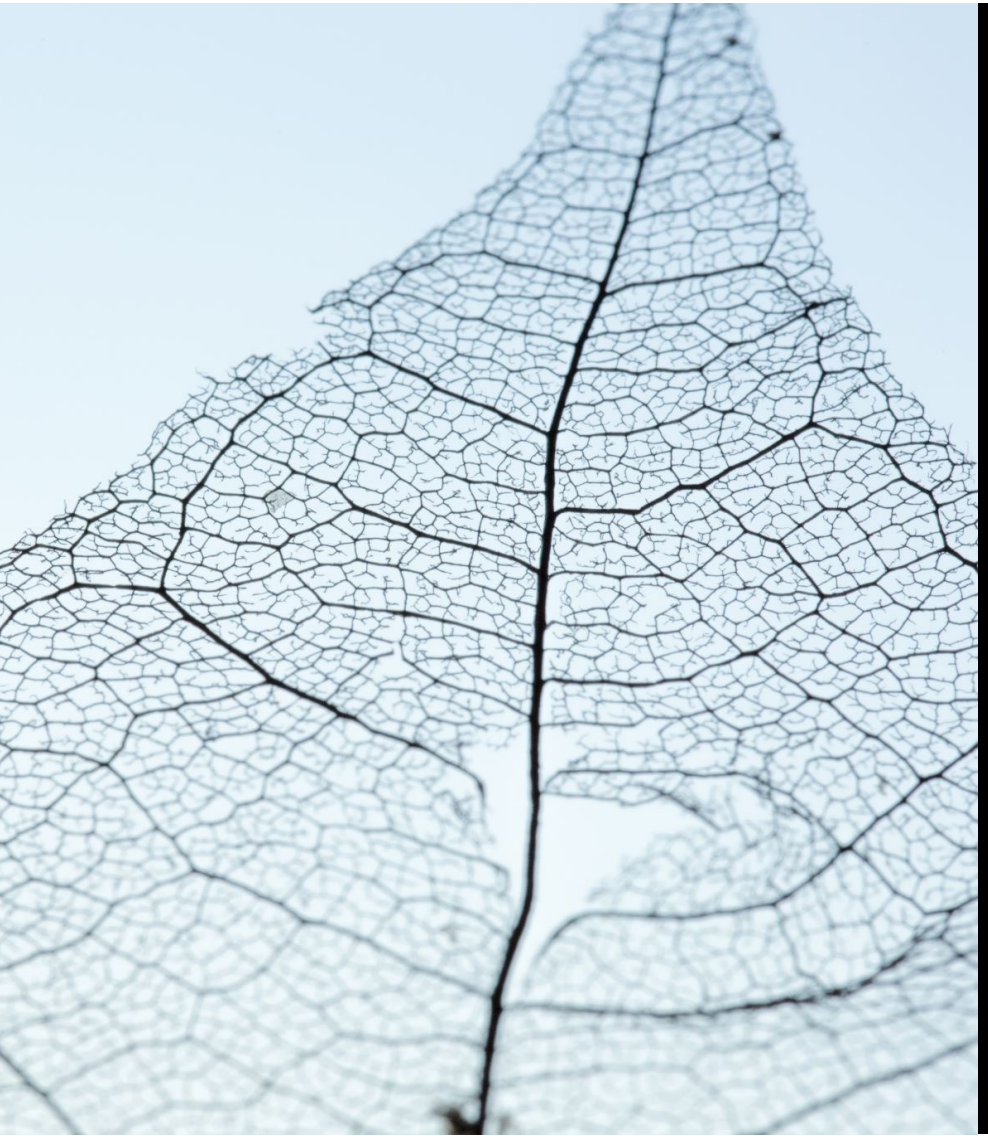

HUMAN CAPITAL ACCUMULATION AND DISASTERS:

EVIDENCE FROM THE PAKISTAN EARTHQUAKE OF 2005

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MOTIVATION

Large localized shocks such as disasters are more common and affect more people

Large literature shows that shocks in childhood have adverse long-term outcomes

- Younger children always hit harder

Increasing calls for insurance programs for disasters (Clark and Dercon 2016)

- Recent literature showing full recovery for host of adult and household outcomes in compensated disasters

What happens after such “compensated disasters” to accumulation of human capital

- Is there (causal) heterogeneity in impacts

This paper approaches these questions in the context of a large, exogenous, “compensated” shock and a four-year retrospective survey with children of all ages

MOTIVATION

"Hongerwinter" during the German blockade in Netherlands towards the end of WWII created famine-like condition

- 18-22,000 deaths, mostly among elderly men
- But a large part of the burden was borne by the unborn: much higher rates of illnesses in adulthood and 10% elevated mortality

Large body of research since then on the impacts of extreme events during early childhood

- Basic finding is two-fold

  First, insults in childhood (and especially early childhood) can have lasting impacts on health, education and earnings

  Second, events do not need to be extreme; maternal stress can lead to low-birth weight, shorter gestation length

Studies either rely on older people (adults) who faced a known extreme event at some point in their childhood, where we don't know what happened during the crisis, and in particular whether people received public compensation (likely not)

- OR (newer cohort) specific outcomes shortly after a natural disaster
- Exception is Frankenburg et al.'s work in Aceh after Tsunami

What we know less about: Suppose people receive (substantial) public compensation after a disaster.

What are the impacts on a range of different outcomes?

WHAT WE KNOW ABOUT DISASTERS

Adverse shocks during childhood have effects on wages, schooling, physical and mental health of adults, particularly if these shocks are during the “critical” period (first 1000 days); Portner (2009) and Baez et al. (2011) are two reviews

- Height for Age (or stature): Alderman et. al. 2006, Akresh et al. 2011, Macchini & Yang (2009)
- Cognitive: Handa and Peterman (2007); Black et al. 2003; Case & Paxson (2010); Glewwe et al. 2001
- Wages: Dercon and Porter (2010): Height losses after a famine led to (predicted) income losses of 3-8%

When large disasters are “compensated”, return to normalcy

- New Orleans, U.S. (Deryugina et al. 2018): Mobility a part of this story
- Kobe, Japan (Sawada and Shimizutani 2008)
- Aceh, Indonesia (Frankenburg et al. 2013)

THIS PAPER STUDIES:

4-year impact of a large earthquake followed by aid to households on household, adult and child outcomes

Is compensation for loss of physical capital sufficient for all recovery?

- What happens to human capital in disasters where families receive substantial compensation
- Combined evidence on stature and cognitive outcomes
- Causal impact identified by geographical variation does not require cohort differences. Therefore we can examine the impact across the age range instead of relative changes across cohorts

THIS PAPER STUDIES:

Focus on identification

Causal impact of large compensated disaster on household, adult and child outcomes

Stringent conditions in our cross-section 4 years after the earthquake satisfied in data

1. **Unanticipated shock**
2. **Affected populations similar to unaffected populations**
3. **Significant destruction but low mortality in affected areas**
4. **Low out-migration**
5. **Low "aid spillovers"**

THIS PAPER STUDIES:

Focus on link between child's background proxied by maternal education and human capital losses in disasters

- Considerable causal evidence linking maternal education to children's schooling (Black, Devereux, and Salvanes 2005)
- Less so for health (McCrary and Royer 2011, Currie and Moretti 2003)

First, examine the usefulness of maternal education as a targeting variable

- Easily measured and not related to the disaster—therefore useful for targeting
- Salient in the Pakistani and many other low-income contexts for child outcomes

Second, examine whether there is a causal link between maternal education and recovery from the disaster

- Employ an IV approach towards maternal education based on the village-of-birth of the mother
- In our setting, maternal education has as large an effect on schooling attendance as +1 SD in wealth

PREVIEW OF RESULTS

Major earthquake in Pakistan causes widespread destruction of physical capital,
followed by extensive aid program that compensated households in installments over one year

Four years later:

1. No difference between affected and unaffected villages in household and adult outcomes or access to key infrastructure

2. Large and significant differences in children's stature and test-scores
   - Height-for-age (stature) effects for children of ages 0-3 (0 is in-utero) at the time of the earthquake, with larger effects for younger children--effects close to 1 standard deviation for children in-utero at time of quake
   - Test score effects for all ages tested (4-12 at time of earthquake); Corresponds to 1.2 school years

3. Maternal education causally mitigates test-score, but not height shock
   - No implication that height shocks cannot be mitigated (see Gunnsteinsson 2016)

4. Census of households: 53% of households had children subject to the height shock; 84% of school-age children had uneducated mothers who bore the full brunt of the test-score shock

OUTLINE

1. Description of the disaster
2. Survey data collected
3. Exogeneity of the shock
4. Results, four years later
5. Maternal education mitigation and IV
6. Discussion and robustness

THE PAKISTAN 2005 EARTHQUAKE

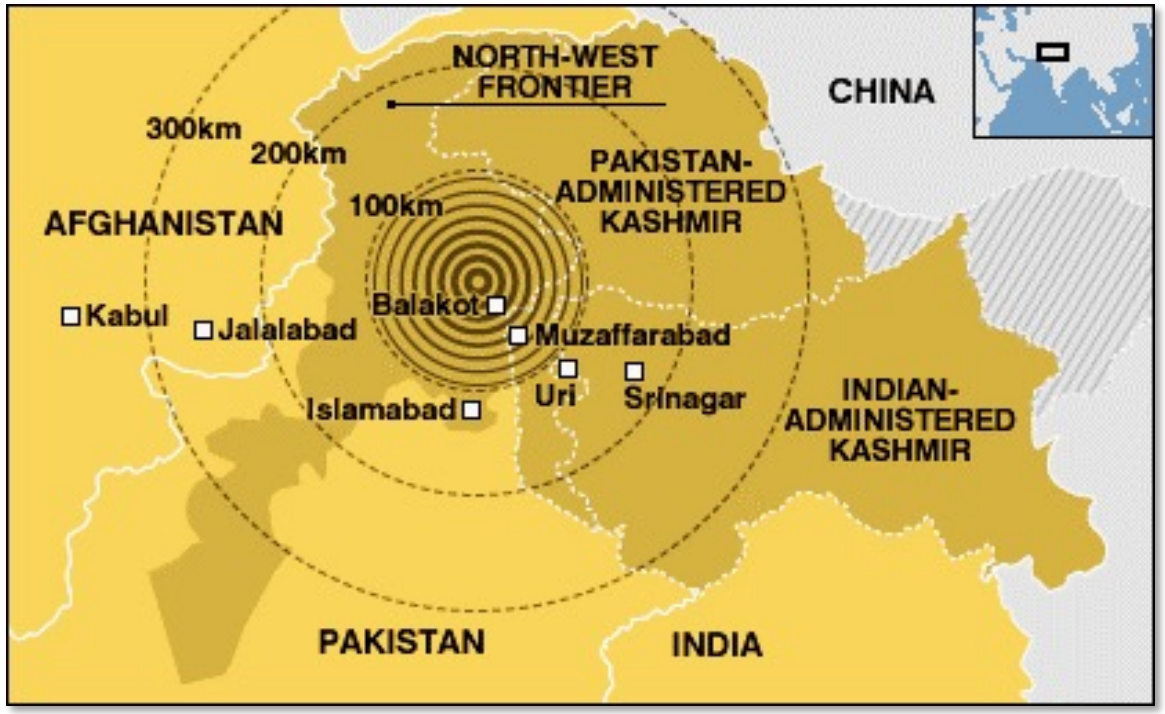
October 2005: Large earthquake hit rural and mountainous Northern Pakistan

- Magnitude 7.6 earthquake left 73-78,000 dead
- >80% of houses and most physical infrastructure destroyed

Earthquake unanticipated: First “big one” to hit after 1935 in the region: Between then and 2005, there were no earthquakes above magnitude 7.0 in Pakistan (a smaller 6.2 magnitude earthquake in the North-West Frontier Province in 1974 affected other districts.)

Large number of fault-lines in the region, all of which are potentially active

- Allows us to control for distance to other fault-lines and construct placebo tests



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SURVEY DATA COLLECTED

FIELD WORK AND DATA

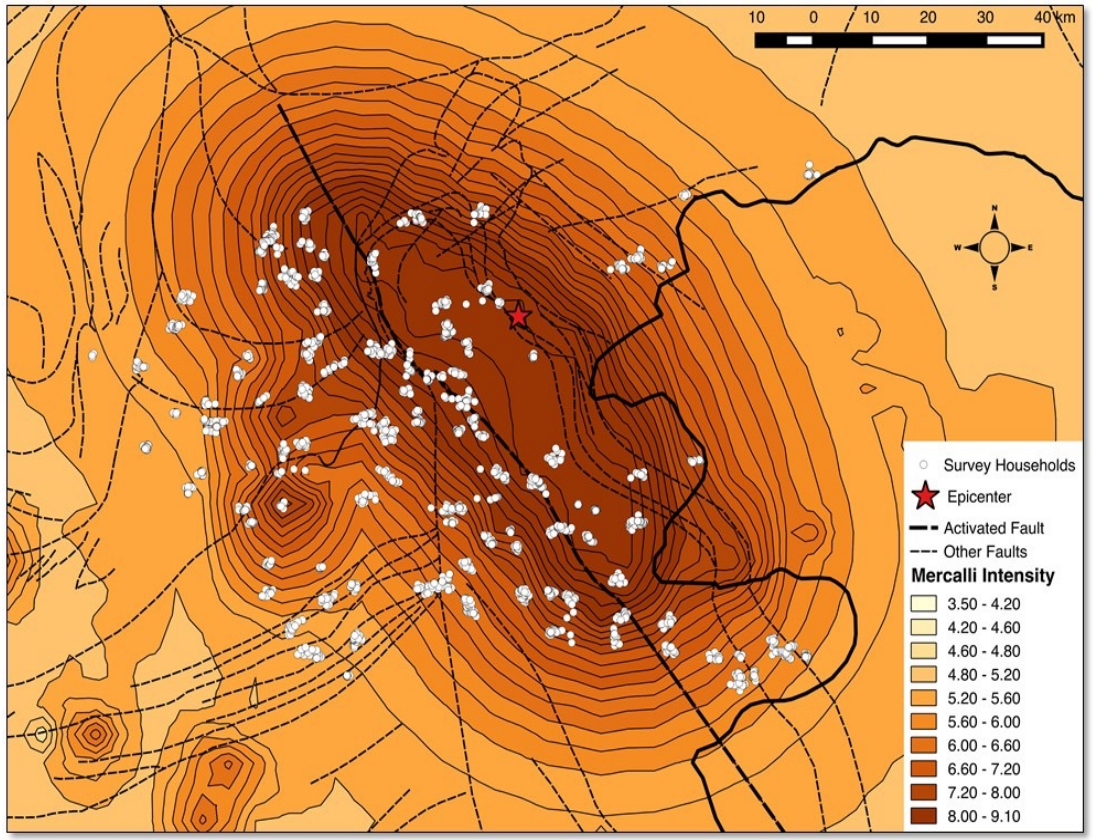
November-March 2005: Extended field trips

June 2009: Census of 126 villages in affected areas (28,297 households)

- Extended census of 8,351 households
- Basic demographic variables + mortality

July-December 2009: Household survey of 2,456 households

- Standard household survey modules
- Measurement of heights for all children > 3 at time of survey (cannot measure younger)
- Test-scores in English, Math and Urdu for all children 7-15 at time of survey (cannot test younger)



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FULL ROSTER FROM HOUSEHOLD SURVEY

HH_Survey _ Female Questionnaire FINAL

Section 1: Household Roster

Answer for: All individuals who currently share the same cooking unit, or have shared the cooking unit for a month or more than one month since the earthquake (including anyone who has died).

- Anyone who was living with the head of household before the earthquake and passed away during the earthquake

1. Member ID	2. Member's Name	3. Member's NIC Number Enter 999999999 if the person is not on any CNIC card. Enter 888888888 if the person has a CNIC card but the respondent does not know the number because the person is away.	4. What is {name's} relationship to the household head? [Use codes below]	5. Mother's ID Use code 99 if mother is not in the roster Mother Id	6. Father's ID Use code 99 if father is not in the roster Father ID	7. {Name's} Gender 1=Male 2=Female	8. What is (name's} age? (Completed Years) (If person has died, record age at time of death) Please fill in completed years over here.	9. What is {name's} marital status? 1=Unmarried 2=Unmarried, but nikah 3=Married 4=Separated 5=Widowed 6=Divorced See note on next page	10. What is {name's} primary occupation? [Use codes below] See note on next page	11. Has {name} obtained any formal (<u>not</u> religious) education ? [Use codes below] See note on next page	12. What is the highest level of formal schooling that {name} has completed? *Record the class and use the code* 20 for *education above Class XII.* Note that the code 55 for kucchi classes can be used even if the person is adult, since he/she may have studied only in kucchi and not gone to Class 1	13. Where was {name} when the earthquake struck? 0=born after Earth quake 1=At home, inside 2=At home, outside 3=At school, inside 4=At school, outside 5=Inside a physical structure 6=Outside a physical structure 7= outside the village 8=outside the district 99=Not sure/do not remember See note on next page	14. Was {name} living in the household before the earthquake? 1=Yes 2=No	15. Is {Name} currently living in this household? 1=Yes 2=No, but alive 3=No, dead	16. WAS name tested today1 =Yes→ Next Child 2=NO	17. Why WAS {Name} not tested 1=Not leaving in the HH 2=Age does not match (Greater than 7 and less than 16 years) 3=working out side the village 4=temporarily living outside village 5=disable(ONLY MENTALLY RETARTED AND BLIND OR UNABLE TO HEAR/SPEAK)

SUMMARY STATISTICS: HOUSEHOLDS

	(1) Mean	(2) SD	(3) 25th	(4) Median	(5) 75th	(6) N	(7) Source of Data
Household Geography							
Distance to Fault (km)	17.5	14.1	5.6	13.6	24.3	28,297	Standard Census
Distance to Epicenter (km)	36.4	17.5	25.1	35.2	48.0	28,297	Standard Census
Closest Faultline (km)	2.8	2.5	0.8	2.0	4.1	28,297	Standard Census
Mean Slope of Union Council (degrees)	21.1	6.7	16.9	22.2	26.1	98	GIS - Union Council Level
District - Abbottabad	20.6%					2,456	Household Survey
District - Bagh	17.5%					2,456	Household Survey
District - Mansehra	27.6%					2,456	Household Survey
District - Muzaffarabad	34.2%					2,456	Household Survey
Household Death, Destruction, and Aid							
Death in Household During Earthquake	6.1%					28,297	Standard Census
Home Damaged or Destroyed	91.1%					8,350	Extended Census and Survey
Home Destroyed	57.2%					8,351	Extended Census and Survey
Received any form of aid	66.8%					2,456	Household Survey
Received any cash aid	46.7%					2,456	Household Survey
Cash Aid Amount (PKR)	116,182	102,982	0	125,000	175,000	2,456	Household Survey
Household Socioeconomic Characteristics							
Household Size	6.1	2.7	4.0	6.0	8.0	2,455	Household Survey
Total Annual Food Expenditure (PKR)	83,208	88,161	37,500	62,280	98,805	2,456	Household Survey
Total Annual Nonfood Expenditure (PKR)	84,207	109,511	26,787	46,183	93,035	2,456	Household Survey
Pre-Earthquake Asset Index	0.00	1.00	-0.55	-0.09	0.57	2,456	Household Survey
Number of children under age 6 during earthquake	1.0	1.1	0.0	1.0	2.0	2,456	Household Survey
Female head of household	10.0%					2,456	Household Survey

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SUMMARY STATISTICS: INDIVIDUALS

	(1) Mean	(2) SD	(3) 25th	(4) Median	(5) 75th	(6) N	(7) Source of Data
Individual Characteristics							
Male	52%					152,435	Standard Census and Survey
Age	24.0	18.4	10.0	20.0	35.0	152,435	Standard Census and Survey
In Utero to Age 11 During Earthquake	33%					152,435	Standard Census and Survey
Children In Utero - Age 11 During Earthquake							
In Utero	9.0%					4,665	Household Survey
Age 0-2	25.7%					4,665	Household Survey
Age 3+	65.3%					4,665	Household Survey
Child's Height (cm)	117.5	22.3	101.0	119.0	132.0	4,096	Household Survey
Child's Weight (kg)	25.6	9.3	18.0	24.0	31.0	4,097	Household Survey
School Enrollment During Survey (Age 1+ during Earthquake)	86.1%					3,589	Household Survey
Private School Enrollment Rate During Survey	21.7%					3,089	Household Survey
Parents of Children In Utero - Age 11 During Earthquake							
Father Completed Primary School	57.3%					4,379	Household Survey
Mother Completed Primary School	22.2%					4,387	Household Survey
Mother's Age	37.425	8.4	31.0	37.0	42.0	4,387	Household Survey
Mother's Height (cm)	157.238	7.8	152.0	157.0	162.0	4,239	Household Survey
Mother's School Access Instrument	0.464	0.5	0.0	0.0	1.0	4,155	Household Survey
Father's Age	43.182	10.0	37.0	42.0	49.0	4,379	Household Survey
Father's Height (cm)	168.579	6.9	165.0	170.0	173.0	3,876	Household Survey

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EXOGENEITY OF THE SHOCK

IDENTIFICATION

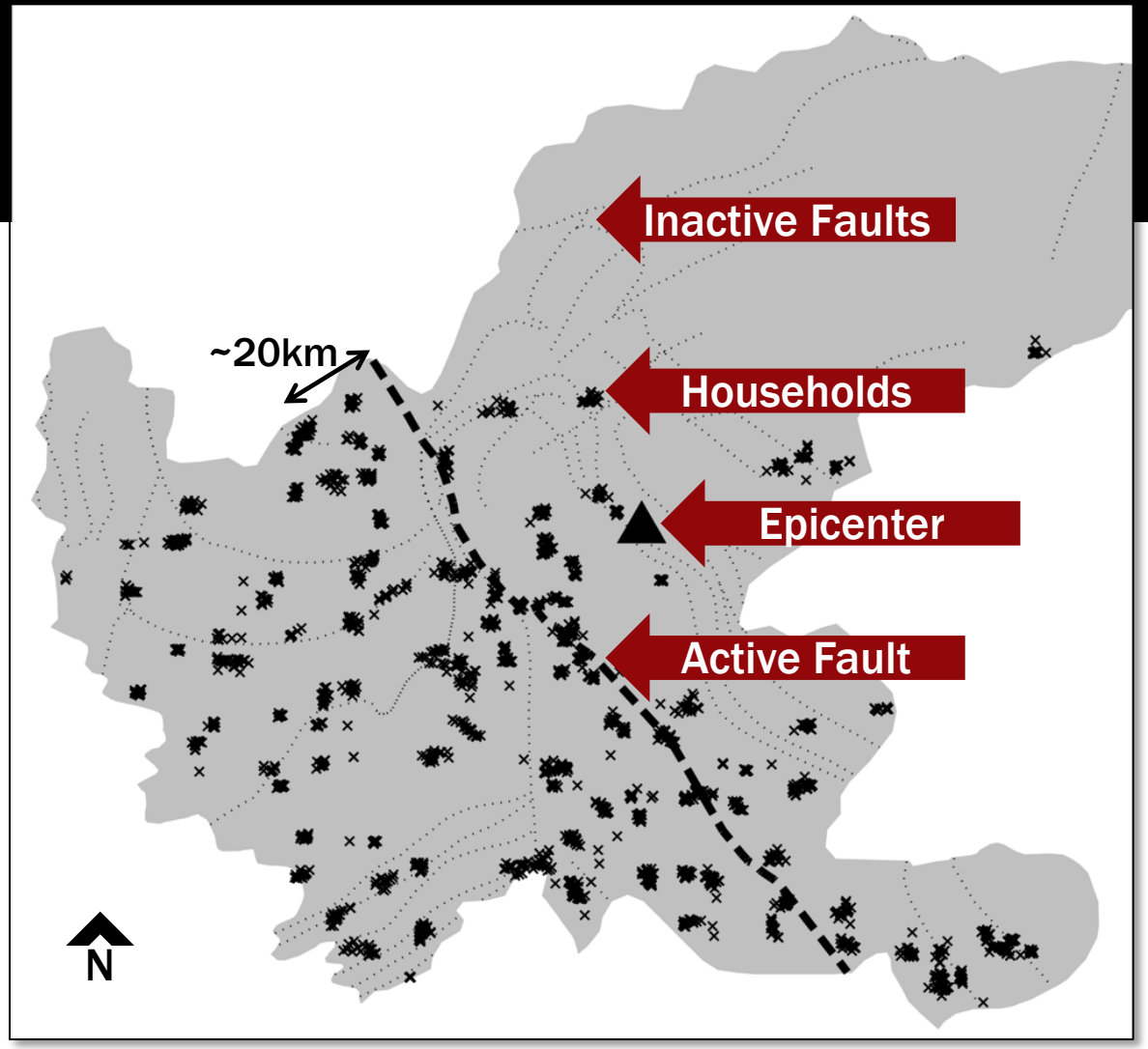
- "Intensity" is correlated with soil types and hilliness –therefore correlated with key characteristics like agricultural productivity
- We use "distance to activated fault" for exposure

Reduced Form:

$$Y_i = \alpha + \beta * Distance\text{-}to\text{-}Fault_i$$

$$+ \gamma * X_i + \delta * District_i + \varepsilon_i$$

- Controls X_i in main regressions include exposure to any fault, local slope, distance to epicenter
- District fixed effects in all regressions and clustering at village level



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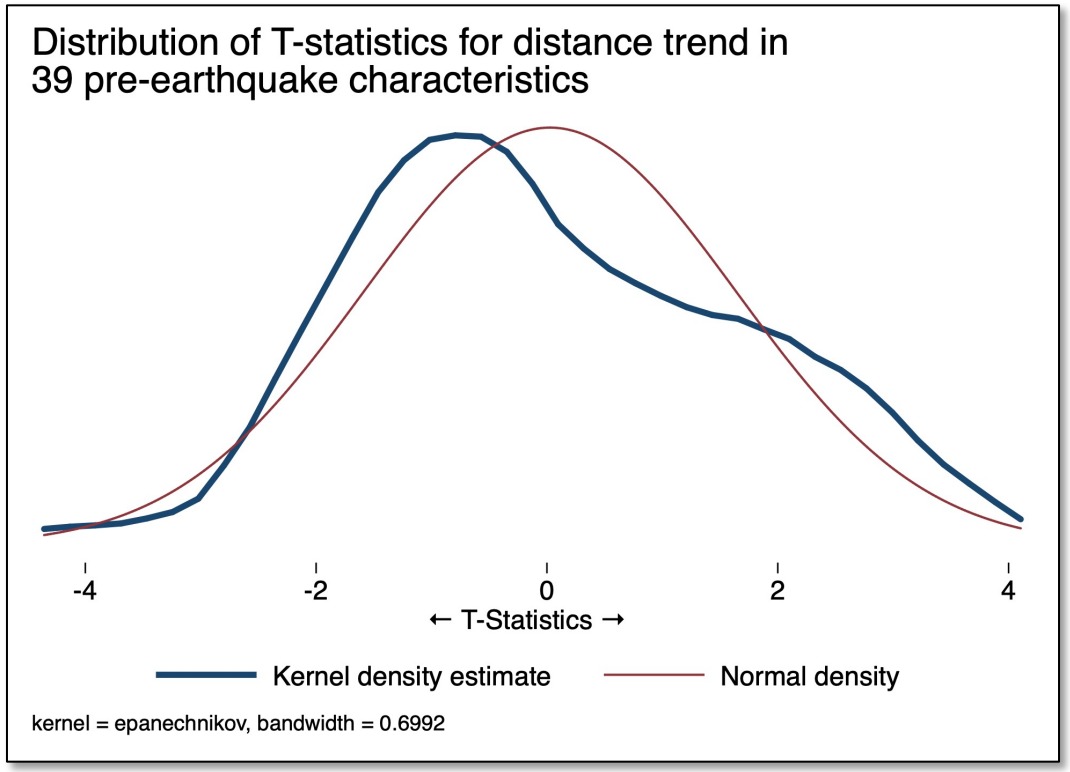
IDENTIFICATION FROM "DISTANCE TO ACTIVATED FAULT"

Previous paper (Andrabi et al. 2017) used exposure to earthquake + aid to show causally higher trust towards Westerners in affected areas post-earthquake

Key features for identification:

1. Unanticipated shock in both timing and location
2. Affected populations arguably similar to unaffected populations
3. Significant destruction but low mortality in affected areas
4. Low out-migration
5. Low "aid spillovers"



DISTANCE-TO-FAULT PRE-CORRELATIONS

	Distance to Faultline Coefficient	N	R2	Mean
Villages (1998 Village Census)				
Total Population	-18.377	126	0.186	3,376.174
	19.625			
Male Population	-9.412	126	0.182	1,685.186
	10.037			
Female Population	-8.965	126	0.189	1,690.988
	9.623			
Muslim Population	-18.273	126	0.186	3,365.388
	19.543			
Literacy Rate	-0.000	125	0.401	0.456
	0.001			
Proportion with Primary Education	-0.002*	126	0.354	0.387
	0.001			
Proportion Females with Secondary Education	-0.000	126	0.143	0.026
	0.000			
Average Household Size	-0.024**	126	0.252	6.970
	0.011			
Number of Permanent Houses	-0.755	120	0.200	223.304
	1.259			
Number of Houses with Electricity	-2.324	112	0.130	290.126
	2.028			
Number of Houses With Potable Water	-1.269	100	0.167	100.083
	0.971			
Village Infrastructure Index	-0.013	126	0.154	0.421
	0.009			

	Households (2009 Household Survey)			
Recall				
Electricity in House	-0.009***	2,456	0.108	0.851
	0.002			
Water In House	-0.003	2,456	0.042	0.452
	0.002			
Permanent House	-0.003	2,456	0.103	0.375
	0.002			
Distance to Closest Market (min)	0.237	2,452	0.089	54.508
	0.336			
Distance to Closest Water Source (min)	0.056	2,456	0.030	9.564
	0.051			
Distance to Closest Medical Facility (min)	-0.086	2,444	0.069	57.421
	0.290			
Distance to Closest Private School (min)	-0.112	2,372	0.039	43.907
	0.251			
Distance to Closest Government School (min)	0.022	2,454	0.035	20.762
	0.085			
Measured				
Distance to Closest Water Source (km)	0.052	2,456	0.215	3.003
	0.035			
Distance to Closest Health Clinic (km)	0.122***	2,456	0.344	5.285
	0.043			
Distance to Closest Private School (km)	0.102**	2,456	0.255	3.318
	0.045			
Distance to Closest Boys School (km)	0.090*	2,456	0.251	1.142
	0.050			
Distance to Closest Girls School (km)	0.009	2,456	0.047	1.271
	0.023			

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2005 KASHMIR EARTHQUAKE: DEATH AND DESTRUCTION

Remote rural area of northern Pakistan

8 October 2005, 8:50am

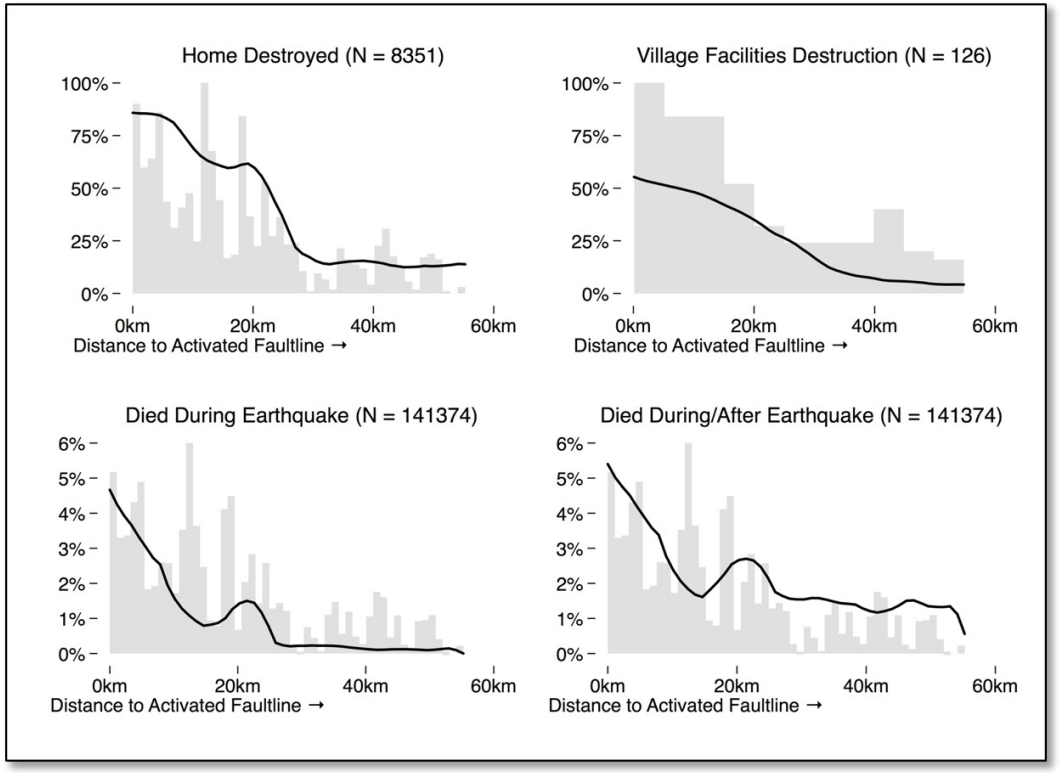
Magnitude 7.6 (similar to 1906 San Francisco)

80% of homes destroyed

73–79,000 deaths

69–128,000 injuries

We base reduced-form identification on intensity of exposure to earthquake



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"JOINT TREATMENT": DISASTER + AID + CASH

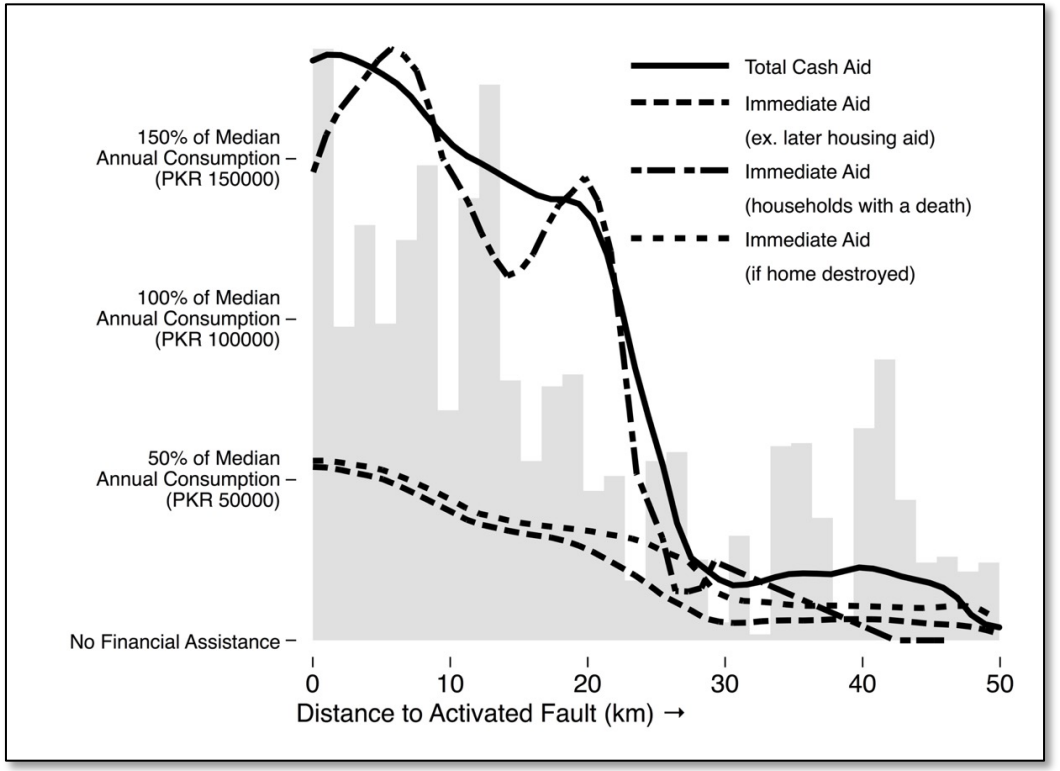
Led by Pakistan Army

Supported extensively by UN & other Western agencies (US military, etc)

Massive delivery of in-kind aid and housing support

Large amounts of cash aid delivered directly to households

Aid delivery pattern almost exactly matches destruction pattern



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AID TOOK TIME TO ARRIVE

RESULTS:
FOUR YEARS LATER

RECOVERY TO PARITY BY 2009

"Building Back Better" –homes near the fault are higher quality: more likely to be masonry (permanent) construction, have electricity, and have running water

Interpreting regressions:

Results are "per km"

Positive slope means "more of X far from fault" (negative means less)

Reasonable on-average comparison is +30km

	(1) Distance to Faultline (km) Coefficient	(2) N	(3) R2	(4) Mean
PANEL A: Household Socioeconomic Characteristics				
Asset Index (PCA) (Post-Quake)	-0.00	2,456	0.122	0.00
	0.00			
Household Infrastructure Index	-0.02***	2,456	0.168	0.00
	0.01			
Permanent House (Post-Quake)	-0.01**	2,456	0.089	0.64
	0.00			
Electricity	-0.01***	2,456	0.142	0.90
	0.00			
Water In House (Post-Quake)	-0.00*	2,456	0.057	0.50
	0.00			
Log Consumption per Capita	0.00	2,456	0.072	10.04
	0.00			
PANEL B: Access to Public Infrastructure				
Log Dist to Gov't School (min)	-0.00	2,454	0.039	2.78
	0.00			
Log Dist to Market (min)	0.00	2,452	0.119	3.62
	0.01			
Log Dist to Distr Office (min)	-0.00	2,449	0.240	4.83
	0.00			
Log Dist to Medical (min)	-0.00	2,444	0.048	3.79
	0.01			
Log Dist to Private School (min)	-0.01	2,369	0.037	3.40
	0.01			
PANEL C: Adult Health				
Adult Height	0.02	6,907	0.007	145.32
	0.02			
Adult Weight	0.02	6,907	0.012	45.59
	0.02			
Adult Height (18-24)	-0.01	1,717	0.012	130.25
	0.04			
Adult Weight (18-24)	0.02	1,717	0.011	34.12
	0.03			

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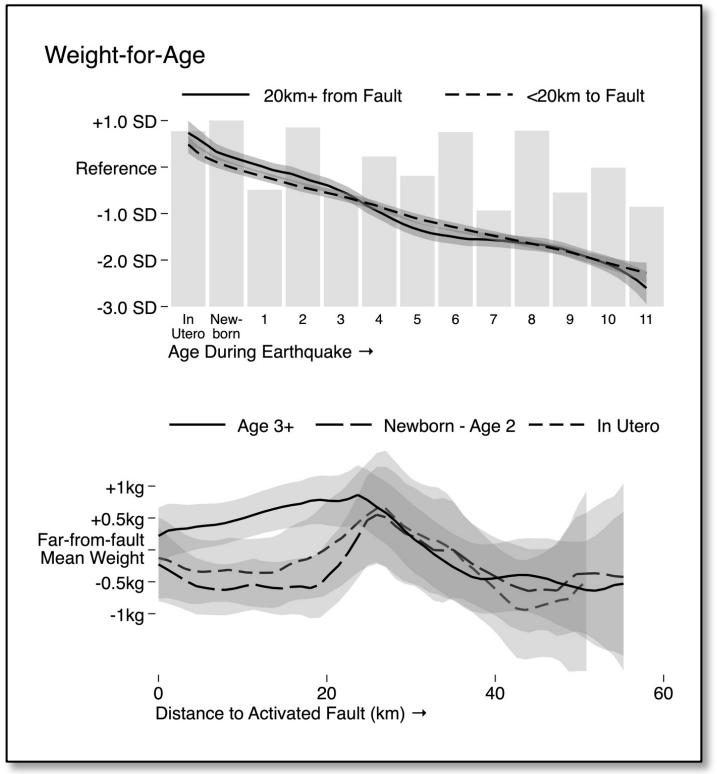
CHILDREN'S WEIGHT WAS UNAFFECTED

No discernible differences in current weight at any age, consistent with recovery

SDs relative to mean of US children in reference population



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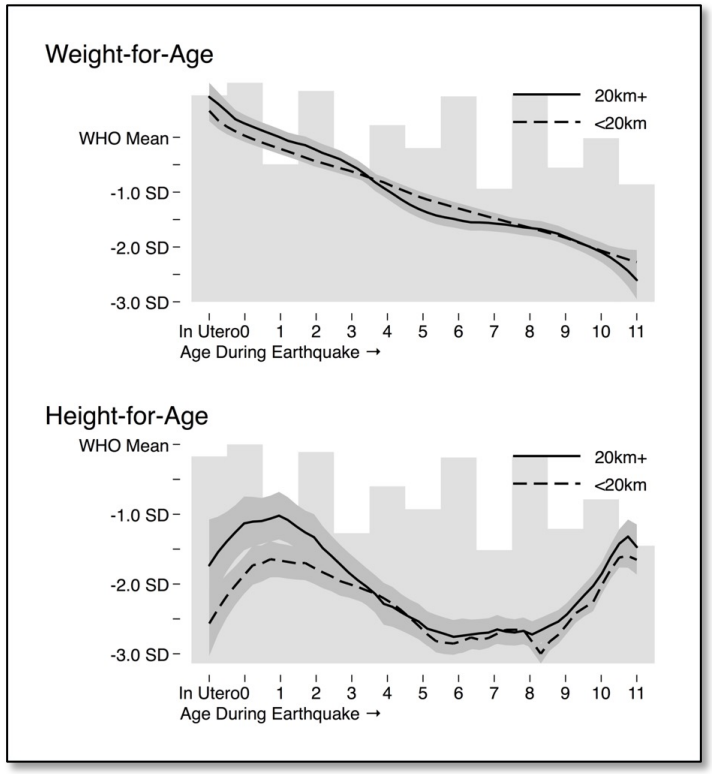
YOUNG CHILDREN'S HEIGHT LAGGED SIGNIFICANTLY

No discernible differences in current weight at any age, consistent with recovery

Large differences in current height for children in utero to age 3 at time of earthquake

Height gap starts at 1.0 SD for the youngest and declines smoothly with age

SDs relative to mean of US children in reference population



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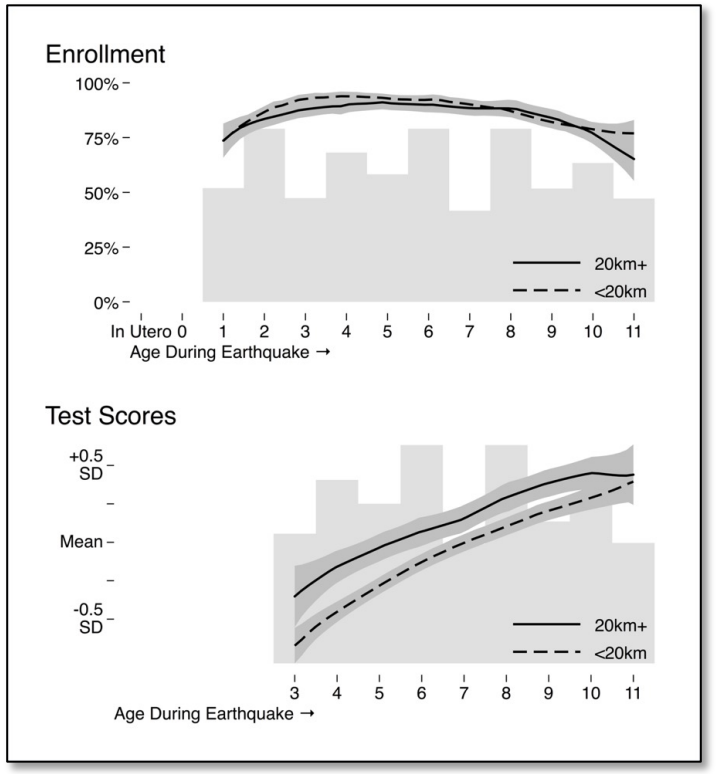
ALL CHILDREN'S SCHOOLING OUTCOMES LAGGED

Custom test administered to all children ages 7–15 at survey time, regardless of schooling status

Testing on English, Mathematics, and Urdu

Overall score calculated with IRT relative to sample mean

Gap of 0.25 SD for exposed group – age invariant, ≈2 years of school completion



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HUMAN CAPITAL: REGRESSION RESULTS

Test score effects are age- and gender-invariant

Robustness checks in paper

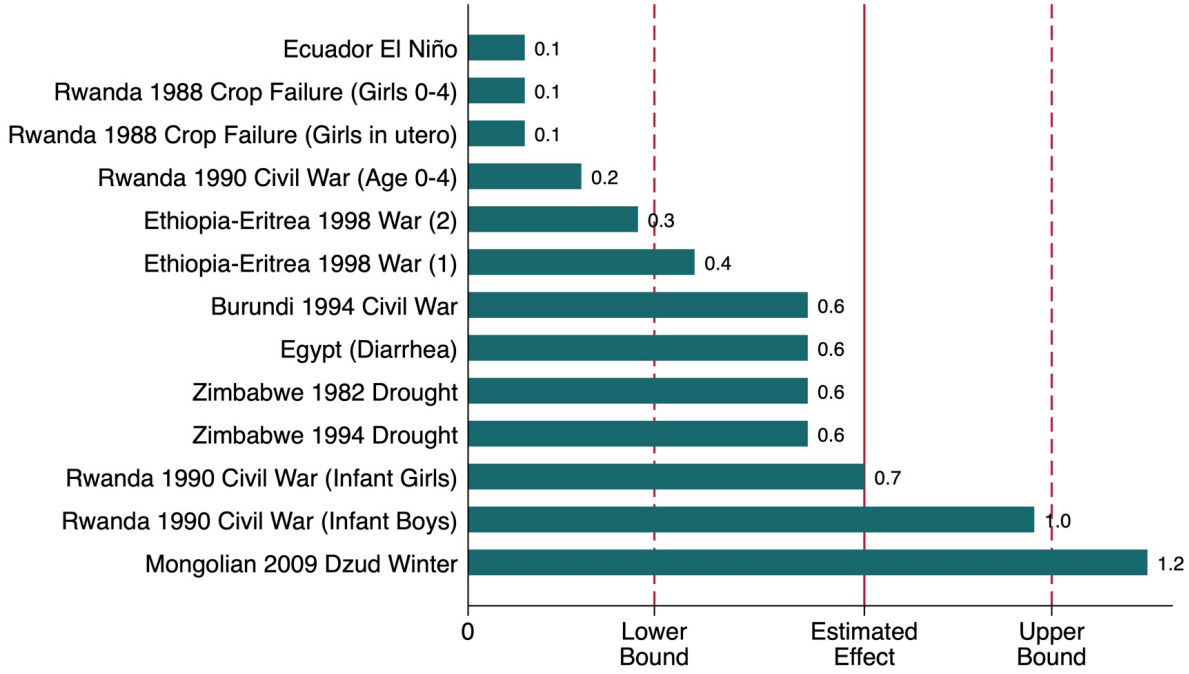
1. Placebo regressions using distances to all other fault lines in the region
2. Re-estimation with unfavorable assumptions about selective missingness and mortality using census roster

	(1) Weight (Z-score)	(2) Height (Z-score)	(3) School Enrollment	(4) Test Scores (IRT)	(5) Test Scores – Gender	(6) Test Scores – Age
Distance from Faultline (km)	-0.007*	0.002	-0.000	0.008**	0.007	0.012***
	(0.004)	*(0.005)*	*(0.001)*	*(0.004)*	*(0.005)*	*(0.005)*
In Utero * Distance from Faultline (km)	0.003	0.036**				
	(0.006)	*(0.017)*				
Age 0-2 * Distance from Faultline (km)	0.005	0.015*				
	(0.005)	*(0.009)*				
Male	-0.041	0.037	0.077***	0.068	0.041	0.066
	(0.048)	*(0.081)*	*(0.016)*	*(0.043)*	*(0.074)*	*(0.044)*
(log) Consumption per Capita	-0.001	0.084	0.026**	0.141***	0.141***	0.139***
	(0.045)	*(0.082)*	*(0.011)*	*(0.045)*	*(0.044)*	*(0.045)*
Distance from Faultline (km) * Male					0.002	
					(0.004)	
Distance from Faultline (km) * Age 6						-0.004
						(0.004)
Distance from Faultline (km) * Age 7						-0.002
						(0.005)
Distance from Faultline (km) * Age 8						-0.007
						(0.005)
Distance from Faultline (km) * Age 9						0.005
						(0.004)
Distance from Faultline (km) * Age 10						-0.008*
						(0.004)
Distance from Faultline (km) * Age 11						-0.008
						(0.006)
Dependent Variable Mean	*-0.944*	*-2.155*	*0.903*	*0.131*	*0.131*	*0.131*
Geographic Controls	X	X	X	X	X	X
Individual and SES Controls	X	X	X	X	X	X
Age Dummies	X	X	X	X	X	X
Regression R2	0.247	0.077	0.074	0.099	0.099	0.104
Number of Observations	4,002	4,001	1,874	1,875	1,875	1,875

BENCHMARKING THE EFFECTS

In our population for children in utero to age 2 we estimate an average impact of -0.7SD.

This is a similar size to the largest effects measured from the Rwandan 1990-91 civil war and the Zimbabwean 1982-84 and 1994-95 droughts.



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BENCHMARKING THE EFFECTS

Use wage-height and wage-years of schooling associations from Pakistan

Assume: Same percentile effect for height in adult life, and test score losses equate to years of schooling loss (World Bank 2019)

Use census of all individuals in the area to compute losses once children are in the labor market

Estimate that at peak losses (when the youngest is 18 and everyone is in the labor market), earnings losses for this cohort are 15%-18%, which corresponds to 5% of earnings in the area

- Mostly due to loss in schooling years, with additional effect of 6% due to loss of height

Multiple (brave) assumptions in this, but could be upper-bound or lower-bound (for instance, no health losses accounted for)

MATERNAL EDUCATION MITIGATION AND IV

MATERNAL EDUCATION AND THE DISASTER-RECOVERY LINK

We define “Maternal education” as mothers with at least primary schooling

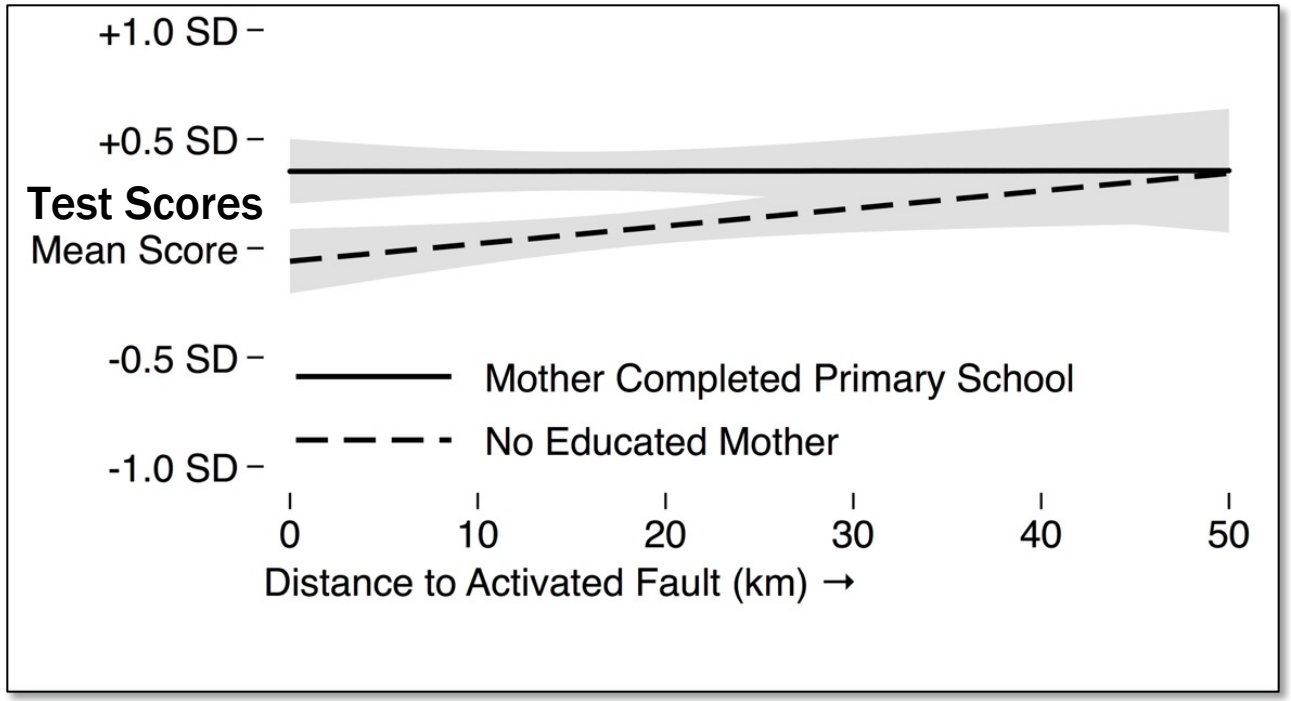
- In our sample, 68% report 0 years of schooling, 10% report primary schooling and 16% report more than primary schooling

We examine the difference in the impact of the earthquake for children by maternal education

MATERNAL EDUCATION MITIGATED IMPACT

For children whose mothers completed primary school, the difference between exposed and unexposed groups disappears completely.

This effect is largest in school-age children (shown) and smallest in those aged 3-4 during the earthquake.



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MATERNAL EDUCATION: OLS REGRESSION

Significant level effect (0.27 SD) as well as large protective interaction effect (removes 87% of the earthquake effect).

Pre-existing achievement inequality is magnified 2-3x between children of educated and uneducated mothers in the exposure zone.

No level effect or protection effect observed in height regression

	(1)	(2)	(3)	(4)
	Test Scores		Height-for-age: In Utero and Age 0-2	
	Maternal Education	Maternal Education Interaction	Maternal Education	Maternal Education Interaction
Distance from Faultline (km)	0.008**	0.009**	0.017	0.016
	(0.004)	*(0.004)*	*(0.01)*	*(0.01)*
Mother Completed Primary School	0.274***	0.398***	0.088	0.030
	(0.051)	*(0.079)*	*(0.230)*	*(0.338)*
Mother's Education * Distance		-0.007**		0.003
		(0.004)		*(0.017)*
Male	0.066*	0.066	-0.147	-0.148
	(0.043)	*(0.042)*	*(0.167)*	*(0.167)*
Log Consumption per Capita	0.121***	0.121***	0.063	0.065
	(0.042)	*(0.042)*	*(0.171)*	*(0.171)*
Dependent Variable Mean	*0.131*	*0.131*	*-1.676*	*-1.676*
Geographic Controls	X	X	X	X
Individual and SES Controls	X	X	X	X
Age Dummies	X	X	X	X
Regression R2	0.113	0.114	0.030	0.030
Number of Observations	1,875	1,875	1,423	1,423

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MATERNAL EDUCATION CAUSALITY: IV APPROACH

Idea: Age-appropriate schooling availability (Card & Kreuger, Andrabi et al., Currie et al.)

Survey contains data on *birth-village* of each mother

Match birth village to census of public schools and create a variable for whether a *girls'* school existed in the village at the time the mother was age 8

- This was the cutoff age for entering school at the time these mothers were young

Use availability of girls' school in village at age 8 as IV for maternal education

- Control for mothers age in fully saturated specification
- Geographical controls (Tehsil)

Exclusion restriction requires that school placement did not respond to demand

- Falsify using existence of school at age 9-14
- Alternative falsification using existence of *boys'* school in the village

MATERNAL IV SPECIFICATION

Our IV regression has as its first stages:

$$\textit{maternal-education}_i = \alpha + \beta_1 * \textit{girls-school}_i + \beta_2 * \lambda_i + \beta_3 * \gamma_i + \eta_i$$

$$\textit{interaction}_i = \alpha + \beta_1 * \textit{Distance-to-Fault} * \textit{girls-school}_i + \beta_2 * \lambda_i + \beta_3 * \gamma_i + \eta_i$$

In the second stage, we regress:

$$Y_i = \alpha + \beta_1 * \textit{Distance-to-Fault} + \beta_2 * \widehat{\textit{maternal-education}_i}$$
$$+ \beta_3 * \widehat{\textit{interaction}_i} + \beta_4 * \lambda_i + \beta_5 * \gamma_i + \varepsilon_i$$

Controls λ_i are maternal birth year indicators, tehsil fixed effects, and village population

Controls γ_i are the same as in the main regression (including district fixed effects)

MATERNAL IV SPECIFICATION: FIRST STAGE + FALSIFICATION

Girls' school at age 9 increases likelihood that mother has some education by 12.5 percentage points, relative to mean of 39.6 percent

Robust to controls and falsification

	(1) Instrument	(2) Recieved School Sometime	(3) Geographical Controls	(4) Boys' School	(5) Girls' School (Other Ages)	(6) Birth Village FE
Distance from Faultline (km)	0.001	0.000	0.001	0.000	0.000	0.004
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.011)
Girls' school present by age 9	0.125***	0.123***	0.116***		0.136***	0.085
	(0.029)	(0.032)	(0.029)		(0.041)	(0.060)
Boys' school present by age 8				-0.012		
				(0.030)		
Girls' school present at age 10-14					0.033	
					(0.050)	
Girls' school present after age 14					0.013	
					(0.033)	
Constant	0.395	-0.402***	0.535	-0.651	-0.599	-1.022**
	(0.345)	(0.119)	(0.545)	(0.620)	(0.590)	(0.476)
Number of observations	987	835	987	987	987	986
F-statistic for Age 9 School Availability	18.310	15.200	16.120	0.160	10.960	1.990

MATERNAL EDUCATION: IV REGRESSION

We use an IV strategy based on the availability of a girls' primary school in the mother's birth village to show that the mitigation is causal.

Robustness checks in paper:

Leave-one-out and leave-two-out analysis of outlier clusters

Analysis using villages with only one school (ruling out school choice as impact channel)

	(1)	(2)	(3)	(4)
	Test Scores		Height-for-age: In Utero and Age 0-2	
	IV Maternal Education	IV Maternal Education Interaction	IV Maternal Education	IV Maternal Education Interaction
Distance from Faultline (km)	0.017***	0.030***	0.007	-0.014
	(0.006)	(0.009)	*(0.02)*	*(0.04)*
Mother Completed Primary School	1.629***	4.821**	-3.352*	-4.985
	(0.558)	(1.873)	*(1.840)*	*(3.600)*
Mother's Education * Distance		-0.139**		0.083
		(0.068)		*(0.126)*
Male	0.059	0.041	-0.212	-0.234
	(0.048)	(0.059)	*(0.172)*	*(0.179)*
Log Consumption per Capita	-0.027	-0.088	0.439	0.471
	(0.069)	(0.108)	*(0.293)*	*(0.310)*
Dependent Variable Mean	*0.135*	*0.135*	*-1.657*	*-1.657*
Geographic Controls	X	X	X	X
Individual and SES Controls	X	X	X	X
Age Dummies	X	X	X	X
First-stage F-statistic	21.632	4.340	19.374	5.127
Number of Observations	1,723	1,723	1,275	1,275

CHANNELS OF IMPACT

We cannot say much about channels, but we make two remarks

Part of test score losses due to school disruption, with every week of additional disruption leading to additional weak of learning losses, BUT:

- Schools closed on average for 14 weeks so cannot account for 1.5-2 years of learning losses
- Formal mediation analysis confirms that disruption accounts for 6-10% of learning losses
- Note that maternal education effect does not go through school switching, since effect stronger in villages with 1 school

We have examined a number of other potential interactions in the data, following the literature

- What is of interest is that maternal mental health, household elevation and household assets do not mitigate test score loss, but the first two mitigate losses in height

POTENTIAL CHANNELS: STATURE

Examine maternal mental health, household elevation and household assets

None of these mitigate the test score effect, but maternal mental health and household elevation both mitigate the height effect

Suggestive, but not causal evidence, that height may be more related to maternal stress and childhood infections—those living in the valleys were more subject to infections

	(1)	(2)	(3)	(4)	(5)	(6)
	Test Scores			Height (In Utero & Ages 0-2)		
	Maternal Mental Health	Household Elevation	Household Assets	Maternal Mental Health	Household Elevation	Household Assets
Distance from Faultline (km)	0.008**	0.012**	0.010**	0.034**	0.047**	0.011
	(0.004)	(0.005)	(0.004)	(0.014)	(0.018)	(0.013)
Above Median Maternal Mental Health, Household Elevation, or Assets	0.056	-0.035	0.288***	0.701**	0.967**	-0.282
	(0.071)	(0.102)	(0.087)	(0.344)	(0.430)	(0.403)
Mitigator * Distance Interaction (km)	-0.003	-0.008	-0.007	-0.047***	-0.041**	0.016
	(0.003)	(0.005)	(0.004)	(0.016)	(0.021)	(0.018)
Mother Completed Primary School	0.279***	0.250***	0.246***	-0.000	0.105	0.076
	(0.056)	(0.054)	(0.054)	(0.240)	(0.230)	(0.237)
Male	0.062	0.076*	0.074*	-0.113	-0.148	-0.147
	(0.044)	(0.042)	(0.043)	(0.187)	(0.166)	(0.167)
(log) Consumption per Capita	0.116**	0.121***	0.107**	0.011	0.072	0.064
	(0.045)	(0.042)	(0.041)	(0.173)	(0.173)	(0.174)
Number of observations	1,705	1,875	1,875	1,224	1,423	1,423
Regression R2	0.109	0.121	0.124	0.042	0.036	0.031
Dependent Variable Mean	0.130	0.131	0.131	-1.632	-1.676	-1.676

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DISCUSSION AND ROBUSTNESS

RESULTS REVIEW:

Setting:

Major unpredictable earthquake

Rural, mountainous area in Pakistan with homogeneous villages throughout

Massive local and international aid

“Compensated shock”: Cash aid to households up to 150% of annual consumption with very low spillovers

No confounding from migration, mortality, risk preference, or fault location (lots of faults in region)

What we find:

Complete recovery, except:

Children then aged 0–3 show major height deficits at current ages 4–7 (0.5–1.0 SD)

Children then aged 3–11 show major educational attainment deficits at current ages 7–15 (0.24 SD)

Children whose mother completed primary school are largely protected from educational (but not height) impact; this protective effect is causal (IV regression)

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DISCUSSION OF RESULTS

Setting of massive in-kind and cash aid, with recovery to parity in infrastructure, consumption, health, and school enrollment

We show that development gaps persist between children affected and unaffected by the earthquake – both nutritional and educational

55% of households had a child who could have been affected by the growth lag

Uneducated mothers were 75% of our sample with 82% of school-age children

Mothers who have completed their primary school education causally provide a baseline gain in test scores (0.27 SD) and a protective effect that mitigates 87% of the earthquake impact (=0.3–0.6 SD)

Therefore the academic advantages of children the top 25% of women are magnified 2-3x relative to others through this differential effect

ROBUSTNESS

Risk profiles of those living closer to the Faultline: Placebo test where we generate effect sizes for each Faultline and examine the joint distribution of effect sizes

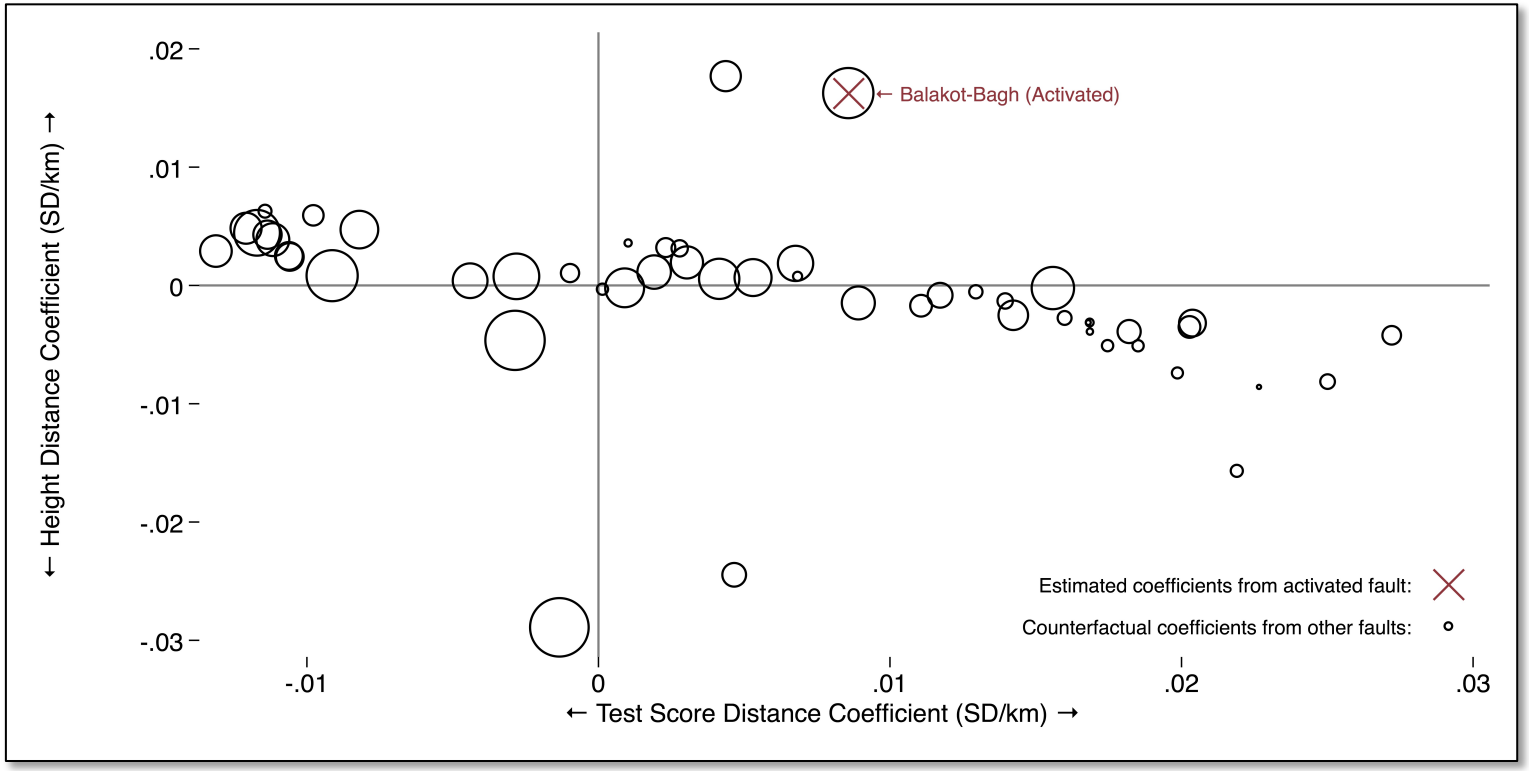
Selective missingness due to mortality and migration

- Lee bounds on test-scores gives us a lower-bound effect of -0.13sd compared to -0.17sd
- On heights gives us -0.33sd compared to -0.70sd

Sensitivity of IV to outliers: Young (2017) suggests “leave-one-out” robustness checks

- Leave-one-out worst case is a maternal IV coefficient of -0.099 compared to our result of -.139
- Leave-two-out gives worst case of -.083 (relative to -.139)

PLACEBO TESTS FOR FAULT EXPOSURE



Placebo regressions using distance to other faults

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SELECTIVE MISSINGNESS MORTALITY/MIGRATION

	(1)	(2)	(3)	(4)
	Test Scores Bounds		Height Bounds (In Utero and Ages 0-2)	
	Lower	Upper	Lower	Upper
Near fault (<20km)	-0.220	-0.130	-1.031	-0.329
Standard error	0.060	0.053	0.219	0.219
Z-score	-3.669	-2.445	-4.714	-1.499
P-value	0.000	0.014	0.000	0.134
Lower bound	-0.337	-0.234	-1.460	-0.758
Upper bound	-0.102	-0.026	-0.602	0.101
N observed	1,875		1,423	
N not observed	442		133	
Trimming proportion	2.06%		4.53%	

Note: Results show the upper and lower bounds obtained by following the Lee (2009) procedure for trimming excess observations with adverse assumptions due to selective unavailability in either treatment or control groups.

MATERNAL EDUCATION CORRELATES

People wanted to see what happens if we use the maternal IV regression on a bunch of things. I think we can restrict to things that "changed with the quake". So, I would do it with school disruption, aid receipts and maternal mental health.

	Mother Did Not Complete Primary School	Mother Completed Primary School	OLS Difference	IV Difference
School Disruption (Weeks)	9.13	9.11	-0.21	-1.89
	0.30	*0.56*	*0.65*	*5.79*
Father Completed Primary School?	0.49	0.86	0.33***	0.48**
	0.01	*0.02*	*0.03*	*0.24*
Enrolled (Post-Quake)	0.90	0.98	0.04***	0.31**
	0.01	*0.01*	*0.01*	*0.13*
Private School (Post-Quake)	0.19	0.30	0.08***	0.25
	0.01	*0.02*	*0.02*	*0.27*
Total Reported Aid Compensation	128,741.90	134,292.52	-1,234.46	-14,122.23
	2,211.38	*4,560.63*	*3,792.40*	*40,828.38*
Asset Index (PCA) (Post-Quake)	-0.07	0.57	0.52***	1.17*
	0.02	*0.05*	*0.05*	*0.62*
Maternal Mental Health (PCA)	-0.78	-0.22	0.42***	-0.51
	0.05	*0.11*	*0.13*	*1.51*
N	1,945.00	441.00	.	.

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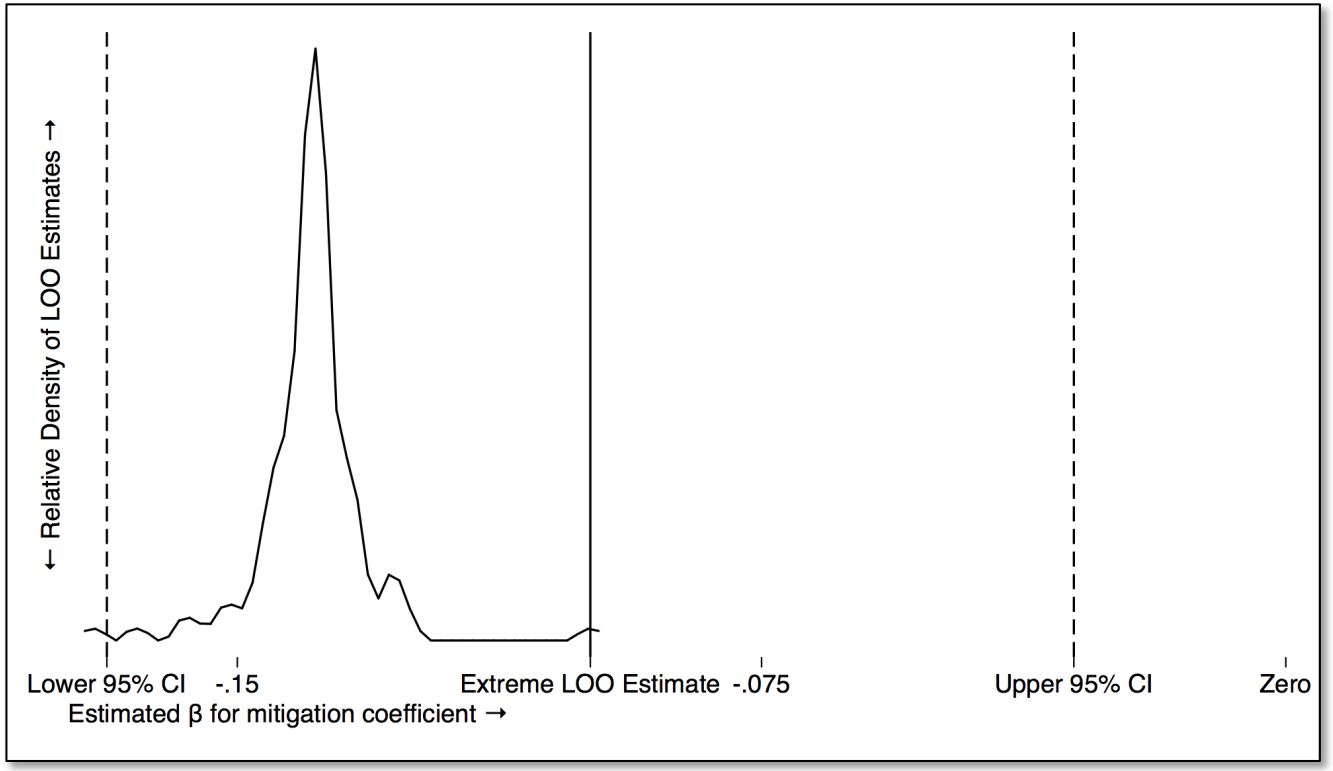
SENSITIVITY OF IV TO OUTLIERS

Distribution of estimates excluding each village sequentially



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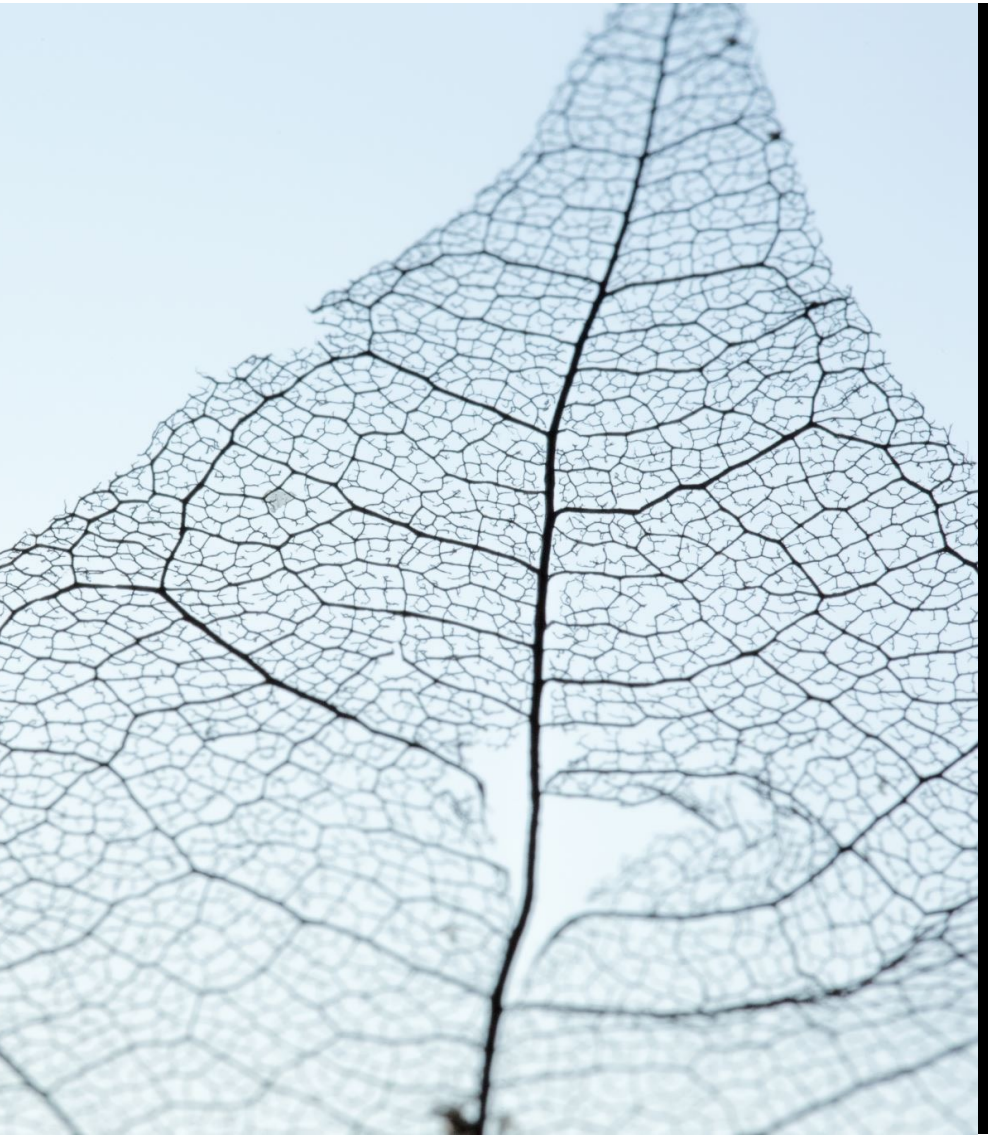

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