Preliminary and incomplete

Child Height After a Natural Disaster

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1. Introduction

The impact of unanticipated shocks on health in very early life and their implications for health in later life is of substantial interest to health and population scientists. Existing work in economics and demography suggests that birth outcomes are worse for children whose mothers are exposed to hardships (stress, nutrition restrictions) during pregnancy, but it is less clear whether these exposures affect physical health after birth. Using extremely rich longitudinal survey data collected in Indonesia before and after the 2004 Sumatra-Andaman earthquake and subsequent tsunami, this study investigates the impact of exposure to a large-scale natural disaster on the linear growth of young children.

A number of plausible biological pathways and studies link experiences of stress and nutritional adversity during pregnancy to adverse physical health outcomes. Exposure to acute or chronic stressful experiences results in the release of hormones, particularly of the hypothalamic-pituitary-adrenal (HPA) axis that, in high concentrations, have been linked to adverse health outcomes, such as premature labor and low birthweight (Beydoun and Saftlas 2008). Studies of the Dutch Hunger Winter suggest that severe restrictions in caloric intake during late pregnancy may result in low birthweight, as well as low adult stature (Stein 1975, Ravelli et al. 1998, Ravelli et al. 1999, Roseboom et al. 2001, Rooij et al. 2010).

A growing literature in economics and demography has used quasi-experimental designs to investigate stressful experiences during pregnancy affects the physical health of offspring. These studies use an unexpected source of stress, such as man-made shocks (Lauderdale 2006, Camacho 2008, Brown 2012) or natural disasters (Torche 2011), combined with birth records to compare the outcomes at birth of children in utero at the time of the event to outcomes of comparison groups of children who were either not in utero at the time of the event and/or whose mothers' geographic locations during pregnancy protected them from exposure. The findings are consistent with biological theory, but the magnitude of their estimated impacts is generally small.

These studies provide useful insights into the relationship between prenatal maternal stress and child health, but the use of vital birth records limits the research in two important ways. First, by relying solely on space and time variation in exposure, the studies cannot account for individual heterogeneity in exposure or maternal stress response. Nor do birth records allow the authors to examine the impact of maternal stress on outcomes after birth, so the duration and permanence of impact cannot be assessed.

In this study we use longitudinal survey data collected in Indonesia before and after an unanticipated natural disaster (the data are from the Study of the Tsunami Aftermath and Recovery, or STAR) to study the impact of in utero exposure to the disruption caused by the 2004 Sumatra-Andaman earthquake and tsunami. Our outcome is child height for the period from around fifteen months (when height likely responds to changes in resources) through sixty months (when attained adult stature is already determined). By tracing linear growth of children over time, we are able to assess both the shorter-term impacts of the disruption and subsequent reconstruction as well as the likely longer-term impacts that will stay with the children into adulthood. By using individual level survey data with measures of exposure and maternal stress response we are able to more directly account for individual heterogeneity than is typically possible.

We find that two years after the disaster children whose mothers were in the second (and possibly third) trimester of pregnancy when the earthquake struck are significantly shorter, given their age, than comparable cohorts of children born three or four years earlier. However, within two or three years, these deficits have disappeared. In addition, these patterns demonstrate a dose-response relationship with measures of maternal exposure to the disaster, suggesting that the disaster is responsible for the reduced growth. The evidence indicates remarkable resilience in the face of adversity, possibly as a result of the massive infusion of assistance to the region after the tsunami. There can be little doubt that catch-up growth is possible.

The next section describes the existing literature. It is followed by a description of the disaster, an outline of our empirical approach and data, which precedes a discussion of the empirical results.

2. Literature

Biologists model the relationship between maternal stress and in utero child health by emphasizing the body's neuro-endocrine response to stressful events, particularly the production of hormones by the HPA axis (the hypothalamus, the pituitary gland, and the adrenal glands). In response to a stressor these glands sequentially produce a series of hormones - corticotropin-releasing hormone (CRH) in the hypothalamus, adrenocorticotropin hormone (ACTH) in the pituitary gland, and cortisol in the adrenal glands.

Biopsychosocial models posit that these hormones may trigger premature labor and delivery as well as restrict fetal growth. Controlled studies of animals and observational studies of humans have provided support to these models (a good review can be found in Beydoun and Saftlas 2008). For example, cortisol encourages the production of placental CRH, which in large amounts has been linked with premature labor in primates. Cortisol has also been linked with restricted fetal growth in sheep. Studies of the formerly popular use of glucocorticoids injections in pregnant women (to aid in the development of fetal organs) have found an association between the use of the hormones and incidence of low birthweight.

Recent studies have emphasized the role of fetal programming – that is, prenatal exposures change physiological development in utero in ways that permanently affect health and well-being. The "Barker hypothesis" draws on the biology of in utero human development and highlights the importance of the specific timing of prenatal insults to understand their impact on fetal development (Barker 1995). Drawing on this model, Barker linked nutritional insults during the fetal period to low birthweight. An influential body of research exploiting the quasi-experimental design inherent in the Dutch Hunger Winter found evidence of birthweight reductions in children exposed to nutritional restrictions late in the fetal period (however the study was unable to separate the effects of pre-natal and post-natal nutritional stress) (Stein 1975, Ravelli et al. 1998, Ravelli et al. 1999, Roseboom et al. 2001, Rooij et al. 2010).[2]

An emerging body of research has sought to identify causal mechanisms in a quasi-experimental framework by relating birth outcomes to maternal stress caused by exposure to natural or man-made shocks. These studies have found that in utero exposure to maternal stress is associated with small reductions in birth weight. Treating the location and timing of landmine explosions in Colombia as random, Camacho (2008) documents a 9 gram reduction in birth weight for children whose mothers were exposed to the stress generated by random landmine explosions in their local area during the child's second trimester. Utilizing an earthquake in Chile, Torche (2011) finds that in utero exposure to the disaster resulted in a 50 gram reduction in birth weight and an increase in the incidence of low birth weights from 4.7 to 6.5%. Work in the United States, using the 9/11 terrorist attacks on New York City and Washington, D.C. as exogenous stressful events have found similar but smaller impacts on birth weight and the likelihood of low birth weight (Lauderdale 2006, Brown 2012).

Scientists and policy makers are interested in the linear growth (growth in height) of young children for a number of reasons. Research suggests that height achieved by the first 2-3

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[2] Barker and the Dutch Hunger studies also found evidence of a link between in utero nutritional insults and later life outcomes (e.g.., elevated risk of cardio-vascular disease).

years of life is strongly associated with ultimate adult height (Martorell 1995, 1999; Habicht, Martorell, and Rivera 1995; Moore et al. 2001; Shrimpton et al. 2001; Bozzoli, Deaton, and Quintana-Domeque 2009). Research from a controlled experiment suggests that children potentially exposed to the protein and calorie-rich nutrition intervention in the INCAP study grew more in the first three years of life (but not after) and remained taller years later (Habicht, Martorell, and Rivera 1995). Because adult height is strongly correlated with socio-economic outcomes, health, and birth outcomes of the next generation (Strauss and Thomas 1998), linear growth in the first years of life may be an important determinant of well-being across the life course.

Several microempirical studies provide recent evidence to this effect. Using longitudinal data of children in rural Zimbabwe and variation in age of exposure to population-level nutrition shocks, Alderman, Hoddinott, and Kinsey (2006) find that children with lower height as pre-schoolers have lower attained grades in school in their adolescence. Similarly Maluccio et al. (2009) find that children potentially exposed in the first 0-3 years of life to a protein-rich nutrition intervention in rural Guatemala (1969-1977 INCAP study) have higher attained grades in school (for females) and higher verbal and non-verbal test scores as adults. Hoddinott et al. (2008) also find that potentially exposed male children had higher adult wages.

Another important question of early life health is whether children who experience a period of reduced growth early in childhood can experience a period of accelerated growth shortly thereafter. This phenomenon is often referred to as linear “catch-up growth” since the child is believed to be “catching up” after a period of reduced growth. Laboratory studies of animal growth controlling nutrition inputs suggest that animals can experience accelerated growth following periods of restricted in utero and post-birth nutrition if the nutrition environment is improved to “normal” feeding amounts (Hector and Nakagawa 2012).

These findings are supported by early epidemiology studies (reviewed by Martorell, Khan, and Schroeder 1994), which find that children in developing countries who remain in the environments in which they initially experienced relatively slow growth remain short into adulthood; however children who move to environments with higher quality nutrition (i.e., the United States and Sweden) appear to experience faster growth. Adair (1999) compares the prevalence of stunting in a cohort of children in the Philippines and finds that the prevalence decreased significantly between the age of 2 and 8.5 years and between 8.5 and 12 years of age, which suggests that linear catch-up growth may have occurred for very short children. Her findings are however limited by the possibility of selective migration from her sample.

A number of authors have also attempted to identify the existence of linear catch-up growth by simply analyzing the relationship between initial child height and subsequent height (examples include Adair; Hoddinott and Kinsey (2001); Federov and Sahn 2005; Yamano, Alderman, and Christiaensen 2005; Mani 2008; and Handa and Peterman 2012). Most have found that initial height is negatively correlated with subsequent height, but not fully so.

The authors generally interpret this as evidence of partial catch-up growth, but as Hoddinott and Kinsey acknowledge, because no specific negative shock to linear growth is used to identify likely candidates for catch-up growth, it is not clear whether the studies are identifying true catch-up growth, or simply a process of regression to the mean across a population unaffected by growth restrictions early in life. This problem highlights the need for a study design that exploits an identifiable exogenous shock to linear growth after which multiple observations on height are available – an approach taken in this study.

3. The Sumatra-Andaman earthquake and tsunami

The 2004 Sumatra-Andaman earthquake occurred on December 26, 2004, measuring 9.1 in moment magnitude scale, with an epicenter 100 miles off the west coast of the province of Aceh in Indonesia. The water displaced by the earthquake resulted in a series of tsunamis, the first of which reached the coast of Aceh 15 minutes after the earthquake. The tsunamis ultimately engulfed 800 km of coastline in Aceh and neighboring North Sumatra and reached 4-6 kilometers inland on average. The disaster resulted in massive physical destruction throughout the coastal region, destroying housing and other household assets, food stores, roads and bridges, sanitation infrastructure, and health facilities (IAHRA 2005, World Bank 2005). Water supplies were also disrupted with an estimated 600,000 wells contaminated and 15,000 hand pumps destroyed (Kohl et al. 2005). Widespread destruction of farming and fishing resources reduced the ability of many households to earn income. The disaster also had significant impact on the psycho-social health of the survivors, inducing elevated levels of post-traumatic stress reactivity (Frankenberg et al. 2008). Mortality was high as well, but was concentrated in a relatively narrow area close to the shore (Frankenberg et al 2011).

Two features of the tsunami suggest that variation in exposure to disaster-induced stressors was exogenous. First, the tsunami was unanticipated. Tsunamis are rare and the geological evidence indicates that mainland Sumatra was last hit by a tsunami some 600 years ago. As a result, planning for a tsunami is unlikely to have played a significant role in household or formal sector behavior in Aceh and North Sumatra prior to 2004. Moreover, no warning system for tsunamis was in place prior to the disaster, so selective exposure as a result of anticipation of the tsunami is unlikely.

Second, local variation in the intensity of exposure to the tsunami (and tsunami-induced stressors) was arguably random. Water inundation was a function of a number of geographic factors, including distance to the coast, elevation, slope, the shape of the coast, and the presence of rivers or canals (Ramakrishnan *et al.*, 2005). As a result, otherwise similar mothers and children experienced different intensities of exposure to tsunami-induced stressors for reasons likely uncorrelated with child health.

In the months after the disaster, aid and assistance flowed into impacted communities. Aid was provided by the Indonesian government, foreign governments and multilateral agencies, international and domestic NGOs, and by friends and families. Assistance came in a variety of forms, including cash, clothing, food, and housing, and infrastructure reconstruction. Previous work suggests that the initial aid was heavily targeted to households from communities with high amounts of physical damage and to households that lost assets like houses, productive assets, and liquid assets (Frankenberg et al. 2009b). These findings suggests that families more intensely exposed to disaster-induced stressors also experienced an improving nutrition environment over time, which in turn may have encouraged linear catch-up growth.

4. Data and methods

Data

The data for this study are drawn from the Study of the Tsunami Aftermath and Recovery (STAR), a longitudinal survey of 26,919 baseline individuals in 6,490 households in tsunami affected and unaffected areas of Aceh and North Sumatra. Baseline data was collected by Statistics Indonesia (BPS) as part of their annual population representative cross-sectional Socioeconomic Survey (SUSENAS) prior to the tsunami from January to May 2004. SUSENAS is considered to be a high quality dataset and is widely cited in the literature. The STAR surveys collect demographic, health, and economic data at both the community, household, and individual level. This includes data on household expenditure, assets, and socio-economic characteristics as well as measurements of individual physical and psychological health and exposure to the disaster.

Five follow-up surveys were conducted annually beginning in May 2005, five months after the tsunami. The first survey (STAR1) was conducted on a sample of SUSENAS households in 11 districts in Aceh and 2 districts in North Sumatra, covering 407 enumeration areas in 369 villages. Districts were chosen to include both areas affected by the tsunami and areas not directly affected by the tsunami, which serve as comparison areas.

All surviving respondents from the baseline who remained on the island of Sumatra or moved to the island of Java (the most populous island in Indonesia) or household members living with baseline respondents were targeted for interview. As a result of these tracking efforts, attrition rates are extremely low with 95% of survivors from the baseline survey having been interviewed at least once in the follow up surveys (Sikoki et al. 2008). In addition, conditional on surviving the disaster attrition from the survey does not appear to be selected on pre-tsunami socio-economic characteristics (Frankenberg et al. 2011).

Although the first STAR follow up survey began five months after the tsunami, the survey did not begin collecting anthropometric data until the second follow-up survey (STAR2), 18-29 months after the disaster. From that point, the data were collected in all subsequent waves. (Mounting a large-scale longitudinal survey in the field quickly after a disaster of the magnitude of the earthquake and tsunami is far from straightforward and field conditions for the early STAR surveys were extremely taxing. Attention in the first resurvey focused on finding survivors and tracing those who had been displaced by the earthquake and tsunami as well as those who had chosen to move.) Height and weight was recorded for all respondents by trained enumerators using Seca stadiometers and scales, respectively.

The STAR survey also collected many measures of community, household, and individual exposure to the disaster that are essential in investigating a dose-response relationship between disaster exposure and child health. These include measures of the geographic proximity of the mother's pre-disaster community (i.e., distance to the epicenter of the earthquake and distance to the coast), measures of the mother's tsunami-related experiences (e.g., whether she heard/saw the tsunami), and measures of mother's post-traumatic stress reactivity (PTSR). The PTSR questions were created using seven items in the Post-traumatic Stress Disorder (PTSD) Checklist Civilian Version (Weathers et al. 1993) and have been validated as accurate measures of post-traumatic stress with other potential victims of stressful events (Blanchard et al. 1996, Smith et al. 1999). The items are listed in Figure 1.

Methods

The model estimated in the analysis is the following:

$$\theta_{it} = C_{it}\beta + X_{it}\gamma + \varepsilon_{it} \qquad [1]$$

where θ_{it} is the height of child i at time t expressed as a height-for-age z-score relative to the median well-nourished child following the CDC standard growth charts (Kuczmarski et al, 2000). C_{it} is a vector of birth cohorts specified in birth quarters. X_{it} is a vector of controls that absorbs gender differences that are not captured by the growth standards, differences in birth order, as well as the month and year of the interview in each wave (since each survey spanned about 12 months). ε_{it} captures unobserved heterogeneity and is assumed to be uncorrelated with C_{it} and X_{it}. Estimations are performed using linear regressions, and standard errors are clustered at the level of the enumeration area to account for the sampling strategy used in the baseline survey.

This model compares the standardized height of cohorts in utero at the time of the disaster to an omitted cohort that is too old for their growth to have been affected by the disaster and its aftermath. The estimate of interest is β, which represents the difference in average height θ between children in each birth cohort in C and the comparison cohort, conditional on the controls X. The 2002 cohort is used as the comparison cohort because children in this group are too old to be affected by the disaster (aged 2-3 at the time of the disaster) but young enough not to have been affected by the 1997 Asian financial crisis (they were born around 5 years after the crisis). Results using the 2001 cohort as the comparison cohort will also be reported as a test of the robustness of the primary findings.

The birth cohorts are specified by birth quarters in order to identify the timing of prenatal exposure and to account for seasonality effects. For example, estimates for children born in the first quarter in 2005 will be determined in a regression where the reference group is children born in the first quarter in 2002, while estimates for children born in the second quarter in 2005 will be determined in a separate but otherwise identical regression that uses children born in the second quarter in 2002 as the reference group.

Gestational age at the time of the disaster is estimated by placing conception 9 months before the date of birth. While there was likely to be increase in pre-term births as a result of the tsunami, most of the children born in the first quarter of 2005 would have been in the third trimester at the time of the tsunami. Likewise children born in the second and third quarters of 2005 would have been in the second and first trimesters, respectively.

The analysis will be stratified by the survey wave in which the data were collected (i.e., 2006-2007, 2007-2008, 2008-2009, and 2009-2010). The stratification allows the impacts to be examined annually over a period of four years beginning one and half to two and half years after the disaster. Our first cut on evidence of the impact of exposure to the disaster on child health comes from an analysis of the measurements in 2006-2007, which provides a cumulative measure of linear growth in the two years following the tsunami. Under the assumptions that intensity of exposure to the disaster was random and that the reference cohort is too old to have its growth affected by the disaster, differences in age-adjusted height between the reference and in utero cohorts should reflect the impact of exposure to the disaster and subsequent responses on the linear growth of the in utero cohort. It should also be noted that since no anthropometric data is available before the first round of height measurements, any prevention of growth loss or catch-up growth that occurred for the in utero cohorts prior to the first round of measurements (perhaps due to responses to the disaster) cannot be separately identified. Evidence of catch-up growth comes from the progression of the estimated impacts over the subsequent years of measurements. We interpret increases over time in the estimated coefficient for a young cohort relative to the reference cohort as evidence that accelerated linear growth may have occurred for the young cohort over the sample period.

Earlier work shows that where tsunami-related mortality was extremely high, strength was advantageous for survival (Frankenberg et al. 2011). If taller, stronger children were at a survival advantage, the resulting group of survivors will not be representative of the full pre-disaster distribution of nutritional status. To reduce the risk of selective mortality the analysis is restricted to the sample of children born to mothers from pre-disaster communities where no significant mortality was caused by the disaster. Since the intensity of exposure to the tsunami along the coast varied idiosyncratically in relation to geography and topography (see Section 3), outside of the high mortality communities, variation in tsunami exposure is assumed to be random. As a result, exposure to the disaster within the analytic sample is not selective in ways that may bias results.

The analysis is also restricted to a sample of children who were eligible to be measured in STAR2, the first wave with anthropometric measurements. This restriction means that we do not analyze children who are "new to the survey," that is children born after STAR2, or those who moved into a household of a baseline survey member. This restriction reduces the influence of sample composition change on the estimates.

The sample size and height-for-age summary statistics of children who were born between 2000 and 2005 and were eligible to be measured in 2006-07 (STAR2), by birth cohort, are shown in Table 1. Fewer younger children are present than older children, suggesting that overall fertility was declining. Height-for-age is increasing from 2000 to 2002, possibly due in part to decreasing effects of the 1997 Financial Crisis. They decrease after 2002, possibly due in part to the impact of the disaster. There are 387 children in the sample who were in utero at the time of the disaster (122 born in the first quarter, 138 born in the second quarter, and 127 born in the third quarter). The children born in the second quarter of 2005 are noticeably shorter than other in utero cohorts. Children born in the fourth quarter, who were conceived after the disaster, are noticeably taller than the other 2005 cohorts, which may reflect selective fertility following the disaster.

We begin by presenting results for the average impact of the disaster on the entire analytic sample of children in utero at the time of the disaster using equation 1. We then stratify the analysis by child sex to investigate heterogeneity in the impact of the disaster. To examine evidence for a dose-response relationship, we next stratify by measures of the intensity of exposure to the disaster. Finally, we stratify by measures of pre-disaster socio-economic status in order to more directly investigate whether the general results are driven by likely correlates of pre-existing differences in child health.

5. Results

Average effects of in utero exposures and subsequent child height

We begin with an analysis of the average impacts of the disaster on children who were in utero at the time of the disaster (born in first, second, and third quarters of 2005). Results for children born in each quarter of 2005 are reported in Table 2.

As shown in column 1 of Panel A, about two years after the tsunami, those children who were born in the second quarter of 2005 are 0.79 standard deviations shorter, given age, than those born in the same quarter, but three years earlier, in 2002. A year later, the gap has shrunk to 0.35 standard deviations. Both gaps are different from zero (column 2 marginally so). Five years after the tsunami (column 4), this cohort of children has made up their initial deficit, and in fact are 0.23 standard deviations taller, given age, than the children born in the same quarter in

2002 (this gap is not significantly different from 0). The children born in the other quarters of 2005 do not differ appreciably (or significantly) from the comparable 2002 cohorts, except for the first quarter children, who by 2009-10 are 0.42 standard deviations taller than the reference cohort.

Panel B of Table 2 presents results using the sub-sample of children measured in each wave. For this group of children, those born in the third quarter of 2005 are 0.61 standard deviations shorter in 2006-07, but make up the difference over time, similar to the pattern observed for the second quarter cohort. This suggests that children born in the third quarter of 2005 cohort may also have been negatively affected by the disaster, although it is difficult to be certain because children in that cohort who attrite from the sample in later waves appear to be healthier and taller in 2006-07 than those that continued to be measured.

Panels C and D present results for individual growth between 2006-07 and each subsequent year of measurement (again, relative to the 2002 cohort born in the same quarter). The results suggest that the height deficit that is present for the Q2 children in 2006-07 is made up gradually over the three years that follow.

To investigate whether the results are being driven by time-invariant differences across mothers, Panel E of Table 2 exploits the presence of siblings in our data and presents results for model [1] including mother fixed effects.[3] The children born in the second quarter are now only 0.35 standard deviations smaller in 2006-07 than their siblings born in 2002—a deficit that is marginally significant. Thus, although the results in the previous panels may partially reflect time-invariant differences between mothers, even controlling those differences, the disaster took a negative toll on the early nutritional status early in life of children born in the second quarter of 2005.

To explore whether the results are affected by the choice of reference cohort, Panel F of Table 2 presents results drawing comparisons with children born in the same quarter in 2001. The comparison children would have been, on average, age 4 at the time of the tsunami. Our main conclusions are not affected by the choice of comparison cohort.

To wit, two years after the tsunami, children born in the second quarter of 2005 exhibit a significant deficit in linear growth. But by five years after the tsunami, these children have caught up, and are no shorter, given age, than the 2001 and 2002 cohorts. Exposure to the

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[3] Birth order controls are excluded from these regressions because of their high correlation with the birth cohorts.

tsunami in utero apparently disrupted growth in very early childhood, but the penalty is not permanent, at least as indicated by height for age.

Five years after the tsunami, children who were conceived after the tsunami and born in the fourth quarter of 2005 are also taller for their age than the comparison cohorts. Faster linear growth for the 2005 birth cohort overall may reflect both catch-up growth from an early childhood deficit and the influence of the massive influx of humanitarian aid and the accompanying resources following the tsunami.[4]

Results stratified by gender of the child are reported in Table 3. For the cohort born in the second quarter of 2005, the height deficit in 2006-07 is larger for females. But no gender differences exist for that cohort one year later, nor are they present five years after the tsunami. Among those born in the first quarter of 2005, patterns for males and females are somewhat different (relative to the 2002 cohort, males are significantly shorter, given age, three years after the tsunami and roughly the same height five years after the tsunami, whereas females are not shorter initially, and they are in fact taller than the older cohorts five years after the tsunami). Because these gender differences are not apparent when comparisons are drawn with the 2001 cohort (not shown), we do not focus on them.

Differential effects within cohort by intensity of maternal exposure

Thus far, we identify the impact of the tsunami by drawing comparisons across different cohorts. In principle, other contemporaneous changes may drive the cohort-specific differences, in which case we may be falsely attributing the differences to the tsunami and its aftermath. We address this concern in this sub-section.

In order to assure that the patterns reflect the impact of the tsunami we turn to a dose-response research design. Specifically, for the 2005 birth cohort, we compare children who were exposed to greater stress in utero to those exposed to less stress (results for all 2005 cohorts can be found in Appendix Table 1). We examine four indicators that are related to maternal stress around the time of the tsunami: distance between the community of residence at the time of the event and the earthquake epicenter, whether the child's mother saw or heard the tsunami, whether the child's mother was exposed to traumatic aspects of the tsunami (such as being caught in the water or watching others struggle), and the psycho-social health of the child's mother.

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[4] One such program involved distribution of sachets of micronutrient-fortified sprinkles in the second half of 2005 and 2006 (de Pee et al, 2007).

Distance to the epicenter of the earthquake is one indicator of the violence of the shaking that occurred on December 26, 2004. Generally, the greater the distance from the epicenter, the less violent the shaking, although soil type induces variation. Moreover, the extent of damage depends on the quality of construction as well as on the size and nature of the tremors. We stratify the sample of communities into three approximately equal sized groups: the closest communities (within 130km of the epicenter), the furthest communities (greater than 250km from the epicenter) and those in between.

Results that stratify the location of the mother prior to the tsunami into each of these three groups are reported in Panel A of Table 4. The general patterns described above persist. In 2006-07 children born in the second quarter of 2005 are shorter, given age, than their comparable cohorts born in 2002, but by 2009-10, these children have more than made up the deficits. The size of the shorter-term deficit declines as distance from the epicenter of the earthquake increases. Children born to mothers in areas that are within 130km of the epicenter are 1.21 standard deviations shorter than comparable children in the 2002 cohort who were born to mothers living in the same areas. Children born to mothers living further away are 0.45 standard deviations shorter than the 2002 cohort – a difference that is not statistically significant. However, the difference-in-difference between those born to mothers closer and further away from the epicenter, which is about 0.75 standard deviations, is statistically significant. There is no statistical difference in the rate of catch up growth between 2006-7 and 2009-10 across the three locations.

Stratification based on distance to the epicenter separates children by maternal location of residence prior to the tsunami. The remaining stratifications are based on each mother's experience of the earthquake, tsunami and their aftermath. The first two draw from a set of measures of the mother's experience of the disaster. The measures include a number of exposures that are plausibly exogenous and potentially stress-inducing. These include whether the mother saw or heard the tsunami, whether the mother was swept away in the water, whether the mother sustained injuries in the disaster, whether the mother saw friends or family members in the water, whether the mother waded through the aftermath of the disaster, and whether the mother saw dead bodies. The first set of results is stratified by whether the child's mother saw or heard the tsunami. The second set of results is stratified by whether the child's mother experienced any of the above exposures.

Results stratified by maternal exposures are reported in Panels B and C of Table 4. As with the distance from the epicenter, the general patterns hold. In addition, the children born in the second quarter of 2005 to mothers who saw or heard the tsunami are 1.03 standard deviations smaller than the reference cohort two years after the disaster while those born to mothers who did not see or hear the tsunami are only 0.51 standard deviations smaller (the differences are significantly different from one another). Similarly, exposure to any of a number of previously mentioned exposures (including saw or heard the tsunami) is associated with a larger gap in height with the reference cohort (0.94 standard deviations) than being born to a mother who was not exposed (0.36 standard deviations). The evidence using measures of maternal exposure to the disaster is consistent and suggests that the difference in average height of children born in the second quarter of 2005 is related to the mother being exposed in some way to the potentially stressful disaster.

Biological theory posits that it is not exposure to a stressor alone that may harm a child's growth but how the mother's body reacts to the stressor physiologically. Therefore, the second set of results based on mothers' actual experiences during and after the disaster is stratified by the level of stress the mother experienced in the aftermath of the disaster (while the children born in 2005 were in utero). This analysis draws on seven items in the Post Traumatic Stress Disorder (PTSD) Checklist Civilian Version (Weathers et al, 1993) (listed in Figure 1). The questions were administered to all survivors age 15 and older in the first STAR resurvey (conducted in 2005-06). For each item, the respondent indicated whether she had experienced the feeling since the tsunami and if so, how frequently when it was most intense, when it began, whether she still experienced it, and with what frequency.

We combine the responses have been combined to create indices of Post Traumatic Stress Reactivity (PTSR) that are intended to reflect the stress-response continuum (Ruscio et al, 2002; Forbes et al, 2005). To provide an indicator of the maximum level of PTSR after the event, responses to the questions on whether the respondent ever experienced each of the seven symptom were scored from 0 (no occurrence) to 3 (occurred often when it was experienced most intensely) and summed across those symptoms so that the scale ranges from 0 to 21. Symptoms of post-traumatic stress based on this scale are known to be strongly linked to the degree of one's own exposure to trauma (Brewin et al, 2000; Briere, et al, 2000; Norris et al, 2002; Foa et al, 2006) and the symptoms have been linked to trauma and destruction experienced at a broader level. (Davidson and McFarlene, 2006.) Our earlier work shows that this scale is predicted by a broad set of exposures to the trauma of the tsunami in the STAR sample and has a Cronbach's alpha of 0.88 (Frankenberg et al, 2008).[5]

The median PTSR score is 7, with less than 10% of mothers reporting no symptoms and over 10% reporting a score of 13 or more. Results of models that stratify children into three levels of PTSR are reported in Panel D of Table 4. In 2006-07, children born in the second quarter of 2005 to mothers who report higher levels of PTSR are shorter than those born in 2002 (the difference between the coefficients is nearly 1 standard deviation and is significant). By 2009-10, the deficit has disappeared.

The weight of the evidence points to a significant negative impact on linear growth during the fetal period and/or first two years of life for children who were in utero at the time of the tsunami and born in the second quarter of 2005. It is not possible to determine whether the deficits in 2006-07 reflect reduced fetal growth, reduced linear growth after birth, or a combination of both. We conjecture that both forces are at play since children born in the first quarter of 2005 – the time of greatest exposure to the physical and economic disruption – do not show significant deficits by 2006-07. However, children born in both the first and second quarter of 2005 show significant catch-up growth between 2006-07 and 2009-10, suggesting that the influx of resources that accompanied the humanitarian aid effort contributed to improved child health. Indeed, five years after the tsunami, overall, children in both the first and second quarter 2005 birth cohorts had more than made up this deficit in linear growth. Children whose mothers experienced higher levels of PTSR do not catch up to the same degree, suggesting that catch-up in child growth is a function of economic resources of the family and the psycho-social resources of the mother.

Differential effects within cohort by mother's pre-disaster socio-economic status

The preceding analysis puts the spotlight on factors that reflect mother's experiences at the time of the disaster, either because of the geographic location of their homes or because of their experiences at the time of the disaster and their subsequent mental health. We now stratify the analysis by the socio-economic status of the mother's pre-disaster household. This analysis will provide evidence of whether the patterns simply reflect pre-existing differences in socio-economic status that play out as differences in height once these children are born, rather than an effect of the disaster itself. The analyses are stratified by three different measures of socio-

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[5] The 7-item check list is also very highly correlated with a longer 30-item scale administered to the same respondents in the second STAR follow-up.

economic status: mother's pre-disaster household per capita expenditure (PCE) and maternal and paternal education.

The results for household PCE are found in Panel A of Table 5. In 2006-07 children born in second quarter in 2005 to mother's from pre-disaster households with household PCE above the sample median are 1.03 standard deviations smaller than children born in the same quarter in 2002, while children from households with lower PCE are only 0.52 standard deviations smaller. As in our other findings, these differences disappear over time. This suggests that the growth reductions seen in the children born in the second quarter in 2005 was likely driven by exposure to the disaster rather than pre-existing differences due to household resources.[6] This also suggests that the negative impact of the disaster was stronger for children from advantaged households, relative to what they would have experienced in the absence of the tsunami, than was the case for children from poorer households.

The results for maternal education are found in Panel B. In 2006-07 significant height differences are present for children regardless of whether their mothers have more or less than six years of education. However by the next year, the children of less educated mothers appear to catch up and later surpass the older cohort (0.63 standard deviations taller than children born in 2002), while children of more educated mothers do not catch up until 2008-2009. The results for father's education (Panel C) are similar.

For PCE and particularly for parental education, it appears that by 2009-10, children born to parents who were at the more disadvantaged end of the SES spectrum before the tsunami are somewhat more likely to surpass their older counterparts with respect to height for age than are children born to parents who were better off before the tsunami. This pattern may arise because the older children of the better off parents are relatively taller for their age before the tsunami, making it particularly difficult for their younger counterparts to surpass them.

In any event, it does not appear that pre-existing differences in background characteristics explain the results for exposure to the disaster.

6. Conclusions

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[6] There is no evidence to suggest that the findings result from issues with our household PCE measure. In every cohort in the sample born before 2003 (too old for their growth to have been impacted by the disaster) children born to mothers from households with above median PCE are taller on average than children born to mothers from households with below median PCE.

Drawing on extremely rich longitudinal survey data collected before and after the 2004 Andaman-Sumatra earthquake and tsunami, this research has examined the impact of the upheaval and disruption surrounding a large-scale unanticipated shock in utero and during the first two years on subsequent linear growth. To avoid complicating the interpretation by having to take into account selective maternal and infant survival, we focus on children whose mothers were living in areas that were not heavily damaged by the tsunami and where there was essentially no excess mortality due to the earthquake or tsunami.

The evidence points to substantively large and statistically significant deficits in height, given age, two years after the earthquake. These deficits are larger among children whose mothers were exposed to greater levels of stress (broadly defined) as a result of the disaster. However, five years after the disaster, the children had made up the deficits compared to their older peers whose height was plausibly not affected by the disaster.

Our results have at least two key implications. First, although the evidence suggests that to the extent that birthweight was affected by the earthquake or tsunami, the size of the impact was small (Frankenberg et al, 2012), it would be premature to conclude that there were no impacts on child health, as some of the literature has suggested. Second, while we cannot rule out other potential long-term health deficits caused by the disaster, its aftermath, or catch-up growth itself (e.g., cognitive, metabolic), short-term negative impacts on linear growth apparently did not translate into longer-term negative impacts for height. Rather, the evidence indicates that the post-trauma resource environment (again broadly defined) plays an important role in mitigating the short-term health costs of early life exposures to negative shocks. This is an important result both from the point of view of the scientific evidence and also from a policy point of view. The massive reconstruction effort almost surely played a role in the recovery of linear growth and the evidence from STAR suggests very high levels of resilience and that, in the appropriate environment, there is substantial scope for catch-up growth in the first few years of life.

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Figure 1: Post traumatic stress reactivity index

Information collected from each adult (>=15 years years of age) about 7 items from PTSD Checklist Civilian Version.

For each item [A] through [G]

Q1: Since the tsunami, have you ever experienced […]?

If yes,

> **Q2:** During the time you experienced […] most strongly did it occur (1) Rarely (2) Sometimes (3) Often?
>
> **Q3:** When did […] start?
>
> **Q4:** Do you still experience […]? (1) No (2) Sometimes (3) Often?
>
> *If not still experiencing,*
>
> > **Q5:** How long did it last?

Items:

- [A]. Repeated, disturbing memories, thoughts, dreams, or experiences of tsunami
- [B]. Feeling very upset when something reminded you of tsunami
- [C]. Avoiding activities or situations because they reminded you of a stressful experience
- [D]. Feeling as if your future will somehow be cut short
- [E]. Trouble falling or staying asleep
- [F]. Feeling irritable or having angry outbursts
- [G]. Being “super-alert” or watchful or on guard

Table 1: Sample sizes and summary statistics

Children eligible to be measured in 2006-07 (STAR2)

		Low mortality areas	
Birth year	N	Height-for-age (2006-07)	
		Mean	SE
2000	608	-1.86	0.06
2001	551	-1.64	0.06
2002	532	-1.59	0.06
2003	508	-1.70	0.08
2004	508	-1.91	0.08
2005	512	-1.77	0.09
2005Q1	122	-1.83	0.16
2005Q2	138	-2.23	0.16
2005Q3	127	-1.64	0.20
2005Q4	125	-1.12	0.22

Table 2: Height-for-age measures of children born after tsunami by birth cohort

Children born of parents not living in heavily damaged areas pre-tsunami

	Year child measured				Year child measured			
Birth quarter	2006-07	2007-08	2008-09	2009-10	2006-07	2007-08	2008-09	2009-10
	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
Height-for-age								
By sample								
	A. Eligible to measure in 2006-07				*B. Measured in each wave*			
2005Q1	-0.11	-0.17	0.07	0.42	-0.07	-0.02	0.23	0.21
	(0.20)	(0.19)	(0.19)	(0.17)	(0.30)	(0.23)	(0.25)	(0.26)
2005Q2	-0.79	-0.35	0.12	0.23	-0.61	-0.41	-0.07	0.26
	(0.19)	(0.19)	(0.19)	(0.17)	(0.24)	(0.23)	(0.20)	(0.19)
2005Q3	-0.05	-0.15	-0.12	0.27	-0.61	-0.32	-0.09	0.28
	(0.21)	(0.17)	(0.17)	(0.16)	(0.25)	(0.26)	(0.25)	(0.22)
2005Q4	0.23	-0.42	0.07	0.37	0.54	-0.42	-0.15	0.41
	(0.22)	(0.21)	(0.20)	(0.16)	(0.33)	(0.31)	(0.25)	(0.23)
Sample Size	3922	3907	3928	4301	2309	2309	2309	2309
Height-for-age growth since 2006-07								
By sample								
	C. Eligible to measure in 2006-07				*D. Measured in each wave*			
2005Q1		0.15	0.31	0.37		-0.01	0.29	0.26
		(0.20)	(0.16)	(0.17)		(0.27)	(0.20)	(0.23)
2005Q2		0.44	0.57	0.91		0.28	0.60	0.91
		(0.18)	(0.19)	(0.19)		(0.22)	(0.21)	(0.23)
2005Q3		-0.02	0.16	0.60		0.25	0.49	0.79
		(0.23)	(0.22)	(0.20)		(0.26)	(0.22)	(0.22)
2005Q4		-0.57	-0.22	0.09		-0.90	-0.62	-0.04
		(0.26)	(0.25)	(0.23)		(0.28)	(0.25)	(0.31)
Sample Size		3119	3060	3347		2309	2309	2309
Height-for-age: Other specifications								
Eligible to measure in 2006-07 sample								
	E. Mother Fixed Effects				*F. 2001 Reference Cohort*			
2005Q1	-0.27	-0.41	-0.06	0.55	-0.06	-0.06	0.19	0.57
	(0.24)	(0.22)	(0.22)	(0.20)	(0.18)	(0.19)	(0.19)	(0.16)
2005Q2	-0.35	-0.13	0.52	0.37	-0.39	-0.16	0.29	0.27
	(0.19)	(0.23)	(0.20)	(0.16)	(0.19)	(0.19)	(0.20)	(0.16)
2005Q3	0.23	0.03	-0.10	0.40	-0.25	-0.33	-0.17	0.12
	(0.24)	(0.20)	(0.20)	(0.20)	(0.20)	(0.18)	(0.16)	(0.17)
2005Q4	0.59	-0.37	-0.19	0.31	0.14	-0.30	0.32	0.46
	(0.31)	(0.25)	(0.23)	(0.19)	(0.22)	(0.21)	(0.20)	(0.18)
Sample Size	3837	3824	3842	4222	3922	3907	3928	4301
Effective Size	2644	2643	2652	3006				

Note: Errors clustered at the level of mother's pre-disaster enumeration area.

Table 3: Height-for-age measures stratified by gender

Children born after the tsunami of parents not living in heavily damaged areas pre-tsunami

	Year child measured				Year child measured			
Birth quarter	2006-07	2007-08	2008-09	2009-10	2006-07	2007-08	2008-09	2009-10
	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
By sex of child								
	Males				*Females*			
2005Q1	-0.36	-0.71	-0.30	-0.09	0.13	0.36	0.47	0.88
	(0.27)	(0.28)	(0.30)	(0.24)	(0.29)	(0.27)	(0.24)	(0.27)
2005Q2	-0.55	-0.41	0.05	0.11	-1.03	-0.27	0.23	0.36
	(0.25)	(0.28)	(0.23)	(0.22)	(0.27)	(0.24)	(0.33)	(0.26)
2005Q3	-0.09	0.04	-0.30	0.18	-0.05	-0.30	0.07	0.31
	(0.32)	(0.27)	(0.25)	(0.23)	(0.30)	(0.25)	(0.25)	(0.23)
2005Q4	0.39	-0.18	0.21	0.33	0.10	-0.70	-0.09	0.47
	(0.32)	(0.26)	(0.25)	(0.23)	(0.30)	(0.33)	(0.32)	(0.26)
Sample Size	2031	2026	2033	2197	1891	1881	1895	2104

Note: Errors clustered at the level of mother's pre-disaster enumeration area. Sample of children eligible to be measured in 2006-07. 2002 reference cohort.

Table 4: Height-for-age measures stratified by exposures to disaster

Children born in 2nd or 3rd quarter of 2005 to parents not living in heavily damaged areas pre-tsunami

	Year child measured				Year child measured				Year child measured			
Birth quarter	2006-07	2007-08	2008-09	2009-10	2006-07	2007-08	2008-09	2009-10	2006-07	2007-08	2008-09	2009-10
	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
A. By distance to the epicenter of earthquake												
	> 250km				*130-250km*				*< 130km*			
2005Q2	-0.45	-0.44	-0.39	0.00	-0.93	0.07	0.79	0.85	-1.21	-0.43	0.50	0.21
	(0.30)	(0.28)	(0.29)	(0.25)	(0.37)	(0.35)	(0.27)	(0.36)	(0.29)	(0.32)	(0.36)	(0.27)
2005Q3	-0.23	-0.05	-0.15	0.25	-0.37	-0.06	-0.37	0.35	0.36	-0.38	0.06	0.24
	(0.25)	(0.23)	(0.22)	(0.19)	(0.46)	(0.39)	(0.41)	(0.27)	(0.50)	(0.33)	(0.42)	(0.37)
Sample Size	1803	1775	1864	1987	1101	1075	1085	1147	995	1035	952	1142
B. By mother's exposure to traumatic aspects of tsunami: Saw/heard tsunami												
	Not exposed				*Exposed*							
2005Q2	-0.51	0.07	0.49	0.71	-1.03	-0.83	-0.17	-0.21				
	(0.25)	(0.23)	(0.26)	(0.25)	(0.30)	(0.30)	(0.24)	(0.19)				
2005Q3	0.05	-0.07	-0.11	0.14	-0.21	-0.32	-0.29	0.54				
	(0.28)	(0.21)	(0.21)	(0.18)	(0.33)	(0.34)	(0.37)	(0.29)				
Sample Size	2337	2446	2506	2682	1482	1362	1312	1516				
C. By mother's exposure to traumatic aspects of tsunami: Any exposure												
	Not exposed				*Exposed*							
2005Q2	-0.36	0.01	0.24	0.46	-0.94	-0.47	0.15	0.18				
	(0.39)	(0.34)	(0.34)	(0.35)	(0.22)	(0.23)	(0.20)	(0.18)				
2005Q3	-0.55	-0.16	-0.20	0.31	0.25	-0.18	-0.11	0.28				
	(0.30)	(0.29)	(0.27)	(0.22)	(0.27)	(0.24)	(0.25)	(0.22)				
Sample Size	1305	1351	1427	1540	2514	2457	2391	2658				
D. By mother's maximum post-disaster PTSR												
	Low [0-6]				*Medium [7-13]*				*High [14-21]*			
2005Q2	-0.60	-0.26	0.20	0.25	-0.82	-0.32	0.11	0.21	-1.45	-0.75	-0.25	-0.29
	(0.31)	(0.30)	(0.35)	(0.31)	(0.31)	(0.30)	(0.25)	(0.23)	(0.46)	(0.52)	(0.65)	(0.49)
2005Q3	-0.39	-0.11	-0.47	0.04	-0.08	-0.23	0.07	0.39	0.42	0.10	0.02	0.75
	(0.31)	(0.30)	(0.26)	(0.23)	(0.26)	(0.27)	(0.29)	(0.26)	(0.56)	(0.55)	(0.68)	(0.60)
Sample Size	1670	1707	1756	1857	1454	1411	1384	1571	392	381	358	414

Note: Errors clustered at the level of mother's pre-disaster enumeration area. Sample of children eligible to be measured in 2006-07. 2002 reference cohort.

Table 5: Height-for-age measures stratified by pre-disaster socio-economic characteristics

Children born in 2nd or 3rd quarter of 2005 to parents not living in heavily damaged areas pre-tsunami

	Year child measured				Year child measured			
Birth quarter	2006-07	2007-08	2008-09	2009-10	2006-07	2007-08	2008-09	2009-10
	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
A. By mother's pre-disaster household per capita expenditure								
	Below median				*Above median*			
2005Q2	-0.52	-0.11	0.24	0.35	-1.03	-0.59	0.05	0.12
	(0.27)	(0.33)	(0.35)	(0.27)	(0.25)	(0.21)	(0.20)	(0.19)
2005Q3	-0.29	-0.35	-0.16	0.25	0.18	0.04	-0.15	0.29
	(0.26)	(0.27)	(0.22)	(0.22)	(0.30)	(0.24)	(0.28)	(0.22)
Sample Size	2010	2059	2056	2326	1892	1830	1848	1950
B. By mother's education								
	0-6 years				*7+ years*			
2005Q2	-0.76	-0.18	-0.02	0.63	-0.81	-0.60	0.14	-0.10
	(0.27)	(0.26)	(0.31)	(0.24)	(0.25)	(0.24)	(0.20)	(0.20)
2005Q3	0.16	-0.38	0.09	0.33	-0.16	0.06	-0.24	0.37
	(0.28)	(0.24)	(0.24)	(0.21)	(0.27)	(0.24)	(0.25)	(0.21)
Sample Size	1931	1950	2025	2208	1906	1874	1817	2014
C. By father's education								
	0-6 years				*7+ years*			
2005Q2	-0.75	-0.09	0.25	0.68	-0.83	-0.58	0.09	0.02
	(0.28)	(0.31)	(0.35)	(0.30)	(0.26)	(0.23)	(0.20)	(0.19)
2005Q3	0.10	-0.39	-0.13	0.09	-0.19	0.01	-0.12	0.37
	(0.31)	(0.27)	(0.27)	(0.25)	(0.27)	(0.25)	(0.25)	(0.22)
Sample Size	1611	1643	1677	1837	2141	2100	2082	2300

Note: Errors clustered at the level of mother's pre-disaster enumeration area. Sample of children eligible to be measured in 2006-07. 2002 reference cohort.

Appendix Table 1: Height-for-age measures stratified by exposures to disaster (All in utero cohorts)

Children born in 2nd or 3rd quarter of 2005 to parents not living in heavily damaged areas pre-tsunami

	Year child measured				Year child measured				Year child measured			
Birth quarter	2006-07	2007-08	2008-09	2009-10	2006-07	2007-08	2008-09	2009-10	2006-07	2007-08	2008-09	2009-10
	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
A. By distance to the epicenter of earthquake												
	> 250km				*130-250km*				*< 130km*			
2005Q1	-0.45	0.07	-0.14	0.23	0.20	0.01	0.38	0.74	0.03	-1.10	-0.23	0.27
	(0.24)	(0.29)	(0.26)	(0.24)	(0.42)	(0.36)	(0.39)	(0.32)	(0.42)	(0.33)	(0.37)	(0.37)
2005Q2	-0.45	-0.44	-0.39	0.00	-0.93	0.07	0.79	0.85	-1.21	-0.43	0.50	0.21
	(0.30)	(0.28)	(0.29)	(0.25)	(0.37)	(0.35)	(0.27)	(0.36)	(0.29)	(0.32)	(0.36)	(0.27)
2005Q3	-0.23	-0.05	-0.15	0.25	-0.37	-0.06	-0.37	0.35	0.36	-0.38	0.06	0.24
	(0.25)	(0.23)	(0.22)	(0.19)	(0.46)	(0.39)	(0.41)	(0.27)	(0.50)	(0.33)	(0.42)	(0.37)
2005Q4	0.03	-0.80	-0.24	0.16	-0.04	-0.33	-0.10	0.63	0.83	0.37	0.92	0.49
	(0.32)	(0.29)	(0.30)	(0.24)	(0.43)	(0.34)	(0.38)	(0.30)	(0.48)	(0.47)	(0.33)	(0.34)
Sample Size	1803	1775	1864	1987	1101	1075	1085	1147	995	1035	952	1142
B. By mother's disaster experience: Saw/heard tsunami												
	Not exposed				*Exposed*							
2005Q1	-0.01	-0.32	0.31	0.47	-0.21	0.01	-0.38	0.36				
	(0.25)	(0.24)	(0.22)	(0.25)	(0.31)	(0.35)	(0.34)	(0.25)				
2005Q2	-0.51	0.07	0.49	0.71	-1.03	-0.83	-0.17	-0.21				
	(0.25)	(0.23)	(0.26)	(0.25)	(0.30)	(0.30)	(0.24)	(0.19)				
2005Q3	0.05	-0.07	-0.11	0.14	-0.21	-0.32	-0.29	0.54				
	(0.28)	(0.21)	(0.21)	(0.18)	(0.33)	(0.34)	(0.37)	(0.29)				
2005Q4	0.55	-0.14	0.18	0.34	-0.07	-0.71	-0.12	0.44				
	(0.29)	(0.25)	(0.23)	(0.21)	(0.32)	(0.33)	(0.33)	(0.27)				
Sample Size	2337	2446	2506	2682	1482	1362	1312	1516				
C. By mother's disaster experience: Any exposure												
	Not exposed				*Exposed*							
2005Q1	0.09	-0.25	0.25	0.37	-0.18	-0.15	-0.04	0.44				
	(0.33)	(0.35)	(0.30)	(0.30)	(0.25)	(0.24)	(0.23)	(0.22)				
2005Q2	-0.36	0.01	0.24	0.46	-0.94	-0.47	0.15	0.18				
	(0.39)	(0.34)	(0.34)	(0.35)	(0.22)	(0.23)	(0.20)	(0.18)				
2005Q3	-0.55	-0.16	-0.20	0.31	0.25	-0.18	-0.11	0.28				
	(0.30)	(0.29)	(0.27)	(0.22)	(0.27)	(0.24)	(0.25)	(0.22)				
2005Q4	0.44	-0.15	-0.12	0.48	0.19	-0.49	0.18	0.35				
	(0.42)	(0.34)	(0.33)	(0.27)	(0.25)	(0.25)	(0.25)	(0.21)				
Sample Size	1305	1351	1427	1540	2514	2457	2391	2658				
D. By mother's maximum post-disaster PTSR												
	Low [0-6]				*Medium [7-13]*				*High [14-21]*			
2005Q2	-0.04	-0.60	0.02	0.44	0.27	0.30	0.12	0.38	-1.03	-0.66	-0.11	0.50
	(0.25)	(0.29)	(0.30)	(0.27)	(0.38)	(0.33)	(0.25)	(0.28)	(0.77)	(0.62)	(1.05)	(0.75)
2005Q2	-0.60	-0.26	0.20	0.25	-0.82	-0.32	0.11	0.21	-1.45	-0.75	-0.25	-0.29
	(0.31)	(0.30)	(0.35)	(0.31)	(0.31)	(0.30)	(0.25)	(0.23)	(0.46)	(0.52)	(0.65)	(0.49)
2005Q3	-0.39	-0.11	-0.47	0.04	-0.08	-0.23	0.07	0.39	0.42	0.10	0.02	0.75
	(0.31)	(0.30)	(0.26)	(0.23)	(0.26)	(0.27)	(0.29)	(0.26)	(0.56)	(0.55)	(0.68)	(0.60)
2005Q3	0.34	-0.27	-0.02	0.50	0.37	-0.42	0.35	0.00	0.72	0.09	0.35	0.76
	(0.39)	(0.35)	(0.31)	(0.28)	(0.33)	(0.33)	(0.34)	(0.28)	(0.63)	(0.47)	(0.49)	(0.45)
Sample Size	1670	1707	1756	1857	1454	1411	1384	1571	392	381	358	414

Note: Errors clustered at the level of mother's pre-disaster enumeration area. Sample of children eligible to be measured in 2006-07. 2002 reference cohort.