor or higher level of education. On the WAMI index, as a measure of socioeconomic status, the mean score was 0.6 ranging from 0.0-1.0.

Scores on the IES-R total and subscale scores in the mothers 20 months after the earthquakes are shown in **Table 2**. A total of 150 (27 %) mothers had an IES-R-score  $\geq 24$ , indicating PTSD as a clinical concern or a probable PTSD diagnosis. A total of 405 (73 %) mothers scored below cut-off of 24 on IES-R, indicating no PTSD.

Scores on the Bayley SE and on the m-ADBB in the 555 infants are shown in **Table 3**. Mean standardized Bayley SE-index score among the infants was 103.4 ranging from 55 to 140. With low scores defined as  $-1SD$  on Bayley SE and considered inadequate, a total of 110 (19.8 %) infants were considered with inadequate socioemotional development, while the remaining 445 (80.2 %) infants were considered as having adequate socioemotional development. The mean m-ADBB-score among the infants was 0.6 ranging from 0-4. A total

of 62 (11.2 %) infants had a m-ADBB-score  $>2$ , indicating socially withdrawn behavior. The remaining 493 (88.8 %) infants scored below the cut-off of two on m-ADBB, indicating no withdrawal behavior.

### **Potentially confounding variables**

Potentially mediating and moderating confounders are listed in **Supplementary 1**, reporting the Pearson correlation coefficients. Of the potential confounders, none were found to significantly covariate on both the exposure variable and the outcome variables. Of the child characteristics, age and weight for age was found to be significantly correlated with the m-ADBB score (respectively,  $<.001$  and  $0.014$ ). Of the maternal characteristics, age was found to be significantly correlated with the total IES score ( $<.001$ ) and similarly all core PTSD symptoms; intrusion ( $.002$ ), avoidance ( $.008$ ) and hyperarousal ( $.003$ ). The mother's educational level was significantly correlated with the total IES-score ( $<.001$ ) and all core PTSD symptoms; intrusion ( $<.001$ ), avoidance ( $<.001$ ) and hyperarousal ( $<.001$ ). The mother's occupation was only found to significantly covariate with intrusion ( $0.024$ ). Of the environmental characteristics, the father's educational level was found to be significant for total IES score ( $<.001$ ) and all core PTSD symptoms; intrusion ( $.002$ ), avoidance ( $.004$ ) and hyperarousal ( $<.001$ ). Family type was only found to significantly covariate with hyperarousal ( $0.050$ ). Based on the findings that no variable covariates for both the exposure and the outcome variables, no adjusted models were performed.

### **Maternal PTSD and socioemotional development in the infants**

Associations between IES-R scores and the Bayley SE scores are shown in **table 4** and **5**. There were no significant associations between IES-R total or subscale scores and the Bayley SE scores in linear regression models (coefficient for the total IES-R:  $-0.00$  (95% CI -  $0.13, 0.13$ )  $p=0.99$ ). In ANCOVAs, dichotomizing the IES-R scores on a cut-off of 24, the estimated marginal mean Bayley SE scores were 102.57 and 105.53 for IES-R $<24$  and  $\geq 24$

respectively (p-value for difference between groups of 0.06). In logistic regressions, there was an OR of 0.80 (95% CI 0.49, 1.30),  $p=0.37$  for delayed socioemotional development (Bayley SE  $<1SD$  of sample mean) if mothers had symptoms of PTSD ( $IES \geq 24$ ) compared to no symptoms of PTSD.

### **Maternal PTSD and socially withdrawn behavior in the infants**

Associations between IES-R scores and the m-ADBB scores are shown in **table 6** and 7. There were no significant associations between IES-R total or subscale scores and the m-ADBB scores in the regression models (IRR for the total IES-R: 1.00 (95% CI 0.99, 1.01),  $p=0.56$ ). Moreover, there were no significant difference between the estimated marginal means for the m-ADBB scores in infants of mothers with IES-R below and above cut-off (0.61 (95% CI 0.53, 0.68) vs. 0.68 (0.55, 0.81) for below and above cut-off respectively (p-value for difference between groups of 0.33). The logistic regressions show no association between maternal PTSD scores above cut-off and infant social withdrawal (OR of 1.11 (95% CI 0.62, 2.01)  $p=0.71$ ).

## **Discussion**

### **Main findings**

The present study examined the associations between maternal earthquake related PTSD symptoms and socioemotional development and social behavior in infants aged six to 11 months. Overall, our results demonstrate no associations between maternal PTSD symptoms and delays in socioemotional development or socially withdrawn behavior in the infants.

**Associations between maternal PTSD and socioemotional development**

We did not find support for the hypothesis that maternal PTSD symptoms was negatively associated with socioemotional development of the infant as measured by the Bayley SE. We also expected that infants of mothers having PTSD symptoms considered of clinical concern or probable diagnosis would have a higher probability of being below cut-off for normal socioemotional development compared to infants of mothers with PTSD symptoms below cut-off. The results are consistent across the analyses with both continuous and dichotomized variables.

The comparison of the present results with results of previous studies is restricted by the lack of previous research on infants social and emotional development in association with maternal PTSD, by inconsistencies in the literature (Cai et al., 2017; van Ee et al., 2011) and by the potential that only parts of socioemotional development is associated (Enlow et al., 2011).

The lack of associations between maternal PTSD and infant outcomes in the present study is in contrast to a previous study of 52 mother-infant dyads in a low-income, urban and ethnic minority sample from Boston, USA, somewhat similarly to the low socioeconomic context of the current study. They found maternal PTSD symptoms to be associated with profound effects on children's emerging self-regulatory abilities, including emotion regulation difficulties in infancy during a still-face setting (Enlow et al., 2011). There are many similarities between the study by Enlow and colleagues and the present study, including infants in their first year of life, in a high-risk setting for PTSD and with use of observational method in addition to parental reports, allowing for comparison of the two. Emotion regulation skills can be understood as part of the socioemotional development measured in the present study, involving development of the ability to monitor, evaluate and modify emotional reactions (Thompson, 1991). The contrasting findings could, however, be

attributed to the use of different measures, with Enlow and colleagues using the Infant-Toddler Social and Emotional assessment (ITSEA) (Carter & Briggs-Gowan, 2006), whereas the present study is based on Bayley SE scores. Compared to the Bayley SE age range from 1-42 months, the ITSEA includes children from 12-35 months of age. Further, while the Bayley SE detect normal or delayed socioemotional development based on 35 items in the socioemotional subscale, the ITSEA has its strength in detecting dysregulation problems based on 166 items to identify socioemotional and behavioral problems (internalizing and externalizing) and competencies. The finding that maternal PTSD symptoms predict emotion regulation difficulties in the still-face study, may suggest that some parts of emotional development is associated with maternal PTSD symptoms in infancy, while other parts, or the emotional development overall, may not find this association, and could account for the contrasting findings with the current study.

Due to the limited research on infant socioemotional development and social behavior in association with maternal earthquake related PTSD symptoms, it seems reasonable to discuss the present findings in light of previous studies including other developmental domains. However, as for research on socioemotional outcomes, previous findings on the association between maternal PTSD and child development are inconsistent. A delay in intellectual development in the infants of mothers with PTSD symptoms was reported using the Developmental Screening Test (DST) in the study on women pregnant during or after the 2008 Wenchuan earthquake (Cai et al., 2017). The DST includes a developmental quotient (DQ) and a mental index (MI). Both the DQ and the MI showed significant differences between infants of mothers with PTSD symptoms compared to infants of mothers with PTSD symptoms below cut-off. The DQ includes measures of social adaptability which seems mostly related to what is measured in the Bayley SE. However, the study only included a joint measure on the DQ and did not report on findings associated with the social adaptability

measure specifically. Potentially, distinguishing between the three variables accounted for in the DQ measure would have yielded a different result, especially considering the small sample size in the study.

A previous study in young children born in the Netherlands, found no delays in development in association with PTSD symptoms when using the Bayley II in the study in asylum-seeking and refugee mothers and development of infants aged 18-42 months (van Ee et al., 2012). The study did not include the socioemotional scale of the Bayley, which measures variables such as ease of calming, social responsiveness and imitation play (Weiss et al., 2010). With findings that neither mental nor psychomotor development was associated with maternal PTSD symptoms, these results suggest that the symptoms are not associated with early child development in general. Overall, the findings on associations between maternal PTSD and general child development are also limited and inconsistent, and it is therefore not yet possible to reach a conclusion.

### **Associations between maternal PTSD and social withdrawn behavior**

The present study did not find an association between PTSD symptoms and socially withdrawn behavior as measured by the m-ADDBB scale. Thus, we did not find support for the hypothesis that maternal PTSD symptoms would be positively associated with socially withdrawn behavior in the infant. We also expected that infants of mothers having PTSD symptoms above cut-off for clinical concern or probable diagnosis on the IES-R would have a more socially withdrawn behavior as measured by the m-ADDBB scale compared to infants of mothers with no or below cut-off PTSD symptoms. Our results indicate no significant association between maternal PTSD and socially withdrawn behavior however, which is further confirmed by the logistic regression analysis with no differences in the odds for social withdrawal in the infant if the mother had PTSD symptoms of clinical concern or a probable diagnosis compared to mothers with no or fewer PTSD symptoms.

To our knowledge, there are no other studies that have examined the associations between child outcomes and maternal earthquake related PTSD symptoms using the ADBB scale as outcome measure. The earlier mentioned study using the Repeated Still Face Paradigm (SFP-R), however, have a similar approach in examining outcomes among the youngest children (Enlow et al., 2011). When using the SFP-R as observational method, the study found an association between maternal PTSD symptoms and emotion regulation difficulties. Infant withdrawal as a type of emotion regulation strategy, can be considered a key element of the infant's response in the face of a non-contingent kind of relationship, as can be observed in a still-face procedure (Guedeney & Fermanian, 2001). While the still-face procedure is used to assess the infant's different responses to an attached and detached caregiver, the ADBB specifically assess the avoidant behavior as response in contexts where the child is expected to engage with others.

Socially withdrawn behavior is considered closely related to and assumed to be a type of internalizing behavioral problem (Rubin et al., 2009). Higher levels of internalizing behavior were found to be associated with severity of maternal PTSD symptoms when using the CBCL to measure infants' behavior and psychosocial functioning in the study on associations between maternal PTSD in asylum-seekers and refugees and development of infants aged 18-42 months (van Ee et al., 2012). No significant association was found for externalizing behavior. The previous findings that internalizing behavior seem more prone to be associated with maternal PTSD symptoms than externalizing behavior, is not consistent with findings on socially withdrawn behavior in the present study. The participating infants were older (18-42 months) in this study compared to our study (6-11 months) however, which could potentially have impacted on the associations.

The lack of associations between maternal PTSD symptoms and child outcomes is in contrast to the findings from older children in previous studies (Jang, Lee & Kim, 2020;

Honda et al., 2019). This may coincide with studies that have found more behavioral problems in older children compared to studies on the youngest (Jang, Lee & Kim, 2020; Honda et al., 2019). The consequences of maternal PTSD symptoms on children might be difficult to detect in infancy. When studying the consequences of maternal earth-quake-related PTSD, follow ups beyond early infancy could be meaningful, and thus follow up studies of the present population could be performed.

One important reason for the discrepancy between the present study and previous studies in older children is that when studying how parental mental health is associated with outcomes in the older children in the context of earthquakes, consequently, the studies will, to a greater extent, be limited by the fact that older children are more influenced by their own experiences of the direct exposure to the earthquake and not only indirectly through their mothers.

### **Potential explanations for our findings**

**Our findings in the theoretical setting.** Based on the theoretical framework presented in the introduction, we expected an association between maternal PTSD and child outcomes. Based on the attachment theory, it would be likely to assume that infants, in being dependent on emotional proximity with their caregiver from the very beginning, is prone to be affected by the caregiver's mental health (Bowlby, 1988). The unique dependency on their primary caregiver to act as a protective shield in the most important phase of attachment is thought to make infants particularly vulnerable (De Young, Kenardy & Cobham, 2011). In comparison, adolescents are less dependent on parents for regulation and have developed a certain level of autonomy, presumably making them more resilient against family stressors (De Young, Kenardy & Cobham, 2011). There are many different possible explanations for the lack of associations in the present study, one being that the present study did not include a measure on quality of attachment between mother and infant. Given that poor quality of

attachment is expected to be related to children's social and emotional development (Bowlby, 1988), our results of no associations could potentially indicate overall good quality of attachment between the infants and their mothers in the current sample, although not directly assessed. In relation to this, about half of the participants report to live in joint families, potentially indicating that living in an extended family could be a protective factor for the infants. Living in a joint family could potentially mean advantages such as more immediate social support for the mother and the benefit of other adults for the infant to rely on if the mother become unavailable due to PTSD symptoms.

As suggested by the transactional perspective (Sameroff, 2009), an examination of both parent and child behavior would better have account for the interdependency in the mother-child-transactions, as well as better explain the potential resilience in the infants. For instance, the birth and development of a child may give new hope to a mother with PTSD. With time, parent characteristics such as their own childhood experiences and child characteristics such as their temperament and development may impact on the transactions between them, for instance on reactivity and regulation, and on the relational patterns that develop between them (van Ee et al., 2015).

Our findings can reflect a reality, that maternal PTSD has little to no impact on the infants' social behavior and socioemotional development. If so, the results could indicate that the youngest children are more resilient to or less affected by the mental health of their mother. The findings could also potentially be explained by other factors mediating or moderating the association not accounted for in the current study, as well as by potential limitations within the sample, measurements and analyses.

**Parenting, emotional availability and responsiveness as mediating factors.** The lack of associations between maternal PTSD and infant mental health could be accounted for by parenting functioning as suggested by the meta-analysis on severity of parental PTSD on

children's psychological distress. The meta-analysis reported parental functioning to be negatively correlated and parental stress to be positively correlated with the association (Lambert, Holzer & Hasbun, 2014). A review also found parental PTSD to be associated with impaired functioning on a number of other parenting domains, including lower parenting satisfaction and more frequent use of negative practices (Christie et al., 2019). Our results could indicate that the mother's parenting was not affected. A methodological weakness of the present study, however, is that we have not included a measure of parenting. Some previous studies have included parenting. The study on associations between maternal PTSD in asylum-seekers and refugees and development of infants aged 18-42 months included a parenting measure using the EA scales (van Ee et al., 2012). The scores on the EA scales indicated that maternal PTSD could impede the mother's ability and capacity to be emotionally available through lack of sensitivity. With parenting measure included, the study found an association between severity of maternal PTSD symptoms and level of internalizing behavioral problems (by CBCL) in the infant. This indicates that inclusion of a parenting measure in the present study could have enabled us to explore if the absence of results could be explained by how the PTSD symptoms affected the parenting practices of the mothers in the current sample. Parenting may potentially be a buffer for adverse child outcomes, as reported in a study on a multi-ethnic sample of 242 trauma exposed mothers and their preschool-aged children. They found maternal responsive parenting behaviors to buffer the negative impact of maternal PTSD on the preschool children's mental health (Greene et al., 2020).

**Age and developmental stage as moderating factors.** With no adverse outcomes in relation to socioemotional development and social behavior in the current sample of infants, and above an assumption that child outcomes might be difficult to detect in infancy, age and developmental stage could moderate the association. Young children are in a phase of

establishing a relational bond with their caregiver (Bowlby, 1988). At the same time, their brain is found to be highly plastic (Kolb & Gibb, 2011). Based on the infants' dependency on their caregiver, their proposed ability to adapt through plasticity might involve that infants could compensate, for instance in situations where the mother with PTSD symptoms become detached and unavailable (van der Kolk, 2000). Consequently, the infants in the current sample could potentially compensate by maintaining their socioemotional development despite the mother's mental health.

Further, the youngest children are in a developmental stage where social and emotional competence increases rapidly and cognitive capacity is considered limited. Less developed social skills in combination with limited social connections may influence the youngest children's opportunities to fulfill the need for safety and security in a time when they need it the most (Salmon & Bryant, 2002). Less developed emotional skills may influence the youngest children's appraisal of the traumatic event, of their emotional response and of their efforts to cope with the traumatic experience (Salmon & Bryant, 2002). However, the current study did not find the infants' social and emotional skills to be negatively associated with maternal PTSD symptoms, potentially due to maternal PTSD symptoms not impacting on parent-child interactions or due to resilient infant characteristics. Further, with cognitive capacity not yet available in an advanced manner, the youngest children might be protected by their limitations to comprehend and conceptualize the disastrous event (Salmon & Bryant, 2002). The earlier mentioned study on 52 mother-infant dyads with the use of SFP-R and the ITSEA scale found maternal PTSD to predict internalizing, externalizing and dysregulation symptoms in infants at 13 months (Enlow et al., 2011). Potentially, a measure of the infants' socioemotional competence later in infancy could have led to discoveries of delays in socioemotional development. As for the present study, these potential delays in development were not found in this sample of infants aged six to 11 months. Going forward,

an interesting approach would be to collect follow up data to examine the same children as they grow older.

**Cultural aspects.** Our findings are based on data from a Nepalese population. Cultural biases may have potentially influenced how the researchers scored the m-ADDBB recordings and how the parents have reported on the Bayley SE scale.

Previous studies indicate that cultural differences appear to exist in social withdrawal (Rubin et al., 2009). The expression of withdrawal behavior appears to be interpreted as reservedness and respectfulness among Chinese parents, likely somewhat more similar to parents from Nepalese cultures, and as an expression of fearfulness among Western parents (Rubin et al., 2009). Rather than seeing the withdrawal as an alarm signal, Eastern cultures such as China seem to perceive withdrawal as a compliant behavior (Rubin et al., 2009). Given the indication that social withdrawal behavior is viewed as more acceptable among some cultures, the parents in these cultures will likely attempt to encourage such behavior, while parents perceiving withdrawal as maladaptive will attempt to discourage the same behavior. Cultural differences can then be seen as part of an explanation for why a lower number of infants were considered withdrawn in the current sample (mean=0.6) compared to normative data (mean=1.9) (Guedeney et al., 2008). Contrary to indications that different cultures perceive withdrawal differently, the study of social withdrawal in infants aged 3-24 months in China, using ADDBB, found a more similar prevalence (mean) of the behavior in Chinese children as reported in European population (Zhou et al., 2021; Guedeney et al., 2008), respectively 2.4 and 1.9. These findings provide less support for the assumption that cultural differences exist within the understanding of social withdrawal behavior.

A previous study on parental knowledge of child development has been conducted in the Bhaktapur district, using a brief questionnaire on developmental skills and stimulation called the Caregivers Knowledge of Child Development Inventory (CKCDI) (Shrestha et al.,

2019). In the 1272 Nepalese mothers interviewed, low levels of knowledge on child developmental milestones and developmental stimulation were found (Shrestha et al., 2019). In addition to lack of knowledge, these results might indicate cultural differences in child-rearing practices and beliefs, potentially also influencing the parental reports on the Bayley SE in the present study. However, the Bayley SE data used in the present study has been translated and back-translated according to standard procedure to assure cultural relevance (Ranjitkar et al., 2018).

### **Strengths and limitations**

**The sample.** A strength of the sample is that the participants are recruited from the community rather than mental health clinics. This contribute to increasing the generalizability of the findings, at least for people in areas, such as Bhaktapur, that are affected by the earthquakes. Also contributing to the generalizability is the finding that 27 % of the mothers reported PTSD symptoms above cut-off, reflecting the ratio of about one fourth found within most studies on PTSD in the aftermath of earthquakes (Dai et al., 2016; Dahal, Kumar & Thapa, 2017). Although not recruited from a clinical population, inclusion of a high risk population of mildly to moderately stunted infants might have resulted in a recruitment of relatively low socioeconomic families (WAMI-index mean=0.6). Risk of stunting (length-for-age z-score <-1) is also an established risk factor for adverse early child development (Black et al., 2017). These risk factors implies that the study does not fully reflect a general population and limits the transferability to the Nepalese population as a whole.

**Sample size.** Although a sample size of 555 mothers and infants, only about one fourth (n=150) of the mothers were found to have PTSD symptoms of clinical concern or probable diagnosis. This limits the statistical power and we cannot exclude the possibility that a larger sample size would yield different results.

***No homogenous group of mothers.*** The sample was not based upon a homogenous group considering when the infants were born compared to when the earthquakes occurred. At the time of the earthquakes, some of the mothers were not yet pregnant, some were pregnant and some had already given birth. This is not distinguished between or accounted for in the present study, and we therefore cannot rule out if the findings would differ between the different groups. The infants born prior to the earthquakes were, like their mothers, directly exposed, making it difficult to determine to what extent the infants' outcomes could be explained by the direct exposure and by the mental health of the mother. Mothers pregnant with their child during the earthquakes could potentially affect the child through prenatal stress (Khatri et al., 2020). These mothers also had to give birth in a disastrous situation, including increased risk of giving birth to a child with low birthweight (Khatri et al., 2020). Mothers who were not already pregnant could potentially affect the child through shared genetical vulnerability, as suggested within the theory of intergenerational transmission of trauma (Yehuda & Lehrner, 2018).

***Prior mental health of the mother.*** No information on mental health in the mothers prior to the earthquakes are accounted for in the present study. Earthquakes makes it possible to study the effects of a major psychological event that is randomly distributed across the populations, however, with lack of information on prior mental health it is difficult to determine if the maternal PTSD symptoms actually are consequences of the earthquakes. The mothers might have been vulnerable to developing PTSD symptoms and other comorbid mental health issues as a result of their living conditions even before the disaster occurred.

***Paternal PTSD symptoms.*** Another important limitation to the sample in the present study is the lack of data on paternal PTSD. Nepal is considered a patriarchal society, meaning that the role of a man in the family and the role of a father in a child's life is influential (Achary, Bhatta & Assannangkornchai, 2018). In the Nepalese culture, the father is seen as a

protector and will likely therefore have a salient role when life treats such as earthquakes strike (Achary, Bhatta & Assannangkornchai, 2018).

The cross-sectional study on a sample of 800 earthquake-affected children, aged 7-16 years, and their parents in Nepal, found that children having a father with PTSD were 3.85 times more likely and children having a mother with PTSD were 2.56 times more likely to develop severe PTSD symptoms compared to children having parents with no PTSD (Achary, Bhatta & Assannangkornchai, 2018). Another study on risk for PTSD in offspring of Holocaust survivors, reported findings suggesting that maternal, and not paternal, PTSD was related to the increased prevalence of PTSD in the offspring (Yehuda et al., 2008).

Although previous studies have indicated differential effects of maternal and paternal PTSD on children (Achary, Bhatta & Assannangkornchai, 2018; Yehuda et al., 2008), a meta-analysis on association between parental PTSD severity and children's psychological distress have presented research suggesting that parental PTSD is associated with impaired parenting for both mothers and fathers (Lambert et al., 2014). The meta-analysis found no significant difference between studies involving traumatized mothers versus those involving traumatized fathers (Lambert et al., 2014). With majority of the research reporting no significant difference between maternal and paternal PTSD, and with knowledge about the cultural aspect on fathers in Nepal, the lack of data on paternal PTSD in the current study could be considered a limitation. Paternal PTSD seems to in fact be of influential relevance for the childrens' mental health and should therefore be included in future research.

**The measurements.** The present study is based on data derived from acknowledged measurements when assessing PTSD symptoms, socioemotional development and social withdrawal behavior. The IES-R scale is a well-known and often used measurement based on an interview to assess symptomatic status of PTSD after traumatic events, such as earthquakes (Weiss, 2007). Within translation of the IES-R from English to Nepalese in the

current study, an acceptable internal consistency was obtained (Kvestad et al., 2019). The Bayley SE scale is a widely used developmental assessment tool, with good psychometric properties which provides good conditions to detect delays in socioemotional development (Leaders Project, 2013). Important to say, because of cultural bias and lack of adequate reference standard, the Bayley Scales should only be used to probe for information, and not to identify disorders or disabilities. The m-ADBB is designed to assess sustained withdrawal reactions in the youngest children (aged 2-24 months). While little is known about the psychometric properties of the modified version, the full version of ADDB is considered with good validity and reliability (Guedeney & Fermanian, 2001). For quality purposes and to ensure high-quality measurements, the m-ADBB assessment was video recorded. The examiners of the m-ADBB were trained by the founder himself, Antoine Guedeney, and in making sure that the infants were well fed and not feeling sleepy or sick, such organic causes could be ruled out as explanations for potentially withdrawn behavior (Ulak et al., 2020).

Previous studies conducted on the youngest children in the context of natural disasters are mostly based on reports from the mothers or from the child itself, as well as interviews with the participants (Achary, Bhatta & Assannangkornchai, 2017; Juth et al. 2015; Honda et al., 2019; Jang, Lee & Kim, 2020; Cai et al., 2017; van Ee et al., 2012). These methods require verbal responses and skills which are limited among the youngest children (Salmon & Bryant, 2002). A review of literature on intergenerational transmission of stress from mother to child have concluded that the field is best studied using correlational analysis of prenatal maternal exposure to stress, subsequent maternal behavioral responses, associated changes in the gestational uterine environment, and offspring outcomes, both biological and psychological (Bowers & Yehuda, 2015). To better understand how infants, toddlers and preschoolers are affected by parental PTSD (psychological offspring outcomes), observational methods to capture behavioral alterations as expression of psychological distress may be the

most efficient (van Ee et al., 2015). Observational methods used are, however, limited (van Ee et al., 2015), and none were found within research related to earthquakes. Unlike majority of the research in this area, the present study included both an observational method and parental reports and interviews.

Although acknowledged, the measures could be vulnerable to bias. Outcome measures used are originally validated in European and US populations and data from the current sample, therefore, may differ from normative data. While other studies have shown that it is possible to reach acceptable agreement with the full ADBB scale (Guedeney, Matthey & Puura, 2013), the baseline study did not reach acceptable interrater agreement, despite the fact that raters received comprehensive training and standardization in order to be certified (Ulak et al., 2020). The poor interrater agreement for the full ADBB potentially indicated difficulties and unclarity in using the scale to evaluate the social behavior of the Nepalese infants in the current sample. A modified version with reduced complexity (Matthey et al., 2005) enabled better interrater agreement and was chosen to achieve more reliable measures of infant social withdrawal in the current setting (Ulak et al., 2020). However, neither the full nor the modified version is validated for the Nepalese population. The Bayley SE scale is also not validated in Nepal, and further studies validating the instruments should be performed.

Standardized training was completed prior to m-ADBB assessment of social withdrawal behavior (Ulak et al., 2020). However, one of the five items seemed to be harder to agree upon and seemed to be scored elevated in this population, namely vocalization (Ulak et al., 2020). Facial expression, vocalizations and general level of activity seem to vary more depending on age and developmental stages. Eye contact and the ability to obtain relationship with observer have been found to be more dependent on relational aspects (Guedeney & Fermanian, 2001). High scores on vocalization indicates low levels of vocal utterances in the Nepalese infants. This finding is consistent with how it in the same sample

was found lower performance than expected on expressive language measured by the Bayley III (Ranjitkar et al., 2018). The low levels of vocalization have also been suggested to be due to cross-cultural differences, for instance infants being more reserved in the face of strangers and caregivers being less talkative with their infants in the Nepalese setting compared to Western cultures (Ulak et al., 2020). This raises the question on whether low levels of vocalization represent normal functioning in Nepal and abnormal functioning in Western cultures, potentially interfering with our results. A methodological challenge when using Western developed measurements in other cultures include how the emics; viewpoints within the culture, disturbs the etics; perspectives from the ones who have developed the measurements and who assume those perspectives to be universal (Headland, Pike & Harris, 1990).

**The analyses.** To analyze the associations thoroughly, both the continuous trend was examined and dichotomization of the exposure and outcome variables was done to check for differences between groups and the odds for adverse outcomes being an infant of a mother with PTSD symptoms. Although conducting several levels of analyses, no analyses on mediating variables were conducted. For instance, data on the mother's degree of exposure to the earthquakes are available (measured with an Earthquake Exposure form) (Kvestad et al., 2019). Based on findings that the severity of exposure to the traumatic event is considered a peri-disaster risk factor, earthquake exposure could potentially mediate the associations between maternal PTSD symptoms and infant outcomes. Other data available and potentially mediating the associations is the gestational status of the infants, and whether prematurity could be considered a mediating factor. Our results indicate that the associations do not necessarily go in a particular direction, as our findings are in contrast with results from previous studies. A number of different mechanisms will likely mediate the association, either as protective mechanisms or risk factors for development of adverse outcomes in the infants.

### **Conclusion**

By using data from a large population-based RCT, we have tested our hypotheses that maternal earthquake related PTSD is negatively associated with the infants' socioemotional development and positively associated with socially withdrawn behavior in infants. Although previous studies find evidence to support an expectation that maternal PTSD symptoms are associated with subsequent adverse child outcomes, our findings on the youngest children indicate no associations with socioemotional development or social behavior, in the context of earthquakes in Nepal. These findings may indicate that maternal earthquake related PTSD symptoms not necessarily is represented in a deterministic relationship with child outcomes, and that several underlying mechanisms, including parental characteristic, both for the mother and the father, such as parenting, emotional availability and responsiveness and child characteristics such as age and development might influence the probability of the child developing adverse outcomes.

### **Implications for future research**

Due to a limited basis of comparable studies, it is still unclear if other studies will find similar results and more studies are needed before firm conclusions can be drawn. If our findings reflect reality, then future studies should examine if these positive and optimistic findings for the infants are stable over time or if adverse outcomes may arise later. With future research, it would be interesting to examine the child's later outcomes, and also if the outcomes are related to the persistence of the maternal PTSD symptoms. The possibility of resilient factors such as parenting and age of the child warrants further investigation in the context of earthquakes. Above all, considering that Nepal is an earthquake prone country, an earthquake likely will occur again. This implies an important need for extended research on maternal mental health and subsequent child outcomes in the context of earthquakes.

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**Table 1:** Baseline demographic features of 555 Nepalese mothers and their infants 6-11 months of age.

	<i>N</i>	%	Range (min-max)
<b>Child characteristics</b>			
Age of the child, months (mean, <i>SD</i> , range)	8	1.8	6 – 11
Gender of the child			
Boy	288	51.9	
Girl	267	48.1	
Gestational status			
Full-term	496	89.4	
Pre-term	59	10.6	
Birthweight (mean, <i>SD</i> )	3040.9	1400.2	
Height for age (z-score – mean, <i>SD</i> , range)	-1.9	0.6	-5.1 – -0.8
Not stunted	372	67.0	
Stunted	182	32.8	
Weight for age (z-score – mean, <i>SD</i> , range)	-1.3	0.5	-4.2 – 1.1
Normal weight	451	81.3	
Underweight	104	18.7	
<b>Maternal characteristics</b>			
Age of the mother (mean, <i>SD</i> , range)	27.6	4.6	17 – 43
Level of education (mother)			
Illiterate or primary complete	203	36.6	
Secondary complete	105	18.9	
Intermediate complete	135	24.3	
Bachelor or above	112	20.2	
<b>Family characteristics</b>			
Level of education (husband)			
Illiterate or primary complete	195	35.1	
Secondary complete	121	21.8	
Intermediate complete	136	24.5	
Bachelor or above	103	18.6	
Family type			
Nuclear	308	51.3	
Joint	292	48.7	
Socioeconomic status* (mean, <i>SD</i> , range)	0.6	0.2	0.0 – 1.0

\*WAMI – water/sanitation, household assets, maternal education and income index.

**Table 2:** Scores on the Impact of Event Scale-Revised (IES-R) in 555 mothers 20 months after the earthquakes.

	Mean ( <i>SD</i> )	Range
<b>Scores on IES-R</b>		
Total score	17.8 (10.3)	0-54
Intrusion	6.7 (4.7)	0-25
Avoidance	6.4 (4.3)	0-22
Hyperarousal	4.6 (3.0)	0-15
	<i>N</i>	%
No PTSD (IES<24)	405	73.0
PTSD as a clinical concern/ probable diagnosis (IES≥24)	150	27.0

\*PTSD – post-traumatic stress disorder

**Table 3:** Scores on the Bayley Socio-Emotional scale (Bayley SE) and the modified Alarm Distress Baby scale (m-ADBB) in 555 children at enrollment (6-11 months old).

	Mean ( <i>SD</i> )	Range (min-max)
<b>Scores on Bayley SE and m-ADBB</b>		
Total score on Bayley SE	103.4 (16.3)	55-140
Total score on m-ADBB	0.6 (0.8)	0-4
	<i>N</i>	%
Scores on Bayley SE (-1 <i>SD</i> = low score)		
Adequate socioemotional development	445	80.2
Inadequate socioemotional development	110	19.8
Scores on m-ADBB (>2 = withdrawn)		
Not withdrawn	493	88.8
Withdrawn	62	11.2

**Table 4:** Linear regression on the relationship between maternal IES-R scores and children's scores on Bayley SE, unadjusted and adjusted. ANCOVA on group differences between mothers with and without PTSD symptoms and children's scores on Bayley SE, unadjusted crude model.

<b>Bayley Socio-Emotional composite score</b>				
Crude model				
	coef.	95 % CI		p
		Lower	Upper	
<b>Linear regression</b>				
Total IES-score	-0.00	-0.13	0.13	0.99
Intrusion	0.05	-0.24	0.34	0.73
Avoidance	-0.07	-0.39	0.24	0.65
Hyperarousal	0.02	-0.44	0.49	0.92
	Mean	95 % CI		p
	(SD)	Lower	Upper	
<b>ANCOVA</b>				
Below cut-off (<24)	102.57 (16.68)	100.98	104.15	
Above cut-off (≥24)	105.53 (15.01)	102.93	108.14	0.06

**Table 5:** Logistic regression on differences between mothers with or without PTSD symptoms and children with low or normal scores on Bayley SE.

<b>Bayley SE scores -1SD</b>				
Crude model				
	OR	95 % CI		p
		Lower	Upper	
<b>Logistic regression</b>				
Below cut-off (IES<24)	ref.			
Above cut-off (IES≥24)	0.80	0.49	1.30	0.37

**Table 6:** Poisson regression on the relationship between maternal IES-R scores and children's scores on m-ADBB, unadjusted and adjusted. Margins on group differences between mothers with and without PTSD symptoms and children's scores on m-ADBB, unadjusted crude model.

<b>Modified Alarm Distress Baby scale</b>				
Crude model				
	IRR	95 % CI		p
<b>Poisson regression</b>		Lower	Upper	
Total IES-score	1.00	.99	1.01	0.56
Intrusion	1.01	.99	1.03	0.48
Avoidance	1.01	.99	1.04	0.41
Hyperarousal	1.00	.96	1.03	0.77
	Mean	95 % CI		p
<b>Margins</b>	(SE)	Lower	Upper	
Below cut-off (<24)	0.61 (0.04)	0.53	0.68	
Above cut-off ( $\geq$ 24)	0.68 (0.07)	0.55	0.81	0.33

**Table 7:** Logistic regression on differences between mothers with or without PTSD symptoms and children with or without social withdrawal behavior measured by m-ADBB.

<b>m-ADBB</b>				
Crude model				
	OR	95 % CI		p
<b>Logistic regression</b>		Lower	Upper	
Below cut-off (IES<24)	ref.			
Above cut-off (IES $\geq$ 24)	1.11	0.62	2.01	0.71

### Supplementary 1: Confounding variables considered as possible covariates by Pearson correlation coefficients.

Supplementary 1: Confounding variables considered as possible covariates to adjust for.

Potentially confounding variables	IES-R scores		Intrusion		Avoidance		Hyperarousal		Bayley SE scores		m-ADDB scores	
	coef.	p	coef.	p	coef.	p	coef.	p	coef.	p	coef.	p
<b>Child characteristics</b>												
ID cheno	0.002	0.339	0.001	0.317	-0.000	0.542	0.000	0.387	0.006	0.118	0.000	0.962
Gender	0.862	0.325	0.460	0.249	0.474	0.194	-0.072	0.774	-2.266	0.088	-0.021	0.744
Age	-0.221	0.370	-0.108	0.334	-0.094	0.359	-0.018	0.793	0.616	0.099	-0.079	<0.001*
Birthweight	-0.000	0.960	-0.000	0.895	0.000	0.791	-0.000	0.725	-0.000	0.883	-0.000	0.204
Height for age	0.123	0.868	-0.002	0.995	0.087	0.778	0.038	0.855	1.750	0.118	-0.099	0.064
Weight for age	0.316	0.543	0.148	0.529	0.179	0.407	-0.012	0.936	1.322	0.090	-0.091	<b>0.014*</b>
<b>Maternal characteristics</b>												
Age	0.321	<0.001*	0.135	<b>0.002*</b>	0.105	<b>0.008*</b>	0.081	<b>0.003</b>	0.253	0.076	-0.002	0.789
Literacy	-1.335	<0.001*	-0.492	<0.001*	-0.447	<0.001*	-0.396	<0.001*	0.606	0.221	-0.021	0.374
Occupation	-0.409	0.072	-0.233	<b>0.024*</b>	-0.120	0.205	-0.065	0.389	0.459	0.185	-0.022	0.176
<b>Family characteristics</b>												
Literacy of father	-1.318	<0.001*	-0.475	<b>0.002*</b>	-0.409	<b>0.004*</b>	-0.434	<0.001*	0.491	0.350	-0.044	0.081
Father's occupation	-0.049	0.892	0.128	0.432	-0.099	0.506	-0.078	0.446	0.735	0.174	-0.042	0.102
WAMI	-4.390	0.140	-1.560	0.249	-1.409	0.255	-1.421	0.093	7.522	0.097	-0.393	0.068
Family type	-0.923	0.292	-0.227	0.569	-0.208	0.569	-0.489	<b>0.050*</b>	-0.820	0.537	-0.065	0.303

\*ID cheno – time of inclusion

\*WAMI – water/sanitation, assets, maternal education and income index