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Abstract

This research note examines children's mortality resulting from forces of nature, including heat exposure, cold exposure, storms and flooding, lightning strikes, avalanches, earthquakes, and volcanic eruptions. Data indicate that in the United States, children's risk of death resulting from natural disasters is relatively low. However, differential risks exist depending on the type of hazard agent involved and between youth populations based on age, gender, and race. Specifically, analyses of mortality data show that risk of death by natural disaster among youth cohorts age 0-24 is highest for infants, the most fragile and dependent segment of our population. The death rate for male children is higher than the death rate for female children across all age cohorts. Data on race indicate that African American male children between the ages of 0-4 are most at risk for death by disaster, while white male children between the ages of 5-24 are most at risk. In terms of risk by age by hazard type, infants and very young children age 0-4 are most likely to die of exposure to extreme heat, 5-14 year-olds are most likely to die in cataclysmic storms and flood events, and youth age 15-24 are most likely to die of excessive cold. These findings have important implications for future research and policy decisions associated with protecting children and youth in disasters.

Keywords: children, disasters, gender, race, mortality, vulnerability

Introduction

The growing literature on social vulnerability and disasters clearly demonstrates that natural disasters and other extreme events do not impact populations equally or at random (Enarson and Morrow 1998; Hewitt 1997; Peacock, Morrow and Gladwin 1997; Wisner et al. 2004). Instead, deaths, injuries, and property loss from disasters tend to reflect larger patterns of social stratification and geographies of social vulnerability (Cutter 1996; Cutter, Boruff and Shirley 2003; Cutter, Mitchell and Scott 2000). Groups that have been identified as particularly vulnerable to disasters include the poor, racial and ethnic minorities, women, the elderly, and children (Anderson 2005; Bolin 2006; Enarson, Fothergill and Peek 2006; Klinenberg 2002). Because of their marginalized positions in society, these groups often have the hardest time preparing for and responding to disasters, and thus suffer disproportionate impacts when a disaster event occurs.

Children are often considered among the most vulnerable in disaster events because of their physical size, levels of psychological and behavioral development, and complete or partial dependence on adults for various forms of support and protection. While numerous studies of post-disaster mental health have shown that exposure to trauma can have a severe impact on the psychosocial well being of children and youth (La Greca et al. 2002; Udwin 1993; Vogel and Vernberg 1993), much less research has focused on children's risk for physical injury or loss of life in disaster.

The research that is available on youth mortality in disasters has examined the number and rates of casualties among children in particular disaster events. Because developing countries are more prone to large-scale catastrophes that cause extensive loss of life, most systematic studies of youth mortality have focused on these contexts. For example, following the 1976 Guatemalan earthquake, Glass and colleagues (1977) compared fatalities among children of different ages and found heightened mortality rates for children aged 5-9 years. In the 1991 Bangladesh cyclone, which may have killed as many as 138,000 people, Ikeda (1995) found that the mortality rate was highest among infants (0-4 years old). Similarly, Parasuraman (1995) reported that approximately 55 percent of those 3,490 individuals who died in the 1993 Latur-Osmanabad (Maharashtra) earthquake in India were children between the ages of 0-14.

Using household survey data, Ramirez and colleagues (2005) assessed how individual and household environmental factors influenced the risk of injury or death for children following the 1999 Kocaeli earthquake in Turkey. They discovered that both non-fatal and fatal injury rates among girls were about twice the rates for boys. They also reported that the youngest age group (0-4 year olds) had the lowest fatal and non-fatal injury rates, while 10-14 year olds were at the greatest risk for injury and death. Although the final death toll will never be known, the 2004 Indian Ocean earthquake and tsunami resulted in the deaths of more than 181,000 people, and it is estimated that at least one-third of these victims were children (Oxfam International 2005). The 2005 South Asia earthquake killed over 18,000 children, many of whom lost their lives while attending schools in buildings that collapsed (International Federation of Red Cross and Red Crescent Societies 2007).

Researchers have identified numerous social and environmental factors that contribute to children being at risk for death in disaster. These include residing in poorer countries and communities (Sapir and Lechat 1986), living in and going to school in substandard structures (Parasuraman 1995), losing a parent or becoming separated from family members (Sapir 1993; Sapir and Lechat 1986), and experiencing malnutrition and poor diet (Webster 1994; Young and Jaspars 1995) or artificial feeding (i.e., bottle feeding) (Kelly 1993). Female children are also at higher risk of death (Ramirez et al. 2005; Rivers 1982; Sapir 1993), at least in developing nations. Research has shown that in some famines more females than males die at as infants or at a very young age, an outcome that is most likely due to discriminatory access to food resources with a bias against female babies and children (Agarwal 1990; Bairagi 1986; Dyson 1991; Greenough 1982; Kidane 1989, 1990; Mariam 1986). There is no consensus in the literature on the age at which children are most at risk for death in disasters, largely because different types of disaster seem to differentially impact children of various age groups (for example, infants may be more at risk for death in flooding and cyclones, while older children may be more at risk in earthquakes).

Although the aforementioned studies have increased our knowledge of which factors may place children at special risk for injury or death in disasters, additional research is needed to better understand the relative vulnerability of children for various types of hazards (Anderson 2005). In recognition of this gap in scholarly knowledge, this research note examines children's mortality in the United States resulting from forces of nature, including heat exposure, cold exposure, storms and flooding, lightning strikes, avalanches, earthquakes, and volcanic eruptions. The U.S. is widely considered one of the most hazard-prone among all nations in terms of the number and types of extreme climatological and geophysical events that periodically affect segments of the population (Mileti 1999). Yet, we know very little about how children's risk of mortality varies by demographic characteristics, geographic location, or type of disaster (Anderson 2005; Bourque et al. 2006).

Data and Methods

We collected mortality data from the Centers for Disease Control and Prevention (CDC) to descriptively analyze how youth mortality by natural forces varies by demographic characteristics, geographic location, and disaster type for every county in the continental U.S. The CDC has created an Internet-accessible public health data system called CDC Wonder. CDC Wonder enables users to search Compressed Mortality Files (CMF) by age cohort, gender, race, urban status, county, and year. CMF data are based on records for all deaths occurring in the United States. Cause of death is defined by the World Health Organization as "the disease or injury which initiated the train of events leading directly to death, or the circumstances of the accident or violence which produced the fatal injury" (http://wonder.cdc.gov/wonder/help/mort.html). Underlying cause of death is selected from conditions indicated by a medical professional on the cause-of-death section of a death certificate. When more than one cause or condition is entered, the underlying cause is determined by the sequence of conditions on the certificate following selection rules specified in the *International Classification of Diseases* (World Health Organization 1992).

Following the *International Classification of Diseases,* edition 10 (ICD-10), the CDC houses data on external causes of mortality and morbidity. A subset of external causes of mortality is called "forces of nature" (X30-X39). This subset includes death by exposure to excessive natural heat; exposure to excessive natural cold; exposure to sunlight; victim of lightning; victim of earthquake; victim of volcanic eruption; victim of avalanche, landslide and other earth movements; victim of cataclysmic storm; victim of flood; and exposure to unspecified forces of nature. We extracted data on all deaths by forces of nature by age, gender, race, and county to describe and analyze mortality risk differentials.[1] We restrict the majority of our analysis to youth cohorts, which we define as aged 0 to 24. Analyses of population and mortality data were conducted in STATA 9.1, SPSS 15.0, and ArcGis 9.

Descriptive Findings

Overall, data show that the risk of mortality by forces of nature is relatively low, compared to more lethal factors like degenerative and infectious diseases. In fact, if one extracts the total number of deaths by natural disaster from a standard life table we find a negligible decrease in death rates and a modest increase in life expectancy across age cohorts. The complete elimination of all death by forces of nature extends life expectancy at birth by about two and a half days (e_x = 76.5843 versus e_x = 76.5912). For African Americans, the elimination of all death by natural disaster would extend life expectancy at birth by about five days. In other words, acts of nature steal about two to five days of life expectancy in the United States, depending on the sex and/or racial status of persons analyzed. Life table analyses for the whole U.S. population are reported in Appendix A and B.

CDC records indicate that 6,108 Americans were killed by forces of nature from 1999-2003. If one extends the time period from 1979 to 2003, the number of persons killed by forces of nature in the U.S. is 31,911. The precise number of persons injured by natural disasters over this time period is unknown—official sources are notoriously inexact. According to data from the Spatial Hazard Events and Losses Database for the United States (SHELDUS)[2] (http://www.cas.sc.edu/geog/hrl/SHELDUS.html), the ratio of injury to death by natural disaster is roughly 7.5 to 1. Therefore, we cautiously estimate over 45,000 Americans were injured by forces of nature from 1999-2003, and about 240,000 people from 1979-2003. According to 1999-2003 statistics, approximately one

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[1] We selected the years 1999-2003 for analysis because these represent the most recent data available under the ICD-10 at the time this manuscript was written.

[2] SHELDUS consists of a county-level inventory of 18 natural hazard types, including hurricanes, floods, wildfires, and drought. Hazard event records include a start and end date, estimated property damage and crop loss, as well as the number of human injuries and deaths. SHELDUS data are derived from public sources like National Climatic Data Center monthly publications and the National Geophysical Data Center's Tsunami Event Database.

American is killed every eight hours by a disaster event (i.e., 1,825 days and 6,108 killed).

As with other causes of mortality, death by forces of nature is distributed unevenly in the population. The most vulnerable segment of the population with regard to death by natural disaster is the elderly. Of the 6,108 deaths recorded between 1999 and 2003, 2,670 were persons 65 years of age and above. This higher death count is not simply a function of age interval size. The age-specific death rate for elderly cohorts (aged 65+) is considerably higher than the rest of the population (1.5 per 100,000 versus 0.276 per 100,000).

Because this is a special issue of *Children, Youth and Environments* devoted to children and disasters, we concentrate our analyses on differential risks of mortality among youth populations aged 0 to 24. Of the 6,108 persons killed from 1999 to 2003, 530 were youth. About one young person dies every three months from a natural disaster. Next, we examine youth mortality by age and sex.

Table 1. Mortality by forces of nature for youth population by age and gender, 1999-2003

	All Population			Males			Females		
Age	Count	Population	Rate	Count	Population	Rate	Count	Population	Rate
< 1	66	19,672,483	0.3355	43	10,066,274	0.4272	23	9,606,209	0.2394
1-4	107	77,386,626	0.1383	63	39,570,332	0.1592	44	37,816,294	0.1164
5-9	39	101,016,130	0.0386	24	51,721,305	0.0464	15	49,294,825	0.0304
10-14	51	103,952,688	0.0491	36	53,255,786	0.0676	15	50,696,902	0.0296
15-19	115	101,426,266	0.1134	95	52,127,018	0.1822	20	49,299,248	0.0406
20-24	152	98,177,969	0.1548	130	50,256,674	0.2587	22	47,921,295	0.0459

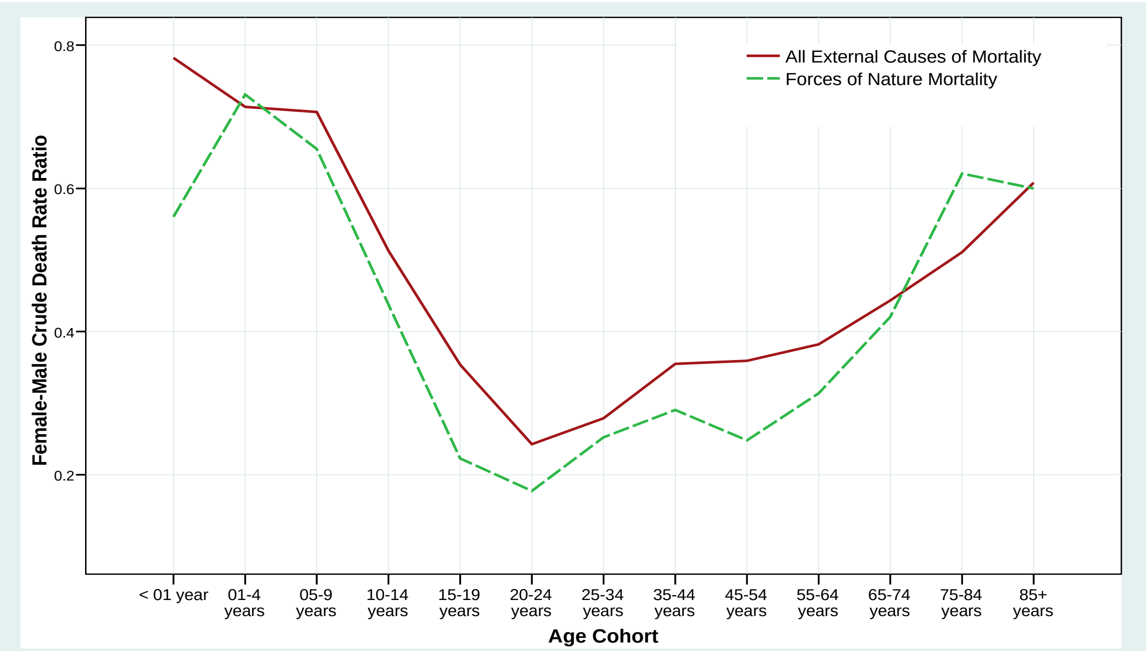
Table 1 shows mortality counts and age-specific death rates for the youth population from 0 to 24, as well as counts and rates for male and female youths.[3] According to Table 1, the risk of death by natural disaster among youth cohorts 0-24 is highest for infants (under 1 year of age). With a crude death rate of 0.3355 per 100,000 persons, the age-specific risk of death for children less than 1 year of age ${}_nM_x = ({}_nd_x / {}_np_x) * 100{,}000$ is almost higher than the combined risk of death for all youth aged 1 to 19. Not until mid-life (40+) does the risk of mortality by nature equal the age-specific risk faced by the most fragile cohort of our population, infants.

Data in Table 1 also show that death rates for male youth are higher than death rates for female youth across all age cohorts. In infancy (0-1), the risk of death by natural disaster is almost two times greater (0.4272 versus 0.2394) for males. The male-female mortality rate differential increases during adolescence. By age 20 to 24, the risk of death by natural forces is almost six times greater for males than females (.2587 versus .0459). This male-female rate differential on death by

[3] All age-specific mortality calculations for forces of nature suffer reliability problems because mortality counts are small relative to age interval sizes.

disaster persists through the life-course, and is highly consistent with data on other *external* causes of mortality and morbidity. Figure 1 compares female-male crude death rate ratios for all external causes of mortality, and forces of nature specifically.

Figure 1. Female-male crude death rate ratios for all external causes of mortality and mortality by forces of nature, 1999-2003



Next, Table 2 reports mortality outcomes for the African American youth population by age and gender. Table 2 indicates that the risk of death by natural disaster is higher for African American children between the ages 0 to 4 (as compared to all children in Table 1). Of the 11 African American infants (less than 1 year of age) killed by a force of nature from 1999 to 2003, all but one died by hyperthermia (or excessive heat). Interestingly, the death rate for African American youth is lower then the overall death rate for all youth ages 5 to 24. As with the national differential between male and female youth on the risk of death by disaster, African American male youth have a higher rate of death than African American female youth. This African American male-female risk differential persists through the youth phase of the life-course. At the 20 to 24 cohort, the African American male death rate is four times higher than the female death rate (.1674 versus .040)—a sexual differential that is considerably lower than the one observed for youth overall.

Table 2. Mortality by forces of nature for African American youth population by age and gender, 1999-2003

	African American Population			African American Males			African American Females		
Age	Count	Population	Rate	Count	Population	Rate	Count	Population	Rate
< 1	18	3,206,072	0.5614	11	1,634,462	0.6730	7	1,571,610	0.445
1-4	26	12,575,096	0.2068	19	6,389,836	0.2973	7	6,185,260	0.113
5-9	6	16,857,640	0.0356	2	8,563,801	0.0234	4	8,293,839	0.048
10-14	7	17,090,860	0.0410	5	8,674,221	0.0576	2	8,416,639	0.024
15-19	16	15,735,584	0.1017	11	7,979,053	0.1379	5	7,756,531	0.064
20-24	15	14,588,437	0.1028	12	7,170,105	0.1674	3	7,418,332	0.040

In Table 3, we show male-female differentials on the risk of mortality by natural forces for white youth. As with the African American population, white male youth have a considerably higher risk of death by disaster than white female youth. Data show white male youth have the highest age-specific death rate among all race and gender subgroups for the ages 5 to 24. In fact, 298 of the 530 youth killed from 1999 to 2003 were white males, constituting 56.2 percent of all youth killed. In percentage terms, about two-thirds (176/267) of all death by disaster between the ages 15 to 24 is inflicted on white male youth. As white male youth constitute 35.3 percent of all persons aged 0-24 (35,054,431/ 99,210,267), this group is clearly disproportionately victimized by forces of nature.

Table 3. Mortality by forces of nature for white youth population by age and gender, 1999-2003

	White Population			White Males			White Females		
Age	Count	Population	Rate	Count	Population	Rate	Count	Population	Rate
< 1	43	15,346,961	0.2802	31	7,859,124	0.394	12	7,487,837	0.160
1-4	76	60,334,302	0.1260	43	30,917,811	0.139	33	29,416,491	0.112
5-9	29	78,447,159	0.0370	20	40,253,361	0.050	9	38,193,798	0.024
10-14	40	81,064,544	0.0493	28	41,613,198	0.067	12	39,451,346	0.030
15-19	83	79,824,781	0.1040	73	41,151,728	0.177	10	38,673,053	0.026
20-24	121	77,449,602	0.1562	103	39,989,173	0.258	18	37,460,429	0.048

Figures 2-7 graphically compare death rates for various sex and gender subgroups. In each figure, the age-specific death rate is on the vertical axis and age cohorts are on the horizontal axis. Many subgroups (in particular, males) obey a U-shaped age-mortality curve. This U-shaped mortality curve is a classic data signature in population epidemiology (Weeks 2008). Remarkably, these graphical results show that external causes of mortality like cataclysmic storms and floods afflict age and sex strata of population like slower onset causes of death (i.e., neoplasms). This result raises interesting questions regarding age and sex-specific abilities to resist death across different types of mortality.

Figures 2-7. Comparing crude rates of death by forces of nature by age, race and gender, 1999-2003

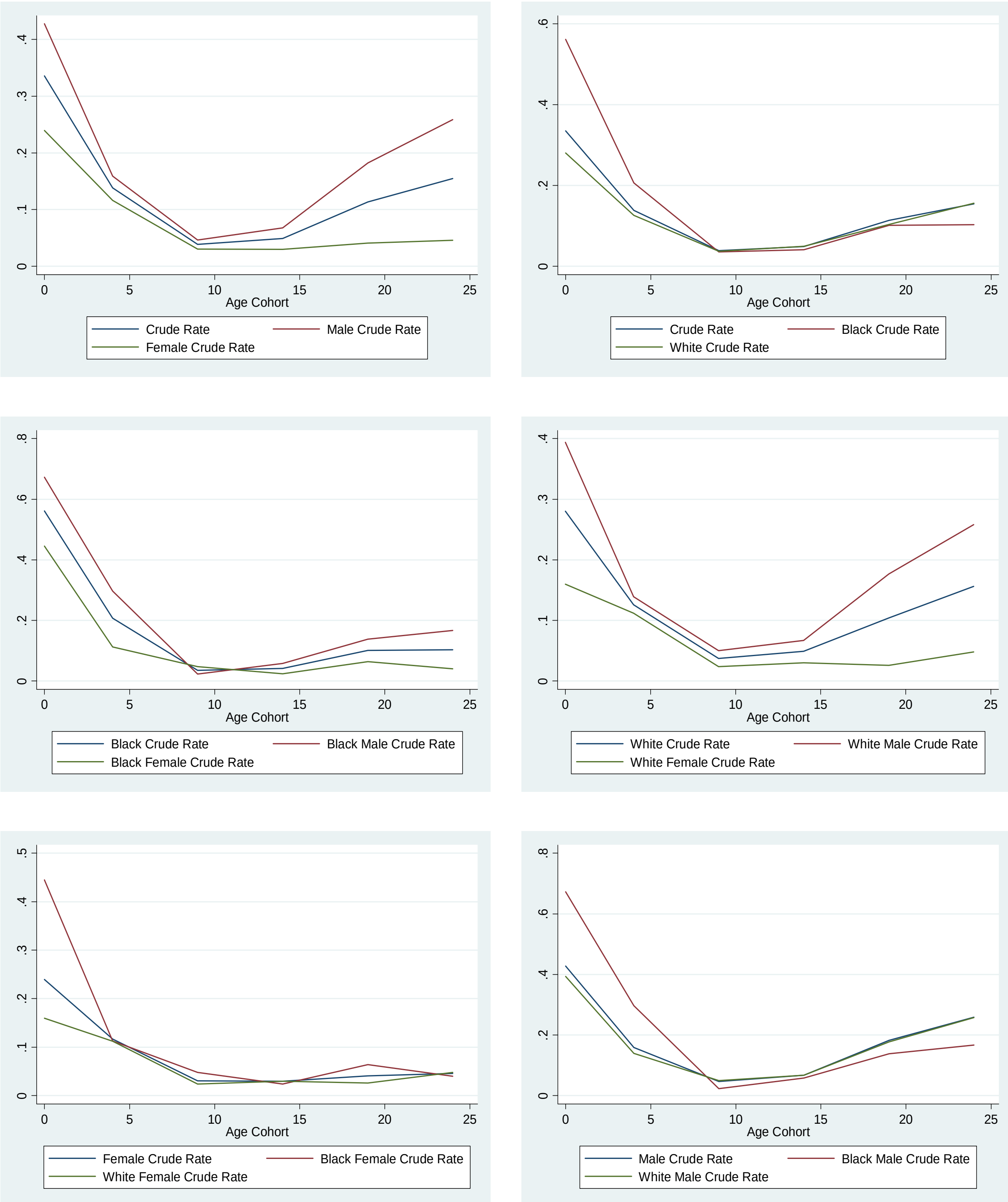


Table 4 is a cross-tabulation of mortality outcomes by types of natural disasters and age cohort. For infants (under age 1), death by exposure to heat is the most lethal subtype of death by forces of nature (50/66 or 75.76 percent), followed by cataclysmic storms and floods (13.64 percent), and exposure to excessive cold (7.58 percent). Infants (under age 1) account for 23.92 percent of all youth deaths by exposure to excessive heat, a figure more than six times greater than their share of the youth population (3.92 percent). Further, infants account for 10.34 percent of all youth deaths by cataclysmic storm and flood, a figure more than two times their share of the youth population. Overall, infants (under age 1) are disproportionately killed by all forces of nature combined, accounting for 12.45 percent (66/530) of all youth deaths. However, in proportional terms, infants constitute only 3.86 percent of all youth.

In percentage terms, hyperthermia is by far the leading killer (among forces of nature) of infants aged 0 to 4—in fact, 134 of the 183 infants killed from 1999 to 2003 were killed by excessive heat. From the ages 5 to 14, the leading killer of children are cataclysmic storms and flood events, accounting for about 37 percent of all deaths by natural disaster in this phase of the lifecycle. In the late youth phase of the lifecycle (15 to 24), hypothermia (or excessive cold) emerges as the top killer among forces of nature.

Table 4. Mortality by types of forces of nature for youth population, 1999-2003

Age Group	Population	Heat Exposure *	Cold Exposure	Storm and Flood[†]	Lightning	Avalanche	Earth-quake	Volcanic Eruption	Total
< 1	19,672,483 (3.92)	50 (75.76) (23.92)	5 (7.58) (4.03)	9 (13.64) (10.34)	0 (0.00) (0.00)	0 (0.00) (0.00)	0 (0.00) (0.00)	0 (0.00) (0.00)	66 (96.98) (12.45)
1-4	77,386,626 (15.43)	84 (78.50) (40.19)	5 (4.67) (4.03)	15 (14.02) (17.24)	3 (2.80) (4.76)	0 (0.00) (0.00)	0 (0.00) (0.00)	0 (0.00) (0.00)	107 (100.0) (20.19)
5-9	101,016,130 (20.14)	8 (20.51) (3.83)	6 (15.38) (4.84)	18 (46.15) (20.69)	5 (12.82) (7.94)	1 (2.56) (2.78)	0 (0.00) (0.00)	1 (2.56) (0.00)	39 (100.0) (7.36)
10-14	103,952,688 (20.27)	13 (25.49) (6.22)	8 (15.69) (6.45)	15 (29.41) (17.24)	12 (23.53) (19.05)	2 (3.92) (5.56)	0 (0.00) (0.00)	0 (0.00) (0.00)	51 (98.04) (9.62)
15-19	101,426,266 (20.22)	24 (20.87) (11.48)	43 (37.39) (34.68)	12 (10.43) (13.79)	20 (17.39) (31.75)	12 (10.43) (33.33)	0 (0.00) (0.00)	0 (0.00) (0.00)	115 (96.51) (21.70)
20-24	98,177,969 (19.57)	30 (19.74) (14.35)	57 (37.50) (45.97)	18 (11.84) (20.69)	23 (15.13) (36.51)	21 (13.82) (58.33)	1 (0.66) (100.0)	0 (0.00) (0.00)	152 (98.69) (28.68)
Total Row % Col. %	501,632,162 (100.0)	209 (39.43) (100.0)	124 (23.43) (100.0)	87 (11.89) (100.0)	63 (11.89) (100.0)	36 (6.79) (100.0)	1 (0.19) (100.0)	1 (0.19) (100.0)	530[‡] (98.30) (100.0)

Notes: * Two counts of mortality by exposure to sunlight were added to mortality counts of exposure to excessive heat; [†] Consistent with the International Classification of Diseases 9th Revision, death by flood and cataclysmic storm were added together; [‡] Mortality counts in rows do not sum perfectly with reported counts in Table 1 because "unspecified causes" of death by natural forces are excluded from this table.

Finally, we organize mortality data in a Geographic Information System. Figures 8 and 9 visualize the spatial distribution of youth mortality by forces of nature at the county scale. Figure 8 shows age-adjusted mortality rates, and Figure 9 shows the count of youth mortality by forces of nature. Both distributions are divided into equal quartiles, with darker colors (in blue) reflecting higher values of youth death by natural disaster, and lighter colors (in yellow) reflecting lower values of natural disaster risk. Both maps show higher concentrations of youth deaths in warmer climates, particularly in Arizona, Southern California, Florida, and Texas. Counties with five or more youth deaths include: Maricopa County, AZ, Navajo County, AZ, Pima County, AZ, Orange County, CA, Mitchell County, GA, San Juan County, NM, Travis County, TX, Los Angeles County, CA, Cook County, IL, Madison County, TN, Clark County, NV, Tarrant County, TX, San Bernardino County, CA, and Harris County, TX. Harris County, TX (Houston) leads all counties with 12 recorded youth deaths by forces of nature between 1999 and 2003.

Figure 8. Spatial distribution of age-adjusted youth mortality (per 100,000) by forces of nature at the county scale, 1999-2003

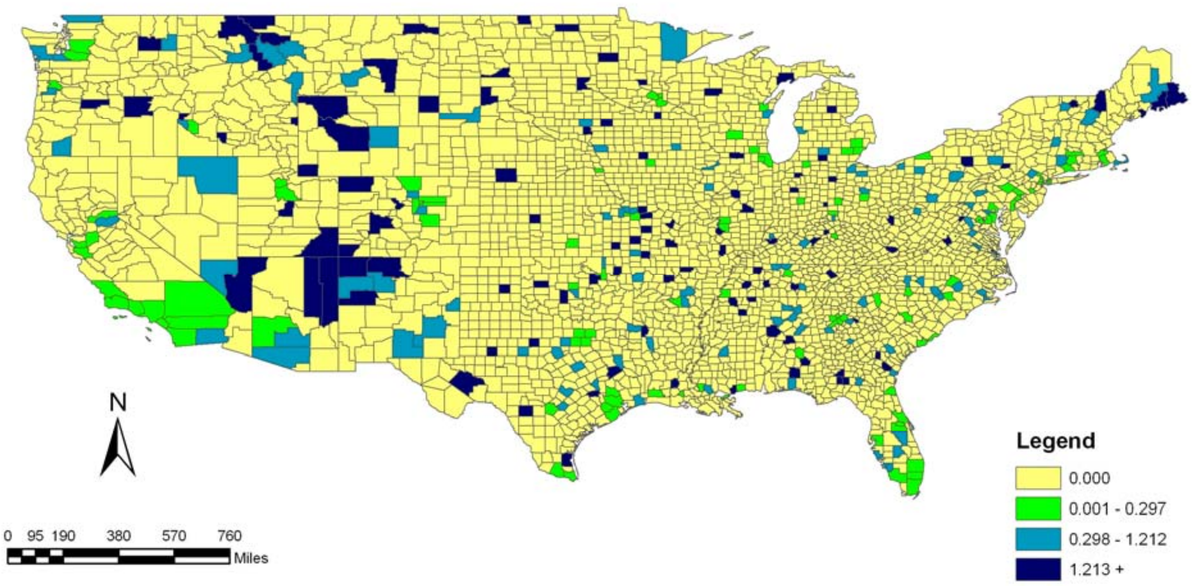
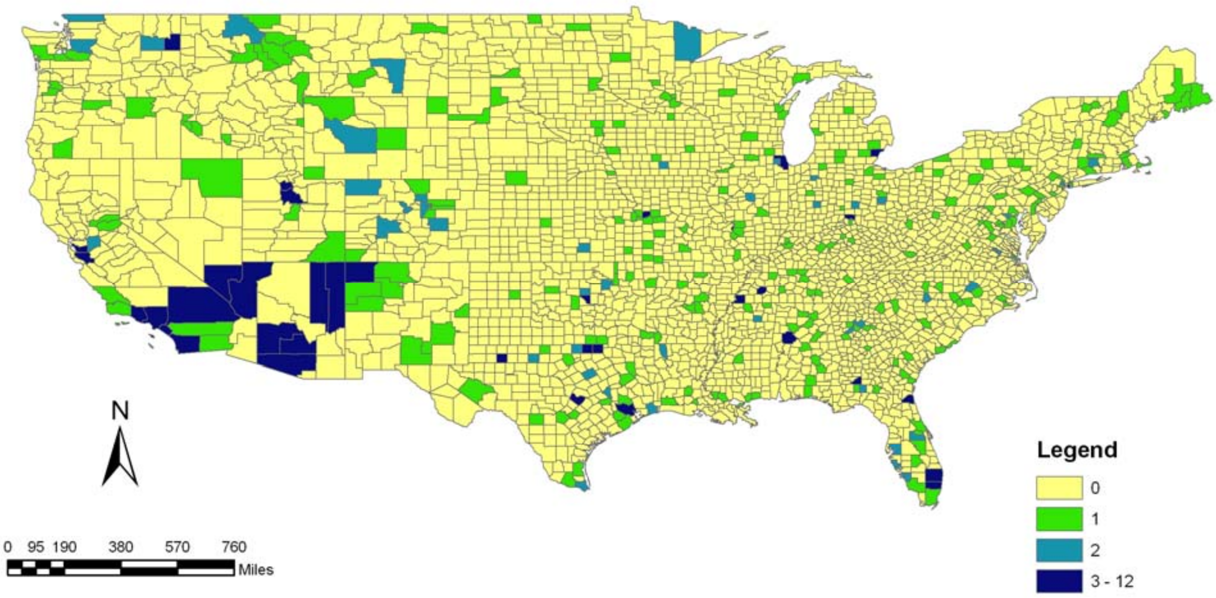


Figure 9. Spatial distribution of youth mortality count by forces of nature at the county scale, 1999-2003



Conclusion

In this research note we provide a detailed inventory of disaster mortality outcomes by age, gender, race, and regional location. Our results provide an empirical basis for theory construction of the differences in mortality risk across different segments of the youth population.

First, data show that of all the age groups examined, infants age 0 to 1 have the highest risk of death from forces of nature.[4] These results appear to contradict Glass et al.'s (1977) maternal protection theory which suggests that the youngest child is insulated against fatal injury in a disaster event (here, speaking of death in earthquakes because the youngest is most likely to be sleeping with the mother). Our data suggest that the youngest members of U.S. society are actually the most vulnerable to death by forces of nature within the youth populations examined.

Our data also show that the risk of death within youth populations appears to obey a U-shaped pattern. This U-shaped age-mortality curve is a classic data signature in population epidemiology, linked to physical vulnerabilities associated with infancy (particularly among male infants). In this sense, natural disasters register and amplify hierarchies of both physical constitution and social disadvantage.

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[4] Longitudinal data show that the risk of death by natural disaster for the whole population has trended downward from 1979 to 2003. In fact, linear specification of the relationship between the risk of death by natural forces and time indicates an almost 40 percent decline. However, the risk of death for infants has remained relatively constant during this time period, with suggestions of a slight increase in recent years.

Second, we show that youth male-female differential on death by disaster is consistent with data on other *external* causes of mortality and morbidity. Scholars theorize that differentials in risk-taking behavior between males and females may account for observed differences in mortality outcomes (Byrnes, Miller, and Schafer 1999; Kruger and Nesse 2004). Additional research is necessary to help understand why male children across all age cohorts (0-24) are more likely to die in disasters in the U.S. This is an important question, given that prior research has consistently shown that female children are more likely to perish in disasters in low-income and developing nations (Agarwal 1990; Bairagi 1986; Dyson 1991; Greenough 1982; Kidane 1989, 1990; Mariam 1986; Ramirez et al. 2005; Rivers 1982; Sapir 1993).

Third, our data also suggest an epidemiological sequence of natural disaster risk by age. That is, specific forces of nature disproportionately kill specific age groups. In infancy (0-4), hyperthermia (or excessive heat) is the top mortality risk. In childhood (5-14), flood events and cataclysmic storms pose the greatest risk. As children move into the late phase of the youth lifecycle (15-24), hypothermia (or excessive cold) constitutes the greatest death risk. This observation of an age-specific disaster epidemiology can provide a more nuanced basis for policy instruments and information campaigns aimed at both parents and youth to reduce youth mortality by forces of nature. For example, numerous studies have shown that adults with children are more likely to respond to disaster warning and evacuation messages than people without children (Carter, Kendall, and Clark 1983; Edwards 1993; Fischer et al. 1995; Houts et al. 1984; Lindell, Lu, and Prater 2005). This body of research suggests that parents would be receptive to hazards education materials that highlight the age- and hazard-specific mortality risks their children may face, particularly if these materials draw on the principles of sound risk communication and include clear, consistent, and precise messages that are delivered through multiple channels (Mileti and Darlington 1997; Mileti and Fitzpatrick 1992; Mileti and O'Brien 1992). Disaster education initiatives aimed at pre-schoolers and school-aged children, such as the Sesame Street *Friends to the Rescue* series and the American Red Cross *Masters of Disaster* curriculum (see Wachtendorf, Brown, and Nickle, this issue), should include information regarding the hazard threats to which youth are most susceptible based on their age group.

Finally, in addition to nuances of age, race, and sex, our analysis is suggestive of a spatial logic of youth mortality by natural disaster. The intersection of demography and geography could lead to even more refined disaster mitigation strategies. For example, geographic areas where extreme heat events are likely to occur ought to be targeted for information campaigns regarding the special risk of excessive heat exposure faced by children, especially very young children. Similarly, in geographies of excessive cold, policy instruments ought to highlight the disproportionate risks faced by white male youth aged 15 to 24. The majority of youth dying by hypothermia are white and male, a population subgroup that is often forgotten in analyses of social vulnerability and extreme weather event outcomes.

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Appendix A. Life table analysis for U.S. population, 1999-2003

Age Interval *x to x + n*	Number of Deaths $_nD_x$	Population $_nP_x$	Probability of Death $_nq_x$	# Alive (100,000) l_{x+n}	# Interval Deaths $_nd_x$	Yrs Lived in Interval $_nL_x$	Yrs in Interval and Later T_x	Expectation of Life e_x
< 1 year	139,599	19,672,483	0.0071	100000.00	705.36	99400.44	7658428.61	76.5843
1-4 years	25,158	77,386,626	0.0003	99294.64	32.28	397101.09	7559028.16	76.1273
5-9 years	15,736	101,016,130	0.0008	99262.36	77.28	496118.59	7161927.08	72.1515
10-14 years	20,471	103,952,688	0.0010	99185.08	97.61	495681.35	6665808.48	67.2058
15-19 years	68,303	101,426,266	0.0034	99087.46	333.08	494604.62	6170127.13	62.2695
20-24 years	92,526	98,177,969	0.0047	98754.38	464.25	492611.29	5675522.51	57.4711
25-34 years	205,855	199,478,338	0.0103	98290.13	1009.11	977855.75	5182911.22	52.7307
35-44 years	451,329	224,531,071	0.0199	97281.02	1935.98	963130.26	4205055.47	43.2259
45-54 years	830,546	194,332,499	0.0418	95345.03	3989.64	933502.14	3241925.21	34.0020
55-64 years	1,239,825	127,862,750	0.0925	91355.39	8448.69	871310.50	2308423.07	25.2686
65-74 years	2,161,256	91,734,377	0.2108	82906.71	17474.30	741695.56	1437112.57	17.3341
75-84 years	3,511,642	62,763,359	0.4372	65432.41	28606.91	511289.52	695417.00	10.6280
85+ years	3,338,771	22,103,900	1.0000	36825.50	36825.50	184127.48	184127.48	5.0000

Appendix B. Life table analysis for U.S. population with deaths by forces of nature extracted, 1999-2003

Age Interval *x to x + n*	Number of Deaths $_nD_x$	Population $_nP_x$	Probability of Death $_nq_x$	# Alive (100,000) l_{x+n}	# Interval Deaths $_nd_x$	Yrs Lived in Interval $_nL_x$	Yrs in Interval and Later T_x	Expectation of Life e_x
< 1 year	139,533	19,672,483	0.0071	100000.00	705.03	99400.72	7659115.52	76.5912
1-4 years	25,051	77,386,626	0.0003	99294.97	32.14	397102.74	7559714.80	76.1339
5-9 years	15,697	101,016,130	0.0008	99262.83	77.09	496121.41	7162612.06	72.1580
10-14 years	20,420	103,952,688	0.0010	99185.74	97.37	495685.26	6666490.64	67.2122
15-19 years	68,188	101,426,266	0.0034	99088.37	332.52	494610.52	6170805.39	62.2758
20-24 years	92,374	98,177,969	0.0047	98755.84	463.50	492620.47	5676194.86	57.4771
25-34 years	205,421	199,478,338	0.0102	98292.35	1007.02	977888.35	5183574.39	52.7363
35-44 years	450,517	224,531,071	0.0199	97285.32	1932.62	963190.14	4205686.04	43.2304
45-54 years	829,598	194,332,499	0.0418	95352.70	3985.50	933599.53	3242495.90	34.0053
55-64 years	1,239,111	127,862,750	0.0924	91367.20	8445.14	871446.33	2308896.37	25.2705
65-74 years	2,160,493	91,734,377	0.2107	82922.06	17472.02	741860.55	1437450.04	17.3350
75-84 years	3,510,554	62,763,359	0.4371	65450.05	28607.69	511462.00	695589.49	10.6278
85+ years	3,337,952	22,103,900	1.0000	36842.35	36842.35	184211.77	184127.48	4.9977