The Impact of Climate Change on the Demography of Meteorological Disaster Mortality

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Abstract

Global warming is likely to affect the frequency and intensity of floods. The actual impact of meteorological disasters on populations will be determined by the interaction of these events with the ability of societies to cope with them. In turn, the resilience of societies will depend on factors like socio-economic development, demographic composition, level of education, institutions, and infrastructure. In this paper, we evaluate the heterogeneous impact of meteorological disasters on populations, along the dimensions of age, sex, and development. In the spirit of model life tables, we combine independent data sources to evaluate the differential impact of floods, storms and hurricanes. The WHO mortality database provides deaths by age, sex and cause for a large number of countries; EM-DAT offers information on number of deaths for different types of disasters, across countries and over time; existing country-specific surveys provide information about age- and sex-specific profiles of mortality for some natural disasters. We evaluate the impact on age- and sex-specific mortality and the consequences in terms of potential years of life lost. The results are relevant to identify subgroups of populations which are more vulnerable to natural disasters and to predict how development may reduce the impact of climate change.

INTRODUCTION

The main purpose of our analysis is to evaluate the impact of floods and related meteorological disasters on the mortality of different population subgroups. In particular, we are interested in some key demographic dimensions: age, sex and socio-economic development. On the whole, less developed countries experience greater loss of life from natural disasters than developed countries. Existing literature suggests that high- and low-income countries may have different age-sex patterns of flood fatalities. Although there is a fairly large body of literature on the health consequences of natural disasters, a systematic analysis of patterns of flood-related mortality broken down by age and sex is still missing.

In this article, we aim to combine existing evidence on disaster-related mortality with a mostly untapped resource in the disaster literature: cause-, sex- and age-specific mortality data. Our goal is to identify patterns of mortality due to meteorological disasters, evaluate how they are related to cause-specific mortality profiles, like the one for “drowning”, and describe quantitatively different patterns, in the spirit of demographic model life tables.

We believe that the identification of patterns of disaster-related mortality by age, sex and level of development is important because it would allow us to predict the extent to which societies will be able to cope with natural disasters as their demographic composition and socio-economic level change.

In this article, we focus on mortality that happened as a direct result of meteorological disasters. Considering direct mortality as a measure of impact has some disadvantages. However we believe that the advantages more than counteract the drawbacks. In addition to direct impacts, floods have a number of indirect effects, which include morbidity and livelihood disruption, which may potentially lead to additional mortality. Although these indirect effects are important, their size is “second” or “third order”, compared to the direct effects. Direct mortality, especially mortality related to drowning accounts for the large majority of fatalities. Measures different from mortality, like economic damage or injuries, could also be considered. However, measures like economic loss may strongly be dependent on the level of GDP for specific countries, and their estimates are much more uncertain. Estimates of direct mortality are more precise. Moreover, the value that societies attach to human life can be assumed to be quite universal around the world, although differences may exist. Therefore, death is an appropriate indicator for comparative analyses.

In the following section, we review the relevant literature on differential vulnerability to meteorological disasters. We then describe the data and strategy for this paper. Finally we present some very preliminary results. As we develop our models and sharpen our analyses, we expect to be able to provide more detailed and comprehensive results.

BACKGROUND

There is evidence that both the frequency and intensity of extreme weather events such as storms, floods and drought have been increasing over the past decades (IPCC 2007), with floods being the most common type of natural disaster worldwide. Being the most fatal kind of hydro-meteorological disaster, during the first decade of the 21st Century, almost half of all fatalities from natural disasters were due to flooding (Alderman, Turner, & Tong 2012). The risk of death does not depend only on the characteristics of the flood e.g. speed of onset, scale, duration, velocity and depth of water, but it is also related to infrastructure, warning systems, development of coastal areas and flood plains, and population settlement (Ahern, Kovats, Wilkinson, Few, & Matthies 2005). With poorer infrastructure, lack of communication and higher population density, developing countries have suffered much higher death rates from floods than more developed countries (Doocy, Daniels, Murray, & Kirsch 2013).

At the individual level, it has been shown that flood-related mortality is not distributed evenly across population subgroups. Gender, age, ethnicity and socio-economic status are reported to be associated with the risk of mortality from floods. Most studies showed that the elderly are more vulnerable to floods (Jonkman, Maaskant, Boyd, & Levitan 2009; Myung & Jang 2011; Thacker, Lee, Sabogal, & Henderson 2008) but it is also reported that very young children especially in low income countries have higher flood-related mortality (Pradhan et al. 2007). Evidence on mortality risk by economic and ethnic characteristics are consistent across nations, with those from minority ethnic groups and those of low socio-economic status/income have far higher risk of flood fatality (Brunkard, Namulanda, & Ratard 2008; Pradhan et al. 2007). Patterns of fatalities differ by gender. In developed countries men experience higher flood-related death; in less developed countries in some situations women have higher risk of mortality from floods (Alderman et al. 2012; Doocy, Daniels, et al. 2013; Doocy, Dick, Daniels, & Kirsch 2013). This highlights the importance of understanding which groups are more vulnerable and in which context.

Empirical studies of demographic differentials on flood-related mortality are overwhelmingly based on flooding events in the United States (Ashley & Ashley 2008; Jonkman & Kelman 2005; Jonkman et al. 2009; Thacker et al. 2008) and a few other developed countries (FitzGerald, Du, Jamal, Clark, & Hou 2010; Jonkman & Kelman 2005). Literature on age-sex differences on flood fatalities are not widely available in developing nations because deaths are often under-registered and data on cause of death are frequently incomplete. Besides, cross-national studies on the impacts of flooding on loss of human life that include both developed and less developed nations are not so common.

DATA & METHODS

Existing literature suggests that high- and low-income countries may have different age-sex patterns of mortality related to meteorological disasters. This study aims at investigating age-sex differentials in mortality from floods, storms and hurricanes across both developed and developing countries. The main purpose of our analysis is to evaluate the impact of meteorological disasters on mortality by age, sex and socio-economic development.

No single dataset provides all the information that we need. Therefore, we combine independent data sources. Using the WHO mortality database[1] for the years 1980-2011, we identify direct and indirect causes of death related to flooding. Drowning and acute trauma (e.g. being hit by objects in fast flowing waters and electrocution) are classified as direct flood fatality. Other deaths that occurred during or after the flooding such as diarrheal deaths, dehydration/heat stroke, cardiovascular or other causes associated with lack of sustaining medical supplies are treated as indirect flood mortality. Flooding events are identified via two primary data sources: 1) CRED International Disaster Database (EMDAT)[2]; and 2) the Dartmouth Flood Observatory (DF) Global Archive of Large Flood Events[3] which record significant floods globally. The EMDAT database provides estimates of the number of deaths related to natural disasters like floods, storms and hurricanes, for all countries of the world, for a large number of years. The World Health Organization (WHO) mortality database offers number of deaths by age, sex and cause, for a large number of countries, together with population size, by age and sex. For some countries, this dataset extends back to the early 1980s, for others to the 1990s.

Mortality related to storms, floods, tidal waves and hurricanes is classified with the code X37 in the International Classification of Diseases-10. The group of causes of death X37 includes deaths due to various specific causes that happen as a result of cataclysmic storms and related natural disasters. The WHO mortality database (Icd 10) provides data on deaths for the group X37 for more than 50 countries. This is a very important resource to study disaster mortality.

In some situations, especially when the size of the natural disaster is contained, data for the group X37 may be missing. In these situations, we concentrate our analysis on a specific cause of death: “accidental drowning and submersion”. The reason why we chose this cause of death is because the large majority of deaths due to meteorological disasters happen because of drowning or submersion (Myung and Jang 2011). The WHO mortality database provides number of deaths due to drowning and population counts, by age and sex. We consider two situations. For countries and years when the

[1] http://www.who.int/healthinfo/mortality_data/en/
[2] http://www.emdat.be/
[3] http://www.dartmouth.edu/~floods/

floods generated a relatively small number of deaths, we take the age- and sex-specific mortality rates for drowning, for the respective year and country, from the WHO database, and we distribute deaths recorded in the EMDAT database to the various demographic groups accordingly. For countries and years when floods were particularly deadly, we look at excess mortality by age and sex for drowning that results from the specific flood (or directly from the group of causes X37). When data for the group of casuses X37 does not exist, we compare the age- and sex-specific profiles of drowning-mortality for the year considered with the expected profile that we estimated by interpolating profiles for the years before and after the deadly flood. Interpolation is generated using smooth splines.

The evaluation of excess mortality requires careful consideration of country-specific situations. In some countries, mortality related to large natural disasters may not be recorded in vital statistics. In these situations, we “borrow” information from profiles of mortality for drowning. We distribute deaths obtained from the EMDAT database to the relevant demographic groups according to the prevailing age- and sex-specific profiles of drowning-mortality for the given year and country. Although this procedure is not optimal for many types of disaster-related mortality, evidence that the age- and sex-specific profiles of flood mortality resemble the ones for drowning (e.g., Myung and Jang 2011) is reassuring.

Our estimates of the age-, sex- and country-specific deaths generated by floods are then used to evaluate potential years of life lost for the different demographic groups across time. The ultimate goal is to document the relationship between flood-mortality and key characteristics of populations and their members: age, sex and socio-economic development. Understanding this relationship will help us assess the potential impact of climate change on mortality and how that differs at various stages of development for countries in different regions of the world. This information will allow us to evaluate the potential ability of societies to cope with climate change in the future, and to identify the groups within a population that are more at-risk of suffering from the consequences of climate change.

PRELIMINARY RESULTS

Figure 1 shows estimates of death rates due to cataclysmic storms, by age and sex, for the USA in 2005. The profiles provide a picture of the differential impact of hurricane Katrina on mortality. Death rates had a tendency to be larger for males than females. The elderly were disproportionately affected by the hurricane, compared to other age groups.

We show figure 1 as an illustrative example of a situation where a large disaster occurred and the people who died were classified as victims of a cataclysmic storm. In this and similar cases, profiles of mortality rates by age and sex can be obtained directly from the WHO mortality database by considering deaths classified with the code X37. Our goal is to extract data of this type for all available countries and identify different patterns of mortality in the context of cataclysmic storms and in the spirit of model life tables.

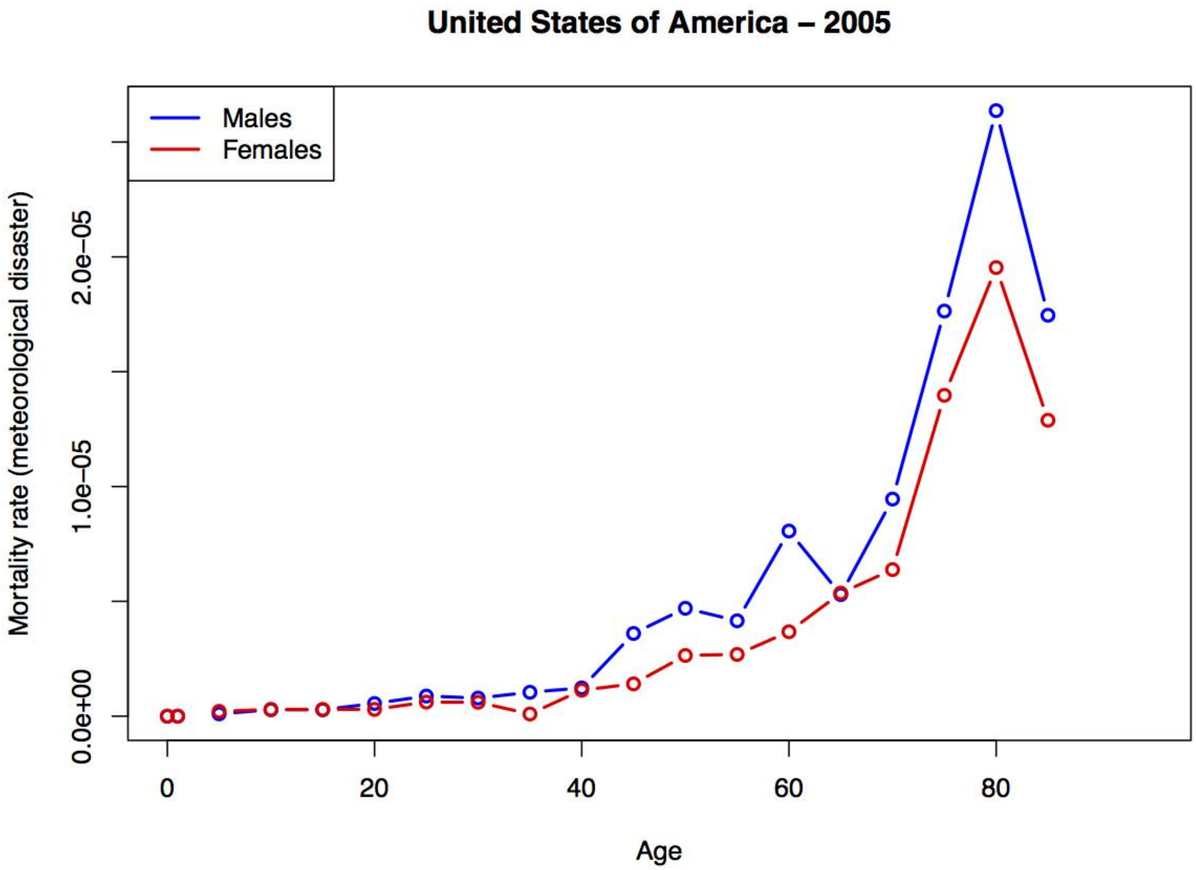

Figure 1: Mortality rate due to cataclysmic storm in the USA (2005), by age and sex. The profiles provide a picture of mortality directly related to hurricane Katrina. Source: WHO mortality database.

We have data for causes of death related to cataclysmic storms for over 50 countries. For those situations where data are either sparse or missing, we “borrow” information from profiles of mortality for drowning. As a proof-of-concept, Figure 2 shows mortality profiles by age and sex for the Republic of Korea, in 1995 and in 2010. The profiles are consistent with flood-related mortality schedules in the existing literature for the Republic of Korea (e.g., Myung and Jang 2011). This suggests that data on drowning-mortality can be used to evaluate a pattern of mortality that may be appropriate for small-scale recurrent meteorological disasters.

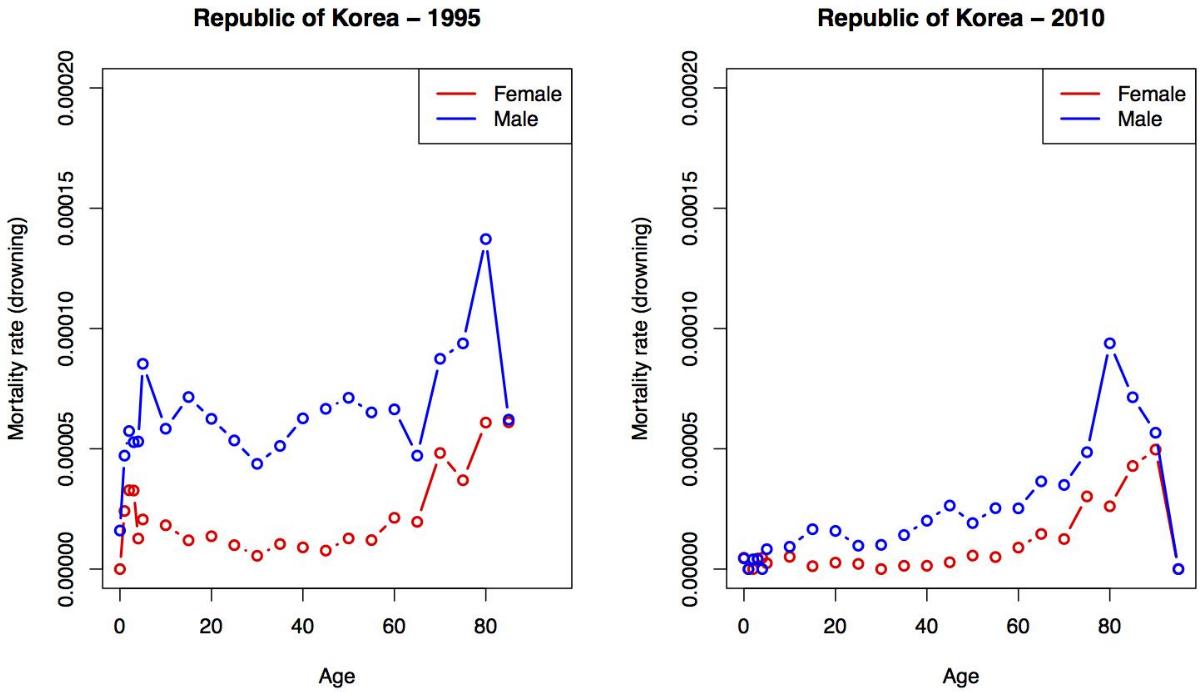

Figure 2: Mortality rate due to drowning for the Republic of Korea, in 1995 and 2010, by age and sex. Source: WHO mortality database.

Figure 2 is also representative of a general trend of improvements of accidental mortality that come with socio-economic and institutional development, as well as higher levels of education. In addition to reductions of deaths, that may be interpreted as improved ability of societies to cope with external causes of death, we observe a decrease over time in the difference between adult male and female mortality.

The examples that we presented are mainly aimed at providing the flavor of the type of analyses that we are undertaking. As we develop our models, merge the data sets and include all the countries for which we have data, we expect to be able to provide precise statements about years of potential life lost due to meteorological disasters, and a fairly comprehensive picture of the demographic dimension of meteorological disaster mortality.

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