How did varying levels of intensity of the 2005 Pakistan earthquake differentially affect women's fertility decisions and children's health outcomes?

Quantitative Master's Project

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Abstract

This paper uses a difference in difference model to investigate the impact of a large scale and high mortality 2005 earthquake in Pakistan on women's fertility decisions and children's health outcomes. Using a nationally representative, cross sectional DHS data from 2006 and geographical data from USGS, this paper investigates how variation in earthquake intensity levels can differentially impact total fertility for women and the likelihood of children suffering from diseases such as diarrhea, Acute Respiratory Infections (ARI) and fever. The post-earthquake results demonstrate a statistically significant increase in total fertility for areas closer to the epicenter of the earthquake, within a 100km radius of the rupture surface and at higher altitudes. Similarly, for children who were in-utero at the time of the earthquake, the probability of having early symptoms of ARI or fever was much smaller in lower earthquake intensity zones compared to the highest intensity zone.

Introduction and Background:

The last decade has witnessed several high intensity and large scale natural disasters around the globe. Some of these disasters have caused significant and unanticipated shocks to the population resulting in high rates of mortality, destruction of infrastructure and loss of assets. The knowledge gains from demographic research have the potential to inform and shape rehabilitative and recovery policies in disaster stricken areas. Thus, the occurrence of these natural disasters has spurred an academic interest to study and better understand the mechanisms through which natural disasters impact population dynamics (Frankenberg et al., 2015).

One of these mechanisms includes the potential effect of disasters on fertility. Large scale natural disasters often result in high rates of adult and child mortality, loss of income and livelihoods, disruption of health services and reduction in food availability. Moreover, in-utero malnutrition adversely effects the health of the fetus and impacts their health outcomes in the future (Julian et al., 2014). All these shocks can impact women's reproductive health, their fertility preferences and decisions to build a family. This family-building, in the context of developing countries, is a potentially integral mechanism through which communities rebuild themselves after a high intensity natural disaster (Frankenberg et al., 2015).

Within this context, this paper aims to gather empirical evidence from the 2005 Pakistan earthquake to answer the following question:

How did varying levels of intensity of the 2005 Pakistan earthquake differentially affect women's fertility decisions and children's health outcomes?

The 2005 earthquake hit the Himalayan region of northern Pakistan and Kashmir on 8th October 2005 at 8.50am (local time) with an intensity of 7.6 on the Richter scale. This was the strongest and largest earthquake on record in the country, killing 83,750 people ((“Kashmir Earthquake”, 2006; Finlay 2009). According to government estimates, approximately 138,000 people were injured, 19,000 children died in widespread collapses of school buildings and a total of 500,000 families were affected (“Kashmir Earthquake”, 2006).

This makes the 2005 Pakistan earthquake the third deadliest disaster of the past decade (Frankenberg et al., 2015). Pakistan's National Disaster Management Authority, has compiled national level statistics about the extent of damage and destruction caused by this earthquake. As in the case of other high mortality natural disasters, these aggregate statistics do not fully highlight the demographic impact of these events and the key mechanisms that link disasters to demographic change over time (Frankenberg et al., 2015).

Literature review:

Definition of Natural Disasters:

Sociological literature defines disasters as ‘non-routine’ events that comprise of combinations of physical conditions with social dimensions of human harm and disruptions (Frankenberg et al., 2015). This definition excludes chronic events such as poverty and seasonal floods or famines. In the case of Pakistan, even though it is located on a seismically active geological plate which makes it susceptible to earthquakes, the 2005 earthquake hit with an unanticipated intensity (Khan & Forni, 2013). The incidence of the earthquake was not unusual as mild earthquakes had hit Pakistan's Northern areas in 2001, 2002 and 2004 (Ahmed, 2013).

However, the unexpected severity of this earthquake allows us to define this as a disaster (Frankenberg et al., 2015).

Natural Disasters and Fertility Outcomes:

A natural disaster can affect population dynamics in many different ways. The most obvious impact is that disasters can kill substantial number of people unexpectedly. The rates and absolute number of deaths and injuries may vary across gender, age and socio-economic status. For example the Indian Ocean tsunami caused higher mortality rates for women than men and young individuals compared to older ones. Disasters can also displace families, damage properties, disrupt livelihoods and public services, and cause temporary or permanent migrations (Frankenberg et al., 2015). A disaster that leads to changes in the local area population composition can have direct or indirect effects on labor and marriage markets (Frankenberg et al., 2015).

Through less obvious mechanisms disasters can also alter fertility decisions. The associated stress during and after an earthquake can influence coital frequency and ability to conceive and bear a child. For example, the incidence of still births and infant mortality increased in the case of the Chinese famine that swept the country between 1958 and 1961(Zhao & Reimondos, 2012). There was also an increase in child mortality as the probability of a child dying between the age of 1 and 4 years increased during the famine period (Zhao & Reimondos, 2012). Similarly, in the case of the 2004 Indian Ocean Tsunami, the rate of miscarriages increased for women from severely affected areas (Frankenberg et al., 2015).

Disruption of health services and lady health workers can impact the supply of contraceptives. For example, study of data from Yogyakarta earthquake in Indonesia revealed that damage to government health facilities reduced people’s access to contraceptive pills, injections and intrauterine devices (IUD). This lack of supply forced the local population to substitute less effective contraceptives methods and led to an 8.3% increase in unplanned pregnancies a year after the earthquake (Hapsari et.al., 2009).

Moreover, loss of children can leave families with fewer off spring than they ideally desired or planned for and can increase the demand for children. However, since disasters can also negatively impact income through loss of assets and livelihoods, families may not have the financial stability to afford another child. Moreover, significant demographic change in the aftermath of a disaster can lead to patterns of union formation that may modify fertility decisions (Frankenberg et al., 2015). For example, during the Chinese famine period, the proportion of ever-married women decreased after the famine due to postponement of marriages. Severe mortality led to an increase in widowers, widows, single parents and orphans. In some areas, there was also an increase in divorce rates and family divisions. This change was accompanied with a marked reduction in total fertility at the national level (Zhao & Reimondos, 2012).

Relatively few studies have been done to separate out the causal effect of large scale mortality on fertility decisions. Over the past three decades, data has been analyzed to evaluate to the impact of humanitarian crises and conflicts on fertility. However, these studies have not been able to fully characterize changes in mid-term and long term fertility trends (Hill, 2004). Even fewer studies have been to done to understand the impact of disasters on demographic processes. One of the reasons for dearth of research in this area is the difficulty of acquiring timely, accurate and ample data after a huge disaster. Studies on this topic use census level data to look at fertility trends before and after a disaster for affected and unaffected populations (Frankenberg et al., 2015).

One of the most comprehensive studies was done with retrospective data from Cambodia during the Khmer Rouge control. The study pinpointed a doubling in fertility rates between 1978 and 1980 from the prewar rates and then a decline. The significant increase in fertility rates occurred shortly after the Vietnamese control of the country which marked an abrupt end to the genocide. Thus, enabling the authors to conclude that the fertility increase was in response to the high mortality shock (Heuveline & Poch, 2007; (Nobles et al., 2015).

From a theoretical perspective, demographic theory posits that an exposure to mortality changes fertility preferences and behaviors of individuals or couples by reshaping the expectation of child survival. This is called the transition effect which explains that decline in mortality rates creates a sense of greater predictability about the external environment and enhances personal agency. These developments encourage a longer term view of family building and incentivizes the adoption of fertility control (Montgomery 2000).This transition effect links mortality and fertility through three main mechanisms: insurance (or hoarding), lactation-interrupted (physiological) effects and replacement (Nobles et al., 2015; Montgomery 2000).

The insurance effect hinges on the idea that expectations about future child mortality exerts a strong influence on the number of desired children. In essence, the insurance mechanism theorizes that an increase in the probability of child survival decreases the number of desired births (Montgomery 2000). The replacement and physiological mechanism are tied together. The death of an own child may increase fertility if the child who died in the disaster was being breast fed by his mother. If a child dies during the lactation period of 20 months during a disaster, the mother stops breast feeding and resumes menstruating, increasing the possibility births immediately after the disaster (Nobles et al., 2015). On the other hand, the death of an own child might prompt a couple to intentionally conceive a child, so that he/she is ‘replaced’ by a child who may not have been born otherwise (Nobles et al., 2015).

Finlay’s paper on the impact of three earthquakes in India, Turkey and Pakistan attributes increases in fertility rates after these earthquakes to the household’s motivation to use additional children as an insurance mechanism to compensate for lost income and assets from the disaster. Finlay argues that children, in the long run, can support the breadwinner of the family in two ways: by participating in the labor marker or becoming care givers for younger siblings and allowing their parents to enter the labor force (Finlay 2009). However, it may be argued that since an earthquake is a one-time ‘non-routine’ event, it cannot alter future expectations of child survival. Thus, fertility responses to a temporary increase in mortality cannot be explained by the hoarding or insurance motivation (Nobles et al., 2015).

Evidence from the Indian Ocean tsunami of 2004, explains increases in fertility through individual and community level replacement effects. The results from this study reveal that the replacement motive extends beyond women who lost at least one child in the disaster. Rather the replacement motive operates through extra-familial, social and communal ties in location specific disasters where fertility is used as a salient mechanism to rebuild the community (Nobles et al., 2015). The study concluded that women who lost at least one child were more likely to bear additional children after the tsunami. For communities, with higher disaster related mortality, even women without children, initiated family building after the disaster (Nobles et al., 2015).

Natural Disasters and Children's health outcomes:

The effect of natural disasters on fertility outcomes, has also offered researchers the opportunity to study the effect of intrauterine nutrition on health outcomes for infants and surviving children (Julian et al., 2014). The "Barker Hypothesis" in 1991 suggested that fetal undernutrition not only impacts the health of the fetus but also increases the probability of diseases in later life (Ugaz & Zanolini, 2011; Julian et al., 2014).

Evidence from the 1944-1946 Dutch famine claimed that infant exposure to the famine was associated with a higher risk of coronary heart disease and anti-social personality disorder in adult life (Julian et al., 2014). Similarly, a 1990 study of the Bangladesh famine in 1974, found that children conceived during the famine were more likely to die before the age of 1 month compared to those not conceived during the famine. Additional research about this famine, revealed that children in-utero during the most severe period of the famine were 32% more likely to die within the first month of their compared to their siblings who were not in-utero at the time of the famine (Julian et al., 2014).

Research on the 1984 typhoon in Philippines suggests that children who were in the first trimester of pregnancy during the typhoon were 0.3-0.5 standard deviations shorter on average compared to non-affected children. Moreover, young children who survived the typhoon were also more sensitive to infectious waterborne diseases such as diarrhea and typhoid fever (Ugaz & Zanolini, 2011). There is also evidence that in-utero maternal stress can reduce birth weight. For example, the high intensity 2005 Tarapaca earthquake in Chile resulted in a substantial (51 grams) reduction in birthweight for infants who were exposed to the disaster in the first trimester of pregnancy (Torche, 2011). Moreover, the increase in morbidity rates immediately after high mortality disasters can also delay children's entrance to school, interrupt attendance and gradually damage learning abilities (Montgomery 2000).

Data and Methodology:

Description of the Dataset:

This paper will use the 2006-2007 Demographic and Health Survey (DHS) data for Pakistan. The DHS is a nationally representative household survey which looks at repeated cross sections of the population (Finlay, 2009).

The DHS survey is divided into four questionnaires: community level, short household survey, long household survey and survey for sample of ever-married women. The data collected includes detailed birth and pregnancy history for women who have been married, their reproductive health, fertility preferences and use of contraceptives. It also includes a brief history of childhood diseases for young children measuring the incidence of fever, diarrhea and acute respiratory infections ("Demographic", 2008).

The DHS survey was fielded in Pakistan in September 2006, almost a year after the earthquake. This data collection activity culminated in March 2007. A total of 95,441 households were surveyed across 972 clusters in the four main provinces of Punjab, Sindh, North West Frontier Province (NWFP) and Balochistan.

Table 1: Number of Households and Clusters Surveyed

Province	Number of households	Number of Clusters
Punjab	43,411 (45.48%)	440 (45.27%)
Sindh	24,960 (26.15%)	260 (26.75%)
NWFP	17,321 (18.15%)	176 (18.11%)
Balochistan	9,749 (10.21%)	96 (9.88%)
Total	**95,441** **(100%)**	**972** **(100%)**

This particular wave of the DHS data contained cluster level GPS coordinates for 957 clusters with missing GPS data for 2 clusters from NWFP, 8 from Punjab and 5f from Balochistan (Table A in the Appendix). This paper merges the household and women-level birth history data from these 957 clusters with the following additional geographical data:

a) *Geographical Coordinates of the Earthquake's epicenter*: Data was obtained from the U.S Geological Survey (USGS) Earthquake Hazard Program's database.
b) *USGS Intensity Measures:* The USGS website collected data on the intensity of the earthquake by asking an online survey about the tremors felt in a location. This data was only compiled for 13 locations in Punjab and 9 locations in NWFP. These locations could not be matched exactly with the DHS data but provided additional information about the earthquake's measured intensity and its relationship with distance to epicenter.
c) *Rupture Surface Data:* The USGS database was used to identify the rupture surface around the earthquake's epicenter along the Himalayan Frontal Thrust. Nine geocoded coordinates along the rupture surface's outline were recorded from the USGS database using ArcGIS.
d) *Elevation Data:* The DHS geographical coordinates of the clusters were used to extract elevation data from USGS and ASTER Digital Elevation Model (DEM) databases. Elevation data was recorded in meters for each cluster.

Caveats and Limitations Section:

There are a few key limitations of the 2006 DHS dataset. This wave of the DHS survey was unable to collect data from the district of Muzaffarabad, where the earthquake's epicenter was located. Thus, information about the most severely affected district is missing in this data. No data was collected from any of the districts in Azad Jammu and Kashmir.

Moreover, this dataset does not contain information about migration of households after the earthquake. This makes it difficult to map the location of pre and post-earthquake births and incidence of diseases accurately. Additionally, the DHS did not capture any data on the changes in the supply of contraceptives during the recovery and rehabilitation process after 2005.

Another important caveat in this paper is that geographical variables of distance to the epicenter or the rupture surface are not perfectly correlated with the level of damage to physical and human capital and trauma amongst survivors. It should also be noted that GPS coordinates in the DHS data are displaced to ensure respondent confidentiality. The GPS coordinates of urban and rural clusters are displaced by 2 and 5 kilometers respectively. Thus, there is some measurement error in the calculation of distance from each individual cluster to the earthquake's epicenter and rupture surface.

Moreover, since the survey's data collection ended within 17 months of the earthquake, the timing maybe too soon study the full impact of the disaster on post-earthquake fertility behaviors and decisions. Given, these limitations, the results of this paper should be interpreted with caution.

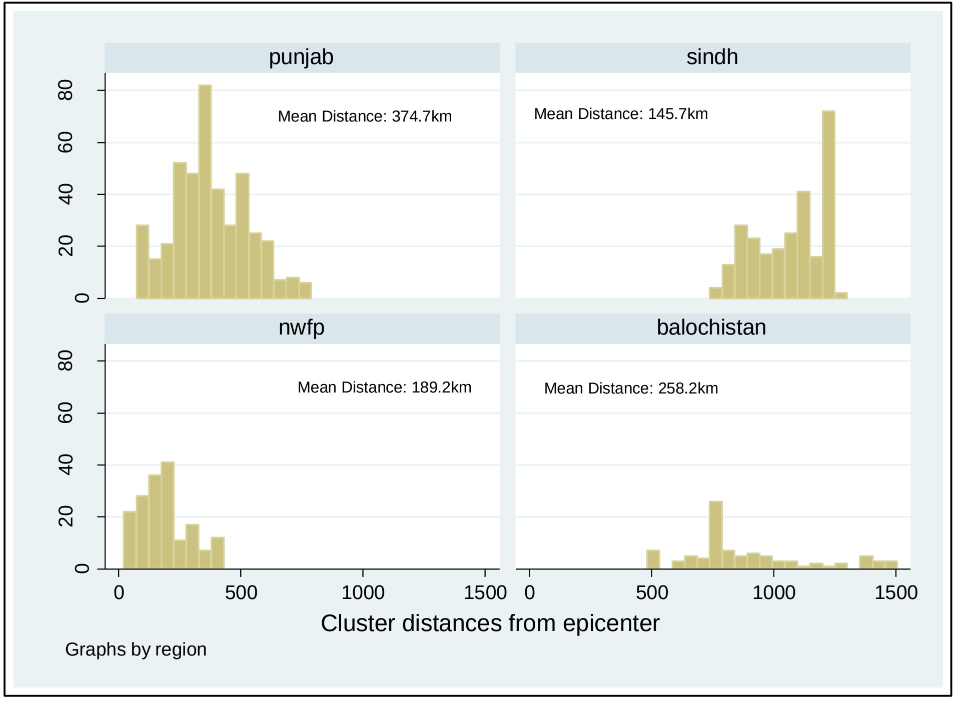
Identification Strategy:

This paper uses different combinations of geographical data to define the intensity of the earthquake.

1) <u>Provincial Boundaries and Distance to Epicenter:</u>

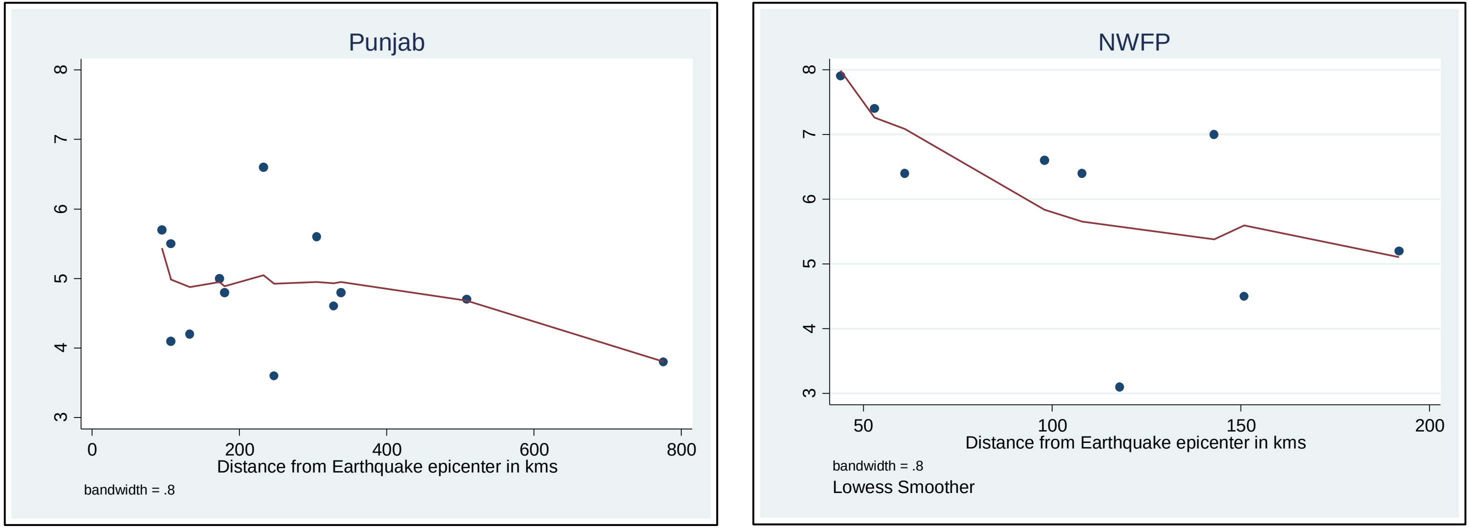
Geographically, the province of NWFP was closest to the epicenter, followed by northern parts of Punjab. The distribution of distances to the epicenter across clusters in the four provinces is shown below:

Figure 1: Distribution of Epicentral Distances Across Provinces



In order to examine the relationship between intensity of earthquake and distance from epicenter in the DHS data, information from the USGS intensity measures was used to confirm that median intensity was much higher in NWFP for distances closer to the epicenter as compared to Punjab. Figure 2 shows that intensity of the earthquake decreases with distance to the epicenter and at any given distance, intensity recorded was slightly higher for NWFP compared to Punjab.

Figure 2: Intensity of Earthquake in NWFP and Punjab



An important check is whether mortality as measured in the DHS dataset is associated with proximity to the earthquake. To assess how geographical location affected post-earthquake mortality rates, difference in number of deaths before and after an earthquake were calculated for each province for two age groups: individuals who are 12 years and above, and 11 years and below.

The rates of deaths were computed for two time periods: three months before the earthquake (July-September 2005) and three months after the earthquake (October-December 2005). This analysis was based on the information in the household roster about recent deaths in the past five years.

Table 2: Mortality Rates Across Age Groups Before and After the Earthquake

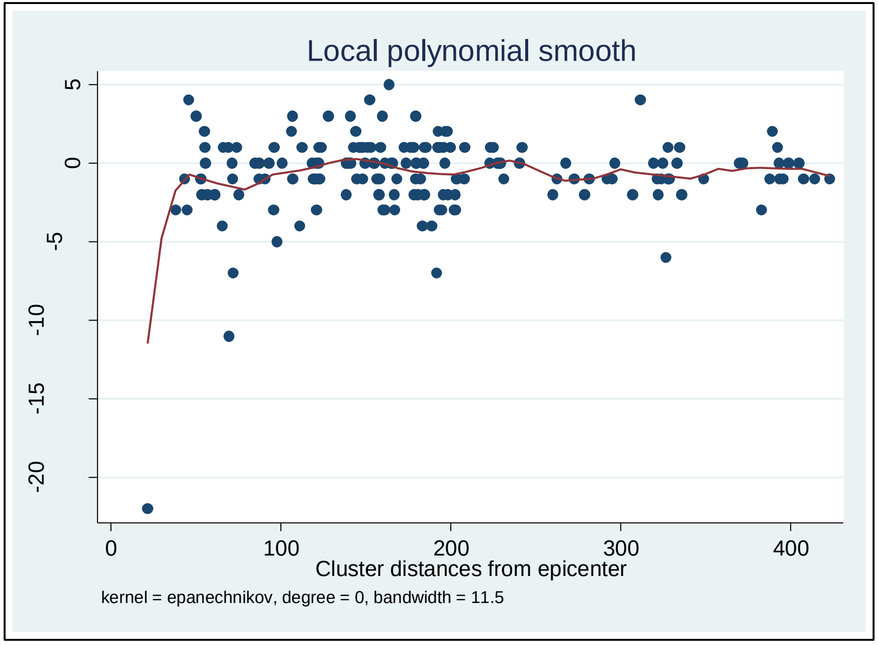
Provinces	**12 years and above**		**11 years and less**	
	Pre-Earthquake Mortality Rates	**Post-Earthquake Mortality Rates**	**Pre-Earthquake Mortality Rates**	**Post-Earthquake Mortality Rates**
Punjab	0.15	0.19	0.13	0.17
Sindh	0.13	0.19	0.18	0.26
NWFP	0.15	0.22	0.10	0.20
Balochistan	0.18	0.11	0.18	0.18

Table 2 demonstrates that there is an increase in deaths after the earthquakes for both age groups in all provinces except Balochistan. NWFP has the highest percentage increase in number of deaths for children aged 11 years and below after the earthquake.

To establish a relationship between these mortality rates and distance to the epicenter, the distribution of deaths before and after the earthquake for all age groups was plotted against cluster level distances to the epicenter for NWFP. The hypothesis was that the difference would be most negative for clusters closer to the epicenter.

For the province closest on average to the epicenter, Figure 3 shows that the difference in absolute number of deaths before and after the earthquake decreases as the distance from epicenter increases. Although the difference in pre and post-earthquake deaths remains negative and statistically different from zero even for distances greater than 250 km[1]this figure clearly demonstrates that the highest mortality effect was seen in clusters closest to the epicenter (less than 50 km from the epicenter).

Figure 3: Difference in Deaths Before and After the Earthquake in NWFP



Moreover, geological studies show that the 2005 earthquake caused a surface rupture in the Himalayas that had never happened before. The surface rupture was shallow with a depth of only 26 kilometers which had caused massive destruction. However, since the surface rupture extended to 75 kilometers in length, most of the destruction caused by landslides was concentrated near the Balakot-Garhi fault line which is closer to NWFP (Naranjo, 2008; Sato et al., 2007). This is further evidence that the earthquake's intensity was higher in NWFP compared to other provinces. Thus, distance to the epicenter may be used to proxy for identifying areas where the intensity of the 2005 earthquake was the highest.

Using the evidence above, two possible definitions of intensity emerge:

a) Intensity can be defined using provincial boundaries. NWFP, with the smallest average distance to the epicenter of 189.2 km (Figure 1) and also the highest recorded earthquake intensity (Figure 2) can be defined as the only province affected by the earthquake.
b) Intensity can be defined as a continuous distance variable for the two high intensity provinces (NWFP and Punjab). For this definition, distance to the epicenter is measured (in kilometers) by calculating the distance of each cluster to the epicenter of the earthquake. The cluster level GPS coordinates given in the DHS data are used to calculate distances to

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[1] A t-test, using distance thresholds, established that the mean of the pre and post-earthquake differences in death is significantly different than 0 at the 95% confidence interval with a p-value of 0.0067 for distances greater than 250 km.

the earthquake's epicenter of 34.493°N, 73.629°E. These geographical distances are calculated in STATA which uses the Vincenty equation to connect two points along the mathematical model of the earth.

2) Distance to the Rupture Surface and Elevation of Clusters:

Geological literature suggests that the distance to fault line and altitude of an area were also key determinants of the severity of the Pakistan earthquake in 2005. The earthquake triggered roughly 2424 landslides mostly occurring on the hanging wall of the sub-Himalayan Balakot-Garhi fault line. 79% of these landslides were small and comprised of shallow rock falls and 9% were large landslides where rockslides cascaded downslope to flatter areas. Almost 47% of the total landslides occurred within 1 and 2 km of the fault line. Thus, another measure of the earthquake's intensity can be defined as distance to the rupture surface along the fault line for NWFP and Punjab.

USGS data was used to confirm the relationship between the distance to rupture surface and the recorded intensity of the earthquake. This information is summarized in Figure A (shown in the attached Appendix) which shows how the blue surface rupture region encapsulates the epicenter (red dot) and is closest to NWFP and Punjab. The two provinces most severely affected by the earthquake: NWFP (Khyber Pakhtunkhwa) and Punjab are located North-West and South East of the surface rupture respectively. High earthquake intensity cities, marked in orange, are clustered around one wall of the rupture surface.

To define intensity as the shortest distance (in kilometers) of each cluster to any of the nine geocoded coordinates along the rupture surface, each cluster in the DHS dataset was matched to its nearest rupture surface coordinate using the neighbor reduction algorithm of the *geonear* command in Stata. To capture the varying effects of intensity within different thresholds, shortest distance to the rupture surface is categorized into different zones where Zone A represents the high intensity zone and Zone C the low intensity (shown in Table 3 below).

Table 3: Zone Categories Collapsed by Distance

Distance to nearest rupture surface coordinate (in kilometers)	**Zone Categories**
Less than equal to 100	*Zone A (High Intensity)*
Between 100 and 350	*Zone B (Medium Intensity)*
Greater than 350	*Zone C (Low Intensity)*

There is additional geological evidence for the 2005 Pakistan earthquake that relates elevation and landslides such that 90% of the landslides took place on altitudes 2000m and less especially concentrated within 1300 and 1400m elevation range. However, landslides occurred at the elevation where the fault exists and the occurrence of landslides cannot not be solely attributed to elevation (Sato et. Al, 2006; Mahmood et. Al, 2015).

To understand how elevation affected the propensity for landslides and damage for a given distance from the rupture surface, nine intensity zones were created as shown in Table 4 below. Distance to the rupture surface along the fault line and elevation of household clusters were combined to create these zones to identify varying degree of earthquake intensity in NWFP and Punjab.

Table 4: Zones for Elevation and Nearest Distance of Cluster to Rupture Surface

Distance to nearest rupture surface coordinate (in kilometers)	**Elevation of cluster (in meters)**		
	Between 1000 and 4000	*Between 500 and 1000*	*Less than 500*
Less than equal to 100	Zone 1	Zone 2	Zone 3
Between 100 and 350	Zone 4	Zone 5	Zone 6
Greater than 350	Zone 7	Zone 8	Zone 9

Section A: Effects of the Earthquake on Fertility

This paper aims to check the hypothesis of increased fertility rates after the 2005 earthquake. In order to test this hypothesis, this paper employs a difference in difference regression model to see how the total number of births including current pregnancies changes for women before and after the earthquake as intensity of the earthquake varies across clusters.

The sample of women includes those who are currently married at the time of the survey in 2006 and have not had a sterilization procedure to prevent future pregnancies. For some of households in this sample there is more than one married woman who was eligible for the DHS "Ever-Married" women's survey. The conception dates for each birth are calculated using the birth history record, assuming that each birth occurred after a 40 week (280 days) long normal pregnancy.[2]

Estimation Equation:

1) **Model Specification I: Using provincial boundary and distance to epicenter as a measure for earthquake intensity**

The difference in difference equation to measure changes in total number of births before and after the earthquake for affected and non-affected areas is as follows:

$$\mathbf{N_{itr}=\beta_1 post +\beta_2 near+\beta_3 post_t{*}near+X'\beta+\varepsilon_{irt}}$$

Here N is the total births including current pregnancy for each individual woman 'i' in region[3] 'r' at time 't'. Total births includes all birth histories from the pre-earthquake time period till the year 2007. 'Post' is the indicator variable for after the earthquake and near is defined in two different ways:

a) As an indicator variable which takes the value of 1 for NWFP and 0 for the other provinces,
b) As a continuous variable for distance to the earthquake's epicenter.

X is the vector of controls which includes mother's age and education, father's education and type of cluster (urban or rural).

2) **Model Specification II: Using distance to rupture surface and elevation as a measure for earthquake intensity**

Using the earthquake intensity zones created in Table 3 and 4, Model specification II uses the following estimation equation:

$$\mathbf{N_{itc}=\beta_1 post_t+\beta_2 zone_j+\beta_3 post_t{*}zone_j +X'\beta+\varepsilon_{irc}}$$

Again, N here is the total number of births including current pregnancy for each individual woman 'i' in cluster 'c' at any time 't'. However this model segments the different time periods in the dataset. For a fixed period of post-earthquake birth histories from 2006 to 2007, pre-earthquake birth histories are divided into three different time periods a) all pre-earthquake birth histories in the dataset, b) pre-earthquake birth histories 10 years before the earthquake and c) pre-earthquake birth histories 5 years before the earthquake

'Post' is the indicator variable for after the earthquake and $zone_j$ represents:

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[2] This assumption adds measurement error to the calculation of total births in Section A and in-utero exposure to earthquake in Section B because a mother's exposure to earthquake related trauma/stress during pregnancy can cause pre-mature births and affect the normal duration of the pregnancy.

[3] Region 'r' refers to province for definition (a) and cluster for definition (b) in Model Specification I.

a) Zones A, B and C from Table 3. Zone A is the high intensity zone, located within 100 km of the rupture surface and Zone C is the low intensity zone, situated more than 350 km away from the rupture surface. Zone C is used as the comparison group in this regression model.

b) The nine zones defined in Table 4 where Zone 1 is the extremely high earthquake intensity zone with smallest distance to the rupture surface and highest elevation whereas Zone 9 is the lowest intensity as it is farthest from the rupture surface and in the lowest elevation category. In this regression model the high intensity Zone 1 is the comparison zone category. It is important to note that Zone 7 and 8 are omitted in the regression model because no data points exists for these zones in NWFP and Punjab.

X is the same vector of controls which includes mother's age and education, father's education and type of cluster (urban or rural).

Results

a) Model Specification I:

Difference-in-Difference Regression Result for all four provinces:

If "near" is defined as an indicator variable taking the value of 1 for NWFP and 0 for all other provinces, then the results in Table 5 show that compared to pre-earthquake births, after the earthquake there is a decrease in number of births in NWFP relative to other provinces (with a coefficient of 0.387) and this decrease is statistically significant with a p value of 0.

For the control variables, there is an increase (coefficient is 0.095) in total number of births as the mother's age increases by one year, a 0.056 and 0.010 decrease in total number of births as the mother's and father's years of education increase by one year, respectively. Urban areas have a lower total number of births compared to rural areas. All these results are statistically significant at the 95% confidence interval.

Table 5: Regression Results for All Provinces using NWFP as affected area

Dependent Variable: Total Number of births (plus current pregnancy) for all Birth Histories in the data	**All provinces**
Post	-3.84***
	(.038)
NWFP	.339***
	(.074)
Post*NWFP	-.387***
	(.091)
Age of Mother	.095***
	(.002)
Mother's education	-.056***
	(.003)
Father's Education	-.010***
	(.002)
Urban	-.077**
	(.030)
N	**15082**

Note: Robust standard errors in parenthesis; *** p<0.01, ** p<0.05, *p<0.1Clustering of standard errors at the cluster level.

Difference-in-Difference Regression Result for NWFP and Punjab.

To explore intra-provincial variations in total number of births, another regression was run to estimate changes in total fertility as distance to the epicenter varied in Punjab and NWFP.

Looking at NWFP alone, results from column (1) of Table 6 below show that after the earthquake there is a decrease (with a coefficient of 3.91) in total number of births compared to before the earthquake. Also, as distance to epicenter increases, there is an increase in total number of births by 0.001. However, this positive relationship between total number of births and distance reverses, when the distance variable is interacted with the post-earthquake indicator variable. Compared to total number of births before the earthquake, there is a decrease (coefficient of 0.002) in total number of births after the earthquake as distance to epicenter increases by 1 km. This result is marginally statistically significant at the 95% confidence interval and indicates that after the earthquake, clusters closer to the epicenter had a relatively smaller decrease in total number of births compared to clusters farther from the epicenter. The secular decline in total number of births after the earthquake is interrupted for clusters closer to the epicenter. This trend holds true for Punjab independently and when Punjab and NWFP are pooled together.

Table 6: Regression Results for Total Fertility for NWFP and Punjab Using Distance to Epicenter as proxy for intensity of Earthquake

Dependent Variable: Total Number of births (plus current pregnancy)	**(1) NWFP only**	**(2) Punjab Only**	**(3) Punjab and NWFP**
Post	-3.91***	-3.20***	-3.77***
	(.172)	(.129)	(.101)
Epicentral Distance	.001**	.002***	.0005**
	(.001)	(.0002)	(.0002)
Post*Epicentral Distance	-.002**	-.002***	-.001**
	(.001)	(.0003)	(.0002)
Age of Mother	.101***	.087***	.090***
	(.004)	(.002)	(.002)
Mother's education	-.058***	-.050***	-.058***
	(.006)	(.004)	(.004)
Father's Education	-.017***	-.010***	-.013***
	(-.004)	(004)	(.0031)
Urban	-.054	-.024	-.048
	(.066)	(.041)	(.037)
N	**2964**	**6244**	**9208**

Note: Robust standard errors in parenthesis; *** p<0.01, ** p<0.05, *p<0.1. Clustering of standard errors at the cluster level

Comparing results from Table 5 and Table 6, it is evident that using provincial boundaries and defining NWFP as the "near" variable masks the post-earthquake increase in fertility for clusters in NWFP (near=1) and Punjab (near=0) which are closer to the epicenter. It indicates that even for NWFP, the province closest to the earthquake's epicenter, the intensity and damage from the earthquake was not homogenous across all its districts and clusters.

The results in Table 6 use distance alone as a measure for the earthquake's intensity and show how the earthquake affected the two provinces closest to the earthquake's epicenter. However, the coefficient on the interaction term provides an extremely marginal decrease in total fertility. To make this interaction term more meaningful, the results from Model Specification II (below) allow us to investigate how the use of additional geographical variables to define the earthquake's intensity may influence changes in fertility rates.

b) Model Specification II:

Difference-in-Difference Regression Result for three distance to rupture surface zone categories:

The results in Table 7 show, that for all three types of pre-birth history time periods, total number of births is higher for the high and medium intensity zones compared to the low intensity zone C. These results are statistically significant for columns (1) and (3) showing that after the earthquake, total fertility is higher in Zone A compared to Zone C by (0.580 and 0.225 units) respectively. This evidence indicates that for clusters within a 100 km radius of the rupture surface, total number of births is significantly higher after the earthquake compared to clusters which were more than 350 km away from the rupture surface. If proximity to the rupture surface is a measure of intensity then these results establish, for smaller distances to rupture surface, a positive relationship between the intensity of the earthquake and total fertility after 2005.

Table 7: Regression Results for Total Fertility with 3 Zone Categories in NWFP and Punjab

Dependent Variable: Total Number of births (plus current pregnancy)	**(1) All Pre- Earthquake Birth Histories**			**(2) Pre- Earthquake Birth Histories from 1995 to 2005**			**(3) Pre- Earthquake Birth Histories from 2000 to 2005**		
	Pre	**Post**	**Interaction (p-values)**	**Pre**	**Post**	**Interaction (p-values)**	**Pre**	**Post**	**Interaction (p-values)**
Zone A	-.580** (.223)	.002 (.034)	**0.014**	-.301* (.176)	.002 (.034)	0.110	-.223** (.102)	.002 (.034)	**0.063**
Zone B	-.284 (.221)	-.001 (.033)	0.229	-.090 (.174)	-.001 (.033)	0.634	-.099 (.101)	-.0001 (.033)	0.413
Age of Mother	.200*** (.004)	-018*** (.001)	0.000	-.018*** (.003)	-.018*** (.001)	0.920	-.055*** (.002)	-.018*** (.001)	0.000
Mother's Education	-107*** (.007)	-.004** (.002)	0.000	-.040*** (.006)	-.004** (.002)	0.000	-.012** (.004)	-.004** (.002)	0.054
Father's Education	-025*** (.006)	-.0002 (.001)	0.000	-.013*** (.004)	-.0002 (.001)	0.000	-.006** (.002)	-.0002 (.001)	0.009
Urban	-.051 (.073)	-.031** (.014)	0.797	-.194*** (.057)	-.031** (.014)	0.006	-.114 (.036)	-.031** (.014)	0.043
N	**4604**	**4604**	**9208**	**4604**	**4604**	**9208**	**4604**	**4604**	**9208**

Note: Robust standard errors in parenthesis; *** p<0.01, ** p<0.05, *p<0.1. Clustering of standard errors at the cluster level

Difference-in-Difference Regression Result for nine zone categories:

Table 8 explores how total fertility changes when distance to rupture surface is combined with varying levels of cluster altitude. The results show that for all three columns, the positive pre-earthquake fertility rates across zones turn negative when interacted with the post-earthquake indicator variable. For column(1) which includes all pre-earthquake birth histories the decrease in total fertility in Zone 4, 6 and 9 is statistically significant compared to Zone 1 after the earthquake with coefficients of- 0.653, -0.321 and -0.615 respectively. Given that fertility rates declined after the earthquake, these results indicate that relative to these zones, which are farther from the rupture surface and at a lower elevation, the high intensity Zone 1 witnessed slower decline in total fertility after the earthquake.

This trend holds true for column (2) with a statistically significant decline in total fertility in Zones 4, 6 and 9 relative to Zone 1 with coefficients of -0.352, -0.337 and -0.415 respectively. Collapsing the zone categories across distance to rupture surface alone, had masked these results in Table 8 for the pre-history birth period from 1995 to 2005 (column (2)). A more refined categorization of zones with the additional variable of altitude picked up these post-earthquake variation in total fertility for three lower intensity zones relative to the highest intensity Zone 1.

For the most recent time period before the earthquake in column (3), we see that even though pre-earthquake fertility rates are similar to those in column (1) and (2), the estimates are more precise indicating smaller recall errors for the most recent birth histories. Results from column (3) show that the differences between Zone 1 and lower intensity Zones 4, 6 and 9 reduce in size due to a narrower birth history window but remain statistically significant. Additionally, differences in total fertility across zone 2, 3 and 5 also become marginally statistically significant at the 10% significant level. Thus, for the most relevant time period, the highest intensity Zone 1 experienced slower rates of decline in total fertility compared to all the remaining lower intensity zones.

In all three columns, the difference in total fertility after the earthquake is the steepest for the farthest and lowest altitude Zone 9 relative to Zone 1.This result combines the effect of distance from the rupture surface and elevation of the cluster. To explore the impact of elevation on fertility patterns, we can see in column (3) that for Zones 2 and 3, which are at the same distance from the rupture surface as Zone 1, the decrease in total fertility relative to Zone 1 is still significant. This difference can thus be attributed to lower levels of cluster elevation.

Results from column 3 also demonstrate that the inverse relationship between mother's age at the time of the survey, and maternal and paternal level of education with total number of births turns positive when interacted with the post-earthquake variable. This indicates after the disaster, total fertility increased even for older and more educated mothers. Interestingly, urban communities after the earthquake see a larger increase in total fertility relative to rural clusters. One possible explanation for this might be that urban areas experienced higher levels of earthquake damage. Most of the damage and destruction to life and property from this earthquake occurred from the collapse of reinforced concrete frame buildings which are concentrated more in NWFP and Punjab's urban than rural areas due to affordability (Maqsood & Schwarz, 2008).

This trend of a decrease in total fertility in lower intensity zones compared to the highest intensity one is consistent with previous evidence on this subject presented by Finlay (2009). Since, the timing, location and magnitude of this earthquake in Pakistan was unexpected, fertility patterns before and after the earthquake can be easily distinguished and attributed to this disaster (Nobles et al., 2015). However, given the dearth of data in the 2006 DHS survey, this paper cannot assess the mechanisms driving this fertility trend. The DHS 2006 survey dataset doesn't have sufficient household or individual level data on child mortality caused by the 2005 earthquake to assess if increase in total fertility after the earthquake in highest intensity zone was driven by the replacement or the insurance effect. The relatively small sample size of households which lost at least one child in the three months after the 2005 earthquake and have a married woman aged 40 years or less (fertile age) will not support a regression analysis to look at the exact demographic mechanism to explain the fertility patterns described in Table 6 and 7.

Therefore, the results presented in Table 7 and 8, are given at the cluster or community level for the worst affected provinces: NWFP and Punjab. The relatively slower decline in total fertility for zone 1 compared to lower intensity zones can be attributed to a) a community level response to the earthquake’s intensity (mortality) or b) damage to health care facilities which might have disrupted people’s access to contraceptives.

Table 8: Regression Results for Total Fertility with All 9 Earthquake Intensity Zones for NWFP and Punjab

Dependent Variable: Total Number of births (plus current pregnancy)	**(1) All Pre-Earthquake Birth Histories**			**(2) Pre-Earthquake Birth Histories from 1995 to 2005**			**(3) Pre-Earthquake Birth Histories from 2000 to 2005**		
	Pre	**Post**	**Interaction (p-values)**	**Pre**	**Post**	**Interaction (p-values)**	**Pre**	**Post**	**Interaction (p-values)**
Zone 2	.005 (.167)	-.113*** (.039)	0.497	-.080 (.140)	-.113*** (.039)	0.817	.051 (.083)	-.113*** (.039)	**0.084**
Zone 3	-.021 (.121)	-.035 (.036)	0.910	.114 (.109)	-.035 (.036)	0.188	.121* (.072)	-.035 (.036)	**0.061**
Zone 4	.541*** (.183)	-.111** (.048)	**0.000**	.241 (.149)	-.111** (.048)	**0.016**	.220** (.010)	-.111** (.048)	**0.003**
Zone 5	.142 (.179)	-.048 (.050)	0.316	.120 (.141)	-.048 (.050)	0.263	.137 (.098)	-.048 (.050)	**0.086**
Zone 6	.277** (.116)	-.044 (.034)	**0.008**	.293*** (.010)	-.044 (.034)	**0.001**	.226*** (.068)	-.044 (.034)	**0.001**
Zone 9	.568** (.241)	-.047 (.045)	**0.016**	.368* (.194)	-.047 (.045)	**0.045**	.318** (.117)	-.047 (.045)	**0.009**
Age of Mother	.200*** (.004)	-.018*** (.001)	0.000	-.019 *** (.003)	-.018*** (.001)	0.897	-.055*** (.002)	-.018*** (.001)	0.000
Mother's Education	-.107*** (.007)	-.004** (.002)	0.000	.041*** (.006)	-.004** (.002)	0.000	-.013*** (.004)	-.004** (.002)	0.044
Father's Education	-.025*** (.006)	-.000 (.001)	0.000	.013*** (.004)	-.000 (.001)	0.000	-.006** (.002)	-.000 (.001)	0.008
Urban	-.040 (.074)	-.031** (.014)	0.916	-.200*** (.058)	-.031** (.014)	0.006	-.119*** (.036)	-.031** (.014)	0.028
N	**4604**	**4604**	**9208**	**4604**	**4604**	**9208**	**4604**	**4604**	**9208**

Note: Robust standard errors in parenthesis; *** p<0.01, ** p<0.05, *p<0.1 Clustering of standard errors at the cluster level

Section B: Effects of the Earthquake on Children's Health Outcomes

The second hypothesis that this paper aims to check is how in-utero exposure to varying levels of earthquake intensity affects children's health outcomes.

Academic literature links the outbreak of water-borne diseases with the occurrence of natural disasters. In developing countries such as Indonesia, India and Pakistan the incidence of diarrhea has been seen to increase in unsanitary and unequipped rehabilitation camps. Similarly, as populations get displaced after high intensity natural disasters, crowding becomes common and this can lead to a high incidence of communicable diseases such as Acute Respiratory Infections (ARI). Incidence of ARI increased by four times in Nicaragua after Hurricane Mitch in 1998 and was the leading cause of morbidity and mortality in Aceh after the Indonesian Tsunami and Pakistan after the 2005 earthquake (Watson et.al, 2007).

This analysis uses a difference in difference regression model to measure the effect of in-utero exposure at the time of earthquake on prevalence of diseases in infants in NWFP and Punjab. The individual children's level DHS data is used for questions regarding the prevalence of infectious diseases and fever for children under the age of five years.

Estimation Equation:

The following regression equations are used to measure the impact of in-utero earthquake exposure on the probability of suffering from five different types of diseases:

(1) $\textbf{Probability of suffering from disease}_{itc} = \beta_1 \textbf{in-utero}_t + \beta_2 \textbf{near} + \beta_3 \textbf{in-utero}_t * \textbf{near} + X'\beta + \varepsilon_{itc}$

(2) $\textbf{Probability of suffering from disease}_{itc} = \beta_1 \textbf{in-utero}_t + \beta_2 \textbf{zone}_j + \beta_3 \textbf{in-utero}_t * \textbf{zone}_j + X'\beta + \varepsilon_{itc}$

In this equation the variables are defined as follows:

- Probability of suffering from a disease is an indicator variable calculated for each individual child 'i' at a given time 't' in a cluster 'c'[4]. It takes on the value of '1' if the child has recently been suffering from the disease and '0' otherwise. The DHS records prevalence of infectious diseases such as 1) diarrhea, and its advanced stage where blood is passed in stool, 2) acute respiratory infections whose initial symptoms include coughing and later short and rapid breaths, 3) fever. The prevalence of these diseases is measured for the two weeks preceding the survey.
- In-utero is an indicator variable taking on values of '1' for children who were in their mother's womb at the time of the earthquake and '0' for all those born before the earthquake. These '0' values are calculated for the most recent time period: a time span of five years (2000-2005).

Children who were conceived after the earthquake were not included in this regression analysis since their conception and in-utero health might have been affected differently by post-earthquake trauma compared to those children who were in-utero at the time of the earthquake.

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[4] 'c' refers to province for definition (a) and cluster for definition (b) in Model Specification I.

Model Specification I:

In equation (1) above, the earthquake's intensity is defined by the 'near' variable which is defined as:

a) As an indicator variable which takes the value of '1' for NWFP and '0' for the other provinces,
b) As a continuous variable for distance to the earthquake's epicenter.

Model Specification II:

In equation (2), the earthquake's intensity is measured using different types of zone categories:

a) Zones A, B and C from Table 3 where Zone A is the high intensity zone, located closer to the rupture surface and Zone C (comparison category) is located more than 350 km from the rupture surface.

b) The nine zones defined in Table 4 where Zone 1 is the extremely high earthquake intensity and Zone 9 is the lowest intensity (comparison category).

In both models, X is the vector of controls which includes mother's age and education, education and type of cluster (urban or rural) and if child is being currently breastfed for diarrhea related health outcomes.

Results

a) Model Specification I:

Difference-in-Difference Regression Result for all four provinces:

Using provincial boundaries to define the earthquake's intensity, Table B (shown in Appendix) shows that, for children less than five years of age, being in-utero significantly increases their probability of having all the surveyed diseases except diarrheal blood. However, when this result is interacted with the NWFP indicator variable, we see a statistically significant result only for column (3). The probability of coughing, an early symptom of Acute Respiratory Infection (ARI) declines by 8.7% points for those children who were in-utero at the time of the earthquake in NWFP relative to the other provinces. This indicates a counter-intuitive impact of being in-utero in the province which was closest to the earthquake's epicenter given that our hypothesis was that higher intensity of earthquake would most adversely affect a child's in-utero health and subsequent immunity levels.

Difference-in-Difference Regression Result for NWFP and Punjab.

To investigate this further, Table C (shown in the Appendix) re-estimates the regression equation using distance to the epicenter as a continuous variable for intensity of earthquake. The effect of being in-utero at time of the earthquake on the incidence of the surveyed diseases is very similar to the results in Table B. For diarrhea and the advanced symptom of ARI (rapid breathing) the positive effect of intrauterine exposure increases, though very minutely, as distance to the epicenter increases. This also indicates that proximity to the epicenter decreases the probability of having these diseases for children who were in-utero at the time of the earthquake.

Model Specification II aims to pick up some effect of the earthquake's varying levels of intensity (defined by additional geographical variables) on children's in-utero health and subsequent incidence of infectious diseases. If the hypothesis is that maternal stress during pregnancy can stagnate the intra-uterine growth of the baby and negatively impact its ability to survive after birth, then children in higher intensity earthquake zones would be more likely to contract these diseases due to weaker immunity and more exposure to disease-spreading factors such as crowding, lack of nutrition, and unhygienic living conditions.

b) Model Specification II:

Difference-in-Difference Regression Result for three distance to rupture surface zone categories:

Using three broad zone categories, the results from Table 9 column (1) show that being in-utero increases the probability of recently having diarrhea by 30.3 percentage points compared to children who were not in-utero at the time of the earthquake and this result is highly statistically significant. However, when the 'in-utero' variable is interacted with the high and medium intensity zone variables the sign reverses but the results no longer remain statistically significant.

For column (3), being in-utero increases the probability of recently having the ARI coughing symptom by 20 percentage points compared to children who were not in-utero at the time of the earthquake and this result is highly statistically significant. However, similar to columns 1 and 2, when the earthquake intensity is interacted with the indicator of whether a child was in-utero at the time of the earthquake, the positive sign in row 1 reverses. For those in the high intensity zone being in-utero at the time of the earthquake reduced the probability of recently suffering from coughing by 15.9 percentage points compared to the low intensity zone. This result is statistically significant at the 95 percent level.

For column (2), (4) and (5), even though the results show the effect of being in-utero at the time of the earthquake remains positive when interacted with zone intensity variables, none of these results are statistically significant.

To investigate these results further, Table 10 shows the results for the same regression equation but with nine earthquake intensity zones.

Difference-in-Difference Regression Result for nine zone categories:

Table 10 column (3) shows that being in-utero increases the probability of coughing, an early symptom of Acute Respiratory Infections (ARI), by 23.6 % points. When this effect is interacted with different zone types we see that even for the same distance to rupture surface, children in-utero in Zone 2 are 37.4% points less likely to suffer from the early stage of ARI than those in Zone 1. This effect can be attributed to the lower altitude of Zone 2. Whereas for Zone 5, we see that moving farther away from the rupture surface and being at a lower elevation than Zone 1, decreases the probability of having the coughing symptom for children who were in-utero at the time of the earthquake by 40.1% points. These results indicate that children in-utero in the higher intensity zone 1 during the earthquake were more susceptible to this early ARI symptom relative to lower intensity zones. It is important to note that collapsing the zone categories along the distance variable (Table 9) masked this variation in effects we see across Zones 2 and 5 in Table 10 for the coughing symptom of ARI.

Similarly, for the incidence of fever, being in-utero increases the probability of having fever by 29.8 % points. However, when this result is interacted with the different zone categories, see that the effect of being in-utero reverses for those in Zone 2 relative to Zone 1. Children who were in-utero at the time of the earthquake were 29.1% points less likely to have fever than those who were within the same 100 km radius from the rupture surface but at a relatively higher altitude.

For the advanced stage of diarrhea in children, we can see reverse results in column (2) where the intensity of the earthquake is negatively related with the incidence of diarrheal blood. Children in in-utero at the time of the earthquake are 20.6% points less likely to experience blood in stool compared to those not in-utero. This result is reinforced by the statistically significant result for Zone 9, the lowest intensity zone, where the incidence of diarrheal blood for children in-utero is 26.1% points higher than those in the highest intensity zone.

A possible explanation for this result could be that recovery and rehabilitative processes were more actively implemented in the worst hit districts. For example, all of UNFPA's rebuilding effort was concentrated in Muzaffarabad (not in our sample) and Mansehra (falls under zone A in our sample). These were the regions where health facilities, maternity centers, mobile clinics and sanitation facilities were established (UNFPA 2006). Therefore, access to better preventive health care facilities in higher intensity zones may have driven this decline in probability of having the advanced stage of diarrhea.

For the remaining diseases (diarrhea and rapid coughing), we don't see any statistically significant results for intra uterine exposure to the earthquake and varying levels of earthquake intensity.

There is an interesting trend in results for the initial stages of diarrhea and ARI (columns 1 and 3) which show a positive but counter-intuitive relationship between urban areas and the probability of having the disease. This relationship becomes negative for the advanced stages of both these diseases (columns 2 and 4) indicating that the incidence of these diseases may not be prevented by being in an urban area but their advanced stages might be. This is plausible given the assumption that urban areas have better and more health care facilities than rural areas.

Table 9: Regression Results for Children's Health Outcomes with 3 Zone Categories in NWFP and Punjab

Dependent Variables for Children's Health Outcomes	**(1) Diarrhea**	**(2) Diarrheal Blood**	**(3) ARI: Coughing**	**(4) ARI: Rapid Short Breaths**	**(5) Fever**
Child in-utero at time of earthquake	0.303***	0.054	0.200**	0.047	0.075
	(0.105)	(0.102)	(0.088)	(0.156)	(0.085)
Zone A	-0.019	0.101	0.049	-0.128	0.065*
	(0.035)	(0.062)	(0.059)	(0.083)	(0.037)
Zone B	0.004	0.058	0.000	-0.095	0.046
	(0.034)	(0.055)	(0.056)	(0.082)	(0.035)
Zone A*Child In-utero at time of earthquake	-0.153	-0.164	-0.159*	0.009	0.005
	(0.110)	(0.111)	(0.094)	(0.166)	(0.092)
Zone B*Child In-utero at time of earthquake	-0.082	-0.116	-0.125	0.050	0.033
	(0.108)	(0.106)	(0.091)	(0.161)	(0.088)
Age of Mother	-0.002**	0.001	-0.000	0.004	-0.001
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
Mother's Education	-0.004**	-0.004	0.000	-0.012***	-0.002
	(0.002)	(0.003)	(0.002)	(0.004)	(0.002)
Father's Education	-0.001	-0.002	-0.000	0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)
Urban	0.033**	-0.079***	0.014	-0.046	0.025
	(0.017)	(0.025)	(0.022)	(0.033)	(0.021)
Child Being Currently Breastfed	-0.022	-0.018			
	(0.014)	(0.027)			
N	**4291**	**956**	**4279**	**1341**	**4285**

Table 10: Regression Results for Children's Health Outcomes with All 9 Zone Categories in NWFP and Punjab

Dependent Variables for Children's Health Outcomes	**(1)** **Diarrhea**	**(2)** **Diarrheal Blood**	**(3)** **ARI: Coughing**	**(4)** **ARI: Rapid Short Breaths**	**(5)** **Fever**
Child in-utero at the time of earthquake	0.242	-0.206*	0.236*	0.125	0.298*
	(0.179)	(0.121)	(0.137)	(0.169)	(0.152)
Zone 2	-0.056	0.079	0.117	0.119	0.110
	(0.053)	(0.149)	(0.082)	(0.114)	(0.078)
Zone 3	-0.039	-0.011	-0.020	0.039	0.027
	(0.050)	(0.122)	(0.073)	(0.103)	(0.064)
Zone 4	-0.021	-0.209*	-0.087	0.000	-0.009
	(0.066)	(0.119)	(0.084)	(0.151)	(0.086)
Zone 5	-0.035	-0.109	-0.023	0.268**	-0.019
	(0.057)	(0.144)	(0.088)	(0.120)	(0.079)
Zone 6	-0.013	-0.024	-0.041	0.076	0.024
	(0.049)	(0.120)	(0.071)	(0.099)	(0.063)
Zone 9	-0.019	-0.098	-0.043	0.180	-0.027
	(0.057)	(0.130)	(0.089)	(0.124)	(0.069)
Zone2*Child In-utero at time of earthquake	0.072	0.069	-0.374**	0.181	-0.291*
	(0.194)	(0.169)	(0.153)	(0.198)	(0.176)
Zone3*Child In-utero at time of earthquake	-0.137	0.108	-0.168	-0.114	-0.222
	(0.183)	(0.126)	(0.143)	(0.181)	(0.157)
Zone4*Child In-utero at time of earthquake	-0.215	0.179	-0.132	-0.020	-0.209
	(0.202)	(0.119)	(0.170)	(0.199)	(0.192)
Zone5*Child In-utero at time of earthquake	-0.053	0.373*	-0.401**	0.100	-0.280
	(0.224)	(0.226)	(0.159)	(0.185)	(0.180)
Zone6*Child In-utero at time of earthquake	-0.005	0.129	-0.152	-0.019	-0.185
	(0.181)	(0.121)	(0.139)	(0.173)	(0.155)
Zone9*Child In-utero at time of earthquake	0.061	0.261*	-0.036	-0.079	-0.223
	(0.208)	(0.157)	(0.163)	(0.230)	(0.174)
Age of Mother	-0.002**	0.001	-0.000	0.004*	-0.001
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
Mother's Education	-0.004**	-0.004	0.000	-0.012***	-0.002
	(0.002)	(0.003)	(0.002)	(0.004)	(0.002)
Father's Education	-0.001	-0.002	-0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)
Urban	0.034**	-0.086***	0.013	-0.055*	0.025
	(0.017)	(0.025)	(0.022)	(0.032)	(0.021)
Child is currently being breastfed	-0.023	-0.017			
	(0.014)	(0.027)			
N	**4291**	**956**	**4279**	**1341**	**4285**

Conclusion and Discussion

This paper explored the question of how exposure to varying levels of the 2005 Pakistan earthquake's intensity differentially impacted fertility rates and the prevalence of diseases amongst children.

The evidence suggests that despite a very small post-earthquake fertility window (of 17 months), higher earthquake intensity zones experienced higher post-disaster fertility rates. Due to lack of data on individual or household level mortality rates, this paper cannot determine whether this increase in fertility was driven by high mortality or lack of access to contraception.

An important finding of this paper is that defining intensity in terms of provincial boundaries conceals the heterogeneous impact of the earthquake across different districts within the same province. Similarly, using distance to the epicenter as a sole determinant of earthquake intensity is unable to capture the additional intensity effect of higher altitudes on fertility rates after the disaster. Combining a more precise estimate of proximity (distance to rupture surface) and cluster altitude shows that the highest intensity earthquake zone experienced an increase in total fertility relative to other lower intensity zones especially for the most relevant birth history period from 2000 to 2005. This gradient in total fertility after the earthquake was the steepest between the highest and lowest intensity zones capturing the combined effect of nearness to the rupture surface and elevation on fertility trends. Using this categorization of intensity zones, the evidence from this paper is consistent with the findings from Finlay's work which demonstrated an increase in post-earthquake fertility for the most affected areas in Pakistan.

For children's health outcomes, using a more refined categorization of earthquake intensity, the results demonstrate a decrease in the incidence of early ARI symptoms and fever for lower intensity zones relative to the highest intensity Zone 1. This is consistent with the findings that exposure to external trauma can induce maternal stress during pregnancy which adversely affects children's early childhood development indicators. The results for the advanced stage of diarrhea show a counter-intuitive and inverse relationship between earthquake intensity and incidence of having diarrheal blood in children less than five years old. However, this data lacks information about access to preventive and curative health care facilities after the earthquake, to enable a more detailed analysis of the how in-utero exposure to varying levels of earthquake intensity affected different stages of the diseases discussed in Section B. This paper would have been able to establish a stronger relationship between intra uterine exposure to stress and children's health outcomes if the DHS 2006 data had information on anthropometric indictors of height and weight.

In-depth data collection and research on largescale and high mortality disasters have the potential to inform policy makers about the demographic mechanisms through which communities react and possibly rebuild themselves. Even though Pakistan has experienced several high intensity disasters such as floods, famines and earthquakes in the last decade, this research exercise highlights the dearth of post-disaster data collected in Pakistan. DHS was unable to collect any data from the most severely affected region of Azad Jammu and Kashmir after the 2005 Pakistan earthquake. This was a major reason why the DHS 2006 data was not able to pick up large household or individual woman level mortality effects on children under the age of 11 years. Similarly, the dearth of information on health care facilities and supply of contraceptives makes it difficult to ascertain the motivation behind an increase in total fertility after the earthquake. The availability of this data can enrich the causal analysis of exposure to varying levels of earthquake intensity on fertility trends.

There should be a focus on gathering individual level data about exposure to trauma to allow researchers to study the impact of high intensity disasters on mental health outcomes for adults and children. Understanding the magnitude and extent of psychological repercussions in the aftermath of disasters can provide useful insights to inform recovery policies and the delivery of resources allocated for mental health illnesses. For Pakistan’s 2005 earthquake, the data available focuses primarily on women’s reproductive health and children’s health outcomes and does not provide similar information for males and older members of the household. This additional dimension of age and gender can also have beneficial implications for future research surrounding demographic processes after natural disasters and potentially fill knowledge gaps for disaster management policy making.

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Appendix:

Table A: Number of Households and Clusters Surveyed with GPS Data

Province	Number of households	Number of Clusters
Punjab	42, 616 (45.36%)	432 (45.14%)
Sindh	24,960 (26.15%)	260 (26.75%)
NWFP	17,130 (18.23%)	174 (18.18%)
Balochistan	9,239 (9.83%)	91 (9.51%)
Total	**95,441** **(100%)**	**972** **(100%)**

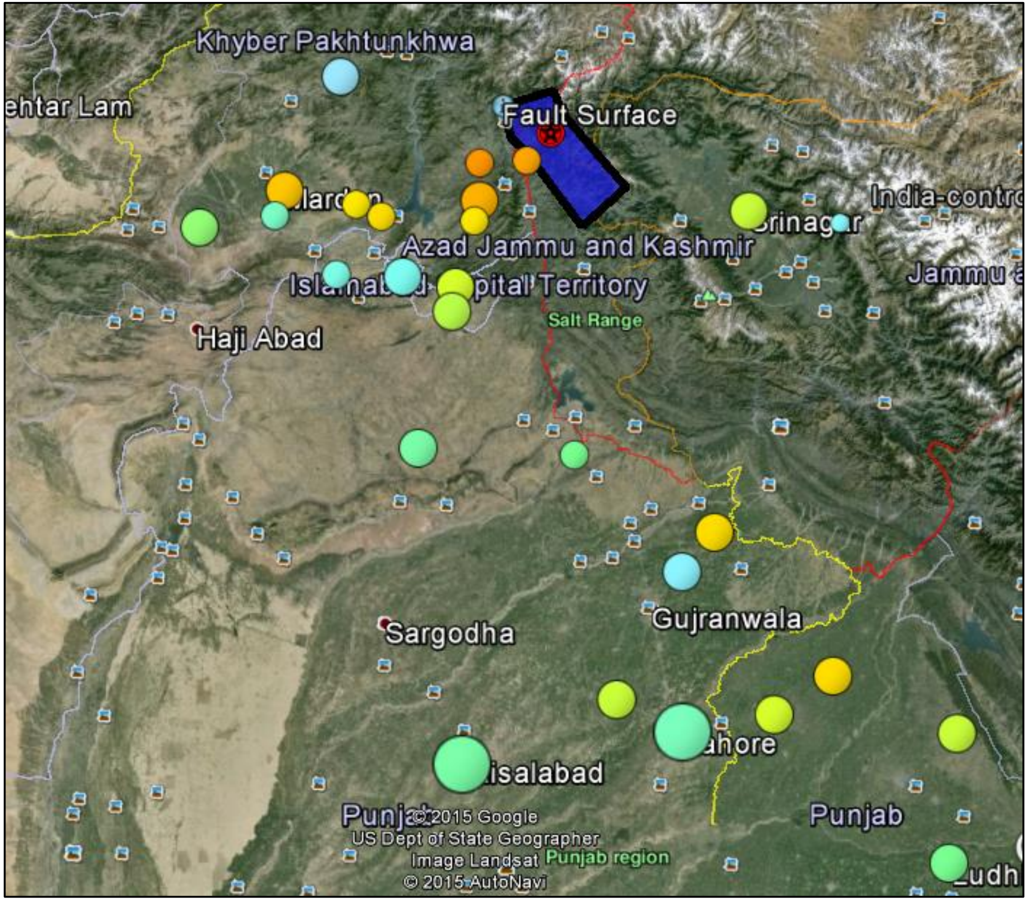
Table B: Regression Results for Children's Health Outcomes for All Four Provinces

Dependent Variables for Children's Health Outcomes	**(1) Diarrhea**	**(2) Diarrheal Blood**	**(3) ARI: Coughing**	**(4) ARI: Rapid Short Breaths**	**(5) Fever**
Child in-utero at the time of earthquake	0.208***	-0.078**	0.100***	0.080**	0.119***
	(0.024)	(0.031)	(0.023)	(0.037)	(0.024)
NWFP	0.055***	-0.057*	0.045*	0.008	0.027
	(0.017)	(0.033)	(0.024)	(0.037)	(0.022)
NWFP*Child in-utero at the time of earthquake	-0.008	0.012	-0.087**	0.014	-0.064
	(0.041)	(0.046)	(0.040)	(0.062)	(0.040)
Age of Mother	-0.002**	0.001	-0.000	0.004	-0.001
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
Mother's Education	-0.003*	-0.005	0.002	-0.013***	-0.001
	(0.002)	(0.003)	(0.002)	(0.004)	(0.002)
Father's Education	-0.001	-0.002	-0.000	0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)
Urban	0.029*	-0.077***	0.016	-0.052	0.027
	(0.016)	(0.025)	(0.022)	(0.032)	(0.021)
Child Currently Being Breastfed	-0.024*	-0.015			
	(0.014)	(0.027)			
N	**4291**	**956**	**4279**	**1341**	**4285**

Table C: Regression Results for Children's Health Outcomes for NWFP and Punjab Using Distance to Epicenter

Dependent Variables for Children's Health Outcomes	**(1) Diarrhea**	**(2) Diarrheal Blood**	**(3) ARI: Coughing**	**(4) ARI: Rapid Short Breaths**	**(5) Fever**
Child in-utero at the time of earthquake	0.109**	-0.086*	-0.020	0.112*	0.046
	(0.044)	(0.051)	(0.042)	(0.063)	(0.044)
Distance to Epicenter	-0.00001	0.00006	-0.0002***	0.0002*	-0.0001*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Distance to Epicenter*Child in-utero at time of earthquake	0.0003**	0.00004	0.0003**	-0.0001	0.0002
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age of Mother	-0.002**	0.001	-0.000	0.003	-0.001
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
Mother's Education	-0.004**	-0.003	0.001	-0.013***	-0.001
	(0.002)	(0.003)	(0.002)	(0.004)	(0.002)
Father's Education	-0.001	-0.002	-0.001	0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Urban	0.031*	-0.076***	0.011	-0.046	0.025
	(0.017)	(0.025)	(0.022)	(0.033)	(0.021)
Child is Currently Being Breastfed	-0.021	-0.018			
	(0.014)	(0.027)			
N	**4291**	**956**	**4279**	**1341**	**4285**

Figure A: Fault Rupture area 2005 Earthquake



Note: Data obtained from USGS.