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

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Introduction

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.

"[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)*

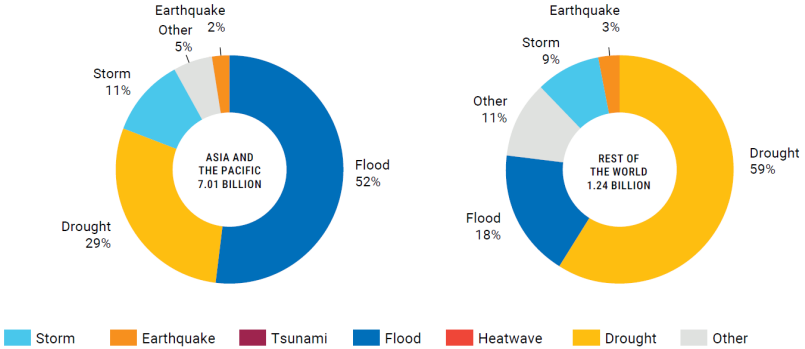


Figure 1: People affected by disasters in the Asia-Pacific region and the rest of the world, 1970-2022

Motivation

- **Children are heavily exposed.**
  - About one billion children across the world are at an 'extremely high risk' of experiencing impacts of climate crisis (UNICEF 2021).
- **Exposure is distributed unequally in children.**
  - Exposure to environmental stressors is highly prevalent and unequally distributed along socioeconomic lines (Torche 2018).
  - Climate change tends to interact with 'non-climatic stressors and entrenched structural inequalities to shape vulnerability (Olsson 2014).

Motivation

- **Direct: disasters $\longrightarrow$ interrupt learning process.**
  - Worldwide 875 million school children live in high seismic risk zones, with 32 million of these children newly enrolled in primary education (Wisner et al. 2004).
  - 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).
- **Indirect: disasters $\longrightarrow$ other stressors $\longrightarrow$ educational outcomes.**
  - Exposure to disasters affect birth outcomes (Currie 2013, Glynn et al. 2001, Torche 2011, Oyarzo et al. 2012, Tan et al. 2009).
  - Employment, wages, and assest prices are affected by natural disasters (Barro 2009, Belasen and Polachek 2008).

Research questions

- Heterogeneous impact of natural disasters on child educational outcomes.
  - Are there heterogeneous impacts on **school enrollment** and **cognitive achievements** for children along gender, age, and SES gradients?
  - Does the **timing** of natural disaster shocks matter for the impacts?
- Resilience of local school systems in protecting child learning.
  - What are the roles of **school shutdowns** and **teacher truancy** in mediating natural disaster effects?
- 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)

Preview of results

- Overall, there is a significant negative effect of early life disaster exposure on enrollment and math skills.
- There is weaker or no corresponding effects from recent disaster exposure on enrollment and math skills.
- There is more persistent negative relationship between early disaster experience and enrollment through school-going ages.
- Age patterning of enrollment and learning effects of disaster exposure differ across national settings.

Related literature and contribution

- We consider early life exposure as well as recent disaster shock.
  - Children exposed to hurricanes *in utero* have lower scores in third grade (Fuller 2014).
  - Prenatal exposure have negative effect on educational or economic performance later in life (Almond and Mazumder 2005, Almond et al. 2009).
- We explore heterogeneity globally and locally with large sample.
  - Negative effects are correlated with social disadvantages (Fuller 2014, Cutter et al. 2003, Zahran et al. 2008).
- We consider multiple disasters rather than single events.
  - Study on impact of disasters on educational outcomes usually uses one disaster in one country (Cho and Kim 2023, Tian et al. 2022, Ciraudo 2020, De Vreyer et al. 2015, Gibbs et al. 2019).
  - There is limited study on broad group of disasters (Opper et al. 2023, Simeonova 2009, Currie and Rossin-Slater 2013).

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.

Linking EM-DAT and MICS data

OCHA Humanitarian Data

- EM-DAT variables **Locations** and **GeoLocation** record location names affected by each disasters.
- Using data on sub-national administrative boundaries (Humanitarian Data), we match disasters in EM-DAT to locations in MICS.
- Using starting and ending year and month of disasters in EM-DAT, interview and birth year and month of children in MICS, we construct children life-cycle disaster exposure history.

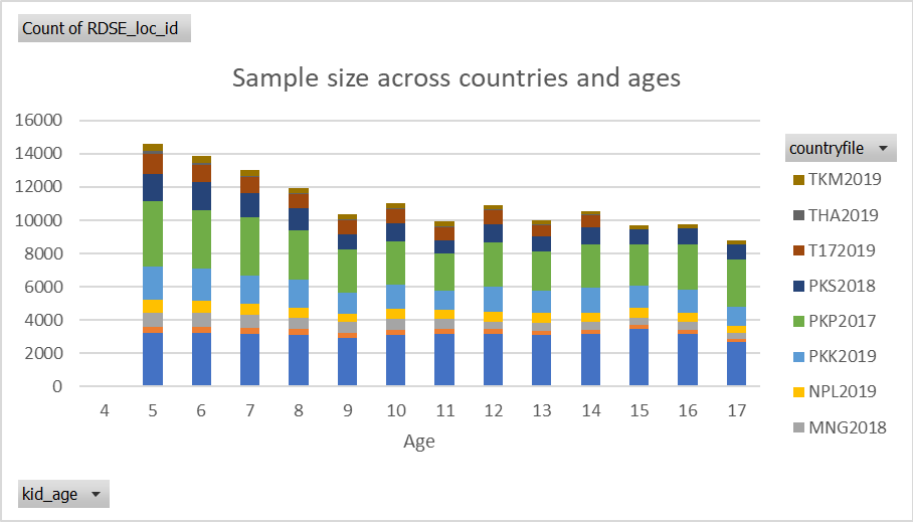
Summary statistics

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

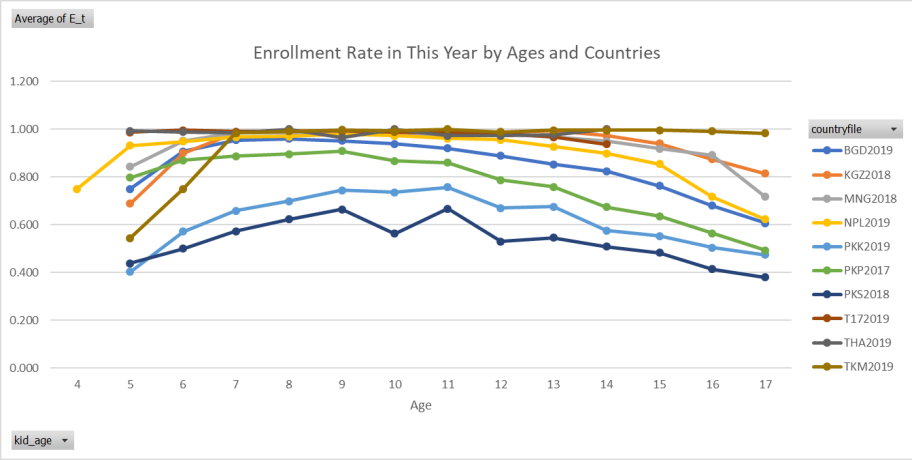


Enrollment, attainment, and math test score

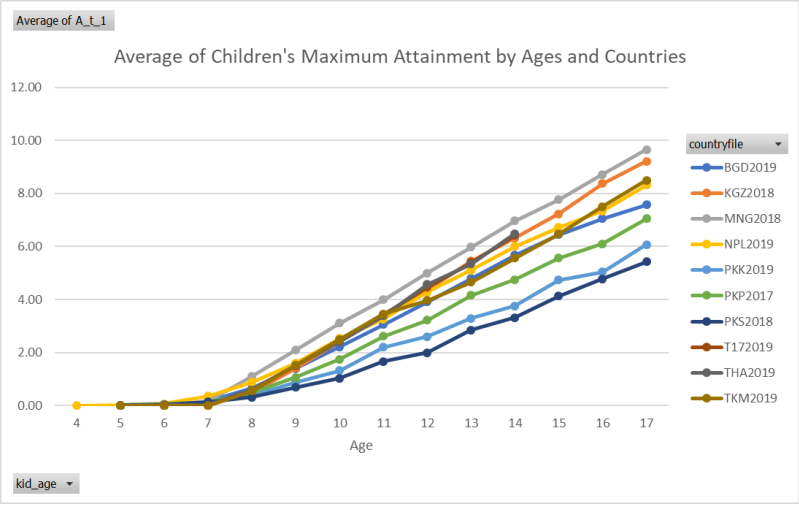
	Mean	SD	Min	Max	N
Ever enrolled	0.88	0.33	0.00	1.00	144426
Enrollment in last school year	0.74	0.44	0.00	1.00	144394
Enrollment in this school year	0.79	0.41	0.00	1.00	144410
Attainment (highest)	3.29	3.34	0.00	16.00	144358
Attainment at start of last school year	2.69	3.06	0.00	16.00	144360
Attainment at start of this school year	3.25	3.32	0.00	16.00	144358
Math score	14.19	7.42	0.00	54.00	78,704

- Math test is for children in age 7-14 only.

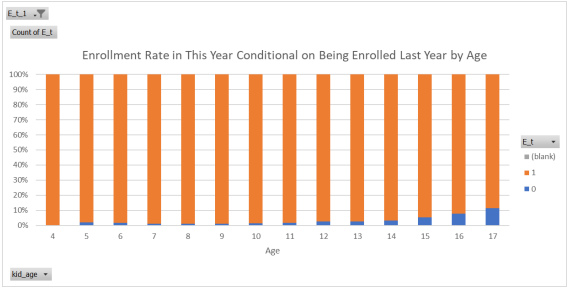
Enrollment rate this year

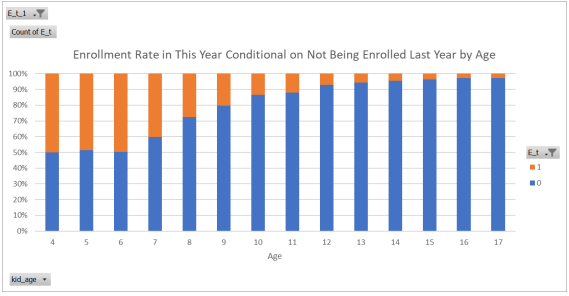


Average highest grade completed by ages and countries



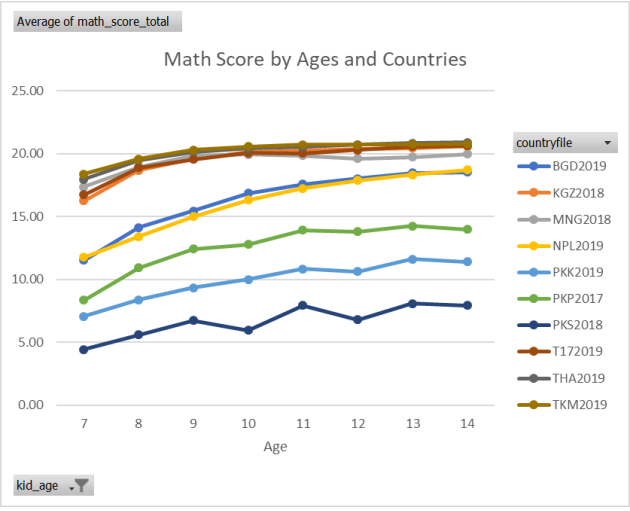
Enrollment transition probabilities by ages





- 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.

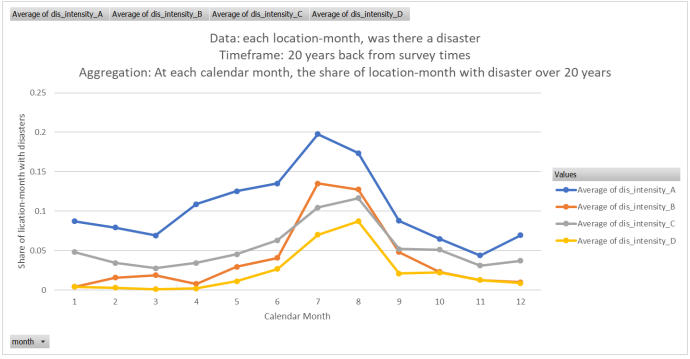
Distribution of math test score



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

Share of location-month in disasters in calendar month over 20 years



- Type A-D: all disasters, only floods, only severe disasters (> 50 people dead or injured, or $> 5{,}000$ people affected), only severe floods.
- For all types, during summer locations are hit by disasters most.
- Focusing on only one category omits large proportion of overal shocks.

Location- and child life-cycle-specific disaster shocks

	Mean	SD	Min	Max	N
Had recent disaster					
in survey mo	0.08	0.27	0.00	1.00	144471
in this year prior survey mo	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
Had disaster at least once given child life-cycle-specific disaster history					
in child's first 1000 days of life	0.58	0.49	0.00	1.00	144471
between 1000 days and 2 yr before survey mo	0.70	0.46	0.00	1.00	144471

Estimation strategy

Estimate enrollment and disaster shocks

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

- $E_{il,t}$ - enrollment status of child i living in location l at start of this school year t.
- 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^p_{iltj} - 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.
- μ_l, $\mu_{g_i(t)}$, μ_t - fixed effects of sub-national location, child age, and survey time.

Estimate math scores and disaster shocks

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

- S_{ilm} - score on the MICS-administered test achieved by child i in location l at survey month m.
- TimeSpan = $\{m12to1, age25mtolastyear, first1000days\}$. most recent year up to survey month, first 1000 days of life, and mid-child life in between.
- D^p_{iltj} - 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	-0.002	-0.004
# of mos. with disaster (DM_A) in first 1000 days	-0.002***	-0.002***	-0.001***
Enrollment in year $t-1$	0.648***	0.641***	0.388***
Attainment at start of t	0.025***	0.024***	0.012***
Female		-0.015***	-0.006***
Mother is alive		-0.015***	-0.009*
Mother is alive × living in same HH		0.029***	0.025***
Father is alive		0.013***	0.012***
Father is alive × in same HH		-0.005**	-0.005**
Mother ever educated		0.037***	0.041***
Mother ever educated × has secondary education		0.004**	0.011***
Observations	144354	143645	143645

Disaster and enrollment, heterogeneity across age group

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

Disaster and enrollment, heterogeneity across age and country groups

	(1)	(2)
Had disaster in most recent 12 months		
× Pakistan		
× Age 5–8	-0.105	-0.105
× Age 9–12	-0.110	-0.101
× Age 13–17	-0.101	-0.103
× Bangladesh		
× Age 5–8	0.044***	0.029***
× Age 9–12	-0.011	-0.009
× Age 13–17	-0.027***	-0.019***
× Other countries		
× Age 5–8	-0.005	-0.002
× Age 9–12	-0.013**	-0.014***
× Age 13–17	-0.013	-0.007
Observations	143645	143632
Within country location FE	Y	
Country × cluster FE		Y

Disaster and enrollment, heterogeneity across age and country groups

	(1)	(2)
# of months with disaster in the first 1000 days		
× Pakistan		
× Age 5–8	-0.006***	-0.005***
× Age 9–12	-0.001**	-0.001
× Age 13–17	-0.001	-0.000
× Bangladesh		
× Age 5–8	0.003***	0.002*
× Age 9–12	-0.002***	-0.001
× Age 13–17	-0.003***	-0.003***
× Other countries		
× Age 5–8	0.002***	0.001***
× Age 9–12	-0.000	-0.001***
× Age 13–17	-0.001	-0.002
Observations	143645	143632
Within country location FE	Y	
Country × cluster FE		Y

The effects of disaster on math test score

	(1)	(2)	(3)	(4)
Recent *disaster experience:*				
had disaster in most recent 12 months	-0.126	0.258	-0.059	0.350
	(0.129)	(0.714)	(0.128)	(0.704)
# of disaster mos. year before last year	-0.011	-0.055	-0.038	-0.107
	(0.080)	(0.238)	(0.079)	(0.240)
Mid-child life *disaster experience, # of disaster months:*				
(> 1000 days) & (< yr. before last yr.)	-0.029***	-0.022**	-0.019*	-0.018*
	(0.010)	(0.010)	(0.010)	(0.010)
Early life *disaster experience, # of disaster months:*				
in the first 1000 days	-0.037***	-0.030***	-0.028***	-0.024**
	(0.010)	(0.010)	(0.010)	(0.010)
Observations	78657	78502	78305	78141
Within country location FE	Y		Y	
Country X cluster FE		Y		Y

Disaster and math test score, heterogeneity across age groups

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

Disaster and math test score, heterogeneity across country groups

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

Disaster and math score, heterogeneity across age and country groups (mid-child life)

	(1)	(2)
# of months with disaster between 1000 days of life and 2 yr before survey mo		
× Pakistan		
× Age 5–8	0.075	0.071
× Age 9–12	-0.043	-0.036
× Age 13–17	0.006	-0.009
× Bangladesh		
× Age 5–8	-0.191***	-0.176***
× Age 9–12	-0.013	-0.017
× Age 13–17	-0.045**	-0.057**
× Other countries		
× Age 5–8	0.023	0.031
× Age 9–12	0.014	0.023
× Age 13–17	0.012	0.022
Observations	78305	78141
Within country location FE	Y	
Country X cluster FE		Y

Disaster and math score, heterogeneity across age and country groups (early life)

	(1)	(2)
# of months with disaster in the first 1000 days of life		
× Pakistan		
× Age 5–8	-0.134***	-0.105**
× Age 9–12	-0.052**	-0.021
× Age 13–17	-0.030	-0.013
× Bangladesh		
× Age 5–8	0.106**	0.107**
× Age 9–12	0.058**	0.036
× Age 13–17	-0.006	0.001
× Other countries		
× Age 5–8	0.006	0.011
× Age 9–12	0.008	-0.001
× Age 13–17	0.086***	0.062**
Observations	78305	78141
Within country location FE	Y	
Country X cluster FE		Y

Conclusions and discussion

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

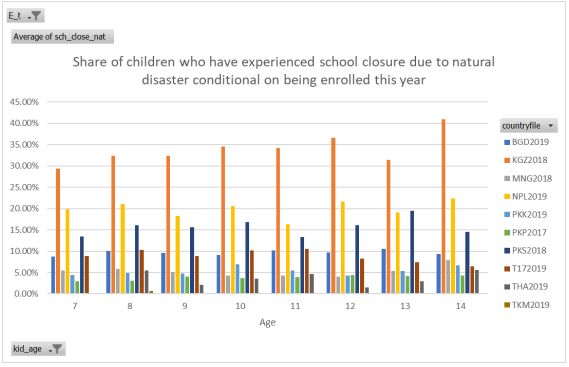
- We will estimate heterogeneous effect of disaster shocks on education by gender and along SES gradients.
- We will model organizational factor measures including school closure and teacher truancy as a function of natural disaster shocks.
- By regressing educational outcomes on both disaster experience and system resilience indicators (closure, truancy), we then explore the role of school system resilience in mediating effect of disaster shocks on educational outcomes.

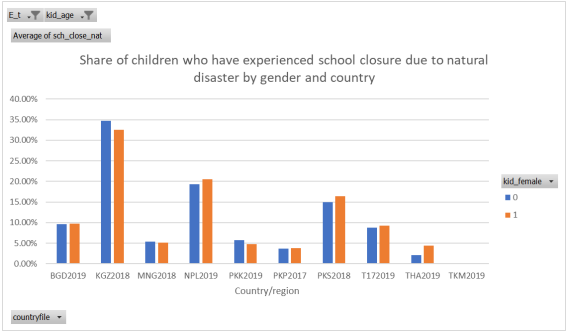
Limitations and challenges

- We do not observe migration status of children or households in MICS data, so there is selection issue treating all children as living in same location in whole life.
- Across national database (EM-DAT) provides information across time and countries with consistent standards, but ability of each government recording and reporting disasters depends on capability of locations.
- There is entry criteria of EM-DAT so that more localized disasters may be missing.
- Locations affected by disasters in EM-DAT is not exactly at same admin level as those in MICS, hence different matching strategy should be applied.

Appendix

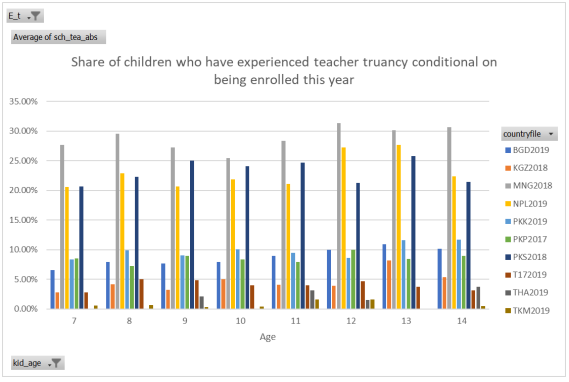
Distribution of school closure due to natural disaster in last 12 mo

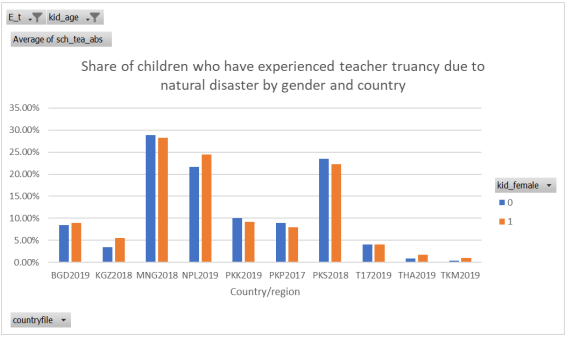




- Kyrgyzstan has highest share for all age groups.
- Nepal and Pakistan Sindh province also have relatively high share.
- Within one country, the difference in this share across ages is not large.
- There is no significant difference across gender.

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.

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