Using models to set a baseline and measure progress in reducing disaster casualties.

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Abstract

In the 2015 UN Sendai Framework the international community has signed up to reduce disaster casualties in the period 2015-2030. The Framework requires signatories to achieve a ‘substantial reduction’ in disaster casualties. However the targets for risk reduction remain unquantified and the ‘current’ baseline is set to be an eleven year 2005-2015 sample from a volatile process in which a small number of high mortality catastrophes dominate the averages. This study sets out to show how a better 2015 baseline can be defined that takes into consideration the volatility of catastrophe occurrence as well as those improvements in disaster reduction that have already been implemented. The question of what constitutes a ‘substantial’ reduction is also explored through finding the best demonstrable performance in reducing disaster casualties on a national level.

1) Introduction

In March 2015, the 2015-2030 United Nations Framework for International Disaster Risk Reduction was signed by representatives from 187 countries in Sendai, Japan. The first goal of the framework is “to substantially reduce global mortality 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). This primary goal invites many questions. Could we qualify what is implied by ‘substantially reduce’, for example through demonstrating what constitutes ‘best practice’ in national Disaster Risk Reduction campaigns? Also, is the 2005-2015 period a suitable sample of the current mean rate of global disaster casualties? Given the inherent volatility in major high mortality catastrophes that dominate the disaster averages, what is the potential that the goal could be achieved, or failed, by chance alone?

This paper proposes a methodology for how to set a baseline of current global natural disaster casualties, and identifies what could be considered best practice in disaster casualty reduction.

2) What is the volatility inherent in global disaster mortality data?

Error! Reference source not found. displays the annual disaster mortality data from 1970-2014. The spikes in the annual mortality statistics tend to be dominated by one or two specific catastrophes in that year. We find that almost 88% of the mortality is provided by the top 16 catastrophe incidents.

The 2005-2014 decade had two years with exceptional mortality: 2008 (dominated by the Wenchuan, China earthquake as well as Cyclone Nargis in Myanmar) and 2010 (the Port au Prince, Haiti, earthquake).

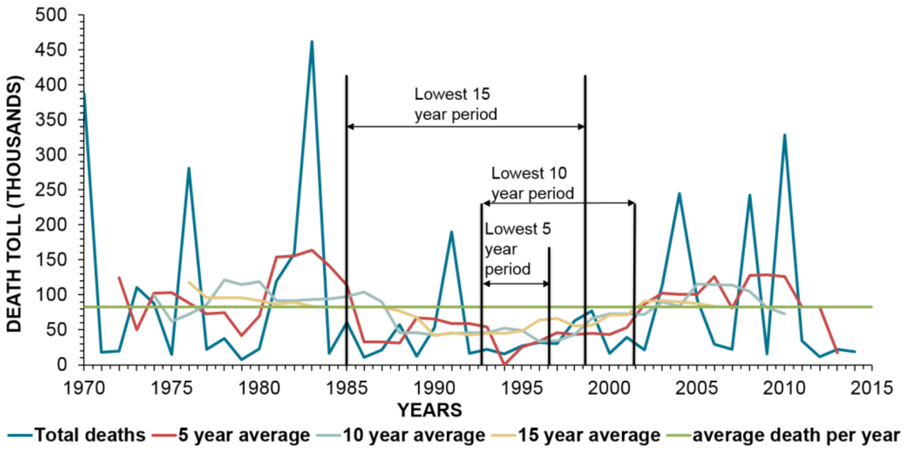

Figure 1: The annual death toll from all natural perils from 1970-2015 (dark blue line). 5 year (red line), 10 year (pale blue) and 15 year (yellow line) moving averages are displayed along with the average deaths per year (green line).

The period from 2005-2014 had higher disaster casualties than any ten year period since 1985 (**Error! Reference source not found.**). When normalizing the data against global population (so this becomes casualties per 100,000 people) the 2005-2014 period becomes closer to the long term average.

There are two procedures that can be applied to this data to improve the designation of a target level of disaster deaths appropriate to the year 2015. First the data can be resampled to explore how the 2005-2014 baseline compares with the distribution of expected casualties in a decade.

Second we can explore changes in the underlying drivers of catastrophe casualties, which would affect the mortality in those events which have occurred since 1970, should they occur today. We might suspect, for example, that thanks to the creation of some 4,000 storm surge shelters in the low lying delta region the 300,000 fatalities in the 1970 Bangla Desh storm surge would not be repeated today. Early intervention and better forecasting has dramatically reduced the expected mortality from droughts in Africa. Then there is increased urbanization since the 1970s. Could that have increased the number of buildings at risk of collapse in an earthquake? We need to consider all the evidence to determine how expected casualties associated with different perils have changed in 2015.

Resampling the large event mortality data was undertaken using 50,000 iterations and the assumption of Poisson event independence to determine the expected mortality over a decade. This was repeated both when leaving the casualties associated with each catastrophe unchanged, and also after applying peril-specific modifications to the mortality rate to capture the principal improvements in issuing forecasts, implementing evacuations and other mitigative actions.

These procedure help identify what could be considered the most appropriate 2015 'baseline' for global catastrophe deaths, from which all future improvements over the next fifteen years should be measured.

3) What constitutes best practice in disaster risk reduction – the Japanese experience

Which country can demonstrate best practice in taking actions to reduce the impact of disasters? Such a country is well qualified to be employed to determine what constitutes a 'substantial reduction' in national disaster deaths over a fifteen year period.

We need a country with scrupulous record keeping, as well as a class of hazard that is not too volatile and infrequent so that empirical data can be used to demonstrate progress. Some hazard types (in particular earthquakes) have low rates of activity but high severity, which makes it impossible to determine mean casualty rates from a few decades of data. For many countries, available information on fatalities or disaster impacts is not complete before 1980.

Japanese flood was found to provide the best demonstration of what can be achieved to reduce disaster mortalities. A national campaign of Disaster Risk Reduction was initiated in 1960 after a storm surge flood in 1959 caused more than 5,000 deaths. The Disaster Countermeasure Basic Act, implemented in 1961, legislated a change from a reactive to a proactive approach to disasters in the country. Regional disaster prevention plans were enforced, including forecasting systems, flood defences, warning criteria, rescue systems and emergency communications. There was large-scale construction of multi-purpose dams for both flood control and water supply, allied with programmes of river channel capacity expansion, increased retention capacity and the production of flood hazard maps.

Several typhoons in the 1940s and 1950s caused more than 1,000 deaths. However, since 1960 there has not been a single typhoon that has caused more than 320 deaths.

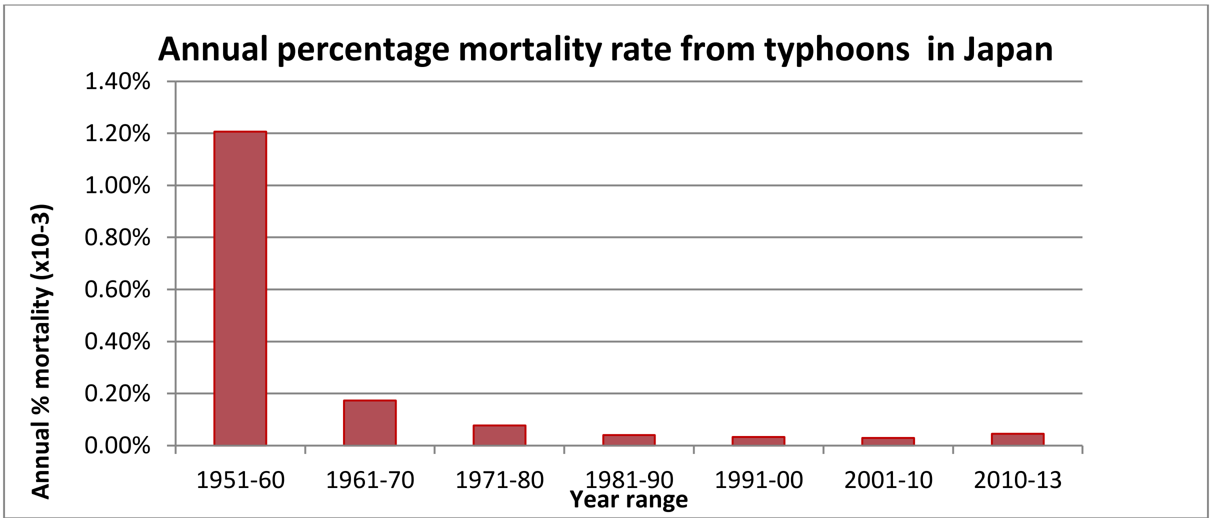

Figure 2: Annual percentage mortality rate (normalised by population) in Japan by typhoon

For typhoons, average annual mortality dropped from 1.2 per 100,000 people in the 1950s to 0.08 per 100,000 people in the 1970s. The Japanese experience highlights the order of magnitude of potential reduction that can be achieved in a rapidly growing economy, which has not previously embraced disaster risk reduction.

Structural flood control measures also led to a significant decrease in the number of houses inundated. However, in comparing statistics on properties flooded and people killed, after the 1970s the policy around evacuations appears to have become weakened. From 1951 onwards, there is a general decrease in deaths per 10,000 houses inundated by typhoons, which has risen by a factor close to 3 since the early 1980s. The initial focus was on saving lives, principally through evacuations. Since the 1980s, trusting in the ubiquitous flood defences, people have become less observant of the need to evacuate when they are warned of an oncoming disaster.

4) Using catastrophe models to measure improvements in disaster casualties.

Given the infrequency of major disasters there is limited information on which to base estimates of either future mean annual losses or losses in rare high-magnitude events. Furthermore, exposure to these events is continually changing as a result of new construction and population increases, especially in high-growth countries. For these reasons, since 1990, the insurance industry has embraced the use of probabilistic catastrophe modelling with a synthetic catalogue of up to 100,000 years of extreme events.

Catastrophe models principally focus on the financial cost of disasters, but have also been developed to model earthquake casualties. To do this requires estimating the probability of building collapse and the distribution of the population within the buildings at two antipodal times of day (such as the middle of the workday and night). The output of such casualty models includes the annualized number of expected fatalities as well as the number of fatalities that can be expected at key 'annual probabilities'.

Fatalities can also be modelled for evacuable hazards like storm surge and tsunami. For these first the numbers in the path of the flood are identified and then, according to the preparedness of the population, availability of forecasts, evacuation plans and destinations, it is possible to estimate the expected fatalities of those who do not evacuate.

Muir-Wood (2012) first proposed that catastrophe models outputting mortality data should be used for setting targets and measuring progress in disaster risk reduction. On March 31st 2015 the Tokyo City Government announced a plan to halve the expected earthquake casualties in the city over the next ten years. The city will measure this target through risk modelling. For a specified scenario Magnitude 7.3 earthquake under the city (comparable to an event that happened in 1855), the city will model the performance of the building stock around collapse rates, fire starts and fire spread, to determine whether they are achieving their goal.

References

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