Economics Development Analysis Journal Vol (1) (2022)

Economics Development Analysis Journal

http://journal.unnes.ac.id/sju/index.php/edaj

Impact of Earthquake on Human Capital Formation

Rizki Hadiman[1]✉ , [2]Sartika Djamaluddin

[1,2]Magister Economics Program, Universitas Indonesia

Article Information

History of Article
Received Octoober 2021
Accepted December 2021
Pusblished February 2022

Keywords:
Natural disasters, Earthquake, Human capital, Cognitive

Abstract

The study of the impact of natural disasters on human capital is still very developed. This study aims to analyze the long-term impact of natural disasters experienced at a child's early age on human capital formation, with a cognitive score as a proxy. Using the Difference-in-Difference method and IFLS data with the 2006 Yogyakarta earthquake observations, this study results imply that natural disasters give their losses to human capital formation. Children who at an early age (around 0-2 years) experienced the disaster had 1,62 points lower cognitive score. The impact on cognitive scores was also more profound for the child's age at the time of the disaster, especially at the age of 1 year and under, compared to the child's position at the age of 4 or 5 years.

✉ Corresponding author : Address: Jl. Kayu Manis, Cibinong, Bogor, West Java
E-mail: rizkihadiman1406@gmail.com

ISSN 2252-6560

INTRODUCTION

Indonesia still faces many possible losses from natural disasters due to its position in an area with much tectonic activity (the Pacific Ring of Fire). In the last few decades, in addition to the Covid-19 pandemic disaster until this research was carried out (2021), Indonesia has received international attention because of several natural disaster events that had a reasonably considerable impact and caused the death of many humans and living things. It resulted in damage to land areas and the destruction of various buildings and infrastructure, resulting in substantial economic losses. Based on EMDAT (2021) on disaster conditions for the period 2000 to 2021, there are a total of no less than 19.14 million people affected by natural disasters, including the sick, injured, and homeless. Earthquakes are natural disasters that almost always cause the most affected victims based on this total. The peak was in 2006, of the total affected by around 3.9 million people, 3.2 million people were victims of the earthquake. As for the value of the damage, an immense total damage value came from natural disasters in 2006, which reached 3.3 billion USD, in addition to 2004 (possibly one of them due to the massive impact of the Indian Ocean earthquake and tsunami) reached 4.5 billion USD. The number affected by natural disasters in this period is also a concern. Based on the same data source, it has increased compared to 1990 to 1999, which reached around 7 million people. The damage and loss with a large amount and value experienced in 2006 was the impact of the Yogyakarta earthquake in 2006 (Appendix 1).

DI Yogyakarta Province is indeed, one of the areas whose geographical and geological conditions are prone to disasters. It is located on an actively moving tectonic plate. It subdues the Indian Ocean and the Eurasian continental plates, making Yogyakarta vulnerable to earthquakes, tsunamis, and volcanic activity. The land area, mainly composed of volcanic material, provides vulnerabilities that make it easy to amplify by vibrations (earthquakes) that originate directly from beneath the land (Tanjung *et al*., 2019). A major earthquake in this area on May 27th, 2006, had a magnitude of 6.3 Mw, with a center about 20 kilometers southeast of Yogyakarta City (Anderson and Marliyani, 2008). This earthquake was the largest in Indonesia in terms of the number of victims in the last three decades besides the tsunami and the Indian Ocean earthquake in December 2004 (9.1 - 9.3 Mw) that hit the provinces of Aceh and North Sumatra. There were around 5,700 victims who died in the Yogyakarta earthquake, while the injured reached 37,000 (Karnawati *et al*., 2008). Approximately 139,000 buildings were destroyed, while 190,000 other buildings suffered heavy damage, which, if estimated, the total loss reached 3.1 billion dollars (28 trillion Rupiah) (Anderson and Marliyani, 2008). The damage caused by the shocks caused spread quite widely to the area around the Yogyakarta Special Region of Yogyakarta. The most vigorous ground shaking was experienced in Bantul Regency, making it the most affected in Yogyakarta Province, followed by Klaten Regency in Central Java Province. Based on these data and the characteristics of the earthquake, which damage is different from other natural disasters, DI Yogyakarta Province and its surroundings do have geological and geographical features that provide the potential for disasters that make the 2006 Yogyakarta earthquake the biggest disaster. The 2006 Yogyakarta earthquake disaster itself still caused total damage (3.1 billion USD) more than the 2018 Palu earthquake and tsunami, which reached 1.45 billion USD (Appendix 1). The 2006 Yogyakarta earthquake also had more affected people (3,177,923 people) than the 2004 Indian Ocean earthquake, which only reached 532,898 people.

Natural disasters bring various dire consequences, particularly impact to human capital formation. If experienced in vulnerable groups, especially in children at an early age, the effects of disasters are obtained from poor environmental conditions, such as the risk of infectious diseases and nutritional deficiencies that are sufficient to interfere with the child's growth process (Pan American Health Organization, 2000). In addition, it would have psychological consequences (Masten and Narayan, 2012), such as the feeling of being threatened by the loss of a loved one and observing events both directly and from the media that illustrate events that cause fear. It can affect children's psychological and brain development in the long term. This condition specifically occurred in Yogyakarta after the 2006 earthquake, as studied by Subratha (2019). Post-earthquake conditions gave children/infants a dire environmental situation in a sensitive period, such as difficulty in breastfeeding and the effects of breastfeeding disease from a deteriorating environment.

Heckman (2007) and Rosales (2014) more specifically observe the long-term impact of harmful interventions such as natural disasters on humans. These negative interventions from the early age of a child's life will determine skills formation and the quality of human capital. Two features shape the long-term impact of natural disasters on a child's human capital. The first, called "self-productivity", shows accumulation of capabilities from the past that forms capabilities accumulation in the future (stock of future skills). This feature explains that if a negative shock occurs at a stage that affects the formation of human capital accumulation, this will affect the child's current capabilities and affect the expansion of skills in the next period. The second, called "dynamic complementary", is that the decline in investment productivity from parents needed in the child's growth process due to natural disasters impacts current capabilities and affects human capital development in the next period. Becauser of the consequences of a natural disaster, the parent's investment in their children can be disrupted, impacting the natural disaster. However, returning to the investment ability of parents, which can vary rather than worsen, can compensate for the negative shock in the formation of human capital. Investment here refers to Becker (1964), where every expenditure to improve the quality and quantity of human capital, including those made by parents for their children, is a form of investment in human capital. Therefore, the overall effect of, especially during-early-life natural disasters on human capital in the future is still ambiguous.

The skills aspect becomes an essential point regarding human capital quality on assessing the relationship between the impact of natural disasters on human capital and its study potential. As Heckman (2007) and Rosales (2014) claimed, natural disasters shock affects children's human capital formation through biological impacts. One of which is through the development of the child's brain to play a crucial role in cognitive skills. The brain is an organ that is still plastic at an early age. The presence of natural disasters shock affects the development of these organs due to the disruption of biological processes. According to Barker (2012), this is primarily at an early age when a baby's natural body does not have enough resources to perfect all aspects of his body. There is a hierarchy of growth priorities in which the brain takes the top priority. Other organs that are still plastic, such as lungs and kidneys, whose development process is slower since the womb, are at the lowest priority.

Based on the human capital development data, it seems to have decreased based on the 2015 to 2018 PISA (Program for International Student Assessment) scores for math, science, and reading scores. Mathematics scores decreased from 386 to 379 in 2015 to 2018, science scores decreased from 403 to 396, and reading scores decreased from 397 to 371 in the same year. When viewed by birth group, the children sample for PISA scoring are children aged 15 years (secondary education). DI Yogyakarta Province and DKI Jakarta gave the highest weighting for PISA scores in Indonesia. When oversampling was carried out in 2018 for this scoring, Yogyakarta and Jakarta gave higher PISA scores than the national average score (Ministry of Education and Culture's Research and Development Agency and PISA, 2018). The decline from 2015 to 2018 shows that children sampled in 2015 and 2018 were each in a baby position when Indonesia experienced the 2006 Yogyakarta earthquake. This data is sufficient to see differences in human capital, although there is no significant difference from other indicators such as years of schooling. The average length of education taken for 2015 data is around 8.32, and in 2019 it is about 8.75. As DI Yogyakarta Province in 2015, it was at an average of 9.59, and in 2019 it was at an average of 9.83 (BPS, 2021).

However, the trend change shown in the PISA score suggests that natural disasters will impact the development of children's cognitive abilities. It is also indicated from 2016 to 2019 data for average final exam (Ujian Nasional) scores on SMP level in DI Yogyakarta Province, which tends to decrease, especially between 2016 and 2018. Likewise, it shows a decline when viewed with other earthquake-affected areas (Kemendikbud, 2021). The corresponding earthquake areas were observed between 2004 and 2007 when the children were early (Appendix 2). Based on these data, it is suspected that the impact of natural disasters experienced by the child at an early age impacted their cognitive performance.

Based on this background, Indonesia still has homework for human capital achievement to encourage its economy and development. The geographical condition of Indonesia, which is vulnerable to the impact of natural disasters, certainly makes it more difficult for Indonesia to achieve this goal. Human capital as a driving factor for the economy has its process related to its formation since the early days of life. So, it must be considered what kind of intervention is experienced by a person in the early days of his life because it can affect skills formation in later stages of life and have a long-term impact (Heckman, 2007). In addition to the significant physical losses such as damage to buildings, residences, infrastructure, and various facilities and infrastructure, The 2006 Yogyakarta earthquake natural disaster as the biggest disaster in the last two decades is indicated to have a long-term impact on children in the formation of human capital. Several studies that examine the natural disasters impact on human capital only look at their short-term effects, such as the impact on school-age children on their educational attainment (Espinoza et al., 2015; Spencer, 2017; Sulistyaningrum, 2017). The question remains: what if the shock or natural disaster is affected since the early age of a child's life, which is a critical period, especially related to the human capital formation.

The study of natural disasters' impact on human capital is also quite potent. It is related to the depiction of human capital itself, which has not used many proxies that better describe the quality/skills. Several studies, such as Carusso and Miller (2015) and Paudel and Ryu (2018), have examined the impact of natural disasters by looking at the effects of shock exposure when experienced at an early age but have not considered this effect on an outcome that describes skills.

Another thing that is interesting to note is the other events influence or disasters that can have an impact on the shock/disaster that is observed (Paudel and Ryu, 2018), as well as intensity difference between households in the same area experiencing a disaster (Langlois et al. al., 2020; Dartanto, 2017; Rini et al., 2021). Several studies have not addressed this point (Rosales, 2014; Shah and Steinberg, 2017; Aguilar and Vicarelli, 2018), so they may still cover the actual effect in estimating adverse shocks or disasters on human capital. Therefore, it is interesting to review the impact of natural disasters on human capital formation. Especially in Indonesia itself, which still has enough potential to assess the impact by looking more closely at the effects in critical positions such as early age and focusing on the effect on the human capital formation in terms of skills.

Paudel and Ryu (2018) empirically observe the impact of the earthquake that rocked Nepal in 1988 on schooling achievement. This research has been devoted to looking at the occurrence of negative exposure/shock when a child is still in a vulnerable position, namely when he was a toddler and when he was still in the womb. Through a quasi-experimental approach, to purify the impact of natural disasters in terms of place and time, the researchers used Difference-in-difference to observe how much influence they had on human capital outcomes in the future. As the basic difference-in-difference specification known in the literature, two interacting dimensions are used to see how much the interest variable influence has on the outcome variable. Paudel and Ryu (2018) also uses two dimensions, but slightly different. The researchers used the birth cohort dimension by separating the birth cohort that experienced an earthquake from the cohort that did not experience an earthquake and the treatment dimension in the form of an earthquake disaster experience. They, which differed from other similar studies, sorted the cohort by considering other significant events in Nepal so that as much as possible, they selected the cohorts that did not experience or were minimally affected by other events and only focused on the experience of the shock in the form of the 1988 earthquake. They found that Babies born in earthquake-affected areas were 13.8% less likely to finish junior high school and 10% less likely to finish senior high school. Their findings show that children belonging to high caste groups can further reduce the negative long-term impacts of earthquake disasters. However, infants belonging to the lower caste group were 17.6% less likely to finish junior high school and 11.9% less likely to finish senior high school. In addition, baby boys exposed to earthquakes performed much better than baby girls. The researchers found strong evidence that earthquakes cause a decrease in the quality of human resources in developing countries. However, what remains unanswered here is how it affects more concrete human capital proxies that better reflect qualities, such as cognitive abilities.

A similar study related to the long-term impact on cognitive abilities was carried out by Rosales (2014) in his research which tried to analyze the long-term cognitive effect of the 1997-1998 El Nino storm. He used a sample of children born in 1998-2002 and looked at the cognitive outcomes from the survey results in 2003 and 2005. He found significant negative estimates on the coefficient of interest for the El Nino storm exposure variable. He concluded that there was an effect of lower cognitive scores in his research as a persistent impact of the storm. However, the concern here is the lack of control over other significant events in the sample. The data used is also a survey conducted to evaluate the cash transfer program. There is a possibility that the program will affect the observed outcomes and affect the magnitude of the estimated results.

A proxy close to that used by Rosales (2014), namely the Mathematics and Language test scores, used by Joshi (2019) to examine the impact of the drought shock experienced by households in rural India. A negative effect was also found for children whose households were exposed to the shock, with test scores found to be lower for children who had experienced the shock. However, he has not seen how the drought shock experience will be shared by toddlers, including those who are still in the fetus. Similar to Rosales (2014), Joshi's research (2019) relies on data on natural disaster shocks in specific regional units, not seeing how the direct experience of households in related natural disasters is.

Shah and Steiberg (2017) conducted a similar study, which studied the shock of high rainfall on children's human capital. The shock was noticed when experienced by children at an early age and its impact over the next few years on cognitive test scores. Although the shock in the context of their research was quite different from the one observed in this study (natural disaster shock), the shock was also found to be quite significant. They identify the shock of high rainfall as a shock that impacts crop yields. They found a statistically significant difference between children who experienced shock at an early age compared to those born during the dry season, with a difference of about 0.014 points against the mean score of 2.63 points. Relatively small considering the difference in the character of the shock, which is not like the shock of natural disasters. They also found that the shock was more pronounced in early infancy.

Based on the background and development of the literature, this study aims to analyze the long-term impact of earthquakes on human capital formation. We will estimate differences in the long term between children who experience earthquake shock at first two years of life and children who do not, regarding its long-term impact on cognitive performance as a proxy for human capital formation in quality (skills). Later, we use the term early-life for calling the first two years of life.

Based on this background, this study contributes to analyzing the impact of natural disasters during early life by using a cognitive score proxy that better reflects the quality/skills of human capital (Woessmann, 2003) by basing it on impact studies based on disaster experience household. Second, this study is specific to one observation of the 2006 Yogyakarta earthquake, the biggest disaster in Indonesia in several years. This study will also control for samples from experiences of significant events or disasters other than the observed catastrophic shock. Third, measuring natural disasters by considering the differences in intensity between households in the same area. It is to capture better the variations in the direct impact of disasters received by households that are not necessarily felt evenly within an area (Langlois *et al.*, 2020; Dartanto, 2017; Rini *et al.*, 2021).

RESEARCH METHODS

This research will utilize data from the Indonesian Family Life Survey (IFLS) 4th wave, which was carried out from late 2007 to mid-2008, and IFLS 5th wave was carried out at the end of 2014 to mid-2015. IFLS is a reasonably rich survey, especially related to direct experience household disaster. The cognitive score measurement module, an advantage of this household survey, will also be utilized, whose score measurement refers to the Raven Progressive Matrices (RPM) with the adjusted Ravens Test method (Strauss *et al.*, 2016). RPM is one of the primary methods in measuring cognitive and educational abilities that can measure the ability to simplify a complex schematic meaning, especially in nonverbal contexts (Raven, 2008). This study observes the 2006 Yogyakarta earthquake as a natural disaster shock because it is one of Indonesia's most significant natural disasters. In addition to the data mentioned in the previous section, earthquakes are natural disasters that always cause the worst impact in terms of victims and damage caused. The samples taken as observations covered the Yogyakarta Province and Central Java Province because these two provinces were the areas that felt and were directly affected by the disaster.

The sample in this study uses a sample of children (the definition of children according to UU No. 23, 2002), which will be divided into two groups. The first group is children who, during a natural disaster, the household where they live is directly affected. The second group is children who are not directly affected during a natural disaster. It is directly affected if at least one household member (ART) dies, is seriously injured or ill, causes direct financial loss, or causes the ART to change residence. It is to distinguish other households in the same area where a natural disaster occurs, but without experiencing anything like the one mentioned above—differencing like this plays a role in differentiating the intensity of disasters experienced by households because of these direct experiences. This distinction measures the experience of natural disasters at the household level (Langlois *et al.*, 2020; Dartanto, 2017; Rini *et al.*, 2021). It can also distinguish it from similar research in which the definition of exposure to natural disasters uses specific regional units (locations), such as whether the area is an area that experiences or has a high intensity of natural disasters being observed or other areas. Exposure to disasters experienced by an area still has different experiences of direct impact when viewed per household in the area.

The sample was also divided into two, namely the sample whose birth was not far from that earthquake (the group whose age was younger, 0-2 years when the disaster was observed) and the sample whose birth was quite far one (the older group, 3-5 years when the tragedy was observed). The position around the first two years of life has significantly differed from the following year regarding the interventions experienced during the growth period (Shah and Steinberg, 2017; Aguilar and

Vicarelli, 2018). The period of conception to the first two years of life is the position in which a child's linear growth is most sensitive to various environmental changes, especially those related to diet, infection, and psychosocial care (de Onis and Branca, 2016). Through this sample, it is hoped that the impact of exposure to earthquakes on natural disasters at an early age in life, both during the womb and when they are babies or toddlers, on individuals of the same age who did not experience the earthquake or who experienced it later in life. The existing sample, in addition, is isolated from exposure to disasters or other significant events. At the early age of the individual's life, the events caused quite socio-economic turmoil, such as the 1997/1998 economic crisis (Paudel and Ryu, 2018). Therefore, the individual sample used in this study was attempted to be minimized from other significant negative exposures at the early age of the individual's life, besides treatment in the form of negative exposure experienced or not experienced in the 2006 Yogyakarta earthquake only.

Based on the theoretical basis built by Baez *et al.* (2010) and Cunha *et al.* (2010) in looking at natural disasters impact that must be taken into account from an early age, natural disasters shock experienced from an early age can affect children's cognitive abilities in the long term. Cognitive abilities represent human capital formation in terms of skills. The empirical strategy used in answering the objectives of this study is to model children's cognitive performance against the 2006 Yogyakarta earthquake disaster experience as a shock experience in the past that was observed by controlling for possible exposure to other natural disasters experienced by households. A quasi-experimental approach is used, namely the Difference-in-Difference (DiD) method, to lock in the effects of earthquake shock against other effects of various confounding factors that affect cognitive formation in the future. There are two critical variables in the specification using this method: the experience of natural disaster exposure variables and the time position variable (individual age) at the time of the natural disaster and the interaction of these two effects. The interaction variable between the experience of exposure to natural disasters and the time position, or in the DiD specification called the double-difference variable, is the variable of interest. This method by separating the effects between the time position of natural disasters and exposure to natural disasters has also been used in studies of the long-term impact of earthquakes on several individual outcomes, including education which aims to proxy the dimensions of human capital. Control variables are also used in this specification to control for individual and household characteristics of the sample (Mueller and Quisumbing, 2010; Bustelo *et al.*, 2012; Caruso and Miller, 2015; Paudel and Ryu, 2018). Fixed effects are also included to control for unobserved characteristics of region and year of birth that have not been included in the set of control variables used. The empirical model in the form of an equation is written as follows:

$$Y_{ijkt} = \beta_1\left(EQ_{ijkt} * agexp_{ijkt}\right) + \alpha_1 EQ_{ijkt} + \alpha_2 agexp_{ijkt} + \boldsymbol{X}_{ijkt} + \boldsymbol{\delta}_t + \boldsymbol{\zeta}_k + \varepsilon_{ijkt} \quad .... (1)$$

The variable Y_{ijkt} as a proxy for the formation of children's human capital is the cognitive test score for individual/child i in household j who life in district k and were born in year t. $agexp_{ijkt}$ is a dummy of children aged 0 to 2 years at the 2006 Yogyakarta earthquake, and coded 0 if they are 3 to 5 years old. The variable EQ_{ijkt} is a dummy with code 1 if the individual's household was directly affected by the 2006 Yogyakarta earthquake, while coded 0 if not directly affected. Through the interaction variable between the dummy $agexp_{ijkt}$ and the dummy EQ_{ijkt}, which is the variable of interest in this study, it will measure the impact of earthquakes negative exposure to an individual's early age on their cognitive scores in the future. The vector variable, $\boldsymbol{X}_{ijkt}$, is a set of control variables that characterize individual and household characteristics. The variables are gender, individual schooling, urban dummy, schooling of the head of the household, gender of the head of the household, household expenditure, household size, electrification, household sanitation conditions, and drinking water consumption, as well as experiences from other disasters close to the 2006 Yogyakarta earthquake. Controlling the experiences of other natural disasters is considered essential to minimize the effect of confounding in estimating the impact of earthquake natural disasters exposure according to the objectives of this study. $\boldsymbol{\delta}_t$ is the fixed effect of the t^th birthday, $\boldsymbol{\zeta}_k$ is the fixed effect of the j^th region, and ε_{ijkt} is the random error component.

The hypothesis of this study is the shock of an earthquake in a child's early life will have a persistent impact on the process of human capital formation with a lower cognitive ability score, which is indicated by the parameter β_1 in equation (2.1), whose direction is estimated to be negative

H_0 : Earthquakes in early life have no impact on children's lower cognitive scores, $\beta_1 \geq 0$

H_1 : Earthquakes in early life have an impact on children's lower cognitive scores, $\beta_1 < 0$

The difference-in-difference specification of (DiD) used requires statistical evidence to test the assumption that the outcome variable conditions (dependent variable) outside of the exposure or shock being observed are parallel (similar characteristics) or are not affected by a trend. The outcome variable that is observed here is the cognitive score. If this assumption is fulfilled, it is said that the coefficient of the interaction variable (which is of interest) will capture the actual effect of exposure or shock. This test was conducted to test how impact evaluation was carried out. The impact that will be observed and measured is the impact of exposure to shock at the beginning of a child's life. The condition of the object being observed will be parallel beyond the impact caused by a shock/intervention, provided that it has been conditioned and controlled with various characteristics.

The existence of an earthquake shock in the early life of a child impacts a lower cognitive score for them, and as will be tested here, so without a shock at that timing, observations should be parallel or unaffected by a trend. It also controls conditions or characteristics and tests this assumption by regressing a placebo test by replicating the DiD framework using an older sample group. Different regroupings were carried out to form the age group dummy variable during the 2006 Yogyakarta earthquake, and the dummy variable was directly affected. Fake samples (other sample groups) are used, namely samples older than the primary sample at the time of the disaster. It is due to the consideration that this group at the time of the disaster was already in its teens and approaching adulthood, so it was pretty different from the characteristics of the primary sample who were still children.

The sample is grouped into two; namely, the older group has births around 1985 and 1986, coded 0, while the younger one has birth around 1987 and 1988, coded as 1. Each of these groups re-differentiated, namely those included as controls (without experiencing the direct impact of the 2006 Yogyakarta earthquake) and those included as groups experiencing the direct impact of the disaster. By dividing the sub-sample like this, it is hypothesized that there will be no significant difference in trends between groups. The entire sample group for this test is 613 samples.

The time dimension in this study is the year of the birth group, as described in the empirical strategy section. The use of a specification test (parallel trend test) like this is done because the DiD specification in this study differs from the basic DiD, whose time dimension is in the form of two time periods (before and after treatment) to see differences in outcomes (cognitive scores) between these periods and between groups. However, using this testing framework, as used in this study, was also used by Gertler (2004), Rosales (2014), and Thamarapani (2017).

Table 1. Placebo Test's Result

Variables	Cognitive Score (Placebo Test)				
	(1)	(2)	(3)	(4)	(5)
Directly affected or not (*EQ*)	0,382	-0,428	-0,316	-0,286	1,464
	(0,80)	(-0,84)	(-0,64)	(-0,50)	(1,65)
Age position at the time of the 2006 Yogyakarta earthquake *(Agexp0)*	0,765*	0,528*	0,500	0,499	0,0173
	(2,26)	(1,98)	(1,63)	(1,58)	(0,05)
Directly affected by the 2006 Yogyakarta earthquake at a younger age **(*EQ*Agexp0*)**	-0,125	0,171	0,0912	0,0746	-0,019
	(-0,13)	(0,18)	(0,10)	(0,08)	(-0,02)
Control Variables					
Individual Characteristics					
Gender	No	Yes	Yes	Yes	Yes
Schooling	No	Yes	Yes	Yes	Yes
Household Characteristics					
Urban	No	No	Yes	Yes	Yes
Household Size	No	No	Yes	Yes	Yes
Household Expenditure	No	No	Yes	Yes	Yes
Household head's gender	No	No	Yes	Yes	Yes
Household head's schooling	No	No	Yes	Yes	Yes
Electrification	No	No	Yes	Yes	Yes
Sanitation	No	No	Yes	Yes	Yes
Drinking Water	No	No	Yes	Yes	Yes
Other Natural Disasters	No	No	No	Yes	Yes
Year of Birth Fixed Effect	No	No	No	No	Yes
Area Fixed Effect	No	No	No	No	Yes
Observation	613	613	613	613	613
Adj. R-Squared	0,006	0,118	0,121	0,119	0,141

Notes: value in parentheses is t-statistics value. It's estimated using the DiD specification, with the same control variable as in equation (2.1) and the same outcome variable, namely cognitive scores, but with different sample groups, namely individuals born in 1985-1988.
* p<0,10; ** p<0,05; *** p<0,01
Source: Data Processed, 2021.

The tests carried out here also use the DiD specification. The interaction variable between the *EQ* variable (affected or not directly affected) and the *Agexp0* variable (whether the position is younger at the time of the disaster) is the observed variable, which will not be statistically significant to prove that the assumption of parallelism of characteristics in this study is fulfilled. The test results are shown in Table 2.1 that the estimation results of the variable coefficient *EQ*Agexp0* are not significant until the level α = 10% (shown without an asterisk). Likewise, when specifications are tested by entering control variables, earthquake shock had no significant impact on lower cognitive scores.

There was no statistical evidence of parallel condition differences in the observed groups, so it supported the results of the DiD estimation (model 2.1) in answering the central hypothesis in this study. It also provides statistical evidence that the estimate obtained to measure the impact is not affected by trends or confounding.

RESULTS AND DISCUSSION

At first, descriptive analysis was used to explain the variables used in estimating the impact of earthquakes exposure in a child's early life on the process of developing human capital later in life in terms of cognitive performance. One thousand fifty-seven sample children were obtained based on the 4th and 5th wave of IFLS by adjusting to the region and age position at the disaster of interest. The distribution of the sample in this study when viewed by gender, as shown in Table 3.1, the male sample constituted more than half of the total sample, which was about 52%.

Meanwhile, if disaggregated by group, the sample in the younger age group (0-2 years old at the time of the 2006 Yogyakarta earthquake) who experienced the direct impact of the disaster had a higher proportion of males reaching 56%, compared to the proportion in other groups. (Table 3.2). Most of the samples at the time of scoring had also taken formal education, i.e., the average length of education was about three years or had attended school up to grade 3 of elementary school. The older sample group (around 3 to 5 years of age at the time of the disaster) had five years of formal education on average. In comparison, the younger sample group had only about one year of formal education on average.

Table 2. Summary Statistic

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
Cognitive Score	1.057	11,0587	3,3968	1	17
Directly affected or not (*EQ*)	1.057	0,1287	0,3350	0	1
Age position at the time of the 2006 Yogyakarta earthquake (*Agexp*)	1.057	0,5894	0,4922	0	1
Directly affected by the 2006 Yogyakarta earthquake at 0-2 years (*EQ*Agexp*)	1.057	0,071	0,2569	0	1
Gender	1.057	0,5241	0,4997	0	1
Schooling	1.057	3,3718	2,0982	0	9
Urban	1.057	0,5506	0,4977	0	1
Household Size	1.057	6,2933	3,0471	1	23
Household Expenditure	1.057	1.791.817,8	1.569.021,9	267.519,44	20.398.516
Household head's gender	1.057	0,8534	0,3539	0	1
Household head's schooling	1.057	7,8657	4,5140	0	16
Electrification	1.057	0,9896	0,1015	0	1
Sanitation	1.057	0,8089	0,3934	0	1
Drinking Water	1.057	0,9896	0,1015	0	1
Other Natural Disasters	1.057	0,0293	0,1688	0	1

Table 3. Mean Value of Variables Based on Age Group at the Time of Disaster and Experience of The Direct Impact

	Older Children (3-5 years old)		Younger Children (0-2 years old)	
	Not Affected	**Directly Affected**	**Not Affected**	**Directly Affected**
Cognitive Score	12,1904	13,1967	10,2318	9,7333
Gender	0,4853	0,4590	0,5530	0,5600
Schooling	5,4477	5,1967	1,9617	1,8667
Urban	0,4987	0,8688	0,5000	0,9200
Household Size	6,0563	6,2131	6,5219	5,8667
Household Expenditure	1.765.842	1.907.238	1.746.308	2.159.656
Household head's schooling	7,4156	9,5246	7,6095	10,6267
Household head's gender	0,8365	0,8688	0,8504	0,9467
Electrification	0,9839	1,0000	0,9909	1,0000
Sanitation	0,7721	0,8525	0,8102	0,9467
Drinking Water	0,9920	0,9672	0,9927	0,9733
Other Natural Disasters	0,0027	0,2459	0,0055	0,1600

Source: Data Processed, 2021.

Overall, around 85% of the samples lived in households with a male household head. Likewise, suppose it is observed based on groups. In that case, the proportions are not much different, except for the younger sample group affected (experienced the direct impact of the disaster), whose proportion reaches 94%. If we look at the household head's schooling, overall, the head of the sample household has taken formal education for seven years. There is a slight difference when observed based on the sample group. The older sample group who experienced a direct impact was in a household where the household's head had studied for nine years. While the younger sample group who also experienced a direct impact was in a household with the head of the household has studied for ten years, or about grade 1 in senior high school (SMA). For the group that did not experience a direct impact, the head of the household had studied up to 7 years or grade 1 on junior high school (SMP), both in the older sample group and the younger sample group. The sample in this study was in a household with an average of 6 members. The older sample group consists of about six people, while the sample of children in the younger sample group is 5 to 6 people. The sample's average household expenditure (2007 conditions), on average, is 1.79 million per month. If observed between groups, there are differences. Households from the sample group of affected children were, on average, higher than households from the sample group of children who were not affected. The affected sample is around 1.91 million per month from the older age group and 2.16 million per month from the younger age group. The unaffected group is about 1.77 million per month from the older age group and 2.75 million per month from the younger age group.

Most of the sample households have electricity. The sample that experienced a direct impact has been supplied with electricity, both in the older and younger samples. The samples that did not experience a direct impact were 98% and 99% who were electrified, respectively, from the older sample group and the younger one. However, sanitation conditions and drinking water consumption still vary. If you look at the recording results from IFLS 4th wave, the sample whose households have proper sanitation is 80.72 percent. Furthermore, Households with proper sanitation are households that defecate using their closet, either with or without a septic tank or shared closet. In addition, households are classified as households with inadequate sanitation. If observed by group, the older sample group whose households have proper sanitation is around 77% to 85%, while the younger sample group is about 81% to 94%.

Households are classified as households with proper drinking water if the primary water source used for drinking is mineral/aqua water, tap water, well/pump water (electricity/hand, etc.), or bucket/well water. The water is already boiled before drinking. If it doesn't hold, households are grouped into households with inadequate drinking water conditions. The sample households that have properly drinking water conditions are 98.96%. Furthermore, based on the disaster conditions, only a tiny part of the sample in this household had other natural disaster experiences for the past five years (from the recording during IFLS 4th wave). There are only about 2% of households who have experienced other natural disasters besides the experience of the 2006 Yogyakarta natural disaster. For answering the study objectives, this factor will also be controlled again to minimize confounding in seeing the magnitude of the impact of exposure to the 2006 Yogyakarta earthquake.

The children in the sample over about eight years after the disaster measured cognitive scores from the children. The cognitive scores measured are quite varied, stretching from 1 to 17, as shown in Table 3.1. The average cognitive score is around 11.05, with a maximum score scale of 17. We also look in more detail by dividing the sample by age group and based on directly or indirectly affected groups, as shown in Table 3.2. There is a difference in scores between the older sample group and the younger sample group. The older sample group had a mean cognitive score between 12 and 13, while the younger group had a lower average cognitive score between 9 and 10. The younger sample group with affected children The direct impact (exposure to the 2006 Yogyakarta earthquake) appears to have a lower average cognitive score of 9.73 than children who did not experience a direct impact with an average score of 10.23. Children from the younger sample group who experienced this direct impact had a lower average cognitive score than those from the older group who experienced the same thing (the average score was 13.19). It is an early indication that children who in their early life received exposure to the earthquake had lower cognitive performance than children who did not experience exposure to the natural disaster in their early life.

Table 4. Cognitive Scores Comparison Based on Several Variables, Using T-Test

Variables (Xi)	Group 1 (Xi = 0)	Group 2 (Xi = 1)	Mean 1	Mean 2	Diff.	t value	p value
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Directly affected or not (*EQ*)	921	136	11,025	11,287	-0,262	-0,850	0,402
Age position at the time of the 2006 Yogyakarta earthquake (*Agexp*)	434	623	12,332	10,171	2,161	10,700	0,000
Directly affected by the 2006 Yogyakarta earthquake at 0-2 years (*EQ*Agexp*)	982	75	11,160	9,733	1,427	3,500	0,001
Control Variables							
Gender	503	554	11,415	10,735	0,680	3,250	0,001
Urban	475	582	10,998	11,108	-0,110	-0,550	0,600
Household head's gender	155	902	11,020	11,066	-0,046	-0,150	0,876
Electrification	11	1.046	9,364	11,076	-1,712	-1,650	0,096
Sanitation	202	855	10,752	11,131	-0,379	-1,450	0,154
Drinking-Water	11	1.046	12,728	11,041	1,687	1,650	0,102
Other Natural Disasters	1.026	31	11,040	11,678	-0,638	-1,050	0,303

Notes: the groups (group 1 and 2) are divided based on the variables in column 1 to test the differences in cognitive scores between the group

Source: Data Processed, 2021.

We also analyze inferentially using the T-test statistic for this cognitive score variable to support that initial indication. The test was divided into two groups (group 1 and group 2) and analyzed whether each group had a significantly different mean cognitive score or not. Based on the group that was directly or indirectly affected (by *EQ*), the sample was divided into two groups: a sample group of children whose cognitive scores were observed previously not directly affected by the 2006 Yogyakarta earthquake and one who directly affected. Based on what Table 4 shows, it can be seen that the average of the two groups was 11.02 and 11.29, and after being analyzed by the T-test, the results obtained were p-values which were not statistically significant. It means that there is no difference in the average cognitive score between children who are directly affected or not directly affected. But we obtained different results while using age position at the time of the natural disaster (by *Agexp*) and interaction variable (by *EQ*Agexp*). When analyzed for group differences using the same test, each of these group divisions, as the results can be seen in Table 4, there are statistically significant differences indicated by p-values that are smaller than α 1%, 5%, and 10%. It means that from the T-test, there is an indication that there is a statistical difference between the younger sample group, who experienced the 2006 Yogyakarta earthquake early in life, and other groups of children in terms of lower cognitive scores. This study uses DiD modeling specifications to estimate the magnitude and direction of the impact of exposure to the 2006 Yogyakarta earthquake in a child's early life on the formation of his human capital, namely in terms of cognitive performance. The observed variable in this specification is the interaction variable between the dummy variable of age position at the time of disaster (*Agexp*) and the dummy variable of the direct impact of the disaster (*EQ*). The modeling specifications use various control of individual and household characteristics to see the robustness of the estimated effect of interest.

It will be seen how consistent the estimation results are after the various control variables are included.

The estimation results of the model specifications can be seen, first, from model (1) (column (1)) in Table 3.4. The estimation results of the variable of interest are shown before including various control variables in the model. The estimated coefficient for this variable is -1.50, with a p-value smaller than α (both at α 1%, 5%, and 10%, indicated by three stars). Statistically, it has a significant effect. It means that exposure to the 2006 Yogyakarta earthquake in the child's early life (two years or below) impacts the performance of a lower cognitive score by an average of around 1.50 points later in life than children who had it later, or than those who didn't have the same exposure.

Table 5. The Effect of Early-Life Shock in the 2006 Yogyakarta Earthquake on Children's Cognitive

Variables	**Children's Cognitive Scores**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Directly affected or not (*EQ*	1,0064**	1,2088***	1,0100**	0,9643**	0,8538**	1,2443*
	(0,4500)	(0,4214)	(0,4753)	(0,4589)	(0,3796)	(0,7091)
Age position at the time of the 2006 Yogyakarta earthquake (*Agexp*)	-1,9586***	1,0001***	0,9133**	0,9122***	0,9084	1,0468
	(0,2166)	(0,2967)	(0,3628)	(0,3111)	(0,6472)	(0,8227)
Directly affected by the 2006 Yogyakarta earthquake at 0-2 years (***EQ*Agexp***)	**-1,5048*** **	**-1,6248*** **	**-1,7353*** **	**-1,7196*** **	**-1,5906*** **	**-1,6100*** **
	(0,5548)	**(0,5544)**	**(0,6040)**	**(0,5290)**	**(0,5523)**	**(0,4978)**
Control Variables						
Individual Characteristics						
Gender	-	-0,3420	-0,3918*	-0,3922**	-0,3001	-0,1909
		(0,2089)	(0,2279)	(0,1945)	(0,2188)	(0,1340)
Schooling	-	0,8421***	0,8154***	0,8152***	1,0708***	1,1201***
		(0,0728)	(0,0732)	(0,0899)	(0,1403)	(0,1607)
Household Characteristics						
Urban	-	-	-0,0218	-0,0195	-0,0218	-0,1560
			(0,2237)	(0,1914)	(0,2093)	(0,2644)
Household Size	-	-	-0,0612**	-0,0618**	-0,0586	-0,0315
			(0,0295)	(0,0285)	(0,0365)	(0,0242)
Household Expenditure	-	-	1,01x10^{-7}*	1,02x10^{-7}*	1,15x10^{-7}*	1,16x10^{-7}**
			(5,46x10^{-8})	(5,71x10^{-8})	(6,18x10^{-8})	(5,63x10^{-8})
Household head's gender	-	-	0,0952	0,0935	0,2209	0,2047
			(0,3033)	(0,2734)	(0,2682)	(0,3246)
Household head's schooling	-	-	0,0952	0,0529**	0,0459**	0,0406*
			(0,3033)	(0,0224)	(0,0181)	(0,0227)
Electrification	-	-	1,7636**	1,7615**	1,7139*	1,7486**
			(0,7801)	(0,8598)	(0,9156)	(0,6936)
Sanitation	-	-	0,1289	0,1331	0,1238	0,1532
			(0,2264)	(0,1959)	(0,2252)	(0,2074)
Drinking Water	-	-	-1,6349**	-1,5981**	-1,3952**	-1,3949**
			(0,6628)	(0,6798)	(0,6110)	(0,5479)
Other Natural Disasters	-	-	-	0,1884	0,2536	0,1940
				(0,5333)	(0,5943)	(0,4770)
Birth Year Fixed Effect	-	-	-	-	Yes	Yes
Area Fixed Effect	-	-	-	-	-	Yes
Observation	1.057	1.057	1.057	1.057	1.057	1.057
Adj. R-Squared	0,1011	0,1970	0,2097	0,2090	0,2241	0,2489

Notes: value in parentheses is t-statistics value * p<0,1; ** p<0,05; *** p<0,01.
Source: Data Processed, 2021.

The specification of model (2) (whose estimation results are shown in column (2), Table 5 it was controlled using individual characteristics, namely gender and length of education that has been taken. It can be seen in the table that gender control is not significant. Still, the estimation results are significant and have a positive sign for the control over the length of the child's education. The estimation results for the child's schooling confirm the arguments of Behrman and Birdsall (1983) and Brouwers *et al*. (2006) that children who go to school have their own experience and knowledge that can outperform children who are not in school. Learning experiences while attending school can expand thinking skills so that the longer a person spends time in education, the more cognitive performance develops. The estimation results on the observed variables show that the direction is still negative with the magnitude of the estimated coefficient of -1.62. The estimation results also obtained that they are still statistically significant with a p-value more minor than the value of α = 1%. The magnitude of this estimate means that controlling for several individual characteristics, on average, exposure to the 2006 Yogyakarta earthquake in the early life (age two years and under) of a child also impacts the performance of a lower cognitive score on average approx. 1.62 points later in life compared to children who experienced it later or those who did not experience the same exposure.

Estimation results of Model specifications (3) are shown in column (3), Table 5. Apart from being controlled by individual characteristics, control was also carried out using several household characteristics, characteristics of the head of the household (gender and length of education), house size households, electrification, sanitation, and drinking water consumption conditions. In terms of direction, it can be seen that the estimation results are still negative with the magnitude of the estimated coefficient this time of -1.74. The estimation results also obtained that they are still statistically significant with a p-value more minor than the value of α = 1%. It means that controlling for some of these characteristics, exposure to the 2006 Yogyakarta earthquake in the child's early life (two years or below) impacts the performance of a lower cognitive score by an average of around 1.74 points later in life than children who had it later, or than those who didn't have the same exposure. The control variable obtained from the estimation results of the model specification (3) also shows a slight change in gender in the estimation results with this specification. Still, this time it is only significant at the level of α = 10%. The variable length of education remained significant up to the level of α = 1% level. From these results, the control variable household size obtained significant results at the level of α = 5% with a negative direction. Confirming from what was found by Marjoribanks (1976) and Blake (1981) that family size (along with the number of children) tends to divide further the resources that exist in the family (even taking into account economies of scale), thus making output in a child tend to be lower. Significant household expenditures and a positive sign indicate positive household support for children's development related to consumption, including children's development and health, so that household expenditures are positively correlated with better cognitive abilities of children.

These results are in line with Becker and Tomes (1986) that parents not only pass on their various endowments to their children but can also influence them in the future through expenditures related to skills, health, learning, motivation, beliefs, and achievements from the past, and various characteristics. The positive and significant estimation results on the household electrification variable also show a separate role in the education process and various consumptions that support children's development to impact children's cognition positively. These results confirm the theory mentioned by Heckman and Masterov (2007) and Fujii *et al*. (2016) that access to electricity is an essential element in adopting communication and information technology, providing education and health services, and supporting various activities. The drinking water consumption variable also shows a significant estimation result but negative. It is most likely the effect of the 2006 Yogyakarta earthquake, which damaged various buildings and gave sediment substances from the debris of building damage that settled and flowed into water sources, and made condition of water quality at that time was worse (Meyer *et al*., 2008). As Ferguson *et al*. (2013) argue, drinking water containing contaminants can impact children's growth, affecting the child's cognition.

Model specification (4) (whose estimation results are shown in column (4), Table 5), apart from controlling for individual and household characteristics, other natural disaster experience factors were also controlled. Based on the IFLS 4th wave, what is included in the survey is disaster experience for the past five years. This control variable is used to anticipate the confounding effect of exposure to other natural shocks in the early days of a child's life. The estimation result of the coefficient of the observed variable shows that the direction is still negative, with the magnitude of the estimated coefficient this time being -1.72. The estimation results are also statistically significant, with a p-value smaller than α = 1%. It means that controlling for some of these characteristics, exposure to the 2006 Yogyakarta earthquake in the child's early life (two years or below) impacts the performance of a lower cognitive score by an average of around 1.72 points later in life than children who had it later, or than those who didn't have the same exposure. The control variable, namely gender, is still significant with a significance of 5% and a negative estimation result. It is enough to confirm Mann *et al*. (1990) saw that women had several advantages in some forms of cognitive tests such as symbol and digit tests. This time the control of the length of household head education was significant at the level of α = 5%. It shows that children whose fathers are noted to have better formal education have better cognitive outcomes than children whose fathers have lower formal education, as confirmed by Cabrera *et al*. (2006); Bronte-Tinke *et al*. (2008); and Baker (2013). Other controls, such as the length of a child's education, household size, household expenditure, electrification, and drinking water consumption, are still significant as the results of the model specification (3) and the direction of the estimation results.

Anticipating various variations that arise from the birth year and the condition of the area of residence also included the fixed effect of the year of birth and the shape of the area of living in the model's specifications (5) and model (6). At the estimation results with this specification, some control variables look insignificant after using a model with complete control variables, such as gender and household size, after including the fixed effect. Still, other control variables, namely the length of children's education, household expenditures, schooling of the household's head, electrification, and drinking water, are significant, as is the direction of the estimation results. However, controlling (according to the theory related to factors that affect cognition) is still carried out here to minimize the presence of omitted variables biased in estimating the actual effect of natural disasters on the cognitive score (Angrist and Pischke, 2009). As for the variable of interest in this study, the estimation results obtained are also statistically significant, with a p-value more petite than α. Therefore, the null hypothesis is consistently rejected with this estimation result, as are the results in columns (1) to (5). The results of the model specification (6) (column (6)) give the magnitude of the estimated coefficient of -1.61, with a significant p-value (lower than α = 1%). It means that controlling for some of these characteristics, exposure to the 2006 Yogyakarta earthquake in the child's early life (two years or below) impacts the performance of a lower cognitive score by an average of around 1.61 points later in life than children who had it later, or than those who didn't have the same exposure. The findings of the estimation of the impact of natural disasters are in line with the results obtained by Rosales (2014) in his research that there is an impact on lower cognitive scores in children exposed to natural disasters at the age of 0 years. However, he found a lower magnitude in different natural disasters background. It also supports the findings of Aguilar and Vicarelli (2018) that the experience of El-Nino storm shock at the age of two years and under has a long-term impact on children's cognitive. This lower score of 1.61 points is also quite deep towards the average score in the sample (11.06 points) compared to the effect of shock on cognitive scores in a similar study by Shah and Steinberg (2017). This more profound magnitude is obtained after considering the intensity of the impact of shock (earthquake), which varies between households, compared to Shah and Steinberg (2017), whose size of shock is in regional units. The nature of the shock itself also indicates this profound magnitude. The 2006 Yogyakarta earthquake was the biggest disaster in the last two decades, which meant significant physical damage such as buildings, houses, and infrastructure and the losses caused to the earthquake. Human capital in the long term is also quite a calculation. Most of Yogyakarta's land area is material from volcanic deposits, which are easily amplified by vibrations whose source is directly from beneath the land, so they are vulnerable to damaged buildings on the mainland (Tanjung *et al.*, 2019). Also, the character of an earthquake disaster is more destructive than other natural disasters (EMDAT, 2021). The difficulty of health facilities, facilities, and infrastructure due to the earthquake's impact certainly had its long-term impact on infants of early ages at that time.

Exploring the analysis of the effect of exposure to the 2006 Yogyakarta earthquake during early life on children's cognitive scores, the effect is also described based on the position of the child's age at the time of the disaster. Previously, we only observed different effects between the position of two years or below child (including *in-utero*) and after that. Now, it is distinguished to analyze in three positions. Respectively, the child's position at one year and under, the position between one and two years, and the position between two and three years. The three of them are formed by a dummy variable (Eq*Agexp1, Eq*Agexp2, and Eq*Agexp3) whose basic categories are children aged between 3 and 5 years (according to the description in the methodology for the distribution of children's age when an earthquake occurs, the maximum is five years). The difference in observations at the different age positions of children is to analyze and prove the position of children in early life who are more vulnerable than later ages. The three observed variables were analyzed for their impact on cognitive scores using the model equation specification (2.1) with the three new dummy variables replacing Agexp.

Table 6. Effect of Early-Life Shock in 2006 Yogyakarta Earthquake on Children's Cognitive Score, Based on Child's Age Position While Disaster

Variables	Children's Cognitive Score	
	(1)	(2)
EQ	2,0979***	2,0526***
	(0,4744)	(0,6861)
Agexp1	-2,1733***	2,2667***
	(0,2524)	(0,8441)
Agexp2	-0,5616**	1,7812***
	(0,2491)	(0,4299)
Agexp3	0,4082	1,4790***
	(0,3096)	(0,3889)
EQ*Agexp1	**-2,7606*** **	**-2,5340*** **
	(0,7886)	**(0,7253)**
EQ*Agexp2	**-1,5858** **	**-2.0399** **
	(0,7134)	**(0,8815)**
EQ*Agexp3	**-2,5552*** **	**-1,9419** **
	(0,9296)	**(0,8423)**
Control Variables	No	Yes
Birth Year Fixed Effects	No	Yes
Area Fixed Effects	No	Yes
Observation	1.057	1.057
Adj. R-Squared	0,1321	0,2517

Notes: value in parentheses is a standard error value. Column (1) results of model estimation without control variables, column (2) results of model estimation with control variables. The three variables of interest (in bold) were analyzed for their impact on cognitive scores using the specification model (2.1); the Agexp variable was replaced by including Agexp1, Agexp2, and Agexp3. The control variables used are the same as those used for the main estimate, the results of which are shown in table 4
* p<0,1; ** p<0,05; *** p<0,01

The estimation results can be seen in Table 6. The estimation results of the coefficients of the observed variables (Eq*Agexp1, Eq*Agexp2, and Eq*Agexp3) obtained that all three have negative directions. Interestingly, it is obtained both before the control variable is entered and after the control variable is entered. The results of the coefficient estimation on the Eq*Agexp1 variable got the estimated magnitude of -2.53 (from the complete model with control variables, in column (2)). It means one-year-old children or below when the disaster had an impact on a more profound cognitive score, namely an average of 2.53 points lower than children who at the time of the disaster were already in a position between the ages of 3 and 5 years.

Estimating the coefficient on the variable Eq*Agexp2 obtained the estimated magnitude of -2.04 (from the complete model with control variables, column (2)). It means children who on the disaster were between the ages of 1 and 2 years impacted a more resounding cognitive score. It had an average of 2.04 points lower than children already in a position between 3 and 5 years old when the disaster. Next, the results of the coefficient estimation on the Eq*Agexp3 variable are obtained with the estimated magnitude of -1.94 (from the complete model with control variables, column (2)). It means children who at the time of the disaster were at the age of 3 years impacted a more profound cognitive score, namely an average of 1.94 points lower than children already in a position between 3 and 5 years of age. It was also found that the coefficient estimation results for the Eq*Agexp1 variable were lower than for the Eq*Agexp2 and Eq*Agexp3 variables. These results give statistical proof that the earlier the child's age when receiving the intervention, including negative exposure to natural disasters, will have a deeper impact on children's cognitive scores in the future.

It supports the theory that various interventions in a critical early position in life can accumulate on children's growth in the following years, which will affect future human capital outcomes (Heckman, 2007). This result is also in line with Aguilar and Vicarelli (2018) founding that the age of two years is more sensitive than the age after that, so the cognitive outcome of children is lower than the age of the year after experiencing a negative shock. Still, the results were more consistent in magnitude related to the child's position over time in this study. As shown in Table 3.5, this result is after estimating the specifications between no control variable and fixed effect with the result using control variable and fixed effect.

The control variables used in full of estimating results are shown in Table 6, which was carried out to minimize the omitted variable bias in estimating the true effect of natural disasters at an early age on the cognitive score (Angrist and Pischke, 2009). The control variables for the length of education of children, household expenditures, household head's schooling, electrification, and consumption of drinking water are still consistently significant as the results in Table 6 with complete specification (Table 6, column (6)). It further shows the consistency of the importance of these variables on children's cognitive later in life. These results further support the main results and analysis, that the impact of the 2006 Yogyakarta earthquake during early life had an impact on cognition, with a direct hit at the age of one year and under giving a more profound effect on children's cognitive than the direct impact on the position of the age after that.

CONCLUSION

Based on the description of the results and discussion of the previous section, this study leads to conclusions that answer the research objectives. The shock of an earthquake experienced by a child in their early days (first two years), which is a critical period, has a long-term impact on an average of 1.61 points lower cognitive score. It is lower compared to other children or children who at the same age are not exposed to the direct impact of the natural disaster. The magnitude is quite large compared to similar studies because the characteristics of the earthquake disaster based on the damage data are indeed greater. It is because the geological and geographical characteristics of the Yogyakarta area and its surroundings make it have a significant impact on natural disaster damage. This finding complements the results of similar studies because it focuses on one observation of the shock of a natural disaster (the 2006 Yogyakarta earthquake). It also has adjusted the sampling to other significant events, such as the 1998 economic crisis whose impact experience was not included in the survey data. Observations of exposure to disaster shock have also been based on the direct impact of households so that the intensity difference is visible compared to similar studies which observed exposure to natural disaster shock based on regional units.

The consistency of the findings of this study has also been confirmed after the parallel conditions of the outcome variables (children's cognitive scores) outside of the shock being observed have been proven statistically, in addition to being consistent after controlling for various characteristics and other disaster experiences. This finding is reinforced by the result that the earlier the child's position during the 2006 Yogyakarta earthquake disaster was experienced, the more profound impact on the outcome of children's human capital formation in the future. Children at an earlier age, especially when they are one year old and under, are more sensitive in accepting the negative effects of natural disasters than children when they are 4 or 5 years old.

The results of this study have important implications that shock or the experience of a disaster at an early age (early life) provides a high cost to the formation of human capital. Given that Indonesia's geographical position offers its vulnerability to losses from the effects of disasters, the results of this study can be used as a basis for evaluating disaster risk reduction planning. Therefore, what can be reviewed is related to post-disaster management and disaster mitigation. Post-disaster management can be re-evaluated to focus more on handling babies and their parents.

REFERENCES

Aguilar, A., dan Vicarelli, M. (2018). El Niño and Mexican children: medium-term effects of early-life weather shocks on cognitive and health outcomes. *Working Paper*.

Anderson, R.A., dan Marliyani, G., I. (2008). *Comparison-contrast notes for the 2006 Yogyakarta and the 1906 San Francisco earthquakes, The Yogyakarta Earthquake of May 27th, 2006*. Los Angeles: Star Publisher.

Angrist, J.D., dan Pischke, J. (2009). *Mostly Harmless Econometrics: An Empiricist's Companion*. New Jersey: Princeton University Press.

Baez, J., Fuente, A., dan Santos, I. V. (2010). Do Natural Disasters Affect Human Capital? An Assessment Based on Empirical Evidence. *IZA Discussion Paper No.5164*.

Baker, C. E. (2013). Fathers' and mothers' home literacy involvement and children's cognitive and social emotional development: Implications for family literacy programs. *Applied Developmental Science*, 17 (4), 184–197. doi:10.1080/10888691.2013.836034

Barker, D.J.P. (2012). Developmental origins of chronic disease. *Public Health*, 126, 185–189.

Becker, G.S., dan Tomes, N. (1986). Human Capital and the Rise and Fall of Families. *Journal of Labor Economics*, 4(3), S1-S39.

Behrman, J. R., dan Birdsall, N. (1983). The quality of schooling: Quantity alone is misleading. *American Economic Review*, 73(5), 928–946.

Blake, J. (1981). Family Size And The Quality Of Children. Demography, 18(4), 421-442. doi: 10.2307/2060941

Bronte-Tinke, J., Carrano, J., Horowtiz, A., dan Kinukawa, A. (2008). Involvement among resident fathers and links to infant cognitive outcomes. *Journal of Family Issues*, 29 (9), 1211–1244. doi:10.1177/0192513x08318145

Brouwers, S.A., Mishra, R.C., dan Van de Vijver, F.J.R. (2006). Schooling and everyday cognitive development among Kharwar children in India: A natural experiment. *International Journal of Behavioral Development*, 30(6), 559-567.

Bustelo, M., Arends-Kuenning, M., dan Lucchetti, L. (2012). Persistent Impact of Natural Disasters on Child Nutrition and Schooling: Evidence from the 1999 Colombian Earthquake. *IZA Discussion Paper, No. 6354*.

Carusso, G., dan Miller, S. (2015). Long run effects and intergenerational transmission of natural disasters: A case study on the 1970 Ancash

Earthquake. *Journal of Development Economics*, 117, 134-150.

Cabrera, N. J., Shannon, J. D., West, J., dan Brooks-Gunn, J. (2006). Parental interactions with Latino infants: Variation by country of origin and English proficiency. *Child Development*, 77 (5), 1190–1207. doi:10.1111/j.1467-8624.2006.00928.x

Cunha, F., dan Heckman, J. (2007). The Technology of Skill Formation. *American Economic Review*, 97(2), 31–47. doi:10.1257/aer.97.2.31

Dartanto, T. (2017). Disaster, Mitigation, And Household Welfare in Indonesia. *LPEM-FEBUI Working Paper-006*.

de Onis, M., dan Branca, F. (2016). Childhood stunting: a global perspective. *Maternal and Child Nutrition*, 12, 12-26. doi: 10.1111/mcn.12231

Espinoza, R., Urzua, S., dan Claro, S. (2015). Natural Disasters, Academic Performance and Reconstruction: Evidence from Chile's 2010 Earthquake and Tsunami. *Lacea*.

Ferguson, K.T., Rochelle, C.C., MacAllister, J.W., dan Evans, G.W. (2013). The physical environment and child development: An international review. *Int J Psychol*, 48(4), 437–468. doi:10.1080/00207594.2013.804190

Fujii, T., Shonchoy, A.S., dan Xu, S. (2016). Impact of Electrification on Children's Nutritional Status in Rural Bangladesh. *World Development*, 102, 315-330.

Gertler, P. (2004) 'Do Conditional Cash Transfers Improve Child Health ? Evidence from PROGRESA's Control Randomized Experiment', The American Economic Review, 94(2), pp. 336–341.

Heckman, J.J. (2007). The economics, technology, and neuroscience of human capability formation. Proceedings of the National Academy of Sciences, 104, 13250–13255.

Heckman, J. J., dan Masterov, D.V. (2007). The Productivity Argument for Investing in Young Children. *Review of Agricultural Economics*, 29, 446-493.

Joshi, Kuhu. (2019). The impact of drought on human capital in rural India. *Environment and Development Economics*, 24, 413–436. doi:10.1017/S1355770X19000123

Karnawati, D., Pramumijoyo, Anderson, R., dan Husein, S. (2008). *The Yogyakarta Earthquake of May 27th, 2006*. New York: Star Publisher.

Langlois, B., Simpson, R., ..., dan, Naumova, E. (2020). Evaluating Indirect Impacts of Climate Change on Fishing and Farm Productivity Using the Indonesian Family Life Survey: An Example Exploring Natural Disasters and Migration. *Current Developments in Nutrition*, 4 (Issue Supplement_2), 141. https://doi.org/10.1093/cdn/nzaa042_006

Mann, V.A., Sasanuma, S., Sakuma, N., dan Masaki, S. (1990). Sex Differences In Cognitive Abilities: A Crosscultural Perspective. *Neuropsychology*, 28(10), 1063-1077.

Marjoribanks, K. (1976). Social learning theory of the family: An analysis. Psychology in the Schools, 13(4), 457–462. doi: 10.1002/1520-6807(197610)13:4<457::AID-PITS2310130422>3.0.CO;2-V

Masten, A. dan Narayan, A. (2012). Child Development in the Context of Disaster, War, and Terrorism: Pathways of Risk and Resilience. *Annual Review of Psychology*, 63, 227-57. doi: 10.1146/annurev-psych-120710-100356

Meyer, P.A., Brown, M.J., dan Falk, H. (2008). Global approach to reducing lead exposure and poisoning. *Mutation Research/Reviews in Mutation Research*, 659(1),166–175.

Mueller, V., dan Quisumbing, A. (2010). Short- and long-term effects of the 1998 Bangladesh flood on rural wages. *IFPRI discussion papers 956*: International Food Policy Research Institute (IFPRI).

Pan American Health Organization. (2000). [*Bencana Alam: Perlindungan Kesehatan Masyarakat]*. Jakarta: Penerbit Buku Kedokteran EGC.

Paudel, J., dan Ryu, H. (2018). Natural disasters and human capital: The case of Nepal's earthquake. *World Development*, 111, 1-12.

Raven, John. (2008). The Raven Progressive Matrices Tests: Their Theoretical Basis and Measurement Model. *Uses and Abuses of Intelligence: Studies Advancing Spearman and Raven's Quest for Non-Arbitrary Metrics*. Unionville, New York: Royal Fireworks Press.

Rini, A.R., Rahadiantino, L., dan Kirana, M. (2021). Coping Strategy of Disaster Effect: Intra-Household Labor Substitutionin Indonesia. *Annals of RSCB*, 25(3), 5383 – 5396.

Rosales-Rueda, M.F. (2014). Impact of Early Life Shocks on Human Capital Formation: Evidence El Nino Floods in Ecuador. *IDB Working Paper Series No. IDB-WP-503*.

Shah, M., dan Steinberg, B.M. (2017). Drought of Opportunities: Contemporaneous and Long

Term Impacts of Rainfall Shocks on Human Capital . *National Bureau of Economic Research*.

Spencer, Nekeisha. (2017). Are tropical storms a failure warning? Evidence from standardized school examinations. *International Journal of Disaster Risk Reduction*, 24, 32-37.

Strauss, J., Witoelar, F., dan Sikoki, B. (2016). The Fifth Wave of the Indonesia Family Life Survey: Overview and Field Report. *RAND Working Papers*.

Subratha, H F Armynia. (2019). [*Asupan Gizi Balita Yang Berada Di Tempat Pengungsian Kabupaten Karangasem*]. *Jurnal Medika Usada*, 2 (1), 24-30.

Sulistyaningrum, E. (2017). The Impact of Earthquake on Child Test Score. *Journal of Indonesian Economy and Business*, 32(2), 104-120.

Tanjung, NAF., Yuniarto, H.P., dan Widyawarman, D. (2019). *[Analisis Amplifikasi Dan Indeks Kerentanan Seismik Di Kawasan FMIPA UGM Menggunakan Metode HVSR]. Jurnal Geosaintek*, 5 (2), 60-67.

Thamarapani, D. (2017). The Long-Run Effects of The Yogyakarta Earthquake on Child Health. *SSRN*.

Wöessmann, L. (2003). Specifying Human Capital. *Journal of Economic Surveys*, 17(3), 239-270. doi:10.1111/1467-6419.00195

APPENDIX

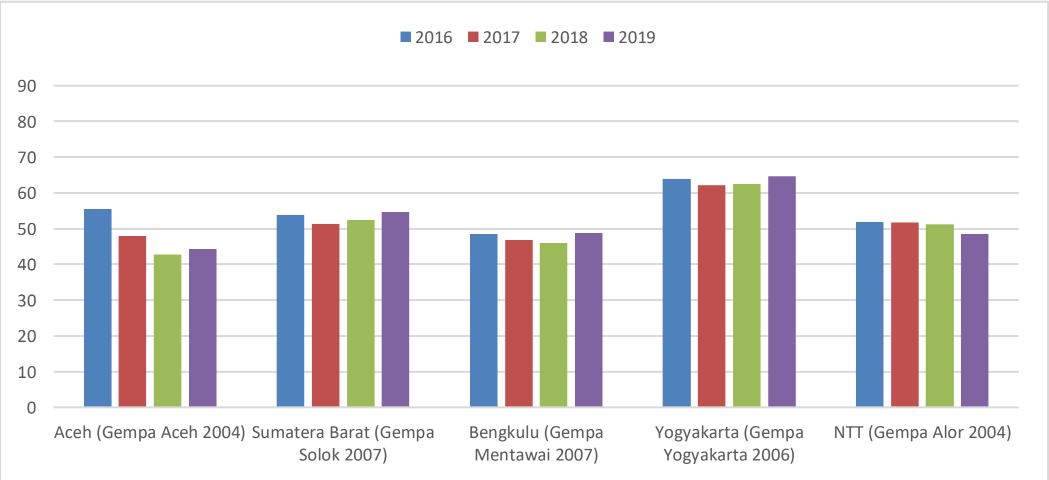
Appendix 1. Data on Impact and Damage of Major Earthquakes in Indonesia

Date	Earthquake Strength	Epicenter	Location Ceenter	Total Affected* (people)	Total Damage Value (000 USD)
November 12th, 2004	7,3 Mw	8.17°N-124.82°E	Alor (NTT)	83.381	-
Desember 26th, 2004	9,3 Mw	3.32°N-95.85°E	Aceh and parts of North Sumatra	532.898	4.451.600
March 28th, 2005	8,6 Mw	2.08°N-97.10°E	Nias Island (Aceh and North Sumatra)	105.313	-
May 27th, 2006	5,9 Mw	7.977°S-110.318°E	Bantul (DI Yogyakarta)	3.177.923	3.100.000
July 17th, 2006	7,7 Mw	9.334°S-107.263°E	Ciamis and Cilacap (West Java)	35.543	55.000
Desember 17th, 2006	6,0 Mw	0.63°N-97.86°E	Mandailing Natal (North Sumatera)	1.200	-
March 6th, 2007	6,4 Mw	0.490°S-100.529°E	Solok, Solok City, Tanah Datar, and Bukittinggi City (West Sumatera)	137.660	200.000
September 12th, 2007	7,7 Mw	4.517°S-101.382°E	Mentawai Island (Bengkulu)	459.567	500.000
November 25th, 2007	6,7 Mw	8.294°S-118.360°E	Sumbawa (NTB)	21.800	-
September 28th, 2018	7,4 Mw	0.18°S-119.85°E	Palu, Donggala (Central Sulawesi)	209.025	1.450.000
January 15th, 2021	6,2 Mw	3.005°S-118.924°E	Majene (West Sulawesi)	100.653	58.700

Notes: Information in this table specifies the observations of earthquakes between 2001 and 2007 to be associated with the average data for the 2016 - 2019 junior high school examination scores from students who experienced an earthquake between 2001-2007
-: no data yet.
* The total affected includes sick, injured, and homeless earthquake victims

Source: EMDAT, 2021 (processed)

Appendix 2. Average National Examination Score for Junior High (SMP) in Some Areas Affected by the Earthquake, 2016-2019



Source: Kemdikbud, 2021 (Processed)