

**NATURAL DISASTER RECOVERY: A PRELIMINARY ANALYSIS OF 21ST CENTURY RELIEF
FUNDING IN NATURAL DISASTERS AND ITS RELATION TO LONG-TERM RECOVERY OUTCOMES**

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Natural Disaster Recovery: a preliminary analysis of 21st century relief funding in natural disasters and its relation to long-term recovery outcomes

Abstract

Natural disasters—earthquakes, floods, drought, and other natural hazards—are globally responsible for tens of thousands of deaths each year. The victims of natural disasters represent an inherently vulnerable population, and it follows that international relief responses should aim to be effective and equitable in these emergencies. This retrospective, preliminary analysis of post-disaster relief funding from 2000-2010 suggests that disaster magnitude (measured by total deaths) is directly correlated to donated funds ($p < 0.01$). Over an approximate six year period, funding was also shown to have a significant, moderate inverse relationship with mortality rate ($p = 0.0139$). No significant relationships were found between funding and infrastructure or workforce in this analysis. Larger natural disasters attract more donations and are more likely to disrupt society for a longer period of time, likely affecting the mortality rate. However, confounders like socioeconomic and political climate, corruption, and geographic vulnerability make it difficult to assess the efficacy of recovery efforts. Ultimately, until tangible metrics (for health and infrastructure outcomes) are reliable, reproducible, and relevant, determining how to best utilize recovery funding and resources remains unclear. This analysis does not seek to criticize post-disaster relief efforts, but rather aims to encourage the development of transparent and efficacious response through the creation of these metrics to better inform future recovery efforts.

Background

Natural disasters—earthquakes, floods, drought, and other natural hazards—are globally responsible for tens of thousands of deaths each year (Stromberg 2007). Though natural disasters have been a recurring constant throughout human history, the frequency and severity of these events has continued to increase with time (Figure 1). While associations to industrialization and climate change have been studied with relation to this pattern (Leaning and Guha-Sapir 2013), until the etiology of natural disasters is addressed, their consequences present a growing global and public health crisis.

Low and middle income countries (LMICs) suffer more deaths and greater economic burden in natural disasters as compared to high income countries (HICs) (Kahn 2005, Kellenberg and Mobarak 2008) due to increased susceptibilities and vulnerabilities (Cutter et al 2018, Yoon 2012, Pelling et al 2002, Weichselgartner 2001). Though efforts are being made to develop a framework for carrying out humanitarian logistics operations (Jahre et al 2007, Cutter et al 2008), it remains that the geographic susceptibilities and structural vulnerabilities of LMICs lead to more deaths, injuries, and displacement during natural disasters (Kahn 2005). Moreover, during the recovery process, socioeconomic and other structural vulnerabilities lead to limited resilience in recovery efforts in these countries. For example, earthquakes have a pattern of recurring in Afghanistan every 2.4 years, interspersed with floods and avalanches, and yet there has been no observable trend in decreasing the death toll caused by these disasters (David 2006). This pattern

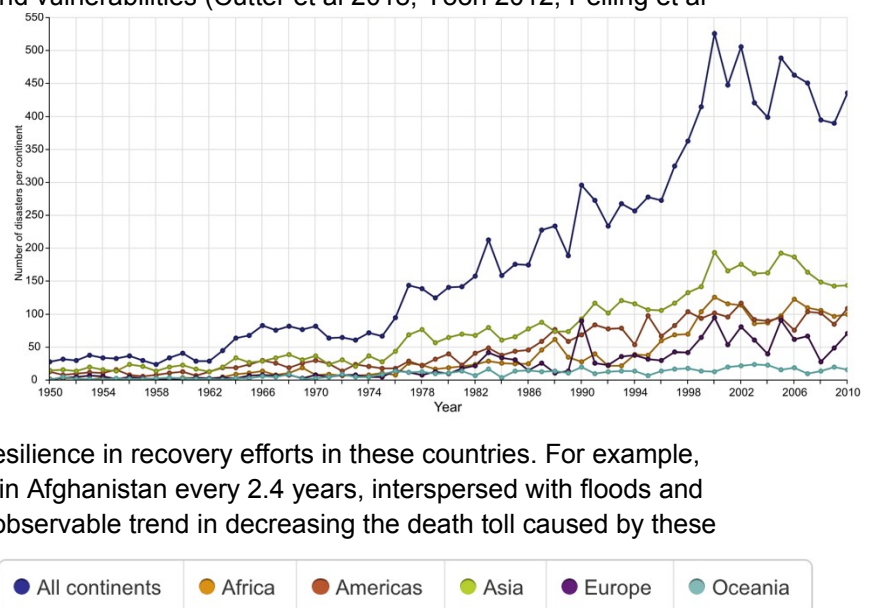


Figure 1: Total number of reported natural disasters between 1950 and 2010

Downloaded from the International Disasters Database
<https://www.emdat.be/>

of increasing natural disasters paired with limited recovery creates a vicious cycle that undermines a population's resilience, increases its vulnerability, and further imbalances economic development.

International bodies and non-government organizations have mounted greater and greater responses to natural disasters, especially with the increasing role of broadcasting, public interest, and social media (Becerra et al 2014, Gilboa 2005). But with the increasing trend of donations based on public attention and media coverage portraying a necessary immediacy in relief funding, funding often outweighs the need (Olsen et al 2003) and ignores the disaster response needs of local agencies (Harris 2006). In the case of the 2004 Indian Ocean Tsunami, media coverage predominantly focused on the destruction and aftermath of the disaster, drawing a significant increase in public attention, and ultimately led to a surplus of funds. However, this coverage drew attention away from a relief appeal from the United Nations for a famine in Sub-Saharan Africa (Alexander 2006). Ultimately, there is no perfect answer when it comes to the decision-making in concurrent recoveries, but it begs the question of funding and resource distribution efficacy and equity.

Undoubtedly, the availability of funding and resources play an important role in disaster relief efforts: both in mitigating the immediate effects of the disaster aftermath and in long term recovery efforts to improve disaster resilience. In the early post-disaster timeline, NGOs can play an invaluable role in creating safety-net hospitals when existing healthcare infrastructure has been destroyed (Kligerman et al 2015). However, increases in funding and resources does not always lead to improved recovery outcomes.

Looking at the 2010 Haiti Earthquake, Haiti received an unprecedented amount of support and aid (Ramachandran and Waltz 2015). However, the post-disaster response revealed persistent weaknesses in international emergency relief, particularly with regard to initial assessment and coordination (Leaning and Guha-Sapir 2013). Geographic susceptibility, political instability, and socioeconomic challenges have undoubtedly contributed to the slow—and ultimately incomplete—recovery. But according to data from the World Health Organization (WHO), Haiti's health expenditure is 48.9% funded through external sources as of 2015, and yet the earthquake recovery process in Port Au Prince continues to struggle. Though transparency in relief funding and financial tracking is becoming more available through organizations like the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA), there are still discrepancies between funds donated and measurable outcomes.

Ultimately, the victims of natural disasters represent an inherently vulnerable population, especially when these disasters occur in an already vulnerable population. It follows then that international relief responses should aim to be effective and equitable in these emergency endeavors. Again referring to the 2010 Haiti Earthquake, the unintended introduction of cholera to the population sparked an epidemic that resulted in significant loss of life beyond that of the disaster itself. While the focus on infrastructure and access to potable drinking water were given more attention with the cholera epidemic, it remains cholera greatly burdened recovery efforts and resulted in significant mortality in an already vulnerable population. Therefore, these relief responses should further aim to be evidence-based when possible and learn from the unintended consequences of past relief efforts.

Data collection and transparency is improving in the international and disaster medicine communities. There is a significant body of literature on natural disasters, their socioeconomic effects, and the trends and patterns of recovery efforts. However, the relationship between recovery funding and tangible recovery outcomes remains unclear. There are a number of difficulties in evaluating this relationship: funding transparency, sociopolitical confounders, and measurable outcome metrics are difficult to assess. This study seeks to explore a preliminary analysis of this relationship in an effort to understand if, for countries experiencing large natural disasters, external funding leads to improved long-term recovery outcomes.

Methods

The initial sample was collected from the International Disasters Database by compiling all climatological, geophysical, hydrological, extra-terrestrial, and meteorological disasters from the year 2000 to 2010. Biological disasters were excluded from the sample to reduce the confounding effect of non-biologic disasters often preceding epidemics. This 10 year range was chosen to attempt to reduce the confounding effect of the significant increase in donations with increasing media coverage.

The sample was further refined to define a “large” natural disasters by including all disasters with total deaths greater than the mean (as defined per Becerra et al 2014). This decision was made as available outcome metrics are recorded by country and the likelihood of smaller disaster affecting a country-wide metric was felt to be small.

This sample was further refined due to constraints from limitations or absent data points from the WHO Global Health Observatory data repository (2018) and the UNOCHA Financial Tracking Service (FTS). As this data is de-identified and publicly available, no IRB approval was required for this study.

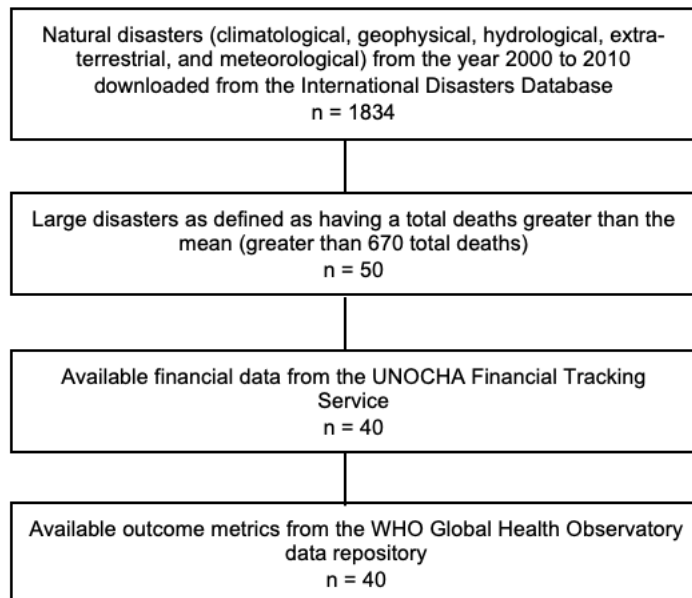


Figure 2: Data inclusion criteria

To assess the effect of natural disaster recovery funding, data was compiled from the FTS by searching funds tagged to each disaster. From this search, the funds were refined by fund destination, that is, by country. Variables were created for total funds (committed and paid). Committed funding describes the creation of a contractual obligation regarding funding. Organizations can spend against a commitment using cash reserves. Paid funding payment or transfer of funds or in-kind goods from the donor to the appealing/recipient organization, resulting from a commitment. The decision to also include paid funds as a variable was in an effort to elucidate the potential relationship of readily available funding with recovery metrics.

Variables for non-government associated funds (committed and paid) were generated by subtracting funds donated by

international government donations from the total to encompass all non-government associated funding, including that from international societies like the Red Cross, non-government organizations (NGOs), and private donors. An effort was made to attempt to quantify the number of NGOs involved in recovery efforts but data regarding this query was limited and unverified in most cases.

Variables were also created to look at funding destinations, namely looking into the committed and paid funding that was received by NGOs to attempt to identify if funding destination played a role in recovery outcomes. As NGOs typically place themselves locally for these disasters with on the ground resources, looking at this distinction was a major goal for this analysis.

Outcome metrics were compiled from the WHO Global Health Observatory data repository due to its thoroughness and range of available indicators. Variables were chosen to address mortality (overall mortality rate, maternal mortality rate), medical personnel (doctors per 10,000 population), and infrastructure (access to sanitation, drinking water infrastructure). Mortality and maternal mortality rate were chosen as health outcome indicators to reflect the population as a whole and a vulnerable subset, respectively. Infant mortality rate was ultimately not included due to limited available data. The medical workforce and sanitation infrastructures were included as outcome metrics as well as a potential variables for measuring a population’s resilience.

These outcome variables were chosen to reflect the pre-disaster, as defined as one year prior to event, and post-disaster, as defined as five years after the event, settings. This six year difference between these variables was created and used to measure the long-term recovery response. In the event data was not included for these defined years, the nearest available year or average of years was used in its place. All ranges were at a minimum 5 years.

Data was analyzed with Stata, a general-purpose software for statistics and data science. All analyses were done with a spearman's correlation. All forty disasters and analyzed data are included in Appendix 1.

Results

This study aims to explore the relationship between funding in large natural disasters and the long-term recovery outcomes to population health and infrastructure. To attempt to validate this study despite its limited sample size, a first analysis was completed to reproduce the relationship between the size of the disaster and funding, as described by Becerra et al 2014. As indicated in Table 1, there is a moderate correlation between total deaths and funding in all financial categories. With this relationship reproduced, it was felt that, even with a reduced sample size, the potential for statistical relationships was robust even to continue examining the financial variables and outcome metrics.

		r	p
<i>Total deaths</i>			
	Total donated funds	0.4988	0.0011*
	Total paid funds	0.4409	0.0044*
	Total funds donated by NGOs	0.5609	0.0002*
	Total paid funds donated by NGOs	0.5054	0.0010*
	Total funds received by NGOs	0.5449	0.0003*
	Total paid funds received by NGOs	0.4125	0.0091*

Table 1: Magnitude of disaster, as measured by total deaths, and its relationship with relief donations

With regard to funding in this disaster setting and outcome metrics, there are a number of weak correlations (Table 2). Total donated funding was weakly correlated with an increase in mortality rate; as these outcome variables reflect the change over a time interval, a positive value reflects an increase in mortality rate over the interval. This relationship help for the financing sub-grouping of paid funding, as well as funding donated and received by NGOs. While maternal mortality rate was included in an effort to examine the potential effects of funding on a more vulnerable population, this relationship was non-significant in this analysis.

Concerning workforce and infrastructure, the relationships were weaker and non-significant. There is a non-significant weak correlation between all financial categories and medical workforce, as measured by doctors per 10,000 population. Similarly, there are no significant relationships between funding categories and sanitation infrastructure (as measured by percentage of total population using basic sanitation services and basic drinking water services). As there was no relationship with these variables, this study also looked at these variables as potential metrics for measuring a country's resilience. As shown in Table 3, there are no significant relationships regarding these metrics.

		r	p
<i>Total donated funds</i>			

<i>Total paid funds</i>	Mortality	0.3859	0.0139*
	Maternal Mortality Rate	0.0026	0.09872
	Doctors per 10,000	0.1184	0.4668
	Access to Basic Sanitation	-0.1195	0.4626
	Access to Basic Drinking Water	-0.1792	0.2686
<i>Total funds donated by NGOs</i>	Mortality	0.3068	0.0542*
	Maternal Mortality Rate	-0.0111	0.9459
	Doctors per 10,000	0.1237	0.4471
	Access to Basic Sanitation	-0.1360	0.4029
	Access to Basic Drinking Water	-0.1035	0.5250
<i>Total paid funds donated by NGOs</i>	Mortality	0.3792	0.0158*
	Maternal Mortality Rate	0.0234	0.8859
	Doctors per 10,000	0.2238	0.1651
	Access to Basic Sanitation	-0.0465	0.7758
	Access to Basic Drinking Water	-0.1204	0.4591
<i>Total funds received by NGOs</i>	Mortality	0.3437	0.0299*
	Maternal Mortality Rate	0.0347	0.815
	Doctors per 10,000	0.2210	0.1705
	Access to Basic Sanitation	-0.01160	0.4758
	Access to Basic Drinking Water	0.0338	0.8361
<i>Total paid funds received by NGOs</i>	Mortality	0.3035	0.0603
	Maternal Mortality Rate	-0.0317	0.8481
	Doctors per 10,000	0.1557	0.3438
	Access to Basic Sanitation	0.0114	0.9450
	Access to Basic Drinking Water	-0.1944	0.2356
	Mortality	0.2518	0.1170
	Maternal Mortality Rate	-0.2101	0.1933
	Doctors per 10,000	0.2304	0.1527
	Access to Basic Sanitation	0.1226	0.4511
	Access to Basic Drinking Water	0.0847	0.6033

		r	p
<i>Doctors per 10,000</i>			
	Total deaths	-0.0164	0.9199
	Total damages	-0.0473	0.7844
<i>Access to</i>			

<i>sanitation</i>			
	Total deaths	0.2061	0.2020
<i>Access to drinking water</i>	Total damages	0.1086	0.5282
	Total deaths	-0.0287	0.8604
	Total damages	-0.0861	0.6177

Discussion

Consistent with the previous literature, this most recent decade of disaster data suggests a significant relationship between size of the disaster (as measured by total deaths) and donated funds. New to this analysis, funding, in all categories, was shown to have a significant, moderate relationship with mortality rate. That is, with increasing funds, there is a corresponding increase in mortality rate. This relationship is most likely due to the fact that larger disasters, with larger death counts, are more likely to disrupt a country's health and affect mortality rate in the long term. It is of note that Haiti, this sample's largest disaster and recipient of the most donations, does not follow this pattern.

Table 3: Potential resilience metrics

The relationship between funding and the secondary outcome metrics did not show significance, but the potential negative relationship between funding and infrastructure development is of note and requires further research. In the secondary analysis, workforce and infrastructure variables were examined as potential metrics for measuring a country's resilience. However, these relationships did not meet statistical significance.

Natural disasters have been an inevitable, recurring chapter in human history. However, as their frequency and severity grows, they are not only increasingly responsible for mortality but contribute to ever widening socioeconomic and healthcare disparities. They have become a global and public health crisis.

The 21st century has seen an enormous rise in media coverage of natural disasters. The vivid tragedy of these events has increasingly inspired humanitarian action from government and non-government bodies alike. Despite this increased response, namely in terms of committed and paid funding, this limited preliminary analysis shows no evidence of improved recovery outcome metrics in health or infrastructure.

However, this study can make very little commentary on the relationship of relief funding and recovery outcomes. The overall paucity of data, lack of data transparency, many cofounders, and limited sample size significantly weaken the results of this analysis. While there are likely important relationships between these variables, or even more likely, unmeasured variables that could better inform the efficacy of long term recoveries, until these metrics are measured, recorded, and researched, the relief responses following natural disasters remain untested and unproven.

Relief funding, from both government organizations and NGOs, is integral to immediate and long term disaster recovery and resilience building in LMICs. But with these vulnerable populations, care should be taken to confirm the balance between beneficence and nonmaleficence, between equity and generosity. This balance can be found by making evidence-based efforts to question, evaluate, and reassess the efficacy and outcomes of these endeavors.

Evidence based medicine has transformed clinical medicine (Sackett et al 1996) and public health (Victora et al 2004, Eriksson 2000). Calls have been made that global health and international efforts should follow these same evidence-based principles (Buekens et al 2004, Richards 2004). Standard of care should be standardized internationally: if evidence-based medicine and public health represent the expected standard, global health initiatives should endeavor to meet these same efforts.

The causal relationships of global health and disaster recovery responses are complex and confounding factors are often impossible to control. But despite these complex challenges, the preliminary steps towards finding solutions should focus on informing our understanding. This limited report does not seek to criticize post-disaster funding or relief efforts but rather aims to encourage these preliminary steps towards evidence-based responses.

Databases

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Appendix 1: Collected and Analyzed Data

