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. During a natural disaster, an average of 5.5 additional infants die for every 100,000 births. There are then 4.6 fewer births per 1,000 women within five years. Lifetime educational attainment rises by up to 0.05 years for people of schoolgoing age during a natural disaster. These changes are associated with various historical and contemporary government characteristics.

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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 2,577 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 who are very young are 0.7 percent more likely to die if they experience a natural disaster. There is then a decrease in fertility: Women living in areas affected by a natural disaster have 0.4 percent fewer children within five years than do women living in other areas. Finally, people who live through disasters as children complete a slight 0.05 additional years of schooling on average.

This study builds upon and contributes to four 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 in the 1990s and 2000s (Evans et al. 2010, Seltzer and Nobles 2017). For example, Nobles et al. (2015) track fertility in coastal areas of Indonesia before and after 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. When I restrict focus to several hundred particularly intense natural disasters in Africa, I similarly demonstrate a positive community-level fertility response, both among women who lost a child during the natural disaster and among women who did not lose a child. However, I further find that the average increase in fertility after losing a child is lower when the child dies during a natural disaster than when the child dies at other times. To my knowledge, this is the first study to document the dampening effect that disasters have on the fertility response to losing a child.

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, 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 storms are followed by the greatest decreases in fertility.

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 droughts, floods, storms, and other natural disasters, 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 storms over the past several decades have been associated with a small increase in child mortality in Africa. As these disasters become more frequent or intense over the next several decades, the costs to child health may rise.

Fourth, these findings suggest the question, what is the role of the state in helping communities prepare for or respond to natural disasters? I begin to answer this question by comparing the changes that follow natural disasters across pre-colonial, colonial-era, and post-colonial government characteristics. There is an extensive literature in economics and political science that measures the relationship between economic growth and the number of local government employees, state agencies, and other measures of state capacity (Acemoglu et al. 2015); between civil and external conflict and tax revenue (Besley and Persson 2008, Gennaioli and Voth 2015); and between fiscal capacity and economic growth (Dincecco and Katz 2014). Cingolani (2015) provides a more extensive review of state capacity, and Michalopoulos and Papaioannou review historical legacies of ethnic and government characteristics in Africa. I find that infant and child mortality rises following natural disasters in areas with legal systems based on British common law. Communities with historically complex local jurisdictional hierarchy experience large increases in fertility after natural disasters. Education particularly rises after natural disasters in areas that were democratic and had high tax revenue soon after colonial independence.

2. Data

2.1 Natural disasters

The Centre for Research on the Epidemiology of Disasters draws on a variety of government, United Nations, and Red Cross/Red Crescent reports to maintain the most globally comprehensive record of natural disasters. This Emergency Events Database records the location and timing of more than 14,000 natural disasters around the world since 1900 (Guha-Sapir et al. 2018). 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. Natural 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 2,577 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. The findings in this paper 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 countries. The Democratic Republic of the Congo has experienced 119 disasters, while Equatorial Guinea has experienced only one. Disasters are also not recorded evenly over time. Although much of the West African Sahel suffered from sustained drought in the early 1910s and again in the early 1940s, 98 percent of recorded disasters occurred over the last half of this period, since 1960. As depicted in Figure 2, the number of disasters per decade remained constant at less than 20 through the 1950s, then climbed starting in the 1960s, peaking at 1,053 in the 2000s. (Because the sample runs through 2016, the number of disasters falls in the 2010s.) Biological and hydrological natural disasters drove this increase, accounting for half of disasters in the 1960s and more than three-quarters of disasters in the 2010s. Although the frequency of natural disasters may have increased due to climate change or other factors in recent decades, the sharp increase in the number of recorded disasters suggests omission of older disasters. However, I do not know of an alternative source that more comprehensively records older disasters. The analyses in this paper focus on the period since 1960 when disasters appear more comprehensively recorded.

2.2 Administrative boundaries

The United Nations Food and Agriculture Administration's Global Administrative Unit Layers database records administrative boundaries in every country between 1990 and 2014 (FAO 2015). The database records the first and second sub-national administrative levels (generally provinces and districts, equivalent to states and counties in the United States), tracking any boundary changes over time. From these 25 years of boundaries, I construct harmonized district boundaries by joining any districts that overlap one another. Table 2 records the number of harmonized districts by country. The median number of districts per country is 49, the mean is 99, and each district has an average land area of 2,000 square miles (5,200 square kilometers). These harmonized boundaries allow me to control for unobserved district-specific characteristics in later regressions.

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. There are nearly 7,500 locations. For each location, I identify the district or districts that contain the location. For disasters that affect whole countries or that have no sub-national location recorded, I mark the disaster as having occurred in every district in the country. Figure 3 maps the incidence of each category of disaster. Biological and hydrological disasters (which, again, are typically epidemics and floods and are the most common categories of natural disasters) have affected nearly every country in Africa. Droughts and other climatological disasters, although less common, also occur widely across 48 countries. Storms and other meteorological disasters have occurred in 40 countries. Geophysical disasters are the most tightly concentrated, occurring primarily in areas of seismic activity in East Africa. Nearly every district in Africa has experienced at least one natural disaster.

The likelihood that a district hit by a disaster quickly experiences another varies substantially by category. Figure 4 presents these likelihoods by decade. Of districts that experienced an epidemic or other biological disaster in the 1960s and 1970s, 10 percent or fewer experienced another the following year. This share rose to 20 percent in the 1980s and 45 percent by the 2010s. Many epidemics last for years, explaining this high serial correlation. Droughts similarly can last for years, and of districts affected by climatological disasters, half or more again experience a disaster the following year. Earthquakes, storms, and other natural disasters do not last as long, so the other categories of disasters exhibit less correlation from one year to the next.

For nearly every category of disaster, the likelihood another disaster occurs rises over time. For example, 35 percent of districts affected by a biological disaster in the 1990s experienced another within one year, and more than 80 percent experienced another within ten years. Earthquakes and other geophysical disasters are the exception to this pattern. In most decades, geophysical disasters are largely uncorrelated over time. For all disasters pooled together, the duration between disasters has been remarkably consistent since the 1980s. About half of places that experience a disaster experience another the following year, and this share rises to 90 percent within ten years. Natural disasters are widespread and, even at the relatively narrow geographic level of districts, frequent.

2.3 Demographic information

Vital registries of births and deaths would offer a comprehensive record of fertility and mortality. However, such registries are largely unavailable in Africa. Instead, I use 175 World Fertility Surveys and Demographic and Health Surveys administered in Africa since 1977 (International Statistics Institute 1974–1981, ICF International 1985–2017). Table 3 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 subsequently died. I use these birth histories to measure fertility and child mortality. These surveys also record women's educational attainment, and many similarly record men's educational attainment.

Table 2 describes the sample of respondents. Of the 1.67 million women surveyed, 1.47 million provide birth histories. Women who provide birth histories have the same average age and years of schooling as all women surveyed, and are nearly two years younger and have 1.5 fewer years of schooling on average than the 461,000 men surveyed. The birth histories record births occurring between 1936 and 2016. Each woman has an average of three children, 8.6 percent of children die before reaching age 1, and 15 percent of children die before reaching age 18. The retrospective nature of birth history surveys introduces possible measurement error if a woman misreports a child's date of birth or, particularly for children who died at a young age long ago, omits mention of the child entirely. Although I cannot observe unreported children, 21 percent of children are recorded as having been born in a year ending in zero or five, barely above the expected 20 percent. This lack of heaping in children's reported years of birth suggests that misreporting of children's dates of birth may not be a substantial concern.

One-hundred and seventeen Demographic and Health Surveys, identified in bold in Table 3, record the latitude and longitude of the community in which each respondent lives. This geocoded sample is representative of the full sample across basic demographic characteristics: average age, years of schooling, number of children, infant mortality, and child mortality are all similar in the two sets of surveys. For most analyses, I focus on these geocoded surveys because they permit identification of whether each respondent lives in a sub-national administrative division in which a natural disaster occurred. Roughly two-thirds of these geocoded surveys additionally record the place in which each respondent was born, and about half of respondents are observed in the same place as where they were born. This sample with migration information is similar in age, educational attainment, and number of children to the broader samples. I focus on this final sample in analyses in section 4.3 that control for migration.

3. Main findings

3.1 Infant mortality

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

$$Died_{idy} = \alpha + \beta Disaster_{dy} + \boldsymbol{X'}_i\eta + \delta_d + \gamma_y + \varepsilon_{idy}. \tag{1}$$

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 district d, died by the end of the following year. $Disaster$

equals one if a natural disaster occurred in year y in district d where the child's mother lives. I restrict the sample to only surveys that are geocoded. The coefficient of interest, β, measures the change in the likelihood of dying in infancy for children born during a natural disaster compared to children born at other times and places. 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, mother's number of other children by year y, and mother's urban/rural location. Finally, the regression includes dummy variables for district of residence and child's year of birth, δ_d and γ_y. Because natural disasters are recorded at the district level, standard errors are clustered by district in this regression and in all subsequent regressions.

Column 1 of Table 5 provides the results of a bivariate regression of $Died$ on $Disaster$. Across the 3.02 million children born since 1960, those born during a natural disaster are 0.40 percentage points less likely to die within a year than are children born at other times. Given that 11 percent of children born at other places and times die within a year, this estimate indicates a 3.6 percent decrease in infant mortality during a natural disaster. The direction of this change is surprising, suggesting that natural disasters are associated with fewer infant deaths.

Column 2 adds demographic controls and district and year fixed effects. The covariates flip the estimated relationship between natural disasters and infant mortality from negative in column 1 to positive in column 2, suggesting that natural disasters tend to occur in time periods and affect places and women that generally have lower infant mortality. This change is consistent with a general improvement in infant mortality Africa that has accompanied the increase in the number of recorded disasters in recent decades (Ahmad et al. 2000). The estimated coefficient on $Disaster$ now indicates that being born during a natural disaster is associated with a 0.00055 percentage point increase in the likelihood of dying within a year, or

0.055 additional infant deaths per 1,000 births. This value is both small and statistically indistinguishable from zero.

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

$$Died_{idy} = \alpha + \sum_{j} \beta_j Disaster_{jdy} + \boldsymbol{X}'_i \eta + \delta_d + \gamma_y + \varepsilon_{idy}. \tag{2}$$

The coefficients of interest, β_j, separately measure the change in the likelihood of dying in infancy for children born during each category of disaster, j. As given in column 3, biological disasters are associated with 2.6 additional infant deaths per 1,000 births, and meteorological disasters are associated with a much smaller increase of 0.019 deaths. The other categories of disasters are associated with reductions of between 1.1 and 5.4 deaths per 1,000 births. Only the increase in infant mortality following biological disasters is statistically significant.

3.2 Child mortality

The left-hand y-axis in Figure 5 measures child mortality rates by age when no disaster occurs. Eleven percent of children aged zero die within a year. This value falls to 6.5 percent for children aged one, and continues to fall until flattening out at less than one percent after about age eight. These values 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. For children at each age, the right-hand y-axis in Figure 8 presents the estimated change in the likelihood of dying within a year when a disaster occurred in the place where the child's mother currently lives, compared to children at the same age living in other places. As in column 2 of

Table 5, children who experience a natural disaster when aged zero have very little additional chance of dying within a year compared to children aged zero who do not experience a natural disaster. A one-year old child living in an area that does not experience a natural disaster faces a 6.5 percent chance of dying within one year. For a child the same age who experiences a natural disaster, this likelihood rises by 0.045 percentage points, or 0.69 percent. Of every 1,000 one-year old children, 65 typically die within a year, and an additional 0.45 children die following a natural disaster. This disaster-related increase in mortality peaks at about 0.4 percentage points for children aged one and two, then remains within three percentage points of zero at older ages. At no age is the difference statistically significant.

As with infant mortality, the relationship between natural disasters and child mortality varies by category of disaster. Figure 6 presents the additional likelihood of dying within one year following a natural disaster, by three-year age group. For children aged 0–2, the chance of dying rises by less than 0.15 percentage points following biological, meteorological, and geophysical disasters, and falls very slightly following climatological disasters. Floods and other hydrological disasters are the exception and are associated with a decline in mortality of more than 0.4 percentage points for this youngest age group. At older ages, all types of disasters are associated with only small increases or decreases in child mortality.

In section 3.3, 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 urban/rural location, years of completed schooling, age in year y, and number of children by year y. In years in which no disaster occurs, 3.0 percent of women have a child die. As given in column 4 of Table 5, the likelihood of having a child die rises slightly by 0.000012 percentage points, or 0.04 percent, when a natural disaster occurs. As given in column 5, biological, geophysical, and meteorological disasters drive this positive relationship between natural disasters and the likelihood a woman loses a child. The estimated coefficients on climatological and hydrological disasters are negative, indicating that child mortality falls during droughts and floods. Again, I return to these estimates in the next section.

3.3 Fertility

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

$$\begin{aligned} Births_{idy} = \alpha + \beta_1 Died_{idy} + \beta_2 Disaster_{dy} + \beta_3 Died_{idy} \times Disaster_{dy} \\ + \boldsymbol{X'}_i \eta + \delta_d + \gamma_y + \varepsilon_{idy}. \qquad (3) \end{aligned}$$

There is one observation per woman each year she is aged 15–44. $Births$ records the number of children that woman i, surveyed while living in district d, 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 district d. There are three coefficients of interest: β_1 measures the change in fertility following the death of a child when no disaster occurs, β_2 measures the change in fertility following a year in which a woman does not lose a child but a natural disaster occurs, 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: urban/rural location, 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 district and year fixed effects, δ_d and γ_y.

Again, column 4 of Table 5 indicates that women are 0.04 percent more likely to lose a child during a natural disaster than at other times. Column 1 of Table 6 provides the results of specification 3 using $Died$ alone (excluding the $Disaster$ and interaction terms). Women have 0.69 additional children on average in the five years following the death of a child. Together, these estimates indicate that women are slightly more likely to lose a child during a natural disaster, and have substantially more children on average following the death of a child. All else equal, this positive fertility response to losing a child would lead to more births following natural disasters.

All else is not equal. Column 2 of Table 6 provides the results of specification 3 using $Disaster$ alone (excluding the $Died$ and interaction terms). Compared to years in which a disaster did not occur, there are an average of 4.6 fewer births per 1,000 women in the five years following a natural disaster. Column 3 presents the results of full specification 3. Women have 0.72 additional children on average in the five years following a year in which a child died but no disaster occurred, but the magnitude of this increase in fertility falls by 0.071 children if the child died during a disaster. The positive fertility response to a child's death weakens by 10 percent if the child dies during a natural disaster. When a disaster occurs but no child dies, women have 0.0024 fewer children on average within five years.

These estimates explain why fertility falls after natural disasters. First, fertility falls among women who do not lose a child. Second, although child mortality increases slightly during natural disasters and fertility rises following a child's death, this mortality-related increase in fertility weakens during a natural disaster. The calculations in Table 7 identify the relative contribution of these two factors in explaining the fall in fertility. Panels I and II in column 1 repeat values from column 4 of Table 5 and column 3 of Table 6. Panel III uses these values to calculate that, among all children born in the five years following a year in which a natural disaster does not occur, 4.63 percent are born to women who lost a child during that year. Panel IV similarly calculates that, in the five years following a natural disaster, 4.48 percent of children are born to a mother who lost a child during the natural disaster. The difference between these values, –0.15 percentage points, indicates that the share of children born into families that lost a child falls after a natural disaster. Even though there are more such families, their fertility response is smaller than the community-level decrease in fertility.

I perform similar comparisons by disaster category using the following specification:

$$Births_{idy} = \alpha + \beta_1 Died_{idy} + \sum_j \beta_{2,j} Disaster_{jdy} + \sum_j \beta_{3,j} Died_{idy} \times Disaster_{jdy} + \boldsymbol{X'}_i \eta + \delta_d + \gamma_y + \varepsilon_{idy}. \quad (4)$$

As with equation 2, this regression now estimates changes in fertility following each category, j, of disaster. Column 4 of Table 6 reports the results from a regression of $Births$ on indicator variables for each disaster (excluding the $Died$ and interaction terms). Aggregate fertility increases after biological and geophysical disasters, and falls after climatological, hydrological, and meteorological disasters. The magnitude of these changes is largest at 14 fewer births per 1,000 women following storms and other climatological disasters. Column 5 reports the results from full equation 4. As in column 3, these estimates identify the relative contributions of child mortality, disasters, and their interaction. Again, when no disaster occurs, women who lose a child have 0.72 more children on average over the following five years than do women who do not lose a child. When biological, climatological, or hydrological disasters occur, this child mortality-related increase in fertility diminishes by up to 0.090 children per woman (or 12.5

percent) following climatological disasters. The fertility response to losing a child strengthens following geophysical and meteorological disasters. As given in Table 7, children born following biological, climatological, and hydrological disasters are between 2.0 and 4.6 percent less likely to be born into a family that just lost a child. Conversely, children born following geophysical and meteorological disasters are more likely to be born into families that just lost a child.

3.4 Educational attainment

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

$$Educ_{idy} = \alpha + \beta Disaster_{dy} + \boldsymbol{X'}_i\eta + \delta_d + \gamma_y + \varepsilon_{idy}. \quad (5)$$

I restrict the sample to people observed as adults (aged 25–79) who have plausibly completed their schooling, and I perform the regression separately at each age between zero and 20. $Educ$ records the years of schooling completed by person i, who was surveyed while living in district d and was age a in year y. $Disaster$ equals one if a natural disaster occurred in district d in year y. The coefficient of interest, β, measures the change in average years of completed schooling for people aged a when a disaster occurred, relative to all other people who did not experience a disaster at age a. The regression also includes a vector, $\boldsymbol{X}$, of demographic characteristics: the person's sex, and the person's urban/rural location. Finally, the regression includes country and year fixed effects, δ_d and γ_y.

Figure 7 provides the coefficient on $Disaster$ from equation 5, estimated separately at each age between zero and 20. People aged zero during a natural disaster complete less than

0.01 fewer years of schooling by adulthood, relative to people who did not experience a natural disaster as infants. This difference remains small for children below schoolgoing age, and for high school-aged children. However, for primary school-aged children, the difference is positive, indicating that living through a disaster at those ages is associated with increased educational attainment by up to 0.05 years. In unreported results, I find that the increase is similar for men and women. Although statistically significant at ages 6–10, the increase is small relative to the average of 4.8 years of schooling completed by women and 6.2 by men.

I estimate the relationship between each category of natural disaster and educational attainment using the following specification:

$$Educ_{idy} = \alpha + \sum_{j} \beta_j Disaster_{jdy} + \boldsymbol{X'}_i \eta + \delta_d + \gamma_y + \varepsilon_{idy}. \tag{6}$$

The coefficients of interest, β_j, separately measure the change in years of completed schooling for people aged a during each category of disaster, j, relative to people who did not experience a disaster at age a. As given in Figure 8, children who live through meteorological disasters complete up to 0.36 additional years of schooling. These storms drive the overall association between natural disasters and educational attainment. For all other categories of disasters, there is little change in educational attainment.

4. Heterogeneity and robustness

4.1 Comparison by decade

The main results in section 3 are calculated using all available disasters since 1960. In this section, I compare demographic changes following disasters by repeating equations 1 through 6 by decade. The first panel of Figure 9 presents the additional likelihood that an infant dies within one year of a natural disaster, compared to infant mortality at other times. (Because there are relatively fewer disasters in the 1960s and 1970s, the confidence intervals are correspondingly wide and are omitted so that their scale does not overwhelm the confidence intervals in later decades.) In the 1960s, natural disasters were associated with 5 fewer infant deaths per 1,000 births. This negative relationship weakened over time, and by the 2010s there were 6 additional deaths per 1,000 births during a natural disaster. Conversely, child mortality falls following natural disasters in the 2010s (although the decrease is not statistically significant), suggesting that fertility fell for older children. Since the 1970s, fertility consistently decreases following natural disasters and lifetime educational attainment increases among children who experience a disaster when aged 6–14. (There are no education estimates for the 2000s and 2010s because few children in these decades reached adulthood in time to be surveyed). These comparisons suggest that no decade alone drives the findings in section 3.

Figure 10 presents demographic changes following disasters by decade, but separated by category of disaster. Because there were few disasters in any single category in the 1960s and 1970s, few geophysical disasters in the 1980s and 2010s, and few meteorological disasters in the 2010s, only the remaining estimates are presented. Biological and climatological disasters drive the overall increase in infant mortality following natural disasters in the 2010s, while hydrological disasters were associated with a decline in child mortality. However, no disaster category is consistently and substantially associated with a particular demographic change. For example, fertility increases slightly following biological disasters in the 1980s and 2002, but decreases slightly following biological disasters in the 1990s and 2010s.

4.2 Intensity of disasters

The disaster database records the number of deaths associated with 67 percent of disasters and the number of people affected by 83 percent of disasters. I designate as intense any disaster in which 100 or more people died, or 50,000 or more people were affected. Figure 11 depicts the incidence of intense disasters since the 1960s. Apart from an increase in the 1980s and 1990s, the share of disasters with 100 or more deaths fell from 19 percent in the 1960s to 9 percent in the 2010s. Apart from increases in the 1970s and 2010s, the share of disasters that affected 50,000 or more people decreased from 25 percent in the 1960s to a 17 percent in the 2000s. The share of disasters that satisfy either criterion similarly declined over time, from 42 percent in the 1970s to a 24 percent in the 2000s. Again, the total number of disasters rose tenfold from the 1960s to the 2000s. Intense disasters increased as well, but not as much. If differential reporting of disasters accounts for the large increase in recorded disasters over time, intense disasters may be less susceptible to underreporting in earlier decades or overreporting in later decades.

To compare the consequences of disasters that are intense with those that are not, I again repeat equations 1 through 6, but with two disaster dummy variables: One that indicates an intense disaster occurred in the given year, another that indicates one or more disasters occurred, none of which were intense. Figure 12 depicts the difference between the estimated coefficients, interpreted as the average demographic change following intense disasters minus the change following disasters that are not intense. Except for biological disasters, intense disasters are associated with increased infant and child mortality. Children are substantially more likely to die during an intense disaster. Similarly, fertility particularly rises and educational attainment particularly falls after intense disasters. These final two changes mirror the large increases in fertility and decreases in educational attainment that Nobles et al. (2015) and Caruso (2017) document following intense natural disasters in Indonesia and Latin America.

4.3 Migration

Boustan et al. (2012) and Drabo and Mbaye (2014) document increased emigration out of areas affected by natural disasters in the United States and around the world. It is therefore of particular concern that the findings in this paper could be driven by selection into migration following natural disasters, rather than any actual changes in mortality, fertility, or educational attainment. I investigate this concern by repeating equations 1 through 6 for just the sample of respondents that are recorded as being born in the same place as they currently live. As indicated in Table 3, roughly two-thirds of geocoded surveys record this basic information, and respondents to these surveys do not differ substantially from the broader set of respondents across age, educational attainment, or number of children. Although the surveys do not record full migration histories, and therefore do not allow exact identification of whether a person directly experienced a particular disaster, people who were born and reside in the same place provide a more accurate sample of people who experienced disasters.

Figure 13 presents changes in mortality, fertility, and educational attainment following natural disasters for three samples: People with geocoded surveys (the full sample used in all results thus far), people with migration status recorded, and people who were born and reside in the same place. For mortality and fertility, place of birth refers to the mother. For all disasters pooled together, educational attainment exhibits the most substantial changes when focus is restricted to only people who have not migrated. In the full sample, disaster exposure is associated with a slight but statistically significant increase in educational attainment. Among people who were born and live in the same place, disaster exposure is associated with a slight but statistically significant decrease in educational attainment. It is therefore possible that education declines for people affected by disasters, but people with lower education tend to emigrate from disaster-affected areas, leaving higher education people behind. In all other comparisons in Figure 13, estimates generally vary only slightly across the three samples, and with much smaller magnitude than the variation across disaster categories.

The collection of demographic surveys in this paper record whether a person was born in the same place as they currently reside, but generally do not generally record place of birth for people who have moved. The surveys therefore cannot be used to compare people who remain behind after a natural disaster to those who leave. I use national census data to perform such a comparison following a 1987 flood in Lesotho, a 1989 drought in Rwanda, and a 1994 flood in Egypt (Minnesota Population Center 2018). As given in Table 8, 12 percent of residents of affected areas in Lesotho 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, leading to a downward bias in the educational attainment observed only among those who remain behind. Compared to migrants from other parts of the country, migrants out of drought-affected areas have more children on average, which again would lead to a downward bias in apparent fertility among those who remain behind. Conversely, emigrants out of drought-affected areas in Rwanda have fewer children, which would suggest upward bias in estimates of the fertility changes following disasters. Although limited, this evidence does not suggest that migrants out of disaster-affected areas are consistently and overwhelmingly selected in a way that explains the main findings in section 3.

4.4 Administrative division level

All findings thus far use disasters geocoded at the district level. Figure 14 compares the findings when disasters are instead coded at the province and national levels. In each case, only geocoded demographic surveys that record the latitude and longitude of each respondent are used. Figure 11 also presents estimates when disasters are coded at the national level and all surveys are used, meaning that anyone living in a country is recorded as affected by a disaster that occurs anywhere in the country. These estimates come from regressions identical to specifications 1 through 6, except with province or country fixed effects in place of district fixed effects. There is little consistent difference in the estimates. For example, biological disasters are more positively and strongly associated with child mortality when coded at the country level, while the reverse holds for meteorological disasters.

5. Government characteristics

In the previous two sections, I document changes in child mortality, fertility, and educational attainment that accompany natural disasters in Africa. These findings suggest the question, why do these demographic changes occur, and what can be done to weaken or strengthen them? As a first step towards answering this question, in this section I document the relationship between these demographic changes and various government characteristics in the pre-colonial, colonial, and post-colonial eras.

Africa comprises hundreds of ethnic groups. The anthropologist George Murdock drew from thousands of reports and other documents from the late nineteenth and early twentieth centuries to generate a map of historical ethnic group boundaries in Africa (Tribal Map of Africa, Murdock 1959) and a database of pre-colonial characteristics of many of these groups (Ethnographic Atlas, Murdock 1967). Although there is substantial evidence that colonization and the slave trade shaped ethnic identity, and corresponding concern about the accuracy of this database as truly recording pre-colonial characteristics, economists have used this information to study the development of institutions in Africa and their relationship with economic growth, gender roles, and political representation (Bolt 2010, Nunn and Wantchekon 2011, Alesina et al. 2013, Fenske 2013, Michalopoulos and Papaioannou 2014, Bentzen et al. 2017, Michalopoulos and Papaioannou 2018).

I use two government characteristics recorded in Murdock's database: levels of jurisdictional hierarchy at the local level, and levels of jurisdictional hierarchy beyond the local level. These two levels of hierarchy are each recorded for 90% of ethnic groups in the database. Jurisdictional hierarchy at the local level ranges from nuclear family to clan. I record as complex any group with local organization above the level of nuclear family. Bolt (2010) argues that these local community structures provided, and may continue to provide, important insurance and solidarity functions. Jurisdictional hierarchy above the local level ranges from zero to four levels. Following Gennaioli and Rainer (2007), I record as centralized any group with two or more levels of hierarchy beyond the local level. Figure 15 compares the distribution of complex and centralized societies. There is a mix of complex and simple jurisdictional hierarchy at the local level everywhere except in West Africa, where nearly all groups are complex. There is a similar distribution of centralized and decentralized hierarchy beyond the local level everywhere except in Central Africa, where nearly all societies are decentralized.

La Porta et al. (1999) demonstrate that countries with legal systems of British, German, or Scandinavian (as opposed to French or socialist) origin exhibit improved governance today. Besley and Persson (2009) similarly demonstrate a relationship between legal origins and present-day protection of property rights and tax system, and many other studies demonstrate the relationship between legal origins and current economic, political, and legal conditions (La Porta et al. 2008). Although many parts of Africa were formally colonized only in the late 1800s, European presence in Africa began in the 1400s, and colonial borders changed over time (Michalopoulos and Papaionnou 2018). Still, legal system origins are tied to colonial identity. As depicted in Figure 16, 20 African countries have a legal system that originates in British common law, the rest in French civil law (La Porta et al. 1999, La Porta et al. 2008).

Finally, I consider two measures of post-colonial state capacity: democratization, and tax revenue as a share of GDP. Fearon and Laitin (2003) find that democratic countries are slightly more likely to others to experience civil war, although the difference is not statistically significant. Dincecco and Prado (2012) find that democracies and countries with higher tax revenue have greater economic performance, and Besley and Persson (2009) demonstrate that tax revenue is associated with legal system origin. As in Fearon and Laitin (2003) and Dincecco and Prado (2012), I measure democratization using the Polity2 index in the Polity IV database (Center for Systemic Peace 2018). The index measures the degree to which a government is autocratic (negative values) or democratic (positive values). I code a country as democratic if this index is greater than zero for five or more of the first ten years after independence (or after 1960 if the country achieved independence before 1960).[1] The World Bank reports tax revenue as a share of GDP starting in 1972 (World Bank 2019). I code a country has having high tax revenue if tax revenue as a share of GDP exceeds an average of 15 percent across the first ten years since independence or since 1972. Figure 17 compares the distribution these two measures of post-colonial state capacity. Both are concentrated in Southern Africa.[2]

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[1] The value of the index remains consistently below or above zero over the whole period in all countries in Africa except Benin, Comoros, Congo, Kenya, Lesotho, Nigeria, Sierra Leone, Somalia, Sudan, Uganda, and Zambia. The choice of cutoff of five years therefore matters little.

[2] Importantly, because countries gained independence at different times, these measures refer to different countries at different times. For example, Ghana gained independence from the United Kingdom in 1957, and experienced a series of coups before stable elections began in 1992. Ghana is therefore coded as autocratic. Although nominally independent for many decades, South Africa's independence is commonly identified as beginning with the first election with universal suffrage in 1994. South Africa is therefore recorded as democratic.

I estimate how demographic changes following natural disasters vary across government characteristics using the following specification:

$$Outcome_{idy} = \alpha + \beta Disaster_{dy} + \delta State_d + \theta Disaster_{dy} \times State_d$$

$$+\boldsymbol{X'}_i\eta + \gamma_y + \varepsilon_{idy}. \qquad (7)$$

There is one observation per child i, or one observation per woman i each year she is aged 15–44, or one observation per person i each year y they are between the ages of six and 14. $Outcome$ records the demographic characteristics considered in sections 3 and 4: whether a child born in year y dies by the end of the end of the next year, whether a woman has a child die during year y, the number of children born to a woman within five years of year y, or the number of years of schooling completed by adulthood. $Disaster$ equals one if a disaster occurred in district d in year y. $State$ records state capacity, and I consider five measures of state capacity: complex pre-colonial jurisdictional hierarchy at the local level, centralized pre-colonial jurisdictional hierarchy beyond the local level, British colonial-era legal origins, democratic more than half of the first ten years following independence, and tax revenue at least 15 percent of GDP during half of the first ten years following independence. The coefficient of interest, θ, records the additional demographic change following a natural disaster in an area with the indicated state capacity characteristic, compared to other areas that experience a natural disaster. The regression also includes demographic characteristics, $\boldsymbol{X}$, of the child, woman, or person; and year of birth or year of observation fixed effects, γ_y. Because government characteristics are generally observed at the country level, equation 7 omits district fixed effects from the earlier regressions.

Figure 18 presents the demographic changes that follow natural disasters in areas with each government characteristic, minus the changes that follow natural disasters in other areas.

There are 10 additional births per 1,000 women following disasters in areas with complex pre-colonial jurisdictional hierarchy, relative to disasters in other areas. There is similarly slightly lower educational attainment for children aged 6–14 during the disasters. Conversely, centralized pre-colonial jurisdictional hierarchy, which again indicates two or more levels of hierarchy above the local level, is associated with a 5 fewer births per 1,000 women and slightly higher educational attainment. This finding, that education rises following natural disasters particularly in areas with greater pre-colonial centralization, agrees with Gennaioli and Ranier (2007), who show that infrastructure, education, and other public goods are better provided today in these areas.

Infant mortality, child mortality, fertility, and educational attainment all particularly rise in areas with a legal system based in British common law, relative to changes that follow disasters in areas based in French civil law. Democratic countries and countries with high tax revenue are similarly associated with increases in educational attainment following natural disasters. These changes of up to 0.35 years of schooling are substantially larger than the overall increase of up to 0.05 years of schooling following all natural disasters, indicating that disasters are associated with declines in education in autocratic countries or countries with low tax revenue.

I use the following specification to estimate the relationship between state capacity and demographic changes following each category of natural disaster:

$$Outcome_{idy} = \alpha + \sum_j \beta_j Disaster_{jdy} + \delta State_d + \sum_j \theta_j Disaster_{jdy} \times State_d$$

$$+\boldsymbol{X'}_i\eta + \gamma_y + \varepsilon_{idy}. \qquad (5)$$

Figure 19 depicts the estimated coefficients of interest, θ_j, that record the change in each demographic outcome associated with disaster category j. The positive relationship between natural disasters and educational attainment in democratic or high-tax revenue countries holds for all types of disasters except meteorological. For other government characteristics and outcomes, the evidence is more mixed. For example, infant mortality particularly rises following meteorological disasters in areas with historically complex societies, following biological and meteorological disasters in areas with legal systems based in British common law, and following biological, hydrological, and meteorological disasters in democratic countries.

Discussion

This paper documents, for the first time, demographic changes following a variety of natural disasters in Africa. Young children are up to 0.70 percent more likely to die during a natural disaster than at other times. The number of children born per woman falls by 0.36 percent in the five years following a natural disaster, and this decrease in fertility is concentrated among women who had a child die during the disaster. Lifetime educational attainment rises by up to 0.05 years for people who were of schoolgoing age during a disaster.

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 emergency response or is sparsely populated.

Further study should explore mechanisms that connect natural disasters to changes in mortality, fertility, and educational attainment. The community-level rise in fertility following natural disasters is particularly notable. As Nobles et al. (2015) propose in explaining a similar community-level fertility increase following the 2004 tsunami in Indonesia, this response may indicate that a community-wide ethic of shared responsibility extends to population rebuilding, particularly following intense disasters. However, I also find that women who lose a child are 10 percent less likely to have another child within five years if the child died during a natural disaster, compared to women who lose a child at other times. I do not yet have an explanation for this negative interaction between disasters and fertility among women who have a child die.

Further study should also explore the causes of differential demographic changes following various categories of natural disasters. Infant mortality rises most substantially during epidemics and other biological disasters, but falls during earthquakes and other geophysical disasters. Fertility rises after biological disasters bur falls especially after storms and other meteorological disasters. Meteorological disasters account for the small overall increase in educational attainment, but educational attainment decreases following floods and other hydrological disasters.

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

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

Note: See section 2.1. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2018).

Table 2: Harmonized second-level administrative divisions recorded in GIS maps

Country	Divisions	Country	Divisions
Algeria	1,541	Mali	50
Angola	159	Mauritania	44
Benin	77	Mauritius	10
Botswana	10	Mayotte	1
Burkina Faso	45	Morocco	40
Burundi	133	Mozambique	144
Cameroon	49	Namibia	98
Cape Verde	22	Niger	38
Central African Rep.	70	Nigeria	486
Chad	52	Reunion	2
Comoros	3	Rwanda	30
Congo	45	Saint Helena	6
Congo, Dem. Rep.	48	Sao Tome & Principe	2
Cote d'Ivoire	21	Senegal	26
Djibouti	11	Seychelles	60
Egypt	343	Sierra Leone	13
Equatorial Guinea	7	Somalia	74
Eritrea	58	South Africa	52
Ethiopia	60	South Sudan	46
Gabon	48	Sudan	87
Gambia	39	Sudan Disputed	1
Ghana	109	Swaziland	54
Guinea	34	Tanzania	148
Guinea-Bissau	40	Togo	20
Kenya	62	Tunisia	261
Lesotho	247	Uganda	290
Liberia	135	Western Sahara	2
Libya	25	Zambia	72
Madagascar	111	Zimbabwe	58
Malawi	28		

Note: See section 2.2. *Data source*: Global Administrative Unit Layers (FAO 2015).

Table 3: 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**)

Note: Geocoded surveys are in bold. See section 2.3. *Data sources*: Demographic and Health Survey (DHS, ICF International 1985–2017), World Fertility Survey (WFS, International Statistics Institute 1974–1981).

Table 4: Characteristics of demographic survey data

	All surveys			Geocoded surveys			Geocoded surveys that record migration		
	Women	Women who provide birth histories	Men	Women	Women who provide birth histories	Men	Women	Women who provide birth histories	Men
Countries	40	40	34	34	34	31	29	29	26
Surveys	175	153	109	117	99	81	67	64	47
Years of survey	1977–2016	1977–2016	1991–2016	1986–2016	1986–2016	1991–2016	1988–2016	1988–2016	1992–2016
People	1,667,217	1,472,021	461,078	1,229,260	1,068,866	381,124	699,225	648,928	214,700
Avg. age	28.8	28.8	30.8	28.9	28.8	30.8	28.9	28.9	30.3
Avg. years of schooling	4.6	4.6	6.1	4.8	4.7	6.2	4.6	4.5	6.4
Share born same place as live	0.48	0.48	0.52	0.48	0.49	0.52	0.48	0.49	0.52
Avg. num. of children		3.0			2.9			3.0	
Children's years of birth		1936–2016			1950–2016			1953–2016	
Share children died age <1		0.086			0.083			0.089	
Share children died age <18		0.15			0.15			0.16	
Share children born yr. 0 or 5		0.21			0.21			0.21	

Notes: Only Demographic and Health Surveys are geocoded. See section 2.3. *Data sources*: Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Table 5: Changes in child mortality during natural disasters

Dependent variable:	Died within 1 year			Had a child die during the year	
Mean of dependent var. when no disaster occurred:	0.11			0.030	
Unit of observation:	One observation per child aged 0			One observation per woman per year when aged 15–44	
Observations:	3,021,148			11,294,830	
	(1)	(2)	(3)	(4)	(5)
Disaster occurred	–0.0040***	0.0000055		0.000012	
	(0.00089)	(0.00050)		(0.00015)	
Biological			0.0026***		0.00085***
			(0.00061)		(0.00019)
Climatological			–0.0011		–0.00018
			(0.00082)		(0.00024)
Geophysical			–0.0054		0.0012
			(0.0036)		(0.0011)
Hydrological			–0.0020		–0.00096***
			(0.00082)		(0.00026)
Meteorological			0.000019		0.00058*
			(0.0013)		(0.00033)
Demographic controls		Yes	Yes	Yes	Yes
District fixed effects		Yes	Yes	Yes	Yes
Year fixed effects		Yes	Yes	Yes	Yes
Constant	0.11***	0.11***	0.11***	0.031***	0.031***
	(0.00011)	(0.00019)	(0.00019)	(0.000052)	(0.000052)
R^2	0.000	0.029	0.029	0.028	0.028

Notes: In columns 2–3, demographic controls are child's sex, child's number of older siblings, mother's age, mother's years of completed schooling, and mother's urban/rural location. In columns 4–5, demographic controls are urban/rural location, woman's age, years of completed schooling, and number of children. See sections 3.1 and 3.2. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Table 6: Changes in fertility following natural disasters

Dependent variable:	Number of children gave birth to within next 5 years				
Mean of dependent var. when no disaster occurred and no child died:	1.28				
Unit of observation:	One observation per woman per year when aged 15–44				
Observations:	11,294,830				
	(1)	(2)	(3)	(4)	(5)
Child died	0.69***		0.72***		0.72***
	(0.0053)		(0.0059)		(0.0059)
Disaster occurred		–0.0046***	–0.0024		
		(0.0015)	(0.0014)		
Biological				0.010***	0.012***
				(0.0021)	(0.0021)
Climatological				–0.0086***	–0.0067**
				(0.0032)	(0.0031)
Geophysical				0.0034	0.017
				(0.0086)	(0.0086)
Hydrological				–0.0013	0.00026
				(0.0026)	(0.0026)
Meteorological				–0.014***	–0.016***
				(0.0031)	(0.0031)
Child died × Disaster occ.			–0.071***		
			(0.0053)		
Biological					–0.090***
					(0.0062)
Climatological					–0.055***
					(0.0076)
Geophysical					0.038
					(0.039)
Hydrological					–0.032***
					(0.0086)
Meteorological					0.072***
					(0.014)
Demographic controls	Yes	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Constant	1.29***	1.31***	1.29***	1.31***	1.29***
	(0.00016)	(0.00053)	(0.00053)	(0.00053)	(0.00054)
R^2	0.21	0.20	0.21	0.20	0.21

Notes: Demographic controls are years of completed schooling, age, number of children, urban/rural location. See section 3.3. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Table 7: Changes in fertility following natural disasters

	(1)	(2)	(3)	(4)	(5)	(6)
	Any disaster	Bio-logical	Climato-logical	Geo-physical	Hydro-logical	Meteoro-logical
I. Likelihood a woman has a child die in year y						
If no disaster occurs: A	0.030174					
Additional likelihood if a disaster occurs: B	0.000012	0.000849	-0.000182	0.001198	-0.000960	0.000579
II. Number of children per woman over the next five years						
If no disaster occurred and the woman did not lose a child in year y: C	1.277722					
Additional number if the woman lost a child in year y: D	0.717619					
Additional number if a disaster occurred in year y: E	-0.002373	0.012452	-0.006696	0.001694	0.000257	-0.015753
Additional number if a disaster occurred and the woman lost a child in year y: F	-0.071097	-0.089952	-0.055009	0.038496	-0.031522	0.072388
III. A year in which no disaster occurs						
Likelihood a child does not die: G=1–A	0.969826					
Likelihood a child dies: H=A	0.030174					
Subsequent number of children per woman who didn't lose a child: I=C	1.277722					
Subsequent number of children per woman who lost a child: J=C+D	1.995341					
Share of children born to women who lost a child: L=(H×J)÷(G×I+H×J)	0.046335					
IV. A year in which a disaster occurs						
Likelihood a child does not die: M=1–A–B	0.969814	0.968977	0.970009	0.968628	0.970787	0.969247
Likelihood a child dies: N=A+B	0.030186	0.031023	0.029991	0.031372	0.029213	0.030753
Subsequent number of children per woman who didn't lose a child: O=C+E	1.275349	1.290175	1.271026	1.279416	1.277979	1.261969
Subsequent number of children per woman who lost a child: P=C+D+E+F	1.921871	1.917842	1.933635	2.035531	1.964076	2.051976
Share of children born to women who lost a child: R=(N×P)÷(M×O+N×P)	0.044803	0.045430	0.044924	0.049003	0.044204	0.049060
V. Change after a disaster occurs						
Share of children born to women who lost a child: R–L	-0.001532	-0.000905	-0.001411	0.002668	-0.002132	0.002725
Percentage change: 100×(R–L)÷L	-3.3%	-2.0%	-3.0%	5.8%	-4.6%	5.9%

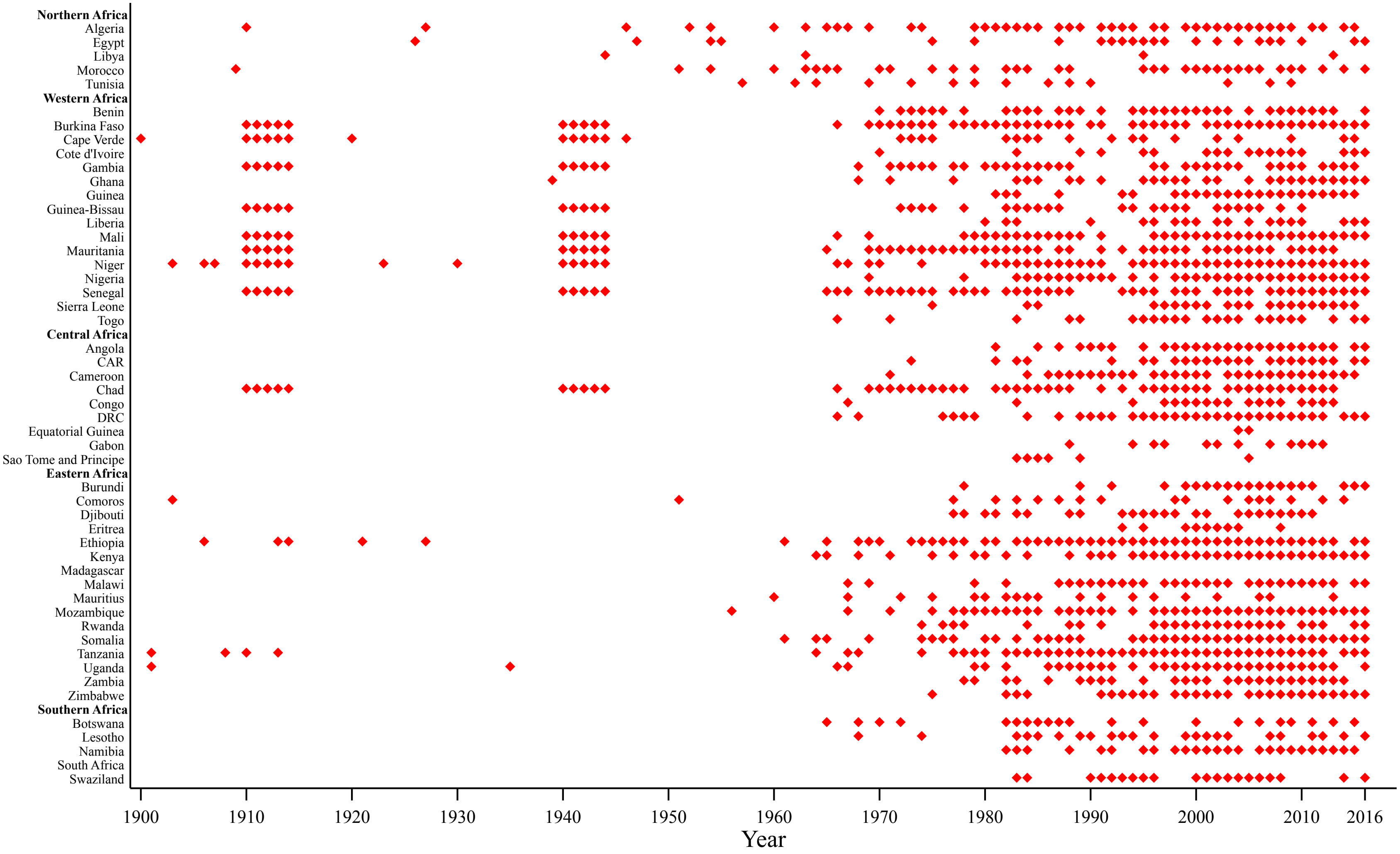
Notes: In columns 1–3, demographic controls are child's sex, child's number of older siblings, mother's age, and mother's years of completed schooling. In columns 4–6, demographic controls are woman's age, years of completed schooling, and number of children. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Table 8: Characteristics of migrants around the time of natural disasters

	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

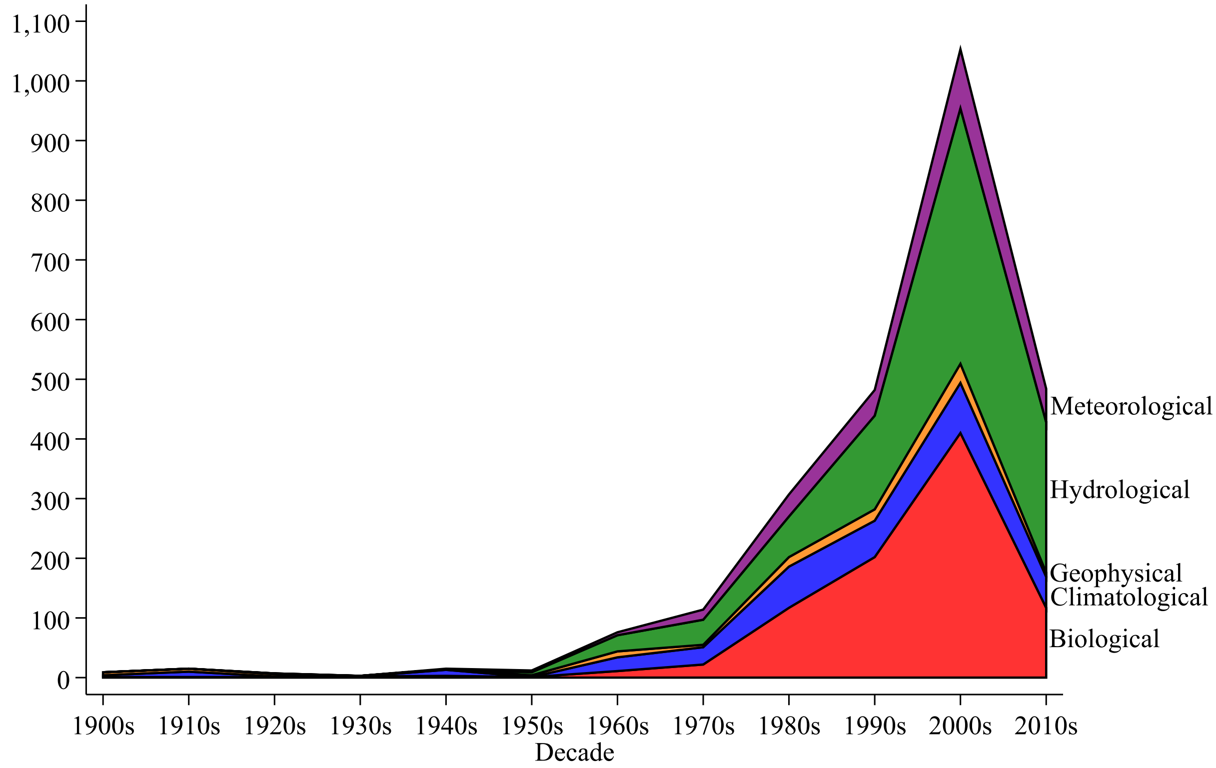
Notes: 1994 flood in Asyut, Sohag, Qena, Luxor governorates of Egypt. 1987 flood in Mokhotlong district of Lesotho. 1989 drought around Kigali in Rwanda. Governorate of residence in Egypt recorded in 1993 and 1996 in the 1996 census. District of residence in Lesotho recorded in 1986 and 1996 in the 1996 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. See section 4.3. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015), IPUMS-International (Minnesota Population Center 2018).

Figure 1: Incidence of natural disasters, by country



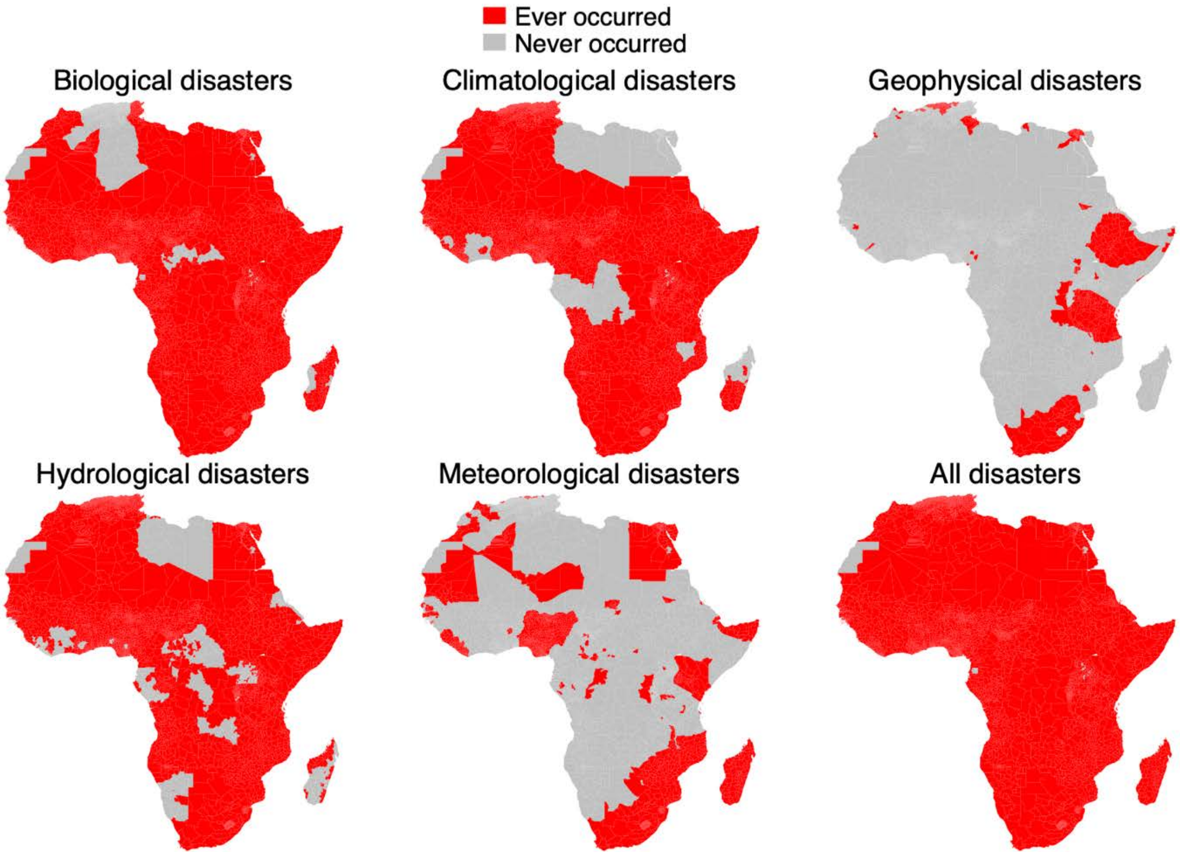
Note: See section 2.1. *Data source*: International Disasters Database (Guha-Sapir et al. 2018).

Figure 2: Number of natural disasters, by decade



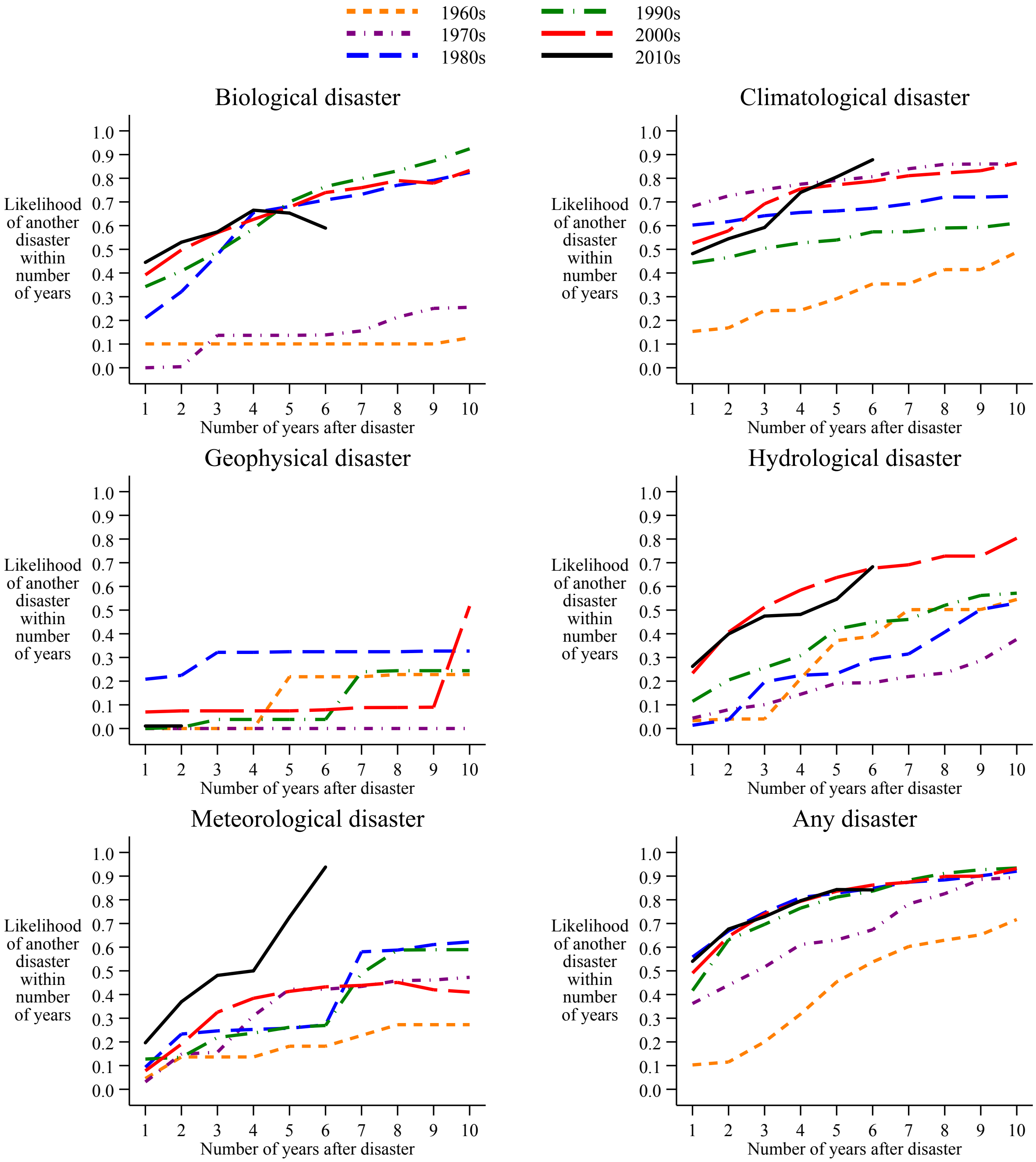
Note: See section 2.1. *Data source*: International Disasters Database (Guha-Sapir et al. 2018).

Figure 3, Location of natural disasters



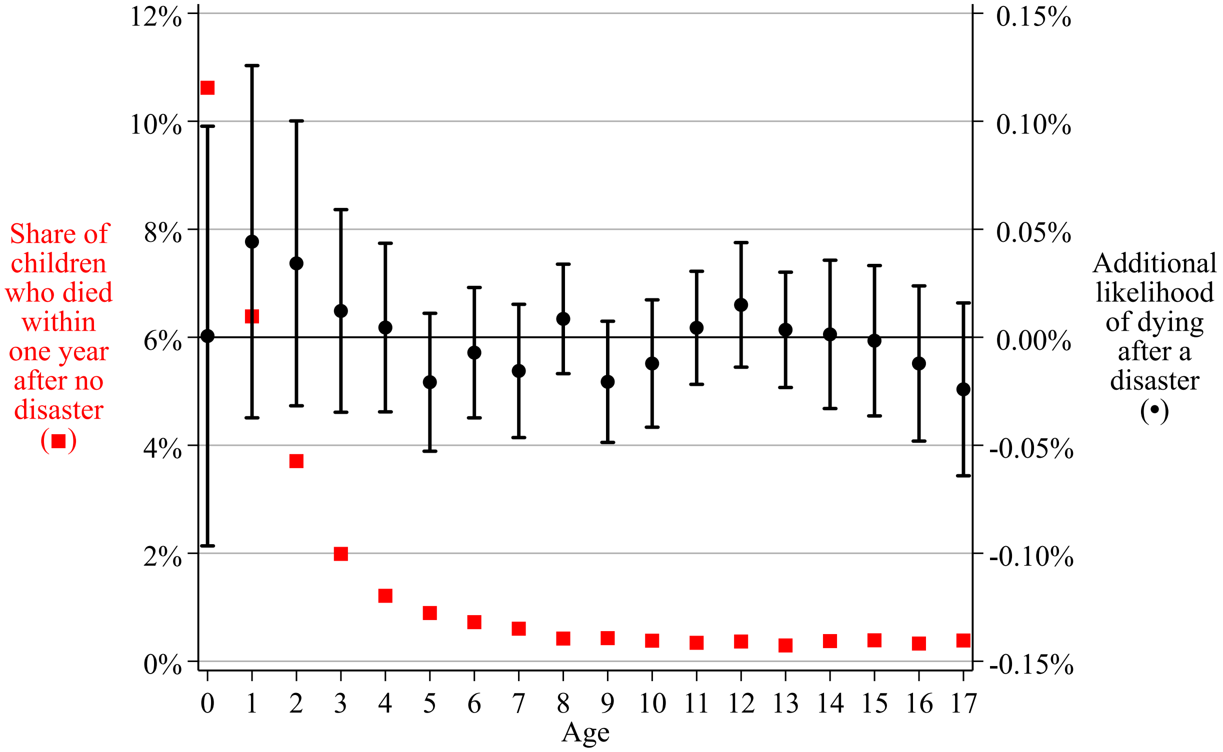
Notes: Each map records the districts where a disaster has ever taken place. See section 2.2.
Data sources: International Disasters Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015).

Figure 4, Duration until next disaster



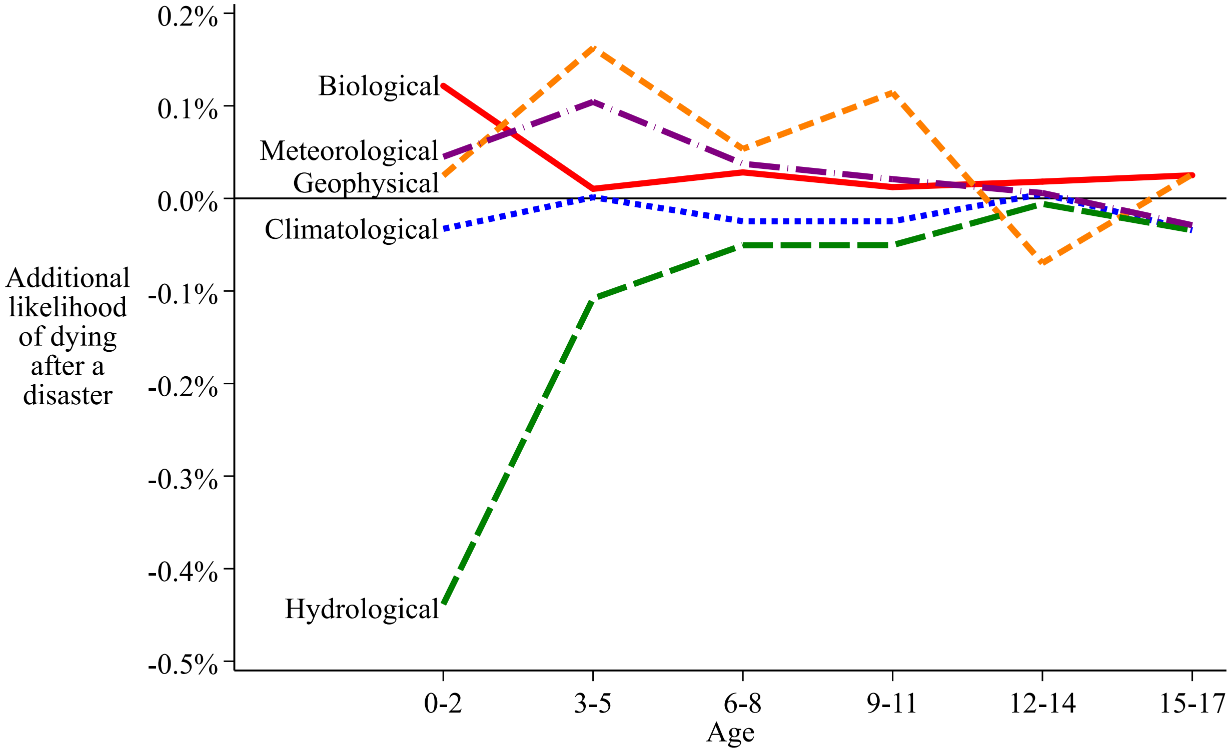
Notes: Starting with a grid of points evenly spaced five arc-minutes apart, each line records the likelihood that a place that experiences a natural disaster later experiences another natural disasters with the indicated number of years. See section 2.2. *Data sources*: International Disasters Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015).

Figure 5: Natural disasters and child mortality



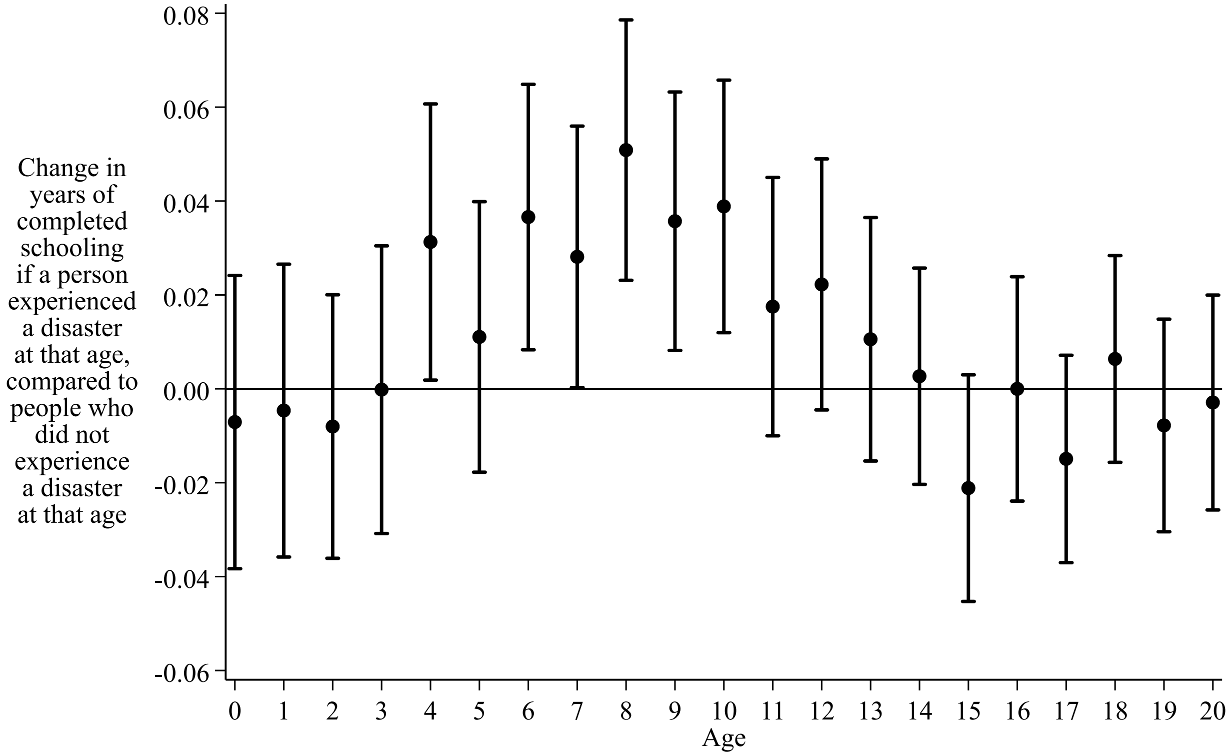
Notes: The right-hand y-axis report measures estimated coefficient β and 95 percent confidence interval from equation 1, repeated for children at each age. See section 3.2. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Figure 6: Categories of natural disasters and child mortality



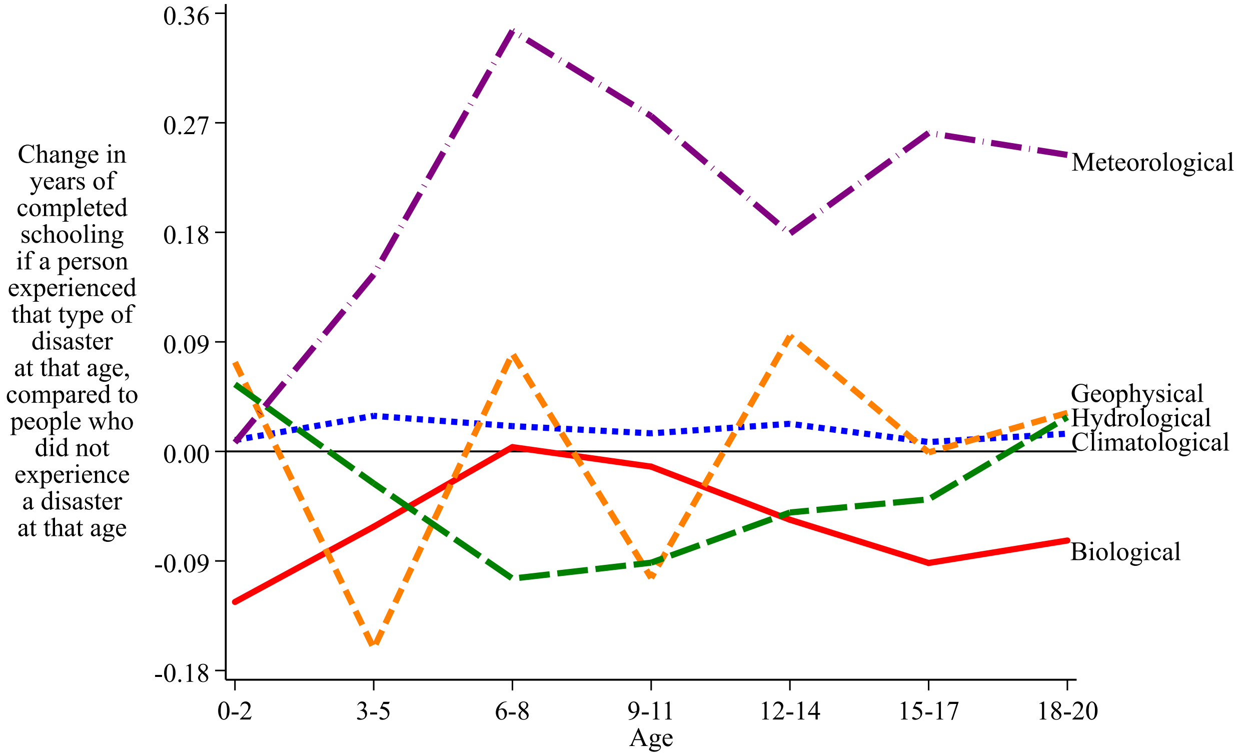
Notes: This figure reports estimated coefficients β_j and 95 percent confidence interval from equation 2 repeated for children at each age. See section 3.2. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Figure 7: Natural disasters and educational attainment



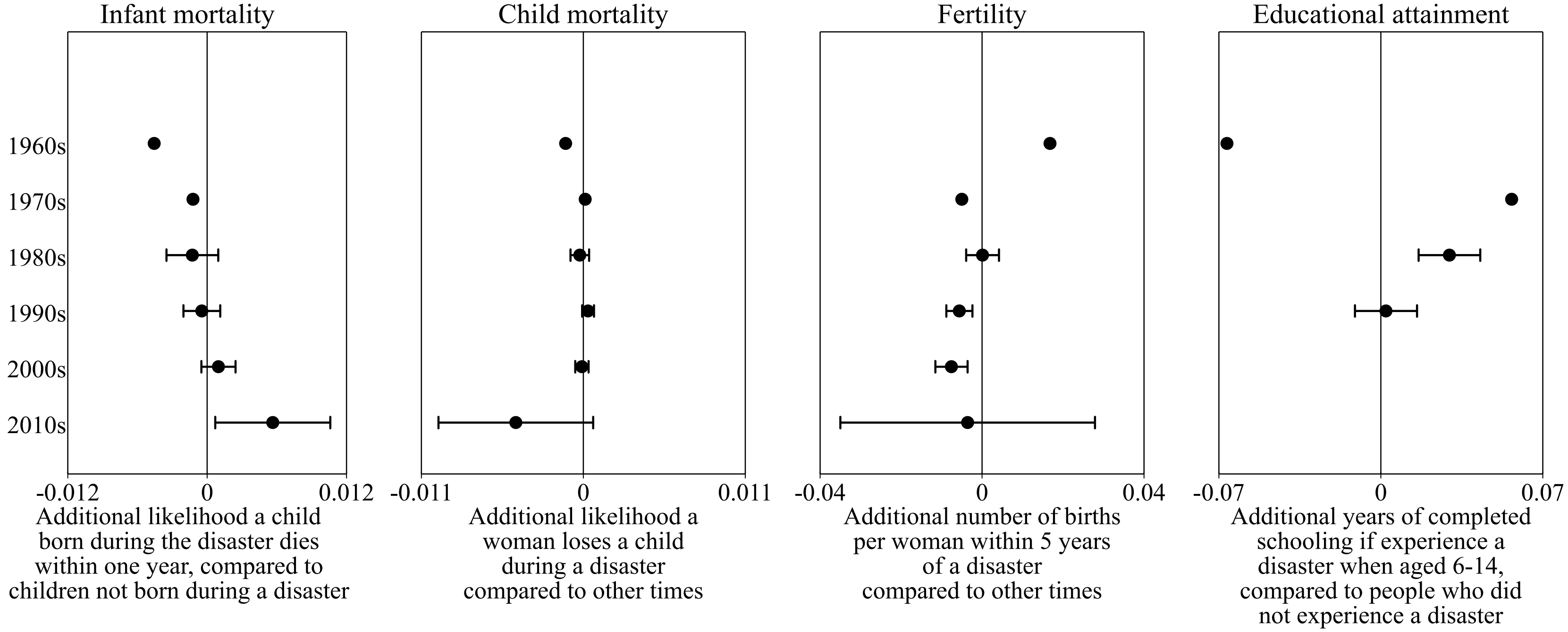
Note: See section 3.3. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Figure 8: Categories of natural disasters and educational attainment



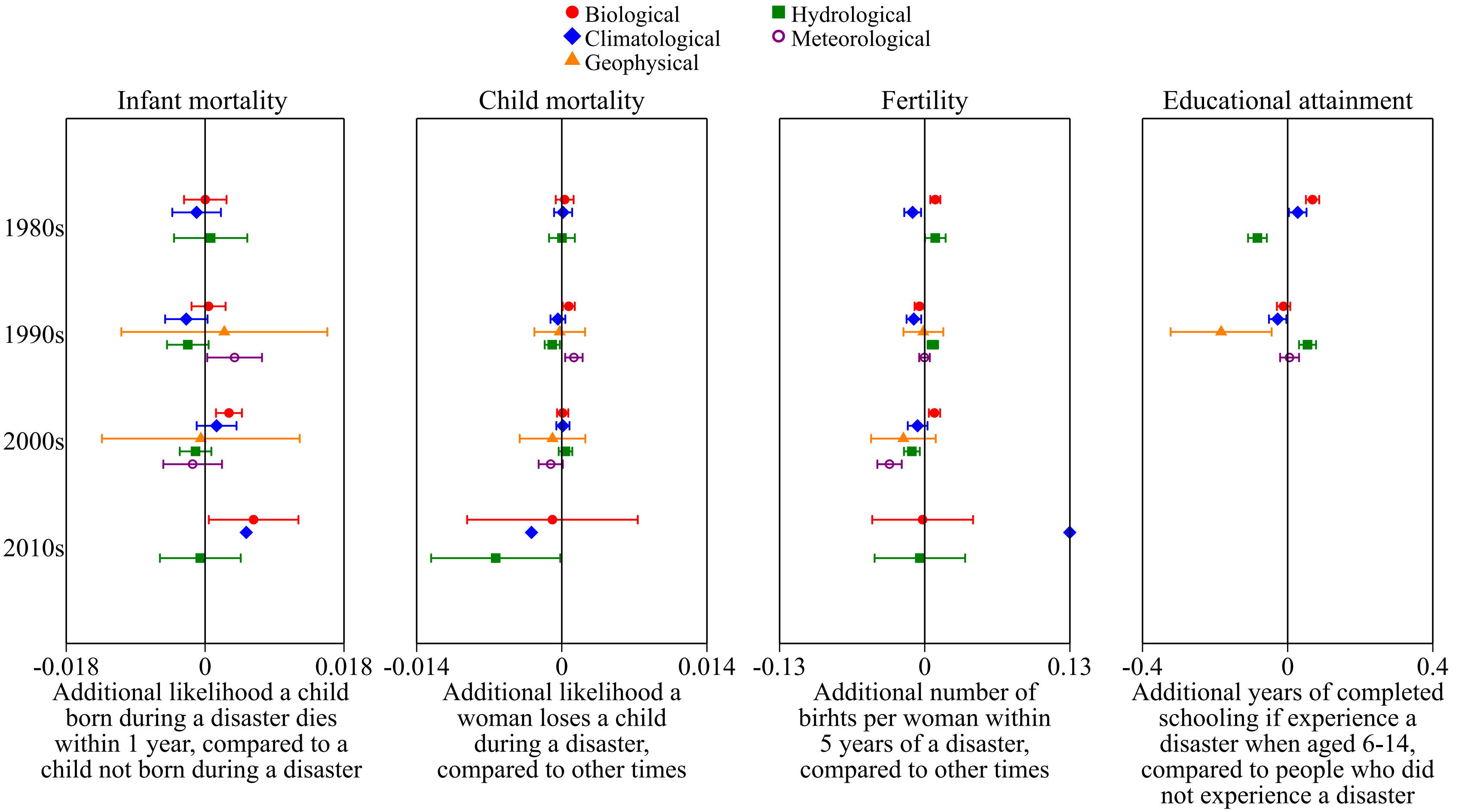
Note: See section 3.3. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Figure 9: Demographic changes following natural disasters, by decade



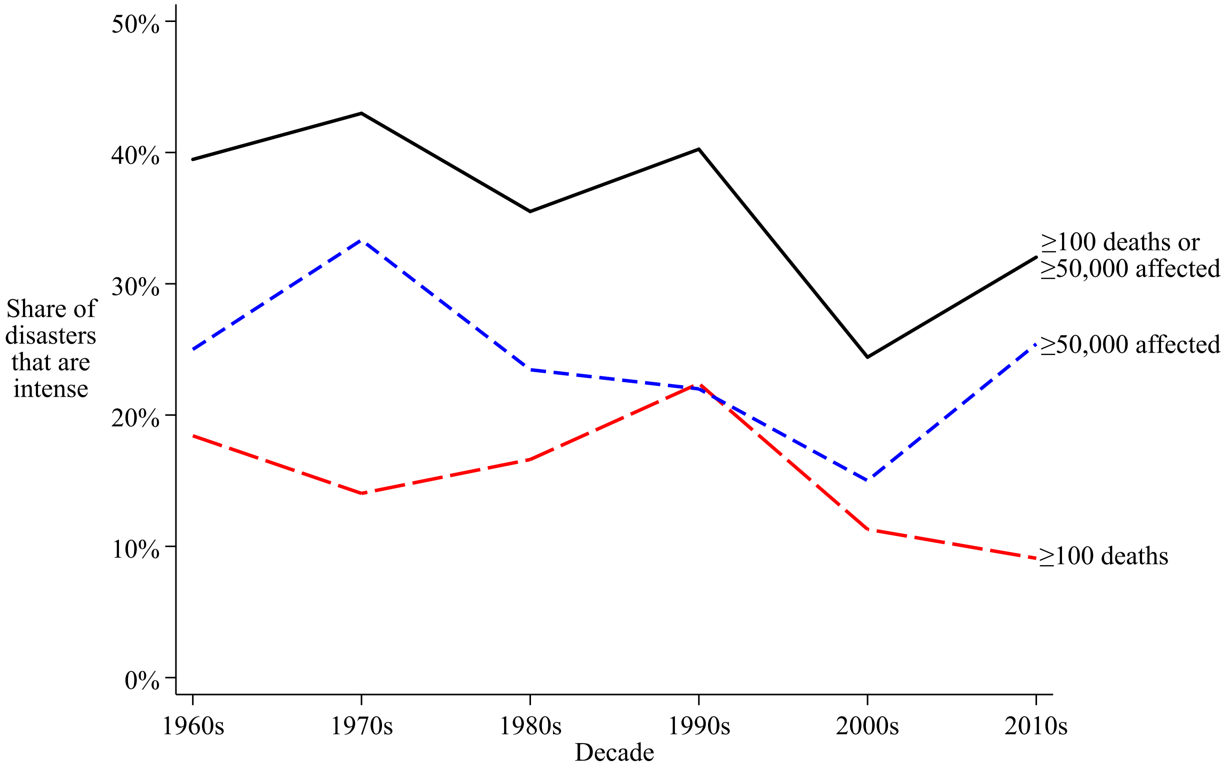
Note: See section 4.1. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Figure 10: Demographic changes following natural disasters, by decade and disaster category



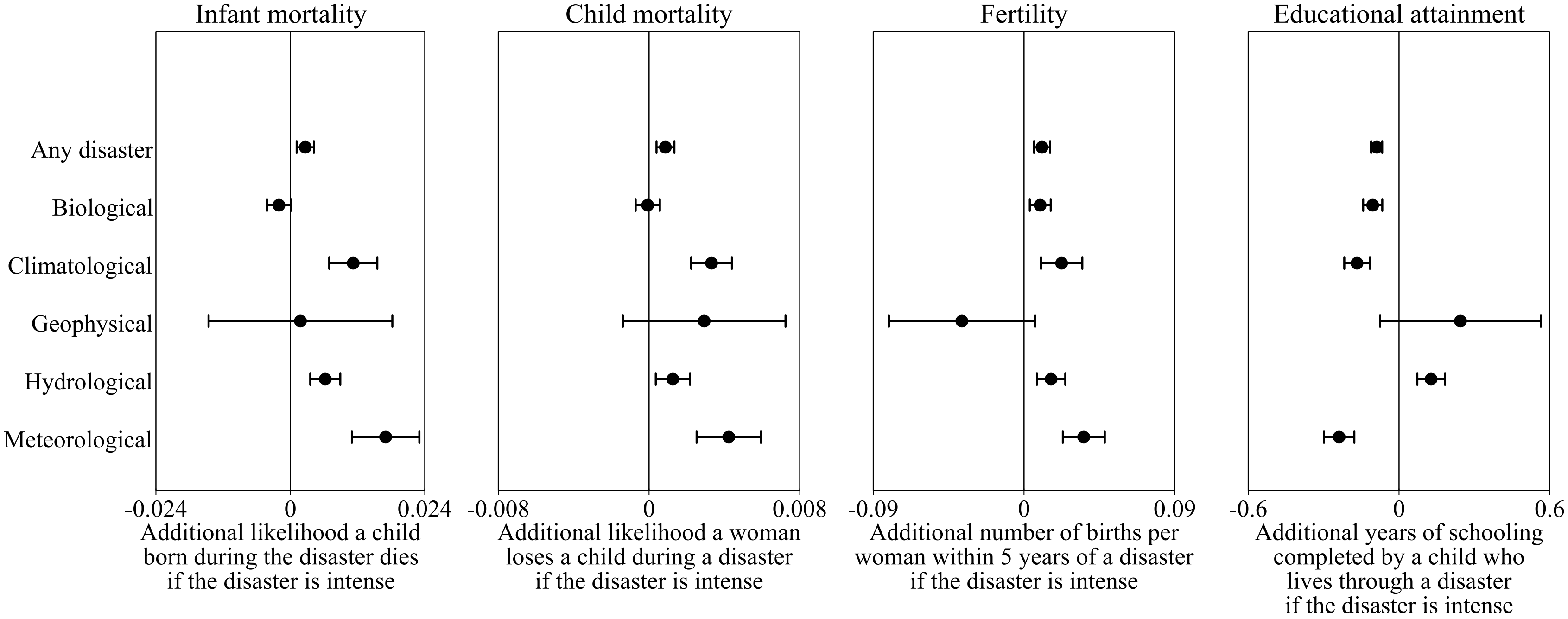
Note: See section 4.1. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Figure 11: Share of disasters that are intense, by decade



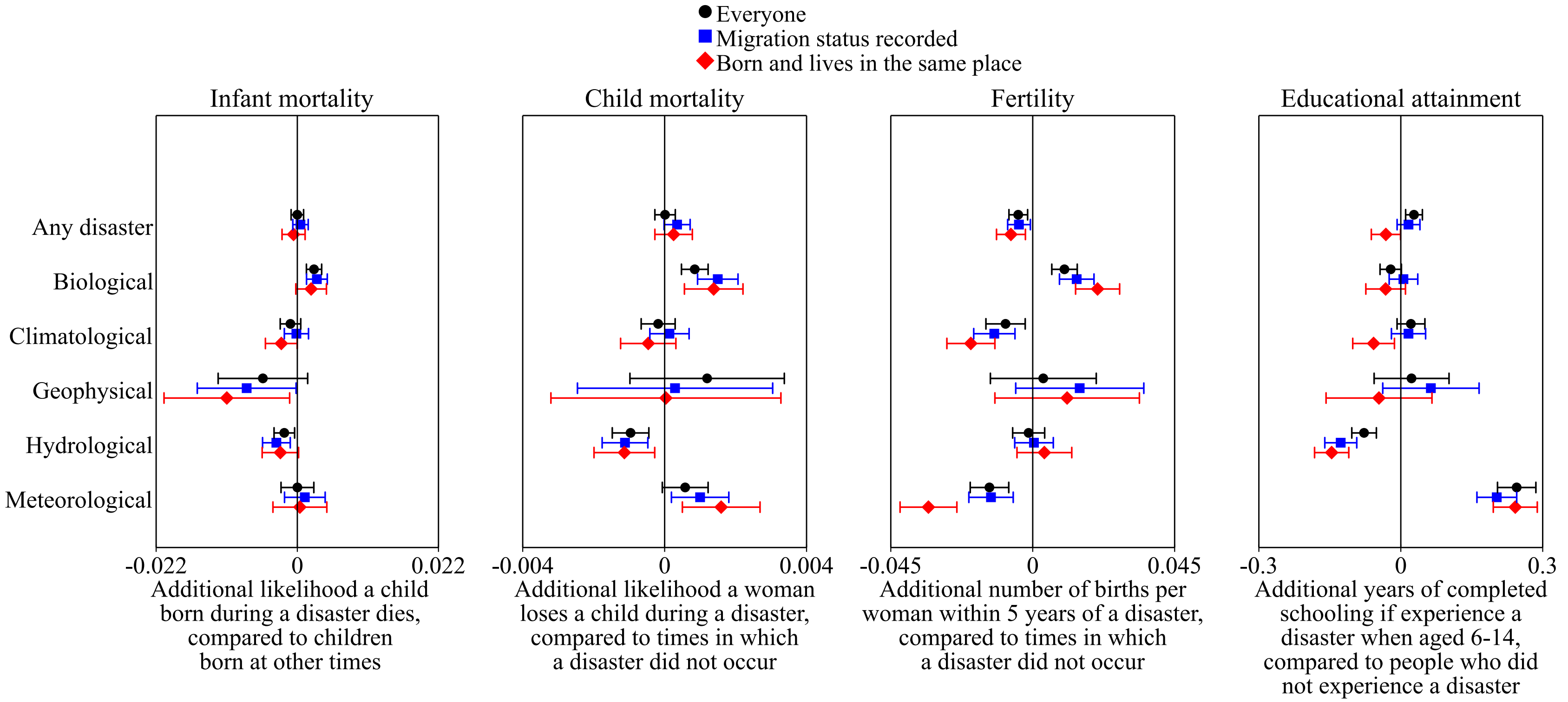
Note: See section 4.2. *Data source*: Emergency Events Database (Guha-Sapir et al. 2018).

Figure 12: Demographic changes following intense disasters, relative to other disasters



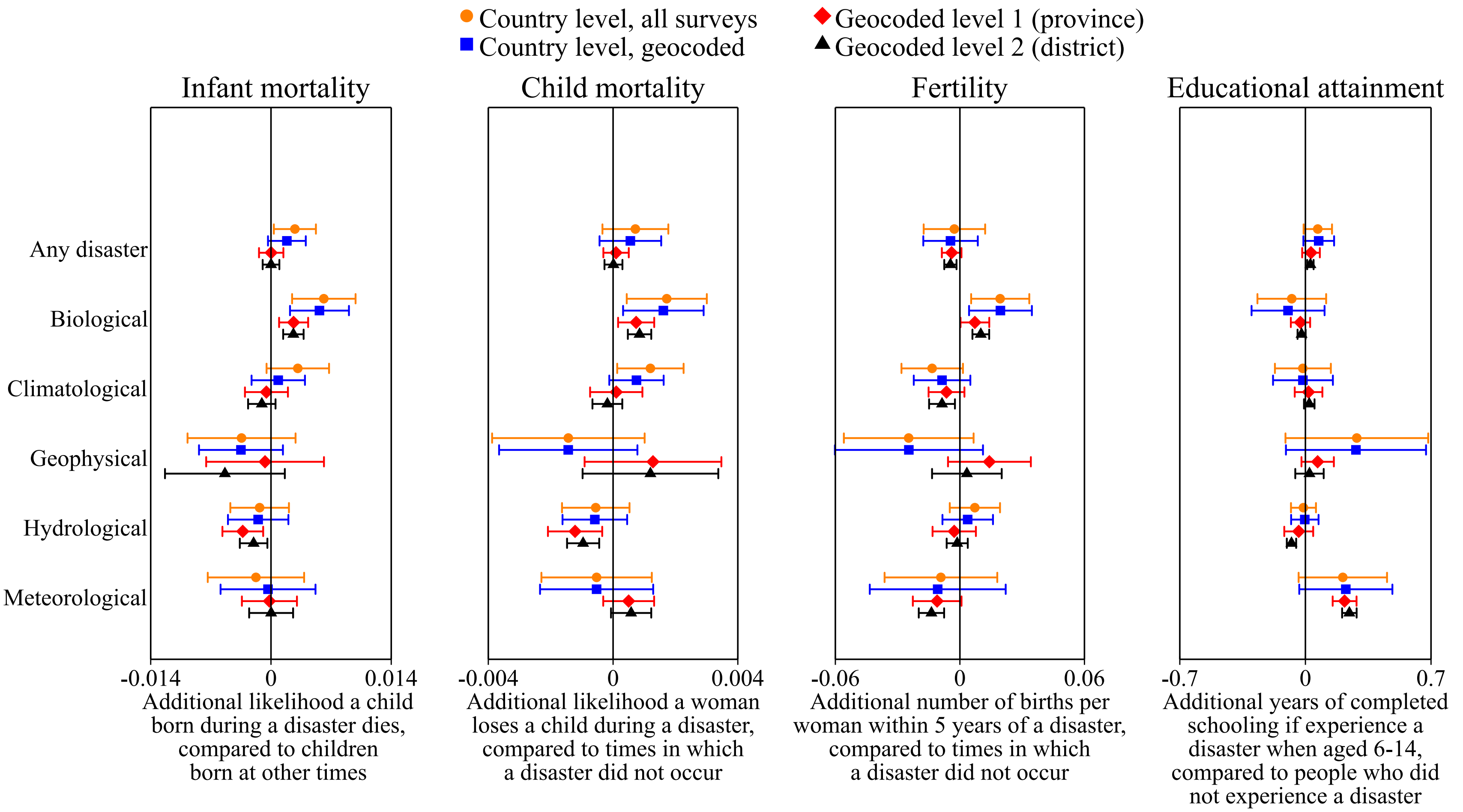
Note: See section 4.2. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Figure 13: Demographic changes following natural disasters, by migration status



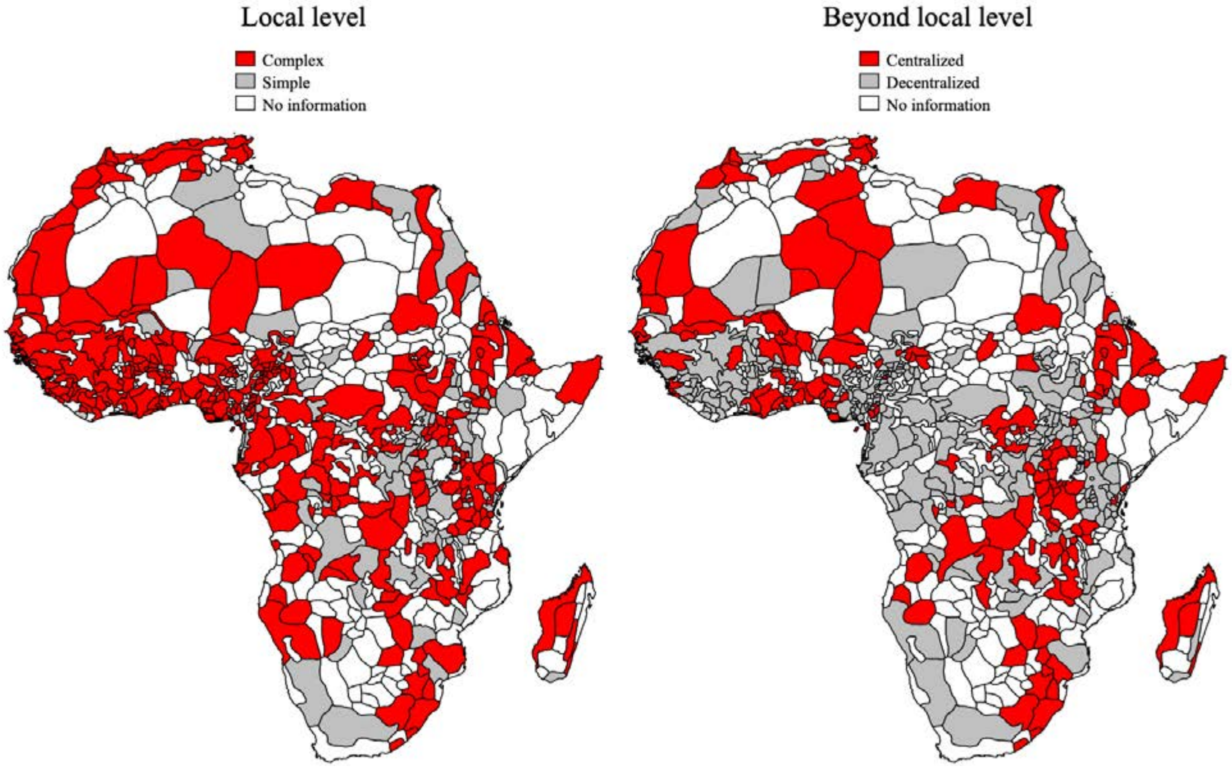
Note: See section 4.3. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Figure 14: Demographic changes following natural disasters, by administrative division



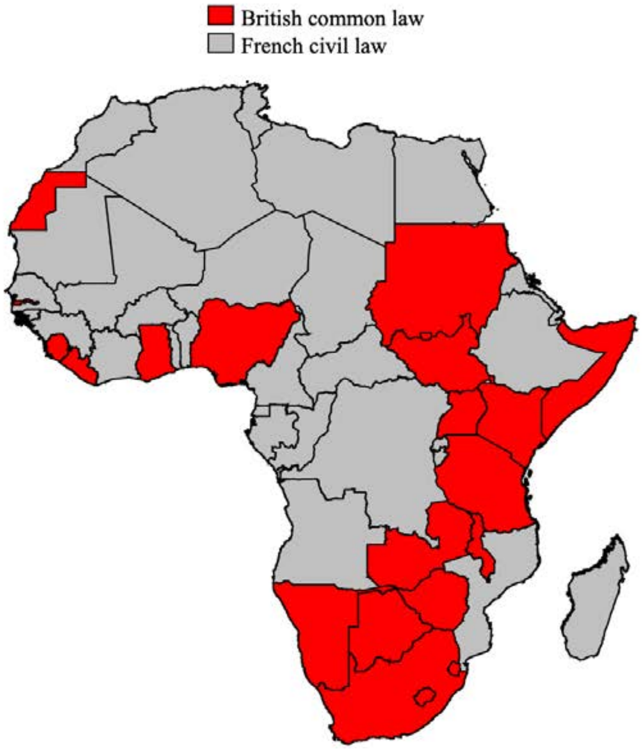
Note: See section 4.4. *Data sources*: Emergency Events Database (Guha-Sapir et al. 2018), Global Administrative Unit Layers (FAO 2015), Demographic and Health Survey (ICF International 1985–2017), World Fertility Survey (International Statistics Institute 1974–1981).

Figure 15: Pre-colonial jurisdictional hierarchy



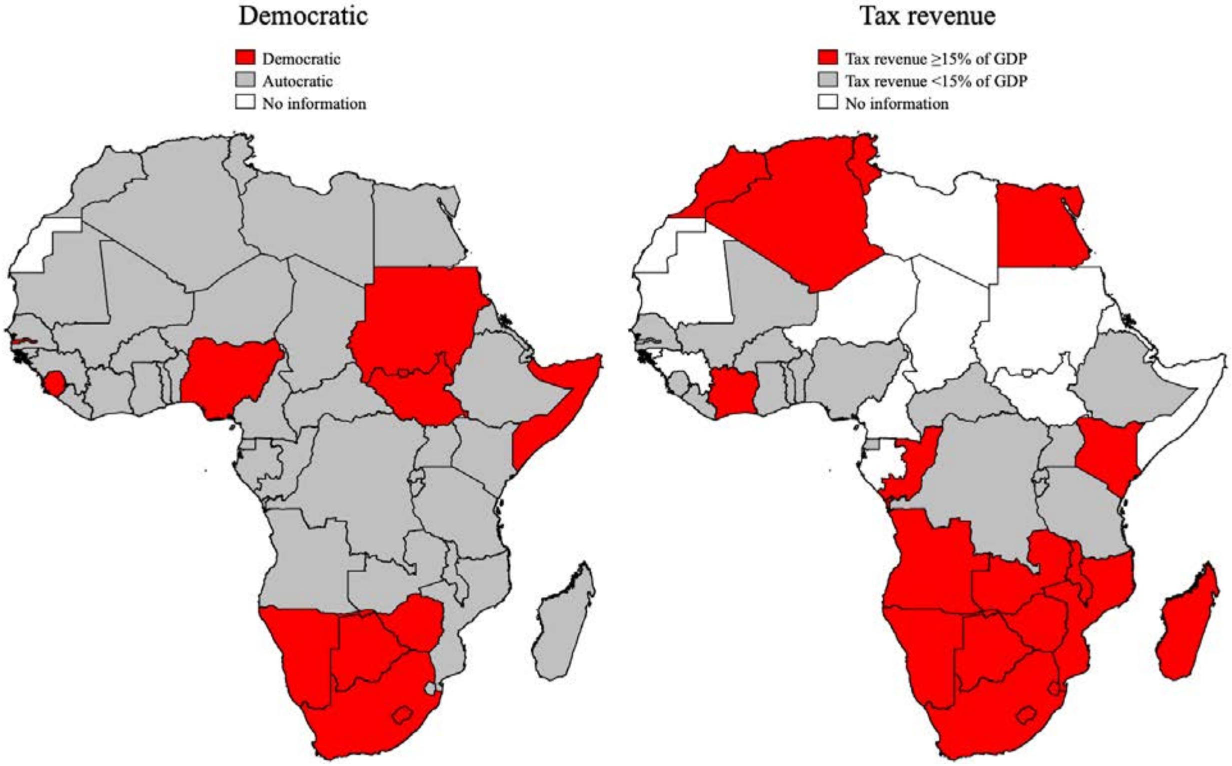
Notes: Local hierarchy above the nuclear family recorded as complex. Two or more levels of hierarchy beyond the local level recorded as centralized. See section 5. *Data sources*: Tribal Map of Africa (Murdock 1959), Ethnographic Atlas (Murdock 1967). Correspondence between Tribal Map of Africa and Ethnographic Atlas from Fenske (2013).

Figure 16: Colonial-era legal origins



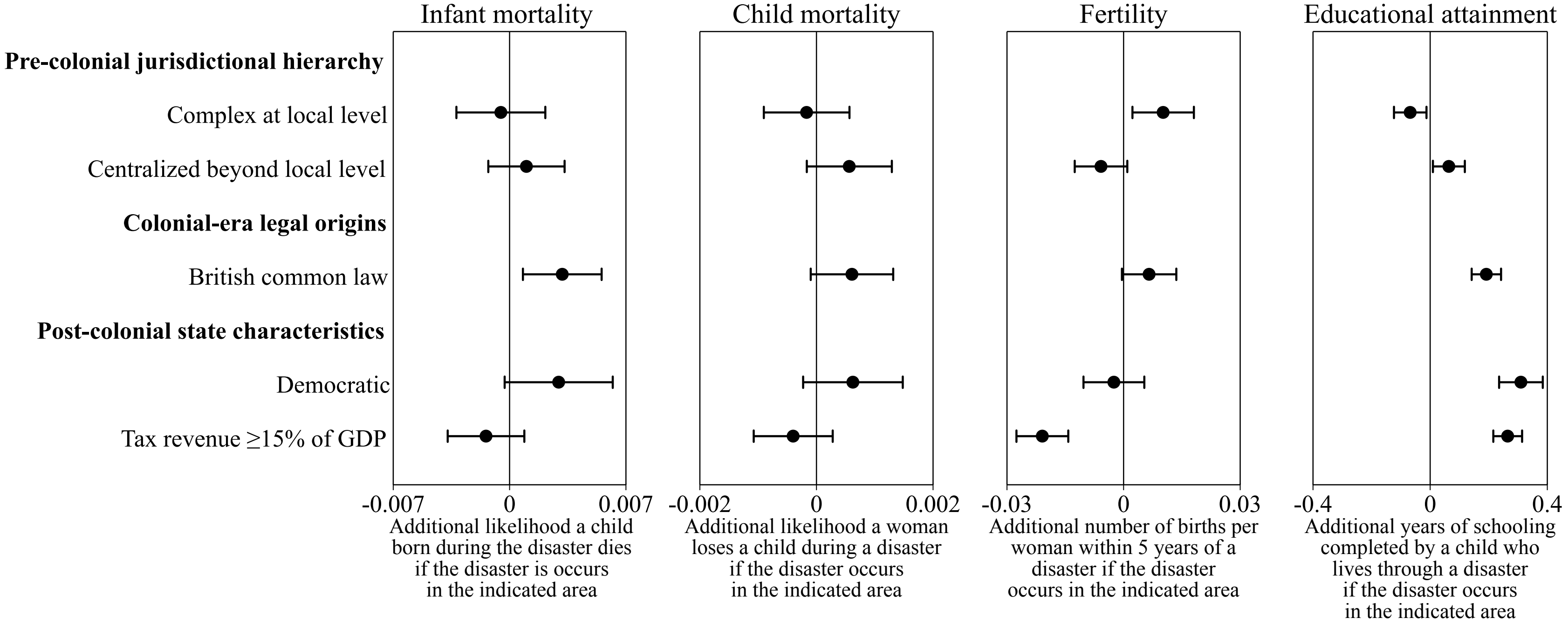
Note: See section 5. *Data sources*: All countries except Western Sahara from La Porta et al. (1999), Western Sahara from La Porta et al. (2008).

Figure 17: Post-colonial state capacity



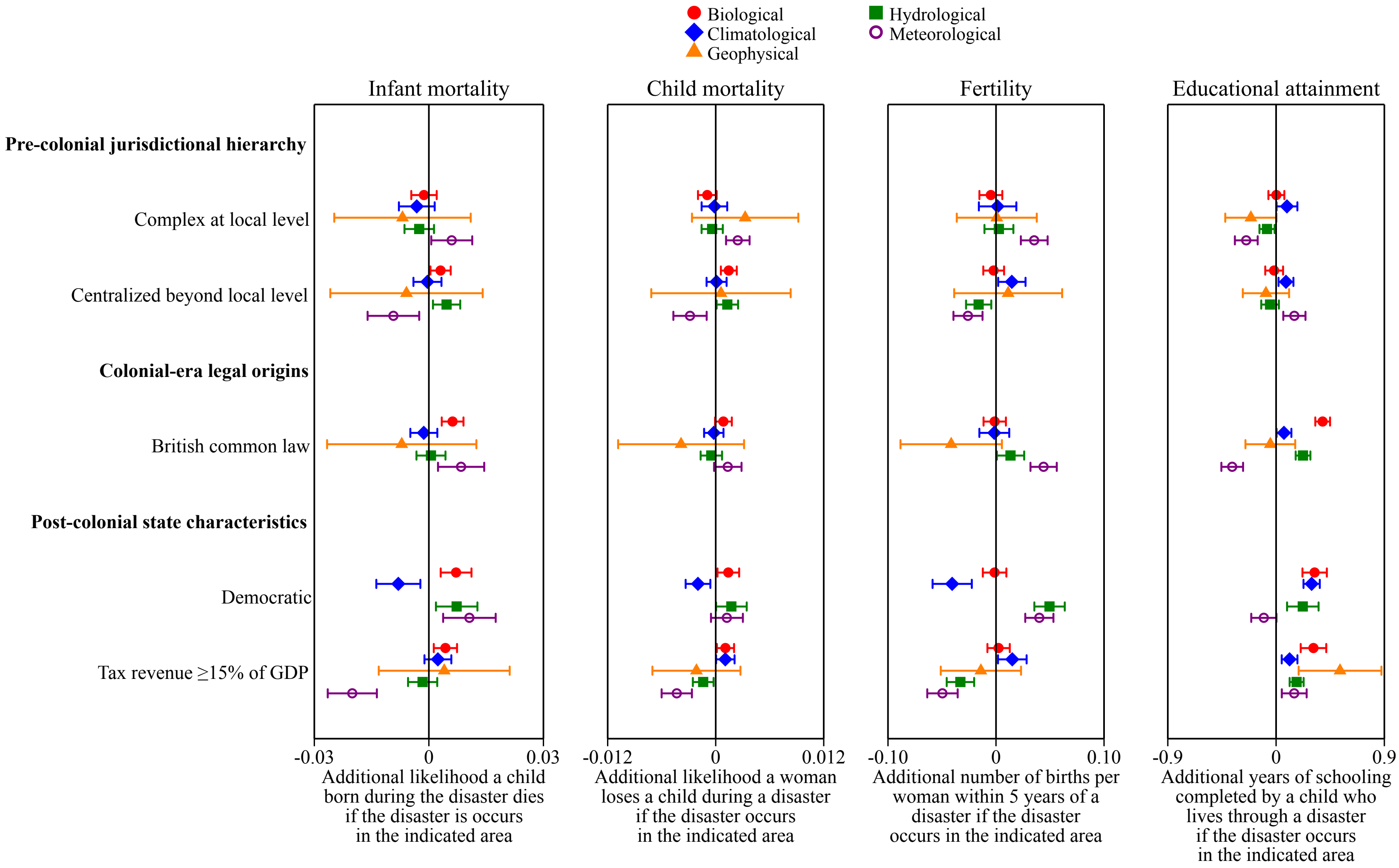
Notes: A country is recorded as democratic if it is recorded as more democratic than autocratic in at least five of its first 10 years after independence. Tax revenue as a share of GDP is recorded for the first 10 available years after independence. See Section 5. *Data sources*: Polity IV database (Center for Systematic Peace 2018), World Bank (2019).

Figure 18: Government characteristics and demographic changes following natural disasters



Note: See section 5. *Data sources*: Tribal Map of Africa (Murdock 1959), Ethnographic Atlas (Murdock 1967), Fenske (2013), La Porta et al. (1999), La Porta et al. (2008), Polity IV database (Center for Systematic Peace 2018), World Bank (2019).

Figure 19: Government characteristics and demographic changes following each category of natural disaster



Note: See section 5. *Data sources*: Tribal Map of Africa (Murdock 1959), Ethnographic Atlas (Murdock 1967), Fenske (2013), La Porta et al. (1999), La Porta et al. (2008), Polity IV database (Center for Systematic Peace 2018), World Bank (2019).