

Long-run Effects of the Yogyakarta Earthquake on Child Health Outcomes*

Dhanushka Thamarapani[†]

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Abstract

The intersection of research on early childhood exposure to natural disasters and its impact on welfare has rejuvenated the public policy debate of targeting the disaster relief to most vulnerable subpopulations. Given the multi-dimensionality of welfare, depending on the proxy, the implications of experiencing such disasters could be vastly different. This paper proxies welfare using a health metric and empirically investigates the interlinks between exposure to the Yogyakarta earthquake on child health using a 21 year long panel dataset. Once I decompose the effect of the earthquake based on variation in the age of exposure I find irreversible damage to welfare arising from loss of human capital. Furthermore the effect appears to be concentrated on children under 2 years at the time of the event with boys being more vulnerable than girls. On a broader spectrum, the long term effects of the earthquake could be even more pronounced as these children grow older.

Keywords: Indonesia; Early Childhood Shocks; Stunting; Cognitive Ability; Morbidity

JEL Codes: I10, J13, J16, O53

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[†] Department of Economics, Clark University, 950 Main Street, Worcester, MA 01610, DThamarapani@clarku.edu, dthamarapani.com

1. Introduction

The mounting evidence in both economic and psychology literatures document the long term implications of in utero exposure to adverse events. The renewed emphasis on the consequences of natural disasters on a multitude of outcomes¹ and the coping strategies² has enriched our understanding of the scope and magnitude of these unprecedented events. Consequently the intersection of research on in utero (and early childhood) exposure to natural disasters has rejuvenated the public policy debate of targeting the disaster relief to most vulnerable subpopulations. The current study provides empirical evidence in their favor.

Among natural disasters, earthquakes constitute a study-worthy case in our pursuit of uncovering the effect on physical and human capital stock. Their magnitudes, nondiscriminatory spread coupled with the near impossibility to predict render earthquakes compelling natural experiments. Complementing earthquake occurrences with household surveys allows one to decompose the effects of experiencing such disasters along varying ages. Hence, comparing across exposure at different ages helps identify critical (sensitive) periods in early childhood where stunted growth may not be later compensated. This is the premise which the current study empirically investigates.

The literature on exposure to earthquakes in early life is relatively new (see for example, Peru: (Caruso and Miller, 2015), Haiti (Cavallo, Powell and Becerra, 2010) Japan (Fujiki and Hsiao, 2015; Noy, 2015). Particularly for Indonesia, a recent study by Gignoux and Menéndez

¹ (Ex. welfare (Sawada, 2007; Cas *et al.*, 2014; Gignoux and Menéndez, 2016), intergenerational transmissions (Caruso, 2015; Caruso and Miller, 2015), human capital (Baez, Fuente and Santos, 2010), risk (Cameron and Shah, 2015), fertility (Nobles, Frankenberg and Thomas, 2015), child health (Datar *et al.*, 2013), and economic growth (Cavallo *et al.*, 2013)).

² For instance (Del Ninno, Dorosh and Islam, 2002; Del Ninno, Dorosh and Smith, 2003; Skoufias, 2003; Athukorala and Resosudarmo, 2005).

(2016) quantifies the effect of being exposed to earthquakes that occurred since 1985 (including the Yogyakarta earthquake) to uncover the welfare dynamics in the aftermath of the disasters. They find that households might be able to recover physical capital in the wake of disasters. Using a proxy for welfare based on an asset/income metric, the study finds no long term adverse effects on welfare.

The rationale for the current study stems from the fact that welfare is multi-dimensional. While aid and relief efforts can help recover the reparable damage in welfare when measured along an asset/income metric, the loss in human capital dimension, thereby the loss in welfare linked to stunted growth, could be irreversible. From an econometric point of view, a sibling-fixed effect model would be the desired approach as it overcomes the endogeneity issues related to timing of birth (i.e. parents choosing to have children during months with favorable weather conditions) as well as genetics that would determine the child health (height). The current study does not limit itself to a sibling sample. Given the impossibility to predict an earthquake (as opposed to, for example, rainfall) the endogeneity in timing of birth becomes less relevant. As for genetics being a determinant of the child stature, Cornwell and Inder (2015) finds that the low stature in Indonesian children is not purely genetics and is more likely to be caused by a range of environmental factors. With the substantial focus in the recent literature on understanding the how deprivation in early childhood affect human capital stock (Almond and Currie, 2011) and uncovering the different stages in life that are crucial to acquiring different types of skills (Cunha and Heckman, 2007), analyzing the exposure to an earthquake in early life presents a worthwhile endeavor for the econometrician to dwell in.

In this paper I study the effect of being exposed to the May 2006 Yogyakarta earthquake and its influence on the child health outcomes. Since early childhood exposure may result in stunted

growth, especially during the first 3 years of life when children grow faster than any other part of life, the adverse effect could be irreversible. Children, particularly those under five, are highly susceptible to natural disasters since they are vulnerable along multiple dimensions: nutrition, injury, drinking water, and sanitation (Favor, 2011:24). Added to the effect is death of a household member or loss of household income that result in both physical and mental health damage. Similarly, pregnant women are also highly prone to adverse effects. Low access to health facilities resulting in low immunization coverage, lack of medically trained personnel, and medical supplies would lead to maternal and neonatal complications and increased morbidity especially in young children (Favor, 2011:265). On the other hand, due to household coping mechanisms and catching up under the right conditions during later life (ex. findings on Filipino children: (Adair, 1999); Bolivian children: (Godoy *et al.*, 2010)) the true impact of exposure is ambiguous.

Thus the contributions of this study can be classified into two categories. First I find that the long term effect of the earthquake depends on the proxy for welfare used. Once it is proxied with a health metric I find irreversible damage arising from loss to human capital. Furthermore the effect appears to be concentrated on children under two years at the time of the event. On a broader scale, the long term effects of the earthquake could be prominent as these children grow older. In addition to identifying the causal links between trauma in early life and child health I uncover the heterogeneity of its impact. The results reveal that the stature for girls is more resilient than that of boys. Overall the findings of this study reveal that, from a public policy perspective, while health interventions and disaster management efforts are detrimental to recovery, there is a significant need for targeting subpopulations that are particularly vulnerable.

The remainder of the paper is as follows: Section 2 is a brief introduction to the Yogyakarta earthquake followed by the empirical methodology in Section 3. The subsequent section lay out the data and econometric issues. The results are detailed in Section 5 followed by the conclusion in Section 6.

2. The Yogyakarta Earthquake in Indonesia

Indonesia has endured many natural disasters, predominantly, earthquakes, tsunamis, and volcanic eruptions as it is located on the Pacific Ring of Fire. Yogyakarta in particular has been one of the disaster prone areas and its geology explains the frequency of natural disasters. Yogyakarta is located on an actively moving tectonic plate and the subduction³ of Indian Oceanic plate against Eurasia Continental plate makes it vulnerable to earthquakes, tsunamis, and volcanic activity (Buwono X, 2008). On May 27, 2006 a magnitude 6.3 Mw earthquake occurred approximately 20 kilometers southeast of the City of Yogyakarta (Anderson and Marliyani, 2008). This was the second largest earthquake in Indonesia in terms of the death toll in the past 30 years. The most severe one was the December 2004 Indian Ocean tsunami and earthquake (9.1 – 9.3 Mw) therein that affected Aceh and North Sumatra Provinces. Despite the magnitude and consequently the damages, from a research point of view, there is no publicly available data to assess the impact of this shock on child health in these regions.

The timing of the Yogyakarta earthquake was between the third and fourth rounds of the largest publically available Indonesian panel survey and the locations that were exposed to the earthquake had been part of the panel study which provides a rich source of data to uncover the

³ In geology, subduction refers to the convergence of tectonic plates as one tectonic plate moves under another and merges.

impacts on a variety of socioeconomic outcomes. I therefore exploit all five waves of the panel survey (detailed in Section 4) in the current empirical investigation.

Before moving on to the empirical framework it is worth delving on the scale of the disaster that brought upon physical and human capital loss as well as drastic changes in the public policy. The reported death toll of the Yogyakarta earthquake was 5,700 while 37,000 people were injured⁴ (Karnawati *et al.*, 2008). About 139,000 buildings were destroyed while another 190,000 buildings endured heavy damages which altogether constituted a 3.1 billion dollar (28 trillion Rupiah) loss (Anderson and Marliyani, 2008). Strong ground shaking was particularly experienced in the Bantul district which was hit the hardest in the Yogyakarta province followed by Klaten district in the Central Java province⁵. In order to facilitate disaster relief and aid efforts, on May 29, 2006 the Indonesian government declared a state of emergency. As both international and local aid started pouring into the devastated areas there was a trigger in the public voice that demanded the gaps in public policy be filled. One such attempt spearheaded by the Indonesian Society for Disaster Management made its way to the House of Representatives which passed the Disaster Management Law No. 24/2007 on March 29, 2007, less than a year after the Yogyakarta earthquake (Puji Pujiyono, 2008). The law charged the Indonesian government to take the responsibility of disaster management and instituted the National Disaster Management Agency. Therefore it is evident that the Yogyakarta earthquake did not simply bring about devastation but also triggered a proactive public policy geared to mitigate the risks and accelerate the rehabilitation efforts. This study is an attempt to provide empirical evidence on how best to allocate limited resources in the wake of natural disasters.

⁴ The population in Yogyakarta region is 8 million.

⁵ Deaths and injuries were reported from the following districts: in Yogyakarta province, Bantul, Sleman, Yogyakarta City, Kulonprogo, Gunung Kidul; in Central Java province, Klaten, Magelang, Boyolai, Sukoharjo, Wonogiri, and Purworejo districts.

3. Empirical Methodology

The empirical framework for the current analysis draws from difference-in-differences estimation technique that allows separating the marginal effect of being exposed to the earthquake at certain stages of life on later outcomes. For each child i in community j in municipality k I estimate the following model:

$$CH_{ijk} = \alpha + \beta Age_{ijk} + \gamma EQ_{ij} + \delta Age_{ijk} * EQ_j + \theta X_{ijk} + FE_{ijk} + \varepsilon_{ijk}, \quad (1)$$

where the child outcomes are denoted by CH . Broadly classified these outcomes are twofold: child stature and other health outcomes. For child stature, I use height-for-age Z scores, (non-standardized) height measured in centimeters (for checking pre-trends as described in the Section 5), and an indicator variable for the likelihood of being severely stunted. The other health outcomes include standardized cognitive ability, a subjective measure of health, and a self-reported indicator for morbidity⁶.

Age is a vector of age groups with indicators for whether the child was in utero, ages 0 to 2, or 3 to 4 at the time of the earthquake. The binary variable EQ takes the value of 1 if the community experienced the earthquake in May 2006⁷. One could identify being in a community that experienced the earthquake as being “treated” in the conventional difference-in-differences framework. In this study I use a cohort of children and adolescents aged 5 to 19 years in 2014 (for reasons detailed in the Section 4). Since the earthquake took place in 2006 and that I define age groups from in utero to age 4, the treatment sample in this case are who satisfy the following

⁶ I refer the reader to the Section 4 for a detailed discussion of these measures.

⁷ If a particular community experienced an earthquake but it was not the May 2006 Yogyakarta earthquake the imputed value for the community is 0. In future analysis I intend to incorporate the ex-ante probability of disaster for communities study if the communities have learnt to adapt from past experience and also get.

two sets of criteria: (1) they were born in a community that was affected by the earthquake; (2) they were born between 2002 to 2007 (7-12 years old by the time of the fifth wave of the survey in 2014)⁸. The control group therefore consists of 3 types of children and adolescents: (1) children who were born between 2007 (post-earthquake) to 2009 (5 to 7 years old in 2014) in any community; (2) children who were born between 20002 to 2007 (7 to 12 years old in 2014) in a community that did not experience the earthquake; and (3) adolescents who were born between 1995 to 2001 (aged 13 – 19 in 2014).

The exposure coefficients, denoted by the vector δ , would then capture the effect of experiencing the earthquake compared to the baseline cohort. Furthermore, disaggregating the exposure based on age I can uncover the effect based on the variation in the age of exposure. X is a vector of control variables detailed in the data section. The specification allows for fixed effects (FE) for municipality, birth year, and birth month. ε is an idiosyncratic error term. The equation is estimated using ordinary least squares method and the standard errors are clustered at the municipality level. Validity of the difference-in-differences identifying assumption are discussed in detail in Section 5.

4. Data and Econometric Issues

The data for the analysis is from Indonesia Family Life Survey (IFLS), a nationally representative panel dataset, implemented by RAND Cooperation and the Demographic Institute at the University of Indonesia. The current study benefits from the rich panel dataset because

⁸ Cohort born in 2007 would have been in utero in 2006 at the time of the earthquake. I use both birth year and birth month in assigning whether the child was in utero. Cohort born in 2002 would be 4 years olds at the time of the earthquake.

apart from providing crucial demographic and community information, the recontact rates throughout the multiple waves have been particularly high thereby limiting the attrition problem that usually plagues panel studies. The first round of the survey fielded in 1993 (hereafter denoted as IFLS 1) covered approximately 7224 households in 13 out of 27 provinces thereby representing 83 percent of the Indonesian population and their heterogeneity that these provinces encompass. The most recent (fifth) round of IFLS took place in 2014, i.e. 21 years after the IFLS 1, and was designed to stay representative of the 1993 households and their decedents. Consequently in IFLS 5 conducted interviews on 15,900 households and the recontact rate of IFLS 1 is 92 percent. In the main analysis, I use information from IFLS waves 2, 3, 4 and 5 which were collected in 1997, 2000, 2007 and 2014 respectively. I test the validity of identifying assumption of the difference-in-differences analysis using data from IFLS 1.

The household survey gathers information on demographics, employment, income, assets and access to credit, as well as educational status of the household members while the fertility modules capture the prenatal visits and information related to child birth. Apart from the household survey all the IFLS waves comprise of a community facility survey where the community (village) leaders are interviewed on, among other factors, the history and climate of the community. Natural disasters were divided into eight categories: flood, earthquake, landslide, volcano eruption, tsunami, drought, forest fire, and fire. Under each category the communities was asked whether they experienced that type of a disaster and if so the year and month of the most severe event. Knowing the exact month of occurrence is important for the study to determine if the child is exposed in utero. For the difference-in-differences analysis I create an indicator variable that identifies the communities affected by the Yogyakarta earthquake and

using the timing of the disaster I then construct the binary variables indicating whether the child (or the mother when pregnant) was exposed to the shock in utero⁹, ages 0 to 2, and ages 3 to 4.

The study sample consists of respondents who are aged 5 to 19 in the fifth and most recent¹⁰ wave (IFLS 5). This age cohort was selected to enable standardizing according to WHO Reference 2007 detailed below. When analyzing the links between childhood exposure to a natural disaster and health in later life, the main interest lies in outcomes that capture the long term health stock. I therefore use two types of measures: stature and other health indicators. For the measure for stature, using the height in IFLS 5 (measured by an anthropometrist), I calculate the height-for-age Z score using the reference data from the WHO Reference 2007 which enables standardizing heights for children and adolescents who are aged 5 to 19 years¹¹. In line with this standardization methodology the extreme values (i.e. 6 or more standard deviations above or below the mean) are set to missing. According to descriptive statistics shown in Table 1 the average child in this sample is about 1 standard deviation below the mean of the reference group. This is consistent with other studies in the literature that use IFLS data (see for example, Cornwell and Inder (2015)).

Apart from this continuous measure for stature, I construct a binary variable indicating the probability of being severely stunted (having low height for age). This indicator takes the value of one if the height-for-age Z score is 3 or more standard deviations below the mean and 0 otherwise. In the sample, about 5 percent of the children are severely stunted. The percentage of

⁹ I have disaggregated in utero period into trimesters in a separate specification. However, there is not enough variation in the data to estimate an effect. Results available upon request.

¹⁰ IFLS 5 was updated on April 14, 2016.

¹¹ In a more conservative specification I restrict the sample to children aged 5 to 10 to limit the growth related to puberty (Cornwell and Inder, 2015).

children whose anthropometrics measures are missing is very low (1 percent). Nonetheless, I conduct robustness analysis to check for systematic selection as detailed in Section 5.3.

The other health measures capture the cognitive, subjective, and morbidity aspects of the child's health. The cognitive assessment was conducted by the Raven's test, which is a test of fluid intelligence. Respondents aged 7 to 14 were given 12 questions while respondents aged 15 to 24 answered 8. For this reason the Raven's test scores are standardized in their respective age specific cohorts prior to pooling. The second measure of other health outcomes is a subjective indicator. In Child Information module (i.e. Book 5) in IFLS, children aged 15 years or younger were asked (in person or in proxy) about their health at the time of the interview. The answer choices include: very healthy, somewhat healthy, somewhat unhealthy, and unhealthy. I therefore create a binary variable where 1 indicates whether the response was very healthy or somewhat healthy and 0 otherwise. The third measure, on morbidity is obtained from the same data module. The respondents were asked whether they showed any symptoms from list of 12 in the four week period prior to the interview. The 12 symptoms include headache, running nose, cough, difficulty in breathing, fever, stomach ache, nausea/vomiting, diarrhea, skin infection, eye infection, toothache, and cold sores. The morbidity indicator takes the value of 1 if the respondent had demonstrated 6 or more symptoms out of the list and 0 otherwise.

Even though the study's focus is on the impact of earthquake exposure on child health, the models include factors accounting for child, mother, and household characteristics that are likely to be relevant. For each child I construct variables that account for various aspects of childbirth and prenatal visits using birth history data that come from previous waves including IFLS 2, 3, and 4. Birth histories are recorded only for children under the age of 5 (Frankenberg and Karoly, 1995; 13) therefore it is crucial to pool information from the wave that is closest to the child's

birth year. The analysis includes binary variables indicating if the mother took iron pills during pregnancy, in which trimester the mother first had checkup at a health facility, and whether the child was delivered at home. As several studies have established the importance of birth weight (Behrman and Rosenzweig, 2004; Currie and Moretti, 2007; Currie, 2009; Coneus and Spiess, 2012) and breastfeeding practices, the regressions control for the birth weight and the number of weeks the child was breastfed. In order to maximize the sample size I also include separate indicators with an imputed value of 1 if there is missing information on prenatal visits, whether weighed at birth, and ever breast fed.

Consistent with the current literature I control for the child's birth order and an indicator whether the oldest child since parental investments and, more importantly, nutrition intake could depend on the birth order of the child and their position in the family hierarchy. Since culture and religious practices could also affect a child's nutrition and health I include ethnicity and religion variables. Another important factor to account for is the family (or mother's) health characteristics that could directly influence the growth of the child through genetics. I use mother's height (measured in centimeters) to account for intergenerational transmission of health. Since the initial socioeconomic status of the parents could also contribute to the child rearing practices I control for the parent's education¹², the per capita household expenditure, family size and mother's age at child birth. Since child's health could be related to the environment he or she lives in I control for the availability of good living conditions (access to electricity, rooms per person, sufficient ventilation, good quality floor¹³, and durable roofing¹⁴). I also account for socioeconomic status (asset wealth) using consumer durables (availability of a

¹² This is the combined years of education for both the parents.

¹³ Good quality floor is defined as being made out of ceramic, marble, granite, tiles, terrazzo, cement, or bricks where the baseline is lumber, bamboo, dirt or other.

¹⁴ Durable roofing is defined as having made out of concrete, wood, metal plates, or roof tiles where the baseline is asbestos, foliage/palm leaves, grass and bamboo.

refrigerator and television). To account for the time invariant regional characteristics and trends I include municipality, birth year and birth month fixed effects and I cluster the standard errors at the municipality level.

One main caveat in the current analysis would be the selection at birth where the poor quality fetuses would not have survived birth (therefore are not part of the survey later on). Previous studies in the literature with a similar focus (Maccini and Yang, 2009; Lokshin and Radyakin, 2012) have conducted robustness checks for sample selection and they find no evidence of selection bias. I follow a similar approach to Cornwell and Inder (2015) in convincing the reader that selection at birth is not a major concern for the current analysis. First, this study focuses on health of children therefore the selection into interview as adults (as in the case of Maccini and Yang (2009)) should be less relevant. Second, sample attrition as a result of mortality is low since the Indonesian infant mortality in 2006 is 32 per 1,000 live births. Therefore the endogeneity issues would not be causing significant bias in the current analysis.

5. Results

5.1 Main Results

Table (2) summarizes the first set of results on child stature. Column (1) models the height-for-age Z score as a function of variability in the age of exposure to the earthquake along with other relevant covariates. Second column is designed to reflect the same model but with non-standardized height. As explained before I am limited to using the non-standardized height when checking for the validity of the identifying assumption (pre-trends), thus I report Column (2) in

the main regressions to facilitate comparison. The continuous dependent variables in the first two columns are replaced by the dichotomous probability of being severely stunted in Column (3).

Even though the stature, measured by standardized (Column (1)) and non-standardized (Column (2)) heights, does not appear to be affected by the earthquake exposure¹⁵, I find highly statistically significant results on the likelihood of being severely stunted (Column (3)). Holding other factors constant, the children exposed to the earthquake in utero are about 20 percent more likely to be severely stunted compared to those not exposed to the shock. The direction of the effect is consistent with a nutrition effect. As for the magnitude, the dearth of studies analyzing the interlinks between early childhood and severe stunting results in a lack of comparison. However, based on studies looking at other shocks in early life (ex. war: Akresh *et al.* (2012), rainfall: Cornwell and Inder (2015)) on stature¹⁶, this magnitude is on the higher end. Experiencing the earthquake in utero is likely to deprive the child through maternal stress, interrupted prenatal care, loss of or reduction in family income, and consequently loss of consumption (nutrition).

In Table (3) I explore other outcomes of health stock apart from height. The three columns in the table reflect models that are designed to capture the earthquake exposure's effect on cognitive ability and self-reported measures of health and morbidity respectively. In Column (1), I find strong evidence that in utero exposure hinders cognitive ability. Based on an average cognitive score of 0.121 standard deviations, the adverse effect more than doubles for the earthquake exposed cohort. The subjective measure of health reported in Column (2) does not exhibit adverse effect while the objective measure of morbidity reflected in Column (3) shows

¹⁵ For the children affected in utero and during ages 0 to 2 the coefficients are negative (the expected sign) yet they are not statistically significant.

¹⁶ Akresh *et al.* (2012) uses adult height (cm) as their dependent variable of choice and Cornwell and Inder (2015) employs Center for Disease Control Prevention 2000 Growth Charts in standardizing child height.

that cohort exposed during ages 0 to 2 appear to have a higher likelihood of being morbid. These findings are consistent with the current literature that emphasizes the first 18 to 24 months of life being crucial to child health. Nutritional deprivation manifested either through poor quality breast milk or direct food intake when weaning are likely to be causing the growth deterrent along cognitive and morbidity dimensions. Overall, the earthquake exposure placed the children under 2 years of age at a disadvantaged position. In subsequent sections I explore the underlying heterogeneous effects that are not visible once aggregated.

5.2 Pre-trends

The identifying assumption for difference-in-differences framework is that prior to the shock there were no differential trends in the outcome variable(s) such that the interacted coefficient is in fact capturing the true treatment effect. Since my hypothesis is that children who are exposed to the earthquake in their early childhood would have reduced stature once adults, the ones who experienced the shock at older ages should have no effect on their health stock. To check whether this is the case, I construct a sample of an older cohort encompassing the age group 14 to 33 at the time of the earthquake¹⁷.

Similar to the main estimation I create two age groups (binary variables): those who were aged 14 to 15 at the time of the earthquake and those who were 16 to 17. I then interact these age groups with the earthquake communities to find the new “treatment group” which now comprise of a much older cohort. As mentioned in the data section the WHO Reference 2007 standardization methodology does not calculate height-for-age Z scores for those who are older than 19 years of age. Therefore, I am limited to using the adult height (measured in centimeters)

¹⁷ This is the 1974 – 1993 birth cohort and they would be aged 21 to 40 in IFLS 5.

as the dependent variable for the pre-trend analysis. This is not uncommon as some seminal studies in the current literature use (non-standardized) adult height with difference-in-differences analysis (see for example, Gertler (2004)).

As for the explanatory variables, since the youngest person in this cohort was born in 1993, which is the same year as the first wave, I recover information pertaining to the mother and the household using IFLS 1. Yet for the majority (approximately 70 percent) of this pre-trend cohort, covariates relating to prenatal care and child birth (length breastfed, prenatal visits, taking iron pills during pregnancy, birth weight, location of child delivery) are missing since these are only recorded for children aged 5 or younger at the time of the survey (Frankenberg and Karoly, 1995; 13). Consequently, I estimate two sets of models. In Table (4) Columns (1), I model adult height (measured in centimeters) as a function of mother's age at birth, mother's height, parent's education, family size, per capita household expenditure, gender, locality, religion, ethnicity, and household characteristics in addition to the municipality, birth year, birth month fixed effects. The second model recorded in Column (2) expands the set of covariates to include all the factors that were previously ignored¹⁸. Under this model the sample size reduces much further. In both cases I find no statistical evidence of pre-existing differential trends. The use of difference-in-differences approach is therefore appropriate for the current study.

5.3 Robustness Checks

Sample selection

¹⁸ This model does not include whether the mother took iron pills during pregnancy since this question was not part of IFLS 1.

Even if the pre-trends hold, another cause for concern could be that certain types of families are adverse to giving anthropometric records and if that the case there could be a systematic selection out of the sample that I am using to estimate. To check for this possibility I estimate linear probability models where the dependent variable is an indicator whether the anthropometric information is available for that individual. The right hand side variables consists of, apart from the variables of interest, all the control variables that were included in the main analysis. Table (5) summarize the results. Overall there is no indication of a systematic sample selection based on the observables. However there could still be unobserved factors that lead to sample selection and the caution is justified.

Children Sample

Some studies in the current literature, for instance Cornwell and Inder (2015), argue that the sensible approach to studying child health is to take a sample of pre-puberty children. Therefore as a robustness check I further restrict my sample to consist of children who are 5 to 10 years of age. According to results summarized in Table (6) I find that the effect of earthquake exposure to be stronger than the results reported in the main analysis (Table (2)). In utero exposure, like in the main analysis, results in about 20 percent higher likelihood of being severely stunted (Column (3)). Interestingly, the children exposed during ages 0 to 2 also have about 17 percent higher likelihood. Hence the adverse effect on child stature appears to be more pronounced in this estimation with this sub group of children aged 5 to 10.

5.4 Heterogeneity

The effect of being exposed to a natural disaster in childhood could vary based on a number of factors. Thus in order to uncover the heterogeneity of the exposure, I interact the variables of interest with the indicator for gender and estimate the differential treatment effect using the triple difference methodology. Using H to denote the heterogeneity factor (in this case being female) Eq. (1) can now be rewritten as follows:

$$\begin{aligned} CH_{ijk} = & \alpha + \beta Age_{ijk} + \gamma EQ_{ij} + \delta H_{ijk} + \delta Age_{ijk} * EQ_{ij} + \theta Age_{ijk} * H_{ijk} + \vartheta EQ_{ij} \\ & * H_{ijk} + \rho Age_{ijk} * EQ_{ij} * H_{ijk} + \sigma X_{ijk} + FE_{ijk} \\ & + \varepsilon_{ijk}. \end{aligned} \tag{2}$$

First I check for the possibility of girls being affected differently than boys. The effect on boys is captured by θ and that of girls by ρ . In Table (7) I summarize the results obtained for this triple difference estimation. Holding everything else constant, boys are roughly 29 percent more likely to be severely stunted if exposed to the earthquake in utero. Furthermore, those who are between ages 0 to 2 have 21 percent greater chance of being severely stunted. For girls the adverse effect is more muted. While there appears to be no effect for girls exposed in utero, those experienced the shock between ages 0 to 2 are about 8 percent more likely to be severely stunted. Therefore overall boys seem to be at a higher disadvantage.

6. Conclusions and Future Work

Understanding the effect of early life shocks and unpacking their mechanisms has become a growing body of the economic literature. While the existing empirical evidence has

established certain links between natural disasters and child health the types of disasters studied are predominantly floods (Del Ninno, Dorosh and Islam, 2002; Del Ninno, Dorosh and Smith, 2003; Buttenheim, 2006; Leiter, Oberhofer and Raschky, 2009; Cameron and Shah, 2015; Carouso, 2015), famines (Neugebauer, Hoek and Susser, 1999; Ampaabeng and Tan, 2013), droughts (Block and Moench-pfanner, 2003), tornadoes (Gunnsteinsson *et al.*, 2014) and the like. Earthquakes which are much rare, on the other hand, have been empirically investigated in only a handful of studies. Indonesia is located on an actively moving tectonic plate and therefore is highly susceptible to natural disasters, especially earthquakes. Thus Indonesia constitutes an interesting case study for the analysis of exposure to earthquakes in early life and its impact on the child health stock. With the notable exception of Gignoux and Menéndez (2016), studies decomposing the effects of earthquakes in Indonesia using publically available data is extremely rare. This paper is an attempt to fill this gap in the literature and contributes to the better understanding of exposure to the Yogyakarta earthquake on specifically child health outcomes using the longest running long panel dataset (21 years) in Indonesia. I find that in utero exposure to earthquake increases the likelihood of being severely stunted and reducing the cognitive ability. For the most part the adverse effect is concentrated on children under 2 years of age and when disaggregated based on the gender, boys seem to be at higher risk than girls. The overarching theme of the current study is that once welfare is proxied by a health metric, the human capital loss (as opposed to physical capital damage) could be irreversible. Therefore from a public policy perspective, this study provides empirical evidence in support of targeting vulnerable sub populations (pregnant women, children (particularly boys) under the age of 2) during aid and disaster relief programs in the wake of natural disasters.

The results are limited by the relative low number of infants and children exposed to the

earthquake since in the IFLS only 313 communities responded to the natural disaster module. In moving forward I intend to use a precise measure of local ground tremors from US Geological Survey database to define the exposure to earthquake as well as the magnitude of the exposure to further strengthen these findings. Furthermore, since in the current analysis most of the effects are observed for the likelihood of being severely stunted, I would conduct further analysis on the likelihood of being stunted (i.e. height-for-age Z score 2 or more standard deviations below the reference group mean) and moderately stunted (i.e. height-for-age Z score between 2 and 3 standard deviations below the reference group mean).

Additionally under the heterogeneity exercise I would interact the variables of interest with a measure of remoteness. The rationale is that the more remote the community is the lower the state of infrastructure would be and therefore the effects of earthquake could be more prevalent. In moving forward I intend to uncover the potential mechanisms including access to credit, prevalence of aid, and mother's education that would help explain the pathways through which the earthquake exposure manifests.

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Appendix

Table 1 - Descriptive Statistics of the Regression Sample

VARIABLES	(1) N	(2) Mean	(3) SD	(4) Min	(5) Max
<u>Child's health measures</u>					
Height (cm)	5,379	135.0	18.51	90.80	185
Height for age Z score	5,379	-1.312	1.038	-5.131	3.427
Probability of being severely stunted	5,379	0.0465	0.211	0	1
Hemoglobin (g/dL)	5,017	12.58	1.505	5.900	18.70
Probability of being anemic	5,379	0.216	0.412	0	1
Cognitive ability (Z score)	4,730	0.121	0.859	-2.457	1.452
Healthy	4,213	0.911	0.285	0	1
Morbidity	4,213	0.0648	0.246	0	1
Low birth weight	4,712	0.0726	0.259	0	1
<u>Age groups and exposure</u>					
In utero	5,379	0.0822	0.275	0	1
Age 0-2	5,379	0.222	0.416	0	1
Age 3-4	5,379	0.106	0.307	0	1
Affected in utero	5,379	0.00279	0.0527	0	1
Affected during age 0-2	5,379	0.00706	0.0838	0	1
Affected during age 3-4	5,379	0.00279	0.0527	0	1
<u>Whether measured</u>					
Whether hemoglobin measured	5,379	0.933	0.251	0	1
Whether weighed after birth	5,379	0.876	0.330	0	1
<u>Child characteristics</u>					
Female	5,379	0.497	0.500	0	1
Birth order	5,379	2.138	1.383	1	11
Oldest child (binary)	5,379	0.413	0.492	0	1
Rural (binary)	5,379	0.405	0.491	0	1
Family size	5,379	6.718	3.128	2	25
Per capita household expenditure	5,379	1.047e+07	1.203e+07	706,560	2.451e+08
Whether delivered at home	5,379	0.374	0.484	0	1
Weeks breast fed	5,379	41.69	45.24	0	392
<u>Mother's characteristics</u>					
Mother's age at birth	5,379	27.26	6.121	13	58
Took iron pills during pregnancy	5,379	0.864	0.343	0	1
Prenatal visits to the health facility:					
1st checkup during 1st	5,379	0.911	0.284	0	1

trimester					
1st checkup during 2nd trimester	5,379	0.0666	0.249	0	1
1st checkup during 3rd trimester	5,379	0.0208	0.143	0	1
Mother's height (cm)	5,379	149.1	18.81	0	187.7
Whether mother's height measured	5,379	0.985	0.120	0	1
Parents' education (combined)	5,379	16.59	7.703	0	39
<u>Household characteristics</u>					
Rooms per person	5,379	1.033	0.580	0.0588	16.33
Availability of:					
Good floor quality	5,379	0.868	0.338	0	1
Good roof quality	5,379	0.896	0.305	0	1
Good ventilation	5,379	0.861	0.346	0	1
Electricity	5,379	0.993	0.0827	0	1
Refrigerator	5,379	0.443	0.497	0	1
TV	5,379	0.943	0.232	0	1

Notes:

[1] The sample is obtained after the linear probability estimation with the dependent variable height-for-age Z score.

Table 2 - Regression Results: Child Height

VARIABLES	(1) Height for age Z score	(2) Adult height (cm)	(3) Probability of being severely stunted
Affected in utero	-0.130 (0.248)	-0.779 (1.741)	0.197*** (0.059)
Affected during age 0-2	-0.125 (0.360)	-0.011 (2.173)	0.133 (0.083)
Affected during age 3-4	0.243 (0.200)	1.888 (1.721)	-0.041 (0.026)
Observations	5,291	5,478	5,291
R-squared	0.247	0.881	0.093
Municipality FE	YES	YES	YES
Birth Year FE	YES	YES	YES
Birth Month FE	YES	YES	YES

Notes:

[1] Standard errors clustered at municipality.

[2] *** p<0.01, ** p<0.05, * p<0.1.

[3] The sample is 5 - 19 years old in IFLS 5 (2014).

[4] Height for age Z score calculated using the WHO Reference 2007 methodology.

[5] Adult height is measured at the time of the survey by trained personnel and is recorded in centimeters.

[6] Probability of being severely stunted is binary variable which equals 1 if the height for age Z score is 3 or more standard deviations below the reference group mean.

[7] All regressions control for birth order, parents' education, mother's height, weeks breastfed, birth weight, prenatal visits, gender, rural, whether delivered at home, whether mother took iron supplements during pregnancy, family size, household expenditure, household characteristics (electricity, TV, fridge, ventilation, good floor, good roof, rooms per person)

Table 3 - Regression Results: Other Health Outcomes

VARIABLES	(1) Cognitive ability (Z score)	(2) Healthy	(3) Morbidity
Affected in utero	-0.279** (0.129)	-0.049 (0.030)	0.023 (0.031)
Affected during age 0-2	-0.350 (0.246)	0.011 (0.019)	0.042** (0.020)
Affected during age 3-4	-0.070 (0.086)	-0.088 (0.110)	-0.032 (0.024)
Observations	4,835	4,138	4,138
R-squared	0.327	0.093	0.086
Municipality FE	YES	YES	YES
Birth Year FE	YES	YES	YES
Birth Month FE	YES	YES	YES

Notes:

[1] Standard errors clustered at municipality.

[2] *** p<0.01, ** p<0.05, * p<0.1.

[3] Cognitive ability is measured through a Raven's test. The sample is 5 - 19 years old in IFLS 5 (2014).

[4] Healthy is a self-reported measure of the health at the time of the survey which takes the value of 1 if the response is very health or somewhat healthy. 0 otherwise. The respondents are 15 years old or younger.

[5] Morbidity is a self-reported measure of the health at the time of the survey which takes the value of 1 if the respondent had demonstrated 6 or more symptoms out of the 12 listed. 0 otherwise. The respondents are 15 years old or younger.

[6] All regressions control for birth order, parents' education, mother's height, weeks breastfed, birth weight, prenatal visits, gender, rural, whether delivered at home, whether mother took iron supplements during pregnancy, family size, household expenditure, household characteristics (electricity, TV, fridge, ventilation, good floor, good roof, rooms per person)

Table 4 – Pre-trend Analysis

VARIABLES	(1) Adult Height (cm)	(2) Adult Height (cm)
Affected during age 14-15	1.469 (1.503)	2.142 (2.593)
Affected during age 16-17	-0.054 (1.316)	0.748 (2.799)
Observations	4,189	1,225
R-squared	0.599	0.714
Municipality FE	YES	YES
Birth Year FE	YES	YES
Birth Month FE	YES	YES
<u>Additional controls</u>		
Birth weight	NO	YES
Prenatal visits	NO	YES
Whether delivered at home	NO	YES
Duration breast fed (weeks)	NO	YES

Notes:

[1] Standard errors clustered at municipality.

[2] *** p<0.01, ** p<0.05, * p<0.1.

[3] All regressions estimated using a linear probability model.

Table 5 - Robustness: Sample Selection

VARIABLES	(1) Whether height measured
Affected in utero	0.003 (0.004)
Affected during age 1-2	-0.001 (0.001)
Affected during age 3-4	-0.000 (0.001)
Observations	5,483
R-squared	0.075
Municipality FE	YES
Birth Year FE	YES
Birth Month FE	YES

Notes:

[1] Standard errors clustered at municipality.

[2] *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

[3] The sample is 5 - 19 years old in IFLS 5 (2014).

[4] All regressions control for birth order, parents' education, mother's height, weeks breastfed, birth weight, prenatal visits, gender, rural, whether delivered at home, whether mother took iron supplements during pregnancy, family size, household expenditure, household characteristics (electricity, TV, fridge, ventilation, good floor, good roof, rooms per person)

Table 6 - Robustness: Children Sample Aged 5 to 10

VARIABLES	(1) Height for age Z score	(2) Adult height (cm)	(3) Probability of being severely stunted
Affected in utero	-0.155 (0.186)	-0.781 (1.166)	0.208*** (0.056)
Affected during age 0-2	-0.181 (0.330)	-0.661 (2.109)	0.169** (0.072)
Affected during age 3-4	-0.223 (0.398)	-1.553 (2.720)	0.018 (0.045)
Observations	2,796	2,799	2,796
R-squared	0.264	0.757	0.120
Municipality FE	YES	YES	YES
Birth Year FE	YES	YES	YES
Birth Month FE	YES	YES	YES

Notes:

[1] Standard errors clustered at municipality.

[2] *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

[3] The sample is 5 - 10 years old in IFLS 5 (2014).

[4] Height for age Z score calculated using the WHO method.

[5] Adult height is measured at the time of the survey by trained personnel and is recorded in centimeters.

[6] Probability of being stunted is binary variable which equals 1 if the height for age Z score is 2 or more standard deviations below the mean.

[7] All regressions control for birth order, parents' education, mother's height, weeks breastfed, birth weight, prenatal visits, gender, rural, whether delivered at home, whether mother took iron supplements during pregnancy, family size, household expenditure, household characteristics (electricity, TV, fridge, ventilation, good floor, good roof, rooms per person)

Table 7 - Heterogeneity Results: Gender

VARIABLES	(1) Height for age Z score	(2) Adult Height (cm)	(3) Probability of being severely stunted
Affected in utero	-0.483 (0.395)	-3.343 (2.747)	0.288*** (0.107)
Affected during age 0-2	-0.385 (0.652)	-2.219 (4.241)	0.206* (0.118)
Affected during age 3-4	0.173 (0.351)	1.308 (2.569)	-0.031 (0.024)
Female * Affected in utero	0.466** (0.216)	3.466*** (1.308)	-0.124 (0.081)
Female * Affected during age 0-2	0.306 (0.679)	2.431 (4.273)	-0.127* (0.076)
Female * Affected during age 3-4	-0.068 (0.402)	-0.735 (2.973)	0.015 (0.044)
Observations	5,291	5,478	5,291
R-squared	0.259	0.892	0.102
Municipality FE	YES	YES	YES
Birth Year FE	YES	YES	YES
Birth Month FE	YES	YES	YES

Notes:

[1] Robust standard errors in parentheses

[2] *** p<0.01, ** p<0.05, * p<0.1

[3] All regressions are estimated using a linear probability model.