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CAUSE-SPECIFIC MORTALITY AND NATURAL DISASTERS — THE URGENT NEED FOR CHANGE.

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ABSTRACT

Introduction

The global threat from natural hazard disasters is accelerating, driven by the earth's deteriorating natural ecosystems, damaged physical environment, rapid urbanisation and population growth. Internationally agreed targets within the Sendai Framework for Disaster Risk Reduction (SFDRR) aim to halt the escalating risk and reduce disaster-related deaths and global impact.

Achieving SFDRR targets requires a robust estimation of global disaster-mortality and targeted health interventions so that people at risk are protected and their deaths are prevented. This study examined whether the information published in medical and scientific literature on cause-specific mortality was reflected in global data collection and reporting.

Method

A literature review and analysis of disaster mortality reported in medical and scientific journals was compared with disaster mortality reported in three global disaster mortality database repository and reporting publications, including CRED, Swiss Re and ADRC.

Results

Cause-specific mortality from natural hazard disasters has been studied, replicated and published for over 30 years in medical and scientific literature. Mortality-risk exists across a time continuum and includes causes not counted in global data or reporting practice.

Conclusion

Global disaster-attributed mortality is significantly underestimated. Data systems restrict the collection of vital evidence about populations vulnerable to death from exposure to natural hazard disasters. Urgent action is required to remove barriers and develop targeted health interventions for vulnerable people that reduce mortality risk, save lives and achieve the SFDRR targets and Sustainable Development Goals on which they depend.

Keywords

Disaster-attributed death, death-certification, Sendai Framework

Introduction

The sixth session of the Global Platform for Disaster Risk Reduction (GP2019) was held in Geneva on the 15th May 2019 providing delegations from 116 signatory nations with the official progress report on seven targets to reduce disaster risk agreed under the Sendai Framework for Disaster Risk Reduction (SFDRR) (UNISDR, 2019a). Member states formed the SFDRR in Sendai Japan, at the World Conference on Disaster Risk Reduction, as a fifteen-year voluntary non-binding agreement and later endorsed by the UN General Assembly in June 2015 (UNISDR, 2019b). The SFDRR established seven targets and four priority areas to strengthen domestic and global disaster risk reduction efforts and, in particular, reduce mortality, the number of people affected, economic loss and strengthen community resilience to disaster events (UNISDR, 2015).

The GP2019 was the last global meeting prior to the deadline for the fifth SFDRR target to 'substantially increase the number of countries with national and local disaster risk reduction strategies by 2020', which presently stands at 92 countries (UNISDR, 2015, p.12, UNISDR, 2019a). The meeting was significant because it confirmed the urgency to address the increasing threat of disaster hazards faced by communities worldwide. Impacts caused by disasters over the past three decades are conservatively estimated at 1.3 million lives lost and 4.4 billion people injured, displaced or left in need of emergency assistance (CRED/UNISDR, 2018). The Swiss Re Institute estimated the cost to the global economy caused from disasters in 2018 was $US165 billion, of which only $US85 billion was covered by insurance, and in 2017 the cost was estimated at $US337 billion, of which $US144 billion was insured (Swiss-Re, 2018; Swiss-Re, 2019).

While the toll on communities from disaster events is increasing, the complexity of disaster risk is rapidly changing. Natural hazard disasters are increasing in frequency, intensity and magnitude, at a rate faster than efforts to protect people, the environment and infrastructure (UNDRR, 2019). Extreme weather events alone have doubled within 20 years (UNDRR, 2019) and the biological systems required by communities to sustain health and life are not recovering from prolific environmental stress, natural hazard impacts and climate change effects (IPBES 2019; Myers et al., 2017). In addition, single hazard disaster events are transforming into compounding and cascading emergencies (UNDRR, 2019) and communities at increased risk from natural hazards, are being compromised by pollution, environmental degradation, urbanisation and population growth (Finnigan, 2019; Landrigan et al., 2018; Whitmee et al., 2015). Furthermore, an amalgam of these factors is adding to disaster risk by driving internal displacement and migration within countries (UNDRR, 2019).

As the dynamic of disaster risk changes, the importance of the SFDRR to the humanitarian agenda must be viewed more broadly than simply aiming to reduce disaster risk and improve community resilience. Unlike other international agreements, the success of delivering many Sustainable Development Goals (SDGs) is dependent on reaching the SFDRR targets (Moller, 2019). Reducing the global impact and human lives lost caused by disaster events directly affect: SDG targets: 1.5 in building community resilience to shocks like disasters; 3.2 to end preventable deaths of newborns and children under five years; 3.4 to reduce premature death from NCDs; 3.9 to reduce preventable deaths from air, water and soil contamination; 3C to increase health financing and health workforce; 3D to strengthen capacity for early warning, risk reduction and management of national and global health risks; 11.5 to reduce the number of deaths, people affected and economic loss from disasters; and 11B to increase the number of cities and human settlements adopting and implementing integrated policies and plans for resilience to disasters (United Nations, 2019a). Failure to reach the outcome intended by any SFDRR target will guarantee failure in reaching one or more of these eight SDG targets. In stark contrast, the relationship between the 2030 Agenda and the Sendai framework targets compares with the Paris Accord (UNFCCC, 2015) in which the five SDG targets agreed in Goal 13 on climate action can be met, irrespective of whether the Paris Accord is delivered (United Nations, 2019b).

The first SFDRR target (Target A) is to 'Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020–2030 compared to the period 2005-2015' (UNISDR, 2015, p.12). To reliably measure a reduction in the mortality rate requires an accurate measurement of deaths caused by disaster events. Typically, considerations around such measurement include the attribution of death from exposure to a hazard and the temporal relationship between the hazard event and death (UNISDR, 2017). The technical guidance developed for measuring the SFDRR targets recommend countries base the attribution consideration on their own methodology and legal considerations (UNISDR, 2017). It also recommends temporal considerations be based on each nations local epidemiology, or four weeks after an earthquake and flood, six months after a drought and a period of 'no new cases' for epidemics (UNISDR, 2017).

For many countries, the health and medical sector are responsible for recording and registering death on local data systems (Lopez et al., 2015; WHO 2013), and lead emergency responses for mass casualty and natural hazard disaster events (Couig et al., 2005; WHO, 2007). The health sector relies on specific information, relating to the cause of death and risk of death from exposure to natural hazard disasters, to effectively plan rapid emergency responses that save lives and reduce premature mortality before, during and after disaster events. Evidence-based morbidity and mortality data is the cornerstone of health emergency planning, providing the detail to scale health resources for rapid diagnostic capacity, ambulatory transport, and treatment and care of people injured, ill or at risk, while maintaining existing healthcare services for existing patients (CDC, 2016; Igarashi et al., 2018; Checchi et al, 2017). The same data is needed to prepare communities for disaster events to protect critically ill people, or large vulnerable populations at risk from impending natural hazards, such as for category four or five cyclones and hurricanes (HAI, 2019; King et al., 2016; Little et al., 2012). In addition, the availability of cause-specific mortality information is essential to compare the cost of disaster risk reduction initiatives relative to the yield of mortality reduction. Such comparisons shape health policy outcomes and inform decisions on risk reduction investment options (Kellett and Caravani, 2013; Phillips et al., 2015).

This research was undertaken to contribute to the discussion and practice of global reporting of disaster-attributed mortality and improve emergency health responses designed to prevent premature death and protect life. The aim was to examine whether the knowledge of cause-specific mortality risk from natural hazard disasters reported in published medical and scientific literature was translated into global disaster data collection and reporting practice.

Research Project Methodology

To understand the scope of cause-specific mortality reporting from natural hazard disasters, in published medical and scientific literature, a literature search using the Scopus database was performed. Search terms used in key-word, title and abstract included 'mortality' OR 'death' OR 'cause of death' AND the specific hazard event: 'earthquake', 'storm', 'cyclone', 'hurricane', 'typhoon', 'thunderstorm', 'sandstorm', 'flood', 'extreme temperature' and 'heatwave'. The search was limited to articles published from 1990 to present, and further limited to human, medical and scientific journals, and published in English. The first search generated results of articles unrelated to the study topic; for example, biomedical processes related to 'storm' or military interventions called 'storm'. These articles and duplicate articles were excluded following a title review. Abstracts of references meeting the inclusion criteria (natural hazard + defined as a disaster + cause-specific mortality reporting + epidemiological feature) were reviewed. Full texts of these abstracts were selected for review and analysis. The references provided in each article reviewed were screened for journal papers meeting the inclusion criteria but not detected in the search.

Medical and scientific literature reporting was compared with global reporting practice, by reviewing details on disaster mortality recorded and reported for the period 2002-2018 by three of the world's largest disaster reporting repositories: the Centre for Research on Epidemiology of Disasters (CRED) database EM-DAT, the Swiss-Re Institute Natural Catastrophes and Man Made Disasters Report and the Asian Disaster Reduction Centre (ADRC) Natural Disaster DataBook. The website of each organisation was searched to locate publications and to seek approval to access database and publications. Publications meeting the selection criteria (mortality reporting + annual analysis + global or regional focus) were then reviewed and analysed for detail on mortality, including cause-specific death or mortality description or nature of hazard exposure or exposure-death risk timeframe.

The three disaster reporting organisations were chosen based on two criteria: for the target audience of the published reports; and, for the longevity of reporting practice. The CRED was established in 1973 as a not-for-profit institution to study health issues in disasters and has since published epidemiological analytical reports since, along with becoming a WHO collaborating centre in 1980 (CRED, 2019). CRED's research focuses on 'all humanitarian and emergency situations with a major impact on human health' (Guha-Sapir, Hoyois and Below, 2015, p.3). Swiss Re is the world's second-largest reinsurer and has published an annual report on insurance risk analyses since 1968, including a yearly report focused on global catastrophes since 2007 (Swiss Re, 2019). The Asian Disaster Reduction Centre (ADRC) was established in 1988 to 'enhance disaster resilience of the member countries' and has published an annual report called the Natural disasters databook since 2002 (ADRC, 2019).

The classification of hazards followed the Peril Classification and Hazard Glossary, published by Integrated Research on Disaster Risk (IRDR, 2014). A 'disaster' was defined using the CRED (2017, p.7) definition as an event that met at least one of the following criteria: '10 or more people reported killed; or 100 more people reported affected; or a declaration of a state of emergency or call for international assistance'.

This study focused on the four natural hazards which have caused the highest cumulative mortality over the decade spanning 2006-2017, as reported by the CRED as 'total deaths' and defined as: 'number of people who lost their life because the event happened (it includes also the missing people based on official figures)' (Guha-Sapir et al., 2017, p.14). The natural hazards reviewed in order of aggregate deaths reported include earthquake (359,419 deaths), storm (178,002 deaths), extreme temperature event (79,636 deaths), and flood (65,010 deaths) (CRED/UNISDR, 2016; CRED/UNISDR 2018; Guha-Sapir et al., 2017).

Results

1. Cause-specific mortality reporting in medical/scientific literature for different hazards

The initial search strategy generated over 4000 references. Following the removal of non-related content, 624 references were selected of which 302 journal papers were reviewed and analysed. These included journal articles on earthquake (60), storms (75), extreme temperature (111), and floods (56). With the exception of extreme hazards, the number of articles for each natural hazard disaster by publication year, increased steadily over each decade from 1990 to 2019.

Table 1. Number of medical/scientific articles that identify death by natural disaster hazard by year of publication.

Natural Disaster Hazard	Year of Publication			
	1989	1990-1999	2000-2009	2010-2019
Earthquake		10	21 (2000-2004=9) (2005-2009= 13)	28 (2010-2014= 17) (2014-2019= 11)
Storm	3	16	17 (2000-2004= 6) (2005-2009= 11)	39 (2010-2014= 22) (2014-2019= 17)
Extreme Temperature		1	46 (2000-2004= 8) (2005-2009= 38)	64 (2010-2014= 37) (2014-2019= 27)
Flood	1	6	21 (2000-2004=4) (2005-2009= 17)	28 (2010-2014= 15) (2014-2019= 13)

The study design for research articles varied widely between and across hazards and included: situation analyses, descriptive studies, retrospective cohort, case-control, case cross over, time series, longitudinal, cross-sectional and systematic reviews. The number of journal articles reporting mortality impacts from specific natural hazard disaster events was not evenly distributed across the global geographical natural hazard risk area, or representative of historical disaster mortality impacts. Articles meeting the search criteria for earthquakes included reports from Armenia, Chile, China, Greece, Haiti, Italy, Indonesia, Japan, New Zealand, Sri Lanka, Taiwan, Turkey, and the United States. Reports from Japan comprised over 46% of articles reporting specific disaster events and 36% of all papers for earthquakes. Papers meeting the criteria for storms included reports from Australia, Bangladesh, Haiti, India, Korea, Myanmar, Puerto Rico, Philippines, Solomon Islands, Taiwan, United States and Vietnam. Reports from the United States comprised 65% of all articles reporting specific storm disasters. Articles meeting the criteria for extreme temperature included reports from Australia, China, Czech Republic, England, Finland, France, Germany, Ghana, India, Israel, Italy, Kenya, Korea, Netherlands, Pakistan, Spain, Portugal, Russia, Siberia, Sweden, Switzerland, Taiwan, United States, Vietnam and Wales. Reports from China comprised 20% of the articles reporting specific extreme temperature events. Articles for floods included reports from Australia, Bangladesh, China, Ethiopia, France, Greece, India, Indonesia, Italy, Mozambique, Nepal, Philippines, Puerto Rico, Solomon Islands, United States and Vietnam. Reports from Bangladesh comprised 25% of articles relating to specific flood events.

The reporting of disaster-attributed mortality relative to the time of onset of the disaster, was not consistent or standardized across published reports, either within the same hazard category or across the four different natural hazard events. Some researchers provided clear descriptions of the temporal pattern between onset of disaster hazard and time of death, while other researchers provided general descriptions of 'weeks' or 'months' following disaster onset. None of the systematic reviews provided a summary analysis of the temporal relationship between hazard onset and death from specific causes. A summary of the temporal relationship between hazard onset and cause-specific mortality described in articles reviewed is illustrated below.

Earthquake

ONSET

Immediate	Days - Weeks	Weeks - Months	Years
Severe trauma of brain or spinal chord	Sepsis	CHD*	Foetal loss
Injury complications subdural haematomas, laceration liver/spleen, fractured pelvis	Multi system organ failure	CVA**	CHD
	Disseminated intravascular coagulation	COPD***	CVA
		Wound infection sepsis	
		Suicide	

Time

Index: CHD-Coronary Heart Disease, CVA-Cerebrovascular Accident, COPD-Chronic Obstructive Pulmonary Disease

Figure 1. Summary of cause-specific mortality from earthquakes reported in medical/scientific literature

Extreme Temperature

ONSET

Immediate	Days - Weeks	Weeks - Months	Years
	CHD*		
	CVA**		
	Respitory Disease		

Time

Index: CO-Carbon Monoxide, CHD-Coronary Heart Disease

Figure 2. Summary of cause-specific mortality from extreme temperature reported in medical/scientific literature

Floods

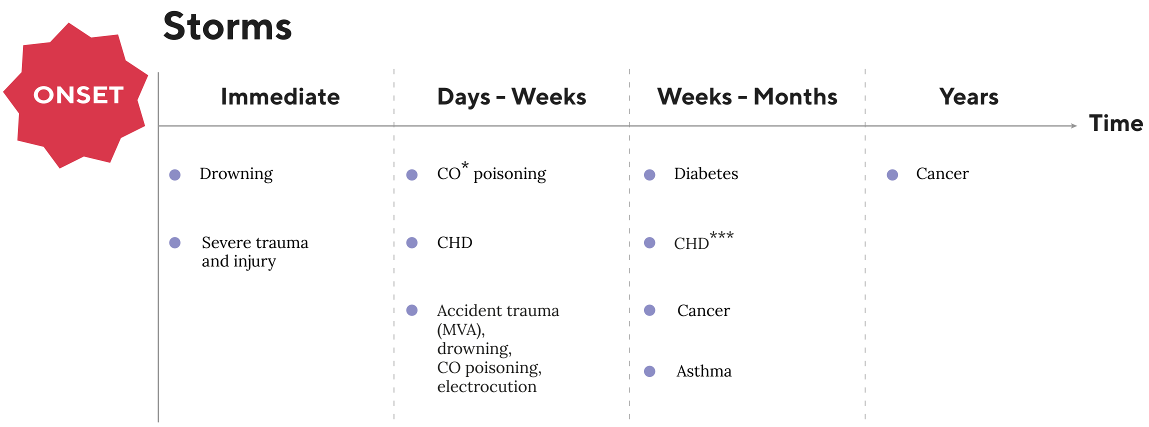
ONSET

Immediate	Days - Weeks	Weeks - Months	Years
Drowning	Diarrhoea	CVA*	CVA
Accident	ARI**	CHD***	Malnutrition
CVA	Accident trauma (MVA), drowning, CO poisoning, electrocution	Malnutrition	
		Tetanus	
	Foetal loss (spontaneous abortion)		

Time

Index: CHD-Coronary Heart Disease, CVA-Cerebrovascular Accident

Figure 3. Summary of cause-specific mortality from floods reported in medical/scientific literature



Index: ARI-Acute Respiratory Infection, CHD-Coronary Heart Disease, CVA-Cerebrovascular Accident

Figure 4. Summary of cause-specific mortality from storms reported in medical/scientific literature

2. Mortality reporting in global databases and publications

i. Centre for Epidemiology of Disasters (CRED)

The search included an investigation of the EM-DAT database and annual statistical reports published by the CRED. The EM-DAT database was accessed following permission. Search data fields include hazard type, year, occurrence, total deaths, injured, homeless, total affected and total damage ($) with search criteria for dates (from 1900 to present), location, and type of hazard. Search options include disaster profiles, disaster trends, country profiles, hazard reference maps and advanced. There were no records of cause-specific mortality or records that relate to the nature of death. The CRED state data is 'compiled from various sources (UN agencies, the US Office of Foreign Disaster Assistance, national governments, the International Federation of Red Cross and Red Crescent Societies, NGOs, insurance companies, research institutes and the media) according to apriority list ' (CRED, 2017, p.7). However, no detail was found on the CRED website or in print about: exclusion criteria; the 'priority list'; or about rules used to manage divergent mortality estimates. As for example, in the equatorial Asia smoke haze crisis or the impact of Hurricane Maria in Puerto Rico (Crippa et al., 2016; Cruz-Cano and Mead, 2019; Kishmore et al., 2018, Koplitz et al., 2016;). A further search and review of CRED reports of annual and multi-year statistical reviews and periodical data analyses and commentaries were performed. These reports showed aggregated data from the EM DAT search fields based on global and regional locales as well as hazard type. A sample of 30 reports from 2000-2018 available on the CRED website was downloaded and reviewed. No report mentioned or differentiated cause-specific mortality for any disaster hazard.

ii. Swiss-Re Institute (SRI)

The search collected twelve annual reports titled 'Natural Catastrophes and Man Made Disasters Report' from the years 2007-2018 inclusive, plus two special reports titled 'Haze risk in Southeast Asia' (SRI, 2018a) and 'Mortality improvement - understanding the past and framing the future' (SRI, 2018b). All twelve annual publications followed a similar generic reporting format, reporting mortality by total crude deaths; deaths per event for 20 most costly events; rank-listing deaths per event for 20 highest 'victims' aggregate; chronological time sequence events; and, number dead, missing & injured.

Cause-specific mortality or the nature of death is not reported or attributed to any disaster event and is not mentioned in any annual reports or in the special report on Haze risk in Southeast Asia. The special report on 'mortality improvement' discusses changes in global rates of all-cause and cause-specific mortality but provides no mention of attribution to any disaster event or disaster hazard. The source of mortality data used in the analysis for each report was not specifically stated; rather, information was said to be from 'newspapers, direct insurance and reinsurance periodicals, specialist publications (in printed or electronic form) and reports from insurers and reinsurers' (SRI, 2018, p.52).

iii. Asian Disaster Reduction Centre (ADRC)

The search collected fifteen annual reports titled 'Natural Disaster DataBook' from the years 2002-2016 inclusive, plus one report on Asian Natural Disaster Databook 1901-2000 (ADRC, 2002). All reports followed a standardised reporting format, which described mortality as counts of people killed relative to hazards, specific cumulative count of 'killed' or 'death toll' of events, with hazards reported as a group and by county frequency. No reports describe cause-specific mortality reported. Data used for analysis in each report was provided by the CRED EM-DAT.

Discussion

The mortality-risk caused from exposure to natural hazard disasters, published in medical and scientific literature for earthquake, storm, extreme temperature and flood, extend beyond the time immediately after onset of the event. Mortality risk is more accurately represented by a time continuum rather than starting and finishing at a fixed point. Such observations have been investigated and reported for at least three decades in medical and scientific journals. Observations from these studies suggest that cause-specific mortality risk cannot be universally applied across hazards. Rather, mortality risk is both hazard-specific and context-specific and relative to preconditions that increase the risk of mortality within vulnerable cohorts. This was especially evident for earthquake, storm and flood in which epidemiological studies repeatedly showed increases in mortality from coronary heart disease and cerebrovascular accidents associated with the disaster event. The difference in mortality risk observed in studies of the same hazard from different locations warrant further investigation. Differences in mortality risk may point toward localised factors, interventions or variables that are protective for vulnerable groups before, during and after exposure to natural hazard events.

The detail relating to cause-specific mortality, described in the medical literature reviewed in this study, contrasts starkly with mortality reporting in the CRED EM-DAT database and CRED, Swiss Re and ADRC reports. These sources provide no detail or inference about the nature or cause of death from natural hazard disasters. Instead, all three describe the hazard itself as the cause of mortality. While these repositories present information obtained by other data recording systems, the absence of acknowledging the cause of death represents a major challenge for the entire disaster risk management sector and for the international community committed to delivering the SFDRR and SDGs. This mischaracterization of mortality risk has inadvertently lead to the underestimation of disaster-related mortality, diminished the potential for surveillance systems to identify emerging threats and skewed risk reduction priorities away from the most vulnerable population, toward mitigation and management of the hazard itself.

The underestimation of global disaster-related mortality occurs in two significant ways. Firstly the calculation of the death toll is effected, along with any confidence interval or range of deaths attributed to the hazard event. Current data recording and reporting systems fail to attribute certain deaths to the disaster event. The same systems also fail to consider longer temporal associations for which deaths should be attributed. For example, the risk of death from Cerebrovascular Accidents (CVA), Coronary Heart Disease (CHD) and Chronic Obstructive Pulmonary Disease (COPD) attributed to the exposure of earthquakes has repeatedly been observed in the months and year after the onset of the hazard. As a consequence of underestimation, attempts to generate greater precision and reliability in mortality counts, through confidence intervals and estimate ranges, are compromised by the exclusion of essential death data. Secondly the reliability of mortality estimates to adequately describe disaster risk, provided by global publishing and surveillance systems, is questionable. The UNISDR recommends the Global Burden of Disease (GBD) as a 'potential resource to understand trends in disaster-related mortality' (UNDRR, 2019, p.275) and recognises it as one of the most valued and reliable statistical analyses used by health policy makers globally (UNDRR, 2019). The GBD study depends on data coded and provided by national government health collection systems along with global data sources, such as the CRED, to perform analyses and generate conclusions. Data provided by national governments and the CRED that suffer from significant underestimations in disaster-related mortality ultimately affect the analysis and conclusion provided by the GBD and the inherent reliability of its estimations.

The disaster-risk management sector has unwittingly applied constraints to disaster-related mortality estimations by restricting the temporal relationship between hazard event and mortality count. The UNISDR inferred time limits were necessary to attribute mortality to a disaster hazard exposure from the definition of disaster-death used in their SFDRR technical guidelines: 'the number of people who died during the disaster, or directly after, as a direct result of the hazardous event' (UNISDR, 2017, p.7). The technical guidelines, developed for the standardization of the measurement of disaster-related mortality across all nations, go further by recommending a four-week cut-off period for earthquake and flood disasters (UNISDR, 2017, p.12). However, the guidelines also recommend countries choose different timeframes for each type of hazard because they have different epidemiology (UNISDR, 2017, p. 10). Prescribing such time-limits defy the published medical literature which has observed associations between cause-specific mortality and exposure to natural hazard disasters over much longer time intervals, such as months and years. The consequence is the ongoing miscalculation of disaster-related mortality. The size of the error or underestimation has yet to be measured but requires urgent examination by the research community to improve the reliability in the measurement of Target A in the SFDRR.

One of the challenges faced by designers of the SFDRR technical guidelines was the requirement to include 'missing-persons presumed dead' in disaster mortality counts. The technical guidance for counting the number of deaths caused from disasters includes the number of people missing and presumed dead (UNISDR, 2017). The decision to time-limit the attribution of death to a disaster event is logical when considering the potential of over-estimations of mortality, where large numbers of people are temporally displaced but not deceased, as occurs in complex humanitarian emergencies (Checchi and Roberts, 2008; Heudtlass et al, 2016; NRC, 2001). The unintended effect of time-limiting death attributed to disasters universally across all hazards is the failure to count mortality that occurs past the time limit. As observed in this study, these counts are significant for deaths caused by CHD, CVA and COPD that can occur after one month from onset of the hazard. Ideally, the challenge of including missing persons presumed dead could have been managed as a subset of the disaster attributed mortality count. Using this approach maintains the time-limit required to count 'missing presumed dead' while at the same time, provides an extended time continuum for attributing death that occurs beyond the time-limit, based on the hazard and cause-specific risk.

The mischaracterisation of mortality risk also restricts the potential for local surveillance and recording to identify emerging health threats caused by exposure to natural hazard disasters. The 'minimum and desirable' data collection recommended for the SFDRR for deaths attributable to disasters includes the 'hazard, geography (administrative unit), sex, age, disability and income' (UNISDR, 2017, p.9). There is no encouragement to provide information about the cause-of-death or nature-of-death. Civil registration and vital statistics (CRVS) and local death registration processes must be structured to capture and monitor information on possible associations between mortality and natural hazard disaster events. For countries at increased risk from natural hazards, developing evidence-based understanding of cause-specific mortality is essential to develop disaster risk reduction initiatives so that cost-effectiveness can be measured. While ICD-10 continues to be the global standard for classifying the cause of any death (WHO, 2016), many low-income and middle-income countries do not have robust CRVS to maintain recording and reporting standards (AbouZahr et al., 2015). The UNISDR technical guidelines advise Member States can choose national methods of measurement and calculation of death (UNISDR, 2017, p. 10). However, this directive will not improve the accuracy of disaster-mortality measurement, especially given more than half of all global deaths are not registered (WHO, 2017).

Continuing to mischaracterise hazards as responsible for death, and avoiding cause-specific mortality analysis, creates a tendency to focus risk reduction efforts toward the hazard, rather than toward actions that target vulnerable populations directly. Recommendations that low-income and middle-income countries address disaster risk through 'improved early warning systems, better preparedness, weather forecasting and greater investment in resilient infrastructure' (CRED/UNISDR, 2016, p.6) fail to emphasise the importance of linking the risk reduction activity with the hazard of the highest priority. Low-income countries predisposed to multiple disaster risks have more to gain from analyses that contrast the cost-benefit for specific threat reduction outcomes rather than adopt approaches used in high-income countries of unknown efficacy and cost within their context; such as, the comparison between investment in early warning systems to reduce the mortality from extreme temperature or drought, compared to increased public health expenditure.

Overcoming barriers that significantly improve natural disaster-attributed mortality recording and reporting require initiatives that address two essential components. Firstly, improved technical guidance on death certification and the practice of linking death to exposure to a disaster hazard is urgently required. Studies examined by this research indicate a significant knowledge gap exists between hazard-specific and cause-specific disaster attributed mortality recording and reporting. An initiative to improve technical guidance must be led by the medical and scientific community who have failed to translate their knowledge and experience of mortality risk across disciplines, and especially into disaster risk and hazard management practice. A targeted domestic and international advocacy programme by health and medical organisations is also urgently needed to draw attention to the knowledge deficit and its consequence for the SFDRR and SDG efforts, and to promote readily achievable solutions. Advocacy approaches have proven highly successful in the past. Regional organisations such as the Economic Commission for Latin America and the Caribbean (ECLAC) and Economic Commission for Asia and the Pacific (ESCAP) played crucial roles in advocacy and support of superior data collection and reporting approaches. These efforts produced the handbook for disaster assessment (ECLAC, 2014) and the statistical yearbook for Asia and Pacific (ESCAP, 2017).

The second essential component requires innovative disaster-specific mortality data collection tools and methods for low-resource contexts that complement existing processes and practices and build local capacity. Methods to improve and support vital registration processes and practice are extensive and have been successfully applied in many countries which lack the financial resources to significantly enhance birth and death data collection and reporting systems (Lopez et al., 2015; Suthur et al., 2019). Such methods can be readily and successfully included in any health system capacity building for low-income country contexts. Specific disaster-mortality data collection processes should never intend to substitute existing processes and systems but rather act as supplements until national systems are resourced to provide improved outputs. Death registration has proven to be more heterogeneous in communities (AbouZahr et al., 2015) and verbal autopsy has been successfully incorporated into CRVS systems when medical certification of cause of death has not been possible (Suthur et al., 2019). Despite significant investment and efforts to advance more robust and reliable CRVS systems globally, the practice of accurate, continuous, near real-time data reporting remains in the distant future (Suthur et al., 2019). Given the time imperative to effect change, innovative bespoke disaster specific mortality tools are more likely to rapidly improve the quality and reliability of data over the short term.

The Global Assessment Report on disaster risk reduction highlighted the importance of achieving a common measurement framework to significantly improve disaster-related statistics (UNDRR, 2019, p.284). Such emphasis was also highlighted by the United Nations Statistical Commission, in March 2019, calling for regional expert groups to consider options for establishing a common framework on disaster-related statistics, including a network to sustain cooperation, strengthen national capacity building, coordination and fundraising to support the initiative (UNDRR, 2019). The World Health Organization thematic platform for health emergency and disaster-risk management research network is ideally placed to support initiatives to develop innovative tools and methods (Kayano et al., 2019). This network is already actively engaged in improving health data collection for disaster events and testing minimum data set requirements for pre and post-disaster health management needs (Kubo et al., 2019).

As the complexity of natural hazard disaster risk increases, improvement in data capture and reporting must occur to inform emergency health intervention and protection programmes to reduce mortality and mass casualty risks. Data anomalies and death reporting challenges have already emerged within this complexity and will likely expand, with an increase in mobile and displaced populations (UNDRR, 2019).

Conclusion

Thirty years of published medical and scientific reporting on cause-specific mortality from exposure to natural hazard disasters has not translated accurately into global data collection or reporting practice. While the magnitude of underestimation and error in global disaster-attributed mortality figures is unknown, of greater concern is the potential absence in recognition of elevated mortality-risk for large discrete cohorts of people vulnerable to natural hazards.

The failure of the disaster-risk management sector to apply medical understanding represents a major challenge for the international community committed to delivering real change for communities through the SFDRR targets and SDGs. It equally represents a significant challenge for governments that invest and rely on health system interventions to prevent death and protect the community from natural hazards, which are beyond their control.

Overcoming this challenge requires urgent improvement in recognising and recording cause-specific disaster-attributed mortality. This includes improving death certification reporting and analysis, along with innovative data capture and reporting initiatives where CRVS systems are not robust. Equally important is a domestic and global advocacy drive, coordinated by disaster health and emergency medicine actors, to draw attention to these deficits and provide simple solutions to remedy the errors. Actions must immediately improve evidence building through the systematic collection of disaster-attributed mortality data and support the minimum dataset standards used for disaster events. Improving the accuracy and reliability of disaster-attributed mortality data will also enhance the clarity of investment decisions by governments and improve cost-benefit assessments on levels required to yield commensurate effects in harm reduction.

The speed of change to the complexity of mortality risk from natural disaster hazards is a warning for the international community. Without urgent change, underestimations of disaster-attributed mortality will continue to compromise emergency health responses required to directly protect people who are vulnerable to death from exposure to natural hazard disaster events.

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