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Investigating the Role of Income Inequality in the Impact of Natural Disasters in Lower Middle-Income Countries

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Abstract

Objectives: The goal of this study was to investigate the relationship between income inequality and rates of death and injury from natural disasters.

Methods: Utilizing data from the World Bank, the Emergency Events Database, and the Central Intelligence Agency I compared rates of income inequality with per capita death and injury rates in 28 lower middle-income countries, from the timespan 2004-2014. Measures of gross national income, the Gini coefficient of income inequality, and total numbers of people affected, injured, and deaths per country were used. Countries were sorted by increasing income inequality and their rates of death and injury charted, in order to visually represent potential relationships between increasing inequality and rates of death and injury from disaster.

Results: Income inequality varies greatly even between countries with similar incomes. Per capita death and injury from natural disasters also varied. However, of the countries included in this data set, the rates of death and injury from disaster did not increase in conjunction with increasing income inequality.

Conclusions: Based on this study, there is not a conclusive relationship between income inequality and rates of death and injury from disasters. More research is necessary, with a larger data set, to further understand the role of nations' income inequality in the impact of natural disasters on their population.

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The impact of natural disasters on human life depends on the economic situations of countries (Rubin & Rossing, 2012; Roberts & Parks, 2007). Poorer countries experience higher per capita death and injuries (CRED, 2015). Overall, the relationship between poverty and deaths and injuries from natural disasters is J-shaped. Per capita deaths and injuries are highest in high poverty countries. The relationship between per capita income and deaths and injuries in countries of all other income levels is less clear (CRED, 2015; Toya, 2007).

Assuming this association between per capita income and deaths and injuries is accurate, it implies that all but the lowest income countries will not see reductions in death and injuries from modest improvements in their per capita income. For example, Kahn (2005) estimated that a lower middle-income country would have to quadruple its per capita income to achieve a reduction of 5 deaths per million population each year due to natural disasters. However, studies to date have mostly focused on a single dimension of economic standing in relation to deaths and injuries from natural disasters—per capita income, the average income across a whole population.

Income inequality may be a better measure for understanding the relationship between a country's economic status and the toll of natural disasters because it measures the distribution of resources within a country, rather than average income (Yamamura, 2015). Income inequality is a reflection of a country's values, political will and political organization (Rodrik, 1999; Anbarci et al., 2004). In countries of high inequality, the wealthier demographic has more power to implement policy and distribute resources, reinforcing values and political wills that favor "valuable" members of society. (Kahn, 2005). This means that, intentionally or not, the wealthier demographic is often given preference in protective and safety measures (Kahn, 2005;

Rubin & Rossing, 2012). Because high income inequality is accompanied by large disparities in infrastructure development and maintenance, preparation for and response to natural disasters is more uneven in countries with high income inequality (Kahn, 2005; Roberts & Parks, 2007). The result could be insufficient protection and safety for those in the poorer segments of the population, increasing rates of death and injury.

In countries with low income inequalities, in contrast, the wealthier populations do not singularly have as much control over the implementation of policy and distribution of resources (Anbarci et al., 2004). Consequently, policies regarding infrastructure and maintenance, and preparation and response for natural disasters, tend to better account for those countries' wealthier and poorer populations (Roberts & Parks, 2007). There are generally fewer population groups left vulnerable or unprotected (Anbarci, 2004), and so rates of death and injury may be expected to be lower. Without focused studies, though, these are speculations.

Two studies have reported that higher income inequality is associated with greater deaths per capita due to natural disasters (Kahn, 2005 & Roberts et al., 2007). This study builds on that work in two ways. First, in addition to studying deaths caused by natural disasters it focuses on injuries. Due to the physical destruction caused by disasters many people are affected in ways that do not necessarily result in death, so injuries should be considered too. Second, this study uses an alternative method for disentangling the joint effects of per capita income and income inequality. Specifically, it compares the effects of natural disasters in countries within the same strata of per capita income, but with varying levels of income inequality, to investigate if income inequality is a significant factor in the impact of disasters on deaths and injuries. I hypothesize that countries with higher income inequality will have higher per capita deaths and injuries from natural disasters.

Methods

Data

This study used three data sources: The Emergency Events Database (EM-DAT), the World Bank Open Databank, and the Central Intelligence Agency World Factbook. The Emergency Events Database is publicly available data, provided by the Centre for Research on the Epidemiology of Disasters (CRED, 2020). This database provided numbers of people affected by natural disasters, injuries, and deaths from disasters in each country. EM-DAT data is gathered from a number of different sources, primarily UN agencies, national governments, and the International Federation of the Red Cross, with specific criteria for natural disaster classification and reporting. The World Bank Open Databank is publicly available global development data compiled by the World Bank (World Bank, 2020). This data provided per capita income (GNI), country populations, and Gini coefficients. The World Bank gathered this information from their financial databases in conjunction with data provided by World Bank member countries (e.g. census data).The Central Intelligence Agency World Factbook is also publicly available data, provided by the CIA (CIA, 2020). This data, gathered from numerous U.S. State Departments and the United Nations Population Division, provided additional Gini coefficients to supplement those missing from World Bank Open Databank.

This study covers the years 2004-2014 because the most recent available EM-DAT disaster data is from 2014. For the purposes of this research the year 2010, the year most countries take their census and thus the year of most available data, was chosen as the year each country's population and per capita gross national income statistics would be gathered from. This study focusses on the countries from the lower middle-income strata, defined by the World Bank

in 2010 as having a per capita gross national income between US$ 996 and US$ 3,945[1]. The number of years of available EM-DAT disaster data for each country between 2004-2014 ranged from one to eleven years. For the purposes of this study, if a country was missing more than three years of reported disaster data it was then excluded. "Missing" was defined as having no number reported or included in EM-DAT. If "0" was reported, however, the year was still included because that is a reported number. This resulted in dropping 27 of 55 countries officially classified as lower-middle income by The World Bank, leaving an analytic sample of 28 lower middle-income countries to compare from 2004-2014.

Gini coefficients were not available for all countries during the 11-year time span chosen, so the decision was made to use the most recent published Gini for each included country.

Measures

Income and income inequality

Per capita income was measured using gross national income in US dollars (USD). Per capita income was provided by the World bank. They calculated it using their Atlas Method for conversion, which adjusts for fluctuations in currency rates. Validity of gross national income reports—regardless of the source or conversion method—is difficult to establish because data is dependent on the accuracy of contribution by individual country's collections and measurements. Further, income is not measured or determined in monetary terms by all populations, making it difficult to measure and even more difficult to compare across multiple countries. Still, per capita income as provided by the World Bank is still the best measure to use because the World Bank relies on their country management units and other official sources for their data. These local

[1] This range does not align with the range of values in gross national income provided in Table 1. This is because the values listed in table 1 are based on the current value of the US dollar, regardless of the year of data

offices can help more specifically account for varying definitions of incomes, providing more accurate measures to the World Bank.

Income inequality was measured using the Gini coefficient. The coefficient ranges on a scale from 0 to 100, with 0 indicating that income is equally distributed among all households and 100 indicating that one household earns all of the population's income. It is calculated by graphing the line of perfect income equality within a population, graphing the line of actual income distribution (called the Lorenz Curve), measuring the area between the two lines, and doubling that area. On such a graph the horizontal axis is the population percentile, and the vertical axis is the cumulative income of the population. The Gini coefficient describes the disparity in distribution of wealth within populations, independent of the total wealth of a country. Similar to measuring gross national income, measuring the Gini index is made complex by there being varying definitions of income across countries, reliability of governments' data collection, and its inability to account for social benefits like housing and healthcare. Further, it is measured based on "household" income, and what may constitute a household is volatile, difficult to track, and not globally universal. However, it is the most commonly used measure of income inequality within countries and it is available for the most countries.

Injury and Death.

Using EM-DAT measurements of total deaths, injures, and peoples affected, I calculated the mean annual rate of death from disasters for each country, which is the average rate of total deaths per total affected peoples by disaster during the years 2004-2014. The same was done for injury rates within each country. EM-DAT defines "affected" as people requiring immediate assistance during a period of emergency, i.e. requiring basic survival needs such as food, water, shelter, sanitation and immediate medical assistance." EM-DAT defines "total death" as the

"number of people who lost their life because the event happened." EM-DAT measure of total number of injuries is defined as "People suffering from physical injuries, trauma or an illness requiring immediate medical assistance as a direct result of a disaster." In order to be classified as a disaster and data be recorded into the EM-DAT database, one of the following must have occurred in a country: ten or more people reported killed, 100 or more people reported affected, declaration of a state of emergency, or call for international assistance.

Of the 28 countries included in the study, between eight and eleven years of disaster data was available, depending on the county. Because there is not a complete 2004-2014 data set available for every country, averaging rates of death or injury from disaster for all countries across the entire 2004-2014 timespan could bias results. It would imply that no disasters occurred in years where data is missing, which could downplay the rates of injury and death from disaster that really did occur in other years. This issue was accounted for in this study by only averaging death and injury rates in each country across the years data was reported in EM-DAT. For example, if the country had 9 years of reported data between 2004-2014, rates of injury and death were only averaged for those 9 years observed.

The average rate of deaths per persons affected by disaster was calculated by dividing the total number of people who died from natural disasters between 2004-2014 by the total number of people affected. To make the rates comparable across countries, this was then divided by the country's 2010 population, as according to the World Bank Open Databank. Finally, this number was divided by the number of years data was available in EM-DAT for each respective country between 2004-2014, to ensure that only years when disasters occurred were being considered in the final average. Average rates of injury per affected people for each included country was

calculated the same was as deaths per affected, again using both EM-DAT data and World Bank Open Databank data.

It is, however, imperative to note that EM-DAT data only represents those deaths and injuries which are reported. In disaster situations, due to the often chaotic nature of the events, disruption of normal emergency systems, and varying abilities of peoples to access help, many deaths and injuries often go unreported. This is further complicated by different countries having different methods of collecting such information from disasters which are not standardized. However, EM-DAT's clearly defined classification of data that may be reported into their system helps standardize these varying methods, even if local recording methods cannot be fully comprehensive.

Analysis

I visually present the associations between income inequality and average rates of death and injury from disaster from 2004-2014 for each country. Countries were sorted according to their Gini index, ranked low to high, in order to see if there was a relationship between increasing income and rates of death or injury from disaster. Due to this small sample size, statistical tests were not done between final rates of death per affected and injury per affected.

Results

Figure 1 is shows the geographic locations of the lower-middle income countries included in this study.

Table 1 lists the countries included in this study, sorted by income. The income inequality of the included countries, measured by the Gini index, ranges from 25.0 to 57.1. The highest rate of injury came from Ukraine, 2.9%, and the lowest rate of injury from Zimbabwe and Papua

New Guinea, 0.0000%. The highest rate of death came from Myanmar, 4.19%, and the lowest from Zambia, .0098%.

Figure 2 shows the distribution of the per capita income and income inequality of the lower-middle income countries. Per capita income ranges from $630 to $3240. For income inequality, there is a wide range of values from 25.0 to 57.1.

Figures 3 and 4 present the rates of death and injury from natural disaster from the countries included in our data set. While there are individual spikes in death and injury rates in Cameroon, Myanmar, Indonesia and Ukraine, it does not appear that rates of injury or death from disaster increase as a country's income inequality increases.

Discussion

Per capita rates of death and injury from disaster are not associated with a nation's income equality in lower middle-income countries. This did not support my hypothesis that countries with higher income inequality would have higher per capita deaths and injuries from natural disasters. Compared to the global distribution of Gini measurements there was a lot of variability in income inequality among countries included in this study, but the rates of death and injury did not increase with increasing income inequality.

This finding differs from two other studies (Kahn, 2005; Roberts et al., 2007) that found a correlation between increasing income inequality and increasing rates of death from disaster, using EM-DAT disaster data and the Gini coefficient as their measure of inequality. Differences in methods could account for the variance in findings between the present study and those of Kahn and Roberts et al. Kahn used EM-DAT data from all countries in his analysis, and modelled a linear relationship between income inequality and death from disaster among them. It is possible

that the observed pattern in my study, or lack thereof, actually does fit into Kahn's estimated pattern, but the same relationship is not apparent because I am only focusing on a specific income level. The lens of this study is narrower. However, based on the results presented in Kahn (2005), it is also possible that there a curvilinear relationship between income inequality and rates of death from natural disasters among countries. Again, the results of my study may fit into this model despite the absence of a pattern exhibited in the present study's results. This could also be due to my small sample size even within the lower-middle income level. This variance in findings across studies illustrates the need for more research regarding the relationship between income inequality and the toll of disasters, especially within countries of the similar economic standings.

There are limitations of the study which—if they could be accounted for in future studies—may allow for more conclusive results. The EM-DAT disaster data was missing multiple years of data for many countries. This not only limited the sample size of countries which could be included, but also meant that the countries which were included had an unequal number of years of reported data. While this was accounted for in the calculations, missing years of data limits a researchers ability to give accurate rates. Natural disasters are episodic by nature, and missing a year data may mean an entire disaster(s) are absent from the data. This affects death and injury rates in ways that cannot be methodologically accounted for, as the impact countries experienced cannot be accurately represented in calculations if the data is absent. Further, the data that is reported is dependent on each country's data collection methods. It is unreasonable to expect standardization of recording and reporting from each country. Each country has different capabilities, and each disaster results in unique circumstances which can make disaster data collection difficult. Regardless of EM-DAT's clearly defined guidelines for what may be entered

into their database, country-level variations in the collection and reporting of data will inevitably affect the consistency of calculated death and injury rates in research like this.

The inconsistent findings between this study and those of Kahn (2005) and Roberts et al. (2007) do not necessarily imply that income inequality is a poor measure for understanding a country's economic status and the toll of natural disasters. Income inequality represents the disparity of wealth among a population, which directly affects peoples' protection and resources, and thus their potential vulnerability, in the event of a disaster. It represents the distribution of wealth and potential resources among a country's population that national averages do not. Thus, it is a crucial measure to keep utilizing in the studying the impacts of disasters on countries.

This study has value as starting point for future research. It is one of few existing studies using income inequality in the study of disasters' impact, and also yielded different results than others published. This emphasizes the need for continued research, as well as how closely methodological variation may affect results. While the present study focusses on the lower-middle income strata, and only some countries within the strata, the methods utilized here can be used to guide continued research. Further research needs to be done with more complete disaster data sets, if possible, so that entire income levels can be studied without the exclusion of any countries or years. Bigger sample sizes will also allow for more statistical testing. This is important not only for the quality of research, but also to make sure the impact of disasters on countries is being accurately understood and represented—that their true stories are being told. Research done within other income levels, regarding income inequality and deaths and injuries from natural disasters, would also allow for comparisons to be made between different income strata. It is possible that within other income strata there may be a more clear relationship between income inequality and average rates of death and injury from disasters between countries. While this study does not have

the results to make policy implications, it can direct further and more robust research which could significantly grow our understanding of the relationship between a country's economic standing and the toll of disaster situations.

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Appendix

Figure 1. Geographic Distribution of Countries Included in this Study

Table 1. Descriptive Table

Included Countries Ranked by Income					
Country Name	**GNI per capita (USD)**	**Gini Index**	**% Injured**	**% Died**	**Years of Reported Data**
Zimbabwe	630	43.2	0.0000	0.0768	2005, 2007-2011, 2013-2014
Cambodia	750	37.9	0.0028	0.0172	2004-2007, 2009-2013
Bangladesh	800	32.4	0.0928	0.0108	2004-2014
Kyrgystan Rep.	850	27.3	0.0171	0.0071	2004-2012, 2014
Myanmar	850	38.1	0.6192	4.1922	2004-2013
Kenya	960	40.8	0.0002	0.0082	2004-2013
Pakistan	1030	33.5	0.2936	0.1693	2004-2013
Mauritania	1170	32.6	0.0012	0.0045	2004-2007, 2009-2011, 2013
India	1220	35.7	0.0114	0.0237	2004-2014
Ghana	1230	43.5	0.0372	0.0633	2005, 2007-2013
Vietnam	1250	35.3	0.0242	0.0158	2004-2013
Sudan	1260	46.3	0.0068	0.0321	2004-2013
Cameroon	1330	46.6	1.2733	1.1499	2004-2013
Senegal	1340	40.3	0.0105	0.0240	2004-2005, 2007-2013
Solomon Islands	1340	37.1	0.0113	0.1128	2007-2014
Zambia	1340	57.1	0.0004	0.0098	2004-2013
Nicaragua	1460	46.2	0.0524	0.0721	2004-2005, 2007-2014
Honduras	1730	50.5	0.0179	0.0415	2004-2014
Papua New Guinea	1740	41.9	0.0000	0.0876	2004-2009, 2011-2013
Bolivia	1780	44.0	0.0032	0.0176	2004-2013
Congo	2120	48.9	0.3325	0.7139	2005-2008, 2010-2013
Nigeria	2140	43.0	0.0204	0.0571	2004-2013
Philippines	2460	44.4	0.1830	0.0231	2004-2014
Indonesia	2530	38.1	1.4102	1.6286	2004-2014
El Salvador	2880	38.0	0.0007	0.0855	2005-2011, 2013
Morocco	2930	39.5	0.7369	0.5834	2004-2006, 2008-2010, 2012, 2014
Ukraine	2980	25.0	2.9162	0.2470	2005-2010, 2012-2013
Angola	3240	42.7	0.0010	0.1391	2004-2013

Figure 2. Distribution of Per Capita Gross National Income and Gini Measurements

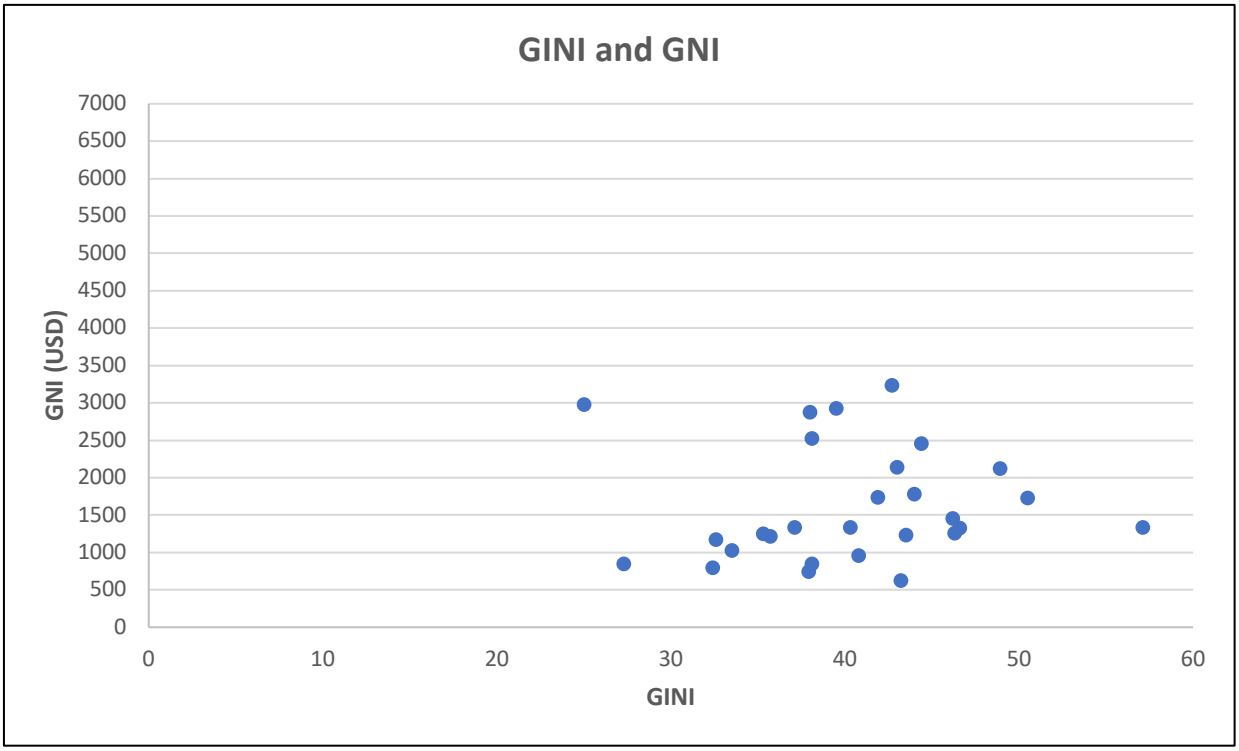

Figure 3. Injury per Affected Population as Income Inequality Increases

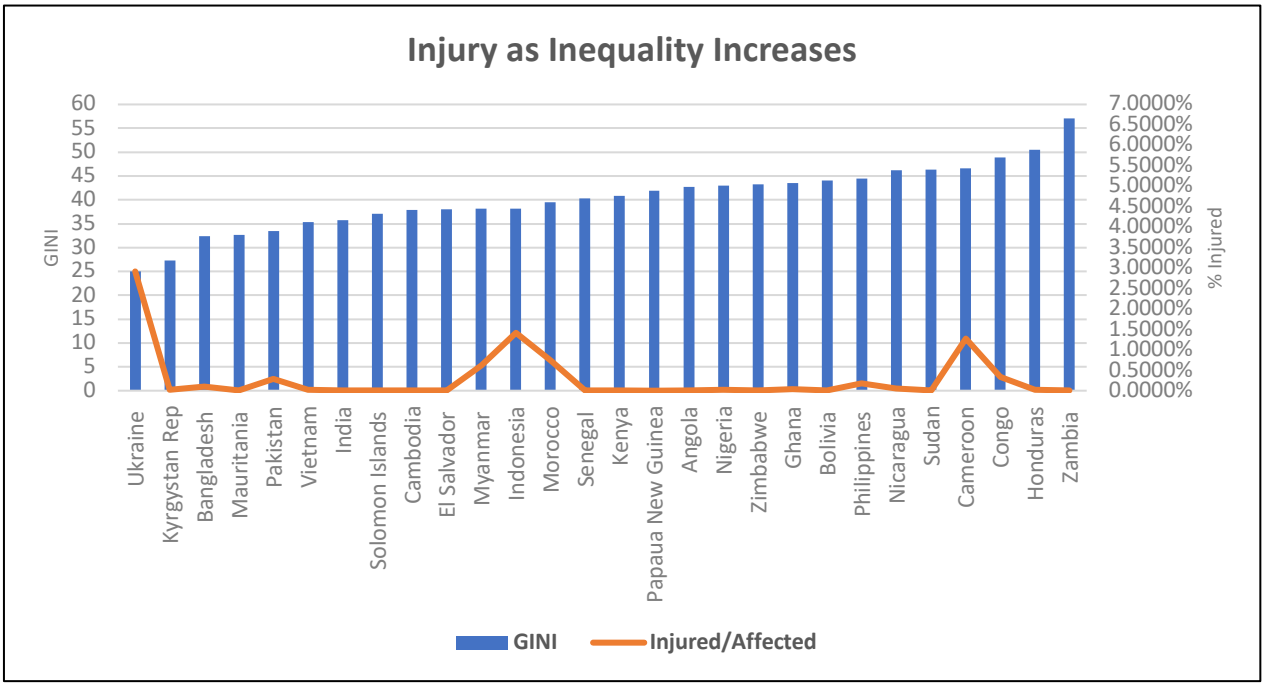

Figure 4. Death per Affected Population as Income Inequality Increases