The Gendered Nature of Natural Disasters: The Impact of Catastrophic Events on the Gender Gap in Life Expectancy, 1981–2002

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Natural disasters do not affect people equally. In fact, a vulnerability approach to disasters would suggest that inequalities in exposure and sensitivity to risk as well as inequalities in access to resources, capabilities, and opportunities systematically disadvantage certain groups of people, rendering them more vulnerable to the impact of natural disasters. In this article we address the specific vulnerability of girls and women with respect to mortality from natural disasters and their aftermath. Biological and physiological differences between the sexes are unlikely to explain large-scale gender differences in mortality rates. Social norms and role behaviors provide some further explanation, but what is likely to matter most is the everyday socioeconomic status of women. In a sample of up to 141 countries over the period 1981 to 2002 we analyze the effect of disaster strength and its interaction with the socioeconomic status of women on the change in the gender gap in life expectancy. We find, first, that natural disasters lower the life expectancy of women more than that of men. In other words, natural disasters (and their subsequent impact) on average kill more women than men or kill women at an earlier age than men. Since female life expectancy is generally higher than that of males, for most countries natural disasters narrow the gender gap in life expectancy. Second, the stronger the disaster (as approximated by the number of people killed relative to population size), the stronger this effect on the gender gap in life expectancy. That is, major calamities lead to more severe impacts on female life expectancy (relative to that of males) than do smaller disasters. Third, the higher women's socioeconomic status, the weaker is this effect on the gender gap in life expectancy. Taken together our results show that it is the socially constructed gender-specific vulnerability of females built into everyday socioeconomic patterns that lead to the relatively higher female disaster mortality rates compared to men. *Key Words: gender, mortality, natural disaster, socioeconomic status, vulnerability.*

The human impact of natural disasters is never entirely determined by nature, but is contingent on economic, cultural, and social relations. In this article we address one important, yet hitherto relatively neglected aspect of disasters (WHO 2002), namely the gendered nature of disaster vulnerability as revealed by gender-specific disaster mortality. Anderson (2000, 86), in a World Bank publication on managing disaster risk, is adamant that "much more research is needed to fully understand the extent to which gender plays a role in differential casualty rates." This article's analysis provides an important step in that direction. Specifically, we analyze the impact of natural disasters on the gender gap in life expectancy, which is the difference between female and male life expectancy at birth (in most countries women live longer than men).

Our study takes seriously gender as an analytical category. We explain the differential impact of natural disasters on female relative to male life expectancy not merely by recourse to different physical exposures and biological or physiological gender differences, but also by the different socially constructed vulnerabilities that derive from the social roles men and women assume, voluntarily or involuntarily, as well as existing patterns of gender discrimination. Our study adopts a vulnerability approach to natural disasters as an analytical concept. Many disaster scholars subscribe to such an approach and have made significant contributions to its development (see, e.g., O'Keefe, Westgate, and Wisner 1976; Cuny 1983; Hewitt 1983; Cannon 1994, 2000; Varley 1994; Wisner et al. 1994, 2004; Cutter 1996; Fordham 2004). As Cutter (1996, 530) has pointed out, vulnerability "still means different things to different people." We adopt the definition of vulnerability given in Wisner et al. (2004), in which an explanation of "the risks involved in disasters must be connected with the vulnerability created for many people through their normal existence," and where vulnerability is defined as "the characteristics of a person or group and their situation influencing their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard" (Wisner et al. 2004, 4, 11).[1] It follows that the impacts of

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natural disasters are never merely determined by nature on its own. Indeed, it becomes even questionable whether one can talk of "natural" disasters at all. Cannon (1994, 14) argues that "there are no generalized opportunities and risks in nature, but instead there are sets of *unequal access to opportunities and unequal exposures to risks* which are a consequence of the socio-economic system" (emphasis in the original). In other words, vulnerability, as used in this article, captures the differential exposure to risks and capacity to cope with risks systematically attributed to people across space and time, which, together with other attributes such as ethnicity or class, are often functions of an individual's gender, the focus of analysis here (see Cannon 1994; Wisner et al. 2004).

There is renewed interest in studying the social impacts of natural disasters across the social sciences. For example, economists have recently studied how a country's low level of economic development, poor quality of governance institutions, and high degree of inequality increase the death toll from earthquakes (Anbarci, Escaleras, and Register 2005) as well as from other types of natural disasters (Kahn 2005). Geographers, sociologists, and other social scientists have addressed the vulnerability of certain groups of people to natural disasters (see, among others, Cannon 1994, 2000; Wisner et al. 1994, 2004; Cutter 1996; Mustafa 2002 and references cited therein). Increasingly, even physical geographers and public health scholars acknowledge that a better mitigation of negative disaster impacts is contingent on a better understanding of the socially constructed vulnerabilities of specific groups of affected people (Noji 1997b; Alcántara-Ayala 2002; Degg and Chester 2005a, 2005b). Within the broader field of disaster and environmental change research, an emergent literature addresses the specific vulnerability of women (Cutter 1995; Bolin, Jackson, and Crist 1998; Enarson 1998, 2000; Enarson and Morrow 1998; Fothergill 1998; Fordham 2004; Bradshaw 2004; Enarson and Meyreles 2004).

Our original contribution is to provide the first systematic, quantitative analysis of gender differences in natural disaster mortality. This is of course only one aspect, but due to its far-reaching consequences (life or death) it is arguably the most important aspect of the gendered impact of natural disasters. Existing studies either do not estimate gender-specific mortality rates and patterns at all (Anbarci, Escaleras, and Register 2005; Kahn 2005) or are confined to single events such that no general conclusions can be drawn (Bern et al. 1993; Ikeda 1995; O'Hare 2001; Oxfam International 2005). It is only by quantitative analysis of mortality rates or summary mortality measures such as life expectancy that we can discern whether the anecdotal evidence captures a general trend. We believe that our contribution buttresses Cutter's (2003, 6) claim in her Presidential Address to the Association of American Geographers that "geography has added a technological sophistication to hazards research that is unrivalled among the social sciences" and that "the discipline is rapidly becoming the driving force behind vulnerability science".[2] In linking spatial patterns of disaster risk to human-generated vulnerability, geography is uniquely positioned to study the impact of natural disasters on socioeconomic systems and groups of people. One of the "most significant themes" listed by Cutter (2003, 7) is the need "to identify, delineate, and understand those driving forces that increase or decrease vulnerability at all scales." This study identifies one important driving force by demonstrating how low socioeconomic status renders women more vulnerable to the mortal impact of natural disasters.

In brief, we find that natural disasters affect women more adversely than men in terms of the effect of disasters on the life expectancy at birth. What this means is that natural disasters on average kill more women than men or kill women at a younger age than men, and the more so the stronger the disaster. Yet the extent to which women are more likely to die than men or to die at a younger age from the immediate disaster impact or from postdisaster events depends not only on disaster strength itself but also on the socioeconomic status of women in the affected country. The higher women's status, the smaller is the differential negative effect of natural disasters on female relative to male life expectancy. What this means is that where the socioeconomic status of women is high, men and women will die in roughly equal numbers during and after natural disasters, whereas when the socioeconomic status of women is low, more women than men die (or women die at a younger age). These results corroborate a vulnerability approach to natural disasters since the more adverse impact of disasters on female compared to male life expectancy is clearly contingent on the extent of socially constructed vulnerability and there is nothing natural in the gendered impact of disasters on life expectancy.[3]

This article is structured as follows: The next section presents arguments and anecdotal evidence suggesting that natural disasters increase female mortality more than male mortality. Two hypotheses are developed from this discussion and are put to an empirical test. The following section then describes the sources of data and the operationalization of the relevant variables for the econometric estimation. A discussion of the appropriate

estimation technique is followed by a presentation of results. We conclude by arguing that our study's findings support a vulnerability approach to natural disasters.

Natural Disasters and the Gender Gap in Life Expectancy

Human beings can and in fact do influence—willingly and unwillingly—the degree to which natural disasters harm people, reduce their welfare, and cost their lives. This section deals with the interaction between natural disasters and societies. For a whole range of reasons, mortality vulnerability to natural hazards is likely to be gender-specific, with women bearing the major burden.

From a conceptual perspective, it seems most fruitful to distinguish between three main causes for gender differences in mortality vulnerability to natural disasters: First, biological and physiological differences between men and women may at times disadvantage women in their immediate response to the disaster. Second, social norms and role behavior may lead to a behavior of women that increases their vulnerability in the immediate course of the disaster. And third, disasters may lead to shortage of resources of basic need as well as a temporary breakdown of social order, in which case the competition between individuals becomes fiercer and existing forms of gender discrimination become exacerbated and new forms of discrimination can emerge. With the exception of the biological and physiological reasons, the higher vulnerability of women is socially constructed and is due to differences in the socioeconomic status of men and women. In the following subsections, we discuss the three main causes in turn. Certainly these causes are not independent and may easily reinforce each other, however for explanatory purposes we discuss them separately and in turn.

Biological and Physiological Differences

Biological and physiological differences in disaster response capacity can lead to differential mortality rates for three main reasons. First, men can be physiologically better equipped to withstand a disaster's physical impact. For instance, if a woman is less strong than male counterparts, she will be more easily swept away by wind or water. This disadvantage is especially severe for women in the final stages of pregnancy, who are less able to self-rescue because of their decreased mobility. On average, women can run less quickly and climb posts, trees, and other rescue points with greater difficulty and lower speed. However, as an Oxfam International (2005) report on the December 2004 tsunami's impact on women in South and Southeast Asia demonstrates, differences in self-rescue ability are partly determined by learned skills and therefore not simply to the result of physiological differences: In affected regions of Sri Lanka, swimming and tree climbing are taught predominantly to boys and men as tasks "that are done nearly exclusively by men" (Oxfam International 2005, 9), which helped males to survive the waves. Ikeda's (1995, 188) study of gender differences in mortality from the 1991 Bangladesh cyclone shows how physical disadvantages interact with social norms and role behaviors that put women at a disadvantage in their self-rescue efforts. She points out that one may ask why the body size of women is on average smaller and lighter[4] (we discuss these issues in more depths below). It is thus potentially misleading when a group of public health scholars uncritically attribute higher female to male mortality from the same event "to factors such as physical size, strength, and endurance" (Bern et al. 1993, 75).

Second, men and women have different propensities to die from various diseases, but the implications for gender-specific disaster mortality are ambiguous. With the possible exception of measles, for which some evidence suggests that women might be more susceptible to death (Garenne 1995), in general men are more prone to acquire and die from parasitic and infectious diseases (Owens 2002). Toole (1997a), in his review of the literature, comes to the conclusion that communicable disease epidemics are rare after most natural disasters, with the exception of droughts and famines. On the whole, there is no reason to suspect that diseases related to natural disasters will systematically disadvantage women. Furthermore, in principle, women are at an advantage in famines and droughts because, unless they are pregnant or lactating, they can better cope with food shortages due to their lower nutritional requirements and higher body fat (Rivers 1982). This can explain in part why overall mortality rates for females are often lower in many famines, particularly the very severe ones of the nineteenth and early twentieth centuries, than they are for men (Macintyre 2002).[5] Nevertheless, in some famines more female than male famine victims die at a very young age or as infants, an outcome that must be due to discriminatory access to food resources in times of famine with a bias against female babies and children; see Mariam (1986, 57) for the Ethiopian famine of the early 1970s, Kidane (1989, 1990) for the Ethiopian famine of 1984/85, Greenough (1982) and Agarwal (1990, 225ff) for the Bengal famine of 1943/1944, and Dyson (1991a, 1991b) for South Asian famines more generally.[6] There are no reliable statistics on the great

Chinese famine of the early 1960s, but the account given by a surviving Chinese peasant woman is revealing: "Families tried to pool their rations and often the husband would rule that any female children should be allowed to die first" (Becker 1996, 3).

Third, large-scale natural disasters can have severe detrimental effects on the social infrastructures of affected countries, reducing access to food, hygiene, health services, and clean water (Noji 1997b). When the basic health care infrastructure is severely damaged or health expenditures are reduced to reallocate public funds for immediate disaster response purposes, obstetrical care is reduced, the number of miscarriages increases, as does maternal and infant mortality.

Social Norms and Role Behaviors

The discussion above would suggest that biologically or physiologically determined sex differences in disaster mortality exist, but that their impact is likely to be weaker than it appears at first sight. Social norms and role behaviors might also provide reasons for gendered disaster vulnerability in putting women at a clear disadvantage when it comes to rescue attempts. We stress that even if women follow these social norms and role behaviors seemingly voluntarily, the norms and roles often derive from the unequal distribution of power between men and women in many societies.

In many countries women's roles are to look after and protect children and the elderly as well as the family's domestic property, which hampers their self-rescue efforts in almost any type of natural disaster (Beinin 1981; Schwoebel and Menon 2004; Oxfam International 2005). Dress codes can restrict women's ability to move quickly, and behavioral restrictions can hinder their ability to relocate without the the consent of husband, father, or brother. For example, in rural Bangladesh women are expected to wear a *sari*, traditional clothing that hampers running and swimming, and to remain in the *bari*, typically the houses of the family and near kin. These strictures can impede their movements and their access to information about cyclone-induced floods (Ikeda 1995). Moreover, a social prejudice against women learning to swim drastically reduces their survival chances in flooding (Cannon 2000, 52).

Often, a traditional division of labor can disadvantage women in the event of certain natural disasters. Oxfam (2005) reports when the tsunami hit the coast of Indonesia many women in the rural coastal areas were at home, whereas the men were out at sea fishing or otherwise away from home. In India many women were waiting at the seashore for the fishermen to arrive. In both cases, many more men were spared because the waves only gather height and strength as they approach shore and have their most fatal impact directly at the coast. Similarly, during earthquakes the men are more likely to be out in the open or in more robustly built factories and public buildings while the women are at home in dwellings more easily struck down by earthquakes. Clearly this type of natural disaster is likely to affect women more adversely, given that inadequate building structures are by far the main cause of earthquake fatalities (Noji 1997a). Even when men are at home, they are not necessarily equally as affected as women. In earthquakes in India men reportedly survive better even those events that hit at night because during warm nights men sleep outside and on rooftops, a behavior impossible for most women who became trapped in their domestic homes (Krishnaraj 1997).

Yet, as with biological and physiological causes for differential mortality rates, a caveat is in place here as well since differences in social roles and behaviors need not always affect women more adversely. The effect really depends on the type of natural disaster. In particular, some evidence suggests that more men than women die directly from severe weather events in the United States such as lightning, thunderstorms, and flash floods (Fothergill 1998). The same is reportedly true for immediate mortality from Hurricane Mitch in Central America in 1998 (Bradshaw 2004, 25). A likely reason is that on average more men are engaged in outdoor work and leisure activities during such events and are more reckless in their behavior toward risk. It is difficult to say whether such findings generalize to other societies, but the point remains valid that social norms and role behaviors often put women at greater risk of disaster mortality, depending on the type of disaster and its context. At times, social norms and role behavior can instead put men at greater risk.

Discrimination in Access to Resources and the Breakdown of Social Order

We have seen so far that biological and physiological differences as well as social norms and role behaviors can disadvantage women in the event of natural disasters. Yet, we have also seen that the evidence is ambiguous on whether these differences will affect women more adversely to a large extent.

In this subsection, we argue that while the gender differences in casualty rates result only partly and potentially in small part from the immediate effects of disasters (e.g., from collapsing buildings in earthquakes or flooded cities and villages), women are much more likely

than men to die after the disaster happened. Those indirect effects can be explained by discrimination in access to resources and the temporary breakdown of social order. In societies with existing patterns of gender discrimination, males are likely to be given preferential treatment in rescue efforts. A telling example is given by a father who, unable to hold on to both his son and his daughter from being swept away by a tidal surge in the 1991 Cyclone in Bangladesh, released his daughter because "(this) son has to carry on the family line" (quoted in Haider, Rahman, and Huq 1993, 64). Men are also likely to access and allocate the assistance given to affected families. Even in the absence of natural disasters, Sen (1988, 454) found that "there is a good deal of evidence from all over the world that food is often distributed very unequally within the family—with a distinct sex bias (against the female) and also an age bias (against the children)." Bairagi (1986) reported that in rural Bangladesh the female children were more adversely affected by famine than were the boys. When natural disaster strikes, these preexisting discriminatory practices become exacerbated and their detrimental health impact on women and girls is intensified. Sen (1988, 459) has reported how women and girls were systematically disadvantaged by food relief in the aftermath of flooding in West Bengal that destroyed crops and farmland. Enarson and Morrow (1998, 21) refer to a relief worker's finding of discriminatory access to relief supplies in the aftermath of the 1991 Bangladesh cyclone (similar experiences are reported by Khondker 1996, 288). Ager, Ager, and Long (1995) found in their study of Mozambican refugees in Malawi in the late 1990s that relief policies were biased in favor of refugee men. A fact sheet by the Pan-American Health Organization (2002) would suggest that this anecdotal evidence from a few natural disasters might be representative of a more general trend, also suggesting unequal power structures as the underlying cause: "The majority of relief efforts are intended for the entire population of a disaster-affected area; however, when they rely on existing structures of resource distribution that reflects the patriarchal structure of society, women are marginalized in their access to relief resources."

Natural disasters, if sufficiently strong, can also have both short-term and long-term negative effects on the affected economies (Benson and Clay 2000, 2003; Freeman 2000; Hines and Jaramillo 2005). Some of these detrimental effects are compensated for by increased migrants' remittances, foreign lending, aid, and investment, but it takes time until they do so (Yang 2005). Women are likely to be adversely affected by damage to economic livelihoods because basic survival strategies such as securing water, food, and wood for heating purposes often fall on women, representing an extra burden on top of caring for and nurturing the family (Enarson 2000). Where natural disasters reduce the purchasing power of households, women can be more adversely affected because in many countries men receive preferential access to resources. When resources become scarcer, then the part of the population suffering from discrimination beforehand will necessarily be hit even harder (for a study of gender-conflicts in access to water and its uses in Bangladesh, see Crow and Sultana 2002). In principle, recovery assistance could be preferentially addressed at those groups most vulnerable to protect them from the negative effect of increased discrimination. Yet, as mentioned above, instead of being granted a preferential role, women are often marginalized in their access to relief resources (Pan-American Health Organization 2002). Many disaster researchers have noted that in most countries relief efforts are almost exclusively managed and controlled by men, systematically excluding women, their needs, competences, and experiences from contributing to these efforts (see, e.g., Enarson 2000; Bradshaw 2004).[7]

There is widespread agreement that the poor are more adversely hit by the impact of natural disasters than are those more well-off.[8] The poor are less likely to be able to afford housing that can withstand seismic activity, they often live in flood- and storm-prone areas as well as on unstable slopes vulnerable to landslides, and they have less access to education and financial resources to overcome adverse impacts (Noji 1997b, 12). Although some have questioned the full extent to which existing evidence backs up the claim of a strong gender bias in poverty (Chant 2006), there is general agreement that poor people on average are more likely to be female. In combination, this implies that women will be more adversely affected by natural disasters since they are more than proportionally represented among the poor. For instance, O'Hare (2001) found that the most vulnerable group affected by Hurricane 07B in the Godavari Delta in India was "migrant, scheduled (low) caste women" who formed the major part of the landless agricultural laborers. The vulnerability resulting from predominantly female poverty is not confined to developing countries, however. For example, UNEP (2004) cites a study by the Japanese government that showed that during the Kobe earthquake in 1995 1.5 times as many women as men died. In Kobe, many elderly single women died because they lived in poor residential areas, which were more heavily damaged and more likely to catch fire.[9]

Lastly, there is some evidence, if not fully conclusive, that domestic and sexual violence against women in-

creases due to disaster-induced stress, alcohol abuse, and the (temporary) breakdown of law and order (Bradshaw 2004). If police, military, and fire brigades are unable (or unwilling) to organize the most severely affected regions, then distributive conflicts, theft, and open violence are likely to emerge. A collapse of social order may be more likely in countries in which the political authority is weak. However, the post-Katrina riots in New Orleans have demonstrated that even superpowers are not safe from disaster-related social unrest.

What is relatively well documented is that law and order are difficult to sustain when victims of natural disasters have to seek refuge in makeshift refugee camps often far away from their home cities or villages (Phuong 2004). In overcrowded camps anarchy rules, leaving unaccompanied women and girls particularly vulnerable to sexual abuse and rape. In addition, as pointed out above, women and girls are also more negatively affected by the often appalling health and hygienic conditions in refugee camps. This situation can become exacerbated if culturally binding norms allow certain forms of female hygienic care only under conditions of privacy and separation from men, which are often impossible to maintain in refugee camps. Toole (1997b) reports mortality rates from several refugee camps that are up to 100 times higher than the normal mortality rate in the country. Data disaggregated according to gender is very rare, but Toole reports data from a Burmese refugee camp in Bangladesh where female infants were twice as likely to die than male infants and the mortality rates of females above the age of five was 3.5 times higher than that of males.

Hypotheses

Biological and physiological differences between men and women, social norms and roles, which differently restrict the behaviors of men and women, emergent resource shortages and the temporary breakdown of social order jointly suggest that more women and girls than men and boys die during and after natural disasters or die at a younger age. Yet, the theoretical considerations of the previous sections also suggest that this effect is conditional on the socioeconomic status of women and on gender relations in the society affected by the disaster. Therefore, we postulate two hypotheses concerning the impact of natural disasters on the gender gap in life expectancy:

Hypothesis 1: Natural disasters reduce the life expectancy of women more than that of men and the effect is increasing in disaster strength.

This is partly because only larger disasters will kill enough people overall to leave their mark on our life expectancy measures but, more important, also because only larger disasters lead to the breakdown of infrastructure and law and order and to the drastically intensified competition for food and other scarce resources, leaving women in societies with rampant discrimination against females more vulnerable to disaster-induced mortality.

Hypothesis 2: Natural disasters reduce the life expectancy of women relative to that of men the more the lower is the socioeconomic status of women.

We expect that women are more adversely affected by natural disasters where female discrimination is more widespread before the onset of natural disaster events. Where there is a pro-male bias in "normal" periods, such bias becomes reinforced and exacerbated in postdisaster periods (Drèze and Sen 1989, 55; Bolin, Jackson, and Crist 1998, 42). Women are more adversely affected by natural disasters if gender inequalities in access to information and economic resources and inequalities in personal freedom of choice before, during, and after disasters create a "gendered disaster vulnerability" (Enarson 1998).

Research Design

Following on from the formulation of testable hypotheses in the preceding section, here we discuss how we measure and operationalize the three main concepts of our analysis.

Measuring Disaster Strength

For most countries in the world, natural disasters are a relatively common event. Our source, the Emergency Disasters Data Base (EM-DAT), collected at the University of Louvain, Brussels, currently includes around 9,700 natural disasters from 1900 to the present. Due to limited data availability on our measure of women's socioeconomic status, our sample is restricted to the period 1981–2002. The sample still covers 4,605 natural disasters since the coverage of natural disasters in EM-DAT is not very comprehensive for the first few decades of the twentieth century. EM-DAT is the only global data set of natural disasters that is publicly available. Two other global data sets are maintained by private reinsurance companies (Swiss Re and Munich Re), but no public access is granted (Guha-Sapir and Below 2002).

To be recorded in the database, an event must fulfill at least one of the following conditions: (a) ten or more people reported as killed; (b) 100 people reported as affected; (c) a state of emergency has been declared; or (d) the country has issued a call for international assistance. Clearly, with the latter two criteria the inclusion of an event in the database is partially endogenous to the response of governmental authorities in affected regions, states, or countries. Platt (1999) shows for the United States how the political struggle over who pays how much for the costs of natural disasters influences the likelihood of an event being declared a "major disaster." It is probable that political considerations in other countries as well affect the likelihood of declaration of a state of emergency or, depending on the circumstances, a call for international assistance. We see no reason why this should bias our results since such political considerations are unlikely to be systematically correlated with our variables of interest. Nevertheless, we will show that our results uphold if we restrict the sample to observations with ten or more people killed.

Most disasters take place in large countries, with the United States (442) leading the list, followed by India (293) and China (125). On the bottom end of the number of disasters, we of course find microstates but also Finland (1), Turkmenistan (2), and Sweden (4). In absolute numbers, the most victims were in Ethiopia (311,286), Sudan (158,252), and Bangladesh (149,225); the respective figure for the United States is 8,001 disaster victims. Accordingly, we find relatively poor countries suffering dramatically more from disasters in terms of people killed than relatively rich countries. Drought- and famine-ridden countries lead in the number of victims per disaster (Ethiopia = 4,716, Sudan = 3,297, Mozambique = 2,374), whereas only about 18 people die from the average disaster in the United States.

The number of deaths per disaster offers a poor description of the nature of our data. Most natural disasters cost few if any lives, but the three most severe disasters—the droughts in Ethiopia and Sudan in 1984 and the flood in Bangladesh in 1991—account for almost half of all fatalities in our sample. In other words, severe disasters are rare events. As a consequence, the distribution of the disaster strength variable is extremely skewed. It follows that we need to carefully check the validity of our results with regard to the leverage that certain influential observations might have on the results (see our bootstrap estimations below).

In operationalizing the EM-DAT data we have made three important choices: First, for the purpose of this study we decided not to focus on a specific disaster type but to consider all types for which EM-DAT provides information together. Our measure of natural disasters includes droughts, earthquakes, epidemics, extreme temperatures, famines, fires, floods, insect infestations, landslides, volcano eruptions, waves/surges, and windstorms. Table 1 provides some summary statistics on each disaster type. We recognize that famines in particular are often triggered by both natural factors and human decisions, but like Drèze and Sen (1989) we believe that these events cannot be neatly separated into "human-made" and "nature-made" types. We exclude disasters triggered by technological hazards such as the large-scale industrial accidents of Bhopal or Chernobyl since they are clearly human-made. Our decision to address all natural disasters together makes it impossible to detect differences between the effects of various disaster types on the gender gap in life expectancy, but we believe that this is inevitable for essentially two reasons: (1) the variance of some subcategories of natural disasters is too low to allow sufficiently efficient estimation, and (2) the EM-DAT unique categorization of each natural disaster into a specific disaster type is open to contestation. A natural disaster is thus, for example, a drought or a famine or a flood even though in the actual event most people might die from epidemics.

Table 1. Summary statistics on natural disasters in sample

Disaster type	Total no. of events	Total no. of deaths	Total no. of people affected
Drought	240	556,687	1,388,252,544
Earthquake	350	107,050	52,661,238
Epidemic	317	105,678	13,346,403
Extreme temp	108	16,897	6,120,497
Famine	36	11,524	57,332,711
Flood	938	119,707	1,731,081,382
Insect infestations	42	0	2,200
Landslide	182	14,228	1,122,215
Volcano	48	25,053	2,501,368
Waves/surges	12	2,724	12,919
Wildfire	103	624	3,523,398
Windstorm	1,121	87,029	340,100,574

Second, since our theoretical considerations suggest that the impact on the gender gap in life expectancy increases with the magnitude of the disaster, we cannot simply use dummy variables for disaster events, but instead we need a measure of disaster strength. We consider the number of people killed as the most important information of the magnitude of a disaster (rather than, for example, the number of people affected). We believe that the number of people killed is a better proxy of disaster strength because it is by far less arbitrary than

the accounts of the number of people affected. EM-DAT defines the category of affected people as all those requiring immediate assistance. But the number of affected people, thus defined, is much more difficult to estimate, and estimates from different sources vary far more than do estimates of the number of people killed. Guha-Sapir and Below (2002) provide some evidence of that in their comparative analysis of the way disasters in four disaster-prone countries are recorded in EM-DAT and the data sets maintained by Munich Re and Swiss Re. They found that estimates of the number of people killed for the same disasters were fairly close across the three data sets, whereas estimates of the number of people affected varied widely and sometimes by orders of magnitude. Quarantelli (2001, 326) in his critique of disaster statistics also points out that "figures on deaths are certainly the most reliable." We do agree, however, with his verdict that even estimates of fatality figures are often subject to uncertainties and sometimes to deliberate distortions, possibly on average tending to overestimate true casualty figures (Quarantelli 2001, 329). The number of killed persons as our disaster strength variable is therefore a proxy rather than an exact measure of the severity of disaster, and there is likely to be measurement error in the variable. However, as long as the error is not systematically correlated with the gender gap in life expectancy, and we see no reason why this should be the case, the measurement error will make our estimates less efficient, but will not bias them.

Third, we divide the number of people killed by the total population of the country hit by the disaster. The use of per capita data is analytically warranted since the influence of natural disasters on an affected country's life expectancy not only depends on the magnitude of the disaster but also on the population size of the affected country. Everything else being equal, the smaller the population size of the country under observation for disasters of a given size, the greater the reduction in life expectancy. The same should hold true when we consider the gender gap in life expectancy rather than life expectancy itself. A disaster that has no influence on the life expectancy can hardly affect the gender gap.[10] Ideally, we would have life expectancy data for subnational regions, so that we could easily estimate the immediate and lingering consequences of a disaster on the affected population. Unfortunately, this information does not exist. The data we have allow analyzing only the average life expectancy at the level of the nation-state. Hence, our disaster strength variable is the cumulated number of people killed by all natural disasters in a given year divided by the affected country's total population.

The Gender Gap in Life Expectancy

To measure the size of the gender gap, we employ data provided by the International Data Base (IDB) of the U.S. Census Bureau, which to our knowledge is the most reliable source for life expectancy data in panel form. In comparison to data provided by the World Bank (2004), the IDP is much better maintained and has far fewer missing data. The IDP was created for scientific purposes, in response to the information requirements of International Program Center (IPC) staff to meet the needs of organizations that sponsor research efforts. The IDB combines data from country sources (especially censuses and surveys) with IPC's estimates and projections, which are based on available census data and group cohort population projection techniques to compute data between the censuses. These projections are based on country-specific fixed-slope logistic interpolations in the years between national censuses. Moreover, recent population and socioeconomic trends are taken into account "if the projected trends are plausible" (U.S. Census 2004, B5). For instance, projection of fertility utilizes trends in age at marriage, the percentage of women using contraception, and existence and scope of family-planning programs, and data on educational attainment are used in life expectancy calculations.[11]

The gender gap in life expectancy shows large variations across time and space. Worldwide, on average, women's life expectancy is 4.69 years higher than that of men. However, in 64 out of 2,266 country-years men actually lived longer than women. In Bangladesh, India, and Nepal this phenomenon is common and can possibly be attributed to the traditional cultural bias against females in these countries. In all other cases a higher male than female life expectancy is the exception rather than the rule. On the other end of the spectrum, the gender gap is largest in post-transition Russia. The life expectancy difference between Russian women and men peaked in 1994, reaching an extraordinary 13.74 years.[12] It is noteworthy that countries from the former Soviet Union hold 49 of the top 50 country-years in terms of gender gap—the notable exception being Guatemala in 1981. In all these cases, women lived to about 70 to 75 years while men on average died at the age of 60 or before.

We use as our dependent variable the ratio rather than the absolute difference in years of female to male life expectancy because under certain conditions[13] changes in the absolute difference of female to male life expectancy can be a misleading indicator of the health effects of events. Therefore, if we measured the gender gap as the absolute difference between the life expectancies of women and men, it is possible that even though an equal

number of men and women die, the gender gap is still decreasing. This, in turn, implies that it is possible that male and female life expectancy can decrease by the same number of years and yet more men had died than women. Furthermore, equal proportional decreases in male and female life expectancy will lead to a larger absolute fall in the life expectancy of the gender with the higher ex ante life expectancy—typically the female life expectancy. This problem is accounted for if we measure the gender gap as the ratio of female to male life expectancy. To be on the safe side, we add the absolute change in population life expectancy as a regressor. In simulations, we found that using the life expectancy ratio and controlling for the absolute changes in population life expectancy removes the distortions that result from the computation of life expectancies.

In our view the IDB data are superior to all alternatives, but they do not come without potential drawbacks. Analyses of IDB data must almost necessarily suffer from correlated errors, since models that are used to predict the values of a certain variable can neither avoid systematic errors nor guarantee serial independence of observations. The imputed data for year $t+1$ cannot be independent of the observation in year t, whether or not that year is imputed. Any regression analysis based on these data inherits these systematic errors. Fortunately, since we have panel data we can use a random-effects estimator with an assumed first-order autoregressive error that deals with the problem of autocorrelation (see the Estimation Procedure subsection).

Women's Socioeconomic Status

To measure the socioeconomic status of women in society we use the measure of women's economic and social rights from Cingranelli and Richards's (2004) Human Rights Database. Using the annual U.S. State Department's *Country Reports on Human Rights Practices*, Cingranelli and Richards coded discrete variables for economic and social rights, each of which takes on one of four values. We add both variables to create a combined measure of women's socioeconomic rights (see the Appendix for details on the range of rights covered and the coding scheme used). Unfortunately, this variable is only available for 1981 onward, which restricts our analysis to the years 1981–2002, after which we have no information on other variables either.

Control Variables

Life expectancy and the gender gap therein are products of geographical, social, economic, and political influences. Some of these influences could be correlated with the variables of our main interest. For instance, the expected number of deaths in a disaster is negatively related to the wealth of the country. Omitted variables correlated with the exogenous variables of interest cause bias when they also exert an influence on the dependent variable. To minimize bias, we follow two strategies: First, climatic and other geographical differences as well as genetic conditions can impact the gender gap in life expectancy and are (approximately) time-invariant (UN Population Division 1988). We therefore include regional dummy variables in our estimations. Second, with per capita income, political stability, and the level of political suppression we add three important time-variant control variables. Data on per capita income are taken from World Bank (2004). Regime stability is defined as the number of years since the most recent three-point change on the Polity score,[14] which is a measure of institutionalized democracy and autocracy popular in political sciences, or the end of transition from a period of lack of stable political institutions. Political suppression is measured by data provided by Freedom House (2004), which bases its scale on expert judgment of the extent of violation of civil and political rights in countries.

Other socioeconomic variables of potential additional interest, such as health expenditures, access to food, and safe water and clean sanitation are not available for many countries in our sample. Moreover, although the severity of disasters is partly determined by per capita income (Kahn 2005) and (possibly) the level of democracy, the infrequent occurrence of natural disasters eliminates the potential correlation between our control variables and disaster strength. In fact, the correlation coefficient between disaster strength and the control variables does not exceed 0.06 in our sample. Therefore, from an econometric point of view, the inclusion of these variables is neither recommended nor warranted.

Estimation Procedure

Our data set consists of annual observations at the country level over the years 1981–2002 for up to 141 countries, but the amount of information available for each country may vary. Our data set therefore consists of what is commonly known as cross-national, time-series, or unbalanced panel data. Analysis of panel data has to deal with the two classical problems of serial correlation and various types of unit heterogeneity. To obtain unbiased and efficient estimates of the model at hand, the estimation procedure of choice has to resolve both problems without causing too many unwanted side

effects (Adolph, Butler, and Wilson 2005; Plümper, Troeger, and Manow 2005). As mentioned, we use a random-effects estimator with an assumed first-order autoregressive error that deals with the problem of autocorrelation. To account for some heterogeneity across countries, we include regional dummy variables. The regions are North America, Central America, South America, Western Europe, Eastern Europe, West Africa, Southern Africa, Northern Africa, West Asia, South and East Asia, and Australia and Oceania.

Estimation Results

Main Results

Our theory predicts a significantly negative effect of the disaster strength variable on the gender gap in life expectancy, and a significantly positive interaction effect between women's rights and disaster strength. Table 2 reports the results from two estimates: model 1 is the baseline model that merely includes disaster strength, women's socioeconomic rights, and their interaction effect; Table 3 adds the control variables. A comparison of the two models shows that the addition of the controls makes practically no difference to the results on our main variables of interest.

Table 2 shows support for our hypotheses, for the gender gap in life expectancy declines with disaster strength (Hypothesis 1). We also find that a higher level of women's socioeconomic rights offsets the negative effect of natural disasters on women, which supports our second hypothesis. The coefficient has the expected positive sign and size,[15] suggesting that the adverse effect of natural disasters on the gender gap in life expectancy is conditioned on the socioeconomic status of women in society. In countries with better rights for women, the adverse impact of natural disasters on women's life expectancy relative to men vanishes.

Table 2. Natural disasters and the change in the gender gap in life expectancy

	Model 1	Model 2
Change in population life expectancy	0.028	0.028
	(0.009)**	(0.009)**
Disaster deaths per thousand people	−0.732	−0.729
	(0.081)**	(0.081)**
Women's socioeconomic rights	−0.049	−0.045
	(0.030)	(0.030)
Disaster deaths x women's socioeconomic rights	0.365	0.365
	(0.052)**	(0.052)**
Per capita income		−0.000
		(0.000)
Political stability		−0.005
		(0.004)
Level of political freedom		−0.072
		(0.021)**
Number of observations	2266	2241
Number of countries	141	141
R^2	0.29	0.28
Wald chi-square test	190.1**	206.3**

Notes: Estimations include regional dummy variables and constant (coefficients not reported). Standard errors are in parentheses. Model 1 is the baseline model that merely includes disaster strength, women's socioeconomic rights, and their interaction effect; model 2 adds the control variables.
**$p<0.01$ (two-sided z-test)

Table 3. Extended estimation results

	Model 1	Model 3	Model 4	Model 5	Model 6
Change in population life expectancy	0.028	0.030	0.017	0.036	0.026
	(0.009)**	(0.011)**	(0.033)	(0.010)**	(0.009)**
Disaster deaths per thousand people	−0.732	−0.743	−0.377	−1.005	−0.772
	(0.081)**	(0.095)**	(0.123)**	(0.692)	(0.083)**
Women's socioeconomic rights	−0.049	−0.050	−0.135	−0.028	−0.045
	(0.030)	(0.039)	(0.066)*	(0.030)	(0.030)
Disaster deaths × women's socioeconomic rights	0.365	0.385	0.178	0.326	0.431
	(0.052)**	(0.065)**	(0.075)*	(0.241)	(0.060)**
Number of observations	2266	1491	894	2266	2266
Number of countries	141	117	121	141	141
R^2	0.29	0.28	0.29	0.29	0.29
Wald chi-square test	190.1**	146.9**	77.4**	108.9**	193.5**

Notes: Estimations include regional dummy variables and constant (coefficients not reported). Standard errors are in parentheses. Model 1 is the benchmark model. Model 3 excludes developed countries. Model 4 excludes observations with fewer than 10 people killed. Model 5 excludes droughts and famines. Model 6 includes only droughts and famines.
*$p<0.05$ (two-sided z-test)
**$p<0.01$.

Robustness Analysis

We conducted a number of robustness tests (see Table 3), starting by replicating our model 1 for comparative purposes. Our results show that the negative effect of natural disasters on the gender gap in life expectancy decreases with higher levels of women's socioeconomic rights. Western countries are characterized by both low natural disaster intensity (in terms of people killed relative to population size) and high women's socioeconomic rights. This begs the question whether our results are perhaps driven by the inclusion of this group of countries in our sample. To check this, in model 3 we excluded from the sample Canada, the United States, and Western European countries as well as Japan, Australia and New Zealand. The results are hardly affected. Next, we have mentioned that what counts as a natural disaster in our source, EM-DAT, can be triggered by the declaration of a state of emergency or a call for international assistance, which may be subject to political considerations. Another criterion, number of people killed is ten or more, is far less subject to political influence unless a country manages to hide or artificially inflate disaster deaths. To check that declarations of states of emergency and calls for international assistance do not bias our results, we include in model 4 only observations with ten or more people killed. The results hold up. In model 5 we exclude droughts and famines from the definition of natural disasters, as these are events of a more chronic nature. The disaster strength variable and its interaction effect become marginally insignificant. However, this is due to the increase in the standard error following the reduction in the variance of the disaster variable for the remaining disaster types, which renders estimation less efficient. But note that the coefficients remain very similar. We do the opposite in model 6 and exclude all natural disasters other than droughts and famines. Results from model 6 are again similar to results from model 1.

We have noted already that severe natural disasters are a rather rare event. Although the main results reported above support our theoretical expectations well, the question is whether they are driven by a few very influential disaster observations. To check this, we now apply a bootstrap estimation of standard errors. The purpose of this test is to see whether the statistical significance of our main variables of interest is robust or is due to the particular population sample at hand. To save space, we report only results of applying the bootstrap test on results of model 1. Applying it to the results for model 2 as well makes little difference. The bootstrap is a resampling technique that sheds some light on the distributional properties of statistics, but it is also useful as a means of obtaining more robust standard errors. The bootstrap algorithm draws repeated resamples (with replacement) from the given population, and then estimates the model at hand. Hence, the sample that we estimate always has the same size as model 1, but the composition of the samples varies, because a single observation from the original dataset can be drawn repeatedly (which implies that other observation will not be included in that estimate). Commonly used replications are 100, 500, or 1,000. The *t*-statistics averaged across a series of say 1,000 samples necessarily have a larger standard error than the model estimated on the basis of the total population. Table 4 reports results on our variables of interest from the bootstrap test with 1,000 replications. They suggest that the disaster strength variable and its interaction effect with women's economic rights remain statistically significant even if the standard errors are bootstrapped. Moreover, we find that the bias-corrected estimates of our coefficients and the standard errors diverge no more than moderately from the results reported in Table 2. It is typically assumed that if the bias is larger than 25 percent of the standard error of the sampling distribution, the bias corrected confidence intervals are likely to be more appropriate than the normal confidence intervals. In our case, the bias is smaller than 25 percent. Our interpretation of model 1 thus remains valid. In other words, we can be fairly certain that the statistical significance of our main variables of interest do not depend on outliers.

Conclusion

Geographers and other social scientists have argued for many years that there is little that is natural about the impact of natural disasters on affected people. As O'Keefe, Westgate, and Wisner (1976) have put it in the title of their early contribution to *Nature*, "taking the naturalness out of natural disasters" is what is needed. Natural disasters do not affect people equally as if by an arbitrary stroke of nature. Instead, the disaster impact is contingent on the vulnerability of affected people, which can and often does systematically differ across economic class, ethnicity, gender, and other factors.

In this article, we addressed one specific impact of natural disasters (disaster mortality) and how it affects women differentially from men. We observed a systematic effect of disaster strength on the gender gap in life expectancy if the disaster affects societies in which the socioeconomic status of women is low. In such societies, natural disasters will kill directly, and indirectly via related postdisaster events, more women than men or will kill

Table 4. Estimation results with bootstrapped standard errors

	Observed	Bias	Std. error	Confidence Interval		
Beta coefficients						
Disaster deaths per thousand people	– 0.7448	0.1342	0.6685	– 2.0565	0.5670	(N)
				– 1.7311	0.3787	(P)
				– 1.7653	0.3511	(BC)
Women's economic rights	– 0.0484	– 0.0025	0.0390	– 0.1248	0.0281	(N)
				– 0.1319	0.0214	(P)
				– 0.1291	0.0215	(BC)
Disaster deaths × women's economic rights	0.3615	– 0.0730	0.3250	– 0.2763	0.9993	(N)
				– 0.1830	0.8356	(P)
				– 0.1595	0.8702	(BC)
Standard errors						
Disaster deaths per thousand people	0.0762	0.0232	0.0764	– 0.0737	0.2261	(N)
				0.0486	0.3538	(P)
				0.0490	0.3634	(BC)
Women's economic rights	0.0284	– 0.0011	0.0029	0.0227	0.0340	(N)
				0.0215	0.0332	(P)
				0.0236	0.0351	(BC)
Disaster deaths × Women's economic rights	0.0488	0.0119	0.0315	– 0.0130	0.1105	(N)
				0.0341	0.1623	(P)
				0.0310	0.1176	(BC)

Note: N = normal, P = percentile, BC = bias corrected.

women at a younger age than men. These findings support a vulnerability approach to natural disasters. There are few reasons why female life expectancy should be systematically more adversely affected by natural disasters than that of men were it only for reasons determined by nature, such as biological and physiological differences that on average disadvantage women and girls relative to men and boys. A systematic effect on the gender gap in life expectancy is only plausible if natural disasters exacerbate previously existing patterns of discrimination that render females more vulnerable to the fatal impact of disasters. That this is no mere speculation is demonstrated by the fact that the adverse impact of disasters on females relative to men vanishes with rising socioeconomic status of women. We acknowledge, however, that much more interdisciplinary research between medical and social scientists is needed to fully understand the interplay between mortality and gender in the presence of natural disasters. We also need more research to fully understand why and how disaster strength interacts with mortality in general and with female mortality in particular.

Our findings require relevant stakeholders to go beyond technical fixes in dealing with natural disasters. True, the underlying cultural, social, and economic patterns that lead to a low socioeconomic status of women and thereby generate their specific vulnerability to natural disasters are not easy to deal with. But this does not mean that nothing can be done. Our finding that, on average, large natural disasters lower the life expectancy of women more than that of men, and particularly so where women have a lower socioeconomic status, implies that policymakers, nongovernmental organizations, and the academic community need to pay closer attention to the gendered nature of disaster vulnerability. Such attention should focus on the special medical, economic, and security needs of women in the aftermath of disasters as well as on mechanisms to ensure fair and nondiscriminatory allocation of relief resources. Developing such policies will not entirely prevent the adverse impact of large-scale natural disasters on women in societies where their everyday socioeconomic status is low. Such policies should, however, reduce the excess disaster mortality of women compared to that of men.

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Appendix: Coding scheme for Cingranelli and Richards's (2004) Women's Rights Measures

The measure of economic rights covers the following:

– Equal pay for equal work

– Free choice of profession or employment without the need to obtain a husband or male relative's consent
– The right to gainful employment without the need to obtain a husband or male relative's consent
– Equality in hiring and promotion practices
– Job security (maternity leave, unemployment benefits, no arbitrary firing or layoffs, etc.)
– Nondiscrimination by employers
– The right to be free from sexual harassment in the workplace
– The right to work at night
– The right to work in occupations classified as dangerous
– The right to work in the military and the police force.

The measure of social rights covers the following:

– The right to equal inheritance
– The right to enter into marriage on a basis of equality with men
– The right to travel abroad
– The right to obtain a passport
– The right to confer citizenship to children or a husband
– The right to initiate a divorce
– The right to own, acquire, manage, and retain property brought into marriage
– The right to participate in social, cultural, and community activities
– The right to an education
– The freedom to choose a residence/domicile
– Freedom from female genital mutilation (FGM) of children and of adults without their
– consent
– Freedom from forced sterilization.

The coding of the variables is as follows:

(0) There are no economic (social) rights for women under law and systematic discrimination based on sex may be built into the law. The government tolerates a high level of discrimination against women.
(1) There are some economic (social) rights for women under law. However, in practice, the government *does not* enforce the laws effectively or enforcement of laws is weak. The government tolerates a *moderate level* of discrimination against women.
(2) There are some economic (social) rights for women under law. In practice, the government DOES enforce these laws effectively. However, the government still tolerates a *low level* of discrimination against women.
(3) All or nearly all of women's economic (social) rights are guaranteed by law. In practice, the government fully and vigorously enforces these laws. The government tolerates none or almost no discrimination against women.

Notes

1. We agree with Varley (1994, 4f.) that the vulnerability approach as an analytical concept is applicable even if one does not subscribe to the critique of capitalism embraced by some of its proponents (see Wisner 2000a, 2000b, and the references cited in Varley 1994, 4). Albala-Bertrand (1993) applies the vulnerability approach within the framework of mainstream economics.
2. Cutter (2003, 7–8) herself describes a number of most significant themes for a geographical research agenda of vulnerability science.
3. See Plümper and Neumayer (2006) for similar results on the influence of militarized conflict on the gender gap in life expectancy.
4. Indeed, based on twin research, medical research has demonstrated that 'environmental factors' (year of birth, region, childhood living conditions, and education) influenced body-height (Silventoinen, Lahelma, and Rahonen 2000). This research shows that biological sex differences are not independent of gender relations—though of course gender differences fall far short of explaining physical differences across sexes in its entirety.
5. Other reasons include the typical out-migration of men, which makes them vulnerable to accidents, attacks and the acquisition of infectious diseases, as well as the reduced fertility rate of women during famines compared to non-famine years (Dyson 1991b; Macintyre 2002).
6. De Waal (1989), however, finds no significant sex differences in child excess mortality in his case study of famine mortality during 1984/85 in Darfur, Sudan, except for the age group between five and nine where more boys seem to have died.
7. While Aquino, Steisel, and Kay (1992) argue that unequal distribution of resources leads to less cooperation, Kramer (1990) demonstrates that not only does an increase in resource scarcity foster cooperation, the increase in cooperation may even partly offset the adverse effects of scarcity. More recently, Hausken (1995) has shown that within-group competition increases if between-group competition becomes fiercer. His findings suggest that resource scarcity may actually increase both cooperation and conflict in a society. Our argument here is consistent with all these diverse arguments and findings, as we simply claim that if resources become scarce, distributive issues become more important. Under this condition, the extent of cooperation determines how many individuals will suffer; societal norms, however, determine which individuals will suffer the most.
8. This is true even for highly developed countries like the United States as the televised pictures of New Orleans in the wake of hurricane Katrina showed so vividly. The

overview article by Fothergill and Peek (2004) demonstrates that this represents a general pattern.

9. Seager (2005), in a commentary published by the *Chicago Tribune*, presented anecdotal evidence according to which most people trapped in New Orleans in the aftermath of hurricane Katrina were (black) women (see also Seager 2006). She estimates that 80 percent of those who did not leave the city within time were women and speculates that a similar ratio will apply to the sex difference in fatalities. However, at least as concerns direct and identified victims from Katrina, the statistics published by the State of Louisiana's Department of Health and Hospitals would suggest that while the victims were predominantly old and African American, an about equal number of men and women died (http://www.dhh.louisiana.gov/offices/publications/pubs-192/Deceased%20Victims_2-23-2006_information.pdf; last accessed 11 July 2006). The possibility remains that more women may have died in the aftermath of and as the indirect consequence of Katrina.
10. The argument that the average life expectancy may remain constant if the female life expectancy declines while the male life expectancy increases is not valid, because natural disasters do not increase the life expectancy of a large subgroup of the population.
11. Recently, the World Health Organization (WHO) has developed new data on Disability Adjusted Life Years (DALYs) lost that represent a very comprehensive and data-intensive measure with less measurement errors than the standard life expectancy measures. DALYs are calculated for individual major disease categories and reflect the years of life lost due to death in the fatal cases as well as the expected disability caused by a disease in non-fatal cases. The great disadvantage is that DALYs are not yet available over a longer period of time, allowing only a cross-sectional analysis, which is a major drawback as explained in the text. Also, while non-adjusted life expectancy is theoretically inferior to disability-adjusted life expectancy, we note that the WHO itself has pointed out that the two are very highly correlated (Mathers et al. 2001, Fig. 4).
12. Reasons were manifold. While Andreev et al. (2003) hold the Russian health care system responsible, other sources report a steep increase in alcohol abuse and deaths from organized crime (McKee 1999).
13. Changes in mortality rates of a specific age cohort affect also person-years lived of older age cohorts due to changes to the number of survivors to older age and this has a larger effect on life expectancy at birth if the life expectancy of the age cohort is higher (Preston, Heuveline, and Guillot 2001, 64). Natural disasters would lead to relatively larger changes in the gender gap in life expectancy if the persons killed have not yet reached age cohorts that show large gender differences in mortality rates. For example, if most individuals killed in a disaster and its aftermath are below 30 years old and if women above 30 are less likely to die at a certain age than men of the same age and women's life expectancy at birth is higher, then the change in the absolute difference between female and male life expectancy is a biased proxy for the mortality rates of that conflict.
14. Polity score data, housed at the Center for International Development and Conflict Management at the University of Maryland, are available at http://www.cidcm.umd.edu/inscr/polity/.
15. Given the estimated coefficients, theoretically there exist combinations of high values of both disaster strength and women's economic rights that would suggest an overall increase in the gender gap in life expectancy. However, such combinations do not exist in our sample.

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