Natural Disasters, Mortality, Fertility, and Educational Attainment in Africa

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Abstract

This paper documents demographic changes associated with natural disasters in Africa. The paper draws on two main data sources: Records of thousands of droughts, floods, and other natural disasters that struck Africa between 1900 and 2016; and large-scale household surveys conducted across Africa since 1977. Infant mortality rises by 1.2 percent during a natural disaster, and women have 0.5 percent fewer children on average in the five years following a natural disaster. There are also long-term changes to educational attainment. Women aged 6–10 during natural disaster have a slight decrease of less than 0.1 years of completed schooling, while men of school age during a natural disaster complete an additional 0.4 years.

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Keywords: Health; Fertility; Education; Natural Disasters; Africa

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1. Introduction

This paper documents demographic changes associated with natural disasters in Africa. The paper draws on two main data sources: Records of 4,591 of droughts, floods, and other natural disasters that struck Africa between 1900 and 2016; and large-scale household surveys conducted in 40 countries in Africa since 1977. The findings indicate that children born the year of a natural disaster face a 1.2 percent higher chance of dying in infancy compared to children born at other times. There is then a fall in fertility: Women living in areas affected by a natural disaster have 0.5 percent fewer children within five years than do women living in other areas. Finally, there are long-term changes to educational attainment. Women aged 6–10 during natural disaster have a slight decrease of less than 0.1 years of completed schooling, while men of school age during a natural disaster have a more substantial increase of nearly 0.4 years.

This study builds upon and contributes to three areas of existing research. First, several excellent studies have documented changes in mortality and fertility following flooding in Bangladesh in 1974 (Hernández-Julián and Mansour 2014), drought in Ethiopia in the early 1970s (Lindstrom and Berhanu 1999), crop failure in Ireland in the late 1840s (Boyle and O Gráda 1986), droughts in Mali in the 1970s and 1980s (Pedersen 1995), and hurricanes in the United States between 1995 and 2001 (Evans et al. 2010). For example, Nobles et al. (2015) track fertility in coastal areas of Indonesia following the 2004 Indian Ocean tsunami. Families that lost a child were more likely to have another child, as were families that did not lose a child. I similarly demonstrate that women in Africa who lose a child are more likely to have another child. However, this increased likelihood is moderated when the child dies during a natural disaster, and I find no evidence for a community-level positive fertility response to natural disasters in Africa. Fertility instead falls in Africa for women who experienced but did not lose a child during a natural disaster.

Second, while most studies of natural disasters focus on a single country, several explore the consequences of a single type of disaster across several countries, such as famines in Africa (Agbor and Price 2014) and earthquakes in Asia (Finlay 2009). Caruso (2016) goes furthest, comparing the consequences of hundreds of floods, volcanic eruptions, earthquakes, cyclones, and landslides across Latin America during the twentieth century. For example, Caruso demonstrates that people who were children during a natural disaster, particularly a flood or landslide, complete fewer years of schooling. However, no study has yet conducted similar comparisons across multiple types of disasters in Africa. I find that infant mortality in Africa particularly increases during epidemics, while fertility particularly falls following droughts and severe storms.

Third, global climate models project that recent changes in temperature, precipitation, and sea level will continue for at least the next several decades. These climate changes carry greater risk of natural disasters, such as floods and droughts, particularly for less developed countries, many of which are located in Africa (Intergovernmental Panel on Climate Change 2012). By documenting demographic changes associated with past natural disasters in Africa, this paper sheds light on the consequences of future disasters. For example, I estimate that each drought and flood over the past several decades has been associated with an average increase of 0.29–1.1 infant deaths per 1,000 births. As droughts and floods become more frequent or intense over the next several decades, the costs to infant health may rise.

2. Data

2.1 Natural disasters

The Centre for Research on the Epidemiology of Disasters maintains the most globally comprehensive record of natural disasters. This Emergency Events Database (EM-DAT) records the location and timing of more than 14,000 natural disasters since 1900 (Guha-Sapir et al. 2016). Every disaster in the database satisfies one of the following criteria: At least 10 people died as a result of the disaster, at least 100 people were affected by the disaster, the affected country declared a state of emergency, or the affected country requested international assistance.

The disasters are grouped into categories: Biological, climatological, geophysical, hydrological, and meteorological. The first column of Table 1 describes the composition of each category across all disasters that occurred in Africa between 1900 and 2016. Epidemics are the most common type of biological disaster. Similarly, droughts, earthquakes, floods, and storms comprise at least three-quarters of all climatological, geophysical, hydrological, and meteorological disasters. Throughout this paper, I separately calculate demographic changes following each category of disaster, and these calculations are therefore driven by epidemics, droughts, earthquakes, floods, and storms.

Figure 1 depicts the timing of natural disasters by country in Africa. Disasters do not occur evenly across the continent. The Democratic Republic of the Congo has experienced 119 disasters, while Equatorial Guinea has experienced only one. Much of the West African Sahel experienced sustained drought in the early 1910s, the early 1940s, and again in the 1970s and early 1980s. By contrast, droughts are relatively rare and floods more common in North Africa.

Ninety-seven percent of recorded disasters occurred since 1965. Although the frequency of natural disasters may have increased along with climate change in recent decades, the sharp increase in the number of recorded disasters after 1965 suggests omission of older disasters. However, I do not know of an alternative source that more comprehensively records older disasters. The main findings in this paper use the full database of disasters, with the qualification that few are recorded before 1965.

2.2 Administrative boundaries

The natural disaster database records the country in which each disaster occurred. For 89 percent of disasters, the database also records the location or locations within the country in which the disaster occurred. I connect each of these sub-national locations to administrative subdivision shapefiles maintained by the Database of Global Administrative Areas (GADM 2018). These electronic maps permit me to connect the location of natural disasters to geocoded demographic data. As indicated in the final column of Table 1, 85 percent of epidemics are geocoded, as are 78 percent of droughts, and more than 90 percent of earthquakes, floods, and storms.

2.3 Demographic information

Vital registries of births and deaths offer the most comprehensive record of fertility and mortality. However, such registries are largely unavailable in Africa. Instead, I use 175 World Fertility Surveys (WFS, International Statistics Institute 1974–1981) and Demographic and

Health Surveys (DHS, ICF International 1985–2017) administered in Africa since 1977. Table A.1 lists each individual survey. These surveys offer the most broadly-comparable demographic information from 40 countries in Africa. Many of these surveys collect birth histories from women of childbearing age, generally aged 15–44 or 15–49. These birth histories record the timing of each of a woman's live births, as well as the dates that any children died. I use these birth histories to measure fertility and child mortality. These surveys also record women's educational attainment, and many of the DHS surveys similarly record men's educational attainment.

Table 2 describes the sample of respondents. Of the 1.67 million women surveyed, 1.17 million provide birth histories. These women are nearly three years older on average than all women surveyed, and nearly than one year older on average than the 461,000 men surveyed. The birth histories record births occurring between 1936 and 2016. Each woman has an average of 4.0 children. One-hundred and seventeen DHS surveys record the latitude and longitude of the community in which each respondent lives. The administrative boundary shapefiles permit me to identify whether each respondent of these geocoded surveys lives in a sub-national location in which a natural disaster occurred.

3. Mortality

3.1 Infant mortality

I estimate the relationship between natural disasters and infant mortality using the following specification:

$$Died_{icy} = \alpha + \beta Disaster_{cy} + \boldsymbol{X'}_i\eta + \delta_c + \gamma_y + \theta_c \times y + \varepsilon_{icy}. \qquad (1)$$

Each observation is a child. $Died$ equals one if child i, who was born in year y and whose mother was surveyed while living in country c, died by the end of the following year. $Disaster$ equals one if a natural disaster occurred in year y in country c. The coefficient of interest, β, measures the change in the likelihood of dying in infancy for children born during a natural disaster. The regression also includes a vector, $\boldsymbol{X}$, of demographic characteristics: child's sex, mother's years of completed schooling, mother's age in year y, and mother's number of other children by year y. Finally, the regression includes dummy variables for country of residence and child's year of birth, δ_c and γ_y, and country-specific linear time trends, $\theta_c \times y$.

Column 1 of Table 3 provides the results of a bivariate regression of $Died$ on $Disaster$. This regression, and all remaining regressions in this paper, are performed using sampling weights that accompany each survey. Across all 4.05 million children recorded in birth history surveys, those born during a natural disaster are 1.1 percentage points less likely to die within a year than are children born at other times. Given that 12 percent of children born at other times die within a year, this estimate indicates a nine percent decrease in infant mortality during a natural disaster. The direction of this change is surprising, suggesting that natural disasters are associated with a reduction in infant mortality.

Column 2 adds demographic controls, country and year fixed effects, and country-specific linear time trends. The estimated coefficient on $Disaster$ now indicates that being born during a natural disaster is associated with a 0.096 percentage point (or 0.8 percent) increase in the likelihood of dying within a year. These additional covariates flip the estimated relationship between natural disasters and infant mortality from negative to positive, suggesting that natural disasters tend to occur in time periods and affect countries and women that generally have lower infant mortality. In particular, as depicted in Figure 1, natural disasters appear more frequent in recent decades, the same period in which infant mortality has fallen (Ahmad et al. 2000).

For the regressions in columns 1 and 2, all disasters are recorded at the country level. In column 3, disaster records at the sub-national level are linked to geocoded survey data when possible. This change allows for more precise identification of whether a child was born in an area affected by a natural disaster. The estimated relationship between natural disasters and infant mortality is now stronger: Being born in an area affected by a disaster is associated with a 0.14 percentage point (or 1.2 percent) increase in the likelihood of dying before age one. Out of every 1,000 children born when there is no natural disaster, 120 die within one year. Natural disasters are associated with an increase of 1.4 infant deaths per 1,000 births.

I estimate the relationship between each category of natural disaster and infant mortality using the following specification:

$$Died_{icy} = \alpha + \sum_{j} \beta_j Disaster_{jcy} + \boldsymbol{X'}_i \eta + \delta_c + \gamma_y + \theta_c \times y + \varepsilon_{icy}. \qquad (2)$$

The coefficients of interest, β_j, separately measure the change in the likelihood of dying in infancy for children born during each type of disaster, j. As given in column 4, being born during a biological natural disaster (which, again, is usually an epidemic) is associated with a 0.39 percentage point increase in the likelihood of dying in infancy. Climatological and hydrological disasters (again, chiefly droughts and floods) are associated with 0.11 and 0.029 percentage point increases in infant mortality. Children born during multiple natural disasters are also more likely to die in infancy. Geophysical and meteorological natural disasters (again, chiefly earthquakes and storms) are associated with 0.54 and 0.52 percentage point decreases in infant mortality. Epidemics, droughts, and floods therefore drive the overall positive relationship between disasters and infant mortality, while earthquakes and storms temper the relationship.

3.2 Child mortality

The red squares in Figure 2 provide child mortality rates by age when no disaster occurs. Nearly 12 percent of children aged zero die within a year. This value falls to 5 percent for children aged one, and continues to fall until flattening out at less than one percent after about age eight. These statistics reflect the high risk of death that young children have faced across much of Africa (Ahmad et al. 2000).

I repeat specification 1 separately for children at each age between zero and 17. The black circles in Figure 2 present, for children at each age, the estimated change in the likelihood of dying associated with a natural disaster occurring that year. As in column 3 of Table 3, children who experience a natural disaster when aged zero are 0.14 percentage points more likely to die within a year than are children aged zero who do not experience a natural disaster. This disaster-related increase in mortality grows to 0.27 percentage points for children aged one, and falls to 0.08 percentage points for children aged two. At all older ages, there is little change in the risk of dying associated with experiencing a natural disaster. A child aged 0–2 living in an area that does not experience a natural disaster faces a 7.5 percent chance of dying within one year. For children aged 0–2 who experience a natural disaster, this likelihood rises by 0.16 percentage points. Of every 1,000 very young children, 75 typically die within a year, and an additional 1.6 children die following a natural disaster.

As with infant mortality, the relationship with child mortality varies by type of disaster. Repeating specification 2 for six three-year age groups, Figure 3 presents the additional likelihood of dying following a natural disaster. As in column 4 of Table 3, biological and climatological disasters are most strongly associated with mortality for very young children, while geophysical and meteorological disasters are associated with reductions in mortality for young children. By age 6–8, these relationships largely disappear and, with one exception, mortality at older ages barely changes following natural disasters. The exception is geophysical natural disasters (such as earthquakes and volcanic activity). The relationship between geophysical disasters and mortality is negative among very young children but grows consistently until the early teenage years. Children aged 12–14 during a geophysical disaster have a 0.24 percentage point greater likelihood of dying within a year. For the oldest children aged 15–17, geophysical disasters, like all other disasters, have little relationship with mortality.

3.3 By mother

In section 4, I measure the number of births following natural disasters. So that I can compare the fertility response to natural disasters with the fertility response to losing a child, I similarly calculate the relationship between natural disasters and the likelihood that a woman loses a child. I again estimate specification 1. There is now one observation per woman, i, each year, y, she is aged 15–44. Demographic controls consist of each woman's years of completed schooling, age in year y, and number of children by year y. In years in which no disaster occurs, 3.3 percent of women have a child die. As given in column 5, the likelihood of having a child die rises by 0.055 percentage points when a natural disaster occurs. As given in column 6, biological, climatological, and geophysical disasters drive this positive relationship between natural disasters and the likelihood a woman loses a child. The estimated coefficients on hydrological and meteorological disasters are negative, indicating that mortality falls during these disasters. Again, I return to these estimates later in section 4.

4. Fertility

I estimate the relationship between natural disasters and fertility using the following specification:

$$Births_{icy} = \alpha + \beta_1 Died_{icy} + \beta_2 Disaster_{cy} + \beta_3 Died_{icy} \times Disaster_{cy} + \boldsymbol{X'}_i\eta + \delta_c + \gamma_y + \theta_c \times y + \varepsilon_{iyp}. \quad (3)$$

There is one observation per woman each year she is aged 15–44. $Births$ records the number of children woman i, surveyed while living in country c, gave birth to in the five years following year y. $Died$ equals one if the woman had a child die in year y. $Disaster$ equals one if a natural disaster occurred in year y in country c. There are three coefficients of interest: β_1 measures the change in fertility following the death of a child, β_2 measures the change in fertility following a natural disaster, and β_3 measures the additional change in fertility after a child dies during a natural disaster. The regression also includes a vector, $\boldsymbol{X}$, of demographic characteristics of the woman: years of completed schooling, age in year y, and number of children by year y. Finally, as in specifications 1 and 2, the regression includes dummy variables for country of residence and year, δ_c and γ_y, and country-specific linear time trends, $\theta_c \times y$.

Women in the sample give birth to 1.13 children on average in the five years following a year in which no disaster occurs and in which they did not lose a child. Column 1 of Table 4 provides the results of a regression of $Births$ on $Died$ alone. The estimated coefficient on *Disaster* indicates that women have 0.30 additional children on average in the five years following the death of a child. Column 2 provides the results of a regression of $Births$ on $Disaster$ alone, and indicates that women have 0.0060 fewer children in the five years following a natural disaster. The magnitude of the change in fertility following the death of a child is fifty times greater than that following a natural disaster.

Column 3 presents the results of full specification 3. The estimated coefficients on $Died$ and $Disaster$ are similar to columns 1 and 2: Women have 0.32 additional children on average in the five years following the death of a child, and have 0.0046 fewer children following a natural disaster. The estimated coefficient on the interaction term, –0.047, has two interpretations: The increase in fertility following the death of a child is diminished if that child died during a natural disaster, or the overall reduction in fertility following a natural disaster is intensified among women who also lost a child during the natural disaster. The relationship between natural disasters and aggregate fertility is therefore not immediately obvious. On the one hand, child mortality rises during natural disasters, and fertility generally rises among women who have lost a child. On the other hand, this positive relationship between child mortality and fertility is moderated if the child died during a natural disaster, less than four percent of women lose a child during a natural disaster, and there is a fall in fertility following a natural disaster among the remaining 96 percent of women who did not lose a child.

Column 1 of Table 5 describes calculations that measure the aggregate change fertility following natural disasters. Panels I and II repeat estimates from Tables 3 and 4. For example, 3.29 percent of women lose a child in a year in which a disaster does not occur, and this likelihood rises by 0.06 percentage points during a natural disaster. Panel III calculates the number of births per woman in the five years following a year in which a disaster did not occur. Women who did not lose a child give birth to 1.1329 children on average, and women who lost a child give birth to 1.4508 children on average (1.1329+0.3179). In the five years following a year in which no disaster occurs, the average women gives birth to 1.1434 children ($(1-0.0329)\times 1.1329 + 0.0329\times 1.4508$). Similarly, in the five years following a year in which a disaster occurs, the average woman gives birth to 1.1374 children. Panel V compares these two fertility estimates. A natural disaster is associated with a decline in fertility of 0.5%, or 6.0 births per 1,000 women, over the following five years.

The remaining columns of Table 5 perform similar calculations by disaster category. Again, the values in panels I and II come from the final columns of Tables 3 and 4. As given in the third row of panel II, only biological disasters are associated with an increase in fertility (of 0.42 percentage points) among women who did not lose a child. The values in panel V similarly indicate that only biological disasters are associated with an aggregate increase in fertility. In the five years following an epidemic or other biological disaster, there are an additional 2.7 births per 1,000 women. All other disasters are associated with an aggregate decline in fertility. This decline is particular large following climatological and meteorological disasters. For example, fertility declines by 30.3 children per 1,000 women following storms and other meteorological disasters.

5. Educational attainment

I estimate the relationship between natural disasters and educational attainment using the following specification:

$$Educ_{icy} = \alpha + \sum_{j} \beta_j Disaster_{jcy} + \delta_c + \gamma_y + \theta_c \times y + \varepsilon_{icy}. \tag{4}$$

There is one observation per adult aged 25–79. $Educ$ records the years of schooling completed by person i, who was surveyed while living in country c and born in year y. $Disaster$ equals one if a natural disaster occurred j years after year y in country c. I group people into five-year periods, j, that record the timing of natural disasters around their year of birth, running from people born 16–20 years before a natural disaster to people born 15–19 years after a natural disaster. A person born within 20 years of multiple disasters therefore belongs to two or more of these groups. The omitted category consists of people born 21 or more years before a natural disaster, 20 or more years after a natural disaster, or in a place in which no disaster occurred. The coefficients of interest, β_j, therefore measure the difference in educational attainment between a person born j years after a natural disaster and a person born long before or after a natural disaster. The regression also includes dummy variables for country of residence and year of birth, δ_c and γ_y, and country-specific linear time trends, $\theta_c \times y$.

Because the sample of women is much larger than the sample of men, I estimate specification 4 separately for women and men. Women in the control group born long before or after a natural disaster complete 3.0 years of schooling on average. As depicted in Figure 4, women born 16–20 years before a natural disaster complete 0.02 fewer years of schooling, a value statistically indistinguishable from zero. This difference remains less than 0.05 for all groups except women born 6–10 years before a natural disaster, who complete 0.07 fewer years of schooling. These are women who were of primary school age when they experienced a natural disaster. Still, this difference is small, and these estimates therefore suggest little relationship between natural disasters and educational attainment for women.

Men born long before or after a natural disaster complete 5.2 years of schooling on average. As with women, there is little substantial change in educational attainment among men born 16–20 years a natural disaster. However, educational attainment in adulthood rises by nearly 0.4 years for men who were aged 11–15 at the time of a natural disaster. This difference then falls for men who were younger when experiencing a disaster, but remains statistically significant and greater than 0.1 through the group of men born 5–9 years after a natural disaster. The difference is then small and statistically indistinguishable from zero for men born 10–19 years after a natural disaster. These estimates indicate that educational attainment rises for men born around the time of a natural disaster, particularly among men who were of school age when they experienced the disaster.

Figure 5 presents the estimates of specification 4 separately for each type of natural disaster. As depicted in panel (a), women born within 20 years of a storm or other meteorological disaster complete approximately 0.6 additional years of schooling compared to women in the control group born long before or after a meteorological disaster or in a country in which no meteorological disaster ever occurred. Biological and climatological disasters are similarly associated with changes of at most 0.2 years of completed schooling. Geophysical disasters are associated with increases of more than 0.5 years of schooling for women of school age. Floods and other hydrological disasters are associated with a drop in educational attainment for women aged 6–15 at the time of the disaster. These estimates indicate that the generally flat relationship between year of birth and year of disaster masks variety by disaster type: educational attainment rises among women born before meteorological disasters and after geophysical disasters, and falls among women born before multiple disasters occur and after hydrological disasters. Hydrological disasters, which comprise roughly one-third of all natural disasters in Africa, therefore drive the overall drop in educational attainment for women who are entering school age at the time of a natural disaster.

Panel (b) depicts similar estimates for men. For example, as with women, meteorological disasters are associated with generally higher educational attainment, and climatological disasters are associated with little change in educational attainment. Biological and geophysical disasters are associated with a steep rise in educational attainment among men born 11–15 years before a disaster, and a decline thereafter (slow for biological disasters, sharp for geophysical disasters). Biological and geophysical disasters therefore explain the overall rise in educational attainment among men of school age during a natural disaster.

Discussion

This paper documents, for the first time, substantial demographic changes following a variety of natural disasters in Africa. Children aged 0–2 are 2.1 percent more likely to die within a year of a natural disaster than after a year in which a disaster does not occur. The number of children born per woman falls by 0.5 percent in the five years following a natural disaster. There is little relationship between the timing of natural disasters and women's lifetime educational attainment, but a substantial increase of nearly 0.4 years of completed schooling for men who experience natural disasters as children.

Caution must be taken in drawing conclusions about causality. Again, the Emergency Events Database records only disasters in which at least 10 people died, at least 100 people were affected, the affected country declared a state of emergency, or the affected country requested international assistance. A natural disaster therefore results from the interaction of a natural event, like a storm, with institutional and demographic characteristics of a community or country, like availability of health care or population size. A natural event may not qualify as a natural disaster if it occurs in an area that has excellent infrastructure or is sparsely populated.

Other studies have demonstrated increased emigration out of areas affected by natural disasters (Boustan et al. 2012, Drabo and Mbaye 2014). Because the demographic surveys used in this paper do not record migration histories, I cannot use them to confirm whether emigration changes during a natural disaster. Additionally, migration may influence measurement of other demographic characteristics if these characteristics systematically vary between migrants and non-migrants. For example, in this paper I find that fertility falls after natural disasters, but such a finding could instead be driven by emigration of women who are more likely to have large families.

I investigate this concern using several national censuses that record whether residents have moved within the country. Table 6 draws on census data to compare the economic and demographic characteristics of people who do and do not emigrate following a flood in Lesotho in 1987, drought in Rwanda in 1989, and 1989 flood in Egypt. In Lesotho, 12 percent of residents of affected areas migrated between provinces around the time of the flood, while only 6 percent of residents of other areas migrated between provinces. Countrywide, migrants are more likely to be women and to have completed more years of schooling. In particular, compared to migrants from other parts of the country, migrants out of drought-affected areas are older, have more children on average, and are less likely to be employed. This relationship between emigration and increased fertility could explain the finding of a reduction in fertility among those who remain behind in disaster-affected areas following natural disasters.

Census data indicate no comparable relationship between selection into migration and natural disasters in Rwanda and Egypt. As given in Table 6, migrants within Rwanda are consistently older, more likely to be male, have fewer children, and are less likely to be working. Similarly, migrants within Egypt are consistently more likely to be older, male, and employed (although these differences are statistically indistinguishable from zero). Although limited, this evidence does not suggest that migrants out of disaster-affected areas are consistently and overwhelmingly selected in a way that increases child mortality, reduces fertility, and raises men's educational attainment among people that remain behind.

Further study should explore mechanisms that connect natural disasters to long-term changes in fertility. For example, the rise in educational attainment for men born around the time of a natural disaster corresponds with smaller cohort sizes due to increased mortality and decreased fertility in the years following natural disasters. Decreased competition for scarce family resources and reduced congestion in schools could explain the increased educational attainment.

Further study should also explore the causes of differential demographic changes following various types of natural disasters. Infant mortality falls most substantially following biological disasters, such as epidemics, while the risk of death among older children rises following earthquakes and other geophysical disasters. Fertility falls after all types of disasters except geophysical disasters. Geophysical and biological disasters drive overall increase in educational attainment for men born around the time of natural disasters, while the increase in educational attainment for women born ahead of geophysical disasters is balanced by a decrease for women born ahead of hydrological disasters.

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Table 1: Characteristics of natural disasters in Africa, 1900–2016

	Disasters	Countries	Geocoded
Biological			
Animal accident	1	1	100%
Epidemic	818	52	85%
Insect infestation	69	24	62%
Climatological			
Drought	312	48	78%
Wildfire	29	15	86%
Geophysical			
Earthquake	84	21	92%
Mass movement (dry)	5	4	100%
Volcanic activity	18	6	89%
Hydrological			
Flood	943	52	97%
Landslide	37	20	97%
Meteorological			
Extreme temperature	15	7	80%
Storm	246	40	91%

Data sources: Emergency Events Database (Guha-Sapir et al. 2016).

Table 2: Characteristics of demographic survey data

	Women	Women who provide birth histories	Men
Countries	40	40	34
Surveys	175	171	109
Geocoded surveys	117	114	81
Years of survey	1977–2016	1977–2016	1991–2016
People	1,667,217	1,167,932	461,078
Average age in years	28.8	31.6	30.8
Average number of children		4.0	
Children's years of birth		1936–2016	

Data sources: Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Table 3: Mortality regression results

Dependent variable:	Died within 1 year				Had a child die during the year	
Mean of dep. var. when no disaster occurred:	0.12				0.033	
Unit of observation:	One obs. per child				One obs. per woman per year when aged 15–44	
Observations:	4,053,898				14,777,658	
Disasters geocoded:	National		Local			
	(1)	(2)	(3)	(4)	(5)	(6)
Disaster occurred	–0.011*** (0.00045)	0.00096* (0.00055)	0.0014*** (0.00048)		0.00055*** (0.00015)	
Biological only				0.0039*** (0.00073)		0.0011*** (0.00023)
Climatological only				0.0011 (0.00083)		0.00077 (0.00029)
Geophysical only				–0.0054 (0.00040)		0.00094 (0.0012)
Hydrological only				0.00029 (0.00088)		–0.00053* (0.00027)
Meteorological only				–0.0052*** (0.0015)		–0.00010 (0.00041)
Multiple types				0.0019*** (0.00078)		0.00064** (0.00026)
Demographic controls		Yes	Yes	Yes	Yes	Yes
Country fixed effects		Yes	Yes	Yes	Yes	Yes
Year fixed effects		Yes	Yes	Yes	Yes	Yes
Country linear time trend		Yes	Yes	Yes	Yes	Yes
Constant	0.12*** (0.00037)	1.58** (0.63)	1.60** (0.63)	1.61*** (0.63)	0.076*** (0.18)	0.062*** (0.18)
R^2	0.00	0.024	0.024	0.024	0.027	0.027

Notes: In columns 2–4, demographic controls are child's sex, child's number of older siblings, mother's age, and mother's years of completed schooling. In columns 5–6, demographic controls are woman's age, years of completed schooling, and number of children. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2016), Database of Global Administrative Areas (GADM 2018), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Table 4: Fertility regression results

Dependent variable:	Number of children gave birth to within next 5 years				
Mean of dep. var. when no disaster occurred and no child died:	1.13				
Unit of observation:	One obs. per woman per year when aged 15–44				
Observations:	14,777,658				
Disasters geocoded:	Local				
	(1)	(2)	(3)	(4)	(5)
Child died	0.30*** (0.0019)		0.32*** (0.0026)		0.32*** (0.0026)
Disaster occurred		–0.0060*** (0.00073)	–0.0046*** (0.00073)		
Biological only				0.0026** (0.0011)	0.0042*** (0.0011)
Climatological only				–0.0076*** (0.0012)	–0.0059*** (0.0012)
Geophysical only				–0.0060 (0.0066)	–0.0058 (0.0067)
Hydrological only				–0.0025* (0.0014)	–0.0023 (0.0014)
Meteorological only				–0.031*** (0.0023)	–0.031*** (0.0023)
Multiple types				–0.0096*** (0.0012)	–0.0071*** (0.0012)
Child died × Disaster occ.			–0.047*** (0.0038)		
Biological only					–0.055*** (0.0058)
Climatological only					–0.052*** (0.0062)
Geophysical only					–0.017 (0.037)
Hydrological only					0.00055 (0.0081)
Meteorological only					0.033* (0.015)
Multiple types					–0.076*** (0.0059)
Demographic controls	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Country linear time trend	Yes	Yes	Yes	Yes	Yes
Constant	–26.21*** (1.08)	–26.05*** (1.08)	–26.20*** (1.08)	–26.07*** (1.08)	–26.07*** (1.08)
R^2	0.16	0.16	0.16	0.16	0.16

Notes: In columns 1–3, demographic controls are child's sex, child's number of older siblings, mother's age, and mother's years of completed schooling. In columns 4–6, demographic controls are woman's age, years of completed schooling, and number of children. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2016), Database of Global Administrative Areas (GADM 2018), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Table 5: Change in fertility following natural disasters

	Any disaster	Bio-logical	Climato-logical	Geo-physical	Hydro-logical	Meteoro-logical	Multiple types
I: Likelihood a woman loses a child							
In a year when no disaster occurs (A)	0.0329						
Change in likelihood when a disaster occurs (B)	0.0006	0.0011	0.0008	0.0009	-0.0005	-0.0001	0.0006
II: Average number of children over following five years							
After a year in which no child died and no disaster occurred (C)	1.1329						
Change in number when a child dies but no disaster occurs (D)	0.3179						
Change in number when a disaster occurs but no child dies (E)	-0.0046	0.0042	-0.0059	-0.0058	-0.0023	-0.0314	-0.0071
Additional change when a child dies and a disaster occurs (F)	-0.0471	-0.0551	-0.0523	-0.0169	0.0006	0.0330	-0.0764
III: A year in which a disaster does not occur							
Likelihood of losing a child: A	0.0329						
Births to women who did not lose a child: C	1.1329						
Births to women who lost a child: C+D	1.4508						
Births per woman (G): (1–A)C+A(C+D)	1.1434						
IV: A year in which a disaster occurs							
Likelihood of losing a child: A+B	0.0335	0.0340	0.0337	0.0339	0.0324	0.0328	0.0336
Births to women who did not lose a child: C+E	1.1284	1.1372	1.1270	1.1272	1.1306	1.1016	1.1258
Births to women who lost a child: C+D+E+F	1.3991	1.4000	1.3926	1.4281	1.4491	1.4524	1.3673
Births per woman (H): (1–A–B)(C+E)+(A+B)(C+D+E+F)	1.1374	1.1461	1.1360	1.1374	1.1410	1.1131	1.1339
V: Change in fertility following a natural disaster							
Change in births per 1,000 women: 1,000(H–G)	-6.0	2.7	-7.4	-6.0	-2.4	-30.3	-9.5
Percent change: (H–G)÷G	-0.5%	0.2%	-0.6%	-0.5%	-0.2%	-2.7%	-0.8%

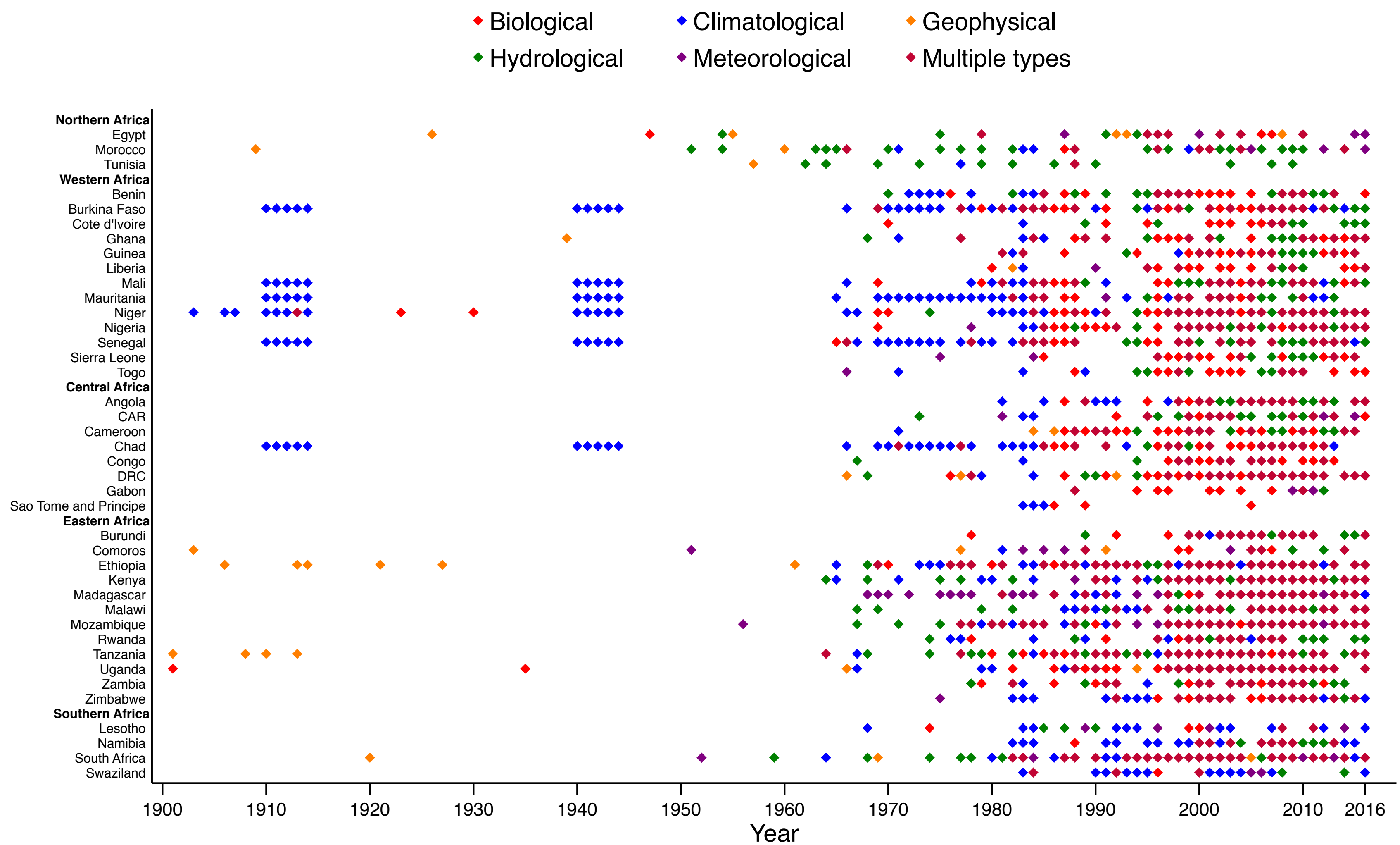
Notes: In columns 1–3, demographic controls are child's sex, child's number of older siblings, mother's age, and mother's years of completed schooling. In columns 4–6, demographic controls are woman's age, years of completed schooling, and number of children.
Data sources: Emergency Events Database (Guha-Sapir et al. 2016), Database of Global Administrative Areas (GADM 2018), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Table 6: Migration

	Area affected by disaster				Elsewhere in country			
	Migrated	Stayed	Difference	P-value	Migrated	Stayed	Difference	P-value
1987 flood in Lesotho								
Migrated between 1986 and 1996	12.1%				5.9%			
Age in years	27.4	26.7	0.7	0.841	27.9	30.7	-2.9	0.025
Male	42.3%	48.1%	-5.8%	0.578	44.0%	47.1%	-3.1%	0.381
Number of children	2.2	2.0	0.2	0.840	1.6	2.3	-0.7	0.006
Currently in school	50.0%	72.9%	-22.9%	0.331	59.5%	72.3%	-12.8%	0.090
Years of completed schooling	6.6	3.6	2.9	0.008	6.7	4.8	1.9	0.000
Currently working	40.9%	54.7%	-13.8%	0.246	55.4%	41.6%	13.8%	0.001
1989 drought in Rwanda								
Migrated between 1988 and 1991	1.2%				2.7%			
Age in years	22.6	20.2	2.5	0.046	22.9	21.0	1.9	0.004
Male	62.4%	49.3%	13.0%	0.000	55.2%	48.1%	7.1%	0.000
Number of children	2.1	3.5	-1.4	0.011	1.7	3.6	-1.9	0.000
Currently working	89.8%	92.6%	-2.8%	0.230	89.1%	94.2%	-5.1%	0.000
1994 flood in Egypt								
Migrated between 1993 and 1996	1.1%				1.0%			
Age in years	24.2	22.8	1.4	0.505	25.0	24.4	0.5	0.566
Male	52.7%	50.2%	2.5%	0.665	52.5%	51.2%	1.3%	0.597
Currently working	43.6%	40.5%	3.1%	0.643	49.2%	48.1%	1.1%	0.716

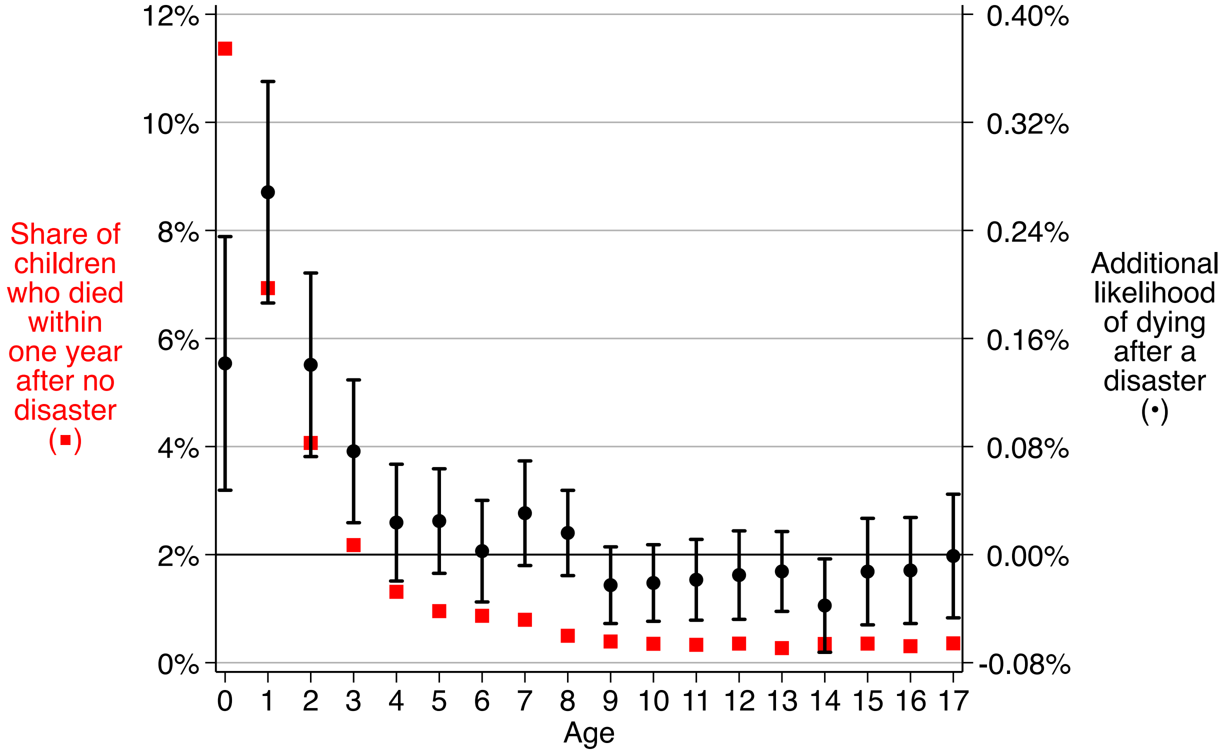
Notes: 1994 flood in Asyut, Sohag, Qena, Luxor governorates of Egypt. 1987 flood in Mokhotlong district of Lesotho. 1989 drought around Kigali in Rwanda. Governorate of residence in Egypt recorded in 1993 and 1996 in the 1996 census. District of residence in Lesotho recorded in 1986 and 1996 in the 1996 census. Province of residence in Rwanda recorded in 1988 and 1991 in the 1991 census. Currently in school recorded for children aged 5–17. Years of completed schooling recorded for adults aged 25 and older. Currently working recorded for adults aged 18–59. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2016), Database of Global Administrative Areas (GADM 2018), IPUMS-International (Minnesota Population Center 2018).

Figure 1: Incidence of natural disasters, by country



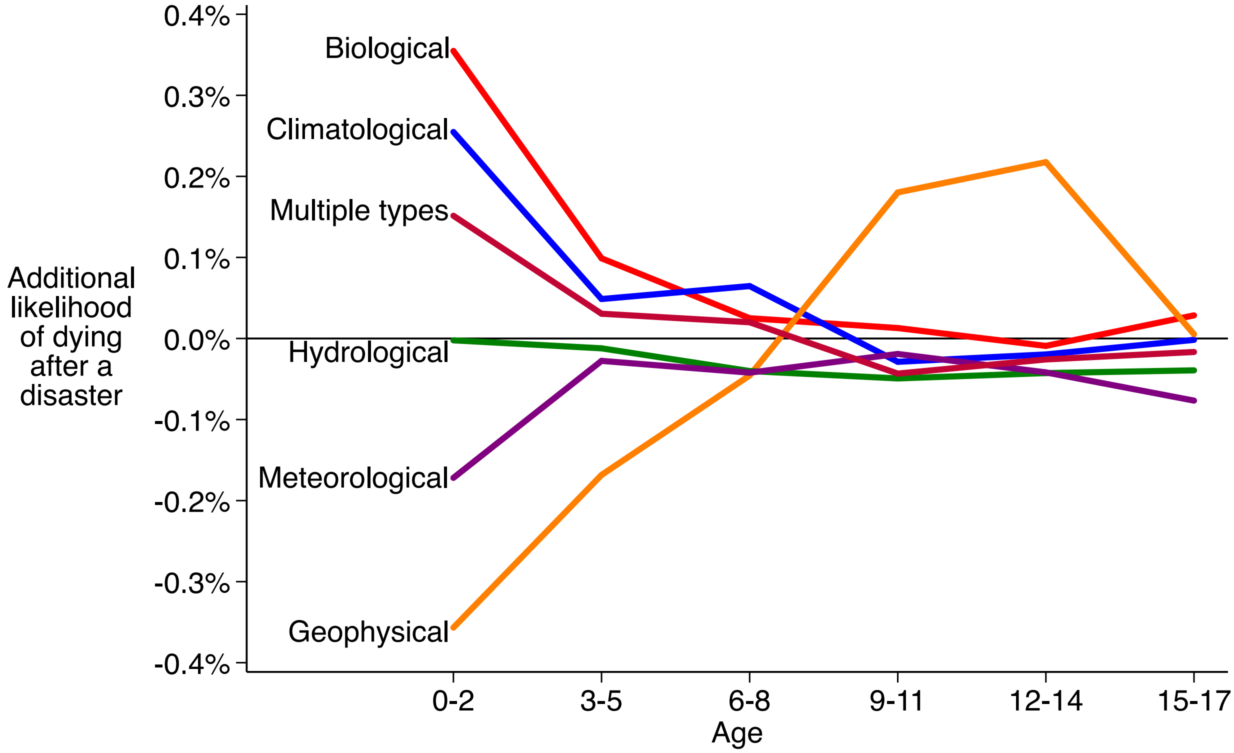
Data source: International Disasters Database (Guha-Sapir et al. 2016).

Figure 2: Natural disasters and child mortality



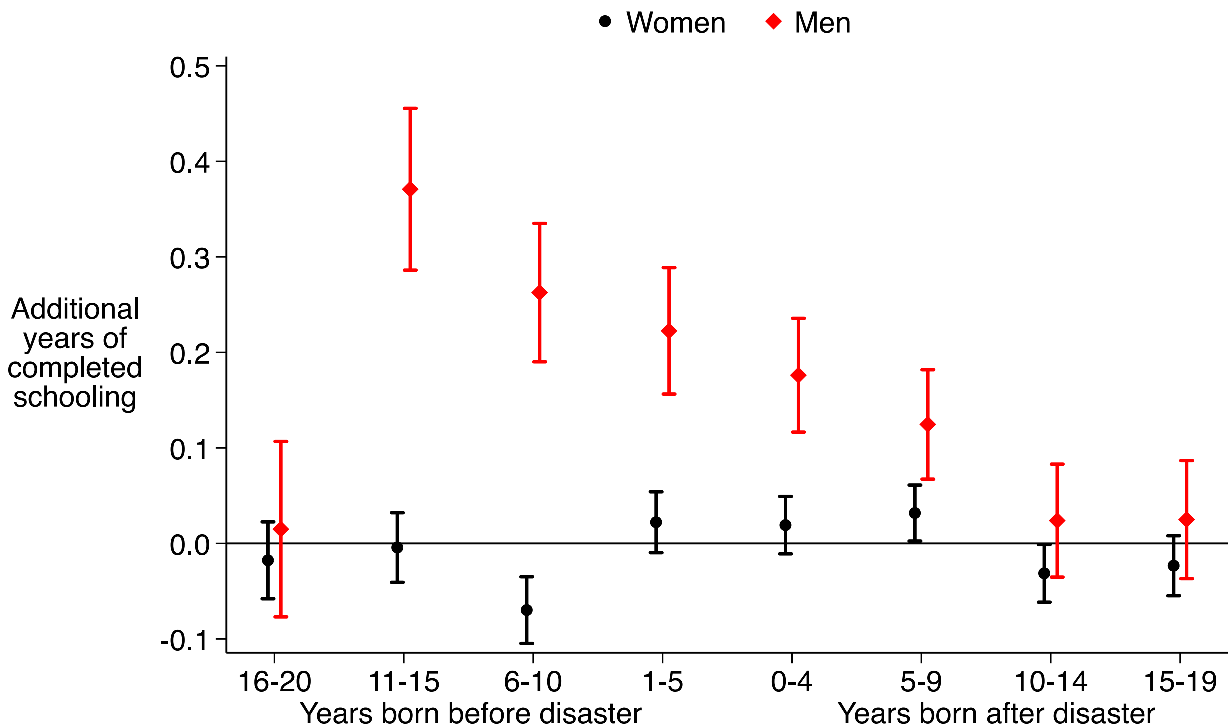
Data sources: Emergency Events Database (Guha-Sapir et al. 2016), Database of Global Administrative Areas (GADM 2018), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Figure 3: Types of natural disasters and child mortality



Data sources: Emergency Events Database (Guha-Sapir et al. 2016), Database of Global Administrative Areas (GADM 2018), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

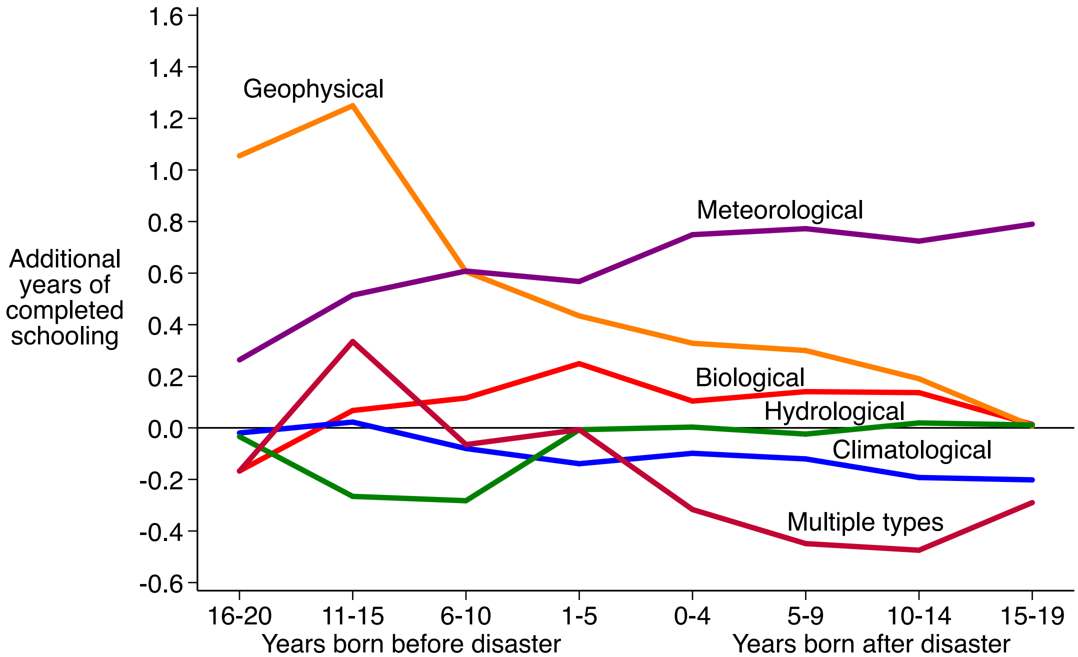
Figure 4: Natural disasters and educational attainment



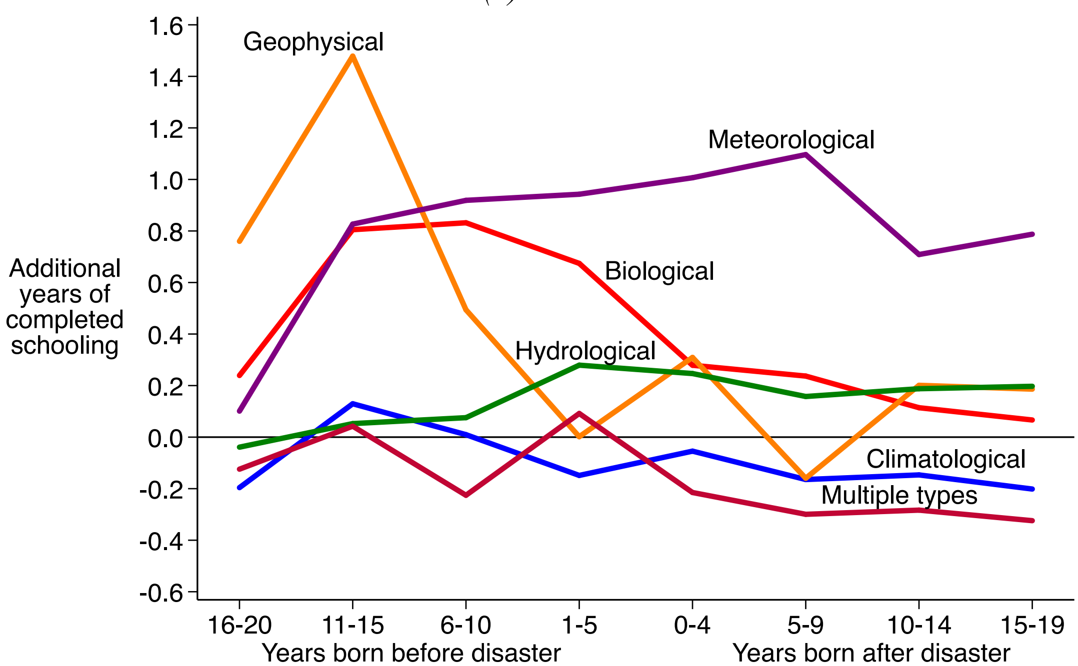
Data sources: Emergency Events Database (Guha-Sapir et al. 2016), Database of Global Administrative Areas (GADM 2018), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Figure 5: Types of natural disasters and educational attainment

(a) Women



(b) Men



Data sources: Emergency Events Database (Guha-Sapir et al. 2016), Database of Global Administrative Areas (GADM 2018), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Table A.1: Demographic surveys

Country	Surveys
Angola	DHS(2006,2011)
Benin	DHS(1996,2001,2006,2011) WFS(1981)
Burkina Faso	DHS(1993,1998,2003,2010,2014)
Burundi	DHS(1987,2010,2012)
Cameroon	DHS(1991,1998,2004,2011) WFS(1978)
Central African Rep.	DHS(1994)
Chad	DHS(1996,2004,2014)
Comoros	DHS(1996,2012)
Congo	DHS(2005,2009,2011)
Congo, Dem. Rep.	DHS(2007,2013)
Cote d'Ivoire	DHS(1994,1998,2005,2011) WFS(1980)
Egypt	DHS(1988,1992,1995,2000,2003,2005,2008,2014) WFS(1980)
Ethiopia	DHS(2000,2005,2011)
Gabon	DHS(2000,2012)
Ghana	DHS(1988,1993,1998,2003,2008,2014) WFS(1979)
Guinea	DHS(1999,2005,2012)
Kenya	DHS(1989,1993,1998,2003,2008,2014,2015) WFS(1977)
Lesotho	DHS(2004,2009,2014) WFS(1977)
Liberia	DHS(1986,2007,2009,2011,2013)
Madagascar	DHS(1992,1997,2003,2008,2011,2013,2016)
Malawi	DHS(1992,2000,2004,2010,2012,2014,2015)
Mali	DHS(1987,1995,2001,2006,2012,2015)
Mauritania	WFS(1981)
Morocco	DHS(1987,1992,2003) WFS(1980)
Mozambique	DHS(1997,2003,2009,2011)
Namibia	DHS(1992,2000,2006,2013)
Niger	DHS(1992,1998,2006,2012)
Nigeria	DHS(1990,2003,2008,2010,2013,2015)
Rwanda	DHS(1992,2000,2005,2007,2010,2013,2014)
Sao Tome & Principe	DHS(2008)
Senegal	DHS(1986,1992,1997,2005,2006,2008,2010,2012,2015) WFS(1978)
Sierra Leone	DHS(2008,2013)
South Africa	DHS(1998)
Swaziland	DHS(2006)
Tanzania	DHS(1991,1996,1999,2003,2004,2007,2010,2011,2015)
Togo	DHS(1988,1998,2013)
Tunisia	DHS(1988) WFS(1978)
Uganda	DHS(1988,1995,2000,2006,2009,2011,2014)
Zambia	DHS(1992,1996,2001,2007,2013)
Zimbabwe	DHS(1988,1994,1999,2005,2010,2015)

Data sources: Demographic and Health Survey (DHS, ICF International 1985–2017), World Fertility Survey (WFS, International Statistics Institute 1974–1981).