Lasting impact on health from natural disasters, potential mechanisms and mitigating effects

Gaurav Dhamija[1,2] and Gitanjali Sen[1*] (ORCID ID: 0000-0001-6947-3664)

[1]Department of Economics, Shiv Nadar University, Uttar Pradesh, India and
[2]Indian Institute of Technology, Hyderabad, India

[*]Corresponding author. E-mail: gitanjali.sen@snu.edu.in; gitan_dutta@hotmail.com

ONLINE APPENDIX

Section I. Reasons for using the IHDS data

The National Family Health Survey (NFHS) data would be the only other data set with the similar information. The first two waves of this cross-section data being collected in 1992-93 and 1998-99, we could use those as counterfactuals before the earthquake. However, the post-earthquake rounds were conducted in 2005-06 (NFHS-3) and 2015-16 (NFHS-4), and, the NFHS-3 does not include the district identifiers making it impossible to identify the severely-affected districts. While the geo-codes were available for the NFHS-4 only, we could not use the anthropometric information of the 0-4 years old children as even the oldest cohort in this data were born in 2010, that is, 9 years after the earthquake. We could not use the anthropometric data of 15-49 years old eligible mothers as Gujarat was surveyed from January 2016 to June 2016 and the youngest female cohort (i.e., 15 years old) would have been born by the time of the earthquake in 2001. We would not be able to capture any woman who was in-utero at the time of the earthquake, if we used this cohort for our analysis. Since, nutrition in-utero is an important determinant of health outcomes in later life, this would have introduced selection bias in our results. Hence, we have used IHDS data instead of NFHS data.

Section II. Reasons for using UK Growth Chart as reference instead of WHO Growth Chart

While one may argue that the WHO 2006 growth charts are more updated growth charts, but it provides the reference charts to calculate HAZ for children aged 0-19 years old. However, our counterfactual group includes females aged 18-23 years old. Therefore, using WHO 2006 Growth Standards for HAZ restricts our counterfactual group to 18-19 years old. In order to check the robustness, we have calculated HAZ for 3-5 years old (treated cohort) and 18-19 years old (counterfactual cohort) using WHO 2006 Growth Standards. Due to this our full sample reduces from 278 to 132 in panel B corresponding to table 2 and from 2057 (1903) to 1037 (957) in the first (last) three columns in panel B corresponding to table 3. These results are presented in the tables A19 and A20. Reassuringly, the results of this analysis are in line with the main results (note, the estimated effects although statistically insignificant, is economically meaningful).

Section III. Addressing the concerns of potential selection bias arising due to districts missing from the IHDS-1 sample

IHDS-1 has not surveyed five of the marginally-affected districts (Banaskantha, Porbandar, Sabarkantha, Navsari, Valsad) and three of the unaffected districts (PanchMahal, The Dangs and Dohad) as their objective was to present national level estimates instead of district level estimates. Unavailability of data from these districts can potentially generate an upward bias in our estimates if the health infrastructure or health outcomes are poorer in these districts relative to the surveyed districts in marginally-affected and unaffected region. To alleviate this concern, we use the village level and child level data from another nationally representative survey of similar nature, that is the National Family Health Survey Data-2 (NFHS-2) surveyed in 1998-99 and compare the village health infrastructure and height of 0-2 years old children in included districts in the IHDS-1 relative to missing districts in IHDS-1 survey. Unfortunately, NFHS-2 has not covered all the missing districts of IHDS-1. However, it gives us an idea of the direction of bias (if there is any) in our results due to unavailability of data from eight districts in IHDS-1. NFHS-2 surveyed five (Banaskantha, Sabarkantha, Valsad, PanchMahal, The Dangs) out of eight districts missing in IHDS-1. We compare the village health infrastructures and height of children from these five districts to nine districts (Amreli, Bharuch, Bhavnagar, Gandhinagar, Junagadh, Kheda, Mahesana, Surat, Vadodra) which were not missing in IHDS-1 and surveyed in NFHS-2 as well. Summary statistics as presented in table A21 do not show any statistical difference in the village health infrastructure and child's height in the districts from marginally-affected and unaffected region which were included and excluded in IHDS-1 except in two indicators (that are, the distance from the sub-center and primary health center). This reassuringly increases our confidence that unavailable data from missing districts is unlikely to bring any upward bias in our main results.

Section IV: Speculating on the effect size on loss in returns from the labor market

There are a few important literature connecting differential childhood growth to cognitive outcomes, education outcomes, labor market returns, which can be connected to speculate the impact of such an early life shock on those outcomes. However, both the education outcomes and labor market outcomes are also found to work through the channel of cognitive development, as well as background conditions of the child, the parents, the socio-economic conditions and several such factors. Hence, when it comes to quantifying the impact on labor market outcomes, the effect

size varies a lot across countries and across studies, based on what all factors have been controlled for. Since the demographic characteristics of population in the western part of India and more so in the state of Gujarat (which shares the border with Pakistan), is very similar to that of Pakistan, we are able to speculate from the existing literature the extent of losses on income and earnings for adults. Following Bossavie *et al.* (2021), that predicts about 0.8 per cent gains in returns to every centimeter in height, that is, a loss of height of about 2.5 cm to 3 cm due to the Gujarat earthquake is expected to lead to 2-2.4 per cent losses in returns from labor market. This is very similar to the findings of Vogl (2014) who finds about 2.3 per cent higher returns on hourly wage in Mexico due to a height gain by the same amount. However, the height premium found by Case and Paxon (2010) in the case of the US and UK data is comparatively much higher, due to potential difference in ethnicity, birthplace, education, differential returns to skills and sorting into high paying occupations. Hence while a generalized conclusion on quantification of such a loss is not the right approach, but it definitely helps to get an idea about the extent of the long term loss of earnings.

Section V. Important appendix tables and figures

Table A1. List of districts used in the main analysis[§]

Treated	**Controlled**			
Gujarat	Gujarat*	Maharashtra	Rajasthan	Madhya Pradesh
Ahmedabad	Amreli	Nandurbar	Bikaner	Sheopur
Jamnagar	Anand	Dhule	Churu	Morena
Kutch	Bharuch	Jalgaon	Jhunjhunun	Gwalior
Patan	Bhavnagar	Akola	Alwar	Datia
Rajkot	Gandhinagar	Washim	Bharatpur	Tikamgarh
Surendranagar	Junagadh	Amravati	Dhaulpur	Chhatarpur
	Kheda	Wardha	Karauli	Panna
	Mehsana	Nagpur	Sawai Madhopur	Damoh
	Surat	Bhandara	Dausa	Satna
	Vadodara	Gondiya	Jaipur	Umaria
	Narmada[#]	Chandrapur	Sikar	Shahdol
		Yavatmal	Nagaur	Sidhi
		Nanded	Jodhpur	Ratlam
		Hingoli	Jalor	Ujjain
		Parbhani	Pali	Shajapur
		Jalna	Ajmer	Dewas
		Nashik	Bhilwara	Dhar
		Thane	Rajsamand	Indore
		Mumbai	Udaipur	West Nimar
		Pune	Chittaurgarh	Barwani
		Ahmadnagar	Kota	East Nimar
		Bid	Baran	Rajgarh
		Osmanabad	Jhalawar	Bhopal
		Solapur		Betul
		Satara		Harda
		Ratnagiri		Hoshangabad
		Kolhapur		Katni
				Jabalpur
				Dindori
				Mandla
				Seoni

Notes:

[§]List of districts used for DLHS data related work is presented in appendix table A5.

*Five marginally-affected districts (Banaskantha, Porbandar, Sabarkantha, Navsari, Valsad) and three unaffected districts (PanchMahal, The Dangs and Dohad from Gujarat) were not surveyed in IHDS-1.

[#] Narmada was the only district which was reported as unaffected and surveyed in IHDS-1.

Table A2a. Earthquake intensities across different locations in the districts of Gujarat

District	Location	MMI	Average
Ahemadabad	Not available	7	7.25
Ahemadabad	Not available	7	7.25
Ahemadabad	Not available	7-8	7.25
Ahemadabad	Not available	7-8	7.25
Ahemadabad	Not available	6	7.25
Ahemadabad	Not available	7-8	7.25
Ahemadabad	Not available	7-8	7.25
Ahemadabad	Patdi	8	7.25
Amreli	Not available	7-8	7.5
Anand	Not available	6-7	6.5
Bharuch	Not available	7-8	7.5
Bhavnagar	Not available	7	7
Gandhinagar	Not available	8	8
Jamnagar	Not available	9	8.07
Jamnagar	Balamba	8-9	8.07
Jamnagar	Beraja	5-6	8.07
Jamnagar	Dhrol	8	8.07
Jamnagar	Dudhai	9-10	8.07
Jamnagar	Dwarka	8	8.07
Jamnagar	Okha	8	8.07
Junagadh	Not available	7-8	9.5
Junagadh	Junagadh	11-12	9.5
Kheda	Not available	6-7	6.75
Kheda	Nandiad	7	6.75

Table A2b. Earthquake intensities across different locations in the districts of Gujarat

District	Location	MMI	Average
Kutch	Adhoi	9-10	8.96
Kutch	Gundala	9-10	8.96
Kutch	Anjar	10-11	8.96
Kutch	Adipur	9-10	8.96
Kutch	Bhachau	9-10	8.96
Kutch	Bhadreshwar	9-10	8.96
Kutch	Bhuj	11-12	8.96
Kutch	Bhujpur	7-8	8.96
Kutch	Bidada	6-7	8.96
Kutch	Chhasra	8-9	8.96
Kutch	Chitrod	8	8.96
Kutch	Deshalpur	6-7	8.96
Kutch	Dholavira	9	8.96
Kutch	Dhori	9-10	8.96
Kutch	Gandhidham	9-10	8.96
Kutch	Kandla	9	8.96
Kutch	Kera Badadia	7	8.96
Kutch	Khavda	9	8.96
Kutch	Kotdi-Roha	9	8.96
Kutch	Mandvi	9	8.96
Kutch	Mota Asambia	10	8.96
Kutch	Nakhatrana	9	8.96
Kutch	Rapar	10	8.96
Kutch	Ratnal	10	8.96
Kutch	Samakhiali	9	8.96
Kutch	Vadala	7-8	8.96
Kutch	Vondh	10	8.96

Table A2c. Earthquake intensities across different locations in the districts of Gujarat

District	Location	MMI	Average MMI
Mehsana	Not available	7-8	7
Mehsana	Modhera	6-7	7
Patan	Lodhai(lodhi)	10-11	8
Patan	Patan	7-8	8
Patan	Radhanpur	6	8
Rajkot	Bagathala	8-9	7.83
Rajkot	Maliya	8	7.83
Rajkot	Morbi	8	7.83
Rajkot	Navlakhi	8	7.83
Rajkot	Rajkot	7-8	7.83
Rajkot	Wankaner	7	7.83
Surat	Surat	7-8	7.5
Surendranagar	Dhrandadhra	8	8
Surendranagar	Jhinjhuwada	8	8
Surendranagar	Kharaghodha	8	8
Surendranagar	Halvad	8	8
Surendranagar	Kuda	8	8
Surendranagar	Surendranagar	8	8
Surendranagar	Bajana	8	8
Vadodara	Jawaharnagar	10	8.17
Vadodara	Luna	8-9	8.17
Vadodara	Vadodara	6	8.17

Source: Hough *et al.* (2002)

Table A3. OLS estimates of the earthquake: sample of 16 districts of Gujarat. Removing migration restriction

Panel A: Outcome is Height (in cm)			
	(1)	(2)	(3)
VARIABLES	Height	Height	Height
Younger cohort*Intensity	-2.237	-2.308	-1.197
	[1.18]	[1.08]	[0.97]
Observations	331	331	331
Number of additional controls	Three	Zero	Nine
Panel B: Outcome is ZHFA in [-6, 6] range			
VARIABLES	ZHFA	ZHFA	ZHFA
Younger cohort*Intensity	-0.437	-0.403	-0.270
	[0.19]	[0.15]	[0.18]
Observations	311	311	311
Number of additional controls	Three	Zero	Nine

Notes: Robust standard errors clustered at the district-age levels are in brackets.
Younger cohorts are females who were in-utero or under the age of 3, and older cohorts are females aged 14–19 years, at the time of the earthquake in 2001.
Intensity is earthquake intensities of 16 districts of Gujarat which include six severely-affected and ten marginally-affected districts.
All specifications include age fixed effects, district-specific time trends.
The first column includes three covariates, such as, ethnicity (SC, ST, OBC or others), religion (Hindu or others) and residence status (urban or rural); the second column is without additional covariates; the third column include all the nine covariates, such as education of the household head, dependent ratio, wealth index, source of income (agriculture or allied activities, agriculture wage labor, non-agriculture wage labor, independent/petty shop, business/salary/pension or others), ethnicity (SC, ST, OBC or others), religion (Hindu or others), source of drinking water (piped, tube well, hand pump or others), toilet facility (open fields or others), and residence status (urban or rural) .
Wealth index is measured by the number of assets owned by the household. Agriculture or allied activities is the reference category for the income source. Others are the reference category for ethnicity and religion both. Piped water is the reference category for the source of drinking water.
Data source: IHDS-1.

Table A4. OLS estimates: sample of 17 districts of Gujarat and districts of others states. No migration restrictions

Panel A: Outcome is Height (in cm)						
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Height	Height	Height	Height	Height	Height
Younger cohort*Severely-affected region	-3.204	-2.775	-3.029	-2.913	-2.508	-2.949
	[1.85]	[1.83]	[1.87]	[1.88]	[1.88]	[1.90]
Observations	2,274	2,274	2,274	2,086	2,086	2,086
No. of additional controls	Three	Zero	Nine	Three	Zero	Nine
No. of districts	98	98	98	88	88	88
Panel B: Outcome is ZHFA [-6, 6] range						
VARIABLES	ZHFA	ZHFA	ZHFA	ZHFA	ZHFA	ZHFA
Younger cohort*Severely-affected region	0.060	0.113	0.096	0.094	0.147	0.093
	[0.34]	[0.34]	[0.36]	[0.34]	[0.34]	[0.36]
Observations	2,181	2,181	2,181	2,000	2,000	2,000
No. of additional controls	Three	Zero	Nine	Three	Zero	Nine
No. of districts	98	98	98	88	88	88

Notes: Robust standard errors clustered at the district-age levels are in brackets.
In the first three columns, counterfactuals are all districts of Maharashtra, Rajasthan, Madhya Pradesh and eleven districts of Gujarat. In the next three columns, counterfactuals exclude the ten marginally-affected districts of Gujarat.
Younger cohorts are females who were in-utero or under the age of 3, and older cohorts are females aged 14–19 years, at the time of the earthquake in 2001. All specifications include age fixed effects, district-specific time trends and survey year fixed effects.
The first and fourth columns include three covariates, such as, ethnicity (SC, ST, OBC or others), religion (Hindu or others) and residence status (urban or rural); the second and fifth columns are without additional covariates; the third and sixth columns include all the nine covariates, such as education of the household head, dependent ratio, wealth index, source of income (agriculture or allied activities, agriculture wage labor, non-agriculture wage labor, independent/petty shop, business/salary/pension or others), ethnicity (SC, ST, OBC or others), religion (Hindu or others), source of drinking water (piped, tube well, hand pump or others), toilet facility (open fields or others), and residence status (urban or rural) .
Wealth index is measured by the number of assets owned by the household. Agriculture or allied activities is the reference category for the income source. Others are the reference category for ethnicity and religion both. Piped water is the reference category for the source of drinking water.
Data source: IHDS-1.

Table A5. List of districts used in the analysis based on DLHS data

Treated	Controlled			
Gujarat	Gujarat	Maharashtra	Rajasthan	Madhya Pradesh
Ahmedabad	Banas Kantha	Aurangabad	Bikaner	Balaghat
Jamnagar	Gandhinagar	Buldana	Barmer	Bhind
Kutch	Junagadh	Jalgaon	Jhunjhunun	Gwalior
Rajkot	Mehsana	Gadchiroli	Bhilwara	Datia
Surendranagar	Sabar Kantha	Sangli	Bharatpur	Chhindwara
	Surat	Amravati	Bundi	Chhatarpur
	The Dangs	Wardha	Dungarpur	Guna
		Nagpur	Jaisalmer	Jhabua
		Sindhudurg	Sirohi	Satna
		Thane	Sikar	Narsimhapur
		Chandrapur	Nagaur	Raisen
		Nanded	Ajmer	Sidhi
		Nashik	Chittaurgarh	Sagar
		Pune	Jhalawar	Ujjain
		Ahmadnagar	Churu	Sehore
		Bid		Dewas
		Osmanabad		Dhar
		Satara		Indore
				Vidisha
				East Nimar
				Bhopal
				Betul
				Seoni

Notes: Remaining districts from the four states are not included in the analysis as they could not be matched across the two rounds of DLHS.

Table A6. Difference in means between severely and marginally or unaffected districts of Gujarat and neighboring states

Mean of variables	Severely-affected	Unaffected	Overall	Difference	Standard error
Sample for the household level outcome variables: Before earthquake (Data source: DLHS-1 in 1998-99)					
Living in Pucca house	0.603	0.312	0.331	0.291	[0.008]
Drinking water	0.725	0.575	0.585	0.150	[0.007]
Age of wife	31.217	30.028	30.107	1.189	[0.121]
Wife's education	4.474	3.255	3.336	1.219	[0.081]
Husband's education	6.846	6.394	6.423	0.453	[0.083]
Wife's ability to read & write	0.539	0.411	0.420	0.127	[0.008]
Husband's ability to read & write	0.774	0.710	0.714	0.065	[0.007]
Wife's age at cohabitation	18.290	16.652	16.760	1.638	[0.045]
Rural	0.563	0.748	0.735	-0.185	[0.008]
Observations	3919	55480	59399	59399	
Sample limited to the women who gave birth in the last two years of survey					
Visit by antenatal health worker	0.336	0.316	0.317	0.020	[0.018]
Number of visits	1.254	0.906	0.926	0.349	[0.114]
IFA tablets given	0.714	0.512	0.524	0.202	[0.017]
Tetanus injection given	0.865	0.730	0.738	0.135	[0.013]
Last born child (male)	0.568	0.538	0.539	0.030	[0.019]
Last born child (birth-year)	1998.117	1997.903	1997.915	0.215	[0.022]
Last born child (month of birth)	6.086	6.230	6.222	-0.144	[0.131]
Observations	724	11941	12665	12665	
Sample for the household level outcome variables: After earthquake (Data source: DLHS-2 in 2002)					
Living in Pucca house	0.586	0.366	0.379	0.221	[0.008]
Drinking water	0.859	0.781	0.786	0.078	[0.006]
Age of wife	30.791	29.295	29.389	1.496	[0.126]
Wife's education	5.113	3.943	4.017	1.169	[0.087]
Husband's education	7.115	6.797	6.817	0.318	[0.085]
Wife's ability to read & write	0.595	0.474	0.481	0.121	[0.009]
Husband's ability to read & write	0.799	0.740	0.744	0.059	[0.007]
Wife's age at cohabitation	18.852	17.078	17.190	1.773	[0.050]
Rural	0.518	0.680	0.670	-0.162	[0.009]
Observations	3602	53663	57265	57265	
Sample limited to the women who gave birth in the last two years of survey					
Visit by antenatal health worker	0.210	0.227	0.226	-0.017	[0.015]
Number of visits	0.528	0.501	0.502	0.027	[0.047]
IFA tablets given	0.786	0.639	0.648	0.147	[0.015]
Tetanus injection given	0.890	0.773	0.780	0.117	[0.012]
Last born child (male)	0.528	0.533	0.533	-0.006	[0.019]
Last born child (birth-year)	2001.485	2001.404	2001.409	0.082	[0.019]
Last born child (month of birth)	6.165	5.965	5.978	0.200	[0.126]
Observations	775	11853	12628	12628	

Table A7. OLS estimates of the earthquake: sample of 12 districts of Gujarat plus surveyed districts of others states

Variables	(1) Wife's age at cohabitation	(2) Wife's ability to read and write	(3) Education (wife)	(4) Husband's ability to read and write	(5) Education (husband)
Post-earthquake* Severely-affected region	0.035	-0.040	-0.273	-0.036	-0.352
	[0.111]	[0.024]	[0.253]	[0.031]	[0.323]
Observations	25,293	25,293	25,293	25,293	25,293
R-squared	0.128	0.158	0.163	0.081	0.090

Notes: Robust standard errors clustered at the district-birth year levels are in brackets.
12 districts include five severely-affected and seven marginally-affected districts. In the main analysis based on IHDS-1 data, we had six severely-affected districts – Ahmedabad, Jamnagar, Kutch, Patan, Rajkot, Surendranagar. Patan is not included in this analysis as the survey for this district was done in the second phase of DLHS-2 which we do not include in the current analysis.
Post-Earthquake takes a value 1 if the observation belongs to first phase of DLHS-2 surveyed in 2002 and it takes a value 0 if it belongs to DLHS-1 which was conducted in two phases in 1998 and 1999. We do not use the second phase of DLHS-2 as there was gap of three years between the earthquake (2001) and the second phase of DLHS-2 (2004).
All the columns include child's month of birth, child's birth year fixed effects and district-specific time trends.
Data source: DLHS-1 and DLHS-2.

Table A8. Difference in means between severely and marginally-affected districts of Gujarat

Means of variable	Severely-affected	Marginally-affected	Overall	Difference	Standard error
Height	129.419	127.857	128.572	1.562	3.62
ZHFA[#]	-1.503	-1.835	-1.687	0.332	0.18
Younger cohort	0.397	0.429	0.414	-0.032	0.06
Intensity	8.018	7.542	7.721	0.476	0.35
Age	14.529	13.950	14.215	0.579	0.97
Dependent ratio	35.999	37.619	36.877	-1.620	2.35
Wealth Index	13.993	14.404	14.215	-0.411	0.61
Income source: agriculture or allied	0.301	0.280	0.290	0.022	0.05
Income source: agri wage labor	0.140	0.193	0.168	-0.053	0.04
Income source: non-agri wage labor	0.169	0.130	0.148	0.039	0.04
Income source: independent/petty shop	0.074	0.099	0.088	-0.026	0.03
Income source: business/salary/pension	0.301	0.292	0.296	0.010	0.05
Income source: others	0.015	0.006	0.010	0.008	0.01
Household Head's Education	4.051	6.124	5.175	-2.073	0.54
Ethnicity: BC	0.596	0.441	0.512	0.155	0.06
Ethnicity: SC	0.103	0.118	0.111	-0.015	0.04
Ethnicity: ST	0.000	0.081	0.044	-0.081	0.02
Ethnicity: OC	0.301	0.360	0.333	-0.059	0.05
Religion: Hindu	0.882	0.857	0.869	0.025	0.04
Drinking water: Piped	0.610	0.609	0.609	0.002	0.06
Drinking water source: Tube well	0.059	0.093	0.077	-0.034	0.03
Drinking water source: Hand pump	0.081	0.155	0.121	-0.074	0.04
Drinking water source: Other	0.250	0.143	0.192	0.107	0.05
Defecation: Open fields	0.404	0.497	0.455	-0.093	0.06
Residence status: Urban	0.368	0.323	0.343	0.045	0.06
% villages in district: medical facility	54.550	80.974	68.874	-26.420	2.02
% villages in district: paved roads	80.476	87.654	84.367	-7.178	1.28
% of rural population in district	53.346	64.811	59.561	-11.460	2.13
Sex Ratio in district	922.154	918.217	920.020	3.937	3.39
Observations	136	161	297	297	

[#]ZHFA (in range [-6,6]) is available for only 124 individuals in severely-affected districts and 154 individuals in marginally-affected districts.
Data source: IHDS-1.

Table A9. Falsification test: OLS estimates of the earthquake with a falsely treated age cohort

Panel A: Outcome is Height (in cm)	(1)	(2)	(3)
Younger cohort*Intensity	-2.036		
	[3.10]		
Younger cohort*Severely-affected region		-0.891	-0.908
		[2.29]	[2.45]
Survey Year FE	No	Yes	Yes
Observations	184	1,351	1,250
Number of additional controls	Three	Three	Three
Number of districts	16	98	88
Panel B: Outcome is ZHFA in [-6, 6] range			
Younger cohort*Intensity	0.508		
	[0.36]		
Younger cohort*Severely-affected region		-0.413	-0.453
		[0.32]	[0.33]
Survey Year FE	No	Yes	Yes
Observations	178	1,328	1,232
Number of additional controls	181	1,342	1,243
Number of districts	16	97	87

Notes: Robust standard errors clustered at the district-age levels are in parentheses.
Younger cohorts are females aged 11-13, and older cohorts are females aged 14–19 years, at the time of the earthquake in 2001.
The first column includes earthquake intensities of 16 districts consisting of six severely-affected and ten marginally-affected districts. Additionally, the second column includes ten marginally-affected districts of Gujarat and one unaffected district from Gujarat and all the surveyed districts of Maharashtra, Rajasthan and Madhya Pradesh as counterfactual districts. The third column excludes the ten marginally-affected districts of Gujarat from the counterfactual group.
All specifications include age fixed effects, district-specific time trends. All columns include three covariates, that are ethnicity (SC, ST, OBC or others), religion (Hindu or others) and residence status (urban or rural).
Data source: IHDS-1.

Table A10. Falsification test: OLS estimates of the earthquake with a falsely treated state

Panel A: Outcome is Height (in cm)	(1)	(2)	(3)	(4)	(5)	(6)
Affected cohort*Affected district	-0.661	-0.544	-0.350	-0.198	-1.148	-1.047
	[1.21]	[1.24]	[1.44]	[1.45]	[0.92]	[0.96]
Observations	2,414	2,250	2,252	2,088	2,936	2,772
Treated State	Bihar	Bihar	Chhattisgarh	Chhattisgarh	UP	UP
Number of additional controls	Three	Three	Three	Three	Three	Three
Number of districts	109	99	107	97	135	125
Panel B: Outcome is ZHFA [-6, 6]						
Affected cohort*Affected district	-0.131	-0.116	-0.264	-0.241	-0.499	-0.479
	[0.17]	[0.18]	[0.18]	[0.18]	[0.16]	[0.17]
Observations	2,318	2,162	2,168	2,012	2,814	2,658
Treated State	Bihar	Bihar	Chhattisgarh	Chhattisgarh	UP	UP
Number of additional controls	Three	Three	Three	Three	Three	Three
Number of districts	109	99	107	97	135	125

Notes: Robust standard errors clustered at the district-age levels are in brackets.
The treated state differs across columns as mentioned. The counterfactuals in the first, third and fifth columns are ten marginally-affected districts of Gujarat, additional one unaffected district from Gujarat, plus all the surveyed districts of Maharashtra, Rajasthan and Madhya Pradesh. The second, fourth and sixth columns exclude the ten marginally-affected districts of Gujarat from the counterfactual districts.
Younger cohorts are females who were in-utero or under the age of 3, and older cohorts are females aged 14–19 years, at the time of the earthquake in 2001.
All specifications include age fixed effects, district-specific time trends and survey year fixed effects.
All columns include three covariates that are ethnicity (SC, ST, OBC or others), religion (Hindu or others) and residence status (urban or rural).
Data source: IHDS-1.

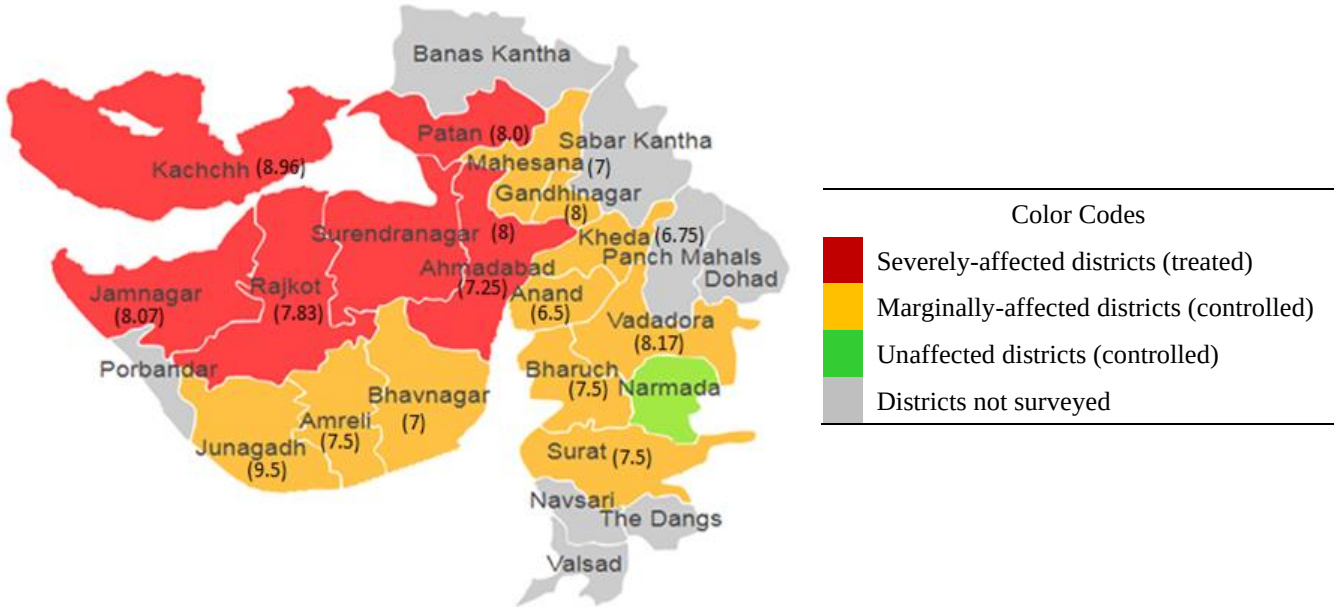

Figure A1. Sample frame of Gujarat districts. Narmada being the only unaffected district surveyed in IHDS-I, has been combined with unaffected district as a comparison.

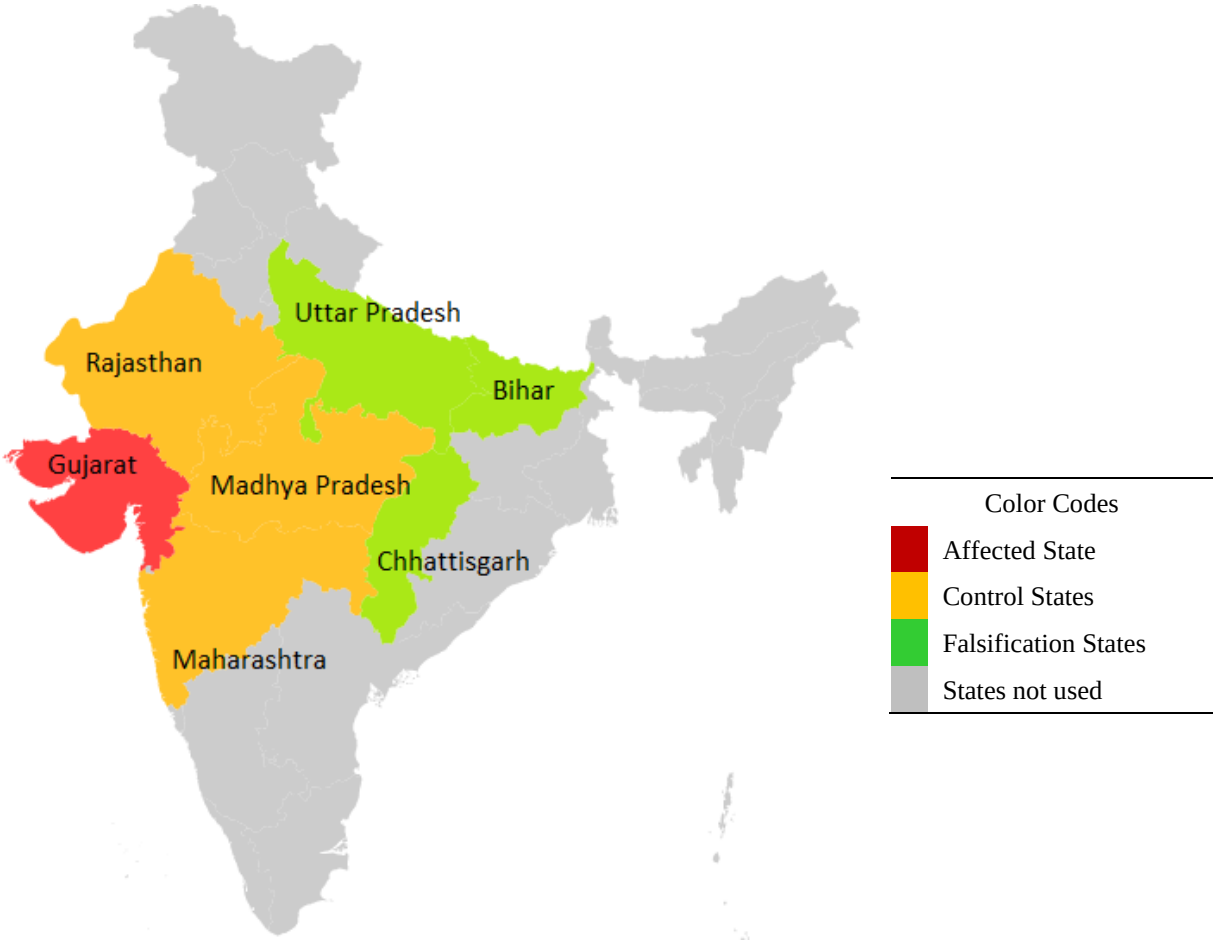

Figure A2. The states of India used for robustness and falsification exercise.

Section VI. Other supplementary tables and figures

For tables A11-A15, we check for robustness of primary specifications (as presented in the main text) by clustering standard errors at the district levels. The corresponding table names from the primary specifications are given in the respective table headers.

Tables A16-A22 are new tables, and they are self-explanatory.

Table A11. OLS estimates of the earthquake: sample of 16 districts of Gujarat. Standard errors clustered at district level, else specifications same as in table 2

Panel A: Outcome is Height (in cm)			
Variables	(1) Height	(2) Height	(3) Height
Younger cohort*Intensity	-2.539	-2.725	-1.667
	[1.29]	[1.13]	[1.04]
Observations	297	297	297
Number of additional controls	Three	Zero	Nine
Panel B: Outcome is ZHFA in [-6, 6] range			
Variables	ZHFA	ZHFA	ZHFA
Younger cohort*Intensity	-0.470	-0.456	-0.317
	[0.21]	[0.16]	[0.16]
Observations	278	278	278
Number of additional controls	Three	Zero	Nine

Notes: Robust standard errors clustered at the district levels are in brackets.
Younger cohorts are females who were in-utero or under the age of 3, and older cohorts are females aged 14–19 years, at the time of the earthquake in 2001.
Intensity is earthquake intensities of 16 districts of Gujarat which include six severely-affected and ten marginally-affected districts.
All specifications include age fixed effects, district-specific time trends.
The first column includes three covariates, such as, ethnicity (SC, ST, OBC or others), religion (Hindu or others) and residence status (urban or rural); the second column is without additional covariates; the third column include all the nine covariates, such as education of the household head, dependent ratio, wealth index, source of income (agriculture or allied activities, agriculture wage labor, non-agriculture wage labor, independent/petty shop, business/salary/pension or others), ethnicity (SC, ST, OBC or others), religion (Hindu or others), source of drinking water (piped, tube well, hand pump or others), toilet facility (open fields or others), and residence status (urban or rural). Wealth index is measured by the number of assets owned by the household. Agriculture or allied activities is the reference category for the income source. Others are the reference category for ethnicity and religion both. Piped water is the reference category for the source of drinking water.
Data source: IHDS-1.

Table A12. OLS estimates of the earthquake: sample of 17 districts of Gujarat plus surveyed districts of others states. Standard errors clustered at district level, else specifications same as in table 3

Panel A: Outcome is Height (in cm)						
Variables	(1) Height	(2) Height	(3) Height	(4) Height	(5) Height	(6) Height
Younger cohort*Severely-affected region	-3.318	-2.937	-3.329	-3.063	-2.711	-3.296
	[2.14]	[2.04]	[2.17]	[2.15]	[2.09]	[2.17]
Observations	2,146	2,146	2,146	1,985	1,985	1,985
Number of additional controls	Three	Zero	Nine	Three	Zero	Nine
Number of districts	98	98	98	88	88	88
Panel B: Outcome is ZHFA (in [-6, 6] range)						
Variables	ZHFA	ZHFA	ZHFA	ZHFA	ZHFA	ZHFA
Younger cohort*Severely-affected region	0.058	0.099	0.050	0.086	0.127	0.042
	[0.17]	[0.18]	[0.19]	[0.18]	[0.19]	[0.18]
Observations	2,057	2,057	2,057	1,903	1,903	1,903
Number of additional controls	Three	Zero	Nine	Three	Zero	Nine
Number of districts	98	98	98	88	88	88

Notes: Robust standard errors clustered at the district levels are in brackets.
In the first three columns, counterfactuals are all districts of Maharashtra, Rajasthan, Madhya Pradesh and eleven districts of Gujarat. In the next three columns, counterfactuals exclude the ten marginally-affected districts of Gujarat.
Younger cohorts are females who were in-utero or under the age of 3, and older cohorts are females aged 14–19 years, at the time of the earthquake in 2001.
All specifications include age fixed effects, district-specific time trends and survey year fixed effects.
The first and fourth columns include three covariates, such as, ethnicity (SC, ST, OBC or others), religion (Hindu or others) and residence status (urban or rural); the second and fifth columns are without additional covariates; the third and sixth columns include all the nine covariates as explained in previous table. Wealth indices are same as explained earlier table notes.
Data source: IHDS-1.

Table A13. Falsification test: OLS estimates of the earthquake with a falsely treated age cohort. Standard errors clustered at district level, else specifications same as in table A9

Panel A: Outcome is Height (in cm)	(1)	(2)	(3)
Younger cohort*Intensity	-2.036		
	[3.28]		
Younger cohort*Severely-affected region		-0.891	-0.908
		[1.87]	[2.17]
Survey Year FE	No	Yes	Yes
Observations	184	1,351	1,250
Number of additional controls	Three	Three	Three
Number of Districts	16	98	88
Panel B: Outcome is ZHFA in [-6, 6] range			
Younger cohort*Intensity	0.508		
	[0.31]		
Younger cohort*Severely-affected region		-0.413	-0.453
		[0.21]	[0.24]
Survey Year FE	No	Yes	Yes
Observations	181	1,342	1,243
Number of additional controls	Three	Three	Three
Number of districts	16	97	87

Notes: Robust standard errors clustered at the district levels are in brackets.
Younger cohorts are females aged 11-13, and older cohorts are females aged 14–19 years, at the time of the earthquake in 2001.
The first column includes earthquake intensities of 16 districts consisting of six severely-affected and ten marginally-affected districts. Additionally, the second column includes ten marginally-affected districts of Gujarat and one unaffected district from Gujarat and all the surveyed districts of Maharashtra, Rajasthan and Madhya Pradesh as counterfactual districts. The third column excludes the ten marginally-affected districts of Gujarat from the counterfactual group.
All specifications include age fixed effects, district-specific time trends.
All columns include three covariates that are ethnicity (SC, ST, OBC or others), religion (Hindu or others) and residence status (urban or rural).
Data source: IHDS-1.

Table A14. Falsification test: OLS estimates of the earthquake with a falsely treated state. Standard errors clustered at district level, else specifications same as in table A10

Panel A: Outcome is Height (in cm)	(1)	(2)	(3)	(4)	(5)	(6)
Affected cohort*Affected district	-0.661	-0.544	-0.350	-0.198	-1.148	-1.047
	[1.46]	[1.51]	[1.44]	[1.47]	[1.10]	[1.15]
Observations	2,414	2,250	2,252	2,088	2,936	2,772
Treated State	Bihar	Bihar	Chhattisgarh	Chhattisgarh	UP	UP
Number of additional controls	Three	Three	Three	Three	Three	Three
Number of districts	109	99	107	97	135	125
Panel B: Outcome is ZHFA [-6, 6]						
Affected cohort*Affected district	-0.131	-0.116	-0.264	-0.241	-0.499	-0.479
	[0.19]	[0.19]	[0.21]	[0.21]	[0.19]	[0.19]
Observations	2,318	2,162	2,168	2,012	2,814	2,658
Treated State	Bihar	Bihar	Chhattisgarh	Chhattisgarh	UP	UP
Number of additional controls	Three	Three	Three	Three	Three	Three
Number of districts	109	99	107	97	135	125

Notes: Robust standard errors clustered at the district levels are in brackets.
The treated state differs across columns as mentioned. The counterfactuals in the first, third and fifth columns are ten marginally-affected districts of Gujarat, additional one unaffected district from Gujarat, plus all the surveyed districts of Maharashtra, Rajasthan and Madhya Pradesh. The second, fourth and sixth columns exclude the ten marginally-affected districts of Gujarat from the counterfactual districts.
Younger cohorts are females who were in-utero or under the age of 3, and older cohorts are females aged 14–19 years, at the time of the earthquake in 2001.
All specifications include age fixed effects, district-specific time trends and survey year fixed effects.
All columns include three covariates, that are ethnicity (SC, ST, OBC or others), religion (Hindu or others) and residence status (urban or rural).
Data source: IHDS-1.

Table A15. OLS estimates of the earthquake: sample of 12 districts of Gujarat plus surveyed districts of others states. Standard errors clustered at district level, else specifications same as in table 4

Panel A:	Shock to Health services				Shock to Household infrastructure	
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Visit by ANH	No. of visits by ANH	IFA tablets given	Tetanus injection given	Type of House 'Pucca'	Drinking water – Tap/Handpump
Post*Severely-affected region	-0.058	-0.380	-0.067	-0.014	-0.038	-0.151
	[0.049]	[0.278]	[0.037]	[0.024]	[0.051]	[0.071]
Observations	25,293	25,293	25,293	25,293	116,664	116,664
R-squared	0.115	0.074	0.216	0.197	0.397	0.282

Notes: Robust standard errors clustered at the district are in brackets.
Twelve districts based on the two rounds of DLHS data include 5 severely-affected and 7 marginally-affected districts. In the main analysis based on IHDS-1 data, we had six severely-affected districts – Ahmedabad, Jamnagar, Kutch, Patan, Rajkot, Surendranagar. Patan is not included in this analysis as the survey for this district was done in the second phase of DLHS-2 which we do not include in the current analysis.
Post-Earthquake takes a value 1 if the observation belongs to first phase of DLHS-2 surveyed in 2002 and it takes a value 0 if it belongs to DLHS-1 which was conducted in two phases in 1998 and 1999. We do not use the second phase of DLHS-2 as there was gap of 3 years between the earthquake (2001) and the second phase of DLHS-2 (2004). Columns (1) to (4) include child's month of birth fixed effects, child's birth year fixed effects and district-specific time trends. Columns (5) and (6) include survey year fixed effects and district-specific time trends.
All the columns include six additional covariates, such as age of the wife, education of the wife, education of the spouse, age at cohabitation, and residence status (urban or rural). Moreover, columns (1) to (4) include the gender of the last-born child.

Table A16. OLS estimates of the earthquake on height and ZHFA for the younger male cohort of (0-3 years old). Sample of 16 districts of Gujarat

Variables	(1) Height in cm	(2) ZHFA in [-6,6]
Intensity	-4.928	-0.640
	[2.33]	[0.34]
Observations	139	124
Age FE	Yes	Yes
Number of additional controls	Seven	Seven

Notes: Regressions are estimated by OLS. Robust standard errors clustered at the district-age level are shown in brackets.
Intensity is earthquake intensities of 16 districts of Gujarat which include six severely-affected and ten marginally-affected districts.
Both the specifications include age fixed effects. Moreover, they also include seven covariates, such as, ethnicity (SC, ST, OBC or others), religion (Hindu or others) and residence status (urban or rural), percentage of villages in a district which have medical facility in their village, percentage of villages in a district which have paved road in their village, percentage of rural population in the district, sex ratio.
Data source: IHDS-1.

Table A17. OLS estimates of the earthquake on ZHFA based on WHO growth standards. Sample of 16 districts of Gujarat

Outcome is ZHFA in [-6, 6] range			
Variables	ZHFA	ZHFA	ZHFA
Younger cohort*Intensity	-0.330	-0.334	-0.245
	[0.23]	[0.24]	[0.23]
Observations	132	132	132
Number of additional controls	Three	Zero	Nine

Notes: Robust standard errors clustered at the district-age levels are in brackets.
Younger cohorts are females who were in-utero or under the age of 3, and older cohorts are females aged 14–15 years, at the time of the earthquake in 2001.
Intensity is earthquake intensities of 16 districts of Gujarat which include six severely-affected and ten marginally-affected districts.
All specifications include age fixed effects, district-specific time trends.
The first column includes three covariates, such as, ethnicity (SC, ST, OBC or others), religion (Hindu or others) and residence status (urban or rural); the second column is without additional covariates; the third column include all the nine covariates, such as education of the household head, dependent ratio, wealth index, source of income (agriculture or allied activities, agriculture wage labor, non-agriculture wage labor, independent/petty shop, business/salary/pension or others), ethnicity (SC, ST, OBC or others), religion (Hindu or others), source of drinking water (piped, tube well, hand pump or others), toilet facility (open fields or others), and residence status (urban or rural) .
Wealth index is measured by the number of assets owned by the household. Agriculture or allied activities is the reference category for the income source. Others are the reference category for ethnicity and religion both. Piped water is the reference category for the source of drinking water.
Data source: IHDS-1.

Table A18. OLS-DID estimates on ZHFA based on WHO growth standards. Sample of 17 districts of Gujarat and surveyed districts of others states

Outcome is ZHFA (in [-6, 6] range)						
Variables	ZHFA	ZHFA	ZHFA	ZHFA	ZHFA	ZHFA
Younger cohort*Severely-affected region	0.152	0.27	0.112	0.118	0.247	0.053
	[0.35]	[0.36]	[0.37]	[0.35]	[0.36]	[0.36]
Observations	1,037	1,037	1,037	957	957	957
Number of additional controls	Three	Zero	Nine	Three	Zero	Nine
Number of districts	98	98	98	88	88	88

Notes: Robust standard errors clustered at the district-age levels are in brackets.
In the first three columns, counterfactuals are all districts of Maharashtra, Rajasthan, Madhya Pradesh and eleven districts of Gujarat. In the next three columns, counterfactuals exclude the ten marginally-affected districts of Gujarat.
Younger cohorts are females who were in-utero or under the age of 3, and older cohorts are females aged 14–19 years, at the time of the earthquake in 2001.
All specifications include age fixed effects, district-specific time trends and survey year fixed effects.
The first and fourth columns include three covariates, such as, ethnicity (SC, ST, OBC or others), religion (Hindu or others) and residence status (urban or rural); the second and fifth columns are without additional covariates; the third and sixth columns include all the nine covariates, such as education of the household head, dependent ratio, wealth index, source of income (agriculture or allied activities, agriculture wage labor, non-agriculture wage labor, independent/petty shop, business/salary/pension or others), ethnicity (SC, ST, OBC or others), religion (Hindu or others), source of drinking water (piped, tube well, hand pump or others), toilet facility (open fields or others), and residence status (urban or rural).
Wealth index is measured by the number of assets owned by the household. Agriculture or allied activities is the reference category for the income source. Others are the reference category for ethnicity and religion both. Piped water is the reference category for the source of drinking water.
Data source: IHDS-1.

Table A19. Summary statistics of village health infrastructure and child's height in the districts included and excluded in IHDS-1

Variables	Districts excluded in IHDS-1	Districts included in IHDS-1	Overall	Difference	S.E.
	(1)	(2)	(3)	(4)	(5)
Distance to Health facilities (in km)					
Sub-Centre	1.200	3.733	2.954	-2.533	[1.149]
Primary Health Centre	11.850	6.733	8.308	5.117	[2.639]
Community Health Centre	15.750	12.889	13.769	2.861	[2.779]
Government Dispensary	11.900	8.822	9.769	3.078	[2.311]
Government Hospital	18.750	18.244	18.400	0.506	[3.990]
Private Clinic	6.850	5.422	5.862	1.428	[1.922]
Private Hospital	15.100	12.911	13.585	2.189	[2.319]
Availability of mobile health unit in the village (=1 if yes and 0 otherwise)	0.050	0.044	0.046	0.006	[0.059]
Number of health or family welfare camps in the last year	2.000	3.667	3.154	-1.667	[1.487]
Observations	20	45	65	65	
Height (in cm)	72.265	71.391	71.638	0.874	[0.828]
Observations	224	569	793	793	
Number of districts	5	9	14	14	

Notes: Column (1) includes three districts (Banaskantha, Sabarkantha, Valsad) from the marginally-affected region and two districts (PanchMahal, The Dangs) from the unaffected region which were not surveyed in the IHDS-1. Column (2) includes nine districts (Amreli, Bharuch, Bhavnagar, Gandhinagar, Junagadh, Kheda, Mahesana, Surat, Vadodra) from the marginally-affected region which were surveyed in the IHDS-1.
Source: NFHS-2.

Table A20. Heterogeneity analysis: OLS estimates of the earthquake using a sample of 16 districts of Gujarat

Panel A: Outcome is Height (in cm)		
Variables	(1) Height	(2) Height
Younger cohort*Intensity*Hindu religion	-0.259	
	[0.76]	
Younger cohort*Intensity* Lower caste		-0.359
		[0.37]
Younger cohort*Intensity	-2.337	-2.445
	[1.27]	[1.26]
Observations	297	297
Number of additional controls	Three	Three
Panel B: Outcome is ZHFA in [-6, 6] range		
Variables	ZHFA	ZHFA
Younger cohort*Intensity*Hindu religion	-0.171	
	[0.08]	
Younger cohort*Intensity*Lower caste		-0.046
		[0.07]
Younger cohort*Intensity	-0.346	-0.430
	[0.22]	[0.20]
Observations	278	278
Number of additional controls	Three	Three

Notes: Robust standard errors clustered at the district-age levels are in brackets.
Younger cohorts are females who were in-utero or under the age of 3, and older cohorts are females aged 14–19 years, at the time of the earthquake in 2001.
Intensity is earthquake intensities of 16 districts of Gujarat which include six severely-affected and ten marginally-affected districts.
All specifications include age fixed effects, district-specific time trends.
Both the columns include three covariates, such as, lower caste (=1 if the individual belongs to a household with SC, ST, OBC and 0 otherwise), Hindu Religion (=1 if the individual belongs to a household with Hindu religion and 0 otherwise) and residence status (urban or rural).
We interact the interaction between younger cohort and intensity with the religion dummy and lower caste dummy in alternative specifications.
Data source: IHDS-1.

Table A21. Heterogeneity analysis: mitigating effects of ICDS usage in earthquake-affected areas on height and ZHFA for the younger cohort (0-3 years old)

Variables	(1) Height in cm	(2) Height in cm	(3) ZHFA in [-6,6]	(4) ZHFA in [-6,6]
ICDS Non-Users in Severely-affected	-4.997		-0.499	
region*Male	[8.58]		[0.84]	
ICDS Non-Users in control region*Male	-5.744		0.050	
	[4.13]		[0.38]	
ICDS Users in control region*Male	-3.997		0.392	
	[3.98]		[0.37]	
ICDS Non-Users in Severely-affected		2.792		0.184
region*Birth Order		[2.95]		[0.12]
ICDS Non-Users in control region*Birth order		1.449		-0.073
		[2.15]		[0.07]
ICDS Users in control region*Birth order		1.079		-0.126
		[2.14]		[0.07]
ICDS Non-Users in Severely-affected region	-4.663	-13.364	-0.747	-1.517
	[6.43]	[6.73]	[0.41]	[0.69]
ICDS Non-Users in control region	4.688	-1.299	0.109	0.284
	[4.21]	[2.82]	[0.25]	[0.27]
ICDS Users in control region	4.416	0.374	0.094	0.598
	[4.16]	[2.63]	[0.22]	[0.22]
Observations	896	896	807	807
Age FE	Yes	Yes	Yes	Yes
Survey Year FE	Yes	Yes	Yes	Yes
Number of additional controls	Eight	Nine	Eight	Nine

Notes: Regressions are estimated by OLS. Robust standard errors clustered at the district level are shown in brackets.
Control group in terms of space includes all the districts of Maharashtra, Rajasthan, Madhya Pradesh and eleven districts of Gujarat. ICDS users in severely-affected region is the reference category.
Eight additional controls are gender of the child (=1 if male and 0 otherwise), ethnicity (SC, ST, OBC or others), religion (Hindu or others) and residence status (urban or rural), percentage of villages in a district which have medical facility in their village, percentage of villages in a district which have paved road in their village, percentage of rural population in the district, sex ratio. In addition to these eight additional controls, we also include the birth order of the child in columns (2) and (4). We interact the ICDS exposure variables with the gender dummy and birth order in alternative specifications.
Data source: IHDS-1.

Table A22. Average intensity of earthquake in treated and control districts

District	Average MMI
Treated districts	
Ahmedabad	7.25
Jamnagar	8.07
Kutch	8.96
Patan	8
Rajkot	7.83
Surendranagar	8
Control districts	
Amreli	7.5
Anand	6.5
Bharuch	7.5
Bhavnagar	7
Gandhinagar	8
Junagadh	9.5
Kheda	6.75
Mehsana	7
Surat	7.5
Vadodara	8.17

Source: Hough *et al.*, 2002.

References

Bossavie L, Alderman H, Giles J and Mete C (2021) The effect of height on earnings: is stature just a proxy for cognitive and non-cognitive skills? *Economics & Human Biology* **43**, 101046.

Case A and Paxson C (2010) Causes and consequences of early life health. NBER Working Paper 15637. National Bureau of Economic Research, Cambridge, MA. Available at http://www.nber.org/papers/w15637.

Hough SE, Martin S, Bilham R and Atkinson GM (2002) The 26 January 2001 M 7.6 Bhuj, India, earthquake: observed and predicted ground motions. *Bulletin of the Seismological Society of America* **92**, 2061–2079.

Vogl T (2014) Height, skills, and labor market outcomes in Mexico. *Journal of Development Economics* **107**, 84–96.