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Can we sustain success in reducing deaths to extreme weather in a hotter world?

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ABSTRACT

In an incredible story of human adaptation, the aggregate global risk of mortality to extreme weather declined by over two orders of magnitude over the past century. Yet the data show that large losses of lives to extreme weather disasters persist in nations typified by poor economic development, weak institutions, and political instability. And currently we are seeing spikes in mortality from extreme heat events in rich nations, including a wave of new reported deaths in Japan, Europe, and Canada during 2018. These events and future projections of increasing exposure suggest that we need to revisit adaptation strategies to deal with the adverse effects of extreme weather disasters across the world.

1. The success story

We have seen a dramatic decline in the absolute number of deaths from extreme weather over the past century – with the majority of deaths occurring prior to the 1960 s (See Fig. 1b and e for data showing this). This is an uplifting story of human adaptation because increases in human population size, and increased habitation on flood plains, have increased net exposure to these extreme weather events, such as floods, droughts, and heat waves (Kundzewicz, 2013; The Royal Society, 2014). The finding is so striking that it formed a key part of the late Hans Rosling's optimistic message to the world on the great progress in human development (Rosling, 2018). It is doubly striking because we may expect reporting to actually increase over time. These massive achievements accompanied equally impressive advancements in science, satellites, telecommunications, early warning systems, rapid deployment of aid, healthcare, antibiotics, insurance, and trade – built for the most part on strong institutions. The fact that deaths to droughts and floods today are orders of magnitude less than the first half of the 20th century is, without doubt, a major achievement of human ingenuity in modern history.

There are, however, some locations and disaster types where the story has not been so uplifting. For example, for droughts, mortality risk remains unacceptably high in sub-Saharan Africa, with the 2010 Horn of Africa drought leading to loss of ~20,000 lives in Somalia (see Fig. 1b). Moreover the magnitude of progress in adaptation to storms has been less impressive compared to floods and droughts. This was illustrated in 2008, when Cyclone Nargis resulted in ~138,000 dead in Myamnar (see Fig. 1c). These deaths stem from institutional weakness, poor economic development and political instability, which are strong indicators of susceptibility to acute climate risks (Intergovernmental Panel on Climate Change, 2012). This would suggest on the surface these problems may be solvable by these countries following the development trajectories seen elsewhere in the world.

2. The role of economic development

Given these successes in reducing mortality to extreme weather, it is alarming that currently reported deaths from heat waves across the world seem to be on the rise. Mortality risk from heat and cold waves has spiked in recent decades in general (although deaths from heat are an order of magnitude greater than that from cold). The major pre-2018, spike in mortality from heat waves was driven by deaths in rich not poor countries. Most notably, in two catastrophic events in Europe and western Asia in 2003 and in 2010 some > 120,000 people lost their lives in excess of those that would have died if these events had not occurred (Fig. 1a) (Robine, 2008; Barriopedro et al., 2011).

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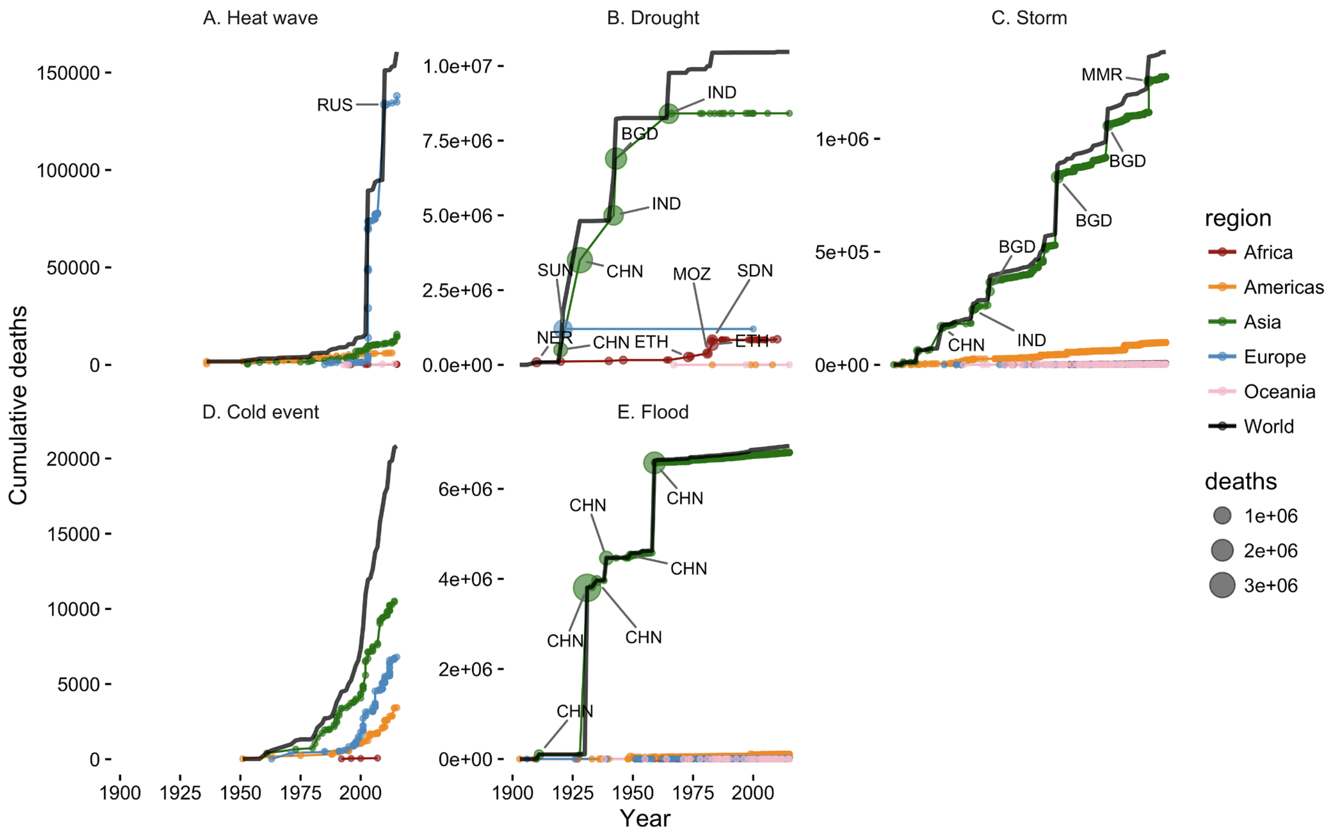

Fig. 1. Global distribution of deaths by extreme weather disasters over 1900–2014, showing spikes in deaths from heat waves in recent decades. All disasters with > 50,000 reported deaths are labelled. RUS = Russia, IND = India, BGD = Bangladesh, CHN = China, SUN = Former Soviet Union, NER = Niger, ETH = Ethiopia, MOZ = Mozambique, SDN = Sudan, MMR = Myanmar. Source: EMDAT-CRED (http://www.emdat.be/).

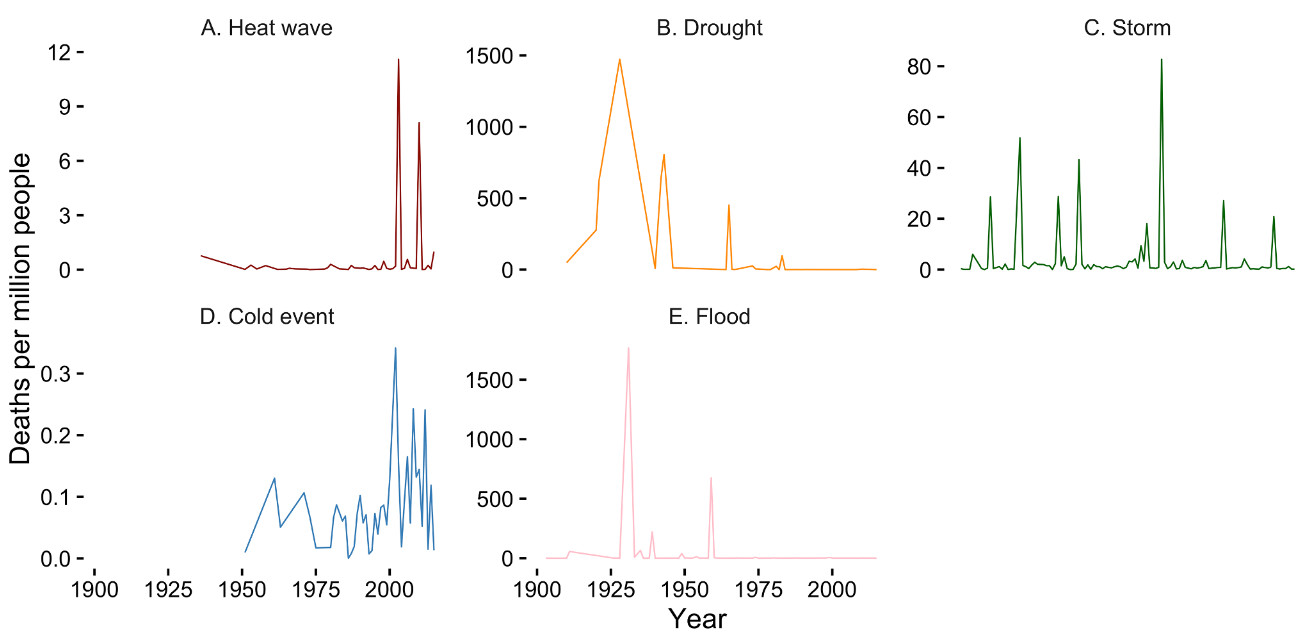

Fig. 2. Trends in the annual proportion of people dying from nationally reported extreme weather disasters over 1900–2014 (expressed as deaths per million), showing recent spikes in deaths from heat waves in 2003 and 2010. Sources: UN population division, HYDE 3.2, EMDAT-CRED.

Importantly, accounting for population size shows the same basic patterns (Fig. 2). In other words, even when controlling for the likely increased exposure, due to population size increase, we still see deaths spiking for heat waves in recent decades. The impact of these events in rich nations show that while economic development may be necessary to protect peoples lives under extreme weather, it is certainly not sufficient.

Over the past ~50–100 years, climate change has in turn been associated with increased probabilities of temperature extremes over > 80% of the observed land area, and increased probabilities of dry and wet precipitation extremes over 41% and 57% of the observed area, respectively (Diffenbaugh, 2017). Anthropogenic forcing was estimated to have led to 70% of the lives lost in Paris and 20% of those lost in London during the 2003 heat wave events (Mitchell et al., 2016). The role of anthropogenic forcing in extreme heat is becoming increasingly clear as climate modeling and computing power have expanded extreme event attribution studies; for example with a new rapid assessment concluding that the anthropogenic forcing increased the probability of the then-ongoing 2018 summer heat wave in Europe by two to five times (World Weather Attribution, 2018).

The effect of temperature extremes on mortality and human health tends to be greatest in cities that are historically cooler, which underpins much of the current concerns, and suggests potentially dangerous impacts from future extremes in higher latitude cities including many cities in the developed world (Zanobetti, O'Neill, Gronlund, & Schwartz, 2012). The lack of experience in managing extreme heat in northern France was a key factor in the mortality from the 2003 heat wave (Poumadère, Mays, Le Mer, & Blong, 2005), and in general it is likely that biased age structure of populations the elderly in rich countries plays an important role in these exacerbating effects. Similar factors likely explain the high mortality during the 2018 summer heat waves in both Quebec, Canada and Japan. This is compounded by the fact that temperature extremes also increase human health threats due to ozone and particulate matter levels in populated regions, by increasing photochemical reaction rates, wildfires and biogenic emissions (Silva, 2017). Simply put, carbon intensive actions underpinning human development in recent past have accrued environmental debts that have increased human mortality risk to extreme weather events and many rich nations are also suffering because of it.

3. We need to build stronger communities

Cultural and social changes can have important effects on the ability of populations to cope and adapt to extreme events, and there is a worry that a break down in social networks might exacerbate negative impacts. Particularly if this decreases trust and increases loneliness (Helliwell & Putnam, 2012). In the USA, people trust each other (NORC at the University of Chicago, 2016) and the government (Pew Research Center, 2017) less today than they did anytime in the last 40 years. Communities with lower levels of trust are less likely to get involved in organizing collective actions in response to emergencies. Less connected people also tend to get sick more often and have heightened stress and mortality risk (Halpern, 2004). Social isolation among some of the elderly was a driver of the high mortality in France during the 2003 heat wave (Poumadère et al., 2005). Poor communication strategies that do not take into account differences in gender, culture, ethnicity and class may exacerbate this further (Cole & Fellows, 2008), which brings additional concern to the ongoing rise in divisive political rhetoric in the social media from leaders of rich powerful nations such as the USA and the UK.

But it might not just be social connections amongst humans that matter for responding or recovering from disaster events. The survival of pets during Hurricane Katrina has been reported to be an important factor in mental health recovery for human owners in the years that ensued after the event (Servick, 2018). A finer focus on the interactions between extreme events and mental health is critical because these are important risks for premature death (Roberts, 2017). In the USA and Mexico depressive tweets rise with hotter temperatures, and also indicate increased upward shifts in mean suicide rates (Burke, 2018). Importantly, such signals could be used as an entry points for intervention.

We have also seen cell phones and social media playing an important role in disaster response (Kryvasheyeu, et al., 2016; Cinnamon et al., 2016). Twitter and other social media sites help disseminate information and co-ordinate relief efforts, as seen in the public response to Hurricane Harvey in 2017. So despite its potential negative impacts on the quality of social interactions, there is undoubtedly a place for social media to play an important role in rethinking how we can manage and respond to extreme events (Palen and Hughes, 2018). Indeed, in Mexico City, during the September 19, 2017 earthquake, social media served as a platform to organize the community, with trusted social and media leaders offering advice on where to deliver medicines, food, tools and even psychological help, through Twitter and Facebook groups. Evidence from 2016 wildfires in Canada suggest that tracking the impacts of an extreme event over social media can also lead to greater levels of concern for the affected population and greater likelihood to offer assistance (Boulianne, Minaker, & Haney, 2018).

The positive impacts of social media for responding to extreme events and helping people cope with climate change offer hope, but the role of social media in increased offline social isolation (Allcott & Gentzkow, 2017), and decline in quality of social interactions in some countries, raises concerns about the strength of communities being built (Shakya & Christakis, 2017). Our current trajectory along the social axis could, if not addressed carefully, also be setting humanity on a path that inhibits, rather than facilitates, long-term adaptation towards reduced mortality in extreme weather events.

4. One-size fits all solutions do not exist

One-size-fits-all solutions do not exist for human adaptation to any kind of extreme weather – particularly heat. Existing solutions may not be optimal for different populations, and the optimal short-term solution may not be suitable in the long-term as the climate continues warming. For example, take the issue of air conditioning. In the USA, air conditioning is estimated to have reduced mortality risk to extreme heat by ~80% over the 20th century (Barreca, Clay, Deschênes, Greenstone, & Shapiro, 2016). In India, it has been suggested that greater access to air conditioning is needed to avert rising mortality risk to heat (Mazdiyasni, 2017). After the May 2010 heat wave in Ahmedabad in India, where 1300 people died, an action plan that was drafted focused on early warning systems, access to potable water and medical care to at risk communities, alongside cooling in public spaces such as temples and malls (Amdavad Municipal Corporation, 2017). However, private air conditioning on the scale of the USA is unlikely to be possible in India, given the scale and nature of the housing stock and electricity system; or wise to recommend given the associated emissions from potent hydrofluorocarbons and large electricity demand. Additionally, while we expect an increase in heatwave-related mortality (Guo, 2018) air conditioning adaptation to higher temperatures may exacerbate health impacts due to worsening air quality (Abel, 2018). Rethinking adaptation to extreme weather events means opting for solutions that make sense locally – that cost little to the urban carbon economy and do not inadvertently degrade human health and well being through other pathways.

5. Looking beyond 2030

Sustaining success in reducing mortality to extreme weather is a wicked problem (Bai, 2017; Horton et al., 2016; Carleton and Hsiang, 2016). New institutional level adaptation relating to growing and ageing populations, heat island effects, urbanization and informal settlements need to be addressed (Mora, 2017; Lowe et al., 2011). However, such adaption, if continually based on increased use of fossil-fuel based energy sources, will only exacerbate the climate change problem in the long term. In the severe case, such as in the Middle East, continued emissions might alter the possibility of human habitability all together (Pal & Eltahir, 2015). Embedding a social equity lens into institutional adaption is a required to make such efforts most impactful. On the most basic level, these challenges suggest three interconnected pillars for climate policy: (i) ensuring high cumulative emitters take on most of the mitigation burden (Chakravarty, 2009), such that, (ii) more vulnerable populations can employ carbon-intensive adaptation strategies where most necessary, and (iii) can access the best climate risk information and climate services available (Lemos, Kirchhoff, &

Ramprasad, 2012).

The recent death spikes due to heat waves show us that our governing structures are too often bounded by short-term thinking. This is not limited to extreme temperatures. Irrigation, which helped humans historically cope with droughts and famines, today contributes to major water security challenges. Roughly ~15% of groundwater was unsustainably extracted from 2000 through 2009 (Doll, Schmied, Schuh, Portmann, & Eicker, 2014), and over half the human population faces intra-annual water scarcity each year (Mekonnen & Hoekstra, 2016). Better understanding of how different trajectories of short term adaptation along multiple physical and social axes (e.g., to ~2030) may exacerbate long-term risk (e.g., out to 2100) are needed. Without aligning these priorities there is a valid concern resurgence of mortality risks to extreme weather events thought to have been averted by past will continue.

6. Sustaining success in reducing deaths to extreme weather

Over the past century humans have shown an incredible ability to adapt to extreme weather events. Economic development has typically underpinned much of this adaptation. But we cannot remain complacent based on previous success given the new challenges ahead. Recent evidence suggests that even developed nations are beginning to show increases in human mortality from extreme weather events caused by greenhouse gas emissions associated with this development. And as we write this commentary, communities in Europe, North American and Japan are recovering from extreme heat waves that led to widespread mortality, morbidity and fire damage.

These and other nations are also being affected by a breakdown of trust, and the loss of quality of social interactions despite increased virtual connectivity. Rapid urbanization poses many new challenges. Revisiting human adaption to climate disasters means tackling these new risks. The history of human civilization is ripe with examples of deploying new solutions or technologies before identifying the long-term implications of their use. Reducing the possibility of negative feedbacks, and linking adaptation more closely to mitigation is critical to ensuring that aggregate progress in human adaptation to extreme weather disasters over the past century does not begin to reverse any time soon.

Conflicts of interest

None.

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