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Earthquake effects: Estimating the relationship between exposure to the 2010 Chilean earthquake and preschool children's early cognitive and executive function skills

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ABSTRACT

Little is known about how the experience of an earthquake affects young children's cognitive outcomes. On February 27, 2010, a severe earthquake shook southern Chile. The earthquake occurred during the course of a large-scale evaluation of an early childhood education intervention (child average age = 53 months) in Santiago, such that one cohort of children ($n = 698$) experienced baseline data collection 3–12 weeks after the earthquake occurred, while a different cohort of children ($n = 720$) did not. In this paper, we used these available evaluation data to conduct two sets of analyses that explore the relationship between preschool children's exposure to the 2010 Chilean earthquake and their early language, pre-literacy, mathematics and executive function outcomes. In the first set of analyses, we employed a propensity score analysis to estimate the short-term effect of the earthquake on preschool- aged children's early learning and executive function outcomes. Results suggest that children who experienced the earthquake had lower scores on some early language and pre-literacy assessments than those who did not, with effect sizes of approximately 20% of a standard deviation. Results from the second set of analyses suggest that among the families who experienced the earthquake, children whose parents reported more earthquake- related stressors performed significantly lower on some early language and pre-literacy outcomes. Implications of these findings for disaster relief efforts and future research are discussed.

1. Introduction

On February 27, 2010 at 3:34 a.m., one of the strongest earthquakes in history shook southern Chile. Santiago, the nation's capital, sits approximately 500 kilometers north of Concepción, the closest major city to the epicenter. While the city experienced much less devastation and damage than communities further south in the country, Santiago and its residents suffered collapsed buildings, blocked roads, and damaged homes (Barrionuevo & Robbins, 2010). This study explores how the earthquake impacted some of Santiago's youngest citizens—its preschool-aged children.

Few research studies explore the effects of natural disasters on young children (Anderson, 2005), and those that do tend to focus on children's mental health, socio-emotional development, or behavioral outcomes following a disaster (Vogel & Vernberg, 1993). Scholars have had fewer opportunities to document the effect of experiencing a natural disaster on young children's early learning skills. The present study contributes to the literature with two sets of analyses that explore the relationship between preschool-aged children's exposure to the 2010 Chilean earthquake and their early language and pre-literacy skills, emergent mathematics ability, and executive function.

The 2010 Chilean earthquake occurred in the middle of the implementation and evaluation of a large-scale teacher professional development program in publically-funded prekindergartens serving a high proportion of low-income families in Santiago (Yoshikawa et al., 2015). The schedule of data collection was such that one cohort of children in the sample began their preschool year and experienced baseline data collection just after the earthquake occurred, while a different cohort of children went through data collection a year earlier, not experiencing the natural disaster prior to taking the assessments. In the first set of analyses, we capitalize on this natural experiment and compare these two groups to estimate the relationship between children's experience of the earthquake and their performance on early childhood outcomes. However, the sampling procedures of UBC were such that pre-existing differences between the two groups may have

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contributed to the selection of children into the cohort that experienced the earthquake versus the cohort that did not. If unaccounted for, these differences could confound any estimated effect of the earthquake. To address these differences, we employ a propensity score analysis with the aim of making the two cohorts comparable on observed characteristics, save their earthquake exposure.

In a second set of more exploratory analyses, we test whether children's post-earthquake outcomes are related to their parents' report of stress following the disaster. Existing research suggests that children whose parents report more stress in the home after an earthquake often have more extreme behavioral or mental health symptoms themselves (Proctor et al., 2007); we test whether this pattern holds for children's early learning outcomes as well. Using only those children who were exposed to the earthquake—the only children for whom we have data on parent stress—we test whether parents' reports of earthquake-related stressors predict their children's early language and pre-literacy skills, emergent mathematics ability, and executive function following the event.

1.1. Disasters and young children

Early studies in the field of disaster research suggested that young children (ages 0–5) are too young to understand the experience of an earthquake, and are unlikely to be affected by the event (Anderson, 2005). However, studies from the past 2–3 decades have made clear that young children do process and react to natural and human-caused disasters and, as a result, can experience emotional and psychological distress (Buchanan, Casbergue, & Baumgartner, 2009; Masten & Osofsky, 2010; Norris et al., 2002; Osofsky & Reuther, 2013). Research suggests that following a disaster, children can experience increased fear, more internalizing and externalizing behaviors, as well as behaviors symptomatic of post-traumatic stress disorder (PTSD), including separation anxiety, reliving the event, and emotional numbness or increased arousal (Norris et al., 2002; Osofsky & Reuther, 2013; Peek, 2008; Silverman & La Greca, 2002). These symptoms have been observed in young children following the experience of an earthquake (Endo, Shioiri, Toyabe, Akazawa, & Someya, 2007; Proctor et al., 2007), as well as other types of human-caused and natural disasters, including the 9/11 terrorist attacks (Chemtob, Nomura, & Abramovitz, 2008; DeVoe & Klein, 2011) and Hurricane Katrina (Osofsky, Kronenberg, Bocknek, & Hansel, 2015).

Research has indicated that the extent of a child's exposure to a disaster—sometimes measured by a child's physical proximity to the disaster (Goenjian et al., 1995) or the degree to which the disaster impacted the child's family, home, and/or immediate environment (DeVoe & Klein, 2011) is positively related to children's post-disaster symptoms. We might expect children living further from a disaster (like those in the sample of the present study) to have fewer symptoms or less extreme reactions than children closer to its epicenter. However, theory also suggests that children and families from disadvantaged populations—e.g. low-income communities, individuals with disabilities, and racial and ethnic minorities—may be more vulnerable to a disaster due to their social position (Peek & Stough, 2010). For example, families who live in poorly constructed homes or who have minimal access to food supplies are more likely to be affected by an earthquake than families with greater resources. As such, low-income families, including those who endure minimal physical destruction or live far from the event, like those in the sample of the present study, may nevertheless be prone to hardship following a disaster.

1.2. The effects of disasters and trauma on children's early learning outcomes

The majority of literature exploring the impact of an earthquake or other disasters on children focuses on symptoms related to PTSD or children's mental health (Anderson, 2005). Far less research has explored how experiencing a disaster might impact other domains of early child development, such as early language, pre-literacy, math skills, or executive function. The few extant studies on the topic suggest that experiencing a disaster might lead to decreased performance on these skills. In their review of literature covering a host of both natural and human-caused disasters, Vogel and Vernberg (1993) found that, on average, school-aged children experienced a decrease in academic performance after experiencing a disaster. This pattern may be caused by students' discontinuity in school experiences due to damaged buildings, displacement, or parents' fear of letting them travel to school or be out their care (Peek, 2008).

Stress or trauma caused by disaster exposure may also result in decreased academic performance. Trauma, defined as a deeply stressful, emotionally painful event that induces short and long-term feelings of fear and helplessness (Breslau et al., 1998; Sagi-Schwartz, 2008), can affect many domains of child development. Following a traumatic event, such as the experience of an earthquake, young children can exhibit difficulty concentrating on tasks at school (Cole et al., 2005; Osofsky & Reuther, 2013; Sagi-Schwartz, 2008). An inability to concentrate on an assessment could lead to short-term negative effects on measures of children's language and literacy, or mathematics skills following a disaster. In addition, children may temporarily regress in academic progress or skill development following trauma, another possible cause of short-term negative effects on early childhood measures of cognitive ability (Cole et al., 2005).

The literature also describes a link between experiencing trauma and children's executive function—including their ability to regulate their behavior and control impulses (DePrince, Weinzierl, & Combs, 2009). Masten and Obradovic (2008) suggest that the fear and anxiety associated with a natural disaster or other crises or traumatic events can negatively affect children's behavior regulation and executive function, while Leskin and White (2007) find a relationship between adults' heightened PTSD symptoms following a trauma and lower performance on executive function tasks.

Few studies explore the effects of natural disaster on cognitive outcomes and executive function; however, researchers have explored the effect of other types of traumas on these outcomes. For example, Sharkey (2010) and Sharkey, Tirado-Strayer, Papachristos, and Raver (2012) found that incidents of community violence decreased children's scores on math and reading achievement, attention, and impulse control a week after the event. While community violence is a qualitatively different type of trauma than that of an earthquake, both types of events have the potential to alter a child's immediate environment and make them fear for their safety, perhaps leading to short-term negative effects on children's cognitive performance.

1.3. The role of caregiver stress in children's response to disasters

Children's interactions with their parents and caregivers may mediate the effects of a traumatic event like an earthquake (DeVoe & Klein, 2011; Masten & Narayan, 2012; Masten & Obradovic, 2008). During and after an earthquake, caregivers can ease children's fears and help regulate behavior and emotions in the face of stress, in a protective fashion (Osofsky & Reuther, 2013). Child resilience in the face of the stress (Bonanno & Mancini, 2008; Masten & Wright, 2009) may, in part, depend on parents' and caregivers' ability to provide a sense of safety and security (Osofsky & Reuther, 2013; Proctor et al., 2007). However, some caregivers may face difficulties during the aftermath of a disaster that may hinder their relationships with their children (Deering, 2000; Kronenberg et al., 2010; Osofsky & Reuther, 2013). As parents cope with their own symptoms after a disaster, they may lack the material and emotional resources necessary to support their children's needs (Scheeringa & Zeanah, 2001), leading to measurable negative effects on children's outcomes. For example, Proctor et al. (2007) found that parental stress mediated the relationship between earthquake exposure and children's distress following the event.

2. The present study

2.1. Earthquake context

In this study, we explore the effects of the 2010 Chilean earthquake on preschool-age children's cognitive outcomes. The 8.8-magnitude earthquake, the 6th most severe quake in the last century, occurred at 3:30 a.m. on February 27, 2010. The epicenter was located off the Pacific coast, near the city of Concepción, approximately 500 km southwest of Santiago (United Stated Geological Survey, 2015). News outlets suggested that millions of people were affected, as the earthquake caused hundreds of deaths and mass physical destruction (Barrionuevo & Robbins, 2010). While the most extreme physical damage was reported closest to the epicenter, Santiago experienced very strong to severe shaking (United Stated Geological Survey, 2015), collapsing buildings and severely damaging roads. Citizens of Santiago reported many fearful days of aftershocks (Snook, 2010). In the month following the initial quake, there were over 1000 aftershocks (Earthquake Engineering Research Institute, 2010), adding to the general of stress of citizens in the country.

2.2. Research questions

Most disaster research only reports on children who experienced the event, without including an appropriate comparison group. These works are limited in their ability to distinguish between symptoms that were caused by the disaster, and those symptoms that might be attributed to preexisting characteristics (Norris et al., 2002). In this study, we capitalize on a natural experiment, and employ a quasi-experimental design and a propensity score analysis to obtain less biased estimates of the relationship between experiencing an earthquake and children's cognitive outcomes. The first research question is: *To what extent did the 2010 earthquake in Chile have a short-term effect on low-income preschool children's performance on their early learning outcomes and executive function?*

This study also builds on previous research indicating that parents' own experience of a natural disaster may affect how their children respond to the event (Kaplan, Stolk, Valibhoy, Tucker, & Baker, 2016; Masten & Narayan, 2012; Proctor et al., 2007). The ideal analyses would involve a test of mediation to confirm whether the effect of the earthquake on children's outcomes is explained by the effect of the earthquake on parent stress. However, such analyses are not possible with the current sample given a lack of data on parent stress for the comparison group. Instead, we explore the relationship between parents' self-report of their earthquake-related stressors and child outcomes. The second research question is: *Do parents' reports of their emotional, material and financial stress after the earthquake predict their children's cognitive outcomes following the event?*

3. Method

3.1. Datasets

Data for this study were collected as part the evaluation of a teacher professional development intervention called Un Buen Comienzo (UBC) designed to improve the quality of preschool in low-income communities in Santiago, Chile (see Yoshikawa et al., 2015, for details). The 2010 Chilean earthquake occurred just before the first wave of data collection of one of the two main cohorts of the study. Child outcome data and family, child, and teacher demographic information were taken from the UBC dataset. We also make use of municipality-level data from a publicly available national Chilean data source, the National Socioeconomic Characterization Survey, administered in 2009.

3.2. Procedures

3.2.1. Sampling procedures

The UBC intervention took place in low-income municipalities in the greater Santiago metropolitan region. Municipalities (or *comunas*) are small administrative divisions within the greater Región Metropolitana, each with its own city council and elected mayor. UBC engaged in a purposive sampling when selecting the participating municipalities. Eligible municipalities were required to: a) have a high proportion of vulnerable children (a minimum of 20%, though most municipalities had higher percentages); b) have a minimum of eight schools with pre-kindergarten and kindergarten classrooms; and c) be located in the metropolitan area of Santiago. Following an application and interview process, UBC selected six municipalities to participate in the intervention and its experimental evaluation. Five of the six municipalities are represented in the analytic sample: two in what we will refer to as Cohort C (the comparison group) and three in Cohort E (the earthquake group). While the municipality selection process took place at two different time points (in 2008 for Cohort C and 2009 for Cohort E), all of the municipalities and their school populations were, as a group, selected to represent low-income children and families in Santiago. One additional municipality from the original dataset was excluded from the analyses. The children from this municipality would have been included in the comparison group because baseline data for these children were collected in 2008 (before the earthquake). We chose to exclude this group because inconsistencies in baseline demographic variables meant these children did not have adequate information for the propensity score analysis.

3.2.2. Data collection and participants

Data were collected during the start of each cohort's preschool year—in March–May of 2009 for cohort C and March–May 2010 for cohort E. The timing of data collection for UBC in relation to the earthquake is critically important to this study. Cohort C (the comparison group) began preschool and experienced data collection the year before the earthquake, while Cohort E (the earthquake group) started preschool and completed child assessments in the first months of 2010, a few weeks after the earthquake occurred. As such, the timing of the 2010 Chilean earthquake in the context of the UBC evaluation created a situation similar to a natural experiment, or a "naturally occurring contrast between a treatment and comparison condition" (Shadish, Cook, & Campbell, 2002, p. 17). We exploit this variation in children's earthquake experiences by comparing these two cohorts to understand how the event affected children's early learning outcomes.

As part of the data collection process, parents completed questionnaires about their children and demographic information about their families. Direct assessments of children's cognitive outcomes and executive function were collected at children's schools or in their homes by a team of trained research assistants. All teachers involved in UBC were also asked to fill out information about their demographic characteristics. For Cohort E, 95% of parent, child and teacher demographic data, and child outcomes were collected 3–12 weeks after the earthquake.

In addition to the demographic questionnaire, parents in Cohort E were administered an "Earthquake Survey." This 29- question

Table 1
Descriptive statistics for the full sample and by earthquake and comparison groups.

	Full Sample mean (sd)	Comparison Group (Cohort C) mean (sd)	Earthquake Group (Cohort E) mean (sd)
n	1418	720	698
Child Outcomes			
Vocabulary	18.25 (4.6)	19.11 (4.63)	17.43 (4.42)
Letter-Word Identification	5.47 (2.42)	5.92 (2.46)	5.06 (2.31)
Dictation	6.00 (1.97)	6.18 (2.00)	5.81 (1.93)
Text Comprehension	3.03 (1.25)	3.22 (1.17)	2.84 (1.30)
Applied Problems	7.89 (3.45)	8.4 (3.61)	7.46 (3.25)
Executive Functioning	2.42 (1.71)	2.55 (1.76)	2.3 (1.65)
Child and Parent Demographics			
Age[a,c]	53.46 (3.68)	53.88 (3.17)	53.03 (3.59)
% male	48.03%	48.75%	47.28%
% with prior early education experience	48.09%	47.29%	48.92%
Mother Education			
% some elementary school	11.18%	11.73%	10.61%
% completed elementary school	13.41%	12.16%	14.68%
% some high school[c]	22.06%	18.03%	26.16%
% completed high school[d]	37.78%	40.20%	35.32%
% some university[d]	13.34%	15.02%	11.63%
% completed university	2.24%	2.86%	1.60%
Father Education			
% some elementary school[d]	9.40%	8.05%	10.81%
% completed elementary school	10.74%	12.07%	9.35%
% some high school	24.96%	23.07%	26.94%
% completed high school	38.23%	36.07%	40.48%
% some university[c]	13.67%	16.72%	10.48%
% completed university[c]	3.00%	4.02%	1.94%
Teacher Demographics[b]			
Teacher age[c]	44.64 (8.10)	42.85 (7.63)	46.50 (8.14)
% with a degree from a University[c]	63.40%	57.71%	69.27%
% with a post graduate certificate	48.27%	50.00%	46.49%
% experience in a government sponsored preschool	15.80%	15.13%	16.47%
% experience in a private preschool	60.65%	60.76%	60.53%
% taught for less than 5 years[c]	15.09%	24.31%	5.59%
% taught for 5–14 years[c]	23.80%	21.11%	26.58%
% taught for 15 or more years[c]	61.11%	54.58%	67.84%
% with less than 5 years experience in K	65.55%	70.76%	60.17%
% with less than 5 years experience in preK[c]	29.34%	43.47%	14.76%

[a] Child age measured in months.
[b] Teacher variables unit of analysis is the classroom mean.
[c] Denotes a statistically significant different between earthquake and control groups at $\alpha < 0.05$ level (demographic variables only).
[d] Denotes a statistically significant different between earthquake and control groups at $\alpha < 0.10$ level (demographic variables only).

supplement to the parent survey was designed by the UBC evaluation team immediately following the news of the disaster (Moreno et al., 2011). The survey gathered information about parents' perceptions of the earthquake's immediate effects on their families' everyday lives, including parent and child stress, and the family financial and material resources.

There are a total of 1418 children in the analytic sample: 698 in the earthquake group and 720 in the comparison group. Children were nested in 57 schools and five municipalities (see Table 1 for sample descriptive statistics). The analytic sample represented 90% of the total number of children sampled in Cohorts C and E ($n = 1583$). We excluded 165 children who were either missing all outcome data or all data on the parent and teacher demographic survey ($n = 127$) or whose pattern of missingness on covariates precluded their inclusion in the missing data strategy ($n = 38$).

3.3. *Measures*

All measures were drawn from the larger UBC dataset. Unlike other analyses of these data (Yoshikawa et al., 2015), we excluded measures of children's socio-emotional development because they were reported by adults (parents, teachers or child assessors). All of these adults experienced the earthquake, and past research suggests that adults' reports of child symptoms following an earthquake may be confounded by adults' own well-being after the event (Masten & Osofsky, 2010). As such, we used only direct child assessments conducted by trained graduate-student data collectors.

3.3.1. *Language, literacy, and emergent mathematics outcomes*

The UBC evaluation team assessed children's language and literacy skills with four subtests from the Woodcock-Muñoz Language Survey Revised Spanish Form (WMLS-R;Woodcock, Muñoz-Sandoval, Ruef, & Alvarado, 2005) including the picture vocabulary, letter-word identification, dictation, and text comprehension subtests. These measures have been tested and validated for Spanish-speaking children in Latin America (Schrank, McGrew, Ruef, Muñoz- Sandoval, & Woodcock, 2005).

The picture vocabulary subtest measures receptive vocabulary and requires the child to point to named pictures. The letter-word identification subtest requires that the child match pictures with words, name letters, and read words aloud from a list. The dictation subtest measures prewriting and writing skills. The text comprehension subtest measures children's understanding of basic passages, using pictorial representations for children at the preschool level. The UBC team used the applied problems subtest from the Woodcock-Muñoz Bateria III Pruebas de Aprovechamiento, Spanish Form (Muñoz-Sandoval, Woodcock, McGrew, & Mather, 2005) to measure children's emergent mathematics skills. This subtest measures numeracy and simple problem solving. Raw scores of all five Woodcock-Muñoz subtests were used. The internal consistency reliability coefficients for the assessments ranged from 0.76 to 0.97.

3.3.2. Executive function

The executive function assessments measure two components of this developmental construct in the preschool- age period: cognitive flexibility and cognitive inhibitory control. Cognitive flexibility and cognitive inhibition are defined as the abilities to suppress prepotent responses and behaviors in reaction to motor or cognitive stimuli (Barata, 2011). The executive function battery contained three assessments: the Dimensional Change Card Sort (DCCS), the Pencil Tapping (PT) task and the Walk-a-Line Slowly (WLS) task. The DCCS measures cognitive flexibility by asking children to sort cards according to one dimension (shape or color) and then according to the other dimension. In the PT task (Diamond & Taylor, 1996), the children were asked to tap twice if the evaluator tapped once and tap once if the evaluator tapped twice. This assessment primarily measures cognitive inhibitory control. The WLS task measures inhibitory control, with a focus on gross motor control. Children were asked to walk along a 6-foot-long piece of string taped to the floor as the assessor timed them. Children were then asked to repeat the task twice, first walking slower and then walking as slowly as possible, for a total of three trials. The WLS total score measures the average percentage reduction by which children reduced their speed on successive trials.

Measurement work (Barata, 2011) suggested these assessments were valid for the Chilean sample, and that all three constructs loaded on to one executive function factor. Given this, we created a unit-weighted composite using children's scores on of all three assessments to represent executive function skills. The composite was coded such that high values on the measure correspond to higher (more desirable) scores on the executive function assessments. Descriptive statistics for all outcomes measures are presented in Table 1.

3.3.3. Earthquake exposure and earthquake-related stressors

The predictor of interest for research question 1, *earthquake*, is a dichotomous variable that indicates whether a child experienced the 2010 earthquake before her preschool year. It was coded 0 for the comparison group and 1 for the earthquake group. This variable does not capture *the nature* of children's earthquake experience but simply whether the earthquake occurred before they began school. For reporting purposes, Santiago was considered one geographic area (United Stated Geological Survey, 2015), and the level of shaking was recorded as consistent across the entire metropolitan area. The binary coding scheme for *earthquake* assumes that all families in Cohort E experienced the earthquake in the same way, as we do not have an objective measure of any variation in children's earthquake exposure.

To answer research question 2, data from the earthquake survey were used to create a subjective measure of parents' reports of the earthquake-related stressors experienced following the event. In creating this measure, we focused on items that measured parents' own experiences, rather than parents' reports of their children's experiences. We also excluded survey items with insufficient variation. Based on these criteria we included nine binary items that measured parents' economic and emotional stressors after the earthquake: 1) whether either parent had an involuntary job interruption following the earthquake; 2) whether the family experienced a loss of income following the earthquake; 3) whether the parent had trouble finding food for their family following the earthquake; 4) whether the parent had trouble paying for food following the earthquake; 5) whether the parent had trouble finding potable water for their family following the earthquake; 6) whether the parent was afraid to send his child to school following the earthquake; 7) whether the parent did not send his children to school after the earthquake; 8) whether any family or friends had been hurt, died, or lost a home following the earthquake; and 9) whether the parent cried or displayed distressed emotions in front of the child following the earthquake.

Based on a principal components analysis indicating that all nine items measured a single dimension, we summed the items to create an index measuring how many of the nine stressors families experienced. The shape of the distribution, with a median falling at 1 stressor and strong positive skew, suggested that the sample fell into two substantively meaningful groups: those families with 0 or 1 stressors, and those with 2 or more. This characterization is consistent with literature suggesting that populations at greatest risk for being harmed by a nature disaster tend to experience multiple hardships (Catani et al., 2010; Peek, 2008). We created a binary variable (*earthquake stressors*) coded "zero" for 1 or 0 stressors (*earthquake stressors = 0*) and coded "one" for 2 or more stressors (*earthquake stressors = 1*). Close to half (42%) of children in the earthquake group ($n = 293$) had parents who reported 2 or more stressors.

3.3.4. Covariates

All analytic models included a set of child and family covariates, including child gender and age, mother's and father's education, and a binary variable indicating whether a child had prior experience in an early education setting. In addition, we adjusted for a set of classroom-level covariates including teacher age, years of overall teaching experience, years of teaching experience in early education settings, experience teaching in a private school setting, experience teaching in a government sponsored preschool, and teacher education, including receipt of a university degree and receipt of an additional teaching certificate.

A municipality covariate measuring municipality-level socioeconomic status was also used in analyses for research question 1. We created a composite by calculating the standardized average of five survey items from the National Socioeconomic Characterization Survey: 1) percent of poor households in the municipality; 2) average total household income; 3) percent of 18 year-old residents with at least a high school degree; 4) percent of residents with private health care and; 5) percent of households that are over-crowded. A principal components analysis suggested only the first principal component rose above an eigenvalue of 1, revealing one dimension of information among the items. The scale had high internal consistency with a Cronbach's alpha of 0.81.

3.4. Data-analytic plan

3.4.1. Research question 1: propensity score analysis

3.4.1.1. Estimating the propensity scores. Although the earthquake was an unplanned, naturally occurring event, the comparison between Cohort C and Cohort E differs from other natural experiments in important ways (Shadish et al., 2002). In most natural experiments, the experience of the treatment—in this case, the earthquake—is exogenous to all other individual characteristics in the sample, allowing for an unbiased estimate of the treatment effect (Murnane & Willett, 2010; Shadish et al., 2002); this was not the case in the current situation. The municipality selection process for the cohorts took place at two different time points; in 2008 for Cohort C and in 2009 for Cohort E. While the selection criteria for the municipalities were the same in each year (see the Procedures section for details) it is possible that the municipalities (and thus children within them) selected in 2008 were different than those chosen in 2009 on characteristics not considered in the selection process. Any differences between these two groups could bias estimates of the relationship between earthquake exposure and children's outcomes.

Indeed, an inspection of the descriptive statistics in Table 1 reveals important demographic differences between the earthquake and comparison groups. For example, the children in the comparison group were, on average, one month older than those in the earthquake group ($t = 2.809$, $p < 0.01$). As age is positively related with performance on cognitive measures, this imbalance could lead the comparison group to have higher scores on the outcome measures, regardless of the earthquake. An unadjusted comparison of the two groups could result in an estimate of the earthquake effect that would be larger than the true effect in the population.

To adjust for such observed differences between the treatment and comparison groups, we employed a propensity score analysis. A propensity score is the estimated probability of assignment to a treatment group conditioned on a set of observed covariates (Rosenbaum & Rubin, 1983). To estimate the propensity scores, we fit a logistic regression model in which the dichotomous variable describing whether or not a child experienced the earthquake before starting preschool (*earthquake*) was predicted by the child-, family-, and teacher-level covariates. Given well-measured covariates and a correctly specified logit model, the propensity score can be thought of as the summary statistic of the systematic selection into the earthquake and control groups conditioned on observed covariates (Murnane & Willett, 2010).

We incorporated the propensity scores as inverse probability weights in multi-level regression models estimating the earthquake effect. In comparison to other possible propensity score methods, such as nearest neighbor matching, weighting by the inverse of the propensity score is thought to be more efficient strategy primarily because it does not require cases without an exact match in the opposing groups to be dropped from the analyses (Hirano, Imbens, & Ridder, 2003; Murnane & Willett, 2010). Observations in the earthquake group were given a weight of *1/p* and observations in the comparison group were given a weight of *1/(1-p)*, where (*p*) is the estimated propensity score (Murnane & Willett, 2010). Children in the earthquake group with high propensity scores were undercounted, while comparison cases with high propensity scores were over-counted in the analyses, effectively comparing children in the earthquake group with children in the comparison group who are most similar to them (Crosnoe, 2009).

3.4.1.2. Evaluating the success of the propensity scores. To test whether the propensity score analysis successfully corrected the sampling differences observed between the two groups (Austin, 2011), we compared balance across the covariates between the earthquake and comparison group in unweighted versus weighted samples. Following standards established by other scholars, we first tested whether the inverse probability weights decreased the number of statistically significant differences between the samples (Austin, 2011). We then explored whether the weights decreased the magnitude of the observed differences between the groups. Based on established standards in the field (Harding, 2015; McCormick, Cappella, O'Connor, Hill, & McClowry, 2015), we aimed for the weighted sample to achieve standardized mean differences between the two groups of no more than 0.05 *SDs*, and *SD* ratios between 0.9 and 1.1 (for continuous variables only).

3.4.1.3. Estimating the relationship between children's earthquake exposure and early learning outcomes. To address research question 1, we fit multi-level regression models that estimated the relationship between children's earthquake exposure and their early learning outcomes. The predictor of interest was the binary indicator *earthquake;* its corresponding coefficient captured the effect of the earthquake on child outcomes at the start of preschool. These models were weighted by the inverse propensity scores as described above to address sampling differences across the earthquake and comparison groups. We also controlled for the observed child, family, and teacher characteristics to further remove any potential bias (Hill & Reiter, 2006) and the composite measure of municipality SES. We accounted for the nesting of children within schools by specifying a random, school-level intercept.

3.4.2. Research question 2: multi-level regression analysis

To address research question 2, we restricted the analytic sample to Cohort E and used a multi-level regression model to explore whether parents' experiences of earthquake following the disaster predicted children's outcomes. A traditional mediation analysis would be ideal to test whether the effect of the earthquake on children's outcomes was accounted for by their parents' experiences. However, due to a lack of information on parent stress in Cohort C, it was not possible to fit such models. The regression model employed here tested whether parent stress predicted variation in child outcomes among the earthquake group only, thus providing insight into the relationship between children outcomes and parents' experiences of the disaster.

In these models, the predictor of interest was the binary indicator *earthquake stressors,* where the corresponding coefficient estimated the predicted mean difference in child outcomes between children whose parents experienced 0 or 1 stressors and children whose parents experienced 2 or more stressors. In addition, we controlled for the child, family, and teacher covariates used in the propensity score model and fixed effects for the three municipalities in cohort E. Finally, the multi-level models accounted for the nesting of children within schools with a random, school-level intercept.

3.5. Missing data

Covariate missingness ranged from less than 1% to 10%. Missing data were addressed by adding binary indicators recording whether or not children were missing on each of the covariates; we imputed the sample mean of each covariate for the missing values (Haviland, Nagin, & Rosenbaum, 2007). It is reasonable to assume that children with similar patterns of missingness in the earthquake and comparison groups may look similar on other observed or unobserved characteristics; thus achieving balance across these indicators would help to remove sampling differences between the two groups (Harding, 2015). As such, we included these missingness indicators in the propensity score analysis and predictive models described above.

4. Results

4.1. Effectiveness of the propensity score model

In Table 1 of the online Supplementary materials, we present results of the balance checks used to assess the success with which the propensity score analysis and inverse probability weighting corrected the sampling differences between the earthquake and treatment groups. The weighting successfully resolved nearly all sampling imbalances. In the unweighted sample, twelve covariates showed statistically significant differences across the two groups; in the weighted sample only 1 covariate showed a statistically significant difference at the $\alpha < 0.05$ level. In addition, the weighting procedures decreased the standardized mean differences, and brought the *SD* ratios closer to 1, for nearly all covariates included in the model.

Table 2
Multi-level models estimating the effect of the earthquake on children's cognitive and executive function outcomes.

	Early Language and Literacy				Emergent Mathematics	Executive Function
	Vocabulary	Letter-Word Identification	Dictation	Text Comprehension	Applied Problems	Executive Function Composite
Earthquake	−0.45	−0.46**	−0.10	−0.27*	−0.21	−0.10
Standard Error	0.31	0.17	0.17	0.11	0.38	0.18
Effect Size	*−0.10*	*−0.19*	*−0.05*	*−0.22*	*−0.06*	*−0.06*
N	1327	1322	1345	1350	1271	1377

Note: Table includes unstandardized coefficients, standard errors and effect sizes. All multi-level models (children nested in schools; *school-level* $n = 57$) incorporate inverse probability weights, direct control of child, family, teacher and municipality covariates.

Table 3
Multi-level models describing the association between parent-reported, earthquake-related stressors, and child outcomes among the earthquake group.

	Early Language and Literacy				Emergent Mathematics	Executive Function
	Vocabulary	Letter-Word Identification	Dictation	Text Comprehension	Applied Problems	Executive Function Composite
Earthquake Stressors	−0.23	−0.31~	−0.22	−0.17~	−0.08	−0.22~
Standard Error	−0.33	−0.18	−0.14	−0.10	−0.25	−0.12
Effect Size	*−0.05*	*−0.13*	*−0.11*	*−0.14*	*−0.02*	*−0.13*
N	687	693	680	690	693	692

Note: Table includes unstandardized coefficients, standard errors and effect sizes. All multi-level models (children nested in schools; *school-level* $n = 57$), direct control of child, family, teacher and municipality covariates, and comuna fixed effects.

4.2. Research question 1: estimating the relationship between earthquake exposure and child outcomes

In Table 2, we present results for research question 1. The estimates suggest a negative and statistically significant relationship between children's earthquake exposure and their performance on two of the four language and literacy outcomes: letter-word identification and text comprehension, with effect sizes of −0.19 and −0.22 standard deviations, respectively. These results suggest that, on average, the children who experienced the earthquake performed less well on these assessments of early literacy. The coefficients describing the effect of the earthquake on children's performance in vocabulary, dictation, mathematics, and executive function had negative signs, but were statistically indistinguishable from zero. As such we found insufficient evidence to suggest that the earthquake had an effect on these domains.

4.2.1. Sensitivity analysis: addressing sample imbalances

Although the propensity score model successfully reduced the statistically significant differences between the treatment and comparison groups on the observed covariates, some sample imbalances remained. We conducted one sensitivity analysis to address this threat to validity. Among children with high propensity scores (0.8 and above)—or those children with a high predicted probability of being in the earthquake group, conditional on the covariates—there was very low representation from children in the comparison group ($n = 26$) as compared to the earthquake group ($n = 208$). This suggests that in the high end of the propensity score distribution, there were few comparison group children with similar characteristics to those in the treatment group. This lack of balance could serve to bias the results. To test the sensitivity of the primary estimates to this imbalance, we re-fit the primary models for research question 1 on a reduced sample that excluded all cases with propensity scores above 0.8. These models produced a similar patterns of results to the primary analyses, suggesting the primary estimates are robust to small sample imbalances.

4.3. Research question 2: estimating the relationship between parents' earthquake related-stressors and child outcomes

In Table 3, we report parameter estimates from the multi-level models that test whether parents' reports of the stressors they experienced after the earthquake predicted their children's outcomes. The results suggest that all of the child outcomes were negatively associated with parents' report of stress following the earthquake, controlling for child, family, and teacher demographic covariates. For three outcomes–letter-word identification, text comprehension, and executive function—the coefficients were marginally significant at the $\alpha < 0.10$ level. When compared to children whose parents reported experiencing none or 1 stressor, those children whose parents experienced two or more stressors following the earthquake scored 0.13, 0.14 and 0.13 *SDs* lower on letter-word identification, text comprehension and executive function, respectively. Consistent with the results from research question 1, these findings suggest no relationship between parents' reports of their stressors following the earthquake and their children's performance on the other language and literacy assessments or the mathematics assessments.

5. Discussion

The primary aim of this study was to understand the effect of the 2010 Chilean earthquake on preschool-aged children's cognitive and executive function outcomes. The results from the first set of analyses indicate that, on average, children who experienced the earthquake just prior to starting preschool performed significantly lower on the letter-word identification and text comprehension assessments than children who did not experience the earthquake before starting school (with effect sizes of −0.19 and −0.22 respectively). While we found no evidence to suggest that the earthquake had a statistically significant effect on children's emergent mathematics or their executive function outcomes, the coefficients associated with these effects were all negative, following the same pattern as the language and literacy assessments.

The second set of results indicated that among the earthquake group, parents' reports of the stressors they experienced following the earthquake were negatively related to the same two language and literacy outcomes, as well as executive function skills. Children whose parents reported experiencing two or more earthquake-related stressors had letter-word identification and text comprehension scores that were significantly lower than children whose parents reported only one or zero stressors following the disaster. While not a true test of mediation, these results are consistent with the presence of mediation, as we found the most robust evidence of a relationship between parent stress and child outcomes for those assessments that had the strongest earthquake effects (i.e. letter-word identification and text comprehension).

The results of this study are aligned with past research suggesting that, over all, experiencing an earthquake is negatively related to young children's developmental outcomes shortly after the event. Most studies find that children experience behavior problems and/or a negative effect on their socio-emotional outcomes following exposure to an earthquake (Vogel & Vernberg, 1993). Few studies connect the experience of a natural disaster and children's performance on language skills. In this regard, the findings in this study are unique in the literature.

The results here are consistent with research exploring the effect of trauma and stress, broadly defined, on child outcomes. Specifically, the earthquake's negative effect on children's language and literacy performance is analogous to Sharkey's (2010) result showing that incidents of neighborhood violence decreased children's performance on reading standardized tests. The children in the present study did not live near the epicenter of the earthquake where the damage and destruction were most extreme. Yet the findings indicate that this relatively minor exposure to the earthquake was negatively related to their performance on some early learning outcomes. These results suggest that even minor or indirect exposure to trauma and stress can have an effect on children's performance on cognitive outcomes.

While the results suggest a negative relationship between parent stress and children's executive function, there was little evidence to suggest that the earthquake had a direct effect on children's executive functioning performance. This is somewhat surprising given that extant research suggests a connection between disaster exposure, trauma, and deficits in executive function (Leskin & White, 2007; Sharkey et al., 2012; Silverman & La Greca, 2002). The absence of a relationship with executive function in the present study may have to do with the assessments used in the UBC evaluation. The three tasks in the UBC executive function battery measure cognitive flexibility and cognitive inhibitory control (see measure sections for more detail). These dimensions of executive function are somewhat different than those used by other studies reviewed here. Specifically, some executive function batteries focus primarily on effortful control (Sharkey et al., 2012). According to Blair and Razza (2007), effortful control includes the "automatic or nonconscious" control of emotional responses (p. 648). By contrast, dimensions of executive function like cognitive inhibitory control capture the "volitional control of cognitive self-regulatory processes" (Blair & Razza, 2007; p. 648). There may be more active cognition involved in cognitive inhibitory control, while effortful control can be automatic. The results presented here may suggest that stress associated with a traumatic event is less likely to impact cognitive flexibility and cognitive inhibitory control.

5.1. *Child outcomes and parent earthquake-related stress*

Young children rely on their parents and caregivers to help them regulate their own emotions and stress response during traumatic experiences. When parents face stressors following a natural disaster, they may have a more difficult time helping their children to process and recover from the event (Osofsky & Reuther, 2013). Parents of children in the earthquake-exposed cohort reported stressors such as loss of income, fear that family and friends had been hurt, and food insecurity as a result of the earthquake and the disaster's aftermath. These circumstances may have led to increased stress in the home, impacting their children's ability to perform on cognitive outcomes. While we were unable to test for mediation, the results from the second set of analysis were consistent with the hypothesis that parents' stress and experiences are one pathway through which children are affected by natural disasters.

The relationship between parents' reports of their own stressors and their children's reactions to the earthquakes outcome also underscores the importance of research that includes direct assessments of child outcomes. Many studies that explore how natural disasters affect children rely on parent or teacher reports of child outcomes. While parents and teachers are sources of invaluable information about child well-being, caregivers' reports of their children's behavior may be confounded by their own experience of the disaster (Masten & Osofsky, 2010). An observed positive relationship between parents' symptoms and parents' reports of their children's symptoms may be upwardly biased if parents who were themselves more affected by the event are also more likely to perceive their children as doing poorly. This confounding factor is one limitation of most past research. The present study has the benefit of direct assessments of children's cognitive outcomes. As such we can be more confident that the relationships observed here are free of this particular type of bias.

5.2. *Implications and future research*

5.2.1. *Implications for parents and practitioners*

This study suggests that exposure to a natural disaster not only affects children's emotional health, as the extant literature suggests, but may also affect language and literacy outcomes. These findings support the existing call in the field to prepare communities with the tools and knowledge to support children and families in the wake of a natural disaster (Masten & Osofsky, 2010). Arbour, Murray, Arriet, Moraga, & Vega (2011) found that the Chilean government's response to the earthquake, particularly with regard to the needs of children, was efficient and effective. While services were administered throughout Chile, the efforts were concentrated in the most severely affect areas, of which Santiago was not one. The results from this study suggest that even children far from physical danger can be affected by the traumatic event. When possible, disaster relief efforts should be taken to scale, and include regions that fall inside *and* outside of the extreme disaster areas. In these less affected areas, disaster relief geared toward children and families might focus on helping parents understand how to support their children while coping with their own stressors.

5.2.2. *Implications for research*

This work raises several questions for future research. First this study is an example of how existing data can be repurposed to address often hard-to-answer questions about children's outcomes following an earthquake. Quasi-experimental techniques might be employed in other settings to study children's development following an earthquake. In addition, more research is needed to unpack the mechanisms through which natural disasters affect children. Our results provide exploratory evidence to suggest a relationship between parent stress and child outcomes following the disaster. With the necessary data (unavailable in this work), future research should include tests of mediation to confirm whether, and how parents' stress or other social and environmental factors contribute to children's experiences following natural disasters.

In this study, we explored the short-term effect (3–12 weeks after the event) of the earthquake on children's cognitive performance. Questions remain as to whether these effects persist over time. Research suggests that most children's behavioral or socio-emotional symptoms following a disaster fade as time passes (Kronenberg et al., 2010; Vogel & Vernberg, 1993). Future research should employ longitudinal data to explore whether the same pattern holds for the language and literacy outcomes tested here.

5.3. Limitations and additional threats to validity

In comparison to other examples of propensity score methods, this study used relatively few covariates to the estimate propensity scores (Austin, 2011; Thoemmes & Kim, 2011). The current dataset contains a rich set of covariates describing family and child characteristics, such as child health status and home literacy practices. However, in the earthquake comparison group, all of these characteristics were measured after the disaster, meaning they could have been affected by the earthquake and were consequently unsuitable for the propensity score model. As such, this study was limited in available variables to contribute to modeling selection into the treatment.

In addition, there are two potential threats to validity to the propensity score analysis that could not be addressed with empirical strategies. First, the study was timed such that the evaluation team collected data for the earthquake treatment group in 2010 and the earthquake comparison group in 2009. If there was a secular time trend affecting children's outcomes, then the primary analyses may be biased. However, there is little reason to suspect that a secular trend would cause changes to child outcomes as large as the observed earthquake effects over the course of a single year. Further, contextual evidence suggests that beginning in 2006, the Chilean government began making financial investments in programs, services, and organizations that support the development of young children (Cárcamo, Vermeer, Harpe la, van der Veer, & van IJzendoorn, 2014). If successful, the presence of these services may have led to a general positive trend in child cognitive skills over time, which would cause the analyses to *underestimate* the negative short-term impact of the earthquake.

Second, it is possible that differences in the testing conditions experienced by children in the earthquake group and the comparison group pose a threat to validity. However, documentation from the evaluation of UBC suggests that the physical infrastructure of nearly all of the schools in the intervention were untouched by the earthquake, and the testing conditions were largely the same across the groups (Moreno et al., 2011).

6. Conclusions

The 2010 Chilean earthquake was one of the strongest in history, and caused devastation throughout the country. Even though Santiago is over 500 kilometers from the area that experienced the most extreme shaking, we found a negative relationship between preschool-aged children's language outcomes and their exposure to the earthquake. This study contributes to the small but growing body of research documenting that, contrary to prior belief, young children may suffer consequences from the trauma of a natural disaster. Understanding how natural disasters impact young children and developing ways to support them in the aftermath, Anderson (2005) argues, should be at the top of the disaster research agenda. Indeed, the results of this study, in tandem with extant research, suggest that addressing the needs of children's caregivers, expanding relief efforts, and taking a holistic approach to child development may be effective strategies to successfully support children and families in post-disaster settings. However, further research is still necessary to understand how these and other strategies can serve to encourage healthy child development in the midst of environmental stress.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ecresq.2016.08.004.

References

Anderson, W. A. (2005). Bringing children into focus on the social science disaster research agenda. *International Journal of Mass Emergencies and Disasters*, *23*(3), 159–175.

Arbour, M. C., Murray, K., Arriet, F., Moraga, C., & Vega, M. C. (2011). Lessons from the Chilean earthquake: How a human rights framework facilitates disaster response. *Health and Human Rights Journal*, *13*(1), 62–73. http://dx.doi.org/10.1080/19345747.2015.1109013

Austin, P. C. (2011). An introduction to propensity score methods for reducing the effects of confounding in observational studies. *Multivariate Behavioral Research*, *46*(3), 399–424. http://dx.doi.org/10.1080/00273171.2011.568786

Barata, M. C. (2011). *Executive function skills in Chilean preschool children*. Cambridge, MA: Harvard University.

Barrionuevo, A., & Robbins, L. (2010). *1.5 million displaced after Chile quake*. The New York Times. Retrieved from <http://www.nytimes.com/2010/02/28/world/americas/28chile.html/> 27.02.10

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*(2), 647–663. http://dx.doi.org/10.1111/j.1467-8624.2007.01019.x

Bonanno, G. A., & Mancini, A. D. (2008). The human capacity to thrive in the face of potential trauma. *Pediatrics*, *121*(2), 369–375. http://dx.doi.org/10.1542/peds.2007-1648

Breslau, N., Kessler, R. C., Chilcoat, H. D., Schultz, L. R., Davis, G. C., & Andreski, P. (1998). Trauma and posttraumatic stress disorder in the community: The 1996 detroit area survey of trauma. *Archives of General Psychiatry*, *55*(7), 626–632. http://dx.doi.org/10.1001/archpsyc.55.7.626

Buchanan, T. K., Casbergue, R. M., & Baumgartner, J. J. (2009). Young children's demonstrated understanding of hurricanes. In K. E. Cherry (Ed.), *Lifespan perspectives on natural disasters* (pp. 3–26). New York, NY: Springer.

Cárcamo, R. A., Vermeer, H. J., Harpe la, C. D., van der Veer, R., & van IJzendoorn, M. H. (2014). The quality of childcare in Chile: Its stability and international ranking. *Child & Youth Care Forum*, *43*(6), 747–761. http://dx.doi.org/10.1007/s10566-014-9264-z

Catani, C., Gewirtz, A. H., Wieling, E., Schauer, E., Elbert, T., & Neuner, F. (2010). Tsunami, war, and cumulative risk in the lives of Sri Lankan schoolchildren. *Child Development*, *81*(4), 1176–1191. http://dx.doi.org/10.1111/j.1467-8624.2010.01461.x

Chemtob, C. M., Nomura, Y., & Abramovitz, R. A. (2008). Impact of conjoined exposure to the World Trade Center attacks and to other traumatic events on the behavioral problems of preschool children. *Archives of Pediatrics & Adolescent Medicine*, *162*(2), 126–133. http://dx.doi.org/10.1001/archpediatrics.2007.36

Cole, S. F., O'Brien, J. G., Gadd, M. G., Ristuccia, J., Wallace, D. L., & Gregory, M. (2005). *Helping traumatized children learn: supportive school environments for children traumatized by family violence*. Boston, MA: Massachusetts Advocates for Children.

Crosnoe, R. (2009). Low-income students and the socioeconomic composition of public high schools. *American Sociological Review*, *74*(5), 709–730. http://dx.doi.org/10.1177/000312240907400502

DePrince, A. P., Weinzierl, K. M., & Combs, M. D. (2009). Executive function performance and trauma exposure in a community sample of children. *Child Abuse & Neglect*, *33*(6), 353–361. http://dx.doi.org/10.1016/j.chiabu.2008.08.002

DeVoe, E. R., & Klein, T. P. (2011). Young children in the aftermath of the world trade center attacks. *Psychological Trauma: Theory, Research, Practice, and Policy*, *3*(1), 1–7. http://dx.doi.org/10.1037/a0020567

Deering, C. G. (2000). A cognitive developmental approach to understanding how children cope with disasters. *Journal of Child and Adolescent Psychiatric Nursing*, *13*(1), 7–16. http://dx.doi.org/10.1111/j.1744-6171.2000.tb00070.x

Diamond, A., & Taylor, C. (1996). Development of an aspect of executive control: Development of the abilities to remember what I said and to do as I say, not as

I do. *Developmental Psychology*, http://dx.doi.org/10.1002/(SICI)1098-2302(199605)29:4%3C315:AID-DEV2%3E3.0.CO;2-T
Earthquake Engineering Research Institute, (2010). Learning from earthquakes: The Mw 8. 8 Chile earthquake of February 27, 2010. Retrieved from https://www. eeri. org/site/images/eeri_newsletter/2010_pdf/Chile10_insert. pdf 2010.
Endo, T., Shioiri, T., Toyabe, S., Akazawa, K., & Someya, T. (2007). Parental mental health affects behavioral changes in children following a devastating disaster: A community survey after the 2004 Niigata-Chuetsu earthquake. *General Hospital Psychiatry*, *29*(2), 175–176. http://dx.doi.org/10.1016/j.genhosppsych.2006.09.006
Goenjian, A. K., Pynoos, R. S., Steinberg, A. M., Najarian, L. M., Asarnow, J. R., Karayan, I., . . . & Fairbanks, L. A. (1995). Psychiatric comorbidity in children after the 1988: Earthquake in Armenia. *Journal of the American Academy of Child & Adolescent Psychiatry*, *34*(9), 1174–1184. http://dx.doi.org/10.1097/00004583-199509000-00015
Harding, J. F. (2015). Increases in maternal education and low-income children's cognitive and behavioral outcomes. *Developmental Psychology*, *51*(5), 583–599. http://dx.doi.org/10.1037/a0038920
Haviland, A., Nagin, D. S., & Rosenbaum, P. R. (2007). Combining propensity score matching and group-based trajectory analysis in an observational study. *Psychological Methods*, *12*(3), 247. http://dx.doi.org/10.1037/1082-989x.12.3.247
Hill, J., & Reiter, J. P. (2006). Interval estimation for treatment effects using propensity score matching. *Statistics in Medicine*, *25*(13), 2230–2256. http://dx.doi.org/10.1002/sim.2277
Hirano, K., Imbens, G. W., & Ridder, G. (2003). Efficient estimation of average treatment effects using the estimated propensity score. *Econometrica*, *71*(4), 1161–1189. http://dx.doi.org/10.1111/1468-0262.00442
Kaplan, I., Stolk, Y., Valibhoy, M., Tucker, A., & Baker, J. (2016). Cognitive assessment of refugee children: Effects of trauma and new language acquisition. *Transcultural Psychiatry*, *53*(1), 81–109. http://dx.doi.org/10.1177/1363461515612933
Kronenberg, M. E., Hansel, T. C., Brennan, A. M., Osofsky, H. J., Osofsky, J. D., & Lawrason, B. (2010). Children of Katrina: Lessons learned about postdisaster symptoms and recovery patterns. *Child Development*, *81*(4), 1241–1259. http://dx.doi.org/10.1111/j.1467-8624.2010.01465.x
Leskin, L. P., & White, P. M. (2007). Attentional networks reveal executive function deficits in posttraumatic stress disorder. *Neuropsychology*, *21*(3), 275–284. http://dx.doi.org/10.1037/0894-4105.21.3.275
Masten, A. S., & Narayan, A. J. (2012). Child development in the context of disaster, war, and terrorism: Pathways of risk and resilience. *Annual Review of Psychology*, *63*(1), 227–257. http://dx.doi.org/10.1146/annurev-psych-120710-100356
Masten, A. S., & Obradovic, J. (2008). Disaster preparation and recovery: Lessons from research on resilience in human development? *Ecology and Society*, *13*(1), 9–24.
Masten, A. S., & Osofsky, J. D. (2010). Disasters and their impact on child development: Introduction to the special section. *Child Development*, *81*(4), 1029–1039. http://dx.doi.org/10.1111/j.1467-8624.2010.01452.x
Masten, A. S., & Wright, M. O. (2009). Resilience over the lifespan. In J. W. Reich, A. J. Zautra, & J. S. Hall (Eds.), *Handbook of adult resilience* (pp. 213–237). New York: The Guilford Press.
McCormick, M. P., Cappella, E., O'Connor, E., Hill, J. L., & McClowry, S. (2015). Do effects of social-emotional learning programs vary by level of parent participation? Evidence from the randomized trial of INSIGHTS. *Journal of Research on Educational Effectiveness*, http://dx.doi.org/10.1080/19345747.2015.1105892
Moreno, L., Treviño, E., Yoshikawa, H., Mendive, S., Reyes, J., Godoy, F., . . . & Rolla, A. (2011). Aftershocks of Chileñs earthquake for an ongoing, large-scale experimental evaluation. *Evaluation Review*, *35*(2), 103–117. http://dx.doi.org/10.1177/0193841X11400685
Muñoz-Sandoval, A. F., Woodcock, R. W., McGrew, K. S., & Mather, N. (2005). *Batería III Woodcock-Muñoz*. Itasca, IL: Riverside Publishing.
Murnane, R. J., & Willett, J. B. (2010). *Methods matter: improving causal inference in educational research*. New York: Oxford University Press.
Norris, F. H., Friedman, M. J., Watson, P. J., Byrne, C., Diaz, E., & Kaniasty, K. (2002). 60,000 disaster victims speak: Part I. An empirical review of the empirical literature, 1981–2001. *Psychaitry*, *65*(3), 207–239. http://dx.doi.org/10.1521/psyc.65.3.207.20173
Osofsky, J. D., & Reuther, E. T. (2013). Young children and disasters. *Zero to Three*, *34*(2), 46–54.
Osofsky, J., Kronenberg, M., Bocknek, E., & Hansel, T. C. (2015). Longitudinal impact of attachment-related risk and exposure to trauma among young children after Hurricane Katrina. *Child & Youth Care Forum*, http://dx.doi.org/10.1007/s10566-015-9300-7, 1–18
Peek, L., & Stough, L. M. (2010). Children with disabilities in the context of disaster: A social vulnerability perspective. *Child Development*, *81*(4), 1260–1270. http://dx.doi.org/10.1111/j.1467-8624.2010.01466.x
Peek, L. (2008). Children and disasters: Understanding vulnerability, developing capacities, and promoting resilience—An introduction. *Youth and Environments*, *18*(1), 1–29. http://dx.doi.org/10.7721/chilyoutenvi.18.1.0001
Proctor, L. J., Fauchier, A., Oliver, P. H., Ramos, M. C., Rios, M. A., & Margolin, G. (2007). Family context and young children's responses to earthquake. *Journal of Child Psychology & Psychiatry*, *48*(9), 941–949. http://dx.doi.org/10.1111/j.1469-7610.2007.01771.x
Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, *70*(1), 41. http://dx.doi.org/10.2307/2335942
Sagi-Schwartz, A. (2008). The well being of children living in chronic war zones: The Palestinian—Israeli case. *International Journal of Behavioral Development*, *32*(4), 322–336. http://dx.doi.org/10.1177/0165025408090974
Scheeringa, M. S., & Zeanah, C. H. (2001). A relational perspective on PTSD in early childhood. *Journal of Traumatic Stress*, *14*(4), 799–815. http://dx.doi.org/10.1023/A:1013002507972
Schrank, F. A., McGrew, K., Ruef, M. L., Muñoz-Sandoval, A. F., & Woodcock, R. W. (2005). *Overview and technical suppl. (Bateria III Woodcock-Muñoz assessment service bulletin no. 1)*. Itasca, IL: Riverside.
Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston: Houghton Mifflin.
Sharkey, P. T., Tirado-Strayer, N., Papachristos, A. V., & Raver, C. C. (2012). The effect of local violence on children's attention and impulse control. *American Journal of Public Health*, *102*(12), 2287–2293. http://dx.doi.org/10.2105/AJPH.2012.300789
Sharkey, P. (2010). The acute effect of local homicides on children's cognitive performance. *Proceedings of the National Academy of Sciences*, *107*(26), 11733–11738. http://dx.doi.org/10.1073/pnas.1000690107
Silverman, W. K., & La Greca, A. M. (2002). Children experiencing disasters: Definitions, reactions, and predictors of outcomes. In A. M. La Greca, E. M. Vernberg, & M. C. Roberts (Eds.), *Helping children cope with disasters and terrorism* (pp. 11–34). Washington, D.C: American Psychological Association.
Snook, M. (2010). *Chile's earthquake: the view from Santiago*.. Retrieved from <http://www.theguardian.com/commentisfree/cifamerica/2010/feb/28/chile-earthquake-santiago/> 28.02.10
Thoemmes, F. J., & Kim, E. S. (2011). A systematic review of propensity score methods in the social sciences. *Multivariate Behavioral Research*, *46*(1), 90–118. http://dx.doi.org/10.1080/00273171.2011.540475
U.S Geological Survey. (2015, January 28). Magnitude 8.8 - Offshore bio-bio, Chile. Retrieved from http://earthquake.usgs.gov/earthquakes/eqinthenews/2010/us2010tfan/#details.
Vogel, J., & Vernberg, E. (1993). Part 1: Children's psychological reponses to disasters. *Journal of Clinical Child Psychology*, *22*(4), 464–484. http://dx.doi.org/10.1207/s15374424jccp2204_7
Woodcock, R. W., Mun˜oz-Sandoval, A. F., Ruef, M., & Alvarado, C. G. (2005). *Woodcock Mun˜oz Language Survey—Revised*. Itasca, IL: Riverside Publishing.
Yoshikawa, H., Leyva, D., Snow, C. E., Treviño, E., Barata, M. C., Weiland, C., . . . & Arbour, M. C. (2015). Experimental impacts of a teacher professional development program in Chile on preschool classroom quality and child outcomes. *Developmental Psychology*, *51*(3), 309–322. http://dx.doi.org/10.1037/a0038785