



Natural Disasters, School System Resilience, and Educational Outcomes in Asia

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October 26, 2023

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Introduction

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Motivation

- Between 1970 and 2019, climate change and extreme weather events have caused a surge in **natural disasters** (Nations 2021).
- Globally, **Asia** accounted for...
 - 1/3 weather, climate, and water related disasters.
 - 1/2 of deaths.
 - 1/3 of associated economic losses.

Motivation

- Children are heavily exposed
 - Approximately one billion children across the world...are at an 'extremely high risk' of experiencing impacts of the climate crisis (UNICEF 2021).
 - Children from socially, economically, or politically marginalized groups could be more vulnerable to ill effects.
 - Schooling can be affected: In Pakistan in 2010, 11,906 schools with > one million children were affected by natural disasters - used as shelter (2,674) or damaged (9,232) (Chang et al. 2013).

”[The Asia-Pacific region] remains the most disaster-prone region...In 2022, over 140 disasters struck...affecting over 64 million people and causing economic damage estimated at US\$57 billion..” —*United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP) (2023, v, 6)*

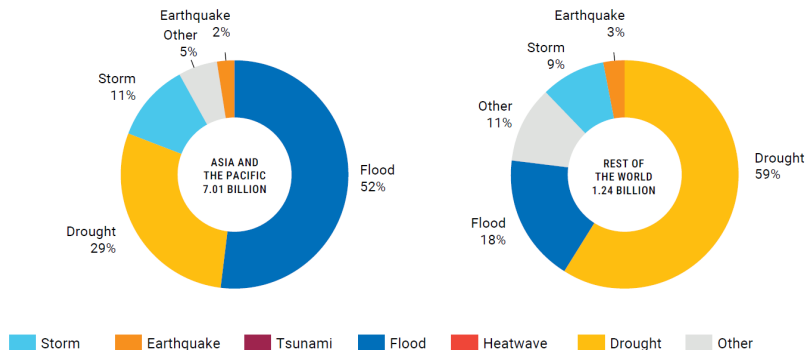


Figure 1: People affected by disasters in the Asia-Pacific region and the rest of the world, 1970-2022

Research questions

- Heterogeneous impact of **natural disasters** on **child development**.
 - Are there heterogeneous impacts on **grade progression, school enrollment, and cognitive achievements** for children along gender, age, and SES gradients?
- Resilience of local school systems in protecting child learning.
 - What are the roles of **school shutdowns** and **teacher absenteeism** in mediating or expaining heterogeneous natural disaster effects across children and localities?
- Seven Asian countries
 - Low- and middle-income countries
 - Pre-pandemic data available
 - South Asia (Bangladesh, Nepal, Pakistan), East Asia and the Pacific (Mongolia, Thailand), and Central Asia (Kyrgyzstan, Turkmenistan)

Data

Data on educational outcomes and school systems

UNICEF Multiple Indicator Cluster Surveys (MICS)

- General information
 - International multi-purpose household survey. 28 years, 118 countries, 355 surveys.
 - Integral part of plans and policies of many governments.
 - Major data source for > 30 Sustainable Development Goals indicators.
- 6th round ([MICS6](#))
 - Child age 5-17 outcomes: grade progression, school enrollment, survey-administered literacy and numeracy assessment test.
 - Education system measures: school closure, teacher truancy
 - Parental and household background.

Data on natural disasters

EM-DAT International Natural Disaster Database (1900-2023)

- Time- and geo-coded (Center for Research on the Epidemiology of Disaster).
- Sources: UN agencies, non-governmental organizations, insurance companies, research institutes, and press agencies.
- Entry criteria: (a) 10 or more people killed, (b) 100 or more people affected, (c) declaration of a state of emergency, (d) call for international assistance.
- **Context variables:** disaster type, administrative level, affected location. ▶
- **Impact variables:** number of death, injured, missing, total affected, economic damages, insured loss, sectors affected, infrastructure affected. ▶

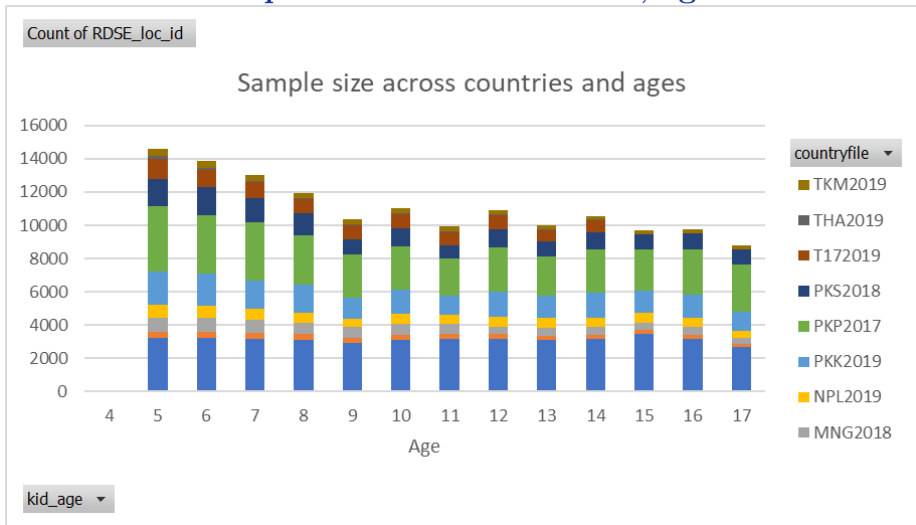
Summary statistics

MICS6 overview and key statistics for children 5-17

Country	Year	Start	End	Obs	Geo info ‡		Enrollment Rate	Share enrolled experiencing school-closure due to natural disaster		Share enrolled experiencing teacher absenteeism	
					Geo-id	N		Mean	S.D.	Mean	S.D.
South Asia											
Bangladesh	2019	01/19	06/01	37925	District	64	0.89	0.09	0.10	0.06	0.06
Nepal	2019	05/04	11/13	7618	Region	7	0.93	0.19	0.13	0.14	0.05
Pakistan	2017-19	2017 12/03	2019 10/23	54072	District	97	0.86	0.08	0.09	0.11	0.12
East Asia and the Pacific											
Mongolia	2018	09/17	12/24	7277	Region	9	0.96	0.04	0.03	0.08	0.05
Thailand	2019	05/18	12/03	9429	Changwat	18	0.99	0.09	0.12	0.04	0.04
Europe and Central Asia											
Kyrgyzstan	2018	09/06	11/19	3754	Oblast	9	0.96	0.37	0.19	0.04	0.04
Turkmenistan	2019	05/02	08/02	3410	Region	6	1.00	0.00	0.00	0.01	0.01

Note: At the smallest geo-identifier available, we compute the share of enrolled in school reporting school closure due to natural disasters (or teacher absenteeism) in the past year and s.d. across geo-identifiers. Smallest geo-identifiers differs across countries.

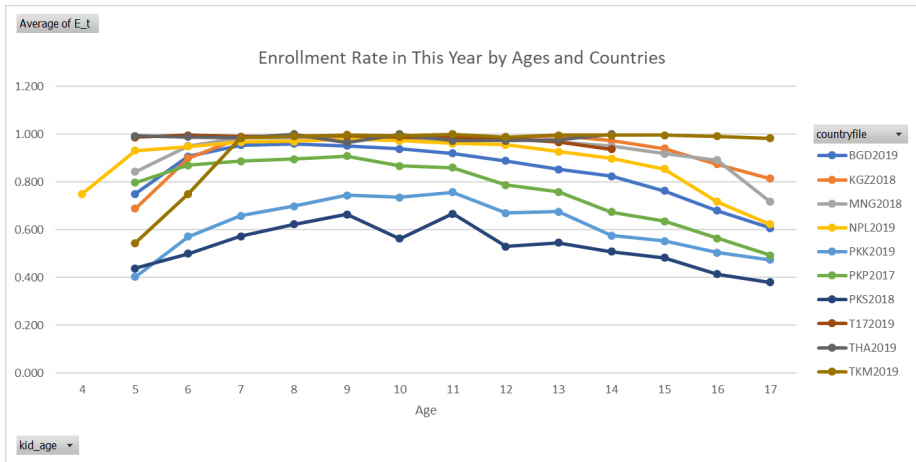
Sample size across countries, ages



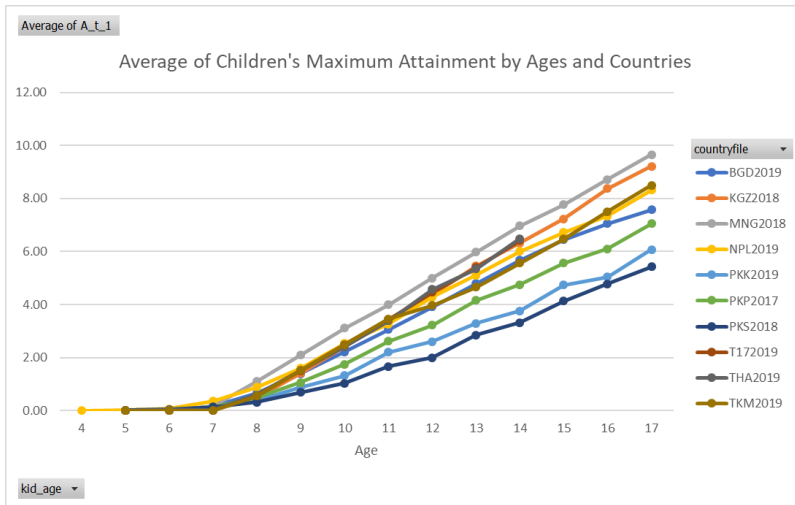
Summary statistics on enrollment and attainment

	Mean	SD	Min	Max	N
Ever enrolled	0.88	0.33	0.00	1.00	144426
Enrollment in last school year	0.74	0.44	0.00	1.00	144394
Enrollment in this school year	0.79	0.41	0.00	1.00	144410
Attainment (highest)	3.29	3.34	0.00	16.00	144358
Attainment at start of last school year	2.69	3.06	0.00	16.00	144360
Attainment at start of this school year	3.25	3.32	0.00	16.00	144358
Progression in last school year	0.72	0.45	0.00	1.00	107295
Retention in this school year	0.15	0.36	0.00	1.00	104196

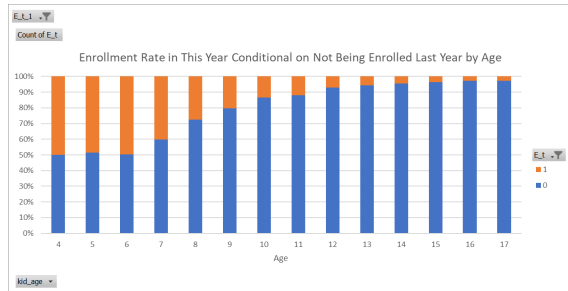
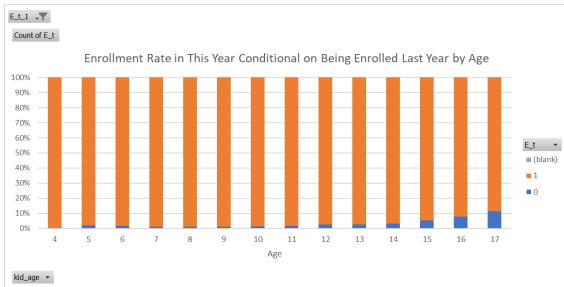
Enrollment rate this year



Average highest grade completed by ages and countries



Enrollment transition probabilities by ages

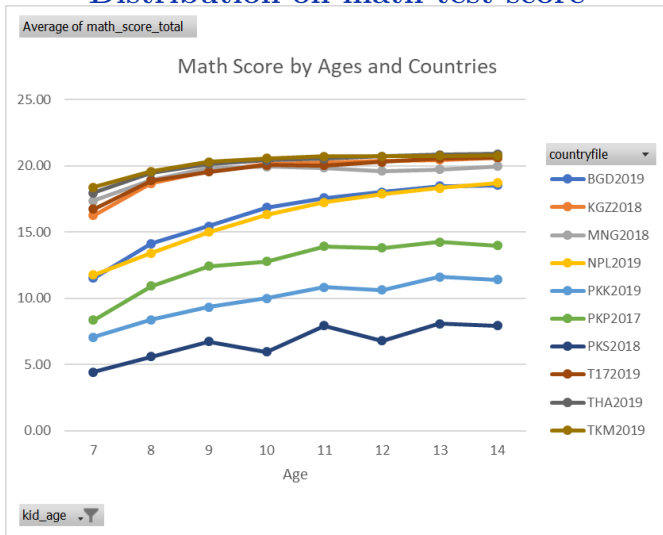


- Share of children who come back to enrollment after not enrolled in the last year decreases with age and falls below 10% after age 11.
- Share of children who are enrolled in last year and continue to enroll in this year is greater than 95% up to age 14, and falls to 88% by age 17.

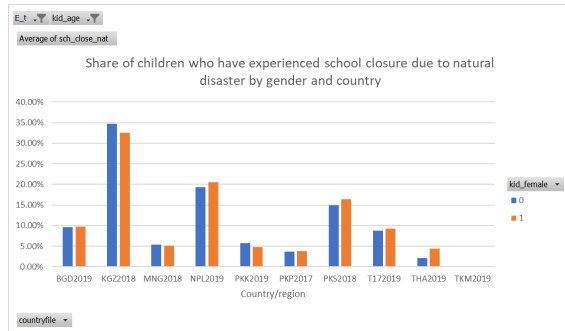
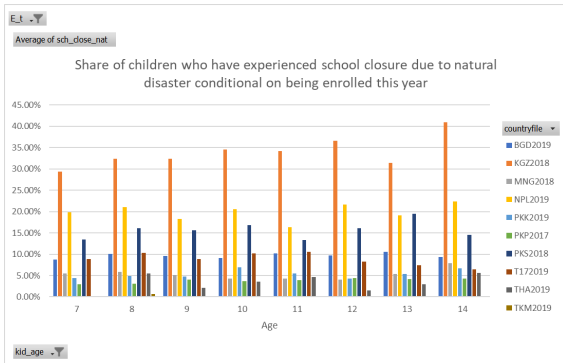
Summary statistics on test score and organizational factors

	Mean	SD	Min	Max	N
Have reading Score	0.59	0.49	0.00	1.00	87,797
Have math Score	0.90	0.30	0.00	1.00	87,797
Read score (total)	73.44	6.75	0.00	77.00	51,644
Math score (total)	14.19	7.42	0.00	54.00	78,704
Have info on school closure due to natural disaster	0.81	0.39	0.00	1.00	87,797
Have info on teacher truancy	0.79	0.41	0.00	1.00	87,797
School closure (natural disaster)	0.09	0.29	0.00	1.00	71,252
Teacher truancy	0.11	0.31	0.00	1.00	69,464

Distribution on math test score

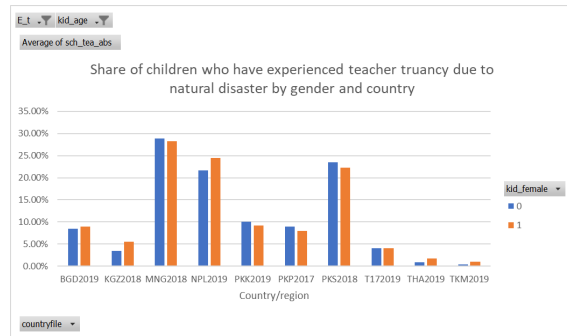
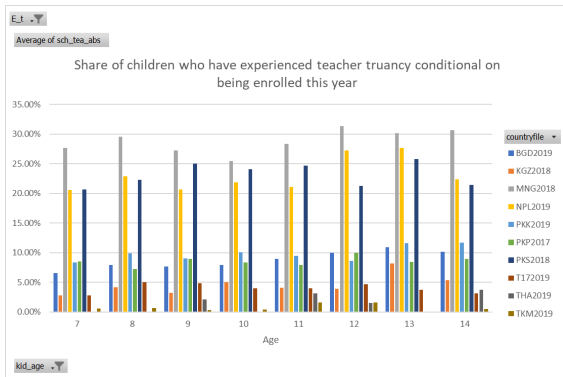


Distribution of school closure due to natural disaster in last 12 mo



- Kyrgyzstan has highest share for all age groups.
- Nepal and Pakistan Sindh province also have relatively high share.
- Within one country, the difference in this share across ages is not large.
- There is no significant difference across gender.

Distribution of teacher truancy in last 12 mo



- Kyrgyzstan has highest share for all age groups.
- Within one country, the difference in this share across ages is not large.

Summary statistics on child and parental characteristics

	Mean	SD	Min	Max	N
Age of child	10.49	3.78	4.00	17.00	144471
Female	0.48	0.50	0.00	1.00	144471
Mother age	37.78	8.68	2.00	95.00	132143
Father age	43.06	9.70	0.00	95.00	116791
Mother ever educated	0.58	0.49	0.00	1.00	144338
Mother has secondary sch education	0.31	0.46	0.00	1.00	144338
Father ever educated	0.69	0.46	0.00	1.00	116768
Father has secondary sch education	0.20	0.40	0.00	1.00	116768
Mother is living in same HH	0.92	0.28	0.00	1.00	144222
Father is living in same HH	0.81	0.39	0.00	1.00	144068

Summary statistics on location- and child life-cycle-specific disaster shock

	Mean	SD	Min	Max	N
<i>Had recent disaster</i>					
in survey mo	0.08	0.27	0.00	1.00	144471
in this year prior survey month	0.55	0.50	0.00	1.00	144471
in year prior to 12 months ago	0.63	0.48	0.00	1.00	144471
<i>Had disaster at least once given child life-cycle-specific disaster history</i>					
in child's first 1000 days of life	0.58	0.49	0.00	1.00	144471
between 1000 days and 2 years before survey mo	0.70	0.46	0.00	1.00	144471

Estimation Strategy

Estimate enrollment and disaster shocks

$$E_{ilt} = \alpha_0 + \psi_0 \cdot E_{il,t-1} + \psi_1 \cdot A_{ilt} + \sum_{j \in \text{TimeSpan}} \alpha^p \cdot D_{iltj}^p + \theta X_i' + \mu_l + \mu_{g_i(t)} + \mu_t + \epsilon_{ilt} \quad (1)$$

- $E_{il,t}$ - enrollment status of child i living in location l at start of this school year t .
- $\text{TimeSpan} = \{m12to1, first1000days\}$, most recent year up to survey month, first 1000 days of life.
- A_{ilt} - grade completed by the end of period $t - 1$ and at the start of period t .
- D_{iltj}^p - natural disaster shock of type p (Type A means any type of disaster).
- X - individual and parental characteristics - parental age, mother's education, whether the child resides with parents, and whether parents are alive.
- $\mu_l, \mu_{g_i(t)}, \mu_t$ - fixed effects of sub-national location, child age, and survey time.

Estimate math scores and disaster shocks

$$S_{ilm} = \alpha_0 + \sum_{j \in TimeSpan} \alpha^j \cdot D_{ilp}^j + \theta X_i' + \mu_{c,A(i,m)} + \mu_l + \mu_{g(i,m)} + \mu_m + \epsilon_{ilm} \quad (2)$$

- S_{ilm} - score on the MICS-administered test achieved by child i in location l at survey month m .
- $TimeSpan = \{m12to1, age25mtolastyer, first1000days\}$. most recent year up to survey month, first 1000 days of life, and mid-child life in between.
- D_{iltj}^p - natural disaster shock of type p (Type A means any type of disaster).
- $\mu_{c,A(i,m)}$ - country- and attainment-specific fixed effects.

Results

The effects of disaster on enrollment

	(1)	(2)	(3)
Had disaster (DB_A) in most recent 12 months	-0.003 (0.005)	-0.002 (0.005)	-0.004 (0.004)
# of mos. with disaster (DM_A) in first 1000 days	-0.002*** (0.000)	-0.002*** (0.000)	-0.001*** (0.000)
Enrollment in year $t - 1$	0.648*** (0.003)	0.641*** (0.003)	0.388*** (0.005)
Attainment at start of t	0.025*** (0.000)	0.024*** (0.000)	0.012*** (0.002)
Female		-0.015*** (0.001)	-0.006*** (0.001)
Mother is alive		-0.015*** (0.005)	-0.009* (0.005)
Mother is alive \times living in same HH		0.029*** (0.003)	0.025*** (0.003)
Father is alive		0.013*** (0.004)	0.012*** (0.003)
Father is alive \times in same HH		-0.005** (0.002)	-0.005** (0.002)
Mother ever educated		0.037*** (0.002)	0.041*** (0.002)
Mother ever educated \times has secondary education		0.004** (0.002)	0.011*** (0.002)
Observations	144354	143645	143645
Within country location FE	Y	Y	Y
Interview year FE	Y	Y	Y
Interview month FE	Y	Y	Y
Child age FE	Y	Y	Y
Enrollment t-1 \times age group controls			Y
Attainment t \times age group controls			Y
Enrollment t-1 \times country controls			Y
Attainment t \times country Controls			Y

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Observations	144354	143645	143645

Disasters and enrollment, heterogeneity across age groups

	(1)	(2)
Had disaster in most recent 12 months		
× Age 5–8	0.008* (0.005)	0.002 (0.005)
× Age 9–12	−0.009** (0.004)	−0.005 (0.004)
× Age 13–17	−0.012** (0.005)	−0.010* (0.005)
# of months with disaster in the first 1000 days		
× Age 5–8	0.001*** (0.000)	0.001* (0.000)
× Age 9–12	−0.002*** (0.000)	−0.001*** (0.000)
× Age 13–17	−0.001*** (0.000)	−0.001*** (0.000)
Observations	143645	143632
Within country location FE	Y	
Country × cluster FE		Y
Interview year FE	Y	Y
Interview month FE	Y	Y
Child age FE	Y	Y
Enrollment t-1 × age group controls	Y	Y
Attainment t × age group controls	Y	Y
Enrollment t-1 × country controls	Y	Y
Attainment t × country controls	Y	Y

Disasters and enrollment, heterogeneity across age groups

	(1)	(2)
Had disaster in most recent 12 months		
× Age 5–8	0.008* (0.005)	0.002 (0.005)
× Age 9–12	−0.009** (0.004)	−0.005 (0.004)
× Age 13–17	−0.012** (0.005)	−0.010* (0.005)
# of months with disaster in the first 1000 days		
× Age 5–8	0.001*** (0.000)	0.001* (0.000)
× Age 9–12	−0.002*** (0.000)	−0.001*** (0.000)
× Age 13–17	−0.001*** (0.000)	−0.001*** (0.000)
Observations	143645	143632
Within country location FE	Y	
Country × cluster FE		Y

Disasters and enrollment, heterogeneity across age and country groups

	(1)	(2)
Had disaster in most recent 12 months		
× Pakistan		
× Age 5–8	−0.105 (0.070)	−0.105 (0.071)
× Age 9–12	−0.110 (0.070)	−0.101 (0.071)
× Age 13–17	−0.101 (0.070)	−0.103 (0.071)
× Bangladesh		
× Age 5–8	0.044*** (0.008)	0.029*** (0.008)
× Age 9–12	−0.011 (0.007)	−0.009 (0.007)
× Age 13–17	−0.027*** (0.008)	−0.019*** (0.007)
× Other countries		
× Age 5–8	−0.005 (0.006)	−0.002 (0.006)
× Age 9–12	−0.013** (0.005)	−0.014*** (0.005)
× Age 13–17	−0.013 (0.009)	−0.007 (0.009)

Disasters and enrollment—heterogeneity across age and country groups

of months with disaster in the first 1000 days

× Pakistan		
× Age 5–8	−0.006*** (0.001)	−0.005*** (0.001)
× Age 9–12	−0.001** (0.001)	−0.001 (0.001)
× Age 13–17	−0.001 (0.001)	−0.000 (0.001)
× Bangladesh		
× Age 5–8	0.003*** (0.001)	0.002* (0.001)
× Age 9–12	−0.002*** (0.001)	−0.001 (0.001)
× Age 13–17	−0.003*** (0.001)	−0.003*** (0.001)
× Other countries		
× Age 5–8	0.002*** (0.000)	0.001*** (0.000)
× Age 9–12	−0.000 (0.000)	−0.001*** (0.000)
× Age 13–17	−0.001 (0.001)	−0.002 (0.001)
Observations	143645	143632
Within country location FE	Y	
Country × cluster FE		Y

The effects of disasters on math scores

	(1)	(2)	(3)	(4)
<i>Recent disaster experience:</i>				
had disaster in most recent 12 months	-0.126 (0.129)	0.258 (0.714)	-0.059 (0.128)	0.350 (0.704)
# of disaster mos. year before last year	-0.011 (0.080)	-0.055 (0.238)	-0.038 (0.079)	-0.107 (0.240)
<i>Mid-child life disaster experience, # of disaster months:</i>				
(> 1000 days) & (< yr. before last yr.)	-0.029*** (0.010)	-0.022** (0.010)	-0.019* (0.010)	-0.018* (0.010)
<i>Early life disaster experience, # of disaster months:</i>				
in the first 1000 days	-0.037*** (0.010)	-0.030*** (0.010)	-0.028*** (0.010)	-0.024** (0.010)
Female			-0.401*** (0.036)	-0.400*** (0.037)
Mother is alive			0.312** (0.158)	0.201 (0.162)
Mother is alive × living in same HH			0.064 (0.075)	0.146* (0.079)
Father is alive			0.246** (0.101)	0.155 (0.106)
Father is alive × living in same HH			-0.235*** (0.057)	-0.205*** (0.060)
Mother ever educated			1.345*** (0.054)	0.980*** (0.058)
Mother ever educated × has secondary			0.991*** (0.044)	0.813*** (0.048)
Observations	78657	78502	78305	78141
Within country location FE	Y		Y	
Country X cluster FE		Y		Y
Interview year FE	Y	Y	Y	Y
Interview month FE	Y	Y	Y	Y
Child age FE	Y	Y	Y	Y
Country X Attainment t FE	Y	Y	Y	Y

The effects of disasters on math scores

	(1)	(2)	(3)	(4)
<i>Recent disaster experience:</i>				
had disaster in most recent 12 months	-0.126 (0.129)	0.258 (0.714)	-0.059 (0.128)	0.350 (0.704)
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<i>Early life disaster experience, # of disaster months:</i>				
in the first 1000 days	-0.037*** (0.010)	-0.030*** (0.010)	-0.028*** (0.010)	-0.024** (0.010)

The effects of disasters on math scores across ages

	(1)	(2)
# of months with disaster in mid-child life		
× Age 5–8	0.002 (0.016)	0.000 (0.017)
× Age 9–12	−0.002 (0.015)	0.000 (0.015)
× Age 13–17	−0.006 (0.014)	−0.004 (0.014)
# of months with disaster in the first 1000 days		
× Age 5–8	−0.036* (0.020)	−0.032 (0.020)
× Age 9–12	−0.001 (0.013)	0.002 (0.014)
× Age 13–17	−0.022 (0.017)	−0.017 (0.018)
Observations	78305	78141
Within country location FE	Y	
Country X cluster FE		Y

Effects of disasters on math scores across countries

	(1)	(2)
# of months with disaster in mid-child life		
× Pakistan	0.008 (0.017)	−0.001 (0.017)
× Bangladesh	−0.051*** (0.014)	−0.056*** (0.015)
× Other countries	0.032* (0.018)	0.048*** (0.019)
# of months with disaster in the first 1000 days		
× Pakistan	−0.089*** (0.016)	−0.069*** (0.016)
× Bangladesh	0.025 (0.019)	0.020 (0.020)
× Other countries	0.033* (0.019)	0.034* (0.020)
Observations	78305	78141
Within country location FE	Y	
Country X cluster FE		Y

Disasters and math scores across countries and ages (mid-child life)

	(1)	(2)
# of months with disaster after 1000 days of life until 2 yr before survey month		
× Pakistan		
× Age 5–8	0.075 (0.063)	0.071 (0.064)
× Age 9–12	−0.043 (0.035)	−0.036 (0.036)
× Age 13–17	0.006 (0.029)	−0.009 (0.029)
× Bangladesh		
× Age 5–8	−0.191*** (0.045)	−0.176*** (0.048)
× Age 9–12	−0.013 (0.025)	−0.017 (0.026)
× Age 13–17	−0.045** (0.021)	−0.057** (0.023)
× Other countries		
× Age 5–8	0.023 (0.025)	0.031 (0.025)
× Age 9–12	0.014 (0.023)	0.023 (0.024)
× Age 13–17	0.012 (0.023)	0.022 (0.024)

Disasters and math scores across countries and ages (early life shock)

of months with disaster in the first 1000 days

× Pakistan		
× Age 5–8	−0.134*** (0.042)	−0.105** (0.043)
× Age 9–12	−0.052** (0.022)	−0.021 (0.023)
× Age 13–17	−0.030 (0.051)	−0.013 (0.052)
× Bangladesh		
× Age 5–8	0.106** (0.046)	0.107** (0.048)
× Age 9–12	0.058** (0.027)	0.036 (0.029)
× Age 13–17	−0.006 (0.024)	0.001 (0.026)
× Other countries		
× Age 5–8	0.006 (0.028)	0.011 (0.028)
× Age 9–12	0.008 (0.025)	−0.001 (0.025)
× Age 13–17	0.086*** (0.026)	0.062** (0.031)
Observations	78305	78141
Within country location FE	Y	
Country X cluster FE		Y

Conclusions

Conclusions

- Overall, there is a significant negative effect of early life disaster exposure on enrollment and math skills, even in regional fixed effects specifications, but weaker or no corresponding effects for recent disaster exposure.
- There is a weak but increasingly negative relationship between recent disaster exposure and enrollment as children age.
- There is a more persistent negative relationship between early disaster experience and enrollment through the school-going ages.
- Age patterning of enrollment and learning effects of disaster exposure differ across national settings.

Next steps

- We will estimate effect heterogeneity of disaster shocks on education by gender and along SES gradients.
- By regressing educational outcomes on both disaster experience and system resilience indicators (closure, truancy), we will explore the role of school system resilience in mediating this effect.

Context Variables (EM-DAT Example) ◀

- Example showing 3 natural disasters in Bangladesh (continued in next slide).

Disaster Type	Origin	OFDA Response	Dis Mag Value	Dis Mag Scale	Latitude	Longitude	Admin1 Code	Admin2 Code	Geo Locations
Flood	Torrential Rain		3882	Km2	23.226	92.13			
Storm				Kph			577		Dhaka (Adm1)
Flood		Yes		Km2				5761...	Bagerhat Barguna... (Adm2)
Storm			130	Kph					

Impact Variables (EM-DAT Example) ◀▶

- Example showing 3 natural disasters in Bangladesh (continued from last slide).

Start Year	Start Month	Start Day	End Year	End Month	End Day	Total Deaths	No Injured	No Affected	Total Damages, Adjusted (‘000 USD)	Total Damages (‘000 USD)
2018	5	20	2018	5	22	21		14000		
2019	3	31	2019	3	31	15				
2019	6		2019	7	28	114		7600000	75000	85854
2019	11	9	2019	11	10	40	71	251506	5785	6622