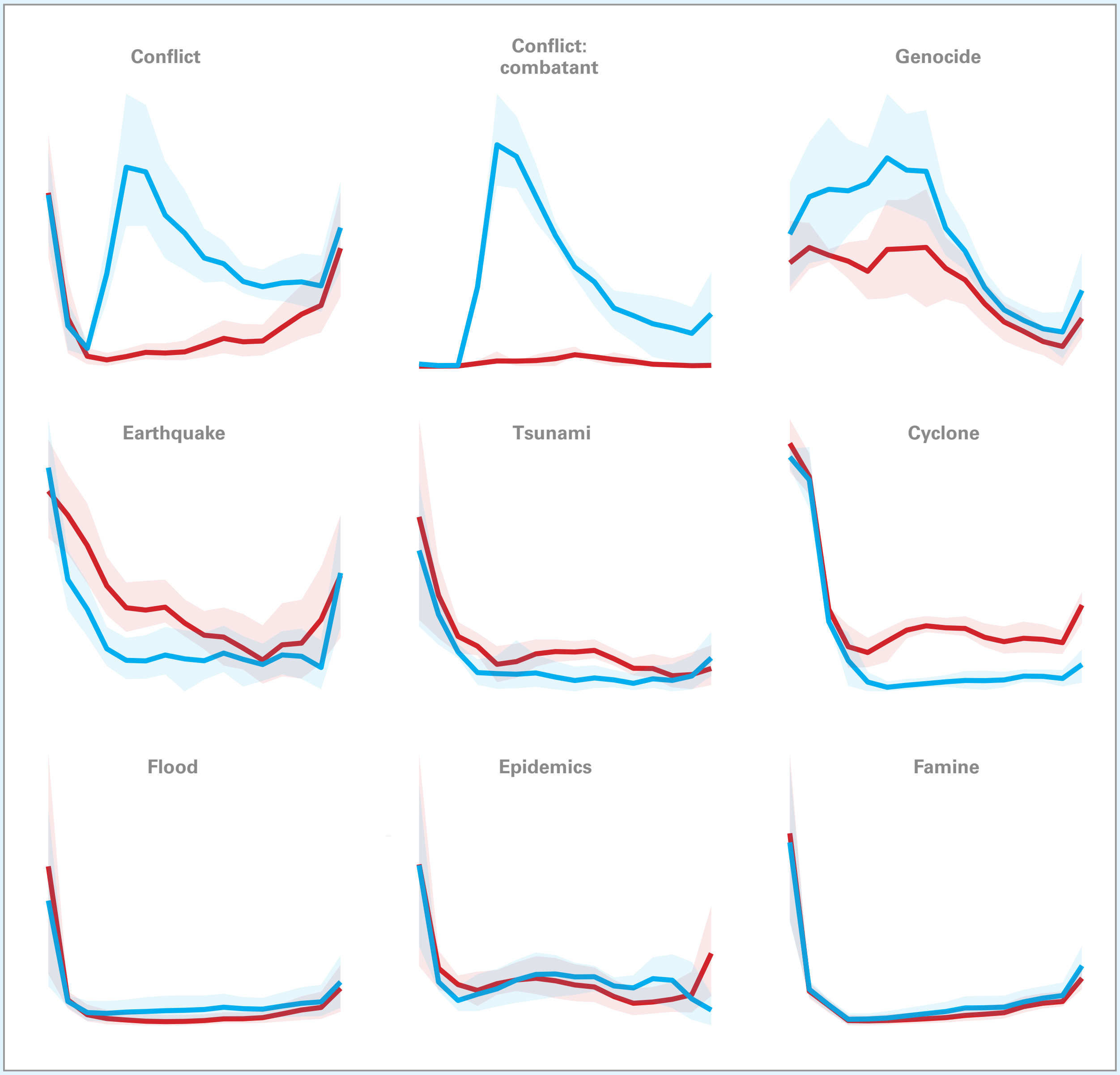
Age-Sex Patterns of Crisis Deaths: Towards a more standard mortality estimation approach



IGME | unicef World Health Organization United Nations WORLD BANK GROUP

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Abstract

United Nations agencies and research groups reporting on age- and sex-specific mortality trends across countries need to take into account conflicts, natural disasters and other crises that cause short-term substantial increases in death rates. In many developing countries, only estimates of total crisis deaths may be available and age-sex distributions are estimated based on very limited data or on assumptions. We carried out an extensive search of published and unpublished studies, population surveys and death registration databases to identify data on the age-sex distribution of crisis deaths. We found data for 164 crises in 57 countries. We used seemingly unrelated regression methods with bootstrap resampling to estimate age-sex distributions for nine types of crisis events. Natural disasters and famines present higher relative risks of death in children and older adults. Conflicts introduce much higher relative risks for men than women and there is a peak in the male relative risk at younger adult ages. Male relative risks are much closer to female relative risks for natural disasters and are somewhat lower for earthquakes, tsunamis and storms, but not for floods, epidemics or famines. In contrast to previous assumptions of constant risk among children under 5 years of age, we found higher risks in the neonatal (0–27 days) and postneonatal (1–11 months) periods than the period between ages 1–4 years. These results will improve the empirical basis for estimation of mortality for crises for which detailed mortality data are not available. However, it is important that governments continue to count deaths and devote attention to estimating mortality during crises.

Summary of findings

- Conflicts and natural disasters often occur in countries without usable death registration data or disrupt normal death registration processes; in many cases, estimates of crisis deaths are not available by age and sex.
- This study has assembled the most comprehensive database of age-sex distributions of crisis death rates available to date, including studies and data from population surveys and death registrations, in order to estimate average relative risks of mortality by age and sex for nine categories of crisis events, including conflict, natural disasters, epidemics and famine.
- A Microsoft Excel spreadsheet is available to enable application of these results to calculate the age-sex specific mortality rates of a crisis event with a specified overall crisis mortality rate or with a specified total crisis death rate among children under 5 years of age.
- The results of this study provide the best empirically based estimates of age-sex patterns of crisis deaths and death rates to date for crises without information on the detailed age and sex of deaths.
- As additional observations of crisis mortality age distributions become available, they can be added to the current database and the estimates of crisis age patterns rapidly updated to account for the new evidence.

Introduction

Conflicts, natural disasters and other crises can substantially increase death rates for specific country-years. Several UN agencies that monitor mortality trends have identified the need for improved estimates of age-sex-specific patterns of crisis deaths.[1] The United Nations Population Division's (UNPD) need for these estimates has increased with the planned upgrade from quinquennial to annual life tables for all countries.[2] Conflicts and natural disasters often disrupt existing strategies for monitoring mortality and surveys are generally not available until some years after a crisis. Annual life tables for the World Health Organization's (WHO) Global Health Estimates (GHE)[3] take crisis events into account based largely on estimates of total crisis death disaggregated by age and sex using limited data from published studies.

The United Nations Inter-agency Group for Child Mortality Estimation (UN IGME) has also been using limited information on age-sex patterns of crisis deaths among children under 5 years of age to account for major crises in its annual estimation and reporting on child mortality trends for Member States.[4] In the last few years, UN IGME has expanded its mortality estimates to cover the age range 0–24 years[4] using similar crisis adjustment methods for older children and youth[5]. Mortality crises include conflicts, natural disasters (floods, earthquakes, tsunamis, storms, volcanoes, landslides, etc.), epidemics (excluding HIV/AIDS, which is explicitly addressed in the estimation process) and famines. Crisis deaths by age group are estimated directly for some specific crises where detailed data are available, or by using all-age or under-five estimates of total crisis deaths and applying standard age patterns by crisis type.

The B3 model used by UN IGME[6] is fitted without crisis years and crisis mortality rates are added to the fitted curve if the crisis meets the following four criteria:

1. crisis mortality rate (${}_5q_0$ or ${}_{10}q_5$) > 0.2 per 1,000 in the relevant age interval

2. crisis age-specific deaths > 10

3. crisis deaths > 10% of non-crisis deaths

4. crisis is isolated to a few years

We carried out a study to improve the empirical basis for crisis mortality age patterns required when only total crisis mortality estimates are available (the most common situation). We focused on identifying available empirical information on age-sex distributions of deaths or death rates for crisis events. This information is available for surprisingly few major historical crises. We were not able to find data on age-sex distributions of mortality or populations at risk for major events such as the Holocaust, the Chinese famine of 1959–1961 and the Haiti earthquake in 2010, and excluded age-sex data based on model life tables or assumptions. Additionally, we only included data for entire crisis events or country-years and did not seek data on specific high-intensity events during military conflict, such as the bombing of Dresden during the Second World War. Despite these limitations, we were able to include data for age-sex distributions for both world wars, the conflicts in Iraq and Afghanistan during the twenty-first century, and a number of other major events, such as the Ukraine famine of 1932–1933.

Review of studies and data sets

We undertook a comprehensive analysis of more than 1,000 articles and books on crisis mortality compiled over the years by UNPD and WHO. We identified studies and data sets with information on age- and/or sex-specific crisis deaths. Relevant material cited by the initial sources was also included, as were relevant studies identified by the Centre for Research on the Epidemiology of

Disasters' Emergency Events Database (CRED EM-DAT).[7] Age-sex mortality distributions were compiled for 107 crises in 41 countries from 71 data sources covering the years 1348–2019, with 64 per cent pertaining to crises since 1950 and 37 per cent to crises since 2000 (see Supplemental Appendix, Table A1).

Population surveys

Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS) and World Fertility Surveys covering the period from 1960 to 2017 were analysed for regions and years with crisis events. Age patterns of under-five mortality were derived from retrospective full birth histories (see Supplemental Appendix, section 2). Age-sex patterns of adult mortality between the ages of 15 and 50 years were calculated from DHS sibling survival histories. Potential crisis events were identified for 749 country-years with total mortality of sufficient magnitude to meet the selection criteria. The surveys analysed for this report are listed in Table A2 and Table A3 of the Supplemental Appendix.

Data were analysed using the demogsurv R package[8] based on observed deaths and person-years by age group converted to cumulative hazard probabilities. For countries with multiple surveys, the unweighted average for country-years was used. Confidence intervals were computed using the jackknife method.[9]

Figure A1 of the Supplemental Appendix shows plots of annual time series of ${}_4q_1$ – the probability of dying between exact age 1 and exact age 5 – for countries with potential crisis events. Excess deaths in the crisis year were estimated using appropriate national or regional non-crisis comparison data (see Supplemental Appendix, section 2). Estimates of the fraction of deaths among infants and among children aged 1–4 years were included in the analysis data set for 12 crises where the ${}_4q_1$ for the crisis period differed with probability $p \geq 80\%$ from the average ${}_4q_1$ for the comparison period or region (see Supplemental Appendix, Table A4).

Sibling survival data from surveys for 38 countries (see Supplemental Appendix, Table A4) were used to compute time series of ${}_{35}q_{15}$, the probability of dying between exact age 15 and exact age 50. Potential spikes in ${}_{35}q_{15}$ estimates for crisis years were identified and age-sex patterns of excess deaths relative to national or regional baseline death rates were examined (see Supplemental Appendix, section 2). In most cases, the expected excess deaths based on GHE estimates of total conflict deaths were too small a fraction of total deaths for the signal to be detected in the sibling data.

The 1994 Rwanda genocide and the 2004 Indian Ocean tsunami were the only two crises with a clear signal in the data and a plausible age-sex pattern of deaths. As the analysis data set already includes age-sex patterns for these two crises from studies, no sibling survival-based data were included in further analysis.

Death registration data

The Human Mortality Database (HMD)[10] was reviewed to identify 27 country-periods where crisis events had occurred (see Supplemental Appendix, Table A5 and Table A6). Estimates of baseline mortality rates were highly sensitive to baseline years selected, age groups selected and method used to estimate baseline mortality. In many cases, the signal was not strong enough to be detected with any confidence. Twelve of the HMD data analyses resulted in age patterns judged useable. These included data for civilian and combatant mortality in both world wars for several countries.

The WHO Mortality Database[11] was also reviewed to identify country-years with crisis events. Analyses of excess deaths were carried out for all-cause deaths, unintentional injury deaths (excluding road injuries) and deaths coded to natural disasters (see online Supplemental Appendix, section 3). For unintentional injury deaths (excluding road injuries), 11 excess crisis deaths were included in the analysis data set for 10 natural disasters (see Supplemental Appendix, Table A7). Excess crisis deaths based on all-cause mortality were included for six conflicts, mainly in Eastern Europe and its borders with Asia (see Supplemental Appendix, Table A8, and for the 2004 Indian Ocean tsunami for Thailand (see Supplemental Appendix, Table A9). Excess crisis deaths for more detailed age groups among under-fives were included for six natural disasters (see Supplemental Appendix, Table A9).

Analysis data set

Data from all sources described above were compiled into a single data set. The raw data set includes a variety of mortality indicators. All observations were converted to age-specific death rates for crisis events, using the study population to convert death counts, or, if that was not reported, the relevant national population estimates (see Supplemental Appendix, section 4).[12]

Age-sex categories used in the studies are variable and inconsistent. Studies were classified into three groups: Group 1 included studies with data for males and females, and optionally both sexes for the same age groups as males and females; Group 2 included studies with data for males, females and both sexes, and had both sexes' data for age groups not available for males or females separately; and Group 3 studies had data only for both sexes combined.

Table 1 summarizes available data by type of event and group. A few studies of conflicts focused specifically on combatant deaths or civilian deaths, though most implicitly or explicitly included all conflict deaths. Figure 1 summarizes the distribution of these 164 data sets by event type and data source.

Analysis strategy for five-year age groups in range 0–75+ years

While age-sex-specific death rates can be converted to age-sex-specific relative risks that are independent of the crisis overall death rate, it is difficult to simultaneously estimate all the risks while allowing sufficient flexibility in age-sex patterns for different crisis types. Instead, we estimated age-sex fractions of total event deaths using seemingly unrelated regression[13] to estimate them all simultaneously (see Supplemental Appendix, section 5). As the age-sex distribution of crisis deaths will depend on the population age-sex structure, event deaths were calculated for a standard population arbitrarily chosen as the world population in 2000 for both sexes combined (see Supplemental Appendix, section 4). Model fitting was performed using procedure SUREG[14] in Stata 15.

The analysis strategy was developed to maximize useable data by event type (see Supplemental Appendix, section 5). The first step was to analyse age-sex distribution of crisis deaths for five-year age groups from 0–4 years up to 75+ years for studies reporting all those age groups, and then to use the results as 'prior' distributions to impute the five-year age group distributions for studies with fewer age groups. There were 141 studies with age groups spanning all ages. All had a final open-ended age group of 60+ years, apart from 10 with a final age group of 50+ years, 10 with 15+ years and two with 5+ years.

Finally, we included events with data spanning only a subset of the full age range, e.g., 15–59 years. Age-sex distributions from the previous step were used to impute a full set of death fractions by sex for five-year age groups up to 75+ years. The full data set (with replicated mixed-event data) included 174 events with event types, as shown in Table 2.

The SUR model was then run on this final data set. Bootstrap resampling was carried out 1,000 times for the final SUR model and used to estimate 90 per cent uncertainty ranges based on the fifth and ninety-fifth percentiles of the 1,000 sets of estimates. Estimates were then smoothed using a three-point moving average for age groups from 25–29 years to 70–74 years (see online Supplemental Appendix, section 5).

Given the very sparse age-sex-specific data available by type of crisis, we decided that it was preferable to make estimates of age-sex distribution that maximized data use rather than withhold part of the available data for testing predictive validity. For most crisis types, the results of such a process would mostly reflect whether the withheld data happened to have distributions close to the average of the data informing the modelling or not.

Estimation of crisis age-sex distributions for under-five age groups

A separate analysis was carried out for more detailed under-five age groups (neonatal, postneonatal and 1–4 years) as additional data for these age categories were available from birth histories and some studies. To maximize use of data, the age-sex fractions for the infant age group were estimated separately and then used to partition the infant fraction from the analysis of the 0/1–4-year data (see Supplemental Appendix, section 6).

The under-five fractions of total crisis deaths for 1,000 bootstrap samples in the full five-year age group analysis were randomly paired with sex-specific estimates of the neonatal, infant and 1–4-year fractions of under-five deaths to produce estimates with 90 per cent uncertainty ranges of age-sex specific fractions for the complete set of age groups – neonatal, postneonatal, 1–4 years, 5–9 years, … 70–74 years, 75+ years (see Supplemental Appendix, section 7).

Resulting estimates of crisis age-sex patterns of mortality

Figure 2 shows the five-year smoothed age-sex patterns for male and female age fractions of crisis deaths in the standard population with 90 per cent uncertainty ranges for nine types of crisis events. The results of the analysis for more detailed under-five age groups were converted to age-sex-specific mortality rates and divided by the overall under-five mortality rate to produce age-sex-specific relative risks for all crisis event types apart from conflict combatants, as shown in Figure 3. Note that although the relative risks are highest in the neonatal age group, neonatal deaths represent only a small fraction of total under-five deaths in the standard population (ranging from just under 3 per cent for epidemics and tsunamis to 5 per cent for conflicts).

The under-five age-sex fractions were applied to the 0–4-year fractions in the five-year age group analysis to produce age-sex fractions for the expanded set of age groups: neonatal, postneonatal, 1–4 years, 5–9 years, … 70–74 years, 75+ years. These fractions were then converted to age-sex-specific death rates in the standard population and divided by the total crisis death rate to produce age-sex-specific relative risks of crisis mortality. We assume that the age-sex-specific relative risks are relatively invariant across population age-sex distributions and thus can be used to estimate age-sex-specific mortality rates and deaths in the crisis population for any crisis that can be mapped to one of the nine event types.

The plots in Figure 4 show these relative risk patterns for the nine event types. The estimated relative risks and their uncertainty ranges are tabulated in Table A15 of the Supplemental Appendix. All types of events have higher relative risks for children under age 5 and for older adults. Relative risks for men are much higher than for women in conflicts and there is a peak in the male relative risk at younger adult ages. Male relative risks are much closer to female relative risks for natural disasters and are somewhat lower for earthquakes, tsunamis and storms, but not for floods, epidemics or famines. Relative risks of mortality tend to be lowest at younger adult ages for natural disasters, in contrast to conflicts. For some age groups in some event types, uncertainty ranges are quite narrow, and this is likely a reflection of the variation in the limited numbers of studies available for these event types.

Limitations, caveats and applications

Estimation of total mortality rates for countries in years with mortality crises is challenging given the lack of detailed mortality data available by age and sex during crises. Many crises occur in countries without useable death registration data. Even in countries where such data are available, crises can disrupt regular death registration. It is often the case that the only estimates of the mortality impact of crisis events are for total deaths, without details on age and sex distributions.

Despite our comprehensive data search, useable data on crisis age-sex distributions of deaths were limited. It was thus not possible to break down crisis categories into more detailed subcategories (for example, by detailed types of conflict or epidemic) or by region. As such, it is possible, for instance, that age-sex distributions differ substantially between conflicts in Europe and Africa. Where age-sex-specific mortality estimates are available for specific crisis events, these should be used rather than the distributions estimated here. When estimates of total civilian and combatant deaths are separately available, the distributions for these two groups should be used rather than the distribution for the ‘conflict (unspecified)’ category.

If age-specific crisis mortality is available for broad age groups (for example, children aged 0–14 years and youth and adults aged 15+ years), these should be used to adjust the estimated mortality distributions provided here. Note that the estimated age-sex fractions for epidemics are an average across a range of infectious agents, excluding HIV. If usable data on age-sex distribution are available for a specific infectious agent (as is the case for Ebola, COVID-19 and some other pathogens), these should be used in preference to the general pattern estimated here.

Given the sparse number of events in most categories, significant effort was undertaken to harmonize the age groups in the final database and to fill in the gaps of studies when some ages were not available. The results show an important difference in the relative risk of dying by age across the different mortality crises. Apart from conflict, the most fragile age groups (under-fives and 60+) tend to have higher relative risks of mortality.

Given the substantial differences in some age patterns across crisis types, we chose to use a model with indicator variables for five-year age-sex groups (and more detailed age groups under age 5), rather than parameterize the shape of the age-sex distributions, and to use SUR to estimate the parameters for the age-sex group fractions under the constraint that they add to 1. Exploratory analyses guided some collapsing of event categories, as seen, for example, in the merging of the ‘conflict (unspecified)’ and ‘conflict: civilian’ categories. However, we did not use significance estimates for regression parameters to further collapse categories without statistically significant differences, as there were cases of significant differences for parts of the age-sex distribution between categories, but not for all age-sex groups. The SUR modelling was thus used to summarize the observed age-sex distributions for each event category. Future analyses using additional observations of crisis age-sex distributions may thus result in some changes to estimated age-sex patterns, particularly for event categories with little current data. Given the limited data availability, we chose not to withhold part of the data set for predictive validity testing but rather to estimate uncertainty ranges for the age-sex patterns.

A very simple approach was taken for the use of data from mixed event types, such as conflict and famine. Such data were added to the analyses for each of the events separately. More detailed information on the relative magnitudes of the two causes of death might allow for a more sophisticated modelling approach, but the small numbers of mixed crisis events in the data do not currently allow it. To use these results for a mixed crisis event, it would be ideal to use estimates of the relative contributions of the two event types to total deaths in order to calculate and apply a weighted-average age-sex distribution.

We did not attempt to include data for crises due to temperature extremes. Very limited data are available for this type of crisis and age-sex distributions are likely to be quite context-specific. It is likely that this type of crisis event will become more common as global warming continues. Technological disasters (such as major industrial and transport accidents) were also excluded from this study.

Conclusion

This study was carried out to maximize the empirical basis for estimated age distributions of crisis mortality rates when specific age-sex data for the crisis are not available. Most crisis events happen in countries without a well-functioning death registration system or where statistical systems break down during times of crisis.

Our results will be useful for groups engaged in estimating and monitoring mortality and life expectancy trends for countries experiencing crises, including those without high-quality death registration systems. However, it is important that countries themselves continue efforts to count deaths and devote attention to estimating mortality during crises. We hope that continued improvements in data collection for crisis events will lead to larger data sets and more detailed analyses of age-sex patterns for specific types of crises and reduce the need for estimated average distributions.

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TABLES

Table 1. Available age-sex-specific mortality data for crises, by event type and group

Event type	Group 1	Group 2	Group 3	Total number
Conflict	20	3	12	35
Conflict and famine			2	2
Conflict: civilian	4	4		8
Conflict: combatant	7	1		8
Cyclone*	3			3
Earthquake	13	5	9	27
Earthquake and tsunami	3		2	5
Epidemics	7		19	26
Epidemics and war	1			1
Famine	20		8	28
Famine and epidemics			3	3
Famine and flood	2		1	3
Flood	6	1		7
Genocide	3		1	4
Tsunami	2	1	1	4
Total	**91**	**15**	**58**	**164**

* This category includes natural disasters described as storms, hurricanes and typhoons.

Table 2. Final total age-sex-specific crisis mortality data sets for five-year age groups, by event type

Event type	No. of events
Conflict	35
Conflict: civilian	8
Conflict: combatant	8
Genocide	4
Cyclone	3
Earthquake	32
Epidemics	30
Famine	35
Flood	10
Tsunami	9
Total	**174**

FIGURES

Figure 1. Available age-sex-specific mortality data for crises, by event type and data type

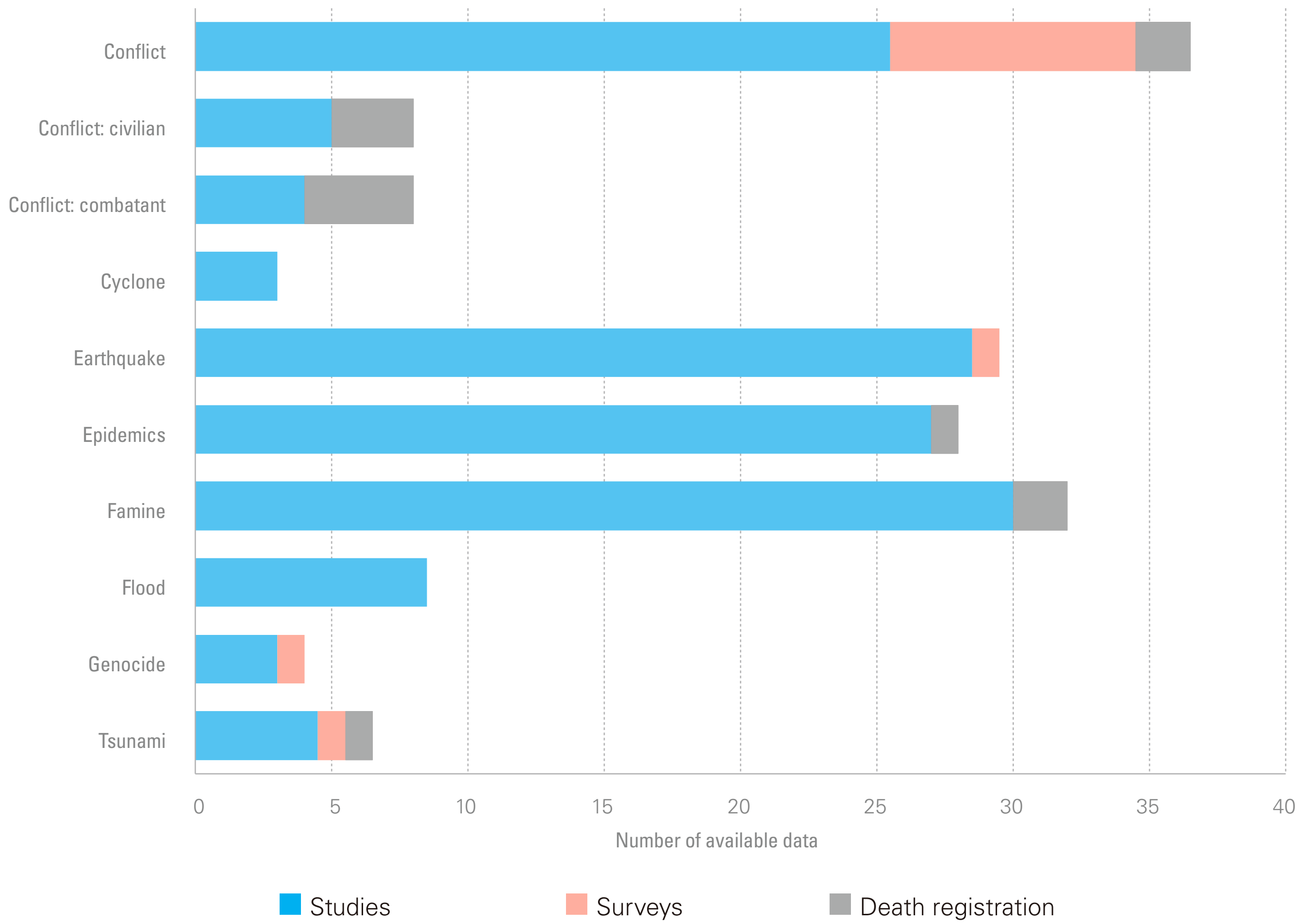


Figure 2. Estimated age-sex fractions of crisis deaths for five-year age groups, by event type

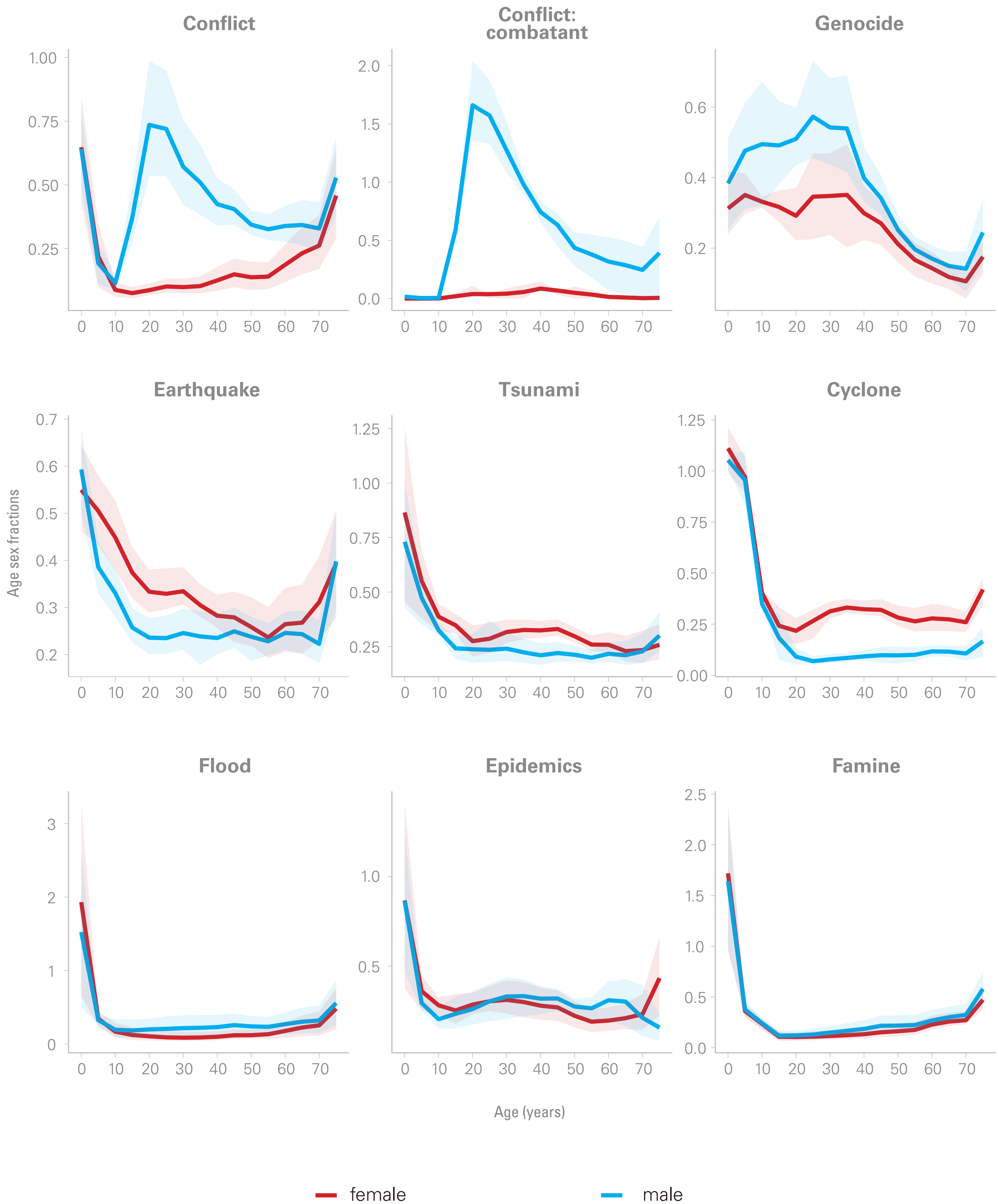


Figure 3. Estimated relative risks of death for age groups under 5 years with 90% uncertainty ranges, by event type

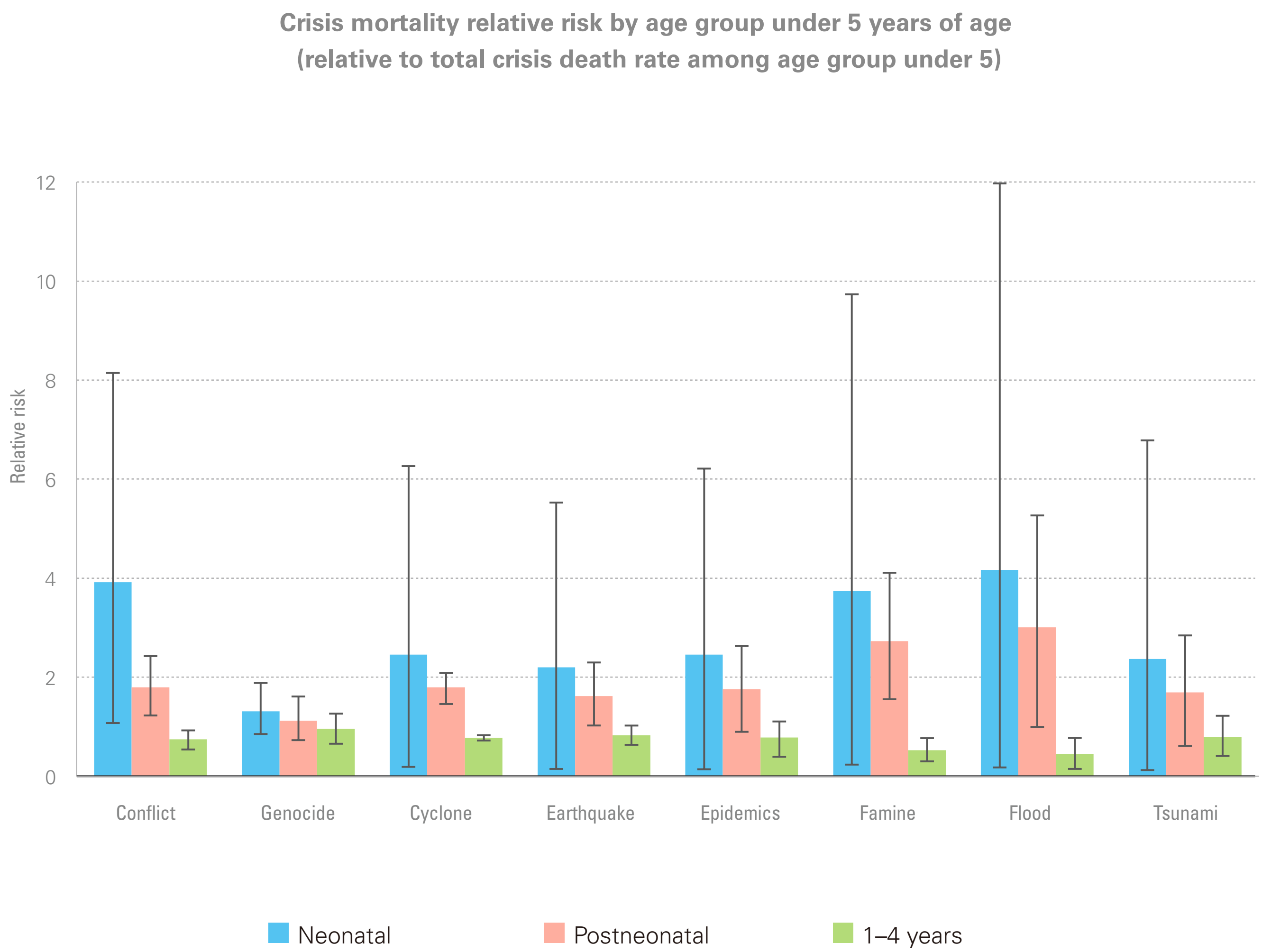
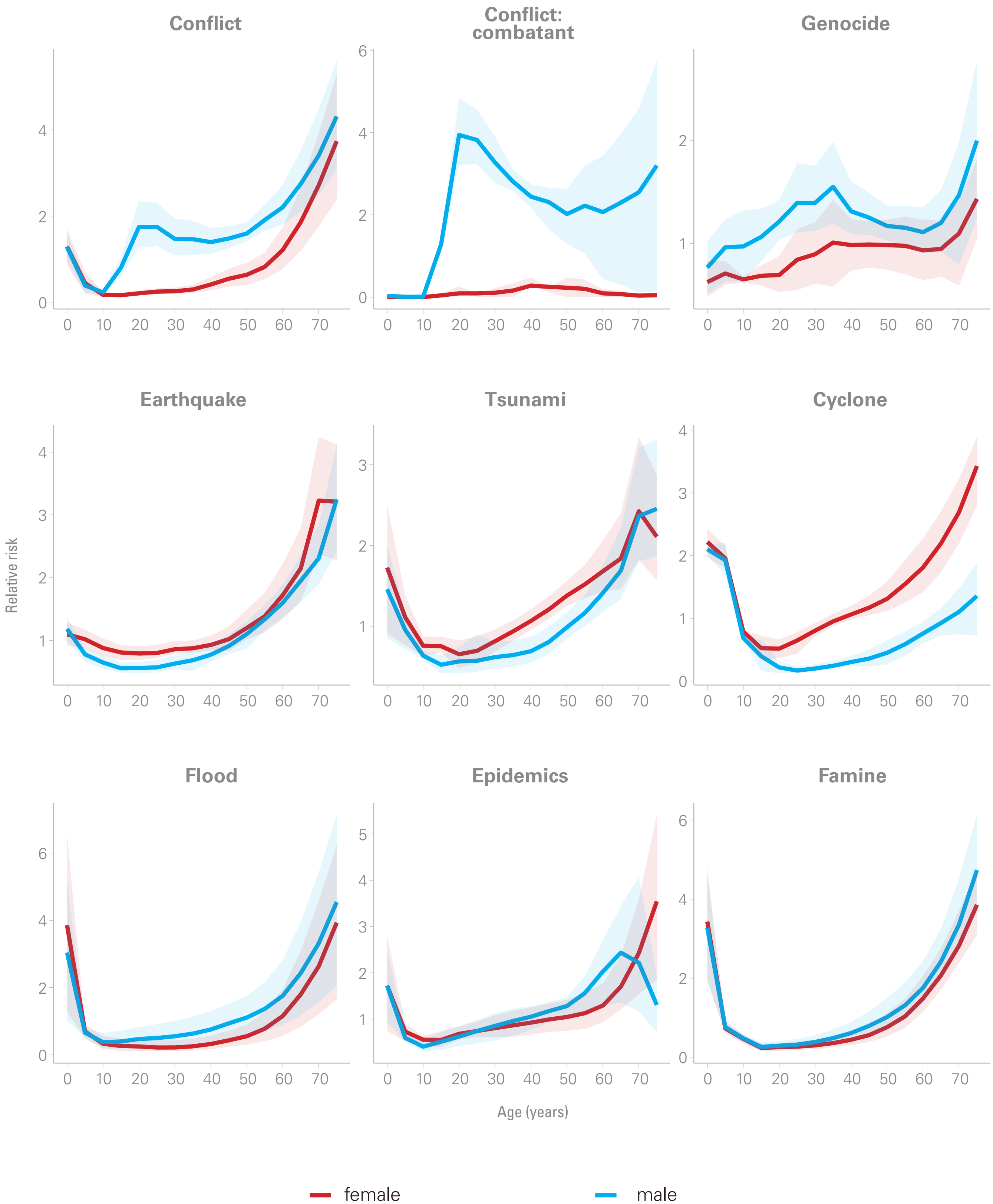


Figure 4. Estimated age-sex-specific relative risks of crisis deaths for full age groups, by event type



Supplementary Appendix

Contents

Tables

Figures

1. Methods – Data from studies

We carried out an extensive search of published and unpublished studies, population surveys and death registration databases to identify data on the age-sex distribution of crisis deaths up to 2019. We focused only on identifying available empirical information on age-sex distributions of deaths or death rates for crisis events. This is available for surprisingly few major historical crises. We were not able to find data on age-sex distributions of mortality or populations at risk for major events such as the Holocaust, the Chinese famine of 1959–1961 and the Haiti earthquake in 2010, and excluded age-sex data based on model life tables or assumptions. Additionally, we included only data for entire crisis events or country-years and did not seek data on specific high-intensity events during military conflict, such as the bombing of Dresden during the Second World War. Despite these data limitations, we were able to include data for age-sex distributions for both world wars, the conflicts in Iraq and Afghanistan during the twenty-first century, and a number of other major events, such as the Ukraine famine of 1932–1933.

Table 1 lists studies and data sets identified with specific information on age- and/or sex-specific distributions of crisis deaths. Crisis deaths include those resulting from conflict, natural disasters (floods, earthquakes, tsunamis, storms, volcanoes, landslides, etc.), epidemics (excluding HIV/AIDS) and famines. Two types of crisis mortality estimates were extracted from these studies:

- Age-sex-specific deaths or death rates estimated directly for the specific event
- Age-sex-specific excess deaths or death rates estimated indirectly by comparing the crisis period or area with a control period or area

Table A1: Studies with crisis mortality data disaggregated by age and sex

Author(s) and date	Full citation
Armenian et al. (1997)	Armenian, Haroutune K., et al., 'Deaths and Injuries due to the Earthquake in Armenia: A cohort approach', *International Journal of Epidemiology*, vol. 26, no. 4, August 1997, pp. 806–813.
Ascherio et al. (1992)	Ascherio, Alberto, et al., 'Effect of the Gulf War on Infant and Child Mortality in Iraq', *New England Journal of Medicine*, vol. 327, no. 13, September 1992, pp. 931–936.
Bern et al. (1993)	Bern, Caryn, et al., 'Risk Factors for Mortality in the Bangladesh Cyclone of 1991', *Bulletin of the World Health Organization*, vol. 71, no. 1, 1993, p. 73.
Boyle and Gráda (1986)	Boyle, Phelim P., and Cormac Ó. Gráda, 'Fertility Trends, Excess Mortality, and the Great Irish Famine', *Demography*, vol. 23, no. 4, November 1986, pp. 543–562.
Burnham et al. (2006)	Burnham, Gilbert, et al., 'Mortality after the 2003 Invasion of Iraq: A cross-sectional cluster sample survey', *The Lancet*, vol. 368, no. 9545, October 2006, pp. 1421–1428.
Carrión Martín et al. (2014)	Carrión Martín, Antonio Isidro, et al., 'Mortality Rates above Emergency Threshold in Population Affected by Conflict in North Kivu, Democratic Republic of Congo, July 2012–April 2013', *PLOS Neglected Tropical Diseases*, vol. 8, no. 9, September 2014, pp. e3181.
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2. Methods – Crisis data from population surveys

Demographic and Health Surveys (DHS),[1] Multiple Indicator Cluster Surveys (MICS)[2] and World Fertility Surveys[3] covering the period from 1960 to 2017 were analysed for regions and years determined to have experienced crisis events. Potential crisis events were identified using a list compiled from three different sources:

- Uppsala Conflict Data Program (UCDP) estimates of conflict mortality, 1989–2017[4]
- Integrated Network for Societal Conflict Research (INSCR) conflict events, 1960–2017[5]
- Centre for Research on the Epidemiology of Disasters, Emergency Events Database (EM-DAT) natural disaster events, 1960–2017[6]

Conflicts were selected from UCDP if there were at least 1,000 deaths or at least 0.1 death per 1,000 population that resulted in at least 10 deaths. INSCR conflict events were included if INSCR-estimated magnitude was greater than 4 for war of independence or international conflict and greater than 2 for civil war or ethnic conflict. These criteria identified 749 country-years with crisis events. For each crisis event, a control period of two years before the crisis year, or in some cases control regions separate to the crisis region, was also analysed.

Natural disasters from the EM-DAT were limited to epidemics, droughts, earthquakes, mass movements, floods, landslides, famines and any combination of those events that resulted in at least 1,000 deaths or a death rate of more than 0.1 deaths per 1,000 population and 10 deaths.

Population surveys used for birth history analysis are listed in Table 2 and for adult sibling survival analysis in Table 3. Full birth histories were analysed for years within 25 years of the survey date in order to compute age patterns of under-five mortality. Full sibling histories for adult deaths in the age range 15–50 years were analysed for years within the 15-year period before the year the survey was conducted. Both types of data were analysed using the demogsurv R package[7] based on observed deaths and person-years by age group converted to cumulative hazard probabilities. For countries with multiple surveys, the unweighted average for country-years was used. Confidence intervals were computed using the jackknife method.[8]

Table A2: Population survey data used for under-five birth history analysis

Country or area	No. of years	Years available	Country or area	No. of years	Years available
Chad	41	1973–2013	Sudan	35	1955–1989
Eswatini	32	1982–2013	Syria	24	1954–1977
Nepal	39	1977–2015	Tajikistan	24	1988–2011
Pakistan	60	1952–2011	Tunisia	58	1954–2011
Panama	24	1952–1975	Türkiye	49	1954–2002
Peru	58	1954–2011	Uganda	52	1964–2015
Philippines	59	1954–2012	United Republic of Tanzania	47	1968–2014
Rwanda	47	1968–2014	Venezuela (Bolivarian Republic of)	24	1953–1976
Sao Tome and Principe	24	1984–2007	Yemen	58	1955–2012
Sierra Leone	29	1984–2012	Zimbabwe	51	1964–2014
South Africa	24	1974–1997	**Total 21 countries**	**2,349**	

Table A3: Population survey data used for adult sibling survival analysis

Country or area	No. of years	Years available	Country or area	No. of years	Years available
Afghanistan	14	2001–2014	Kenya	30	1984–2013
Angola	14	2001–2014	Liberia	20	1993–2012
Brazil	14	1982–1995	Malawi	37	1978–2014
Burkina Faso	25	1985–2009	Mali	30	1982–2011
Burundi	20	1996–2015	Morocco	25	1978–2002
Cambodia	28	1986–2013	Mozambique	28	1983–2010
Central African Republic	14	1980–1993	Myanmar	14	2002–2015
Chad	31	1983–2013	Nepal	24	1992–2015
Colombia	8	2001–2008	Niger	34	1978–2011
Congo	20	1991–2010	Nigeria	19	1994–2012
Democratic Republic of the Congo	20	1993–2012	Peru	33	1978–2010
Ethiopia	30	1986–2015	Philippines	19	1979–1997
Eswatini	14	1992–2005	Rwanda	29	1986–2014
Gambia	14	1999–2012	Sao Tome and Principe	14	1994–2007
Guatemala	14	1981–1994	Sierra Leone	19	1994–2012
Guinea	27	1985–2011	South Africa	14	1984–1997
Haiti	30	1986–2015	Uganda	35	1981–2015
Indonesia	32	1980–2011	United Republic of Tanzania	25	1990–2014
Jordan	14	1983–1996	Zimbabwe	35	1980–2014
			Total 38 countries	**867**	

Analysis of birth history data for under-five deaths

To identify potential crisis mortality signals in the under-five birth history data, annual time series of $_4q_1$ – the probability of dying between exact age 1 and exact age 5 – were calculated from the birth history data and from the WHO Global Health Estimates (GHE) 2016 life tables, which included annual estimates of crisis deaths.[9] Figure A1 shows plots for countries with potential crisis events. Due to the limited data and relatively small numbers of observations involved in the excess crisis deaths, data were analysed for both sexes combined. An exploratory sex-specific analysis found a wide range of sex ratios of excess deaths, including some implausible patterns.

For potential crisis signals identified in these plots, the excess deaths in the crisis year were estimated using appropriate national or regional non-crisis comparison data and the age-sex-specific excess deaths plotted. Where the surveys allowed, data were extracted for the crisis region and for other 'baseline' regions. To the extent possible, two to three years on either side of the potential crisis peak were chosen for comparison, though where necessary, additional mortality peaks in the comparison period were excluded.

The plots in Figure 1 show $_4q_1$ time series from survey birth histories (blue line) together with estimated $_4q_1$ time series from the GHE 2016 life tables (red line). The dots on the horizontal line at the bottom denote crises identified from three independent databases as described above. Note that red dots denote crisis years for which the survey-based $_4q_1$ estimate differs significantly with probability $p \geq 80\%$ from the average for the prior two years. Revised control periods or regions were used for final selection of crisis data to include in this study.

Figure A1: Plots comparing $_4q_1$ from survey birth histories and GHE 2016

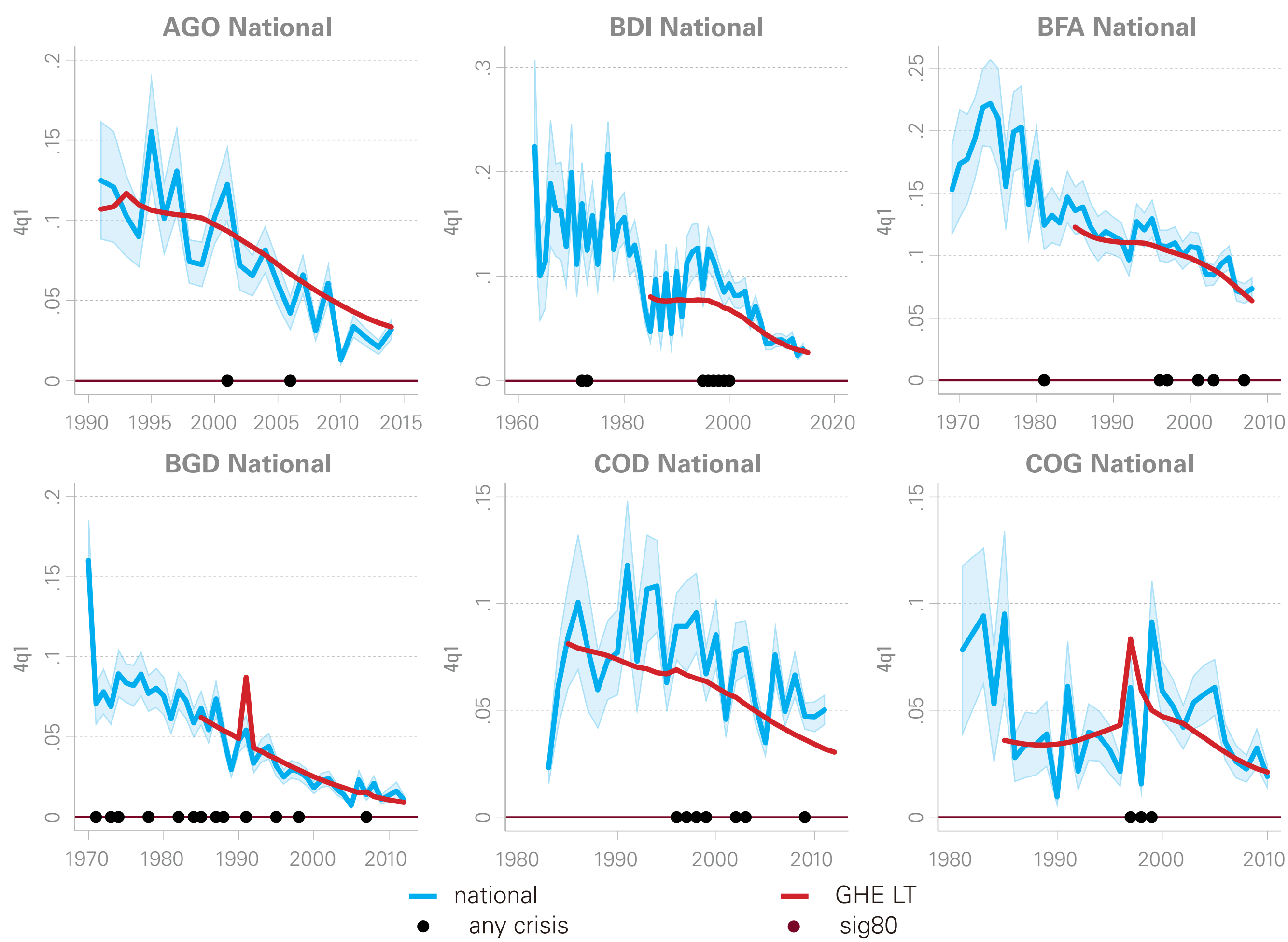


Figure A1 (continued): Plots comparing $_4q_1$ from survey birth histories and GHE 2016

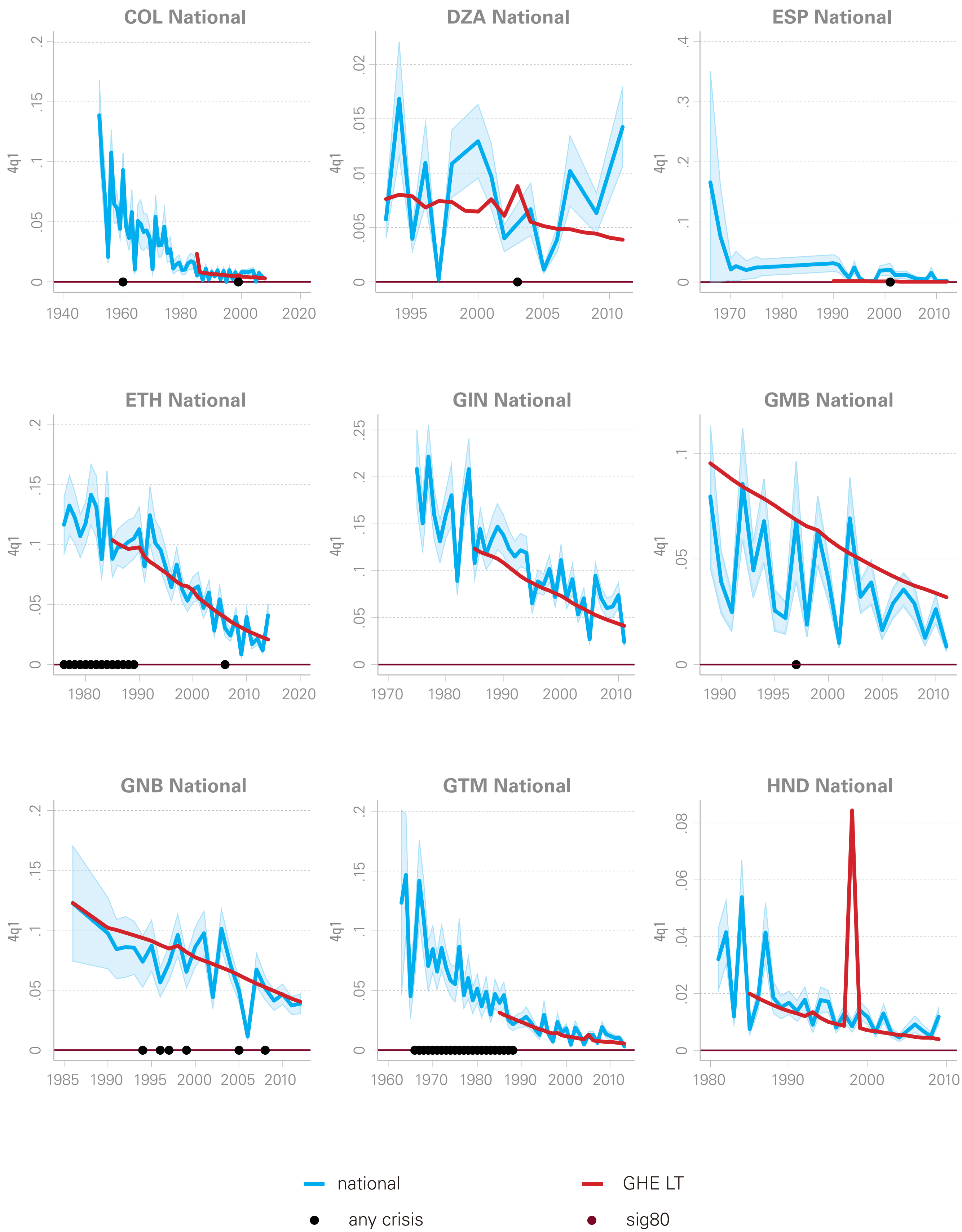


Figure A1 (continued): Plots comparing ${}_4q_1$ from survey birth histories and GHE 2016

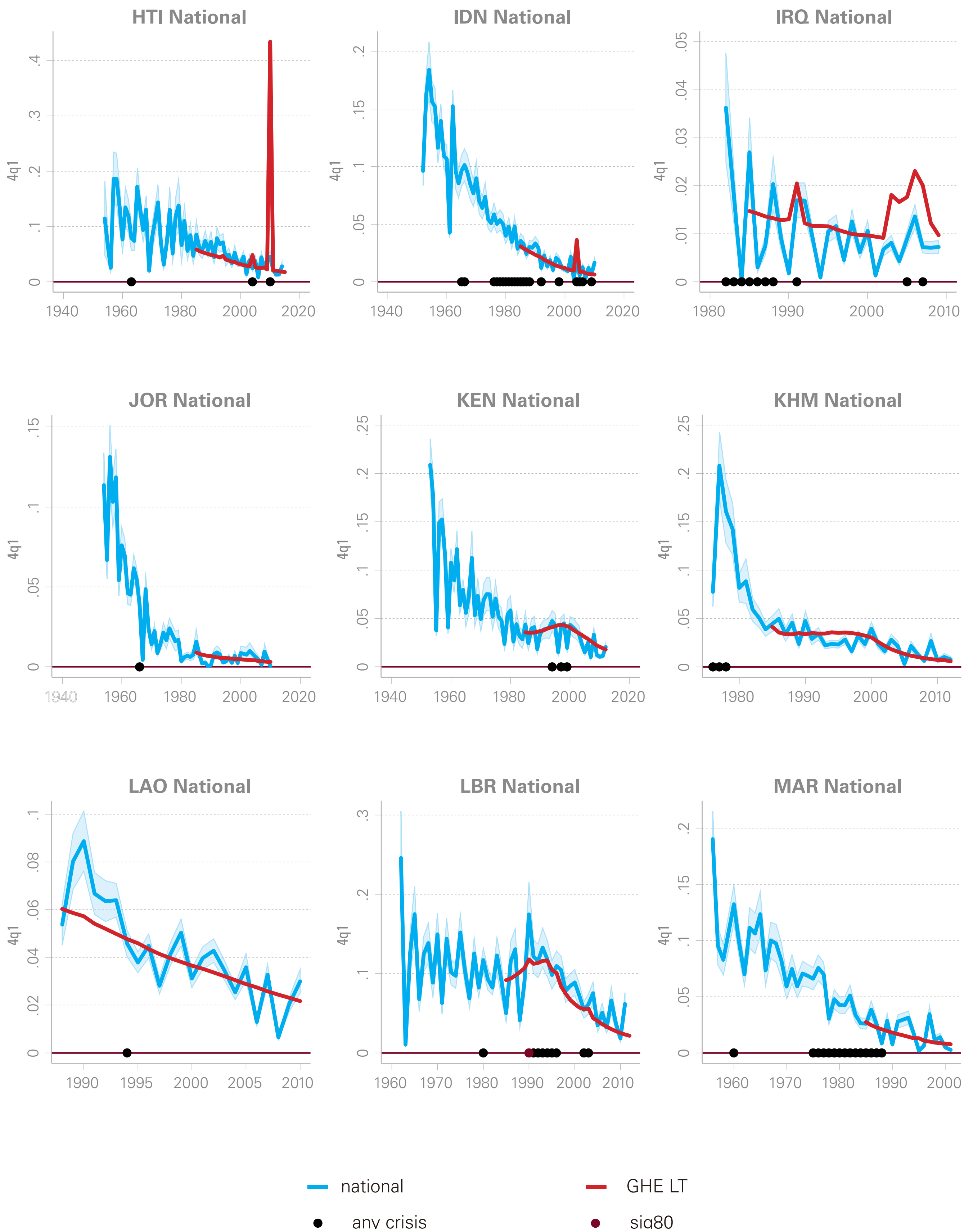


Figure A1 (continued): Plots comparing ${}_4q_1$ from survey birth histories and GHE 2016

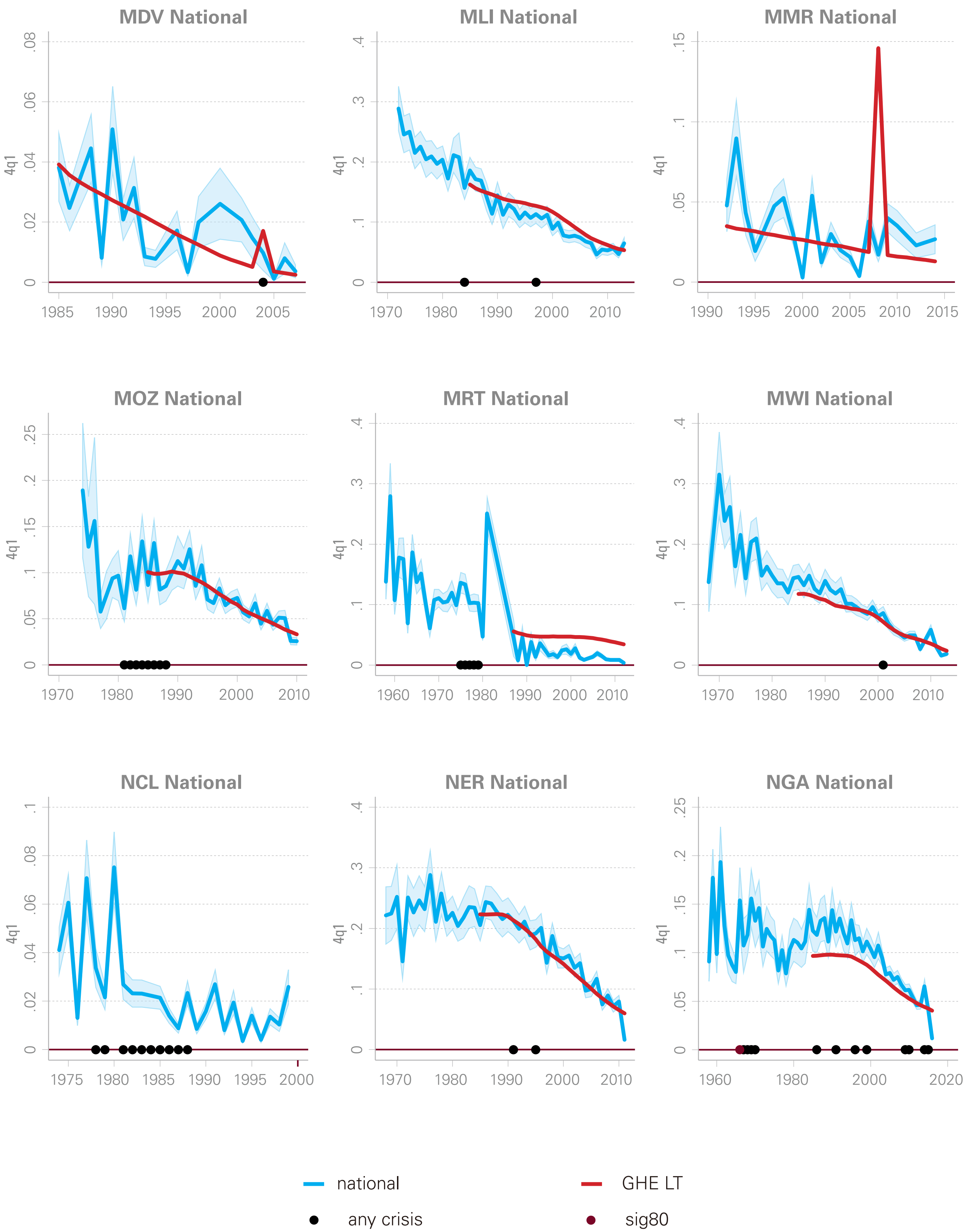


Figure A1 (continued): Plots comparing ${}_4q_1$ from survey birth histories and GHE 2016

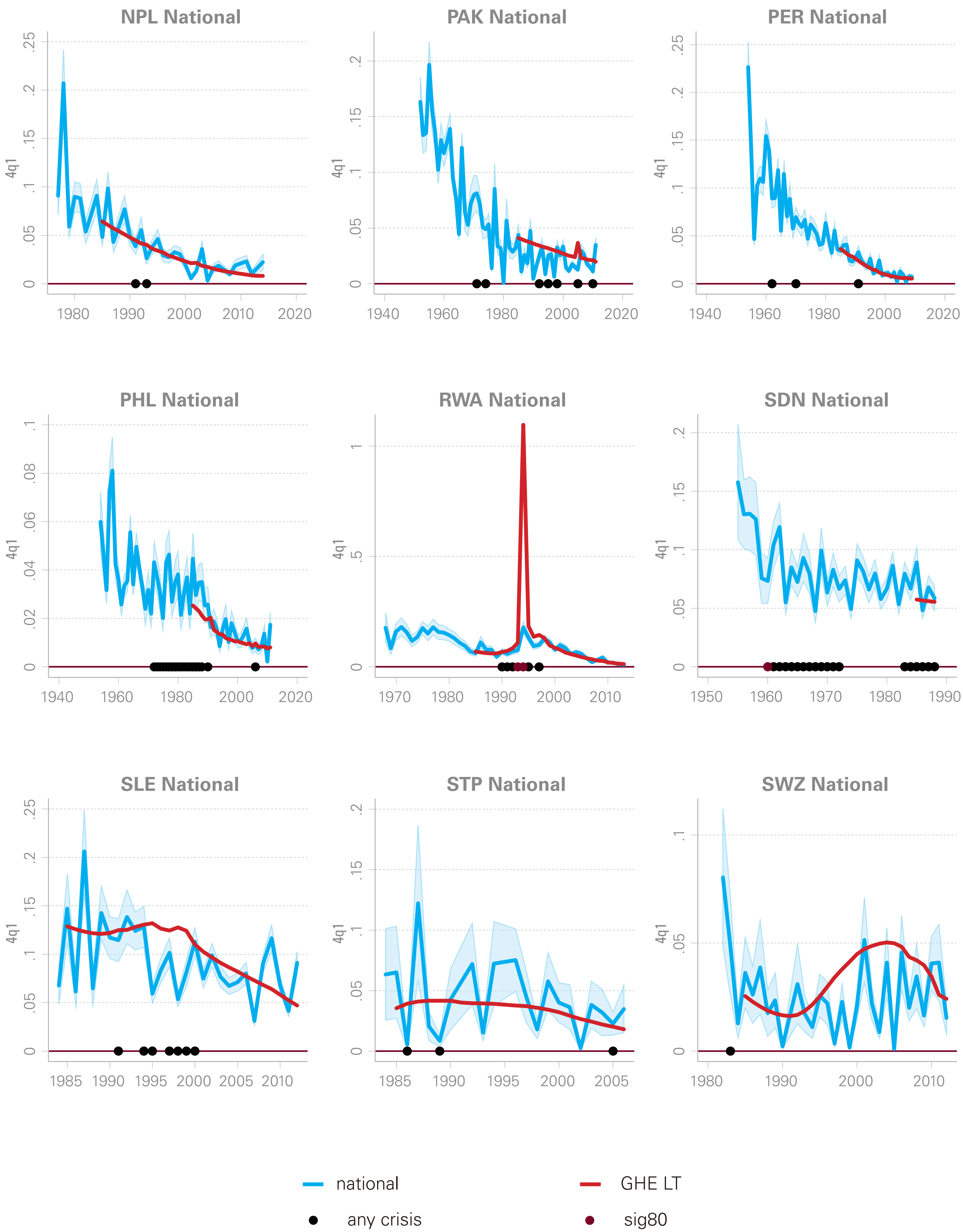


Figure A1 (continued): Plots comparing ${}_4q_1$ from survey birth histories and GHE 2016

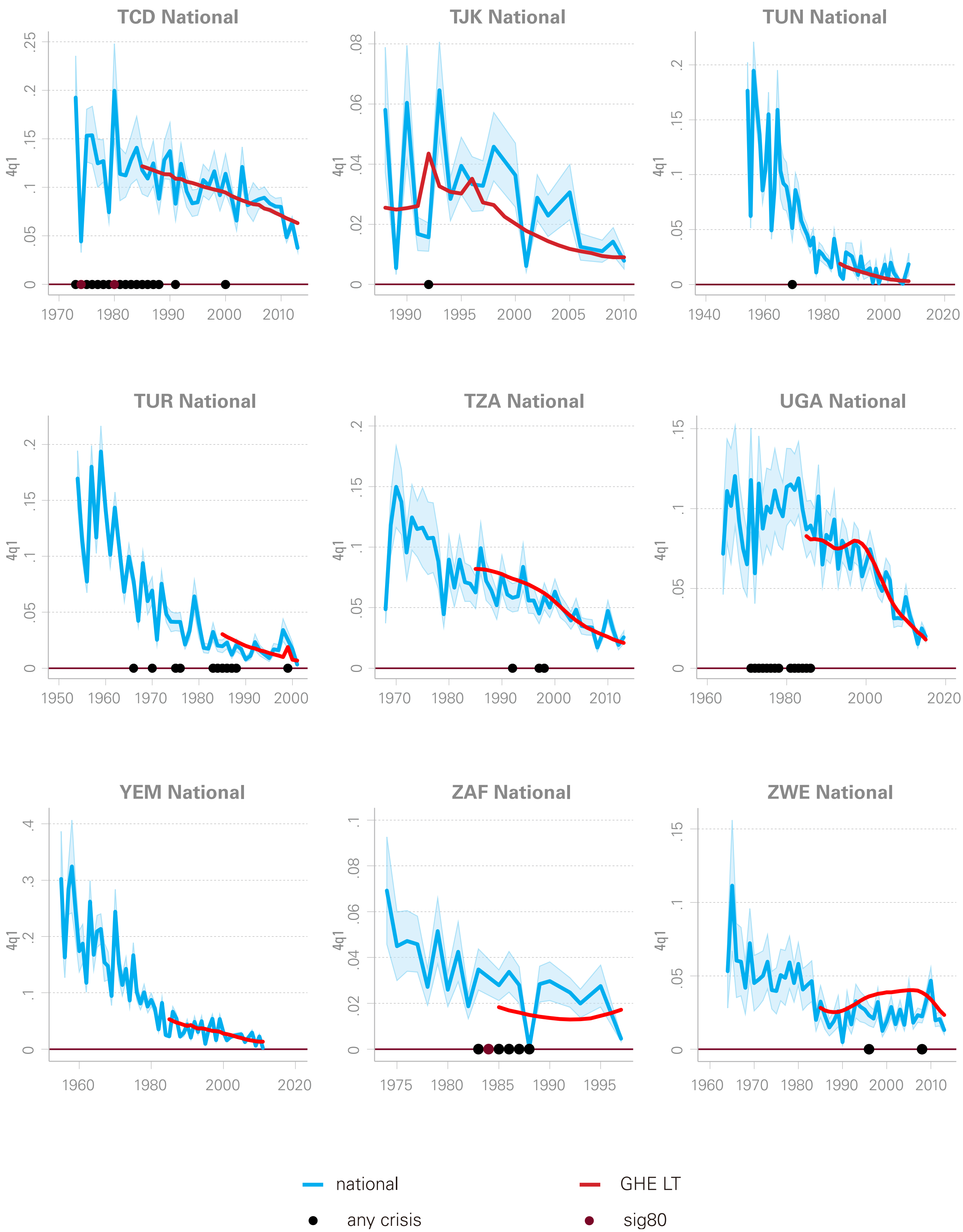


Figure A1 (continued): Plots comparing $_4q_1$ from survey birth histories and GHE 2016

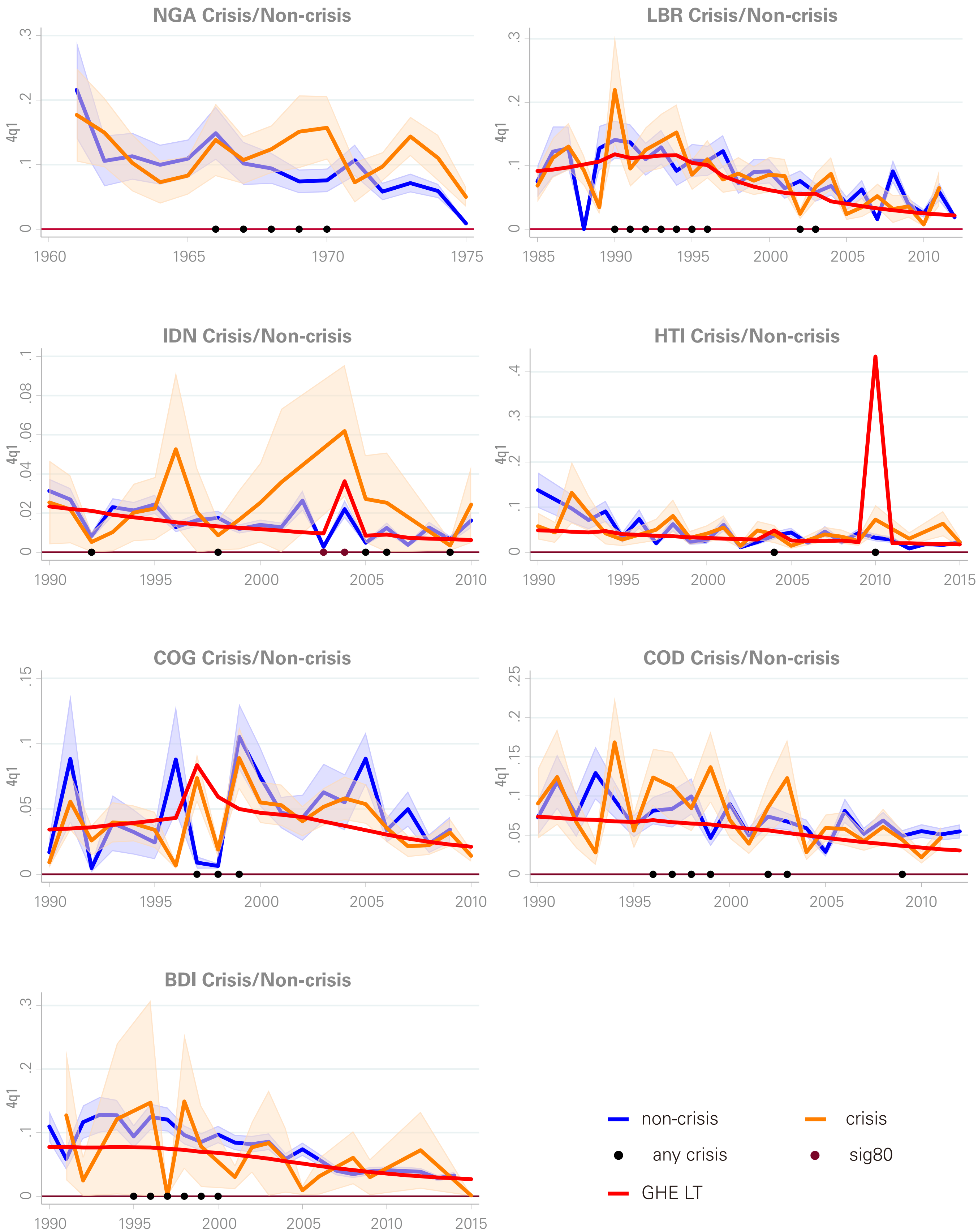


Table A4: Under-five crisis age patterns included in subsequent analysis

Country or area	Year	Event	Region	Sex	Neonatal/postneonatal	Infant/1–4 years
Cambodia	1977-78	Conflict	national	both	yes	yes
Chad	1980	Conflict	national	both		yes
Colombia	1960	Conflict	national	both		yes
Congo	1999	Conflict	national	both	yes	yes
Haiti	2010	Earthquake	crisis region	both		yes
Indonesia	2004	Tsunami	crisis region	both	yes	yes
Liberia	1990	Conflict	crisis region	both		yes
Liberia	1990	Conflict	national	both		yes
Nigeria	1966	Conflict	national	both	yes	yes
Nigeria	1968–70	Conflict	crisis region	both	yes	yes
Nigeria	2014	Conflict	national	both		yes
Rwanda	1994	Genocide	national	both	yes	yes

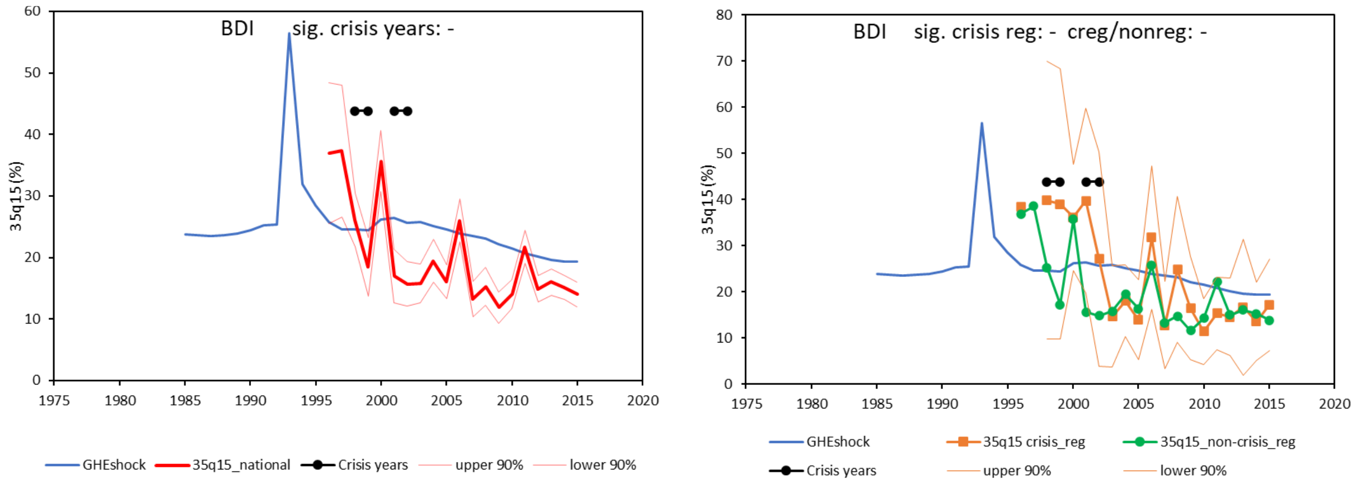
Estimates of the fractions of infant and 1–4-year deaths were included in the overall analysis of crisis age patterns in cases where the ${}_4q_1$ for the crisis period differed with probability $p \geq 80\%$ from the average ${}_4q_1$ for the comparison period or region. Available age fractions for neonatal and postneonatal deaths were also included for events for which the infant/1–4-year fractions were included, except for a few cases where the neonatal fraction was 1. Age-specific estimates for under-five crisis mortality were included from survey birth histories for the events listed in Table 4.

Analysis of sibling survival histories for adult crisis mortality

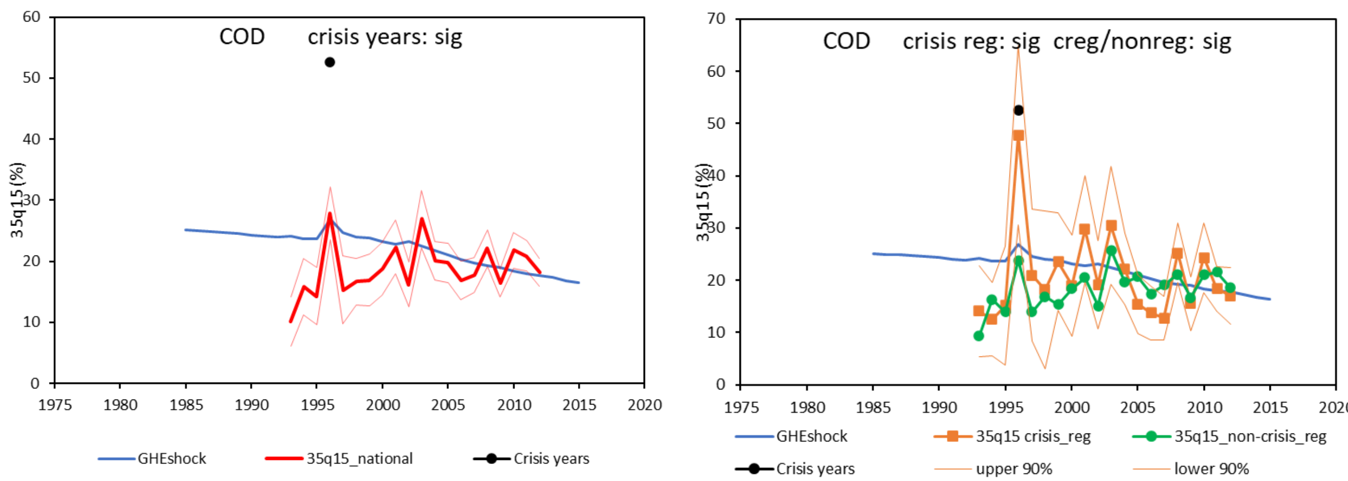
Sibling survival data from surveys for 38 countries were used to compute time series of ${}_{35}q_{15}$ – the probability of dying between exact age 15 and exact age 50. These were compared to plots of ${}_{35}q_{15}$ from the GHE 2016 life tables,[9] which included separate annual estimates of crisis deaths. Potential spikes in ${}_{35}q_{15}$ estimates from the survey data were identified and age-sex patterns of excess deaths relative to national or regional baseline death rates were examined (see Figure A2). In most cases, the expected excess deaths based on GHE estimates of total conflict deaths were too small a fraction of total deaths for the signal to be detected in the sibling data. The Rwanda genocide in 1994 and the Indian Ocean tsunami in 2004 were the only two crises with a clear signal in the data and a plausible age-sex pattern of deaths. The Ethiopian conflict in 2000 is a third possibility, though it is unclear that the age pattern adds any real information. As the analysis data set already includes age-sex patterns for the Rwanda genocide and the Indian Ocean tsunami from studies, no sibling survival-based data were included in the overall data set for further analysis of age-sex distributions of crisis deaths.

Figure A2: Plots of ${}_{35}q_{15}$ from survey data and GHE 2016

Burundi: 1993 "genocide" and 1993–2005 civil war



Democratic Republic of the Congo: 1996 conflict



Congo: 1997 conflict

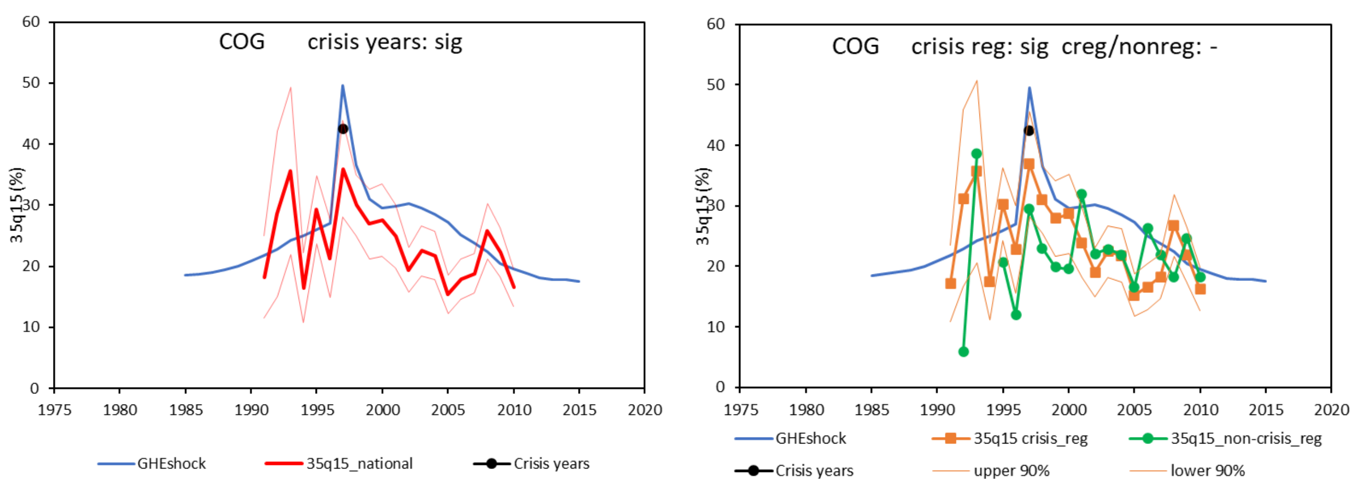
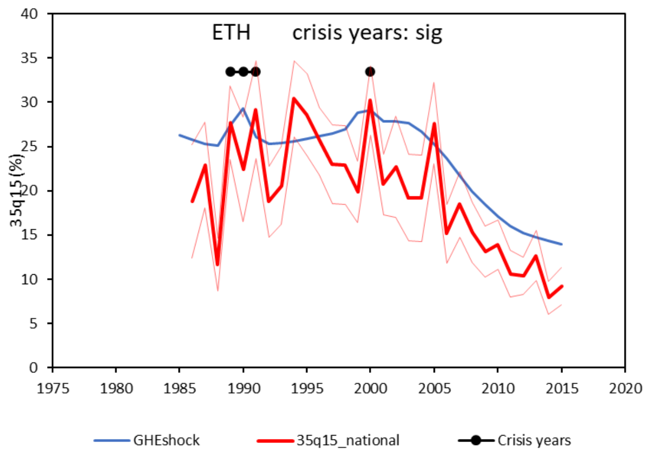
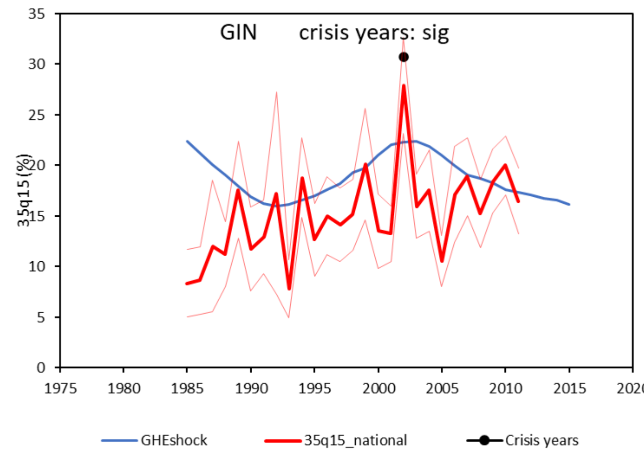


Figure A2 (continued): Plots of ${}_{35}q_{15}$ from survey data and GHE 2016

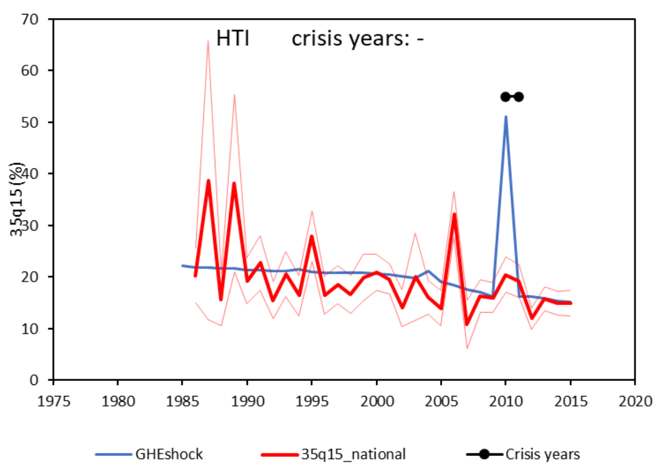
Ethiopia: 1989–1991 conflict and 2000 conflict

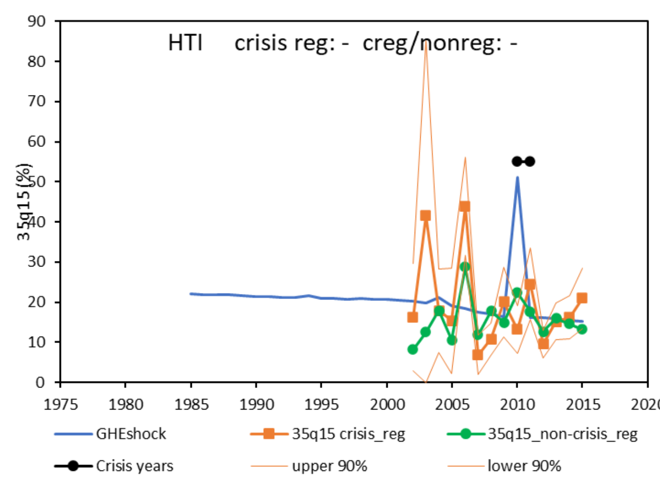


Guinea: Peak in sibling deaths not associated with known crisis

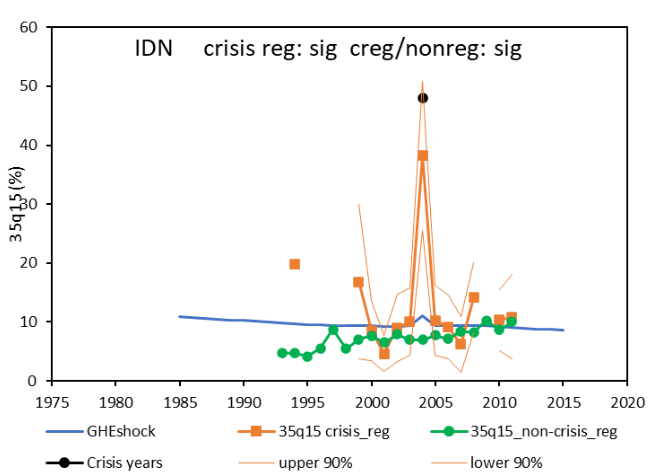


Haiti: 2010 earthquake





Indonesia: 2004 Indian Ocean tsunami



Cambodia: 1989 conflict

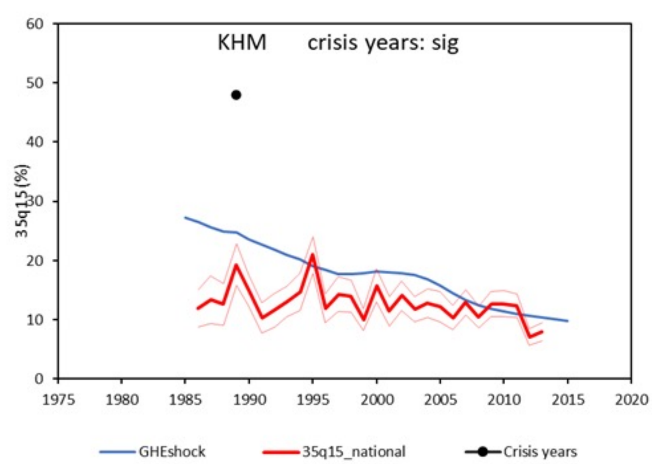
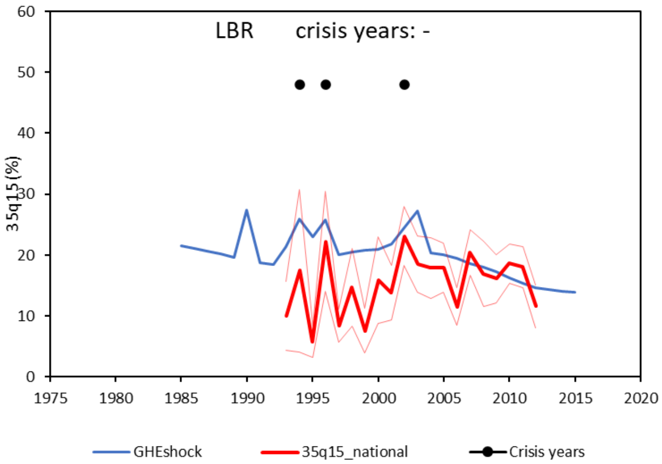
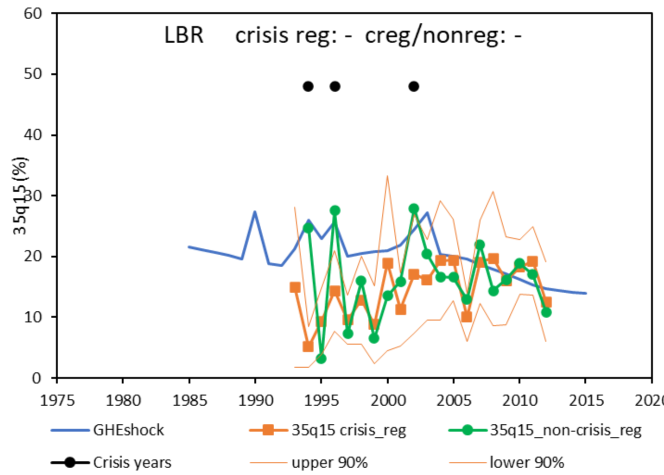


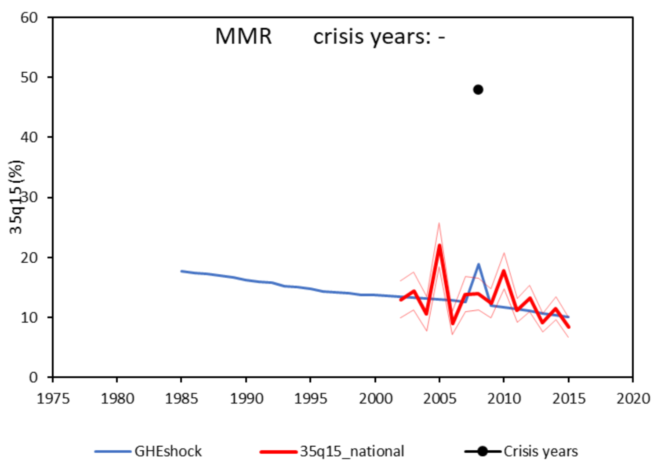
Figure A2 (continued): Plots of ${}_{35}q_{15}$ from survey data and GHE 2016

Liberia: conflict

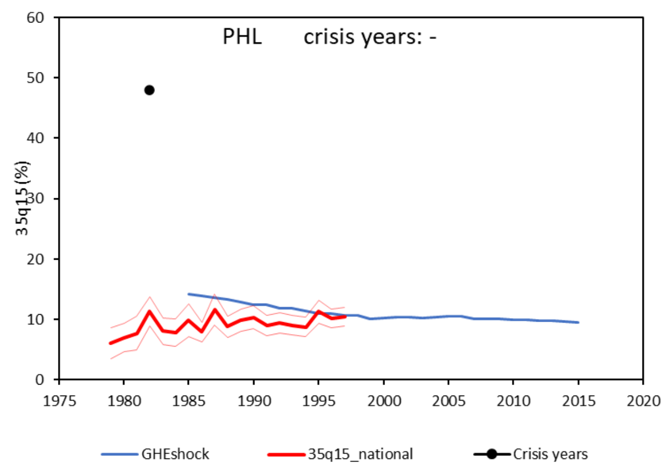




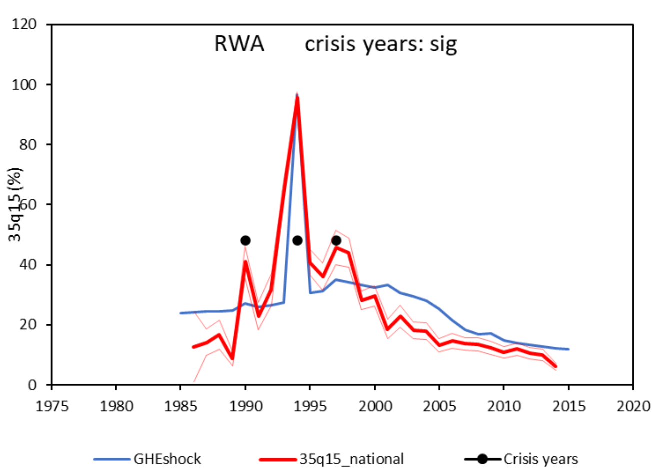
Myanmar: Cyclone



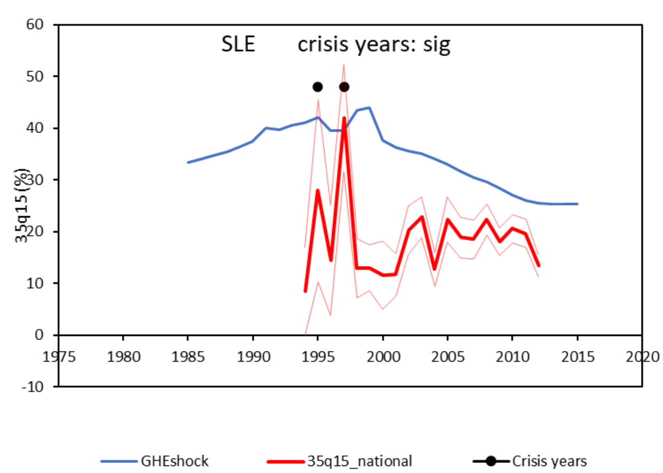
Philippines: Cyclone



Rwanda: 1994 genocide



Sierra Leone: Conflict



3. Methods – Death registration data

The Human Mortality Database (HMD)[10] contains national life tables carefully constructed from available death registration data of sufficient completeness and quality. The HMD was reviewed to identify country-years in the database where crisis events had occurred. This analysis was done in two steps. In the first, all HMD data for years 1953 onwards were reviewed for crises using conflict and natural disaster mortality estimates from the WHO GHE 2016[9] and natural disaster deaths from EM-DAT[6]. Table A5 lists the crises identified and the available years selected to provide baseline mortality rates.

Baseline non-crisis mortality rates by age and sex were estimated using two methods: (a) simple average rate of baseline years and (b) Poisson regression of age-specific deaths with population offset. Initially, five-year age groups were used, but substantial fluctuations were found above and below baseline rates for most of the crisis years analysed. Some analyses were repeated with broader age groupings, but the implied age patterns were found to be substantially dependent on the age groupings chosen. None of the HMD data analyses resulted in age patterns judged useable.

For most of these crises, the estimated EM-DAT total deaths represent only a very small proportion of total annual deaths. Estimates of baseline mortality rates are highly sensitive to baseline years selected, age groups selected and method (average versus regression prediction). In most cases, the signal is clearly not strong enough to be detected with any confidence.

In the second step, HMD data available for some countries for years prior to 1953 were reviewed to identify potential crises resulting in increased mx for crisis years. For France and England and Wales, life tables were available for the two world

Table A5: HMD data availability for country-years with identified crises from 1953 onwards

Country or area	Event type	Crisis year(s)	Baseline years	Avg. annual baseline deaths	EM-DAT/ WHO crisis deaths
Iceland	Landslide	1995	1999–2000	1,796	34
Italy	Landslide	1963	1960–1962, 1964–1966	494,000	1,917
Italy	Earthquake	1980	1977–1983	969,000	4,689
Japan	Earthquake	1995	1992–1998	1,785,735	5,297
Japan	Earthquake/Tsunami	2011	-	-	19,848
Russian Federation	Storm/Landslide/Transport/Industrial/Temp	1995	1992–1994, 1996–1998	3,635,119	599
Russian Federation	Earthquake	1995	1992–1998	3,635,119	1,985
Russian Federation	Conflict	1999–2000	1996–1998, 2001–2003	382,100	-
Taiwan Province of China	Earthquake	1999	1984, 1986, 1988, 2003, 2005, 2006	253,308	2,265
Taiwan Province of China	Epidemic	2003	-	262,450	37
Taiwan Province of China	Flood/Storm	2005	-	279,550	34
United States of America	Conflict	2001	1999–2000, 2002–2003	483,000	2,996

wars for civilians only and for total population. It was possible to extract combatant age-sex patterns of mortality for these two populations by subtracting civilian baseline mx from total population mx.

Twelve major crises were identified for which plausible mortality age-sex patterns could be extracted from the HMD data (see Table A6). These were included in the analysis data set.

The WHO Mortality Database[11] was also reviewed to identify country-years with crisis events. For natural disasters, deaths coded to the ICD codes for natural disasters were analysed. The only crisis with complete coding of crisis deaths to natural disaster codes giving total deaths close to that reported by EM-DAT and other sources was the 2011 tsunami in Japan.

For other natural disasters and conflicts, a further analysis of excess deaths for all causes and excess deaths for unintentional injury deaths (excluding road injuries) was carried out. Excess deaths were calculated as deaths in the crisis year minus average deaths per year based on six years of data (three before and three after the crisis year). For all cause deaths, the only crisis with useable data was for Thailand in 2004 (Indian Ocean tsunami). Using death registration data for unintentional injury deaths (excluding road injuries),[11] excess crisis deaths were included in the analysis data set for the 10 crises listed in Table A7.

All-cause death registration data gave useable age-sex patterns for excess deaths due to conflict for the events listed in Table A8 and were included in the analysis data set.

Table A6: HMD data availability for country-years with identified crises prior to 1953

Country or area	Event type	Crisis year(s)	Baseline years	Included in analysis dataset
Australia	Conflict: combatant	1943–1945	1938, 1939, 1947	No
England and Wales	Conflict: combatant	1914–1917	1913, 1920*	Yes
England and Wales	Conflict: combatant	1939–1945	Civilian: 1937, 1938, 1946	Yes
Finland	Conflict	1939–1945	1938, 1946	Yes
France	Conflict	1870–1871	-	Yes
France	Conflict: civilian	1914–1917	1913, 1920*	Yes
France	Conflict: combatant	1914–1917	1913, 1920*	Yes
France	Conflict: combatant	1940–1945	Civilian: 1937, 1938, 1946	Yes
France	Conflict: civilian	1940–1945	1938, 1939, 1947	Yes
Italy	Conflict	1940–1946	1938, 1939, 1948	No
Netherlands	Conflict: civilian	1940–1943	1938, 1939, 1946	Yes
Netherlands	Famine	1944–1945	1938, 1939, 1947**	Yes
Sweden	Famine	1773	-	Yes
Sweden	Epidemics	1831	-	Yes
United States of America	Conflict: combatant	1941–1945	1940, 1946	No

* Data for the flu pandemic years 1918 and 1919 excluded (included in analysis data set from Murray et al. 2006).
** Conflict mortality rates assumed same as for 1940–1943 and subtracted from excess over baseline.

For crises identified above in the death registration data for analysis of the five-year age group patterns, the under-five age patterns were also analysed. Age-specific estimates of excess crisis under-five deaths from the WHO Mortality Database were included for the six natural disasters listed in Table A9.

Table A7: Crises for which data were included from registered unintentional injury deaths (excluding road injuries)

Country or area	Year	Event
Armenia	1988	Earthquake
Chile	2010	Earthquake
Iceland	1995	Landslide
Italy	1963	Landslide
Italy	1980	Earthquake
Italy	2009	Earthquake
Japan	1995	Earthquake
Japan	2011	Tsunami
Netherlands	1953	Famine
Peru	2009	Landslide

Table A8: Conflicts for which data were included from all-cause death registration data

Country or area	Year	Event
Albania	1997	Conflict
Azerbaijan	1992–1994	Conflict
Chile	1973	Conflict
Croatia	1991–1992	Conflict
Guatemala	1981	Conflict
Tajikistan	1992–1994	Conflict

Table A9: Natural disasters for which data for under-five deaths were included from death registration data

Country or area	Year	Event	Sex
Japan	2011	Tsunami	Male, female
Italy	1980	Earthquake	Both sexes
Italy	2009	Earthquake	Both sexes
Italy	1963	Landslide	Both sexes
Netherlands	1953	Famine	Both sexes
Thailand	2004	Tsunami	Male, female

4. Preparation of the analysis data set

Data from all sources described above were compiled into a single data set. All observations were converted to age-specific death rates for crisis events, using the study population to convert death counts, or if that was not reported, the relevant population estimates from *World Population Prospects*[12] or historical population data[13]. Where total deaths for a crisis event and control population were reported, the event death rates were computed by subtracting control death rates from crisis death rates.

The age-sex categories used in the studies are highly variable and inconsistent. Some studies do not include age groups covering all possible ages and many do not split deaths by sex. Studies were classified into three groups based on availability of sex-specific data (sex coded as 1 = male, 2 = female, 3 = both sexes):

Group 1 studies with sex = 1, 2 data and optionally sex = 3 for the same age groups as sex = 1, 2

Group 2 studies that have data only report sex = 1 or sex = 2 but not both in addition to sex = 3

Group 3 studies that have data for sex = 3 only

Table A10 summarizes available data from all data sources, by type of event and group. A few studies of conflicts focused specifically on civilian deaths or combatant deaths, though most implicitly or explicitly included all conflict deaths. As age-sex distributions are very different for civilians and combatants, these event types were separately identified where possible.

Table A10: Available age-sex-specific crisis mortality data, by event type and group

Event type	Group 1	Group 2	Group 3	Total
Conflict	20	3	12	35
Conflict and famine	-	-	2	2
Conflict: civilian	4	4	-	8
Conflict: combatant	7	1	-	8
Cyclone	3	-	-	3
Earthquake	13	5	9	27
Earthquake and tsunami	3	-	2	5
Epidemic	7	-	19	26
Epidemic and war	1	-	-	1
Famine	20	-	8	28
Famine and epidemic	-	-	3	3
Famine and flood	2	-	1	3
Flood	6	1	-	7
Genocide	3	-	1	4
Tsunami	2	1	1	4
Total	**91**	**15**	**58**	**164**

Study data are sparse for most event types and an analysis strategy was developed to maximize the useable data by event type. A preliminary analysis estimated age patterns for three broad age groups – 0–14 years, 15–59 years and 60+ years – and then more detailed five-year age patterns within each group. This led to implausible discontinuities across the five-year age groups due to inclusion of different subsets of studies in the analysis within each broad age band. The analysis strategy thus consisted of analysing the age-sex distribution of crisis deaths for five-year age groups – 0–4 years, 5–9 years, … 70–74 years, 75+ years – starting initially with studies that provided data for those age groups, and then using the results as 'prior' distributions to impute the full five-year age group distributions for studies with fewer age groups. There were a few studies with non-standard age groups such as 0–5 years, 6–10 years, 11–15 years, … or use of a non-standard boundary such as 18 years. In these cases, death numbers were imputed to standard five-year age groups assuming uniform death distributions by age within age groups. In all, there were 141 studies with age groups spanning all ages. All had a final open-ended age group of 60+ years, apart from 10 with a final age group of 50+ years, 10 with 15+ years and two with 5+ years.

Since the age-sex distribution of crisis deaths will depend on the population age-sex structure, event death distributions were calculated for a standard population arbitrarily chosen as the world population in 2000 for both sexes combined. Males and females were assumed to have the same age distributions.

5. Estimation methods

Seemingly unrelated regression (SUR) method

We used a regression framework to estimate the age-sex distribution of crisis deaths by event type for 16 age groups. One approach would have been to estimate each age-sex death fraction f as the dependent variable in 16 separately estimated equations for each sex. However, this strategy ignores the fact that the proportions must sum to 1 across both sexes. The correct regression model thus involves one fewer equation and a constraint that the proportions sum to 1. We followed the approach developed by Aitchison[14] by dividing the proportion of deaths in each age-sex group by the proportion in a selected 'base' age-sex group b (and sex = 1 if sexes are separately identified):

$$y_{as} = f_{as} / f_{b1}$$
where a is age (≠b) and s is sex 1, 2

The vector of dependent variables is then assumed to be multivariate normal and is estimated for each event type by including dummy variables for all event types except a base category. To account for the correlated nature of the dependent variables, we estimated the entire set using seemingly unrelated regression (SUR). The resulting age-sex fractions are then computed as follows:

$$f_{b1} = 1/(1+\sum_{a \neq b,s} y_{as})$$
$$f_{as} = y_{as} \times f_{b1} \qquad \text{for } a \neq b$$

Model fitting was performed using procedure SUREG[15] in Stata 15.

Estimation strategy for 16 five-year age groups, from 0–4 years to 75+ years

The first step was to estimate a set of age-sex fractions by event type (labelled 'prior1') for the 56 studies that had data by sex for a complete set of five-year age groups up to 75+. This included one study with the mixed-event type 'Epidemic and war'. The study data were replicated for each of the two events. An initial analysis found that the 2011 Japan tsunami had a very high proportion of deaths (0.137 for men and 0.103 for women) in the 75+ age group, which was much higher than that of the earthquake distribution. For a general tsunami age pattern, this outlier would likely result in an overestimate of deaths in the 75+ age group. To estimate the general tsunami age pattern, these proportions were replaced by the 75+ proportion from the initial analysis for floods: 0.0497 (men) and 0.042 (women). The flood proportions were the highest for the other disaster types (typically around 2–3 per cent of the 75+ age group in the standard population).

The second step was to estimate a set of age-sex fractions by event type (labelled 'prior2') for the 72 events that had data for a complete set of five-year age groups up to 60+. As before, data for mixed-event types were replicated for each of the component events. Prior1 was first used to impute sex-specific fractions for Group 2 and Group 3 studies (see section 3 for definition of groups). Prior1 was then used to impute death fractions for five-year age groups up to 75+ for studies with a broader final open-ended age group.

The third step was to estimate a set of age-sex fractions by event type (labelled 'prior3') for the 141 events that had data for a complete set of age groups covering all ages. As before, data for mixed-event types were replicated for each of the component events. Prior2 was first used to impute sex-specific fractions for Group 2 and Group 3 studies. Prior2 was then used to impute death fractions for all five-year age groups up to 75+. The event type 'cyclone' appeared for the first time in this step and did not have a prior age-sex distribution. The prior2 distribution for flood was used for cyclone. The data available for each event type are shown in Table A11 (mixed-event types are counted twice in this table).

The final step was to include events with data spanning only a subset of the full age range, e.g., 15–59 years. Prior3 was used to impute a full set

Table A11: Available age-sex-specific crisis mortality data for full age range 0–75+, by event type

Event type	No. of events
Conflict	25
Conflict: civilian	8
Conflict: combatant	8
Genocide	2
Cyclone	3
Earthquake	28
Epidemics	28
Famine	34
Flood	10
Tsunami	7
Total	**153**

of death fractions by sex for five-year age groups up to 75+. The full data set (with replicated mixed-event data) included 174 events for 10 event types (see Table 2 in the main paper).

The SUR model was run on this final data set to produce estimates for the age-sex fractions of deaths in the standard population. These fractions were then converted to age-sex specific mortality rates and scaled to a standard overall crisis mortality rate for the population. It is assumed that the age-sex specific relative risks of mortality are the relevant parameters that apply across populations with different age structures and can be used to estimate crisis mortality age patterns in real populations and specific periods.

Uncertainty estimation

Bootstrap resampling was carried out 1,000 times for the final SUR model and used to estimate 90 per cent uncertainty ranges based on the fifth and ninety-fifth percentiles of the 1,000 sets of estimates. Because there were small numbers of observations for most event types, and within-event-type variation as large as or larger than across-event-type variation, uncertainty ranges tend to be relatively broad. Estimates for a given event type were often not statistically significantly different from those for some of the other event types for some age-sex categories. Despite this, estimates were prepared for each of the 10 event types as the most appropriate summary of the age-sex pattern of deaths in the relevant data sets.

Smoothing

The estimates of age-sex fractions for five-year age groups in the standard population have quite wide uncertainty ranges and point estimates in adult age groups showed considerable variation across age groups for some event types. Estimates were then smoothed using a three-point moving average for age groups from 25–29 years to 70–74 years. Upper- and lower-relative uncertainty bounds were also replaced by their three-point moving average if that resulted in wider uncertainty. Figure A3 illustrates the effect of smoothing for three event types where there was substantive smoothing.

Figure A3: Five-year age-sex fractions by event type, before and after smoothing

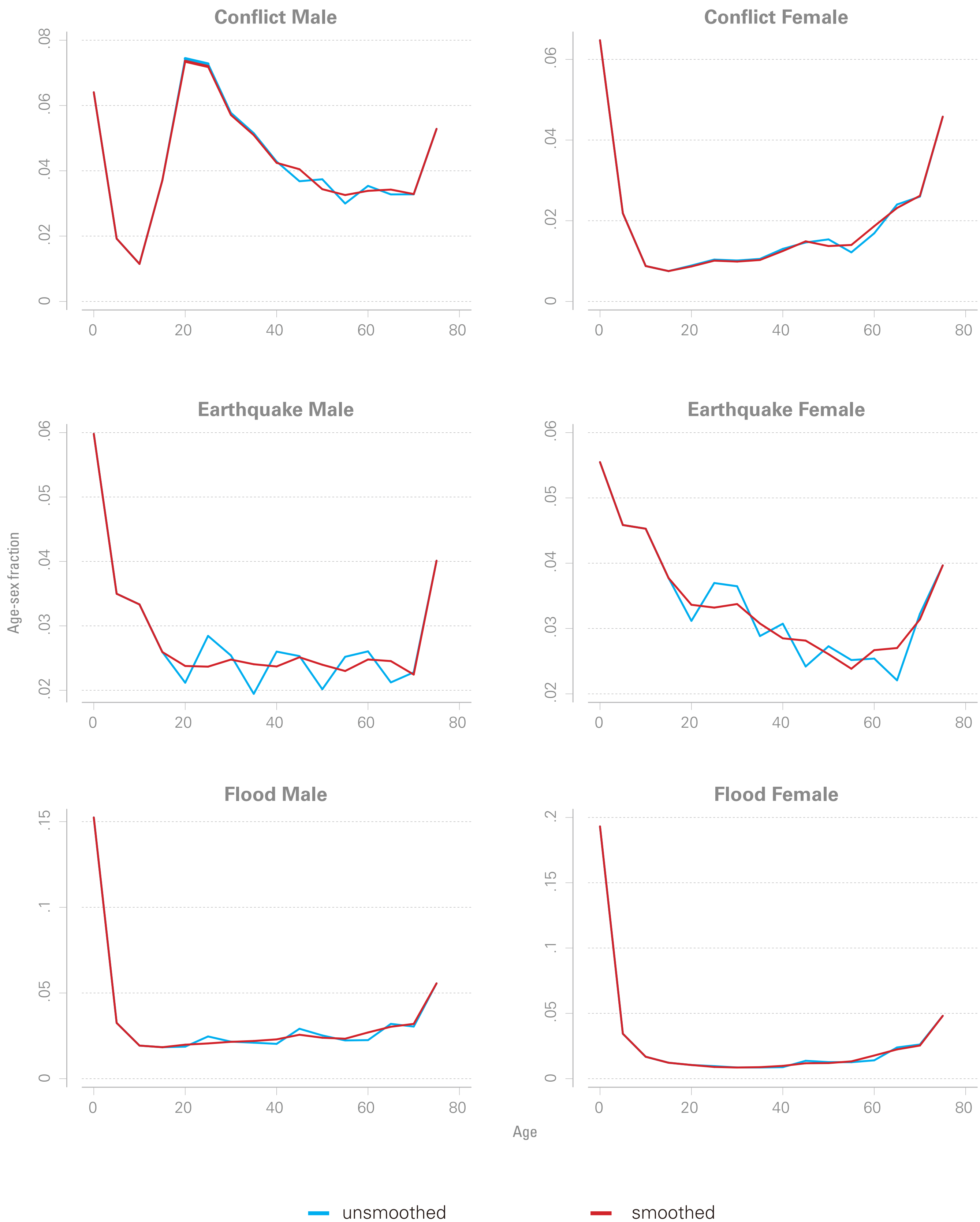


Table A12: Estimated neonatal fractions of infant deaths

Event type	Neonatal fraction	Lower-uncertainty bound	Upper-uncertainty bound
Conflict	0.148	0.0528	0.301
Natural disaster	0.115	0.010	0.298
Genocide	0.096	0.010	0.279

6. Estimation of crisis age-sex distributions for under-five age groups

Apart from the birth history data for children under age 5, there were additional study data for the under-five age group only, so a separate analysis was carried out for more detailed under-five age groups (neonatal, postneonatal and 1–4 years) to provide an age-sex breakdown of the under-five crisis death fraction from the full five-year age group analysis (described in section 4 above).

There were only 12 events with data for neonatal and postneonatal age groups under 1 year and only one with a breakdown by sex. Age-sex fractions for the infant age group were estimated separately and then used to partition the infant fraction from the analysis of the 0 and 1–4-year data.

Estimation of neonatal fraction of crisis infant deaths

In contrast to the 12 events for neonatal/postneonatal split, there were 24 studies for age groups infant and 1–4 years, all including sex-specific data. For this reason, the age-sex fractions for the infant age group were estimated separately.

The neonatal/postneonatal age distribution was analysed for both sexes combined and the standard population assumed to have 1/12 neonates and 11/12 aged 1–11 months. There were insufficient event types to estimate each separately, so the data were analysed for two broader categories: conflict and natural disasters. There was also one study for the 1994 genocide in Rwanda; the uncertainty range for genocide was assumed to be the same as that for conflict. The SUR analysis with bootstrap resampling resulted in the estimates for the neonatal fraction of infant deaths shown in Table A12.

Estimation of infant and 1–4-year fractions of under-five crisis deaths

For analysis of infant/1–4-year distribution of deaths under age 5, data with mixed-event type were replicated for each of the event types. The standard population was based on the world population in 2000, with an infant population fraction of 0.2084 and a 1–4-year population fraction of 0.7916 of the total under-five population. Standard population numbers for boys and girls are assumed equal.

Estimation of age-sex fractions under age 5 was carried out in two steps. First, we estimated ‘prior’ infant and 1–4-year fractions by sex using Group 1 data. Data for the 2011 New Zealand earthquake were dropped from analysis, as there were three infant deaths and no child deaths in the 1–4-year age group. That left 33 studies for the following event types: conflict (10), famine (15), epidemic (4), tsunami (2), earthquake (1) and flood (1). Data for earthquake, tsunami and flood were grouped together as event type ‘natural disaster’.

The resulting age-sex fractions for under-five deaths and the sex ratios are shown in Table A13.

Table A13: Estimated age-sex fractions for infant and 1–4-year deaths

	Infant deaths		1–4-year deaths		M/F sex ratio	
Event type	**Male**	**Female**	**Male**	**Female**	**Infant**	**1–4 years**
Conflict	0.299	0.231	0.249	0.220	1.295	1.132
Natural disaster	0.242	0.242	0.233	0.281	1.000	0.832
Epidemic	0.218	0.160	0.256	0.211	1.360	1.211
Famine	0.306	0.312	0.177	0.203	0.979	0.875

Given the small number of observations, most of the sex differences are not statistically significant. Estimates for epidemics are based on only four studies from 1808, 1831, 1834 and 1918. Estimates for famine are based on 15 observations, of which nine are prior to the twentieth century and six are from the twentieth century. However, there is not much difference for famine estimates if early famines (<1900) are excluded. These results were used as a 'prior' distribution to impute sex-specific fractions for Group 3 studies for both sexes combined. The high sex ratio for infants in epidemics was adjusted downwards to 1.36 based on the average ratio of infant/child sex ratios of 1.115. With the inclusion of Group 3 data for under-five crisis deaths, there were 47 events, as shown in Table A14.

Note the data are extremely sparse for most event types, particularly when it comes to sex-specific data. Two outlier observations from Turpeinen[16] for famine and epidemic in the 1830s have an infant fraction of 1. These two observations were dropped as implausibly high.

Estimation of full age-sex fractions of under-five crisis deaths

Sex-specific estimates of the neonatal fraction of infant deaths from 1,000 bootstrap samples were randomly paired with estimates of the infant and 1–4-year fractions of under-five deaths to produce estimates with 95 per cent uncertainty ranges of age-sex specific fractions of under-five crisis deaths for neonatal, postneonatal and 1–4-year age groups.

Estimation for all age groups to 75+ with more detailed under-five breakdown

The under-five fractions of total crisis deaths estimated in section 5 for 1,000 bootstrap samples were randomly paired with sex-specific

Table A14: Data availability for under-five crisis deaths, by event type

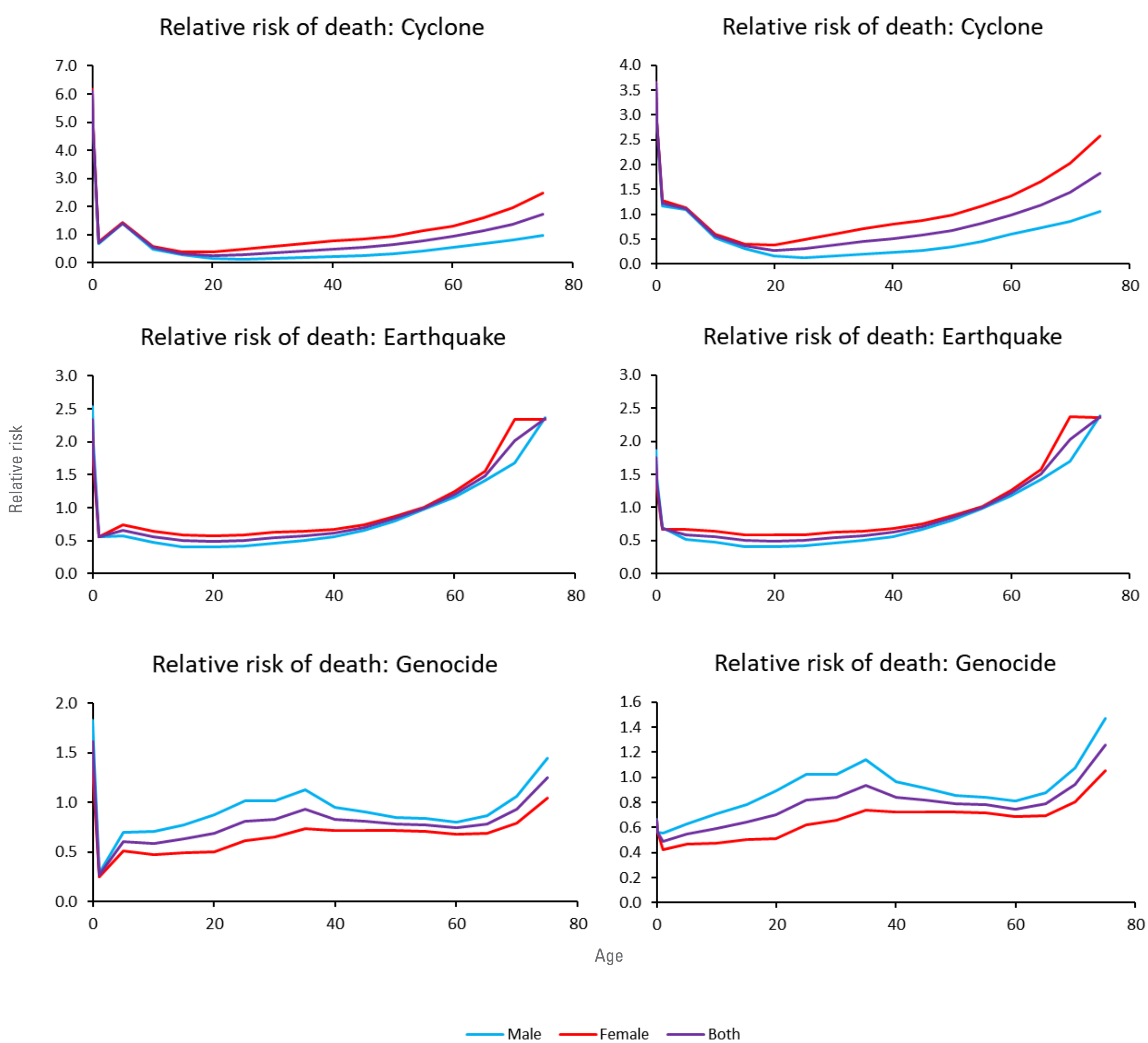
Event type*	All data	Group 3	Group 1
Conflict	19	12	7
Conflict: civilian	3	0	3
Earthquake	6	4	2
Epidemic	19	15	4
Famine	28	13	15
Flood	2	1	1
Genocide	1	1	0
Tsunami	3	1	2
Total	**81**	**47**	**34**

* Mixed-event types appear twice in the above table

estimates of the neonatal, infant and 1–4-year fractions of under-five deaths to produce estimates with 90 per cent uncertainty ranges of age-sex specific fractions for the complete set of age groups – neonatal, postneonatal, 1–4 years, 5–9 years, … 70–74 years, 75+ years.

The full age patterns contained a trough for the age group 1–4 years followed by a peak in 5–9 years for three event types: cyclone, earthquake and genocide. This pattern results from the analysis strategy of estimating the detailed under-five age patterns separately using a different set of studies with relevant age groups and then nesting it within the broader five-year age group pattern. The age patterns for these three event types were further smoothed by replacing the 5–9-year death rate by an average of the death rates for age groups 0–4, 5–9 and 10–14 years. For earthquakes, this did not sufficiently remove the discontinuity in the age pattern, and the 5–9-year death rate was simply reduced by 10 per cent. The smoothed age patterns for these three event types are shown in Figure A4.

Figure A4: Event types with additional smoothing for child age groups (revised version on right)



7. Results

Table A15: Estimated relative risks of crisis mortality, by age, sex, crisis type

Event type	Age	Age-specific death rates given total crisis death rate of 1 per 1,000 population								
		Male	90% uncertainty range	90% uncertainty range	Female	90% uncertainty range	90% uncertainty range	Both sexes	90% uncertainty range	90% uncertainty range
Conflict	0-4	1.28	0.96	1.59	1.29	0.85	1.70	1.29	0.93	1.61
	Neonatal	5.10	1.45	10.25	4.59	1.21	9.66	4.85	1.36	9.91
	Postneonatal	2.41	1.59	3.31	2.16	1.30	3.09	2.29	1.47	3.16
	Infant	2.63	1.85	3.47	2.36	1.44	3.27	2.50	1.68	3.36
	1-4	0.92	0.68	1.20	1.01	0.65	1.37	0.97	0.69	1.27
	5	0.39	0.22	0.55	0.44	0.20	0.71	0.41	0.21	0.63
	10	0.23	0.17	0.28	0.17	0.12	0.23	0.20	0.15	0.25
	15	0.80	0.59	1.06	0.16	0.12	0.22	0.48	0.37	0.61
	20	1.75	1.27	2.34	0.21	0.16	0.27	0.97	0.74	1.28
	25	1.75	1.30	2.31	0.25	0.19	0.32	1.00	0.77	1.28
	30	1.47	1.08	1.94	0.25	0.19	0.34	0.86	0.67	1.09
	35	1.46	1.10	1.89	0.29	0.21	0.41	0.88	0.69	1.09
	40	1.40	1.12	1.73	0.41	0.28	0.59	0.90	0.73	1.11
	45	1.48	1.26	1.77	0.54	0.36	0.77	1.01	0.84	1.22
	50	1.60	1.41	1.86	0.64	0.40	0.92	1.12	0.94	1.34
	55	1.91	1.66	2.26	0.82	0.53	1.15	1.37	1.13	1.65
	60	2.21	1.80	2.72	1.21	0.77	1.74	1.71	1.32	2.19
	65	2.75	2.09	3.53	1.86	1.19	2.67	2.31	1.69	3.07
	70	3.41	2.48	4.49	2.72	1.75	3.94	3.07	2.18	4.21
	75+	4.32	3.10	5.61	3.74	2.38	5.29	4.03	2.81	5.45
	All ages	**1.38**	**1.26**	**1.52**	**0.62**	**0.48**	**0.74**	**1.00**	**1.00**	**1.00**
Conflict: combatant	0-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Neonatal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Postneonatal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Infant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01
	15	1.28	1.08	1.45	0.04	0.00	0.10	0.66	0.59	0.73
	20	3.94	3.21	4.85	0.09	0.09	0.26	2.06	1.61	2.61
	25	3.82	3.23	4.56	0.09	0.01	0.09	1.92	1.62	2.29
	30	3.27	2.77	3.90	0.11	0.00	0.23	1.69	1.39	2.06
	35	2.81	2.58	3.11	0.16	0.00	0.34	1.48	1.29	1.72
	40	2.44	2.17	2.74	0.28	0.27	0.48	1.34	1.17	1.54
	45	2.31	1.64	2.66	0.25	0.12	0.24	1.30	1.01	1.44
	50	2.02	1.30	2.63	0.23	0.00	0.48	1.12	0.89	1.40
	55	2.22	1.05	3.21	0.20	0.00	0.42	1.21	0.74	1.61
	60	2.07	0.44	3.43	0.09	0.00	0.20	1.08	0.32	1.72
	65	2.30	0.30	3.97	0.07	0.00	0.15	1.19	0.23	1.99
	70	2.55	0.11	4.59	0.04	0.00	0.08	1.30	0.09	2.30
	75+	3.20	0.14	5.74	0.05	0.00	0.10	1.62	0.12	2.87
	All ages	**1.91**	**1.79**	**2.00**	**0.09**	**0.00**	**0.21**	**1.00**	**1.00**	**1.00**

Table A15 (continued): Estimated relative risks of crisis mortality, by age, sex, crisis type

Event type	Age	Age-specific death rates given total crisis death rate of 1 per 1,000 population								
		Male	90% un-certainty range	90% un-certainty range	Female	90% un-certainty range	90% un-certainty range	Both sexes	90% un-certainty range	90% un-certainty range
Cyclone	0-4	2.10	2.01	2.17	2.22	1.97	2.42	2.16	2.03	2.29
	Neonatal	5.02	0.41	13.79	5.03	0.38	13.55	5.03	0.40	13.88
	Postneonatal	3.91	3.13	4.50	3.91	3.08	4.71	3.91	3.17	4.55
	Infant	4.00	3.69	4.24	4.00	3.55	4.38	4.00	3.73	4.28
	1-4	1.60	1.43	1.75	1.75	1.55	1.92	1.67	1.54	1.80
	5	1.41	1.22	1.61	1.51	1.39	1.66	1.46	1.40	1.51
	10	0.69	0.68	0.69	0.79	0.77	0.81	0.74	0.73	0.75
	15	0.40	0.16	0.66	0.52	0.33	0.72	0.46	0.25	0.68
	20	0.22	0.12	0.32	0.52	0.37	0.66	0.37	0.26	0.49
	25	0.17	0.12	0.23	0.65	0.43	0.78	0.41	0.30	0.48
	30	0.20	0.15	0.27	0.80	0.71	0.93	0.50	0.48	0.57
	35	0.24	0.20	0.32	0.95	0.87	1.07	0.60	0.59	0.64
	40	0.30	0.23	0.40	1.06	0.98	1.20	0.68	0.68	0.73
	45	0.36	0.23	0.51	1.17	1.05	1.36	0.76	0.76	0.81
	50	0.45	0.27	0.65	1.31	1.12	1.59	0.88	0.83	0.95
	55	0.59	0.40	0.79	1.55	1.25	1.93	1.07	1.00	1.19
	60	0.76	0.60	0.95	1.81	1.42	2.27	1.29	1.14	1.49
	65	0.93	0.72	1.16	2.19	1.73	2.71	1.56	1.33	1.87
	70	1.10	0.75	1.48	2.69	2.19	3.22	1.90	1.58	2.33
	75+	1.36	0.72	1.89	3.43	2.79	3.89	2.39	1.92	2.89
	All ages	**0.75**	**0.73**	**0.77**	**1.25**	**1.23**	**1.27**	**1.00**	**1.00**	**1.00**
Earthquake	0-4	1.18	1.00	1.36	1.10	0.92	1.29	1.14	0.97	1.32
	Neonatal	3.12	0.23	8.13	3.02	0.22	7.98	3.07	0.22	8.10
	Postneonatal	2.41	1.64	3.27	2.33	1.60	3.17	2.37	1.63	3.23
	Infant	2.54	1.80	3.32	2.54	1.80	3.39	2.54	1.79	3.34
	1-4	0.95	0.69	1.25	1.02	0.76	1.32	0.98	0.73	1.28
	5	0.78	0.66	0.89	1.02	0.87	1.17	0.90	0.79	1.00
	10	0.65	0.55	0.75	0.88	0.74	1.03	0.76	0.67	0.86
	15	0.56	0.49	0.64	0.81	0.69	0.92	0.68	0.60	0.77
	20	0.56	0.48	0.66	0.79	0.69	0.90	0.68	0.59	0.77
	25	0.57	0.49	0.69	0.80	0.72	0.93	0.69	0.61	0.79
	30	0.63	0.54	0.77	0.86	0.79	0.99	0.75	0.67	0.86
	35	0.68	0.51	0.84	0.87	0.80	1.00	0.78	0.65	0.90
	40	0.77	0.66	0.94	0.93	0.84	1.08	0.85	0.76	0.99
	45	0.91	0.78	1.10	1.02	0.83	1.22	0.96	0.86	1.13
	50	1.10	0.87	1.30	1.20	1.01	1.49	1.15	1.01	1.37
	55	1.34	1.16	1.57	1.39	1.13	1.76	1.36	1.17	1.63
	60	1.60	1.37	1.89	1.72	1.34	2.22	1.66	1.37	2.02
	65	1.95	1.61	2.36	2.15	1.62	2.79	2.05	1.64	2.55
	70	2.31	1.89	2.83	3.23	2.38	4.24	2.77	2.16	3.48
	75+	3.25	2.42	4.12	3.21	2.27	4.12	3.23	2.37	4.11
	All ages	**0.91**	**0.87**	**0.95**	**1.09**	**1.05**	**1.13**	**1.00**	**1.00**	**1.00**

Table A15 (continued): Estimated relative risks of crisis mortality, by age, sex, crisis type

Event type	Age	Age-specific death rates given total crisis death rate of 1 per 1,000 population								
		Male	90% uncertainty range	90% uncertainty range	Female	90% uncertainty range	90% uncertainty range	Both sexes	90% uncertainty range	90% uncertainty range
Epidemics	0-4	1.72	0.93	2.49	1.72	0.74	2.80	1.72	0.85	2.65
	Neonatal	3.56	0.22	10.27	3.24	0.16	10.05	3.42	0.19	10.22
	Postneonatal	2.76	1.37	4.33	2.51	0.99	4.35	2.65	1.20	4.38
	Infant	2.82	1.45	4.33	2.57	1.05	4.37	2.71	1.26	4.37
	1-4	1.43	0.76	2.10	1.50	0.64	2.44	1.46	0.70	2.25
	5	0.60	0.51	0.70	0.73	0.52	0.90	0.66	0.53	0.77
	10	0.40	0.30	0.54	0.55	0.45	0.64	0.48	0.41	0.57
	15	0.51	0.34	0.72	0.55	0.39	0.75	0.53	0.36	0.73
	20	0.62	0.42	0.85	0.68	0.56	0.84	0.65	0.49	0.84
	25	0.74	0.47	0.98	0.74	0.61	0.95	0.74	0.55	0.96
	30	0.85	0.54	1.13	0.81	0.61	1.08	0.83	0.57	1.10
	35	0.96	0.64	1.22	0.86	0.62	1.18	0.91	0.63	1.20
	40	1.05	0.77	1.28	0.92	0.67	1.25	0.99	0.72	1.26
	45	1.17	0.92	1.37	0.99	0.72	1.34	1.08	0.82	1.35
	50	1.28	1.03	1.48	1.05	0.75	1.42	1.16	0.89	1.45
	55	1.56	1.14	1.93	1.13	0.79	1.56	1.34	0.99	1.70
	60	2.03	1.29	2.70	1.29	0.93	1.77	1.65	1.18	2.11
	65	2.44	1.36	3.44	1.70	1.21	2.36	2.06	1.44	2.63
	70	2.22	1.17	4.07	2.43	1.54	3.59	2.33	1.63	2.96
	75+	1.30	0.70	1.94	3.54	1.86	5.41	2.42	1.71	3.08
	All ages	**1.00**	**0.98**	**1.02**	**1.00**	**0.98**	**1.02**	**1.00**	**1.00**	**1.00**
Famine	0-4	3.28	1.90	4.62	3.43	1.94	4.81	3.35	1.92	4.71
	Neonatal	11.70	0.76	31.66	11.54	0.75	31.14	11.61	0.76	31.35
	Postneonatal	9.14	4.87	13.68	9.02	4.88	13.30	9.07	4.85	13.43
	Infant	9.35	5.29	13.65	9.23	5.15	13.18	9.28	5.22	13.36
	1-4	1.68	0.90	2.58	1.91	1.03	2.81	1.79	0.98	2.70
	5	0.76	0.63	0.92	0.73	0.60	0.88	0.74	0.62	0.90
	10	0.48	0.36	0.58	0.46	0.34	0.56	0.47	0.35	0.57
	15	0.26	0.16	0.37	0.23	0.15	0.34	0.25	0.16	0.35
	20	0.29	0.19	0.40	0.25	0.16	0.35	0.27	0.18	0.37
	25	0.32	0.22	0.46	0.26	0.18	0.40	0.29	0.20	0.42
	30	0.38	0.27	0.56	0.30	0.20	0.44	0.34	0.24	0.50
	35	0.48	0.34	0.70	0.36	0.24	0.52	0.42	0.29	0.61
	40	0.61	0.42	0.89	0.44	0.30	0.64	0.52	0.36	0.76
	45	0.79	0.54	1.16	0.56	0.38	0.81	0.67	0.46	0.98
	50	1.01	0.69	1.49	0.76	0.52	1.10	0.88	0.61	1.29
	55	1.31	0.94	1.89	1.03	0.74	1.48	1.17	0.85	1.67
	60	1.75	1.35	2.43	1.49	1.14	2.06	1.62	1.26	2.23
	65	2.42	1.98	3.25	2.07	1.70	2.76	2.24	1.86	2.98
	70	3.35	2.77	4.52	2.82	2.39	3.71	3.09	2.59	4.09
	75+	4.73	3.62	6.13	3.86	3.09	4.75	4.29	3.37	5.41
	All ages	**1.05**	**1.02**	**1.09**	**0.95**	**0.91**	**0.98**	**1.00**	**1.00**	**1.00**

Table A15 (continued): Estimated relative risks of crisis mortality, by age, sex, crisis type

Event type	Age	Age-specific death rates given total crisis death rate of 1 per 1,000 population								
		Male	90% uncertainty range	90% uncertainty range	Female	90% uncertainty range	90% uncertainty range	Both sexes	90% uncertainty range	90% uncertainty range
Flood	0-4	3.04	1.01	5.21	3.85	1.30	6.54	3.45	1.16	5.88
	Neonatal	12.39	0.59	37.07	14.17	0.66	42.71	13.28	0.64	40.06
	Postneonatal	9.74	3.03	16.95	11.12	3.49	19.38	10.43	3.24	18.18
	Infant	10.67	3.54	18.32	10.67	3.59	18.13	10.67	3.59	18.26
	1-4	1.43	0.47	2.46	1.66	0.56	2.82	1.55	0.51	2.66
	5	0.68	0.52	0.82	0.69	0.48	0.91	0.68	0.51	0.85
	10	0.35	0.17	0.61	0.33	0.17	0.56	0.35	0.18	0.60
	15	0.33	0.15	0.60	0.26	0.11	0.49	0.33	0.15	0.60
	20	0.47	0.24	0.82	0.25	0.11	0.45	0.36	0.18	0.63
	25	0.50	0.26	0.91	0.22	0.11	0.43	0.36	0.19	0.67
	30	0.55	0.28	1.01	0.22	0.11	0.43	0.38	0.20	0.73
	35	0.63	0.32	1.13	0.25	0.13	0.48	0.44	0.23	0.81
	40	0.75	0.38	1.30	0.32	0.17	0.57	0.54	0.28	0.94
	45	0.94	0.50	1.53	0.43	0.23	0.72	0.68	0.37	1.12
	50	1.11	0.60	1.75	0.55	0.30	0.90	0.83	0.46	1.32
	55	1.37	0.72	2.16	0.78	0.40	1.28	1.07	0.57	1.71
	60	1.76	0.89	2.82	1.16	0.56	1.96	1.46	0.74	2.38
	65	2.43	1.17	3.96	1.80	0.83	3.11	2.12	1.01	3.53
	70	3.32	1.56	5.43	2.63	1.21	4.57	2.99	1.40	5.00
	75+	4.54	2.04	7.13	3.93	1.65	6.24	4.24	1.86	6.70
	All ages	**1.09**	**1.00**	**1.21**	**0.91**	**0.79**	**1.00**	**1.00**	**1.00**	**1.00**
Genocide	0-4	0.77	0.51	1.02	0.62	0.48	0.83	0.69	0.49	0.93
	Neonatal	0.90	0.55	1.24	0.90	0.64	1.19	0.90	0.60	1.20
	Postneonatal	0.77	0.47	1.06	0.77	0.54	1.02	0.77	0.51	1.03
	Infant	0.78	0.48	1.07	0.78	0.55	1.03	0.78	0.52	1.04
	1-4	0.76	0.46	1.08	0.58	0.41	0.80	0.67	0.44	0.94
	5	0.79	0.52	1.01	0.64	0.54	0.75	0.75	0.56	0.93
	10	0.81	0.53	1.10	0.65	0.62	0.68	0.81	0.65	0.99
	15	0.87	0.68	1.10	0.69	0.59	0.79	0.87	0.80	0.99
	20	1.21	1.03	1.42	0.69	0.53	0.88	0.95	0.81	1.07
	25	1.39	1.11	1.78	0.84	0.55	1.14	1.12	0.83	1.37
	30	1.39	1.12	1.75	0.89	0.61	1.21	1.14	0.92	1.36
	35	1.55	1.19	1.98	1.01	0.58	1.42	1.28	1.05	1.54
	40	1.31	1.09	1.60	0.98	0.73	1.24	1.15	0.96	1.35
	45	1.25	1.08	1.49	0.99	0.76	1.21	1.12	0.95	1.31
	50	1.17	1.03	1.37	0.98	0.74	1.23	1.08	0.89	1.28
	55	1.15	0.99	1.36	0.98	0.70	1.26	1.06	0.85	1.31
	60	1.11	0.90	1.35	0.93	0.64	1.23	1.02	0.77	1.29
	65	1.20	0.92	1.52	0.95	0.67	1.23	1.07	0.80	1.37
	70	1.47	0.79	1.98	1.10	0.59	1.41	1.28	0.69	1.70
	75+	2.00	1.24	2.77	1.43	1.04	1.82	1.71	1.14	2.30
	All ages	**1.18**	**1.08**	**1.29**	**0.82**	**0.71**	**0.92**	**1.00**	**1.00**	**1.00**

Table A15 (continued): Estimated relative risks of crisis mortality, by age, sex, crisis type

Event type	Age	Age-specific death rates given total crisis death rate of 1 per 1,000 population								
		Male	90% uncertainty range	90% uncertainty range	Female	90% uncertainty range	90% uncertainty range	Both sexes	90% uncertainty range	90% uncertainty range
Tsunami	0-4	1.46	0.85	2.00	1.73	0.90	2.51	1.59	0.87	2.26
	Neonatal	3.40	0.20	9.76	3.59	0.20	10.50	3.50	0.20	10.14
	Postneonatal	2.64	1.12	4.38	2.79	1.10	4.71	2.72	1.12	4.56
	Infant	2.70	1.15	4.37	2.86	1.10	4.77	2.78	1.15	4.58
	1-4	1.13	0.61	1.73	1.43	0.72	2.21	1.28	0.67	1.97
	5	0.96	0.71	1.16	1.11	0.77	1.38	1.03	0.74	1.27
	10	0.64	0.59	0.70	0.76	0.63	0.87	0.70	0.63	0.75
	15	0.52	0.42	0.64	0.75	0.67	0.87	0.64	0.56	0.74
	20	0.56	0.42	0.74	0.65	0.48	0.83	0.61	0.46	0.77
	25	0.57	0.44	0.90	0.69	0.54	0.87	0.63	0.50	0.79
	30	0.62	0.47	0.80	0.81	0.68	0.96	0.72	0.61	0.85
	35	0.64	0.50	0.83	0.94	0.82	1.07	0.79	0.70	0.91
	40	0.69	0.55	0.87	1.07	0.95	1.21	0.88	0.79	1.00
	45	0.81	0.66	0.99	1.21	1.09	1.37	1.01	0.82	1.15
	50	0.99	0.84	1.17	1.38	1.25	1.56	1.18	1.07	1.35
	55	1.17	1.00	1.39	1.52	1.35	1.76	1.34	1.19	1.56
	60	1.41	1.18	1.76	1.68	1.42	2.06	1.55	1.31	1.90
	65	1.69	1.33	2.22	1.84	1.46	2.40	1.76	1.40	2.30
	70	2.36	1.80	3.21	2.42	1.82	3.34	2.39	1.82	3.27
	75+	2.45	1.86	3.31	2.11	1.57	2.87	2.28	1.72	3.09
	All ages	**0.89**	**0.85**	**0.95**	**1.11**	**1.05**	**1.15**	**1.00**	**1.00**	**1.00**

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The United Nations Inter-agency Group for Child Mortality Estimation (UN IGME) was formed in 2004 to share data on child mortality, improve methods for child mortality estimation, report on progress towards child survival goals and enhance country capacity to produce timely and properly assessed estimates of child mortality. The UN IGME is led by the United Nations Children's Fund and includes the World Health Organization, the World Bank Group and the United Nations Department of Economic and Social Affairs, Population Division, as full members.

The UN IGME's independent Technical Advisory Group, comprising leading academic scholars and independent experts in demography and biostatistics, provides technical guidance on estimation methods, technical issues and strategies for data analysis and data quality assessment. The UN IGME updates its child mortality estimates annually after reviewing newly available data and assessing data quality. Country-specific estimates and the data used to derive them are available at <www.childmortality.org>.