Wageningen UR

The AfterMath of natural disasters

A quantitative analysis of the effects of natural disasters on human health

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PREFACE

After twelve months, it is time to end this research and to write my preface. It has been a long journey. Whether it was too long I do not know, good things take time, that is what they say. I have thought about excuses, and I even found some: I can say I started a company in Zimbabwe or that I changed to another apartment. I can even say that on the first night in my new apartment fire-fighters had to distinguish a fire. But nay, none of these is the excuse I would like to use. I am a dreamer, that is my excuse.

During the first months of my thesis I was inspired by Michael Marmot and his work on the unequal spread of health. I was inspired by Hans Rosling and several of his speeches on TED.com. My dream was to be like those guys, to share their ideas and to spread their vision. For those who wonder who Rosling and Marmot are. Basically what they show with their statistics is the absurd spread of health. Americans earning ten times more than Cubans have a life expectancy that is not a year higher than that of Cubans. What is more, life expectancy in the USA is very much depending on which neighbourhood you grow up in. There is a difference of twenty years of life expectancy between poor and rich neighbourhoods. Twenty years! In the richest country in the world! Some neighbourhoods in the USA have a life expectancy lower than that of developing countries. These statistics made me angry. It made me wondering whether I could produce statistics that are not just statistics, but statistics that make you angry inside, statistics that are overwhelming, that stick to your mind. I was hoping to become a nerd with a cause, a nerd who would introduce righteousness through statistics. How cool would that be?!

Most likely you are now wondering whether or not I succeeded. I do not know, that is something you must decide after reading this report. Personally I think I did not succeed, at least not in the way Marmot and Rosling did. I was in the happy position that my supervisor came up with the fantastic idea to study the long term effects of natural disasters on health. It is not a mind-blowing idea that there could be long term effects of natural disasters on health. It is mind-blowing that nobody has ever done research on it (with quantitative data). My wish is that others will criticize this report and do what had to be done long time ago. To find out whether there are long term effects of natural disasters on health or not. And if there are, that people will build policies and arrange precautionary measures, because it is unethical that so many people are still dying for no good reason.

I would like to thank Jeroen Klomp for being patient with me, with my general lack of knowledge on econometrics, and off course for this wonderful research topic. I would like to thank Evelien Smit for her comments now and then. Thijs Boer for being the best business partner, for helping my get distracted from my thesis way too much. Marianne Venema for taking too much of my time. Martijn vd Graaf and Tonie for Sunday nights. And of course Michael Marmot, Hans Rosling and several other great researchers, for inspiration and their research for impact!

Enjoy!

Gert-Jan Smit,

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INTRODUCTION

When we think of natural disasters, we think of chaos, devastating events, diseases, a lot of victims and an outcry to the international community to provide aid, shelter and funds to rebuild the country. Natural disasters can be disastrous for health that is for sure. In some occasions the impact is enormous, however in other occasions their impact can also be relatively small. To get more insight in the real impact of disasters on health, we should not only look at the direct casualties or the short-term (indirect) casualties. We should also get insight in long-term effects of natural disasters on health.

Unfortunately research on long-term effects of natural disasters on health is scarce. The majority of research has a focus on short-term effects (which gives us great insights) but the focus is only up to a few weeks after the initial disaster. The few studies on long-term effects have a strong focus on stress/psychological health (Felix et al., 2011, Kessler et al., 2008, Kolves et al., 2012, Logue et al., 1981, Weems et al., 2007, Weems et al., 2010). Other health effects (injuries and other non-communicable diseases) are rarely studied. The studies we have are mainly case studies, their disadvantage is that they are often missing a baseline study (as the research started after the disaster took place). Another disadvantage is that these studies are often not generalizable as disasters are very dissimilar and local circumstances are very diverse. These studies have a local scope and should be interpreted as such. Their value for other regions/countries is minimal.

Our research will step into this gap. As we work with quantitative analysis we are able to include all disasters listed in the EM-DAT database over the years 2002 and 2004. In addition we are not limited to psychological diseases, as we use data on all diseases (divided into three categories). The use of a baseline (2002) makes the outcomes more reliable (although we have no other quantitative studies to compare with). Working with a baseline study makes it possible for us to research changed patterns. We do not explain differences in health patterns around the world. We are able to carry out this research through DALY, which is an artificial indicator created by the World Health Organization (WHO) designed to give an indication of Disability Adjusted Life Years. The official definition is: The sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability. In addition we use data from the university of Louvain on disasters.

Our research set up is (as far as we know) new in its kind. It will be the first quantitative study on long-term effects of natural disasters. In addition it will be the first research with an international scope. The research itself is based upon a study of Ghobarah et al. who study the long term effects of wars on health (Ghobarah, 2004).

Before we start with our research and our results, we dive deep, deep into disasters, what they are how they work and what we know on how they affect health.

1. WHAT DO WE KNOW ABOUT NATURAL DISASTERS?

1.1 CHANGED PATTERNS (OVER THE LAST CENTURY)

Natural disasters are quite common, every day we see them on the news, often far away, but also regularly in places where we might have travelled ourselves. Better information technologies can make it appear like natural disasters are increasing in number and in severity. In fact the number of reported disasters has indeed increased. This is mainly due to better information technologies and population growth (as well as urbanization). The chance that a disaster is meeting the minimum requirements of a disaster (amount of casualties, damage etc., see also paragraph 2.3.) is bigger when more people are on the planet or living within the disaster area

But on the other hand we see that the amount of people reported killed has dropped over the last century (see figure 1 and 2). There are huge possibilities to bring this number further down. What we see is that in developed countries, casualty rates are low, while casualty rates in developing countries are relatively high. The drop in casualty rates during the last century can mainly be explained by the development in (parts of) the world. This change of patterns has been made possible by the availability of better housing, better sanitation, higher income, better preparations, better warning systems, planned evacuation etcetera (Schultz et al, 2005).

Next to technical and economic progress, there has also been an institutional progress. Amartya Sen claims that all countries can face a drought, but only undemocratic countries face malnutrition (Sen, 1981). Although one can argue with Sen on definitions and exemptions. The point that Sen is making is that a natural disaster (such as a drought) does not have to lead to a catastrophe, it depends on good policies whether or not a disaster develops into a human catastrophe. Sen's theory is one of the explanations why developed countries face low mortality and low casualty rates after the occurrence of a disaster. Shultz et al. state that there has been a shift (in developed countries) from deaths occurring during the impact phase of tropical storms (which used to account for 90% of all deaths), to deaths occurring before and after the impact phase. Car accidents, electrocutions from fallen power lines and even chain-saw injuries are now accounting for the majority of casualties from tropical storms (Shultz et al, 2005).

Figure 1. Natural disasters reported

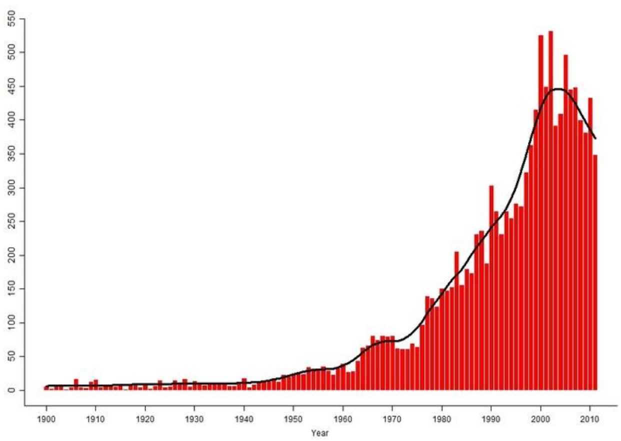
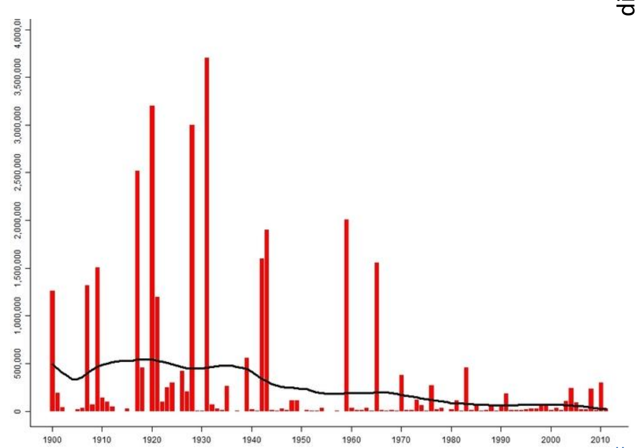


Figure 2. People reported killed by natural disasters



1.2 IMPACT OF DISASTERS

Usually researchers divide the disaster period into four phases; pre-disaster, disaster (or impact phase), relief phase and post-disaster phase (March, 2002). When we picture a storm, these stages are relatively easy to picture. During the pre-disaster phase, people flee the area, or take necessary preparations. During the disasters phase, the storm hits in, when the storm is over, people go outside and see what the damage is. Neighbours help each other and wounded people get bandages or other first aid solutions. After a while; sometimes hours, sometimes days, professional aid is provided, which is the onset of the relief phase. When the professionals leave the area, evacuees return to their homes, people start fixing their houses, the post-disaster phase has started.

Phase	Characteristics	Type of casualties
Pre-disaster phase	Preparation, evacuation	Small incidents, wounds
Disaster/impact phase	Direct casualties,	Crush injuries, drowning
Relief phase	Relief agencies provide aid	Direct: delayed casualties Indirect: Contaminated water/ sanitation, discontinuity in medicine usage/ treatment
Post-disaster phase	People return home, rebuilding	Indirect: accidents, epidemics

The above phases are relatively easy to picture for a storm, but they are not always clear, such as in the case of a drought. A period of drought does not necessarily evolve into a disaster, and when it will, it needs to be dry for weeks or months before it will lower the groundwater and water storages to a level where it becomes critical. So in this case the pre-disaster phase endures for months. It becomes even more difficult to distinguish the disaster phase. There is no clear deviation between the disaster and the relief phase, as usually the professional aid comes in, while the disaster (drought) is still evolving. So while we discuss the impact of disasters, we must keep in mind that no condition can be generalizable. The different types of disasters have their commonalities, but even these are very different from each other. Local circumstances, timing of the impact, the power of the impact etc. are making every disaster unique.

Direct/indirect

In general most casualties arise during the impact phase. Though for the first time in history there is a trend in developed countries, that there are more casualties before and after the disaster, than during the disaster itself (Shultz et al, 2005).

From the start of the relief phase the inducement of all casualties can be divided into two pathways. The first is a direct effect, the second is an indirect effect. The first group is a group of people that are affected by the disaster, they are treated but help comes too late, these are 'delayed' casualties. Within the second group we find people that die of indirect causes. People that die due to 'simple' diseases that are not treated, think of chronically ill who miss their treatment or lack medication (which worsens their illness). Another important indirect effect is the outbreak of epidemics or the contamination of drinking water/sanitation systems. Not functioning of, in this case; the healthcare sector or the sewerage system, are the pathways through which the impact of the disaster is continued.

1.3 TYPES OF DISASTERS AND THEIR CHARACTERISTICS

Now we have seen how the general effect of disasters is on health. It is important to look into detail, how the different disasters affect health. We describe the characteristics of the four main disasters (or group of disasters) and we describe what their effect on health is.

FLOODS

Flooding accounts for 40% of all natural disasters worldwide and causes about half of all deaths from natural disasters. (Noji 1991 cited by Ohl & Tapssell, 2000). Floods occur as a result of heavy rainfall but can also be due to melting of snow, breaking of a dam, breaking of a dike, a storm or heavy tide (Few et al., 2004). As such, floods are very diverse. There are two important constraints that predict the impact of a flood. The first is the predictability of the flood. In some cases (such as a storm) floods can be well predictable. While in other cases, floods can totally overwhelm people (Du et al, 2010). The second is the speed of the water rise. In some cases we speak of flash floods, were flood happens suddenly and water rises quickly. It speaks for itself, that these floods are very deadly (Few et al., 2004, Kunii et al, 2002).

Different than other disaster types, floods usually displace a lot of people and de-organize big areas. Power cuts and contaminated water sources are common (Ohl & Tapsell, 2000, Fewtrell and Kay, 2006). Floods do not per se cause a lot of injuries (directly). As storms are well predictable, people usually have enough time to go to safe heavens, which minimizes (the direct) casualties. As such storms are not likely to overload the existing medical system *(*Bartels and van Rooyen, 2012*,* Fewtrell and Kay, 2006*).* The major cause of death is drowning, most of these deaths occur during the impact phase. Though even after the initial impact phase drowning is a threat. Think of people returning to their homes (or trying to flee the area) crossing flooded rivers (Ohl & Tapsell, 2000). Other casualties arise when people hurt themselves before or after the peak of the flooding; car, chainsaw and other accidents are common (Ohl & Tapsell, 2000).

Normally media speak of big risks for diseases (as they tend to dramatize the facts), but these are usually minimal (Ohl & Tapsell, 2000, Kunii et al, 2002). Local circumstances are very important. (Epitrends, 2012). Waraich et al. find that after the 2010 floods in Pakistan, especially the already vulnerable people were affected (Warraich et al, 2010, Kunii et al, 2002). Poor hygiene practices and no practices to purify water sources are a big threat. Kunii et al. state that the 1998 flooding in Bangladesh endured for 75 days in some areas, though the 1988 flooding's peaked during 21 days. These factors might influence the outbreak of diseases. The occurrence of pools that stay behind after floods, creates an overwhelming number of breeding sites. In combination with warm weather, this is the perfect habitat for vectors. The characteristics of a disaster can be perfect for vector borne diseases to grow big. "The crowding of infected and susceptible hosts, a weakened health infrastructure, and interruptions of on-going control programs are all risk factors for vector borne disease transmission." (Lifson, 1996 cited by Watson et al, 2007).

When we look at the diseases that occur after disasters, we find "increased rates of diarrhoea (including cholera and dysentery), respiratory infections, hepatitis A and E, typhoid fever, leptospirosis, and diseases borne by insects" (Ohl & Tapsell, 2000, Fewtrell and Kay, 2006). Kunii et al. found that fever (63.6%), respiratory problems (46.8%), diarrhoea (44.3%) and skin problems (41.0%) are the major consequences of floods (Kunii et al., 2002). These diseases are mostly not epidemic but mainly endemic (Kunii et al., 2002).

Floods affect a major amount of people with 'small' sicknesses or symptoms of diseases, such as fever and diarrhoea. The scale of these 'small' diseases is big, with no disparity between developed and developing countries (Kunii et al, 2002, Ohl & Tapsell, 2000). There is a great risk for contaminated water supply. In developed countries, power cuts are common, these cuts affects a much bigger area than the initial affected area. It is common that this will result into 'small' diseases, such as diarrhoea (as people eat food that has not been cooled for some hours to some days).

LONG TERM EFFECT

As we are looking to find how disasters affect long term health. It is interesting to see what researchers have found on the long term effects of floods on health. Llanes et al. find that floods are associated with malnutrition. "Children exposed to floods during their first year of life presented higher levels of chronic malnutrition." (Llanes et al, 2011) In the period after the flooding a rise in hospital attendance may be expected, with no specific disease accounting for this rise (but increased stress might be the explanatory factor) (Ohl & Tapsell, 2000). Social support after floods (or after natural disasters in general) is believed to be an important constraint for victims to cope with their trauma, and increased stress afterwards. The disaster phase is often very traumatic for people, people do not know how to react. Even when the disaster phase endures for days (as is often the case with floods) people can face endured restlessness and 'not normal' behaviour. Caroll et al., quote a lady who had experienced a flood, the lady describes how she was doing the dishes (which weren't dirty) only to fill the time, only to keep busy (Caroll et al., 2005). If people do not find ways to cope with stress, originating from the disaster (or its direct aftermath), stress can cause serious health problems in the long run. Not only mental health problems, but also cardiovascular diseases etc. (Ohl & Tapsell, 2000, Du et al., 2010).

Next to mental health problems (which are dominating literature) it may be expected that people have long term health effects from disability (Du et al., 2010). In addition people suffer from exacerbation of chronic diseases (for instance diabetes and cardiovascular diseases) due to lack of access to healthcare and/or medicines during and after the disaster (Epitrends, 2012). It is not clear how communicable diseases have long term effects. Though recently some researchers have stated that there are linkages between communicable and non-communicable diseases (Ogoina and Onyemelukwe, 2009, O'Connor et al, 2006, Bach 2002, Maher et al, 2010). There are linkages between hepatitis B and C and cancer, but also between HIV and dementia (see the appendix for an overview). In addition recurrent infections can increase the risk for non-communicable diseases. For instance recurrent respiratory diseases can cause lung cancer and asthma (Ogoina and Onyemelukwe, 2009, O'Connor et al, 2006, Bach 2002, Maher et al, 2010).

Luckily floods do not per se lead to the spread of epidemics (Ohl & Tapsell, 2000, Kunii, 2002, Floret et al., 2006). For the spread of epidemics some special circumstances are required, which are most of the time not met. Though in the case of great movements of people, when people crowd together in refugee camps, the risk for epidemics will increase dramatically (Floret et al., 2006, UNHCR, 2011, van Rooyen and Leaning, 2005). Nevertheless, the low risk for epidemics after floods does not mean there are no diseases, there is still a great variety of diseases that occur among the people. Endured diseases (even minor diseases, such as diarrhoea or a simple flu) can have long term effects as they can increase the risk for non-communicable diseases in the long run (Ogoina and Onyemelukwe, 2009).

Weinstein states that in some cases, prevention of malaria directly after the disasters, may in the long term have the opposite effect. As too much use of malaria drugs, can make the parasite resistant against drugs (Weinstein, 2010). These are very difficult statements, as often no baseline study has been conducted (as we work with disasters).

STORMS

Storms are very similar to floods in their mortality and disease characteristics. Storms usually result in huge material damage and are (to some extent) well predictable. In general it is possible to evacuate (part of) the population, or at least to take some precautionary measures. As such, storms are quite unique, as they are the only disaster with a clearly distinguished pre-disaster phase. During this phase, casualties arise during evacuations or while people are taking precautionary measures. This phase mainly gives rise to injuries, while deadly accidents are rare (Few et al., 2004). The pre-disasters phase is very important to mitigate possible future casualties. If people are able to take necessary precautionary measures, this will keep casualty rates down. Even small measures as arranging candles, something to boil water and blankets can be very helpful (Caroll et al., 2005). Usually storms do not cause massive population movements. But they do sometimes, even in highly developed countries, such as with hurricane Katrina.

Storms do not cause a huge amount of serious injuries, this is mainly due to the fact that people have taken shelter. People are often not affected at all, or deadly wounded (Lechat, 1979, Bartels & van Rooyen, 2012, Shultz et al., 2005). Overall drowning is the major killer during storms, in addition people are buried under collapsed buildings or burned by fires (Keim, 2006). There are huge differences in how hard a storm hits a country. Overall casualty rates are high in developing countries and low in developed countries (Keim, 2006). This is mainly due to early warning systems, quality of housing and quality of the medical system. In the case of developed countries, the majority of casualties are in the post-impact phase (Shultz et al., 2005). Car accidents, electrocutions, and other accidents are a serious threat (Shultz et al., 2005). Before there were modern warning, evacuation and shelter systems, drowning used to account for 90% of cyclone mortality (Shultz et al., 2005).

First aid is usually provided by local people, which is similar to earthquakes, where major rescues are done by locals, not by professionals. Storms do not per se lead to epidemics (Keim, 2006). Even though people are vulnerable, they are usually capable of securing a basic level of hygienic practices, which protects them against the spread of epidemics. Nonetheless, people are more vulnerable for diseases than under normal circumstances. There are a lot of diseases that can break out and even more threats to health that need be taken care off (Perera et al., 2012). Problems with electricity, contaminated drinking water (Perara et al., 2012), loss of shelter and damage to the health care system are common (Keim, 2006). Similar to floods, these problems in infrastructure do mainly lead to ‘small’ diseases, such as diarrhoea and the flu. The levels of people affected by ‘small’ diseases and symptoms of diseases are similar in developed and developing countries.

LONG TERM EFFECTS

Injuries can have long term effects, especially when people are not able to work anymore. These people become an economic burden on their families and wider society. (World Bank, 2008 cited by Wisner, 2009, OCHA, 2008 cited by Wisner, 2009, Kumar et al., 2005 cited by Wisner, 2009). Especially when people are not treated in time or when a wound gets infected, injuries can have major effects on ones capabilities.

After the storm, people may suffer from toxic materials in the water, which they accidently swallow when they are in the water. These toxic materials stay behind when water levels drop (as storms, usually cause flooding), contaminating houses and other buildings (Perera et al., 2012). Houses can also be affected by mold, which can cause serious health problems.

Storms are a serious disturbance of normal living and are likely to cause long-term mental health problems. People suffer from depression and post-traumatic stress syndrome months and years after the disaster (Gregg et al., 1989, Goodwin and Donaho 2010, Shultz et al., 2005).

EARTHQUAKES/TSUNAMIS

Earthquakes are extremely devastating. They are not predictable and unfortunately there are quite some big cities in earthquake prone areas (Istanbul, Tokio, Los Angelos). Earthquakes are especially destructive when they occur in the evening or during the night, when people are generally indoors (Alexander, 1996). Besides timing, the type (and quality) of constructions is an important factor, countries with weak construction practices are very vulnerable for high casualty rates. With state of the art architecture most buildings will not collapse.

Most victims from earthquakes are due to collapsed buildings. Earthquakes are the only type of disaster that cause an extreme amount of injuries (Lechat, 1979). Most people die on the spot, directly or within few hours after the incident. People that are trapped between buildings die of crush injuries, chocking, dehydration and suffocation (from dust) (Alexander, 1996). Typical injuries are crush injuries, broken bones, spinal damage, bruises, cuts, head injuries etc. (Bartels en van Rooyen 2012). Burns are common, with fires as the main cause. When an earthquake hits during, or before dinner, burns (due to boiled water or food) can have a high casualty rate (Alexander, 1996).

Earthquakes can cause great chaos especially when important infrastructures are destroyed. Especially roads, bridges and medical facilities are crucial. The destruction of these infrastructures makes it hard for victims to get relief, but also for relief agents to supply medical facilities and to reach victims. Typically earthquakes are associated with infectious diseases, as water and sanitation are often affected by the earthquake. In addition injured people are more vulnerable for infections. Open wounds should be treated to prevent infections and blood poisoning to spread. But in general it is not expected that earthquakes lead to epidemic outbreaks (Floret et al., 2006, Bartels and van Rooyen, 2012, Alexander, 1996).

Inquests have shown that with earthquakes most people die directly or within six hours after the initial shock (Alexander, 1996). People need about half an hour after the earthquake to become aware of their situation and what to do (Alexander, 1996). When they know what to do, up to 75% of civilians is involved in rescue operations (Lechat,1990). Hence, the most important aid is given by local people, not by professionals, as they cannot provide aid to so much people at once (and cannot be there in time). For some areas, where potential risk is high, it might be helpful to train volunteers to lead these rescue operations. As professional rescue teams will be too late and cannot in short time respond to the overwhelming number of affected people. This is especially truth for areas with potential risks for earthquakes (Bartels and van Rooyen, 2012). The role of professionals is mainly that they can contribute to the recovery of the vital infrastructure within the country. Their roll is primarily to prevent bigger problems to happen. Which is different from what media might portray them, as the rescuers of lives.

With earthquakes, there is a clear distinction between direct and indirect casualties. Within the first group we have people that die directly on the spot. In addition there is a group that has lost too much blood, their vital functions are too much affected, or their state is so weak that they die within a few hours to a few weeks after the disaster (Lechat, 1990). In the second group we have people that die within a few hours or a few days without direct access to healthcare. Think of people buried, waiting to be freed, people that lose blood and people with severe multiple injuries. Under normal circumstances these people are 'perfectly' treatable, but only when they get relief. The overwhelming number of injuries, lack of infrastructure (or destroyed infrastructure) are important constraints that cause these 'unnecessary' deaths and injuries (Schultz et al, 2005). Within this group, we also find people with chronic diseases, these people can have problems to get their medicines or miss their regular treatment/health check. This can worsen their sickness which can have long term effects (Epitrends, 2012). Within this phase, also new casualties arise, water sources are often contaminated (for developed as well as developing countries) (Perara et al., 2012, CDC 2010). When people return to their homes, mold can be a serious threat (Perera et al., 2012).

LONG TERM EFFECTS

Earthquakes usually cause a great amount of injuries. When these injuries are not treated well, (and when they are) they can have serious long term effects (WHO, 2008). When people miss limps they might not be able to work anymore (or to do the work they used to do). The care of these people can become an economic burden on their families and society in general. (World Bank, 2008 cited by Wisner, 2009, OCHA, 2008 cited by Wisner, 2009, Kumar et al., 2005 cited by Wisner, 2009).

When we look at the long term effect of earthquakes, we see that an earthquake can have an effect on already vulnerable (ill) people. Kobayashi et al. find that people with asthma (and other lung diseases) visited the hospital more often in the first few weeks after the Japan earthquake of 2011. This normalized after six weeks (kobayashi et al., 2012). In addition, a significant number of people is affected by cardiovascular diseases in the first few weeks after the disaster, this continues up to six weeks after the earthquake (Bartels and van Rooyen, 2012). Liu et al. found that after the 2008 earthquake in Sichuan, China, children faced post-traumatic stress syndrome and anxiety, which continued after six and twelve months after the earthquake. Older children had more problems and especially the ones who were exposed to death, bereavement and extreme fear had psychological problems (Liu et al, 2011). Besides mental health problems, earthquakes can have effect on physical health, especially the effect of dust, from collapsed buildings and from fires, can cause serious health problems (mainly respiratory diseases) (Alexander, 1996).

TSUNAMIS

Earthquakes, can stand in itself, but can also create a tsunami. The epidemiology of a tsunami is very similar to that of a cyclone or a hurricane (van Rooyen and Leaning, 2005). Nonetheless the tsunami itself is a sort of flash flood (on a coastal line). If the earthquake or tsunami leads to crowding it is likely that diseases will spread (van Rooyen and Leaning, 2005). Especially young children are (deadly) vulnerable for respiratory diseases and particularly measles, when they find 'shelter' in refugee camps (van Rooyen and Leaning, 2005).

DROUGHTS

During the last century droughts have been major killers, accounting for a majority of all deaths caused by natural disasters. At the moment, Africa is the only continent in the world where droughts have led to large scale acute malnutrition in the last 40 years. The last famines outside of Africa have been in China (1958-1961 during the great leap forward) and in Bangladesh (1974). (leaving out the mid- 1990's famine in North Korea as an exceptional situation).

Droughts are generally speaking the occurrence of a period of time with very low rainfall levels. It depends on regions, local demand and coping strategies whether lower than normal rainfall leads to a drought (Kalis et al., 2009). As such, good rainfall in one region would be considered as a shortage of rain in another region. In addition; famines are highly preventable. They develop over time and are well manageable, their occurrence is not per se due to droughts. A failing harvest is not per se the cause a famine. In such cases a declining harvest combined with market failure, a failing state and a failing response, leads to famine (Devereux, 2009). Amartya Sen states that "there has never been a famine in a functioning multi-party democracy." (Sen, 1999 cited by Devereux 2009, Sen, 1981) Whether this is true is another discussion, nevertheless it is clear that in developed countries famines have not appeared for quite a while.

Droughts, leading to a famine occur in countries where chronic food shortages as well as poverty and under-5 mortality rates are high. The population is vulnerable, the market is vulnerable, production techniques are vulnerable and the state is vulnerable. If response is also undermined by international diplomacy and/or strategic interests from international donors, this leads to large scale famine. As Devereux puts it clearly: "All famine-prone countries are landlocked and extremely poor, with levels of malnutrition and premature mortality so high that a 'permanent emergency' has become 'normalised'" (Devereux, 2009). The health effects of droughts can thus lead to malnutrition and associated diseases. In developed and developing countries, droughts can lead to air pollution, due to pollen in the air as well as wildfires (Kalis et al, 2009). This can lead to respiratory diseases, but also to pneumonia and bronchitis. In addition droughts can give rise to vector borne diseases as water sources get smaller, become more swampy and flowing water becomes stagnant. Furthermore these water sources get warmer, which makes it a better habitat for several diseases (CDC, 2010). Another factor that influences water quality is that lower water levels can increase the concentration of toxic materials in the water (CDC, 2010). Droughts can also lead to infected groundwater, when water levels drop to fast, there is an increased risk for contaminated water (CDC 2010).

Hygiene is very important, though in cases of droughts, people are careful with the use of water. This can have effect on even basic hygienic measures such as washing hands (CDC, 2010). The impact of droughts is mainly on infectious diseases, there is not a known effect of droughts on non-communicable diseases. What we know is that this group is more vulnerable overall. When a drought is causing a drop in living conditions, this might affect those that are chronically ill. Especially people with asthma or other respiratory diseases are vulnerable for the effects of droughts, due to pollen and dust in the air (CDC, 2010).

LONG TERM EFFECTS

The long term health effects of droughts are generally described above. The major long term effect of droughts on health is malnutrition and in some cases even famine.

As described above, a drought can have a negative effect on air as well as water quality. This period of worsened air/water quality can have long term effects on health. During the period of lower than normal air quality one can obtain a respiratory disease. These illnesses can endure even when the drought has already ended. The same holds for worsened water quality. The effect of bad water quality affects people with diseases that can endure for a longer period. There is also an effect through worsened economic status. As (ground) water quality has an effect on soils. When soils (or rivers) are contaminated, this has effects on harvest, from fisheries as well as from what one grows on their soils. When soils are not, or not enough, arable any more, people face lowered harvest from their soils. This can cause long-term economic effects, and through economic effects also lowered health status. As people are less able to produce (or buy) good food or to pay for good health care. Lower harvests have an effect on malnutrition. Which adds up to the above described risk for malnutrition through the direct effects of the drought itself.

1.4 EPIDEMICS AS A LONG TERM EFFECT

In history epidemics (like the black death) have taken millions of lives. In recent history epidemics are not that big anymore. Lately there has been quite some rumour about SARS and the Mexican flu, but these are not comparable with historical outbreaks. The biggest threat for epidemics does not come from natural disasters, more likely are they caused by human disasters, such as wars (Noji, 1997). There is a general believe that there is a high risk for epidemics after disasters. Though most of the time, the risk for the outbreak of epidemics is low ((Floret et al., 2006, UNHCR, 2011, van Rooyen and Leaning, 2005). Overall natural disasters do not cause great population movements (Noji 2005 cited by Watson et al, 2007). Displacement, especially of already vulnerable and undernourished people, is a major threat for the outbreak of epidemics. Especially the combination of these two factors;

crowding, and vulnerable people can be disastrous (Lifson 1996 cited by Watson et al, 2007, vanRooyen and Leaning, 2005, UNHCR, Noji 1997 cited by Tekeli-Yesil, 2006). In the case of wars, it is much more likely that these conditions are met. As long as people do not flee their houses and crowd together, these risks remain low. Most of the time good hygiene practices and good response from the health sector (and aid relief/government) are sufficient to tackle the risk for epidemics.

The majority of victims after disasters are not deadly affected. The majority of casualties are 'small': a small wound that is not treated can get infected, diarrhoea can lead to dehydration etcetera. In such a way small diseases can have major effects on human health. The professionalization of the relief sector has declined the risk for these kind of effects. Starting from the 1970's, research and documentation have led to guidelines, recommendations, standardised emergency units, assessment techniques, supply management techniques and technical manuals (Noji, 1997). All these interventions and knowledge make governments and relief agencies capable of coping with the risks of epidemics after disasters.

Recently some researchers have emphasised that there are multiple relationships between communicable diseases and chronic-diseases. Hepatitis B and C make people more vulnerable for cancers. HIV is related to dementia, and measles could lead to blindness. In addition there is proof that chronic infections can lead to cancers (Ogoina and Onyemelukwe, 2009, O'Connor et al, 2006, Bach 2002, Maher et al, 2010). As people are likely to have chronic malaria, or chronic respiratory infections (due to tuberculosis or cooking on charcoal) these chronic infections may in the future lead to non-communicable diseases (Ogoina and Onyemelukwe, 2009, Bach 2002, Kapiga, 2011, Maher et al, 2010). See the appendix for a list of infectious diseases that have been linked to non-communicable diseases. It is only recently that researchers have listed these relationships. For single diseases these relationships were already known, but only recently researchers have emphasised a pattern of communicable diseases that lead to non-communicable diseases. It can explain why there is such a high prevalence of non-communicable diseases in developing countries (Abegunde et al 2007, cited by Dalal et al. 2011, O'Connor et al, 2006). In general people tend to think that developing countries experience lower rates of NCD's, which is a big understatement (Dalal et al, 2011, Maher, 2010). It will be a great challenge for policymakers, to tackle this double burden of disease.

1.5 POST-TRAUMATIC STRESS

As we described the risk for epidemics after disasters in general, it is also good to discuss the risk for post-traumatic stress after disasters. This is a general risk that counts for every type of disaster (Felix et al., 2011, Kessler et al., 2008, Kolves et al., 2012, Logue et al., 1981, Weems et al., 2007, Weems et al., 2010).

Weems et al. describe how stress and anxiety increased in the period after hurricane Katrina struck the USA. Liu et al. find that the 2008 earthquake in Sichuan, China, children faced post-traumatic stress syndrome and anxiety, this continued after six and twelve months after the earthquake. They find that especially older children had more problems, especially the ones who had been exposed to death and bereavement (Liu et al, 2011).

March finds that if people are evacuated this leads to “total disruption of an individual’s personal coping mechanisms.” As people stay in shelters, they lack privacy and they act outside their normal atmosphere. Lack of communication makes it difficult to get in touch with their natural support groups or others in their community. They are surrounded by people in the same isolated position (March, 2002). Social support after natural disasters is believed to be an important constraint for victims to cope with their trauma, and increased stress. If people do not find ways to cope with stress, originating from the disaster (or its direct aftermath), stress can cause serious health problems. Increased stress after disasters might also lead to a rise in hospital attendance. (Abrahams et al., 1974 cited by Ohl & Tapsell, 2000, Bennet, 1968 cited by Ohl & Tapsell, 2000).

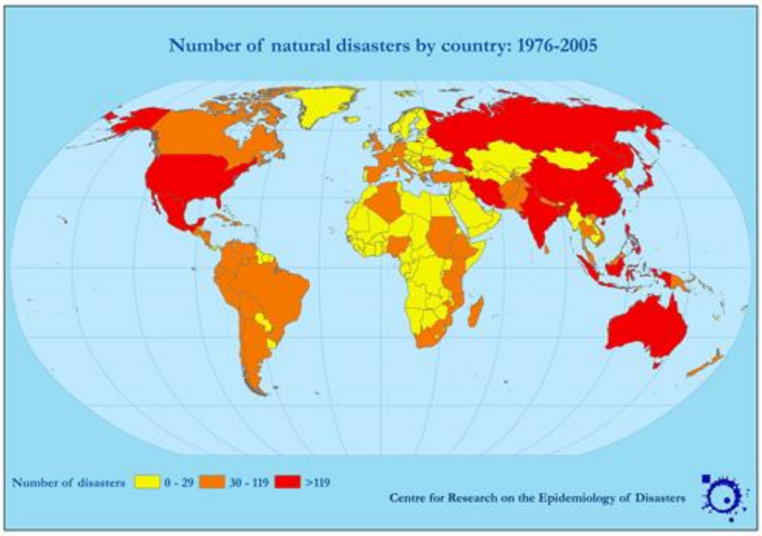
A thorough literature overview on suicide rates after natural disasters is given by Kolves at all. They find that; “overall, there does not seem to be any clear direction in suicide mortality following natural disasters, as different studies show different patterns.” Kolves and colleagues emphasize one interesting study on the Nantou earthquake in Taiwan in 1999. After this earthquake a major increase in male suicide rates has been reported. According to the researchers, economic changes in Taiwan at that moment might have been of influence on suicide rates (Kolves et al. 2012). It thus seems that the natural disaster itself can be an important accelerator of suicide rates, but it depends on other factors whether the effects of a natural disaster make people end their lives or not. In some cases the male suicides rates increase while in others the female suicide rates increase and cases in suicide rates are stable (Kolves et al., 2012). Exposure level; severe destruction to property, injuries to relatives, and danger to life are important factors that influence suicide rates. In addition initial income or economic circumstances (unemployment, overall economic environment) seem to influence suicidal rates (Chuang and Huang, 2007; Kessler et al., 2008; Liu, 2004 cited by Kolves et al., 2012

Most studies focus on the first year after the disasters (Rhodes et al, 2010, Gordon et al. 2010 cited by Kolves et al., 2012). Some go further, up to a period of eighteen months after the disaster (Kessler et al., 2008). However, just a few studies go beyond these eighteen months. Felix et al. did and found that the significant results after eighteen months had faced out in a new study 30 months after a hurricane George struck Puerto Rico in 1998 (Felix et al., 2011). But others even find significance up to 24 and 30 months after the disaster, as did Weems et al. (Weems et al., 2010 cited by Felix et al, 2011).

1.6 DIFFERENCES AROUND THE WORLD

Another important factor in the epidemiology of disasters is the region in the world. Some regions in the world are more vulnerable for natural disasters than others. For instance tropical storms typically exist between a latitude of 30° North and 30° South. (Shultz et al, 2005)

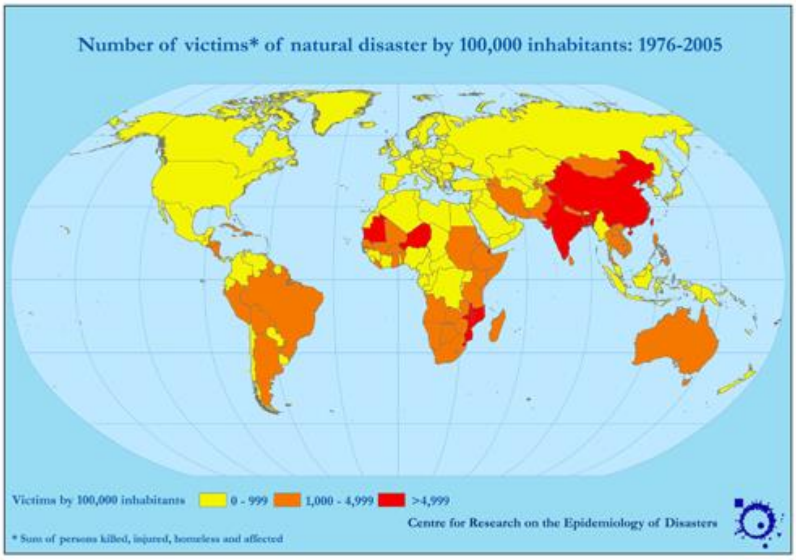
Figure 3.Number of natural disasters by country (1976-2005)



If we look at the occurrence of natural disasters around the world, we see that especially, Oceania, Northern America and Asia (including Russia and the middle east) are facing a high number of natural disasters. The African continent is facing much less disasters, the same holds for Eastern Europe, Scandinavia and former Soviet Union states. Western Europe and most of Southern America face a moderate amount of natural disasters. Differences can be due to several factors, namely the size of a country (though Canada faces less natural disasters than Japan), whether disasters are reported at all (in the case of Greenland, this is very unlikely), the number of people living in a country (as one qualification for a natural disaster is that ten or more people are reported to be killed by the natural disaster (EM-DAT)), the distance to the equator (as tropical storms typically occur within 30° North and South of the equator (Shultz et al., 2005)), it might also be reasonable to expect that droughts are more likely to occur in areas that are closer to the equator).

Another way to look at disasters is by their number of victims per 100.000 inhabitants (see figure 4). In this way, we see different patterns, Northern America, Europe and Russia are very save places. While Southern America and Australia are moderately affected. Asia and Africa are the only regions with high risk. For Asia, this is mainly in South, South-East Asia. In Africa moderately to highly affected regions are southern, eastern and western Africa, northern and central Africa appear to be quite save.

Figure 4. Number of victims of natural disasters by 100.000 inhabitants (1976-2005)



1.7 OVERVIEW OF THE EXPECTED RELATIONS BETWEEN DISASTERS AND DISEASES

Table 1 gives an overview of the expected relations between disasters and diseases (in the categories we will also use in our regressions). As such the table below is a summary of the above paragraphs. We emphasize the direct as well as the indirect effects of disasters. All disasters have side effects. These side effects on their turn, do also have an impact on health. For example earthquakes destroy infrastructure, such as hospitals. This affects health, as health care services are temporarily not available. Droughts are the only type of disaster that do not destroy infrastructure (though in general famines only occur in countries where basic infrastructure levels are already low).

Table 1. Expected relations between disasters and diseases (with sources)

	Direct effect				Indirect effect		Sources
	Communicable	Non-communicable	Injuries	Health Impact	Healthcare	Sanitation	
Geophysical	X	X	D	Stress, mental health, respiratory diseases, skin problems (in case of crowding, outbreak of respiratory diseases), injuries (disability).	X	X	Alexander (1996), Bartels en van Rooyen (2012) CDC (2010), Epitrends (2012), Lechat (1979), Lechat (1990), Perara et al. (2012), Schultz et al. (2005), WHO (2008), Wisner (2009)
Meteorological	X	X	D	Stress, mental health, contamination by toxic materials	X	X	Caroll et al. (2005), Few et al. (2004), Goodwin and Donaho (2010), Gregg et al. (1989), Keim (2006) Lechat, (1979), Perera et al. (2012), Shultz et al. (2005), Wisner (2009)
Hydrological	X		D	Stress, mental health, exacerbation of chronic diseases, injuries (disability)	X	X	Bach (2002), Bartels & van Rooyen (2012), Du et al. (2010), Epitrends, (2012), Few et al. (2004), Fewtrell and Kay (2006), Kunii et al. (2002), Maher et al. (2010), O'Connor et al. (2006), Ogoina and Onyemelukwe (2009), Ohl & Tapssell (2000) UNHCR (2011), Warraich et al. (2010), Watson et al. (2007), Weinstein (2010)
Climatological	X			Respiratory diseases, in case of crowding, outbreak of respiratory diseases)			CDC (2010), Devereux (2009), Kalis et al. (2009)

X = Based on literature study, a relation is expected.

D = There is evidence, but only for developing countries.

For a more extensive overview of the different typologies and definitions for every type for disaster, see table 2.

2 THEORETICAL FRAMEWORK

Our hypothesis is that there are long term effects of natural disasters on health. This effect can easily work through specific diseases, or it can only be present among certain types of disasters. The WHO data allows us to work with three types of diseases (communicable, non-communicable and injuries). In addition the disaster data allows us to work with five types of disasters, see below for their definitions and the main disaster types in every category. We only use four types of disasters, as we left out biological disasters. Biological disasters are too much correlated with other types of disasters. As epidemics can be the disaster, as well as being the result of another disaster. Using these categories is interesting as it gives us a bigger chance to get results. What is more, it gives us a better understanding of how natural disasters affect health in the longer run.

Table 2. Disasters as categorised by EM-DAT (EM-DAT, 2012d)

Subgroup	Definition	Disaster Main Type
Geophysical	Events originating from solid earth	Earthquake, Volcano, Mass Movement, (dry),Tsunami
Meteorological	Events caused by short-lived/small to meso scale atmospheric processes (in the spectrum from minutes to days)	Storm (tornado, cyclone, snowstorm)
Hydrological	Events caused by deviations in the normal water cycle and/or overflow of bodies of water caused by wind set-up	Flood, Mass Movement (wet)
Climatological	Events caused by long-lived/meso to macro scale processes (in the spectrum from intra-seasonal to multi-decadal climate variability)	Extreme Temperature, Drought, Wildfire

As described in table 1, we expect to find several correlations between the diseases and disasters. Let us summon which relations we are expecting. We list these relationships per disease category.

Communicable diseases

What we expect to find is that all types of disasters correlate with communicable diseases. This works mainly through indirect effects. The existence of breeding sites 'created' by the disaster can cause massive outbreaks of communicable diseases, in some cases this is diarrhoea in others this can be typhoid or cholera (Kunii et al., Waraich et al). The risk for communicable outbreaks rises sharply when people flee the area. In these cases people go to crowded safe havens to look for food (aid). These areas are very vulnerable for communicable diseases (Noji & Toole, 1997, Watson et al., 2007). Only few disasters are likely to cause people to flee their normal habitat. In the case of climatological it is likely that people, affected by hunger will be extra vulnerable for diseases, which makes the outbreak of communicable diseases very likely.

However it seems logic to find a relation between communicable diseases and the four types of disasters, some researchers warn to believe in the myth that 'epidemics and plagues are inevitable after every disaster' (Noji & Toole, 1997). "The reality is that epidemics do not spontaneously occur after a disaster….the key to preventing disease is to improve sanitary conditions and educate the public." (Noji & Toole, 1997) see also (Watson et al., 2007)

Non communicable diseases

There is some basic evidence for the relationship between non-communicable diseases and disasters. (Felix et al., 2011, Kessler et al., 2008, Kolves et al., 2012, Logue et al., 1981, Weems et al., 2007, Weems et al., 2010). These studies have mainly been focusing on mental health; depression, post - traumatic stress syndrome, stress, suicide etc. In addition their scope has been on tropical storms, tsunamis and earthquakes. Because of the lack of evidence, I mark these with an E from expected.

There is evidence that non-communicable disease can suffer from a temporary unavailability of health services (Lechat, 1979, Epitrends, 2012).

More recent studies have linked communicable diseases with non-communicable diseases (Ogoina and Onyemelukwe, 2009, O'Connor et al, 2006, Bach 2002, Maher et al, 2010). Which would mean that biological disasters are related to non-communicable diseases. Measles is related to blindness, hepatitis B and C are related to cancer and several parasite have been associated with asthma. For a more thorough overview see the appendix. Especially the emphasise that recurrent infections can lead to cancers or malfunctioning of vital organs is interesting. Which would mean that multiple respiratory diseases or multiple liver infections lead to asthma/chronic liver problems or even lung/ liver cancer. Several of these relationships were known for quite some time, but it was only recently that researchers recognised a general pattern. Which was that communicable diseases are often the cause, or at least one of the causes, for chronic diseases (Ogoina and Onyemelukwe, 2009).

Injuries

As described in the chapter 1, the amount of people reported killed has declined throughout last century. This can be explained by better precautionary matters, better health infrastructure and better housing. The same story can be told for people affected, natural disasters do not per se cause a lot of victims (Lechat, 1979, Bartels & van Rooyen, 2012, Shultz et al., 2005). Especially in developed countries, where housing is good and people can be warned (for instance for a tropical storm) not so much people are injured. So only in countries where development is low, significant injuries are expected (Shultz et al., 2005)

Among the different natural disasters, we find that especially earthquakes cause a lot of injuries, especially crush injuries (Lechat, 1979). People expect that storms and floods do also cause a lot of injuries, this is not per se truth as people are often not affected at all, or deadly wounded (Lechat, 1979, Bartels & van Rooyen, 2012, Shultz et al., 2005).

2.1 METHODOLOGY

Researchers have mainly been focussing on the short term effects of natural disasters on health. Our hypothesis is that natural disasters do have effect on long term health (1-2 year). The relation between health and disasters is exogenous, which makes it relatively easy to study.

Dataset

To measure the longer run effects of disasters, we use DALY data as an estimator for health. DALY is an artificial indicator created by the World Health Organization (WHO) designed to give an indication of Disability Adjusted Life Years. The official definition is: The sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability. We calculate the difference between the DALY data in 2002 and 2004. We regress this against a dataset in which disaster data as well as control variables are included. See below for the schematic overview.

The disaster data comes from EM-DAT (university of Louvain), we will use the four categories as listed in table 2. The natural disasters will be listed by country as a count variable. Which means that we expect that the more disasters have occurred, the higher the effect is on human health. Due to the fact that disasters are very different in their effect, we use the definition from Munich Re for great disasters to extract the bigger disasters. 'Small' disasters are less likely to have an effect on country level (which is what we measure with our data). With the selection of great disasters, we extract the disasters that are likely to have an effect on our data. See appendix 1 for definitions on disasters as well as on great disasters.

In addition we use 21 explanatory variables of which a relationship is assumed (based on literature study). These variables are measured in the years before/and during the disaster period, in order to measure the (pre-)disasters conditions (we use the averages over these years). The data covers world wide data, which contains 182 countries, most likely some of these will be dropped out, due to missing data.

Table 3. Research set-up

	Daly	Disaster data	Control variables
Dataset:	2004 minus 2002	2002-2004	1999-2002*

*One exception is GDP, of which we use the data from 1982. This is because there is too much correlation between DALY and GDP 2002. By using GDP 1982 we control for initial development levels.

Robustness regression

By using Robustness regression we test whether the change in DALYs can be explained by the occurrence of a natural disaster. This method is used when there is a believe that one or more of the underlying assumptions for a 'normal' regression has been violated. We started our analysis with ordinary least squares method, but this gave very confusing outcomes, as it resulted in negative results. This would mean that disaster would be beneficial for health, which is the opposite of what we expect to find.

In our case, it is likely that our data is not perfectly linear, the threat of outliers is pretty big. What is more, as we work with all countries in the world, we work with the poorest as well as the richest countries. It is well possible that there are groups of countries that lay far from each other, which makes it impossible for ordinary least squares regression to get relying results.

Robust regression in Stata is based on ordinary least squares regression. Stata starts with OLS, while it measures Cook's D for each observation. It then drops any observation with Cook's distance greater than 1. With a combination of Hubers weight and biweighting techniques, other variables are weighted and revalued (Verardi & Croux 2009, cited by IDRE, 2013). By doing this, Stata enables us to use as many as possible data entries. Otherwise they would be excluded from our analysis. Robust regression is about 95% as efficient as OLS (Hamilton, 1991, cited by IDRE 2013). The power if this method lies in its prediction power. By using 21 explanatory variables, we hope to optimise the prediction power of the model.

The least squares method is a method that draws a linear line through the variables, which represents the shape of the variables the best. By taking the distance from every variable to this line, squaring it and comparing it to the distance between the variables and the mean (also squared), one can calculate R, which gives the prediction power of the model. The higher R, the more is explained, 0 is perfect misfit, 1 is perfect fit (all the variables are on the line) (Ott and Longnecker, 2010) (Field, 2009) (Verbeek, 2008).

The outcomes are: the intercept; α, the slope; βX (explanatory variables) and the prediction error; ε.

When we put this into a formula we get:

$$lnDALY2004_p = \alpha + \beta X_{it} + \delta lnDALY2002_p + \varepsilon_{it}$$

By extracting $lnDALY2002_p$ from both sides of the equator we get:

$$lnDALY2004_p - lnDALY2002_p = \alpha + \beta X_{it} + (\delta - 1)lnDALY2002_p + \varepsilon_{it}$$

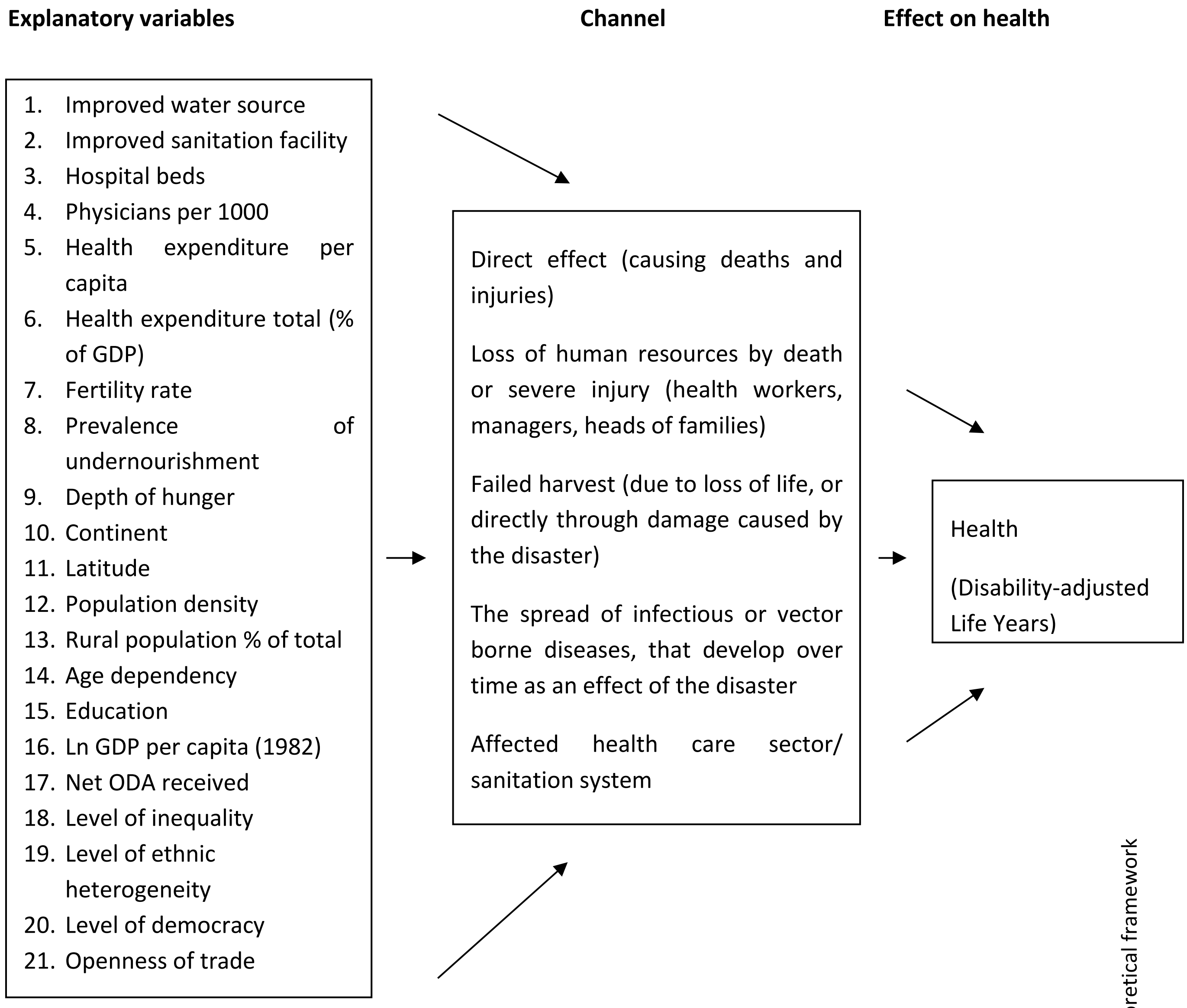
We take the difference between health (measured as DALY) in year t (2004) and health in year t-2 (2002). We regress the difference in health against DALY 2002 (our baseline study). In addition we use our explanatory variables (see figure 6) plus the disaster data. What is not explained by our variables will be measured by ε (the error term).

Where $DALY_t$ is disability adjusted life expectancy in 2004, where year 2002 represents DALY for the year 2002. Where p stands for; corrected for population size and i stands for country (as 182 countries are included). DIS stands for the occurrence of a disaster (this variable is measured with a counted variable). ε is the sum of residuals. All control variables are measured over 1999-2002. The disaster data is measured over 2002-2004.

2.2 MODEL

Our hypothesis presumes that there is a negative relation between natural disasters and health. This relation works through five effects (direct effect, loss of human resources, failed harvest, spread of diseases, affected health care sector/sanitation system). It is beyond the scope of this research to measure how this impact works. The five effects are difficult to measure and there is too much overlap between the effects. To cover this, we use 21 explanatory variables that are related to one or more of the causal effects. For example, urban growth can have effect on the direct effects, as urban areas are more vulnerable for disasters, but in addition urban growth can explain the spread of infectious diseases, as these are more likely in crowded areas.

Figure 5. Research set-up



The above framework is based on the framework used by Ghobarah, Huth and Russet, 2004. They have done several studies where they use DALY (or its precursor, HALE) to predict the long-term effects of wars (Ghobarah et al., 2003, Ghobarah et al., 2004b) but also to explain the differences worldwide in human health/human misery (Ghobarah et al., 2001, Ghobarah et al., 2004a). Our framework (figure 5) is based on their work on human misery (Ghobarah et al., 2001, Ghobarah et al., 2004a). In their study they use the variation in HALE and explain this by GDP, income inequality, education level, ethnic heterogeneity, rapid urbanization enduring international rivalry and democracy. We will include the same indicators, but we replace international rivalry with the data on disasters (which we get from EM-DAT). In addition we do not use the growth in urbanization, but urbanization levels, as in our case crowding is important, not the speed of increase.

In total we start our analysis with 21 explanatory factors, in the following, we will explain why these factors are related to health and why we include them in our model. As mentioned above several indicators are based upon the work of Ghobarah, Huth and Russet, but we include some extra. This will enrich our model, at the same time we need some extra (mainly geographic and demographic) indicators as natural disasters have different properties than wars.

Quality of sanitation/ health sector

The ability of people to secure a basic level of hygiene and to attain medical facilities is a very important factor to measure how well people are able to react to a disaster (Perara et al., 2012, Ohl & Tapssell, 2010) If peoples basic health level is already low, they are more vulnerable when a disaster hits their place of living. To measure the level of hygiene and the quality of the medical sector we use several indicators. We use health expenditure per capita and health expenditure as a percentage of total GDP to get insight in how much of a countries resources are being allocated to the health sector. We use fertility rate, which is a good indicator for development levels (Sachs & Malaney, Rosling, 2009). The last two indicators give insight on chronic malnutrition, which is an important contributor for famines, as they are a result of droughts (Devereux, 2009). But off course chronic malnutrition makes people also more vulnerable during the occurrence of other disasters.

1. Improved water source
2. Improved sanitation facility
3. Hospital beds
4. Physicians per 1000
5. Health expenditure per capita
6. Health expenditure total (% of GDP)
7. Fertility rate
8. Prevalence of undernourishment
9. Depth of hunger

Geographic/demographic circumstances

The place in the world is off great importance, for instance in the case of droughts, as they are more likely to occur in places where rain levels are usually low. Tropical storms typically exist between a latitude of 30° North and 30° South (Shultz et al, 2005).

In addition it is important if the area that is struck by a disaster is densely populated or not. This works through a direct effects. An earthquake in Greenland causes less deaths than an earthquake in or nearby a big city in Japan. There is also an indirect effect, as diseases are more likely to spread in crowded places (van Rooyen and Leaning, 2005, UNHCR, Watson et al, 2007, Noji 1997 cited by

Tekeli-Yesil, 2006). Age dependency is giving us insights in how much young and old people (people who are dependent of others for income and care) there are for every grown up (the people that are expected to provide). The more people there are depending, the harder it gets to provide these people a basic level of care and to resist and recover from a disaster (vanRooyen and Leaning, 2005, Ngo, 2001)

10. Continent
11. Latitude
12. Population density
13. Rural population % of total
14. Age dependency

Development level

The health effects of disasters are generally higher in developing countries compared to developed countries. This is partly explained by their health status. Also level of education and buying power are important factors, they explain the capability of people to prepare and recover from disasters (Sen & Dreze, 1999 cited by Ghobarah et al, 2004b; Evans et al., 2000a cited by Ghobarah et al., 2004b). We use GDP per capita for the year 1982, as the correlation between our DALY data and GDP 2002 is too high. The data for 1982 gives a good insight in how GDP levels influence health. In addition we use net ODA (official development aid) received. Receiving ODA is a good indicator for being developed or not.

15. Education
16. Ln GDP per capita (1982)
17. Net ODA received

Level of diversity

The existence of minorities in countries is an important explanatory factor, as minorities are often suppressed (or supress other minorities). In addition we add level of inequality. The overall GDP in a country can be high, but the spread of wealth (and other favours) might be very unequal. (Przeworski et al., 2000, Moon, 1991; Moon and Dixon, 1992; Wilkinson, 1996; Foege, 2000:7, all cited by Ghobarah, 2004b)

18. Level of inequality
19. Level of ethnic heterogeneity

Institutions/openness

The last two explanatory variables are explaining the level of the institutions and the openness of a country. According to Sen, famines do not happen in democracies (Sen, 1981). In democracies, the people demand good policies, and good policies are important to take precautionary measures. Policies for famine prevention, laws for the construction of houses (to prevent them from collapsing) but also the construction of dikes and a good quality health care (Przeworski et al., 2000, Olson, 1993; Bueno de Mesquita, Morrow, Siverson, and Smith, 1999; Lake & Baum, 2001, all cited in Ghobarah et al., 2004b).

Openness of trade is explaining how open a country is for other countries. Countries that are more open, have less difficulties in letting foreign aid workers, medical supplies in.

20. Level of democracy
21. Openness of trade

2.3 DATA COMPOSITION

Our analysis is done with DALY data. This artificial indicator composed by the WHO is a very good indicator to measure health. The official definition is: "The sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability." (WHO) To correct for population size, we divide the DALY indicator by population size (we do this apart for DALY2004 and DALY2002). The second step is that we take the difference between the two indicators (which has been put in logarithmic skill) to get the increase or decrease of DALY (in percentages) between 2002 and 2004. To finalize our indicator we put the data into logarithmic scale. The DALY data is divided into three categories; communicable diseases, non-communicable diseases and injuries. Together with the total data (which is the sum of these three categories) we thus have four DALY indicators.

The disaster data comes from EM-DAT, which is part of the university of Louvain. This research unit (specialised in disasters) keeps track of all (reported) disaster around the world. In order to fit within their database, at least one out of four conditions must be met (EM-DAT, 2012a):

- Ten or more people reported killed.
- Hundred or more people reported affected.
- Declaration of a state of emergency.
- Call for international assistance.

Our data is constructed in a way that we count the amount of disasters. We do not keep track of the different disasters. We do this to see how disasters affect countries, one disaster might not have that much impact, but the occurrence of multiple disasters within a short time (in our case, three years) might have. In this way we measure the increased impact after multiple disasters. In addition we use four categories used by EM-DAT to categories disasters (see table 2). We use these categories, as disasters have different effects on health (as described in the first chapter). We expect to find outcomes within some categories, but not all (see table 1). We use count variables for this data too.

In addition we use a definition of Munich Reinsurance (Munich Re). This definition enables us to extract all major disasters. This leaves out the majority of disasters, but extracts the ones with a major impact. The Munich Re definition is as follows (Munich Re, 2006): The affected region's ability to help itself is distinctly overtaxed if:

- Interregional or international assistance are necessary
- Thousands of people are killed
- Hundred thousands of people are made homeless
- Substantial economic losses
- Considerable insured losses

The strength of this definition lays mainly in the fact that its focus is not only on casualties, but also on damage. This gives us a better interpretation of disasters, first of all because the disasters with 'real' impact are extracted. Secondly because it controls for level of development. Disasters are known to cause more deaths in less developed countries, which makes them easier to be taken up into data, whereas a disaster of the same size would not be reported in a developed country, as its impact would not be big enough. The Munich Re definition makes it easier to control for these problems, as they also take into account the economic and insured losses.

For an overview of the amount of disasters included in our dataset, see table 4.

Table 4: Overview disasters by category

	All	Large
Total	1283	193
Hydro	512	76
Meteo	302	51
Clim	149	43
Geo	132	23

As some countries are bigger than others, we need to correct our disaster data for country size. We do this by dividing the disaster data by country size. We multiply this outcome by 1000 in order to maintain normal coefficients (this does not have effect on significances).

2.4 SELECTION OF EXPLANATORY VARIABLES

The selection of variables is done through a general to specific analysis. This is an analysis in which the regression is done several times. In every new regression, the most significant variable will be left out. This is done until none of the explanatory variables gives a significant value. These 'rest' variables are kept out of further analysis. We do this, in order to extract only the most significant variables. In our further analysis we will only use these most significant variables, as too much variables will result in more degrees of freedom. We try to create the optimal balance between degrees of freedom and explanatory variables in order to get a model with the biggest prediction power. As we only have a small sample, too much degrees of freedom will affect our prediction power.

We select the variables one by one. When we would only do a single regression and then select the significant variables, we would not correct for correlation between the data. As variables are interrelated, they are sometimes not significant, as the variety in (DALY) data can already be explained by another variable. With every regression, indeed the significances vary. Within this general to specific analysis, the disaster data is still left out as an explanatory variable as we do not want the correlation between disaster data and the other variables to influence the selection of the explanatory variables.

We start with 21 explanatory variables of which a relation is expected, based on literature study (see figure 5 and paragraph 2.2). In this general to specific analysis we use ln(daly04)-ln(daly02) (both corrected for population size) as the dependent variable. Only a few variables are significant, namely; LnGDP82, latitude and openness of trade. Other variables are left out because they are not significant or because they correlate too much with the DALY data. Instead we add another variable, which is the DALY variable over 2002, we add this variable in order to measure the increase in DALY (and not the levels of DALY). In this way DALY2002, operates as our baseline study. The explanatory variable for continent is divided into six dummy variables, one for each continent. STATA leaves out the dummy for Oceania, as there are not enough countries on this continent to include reliable results.

We decide to use the following variables in our regression: lndaly02, 6 continent dummy's, ln GDP 82, latitude and openness of trade. We only use the data on great disasters (based on the definition of Munich Re) as this data is much more robust than the total disaster data. See table 5 for the results of this regression.

Important in interpreting the results is that the sign is opposite of what you might expect, as a positive result is negative instead. Which is the same as with a positive blood test, which is clearly a negative outcome for the patient. For the analysis we use the command RREG, which stands for robust regression. As explained in paragraph 2.3, we use this method to produce more reliable results. Other analyses might not be reliable when basic assumptions are not met. Robust regression is designed to circumvent these limitations.

Table 5: Regression with all selected variables

difflndaly0402_allc	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lndaly02_allc	-.1105341	.0298135	-3.71	0.000	-.1695342	-.1695342
Ln GDP 82	-.0225246	.009398	-2.40	0.018	-.0411229	-.0039263
Latitude	-.0024555	.0008376	-2.93	0.004	-.0041132	-.0007978
Openness of trade	-.0004044	.0001846	-2.19	0.030	-.0007697	-.0000392
Africa	-.0169329	.0437512	-0.39	0.699	-.1035152	.0696494
Asia	.0021554	.0405526	0.05	0.958	-.0780969	.0824077
Southern America	-.0088325	.0451567	-0.20	0.845	-.0981963	.0805313
Europe	.1007424	.0478524	2.11	0.037	.0060439	.1954408
Northern America	.0128569	.0412273	0.31	0.756	-.0687308	.0944446
Cons	.024399	.024399	0.37	0.715	-.1075795	.1563774

Table 5 gives us the results of our first regression with the selected variables (without disaster data). Lndaly02 is significant, which means that the increase in DALY over the years 02-04 can partly be explained by the level of DALY in 02. As this variable acts as our baseline study, we must conclude that a baseline is indeed explaining part of the variance of the difference between DALY over the years 02-04.

The continent dummies are not significant, except for Europe. As the health status of Europe is relatively high, it is not likely that health increased a lot in Europe during the researched period. A small change can thus already be significant.

As mentioned above, Oceania is dropped by STATA. LnGDP82 (per capita) is significant. As we know that development level (and income level) is highly related to health, but also to health after disasters, we decided to use income 20 years before the disaster. This gives reliable information on health levels, but less correlation between income and health levels. Here we see that this data is indeed explanatory for the difference in health levels between 2002 and 2004. Latitude is also significant, as expected. As countries closer to the equator are more vulnerable for disasters (tropical storms, droughts see also paragraph 1.6). Our last variable is openness of trade, which is indeed significant. As we expected, countries that are more open for trade are also more open for health interventions from other countries. The constant term is not significant.

Table 6 Regression properties

Number of obs	136
F(11, 124)	4.70
Prob > F	0.0000
R-squared	0.2513
Root MSE	0.094

The total amount of countries used in this regression is 136 (out of a total of 182). The F-value is 4.70, which is significant. Which means that the null-hypothesis for the model is not true. This means that there are grounds to believe that an effect from 'outside' has got influence on the measured data. In our case we believe that disasters are having effect on health, which makes it possible for us to explore whether or not disasters are having an effect on our data.

The R^2 gives us the prediction power of the model. From the total variance to be explained, somewhat more than 25% can be explained. Root MSE is the standard deviation of the residual of the model. Which measures the variance of the residual in the model.

3 RESULTS

3.1 MAIN FINDINGS

Table 7: Outcomes per category

	All diseases		Communicable		Non-communicable		Injuries	
Total large	1.203988	**0.018**	.3311479	0.767	.3926771	0.470	1.080668	0.434
Hydro large	5.789555	**0.000**	1.336073	0.608	-.4278747	0.669	4.32007	0.252
Meteo large	1.375458	0.224	.8942812	0.760	1.402456	0.194	-2.081751	0.496
Clim. large	.6331997	0.423	-.7824797	0.697	.2730043	0.724	1.792663	0.393
Geo large	18.7316	**0.000**	-1.26369	0.899	.3586896	0.925	-12.88398	0.657

The above figure gives us the results for the several regressions for all different categories. We see that in total we have three significant results (those in bold letters). Of which two results up to 0.000. The significances are all among the category all diseases, which means the sum of the three sub-categories (communicable, non-communicable and injuries). In some way, only the sum of diseases is significant. This can be due to the effect of adding up the diseases. For example the chance of someone getting sick after an earthquake is bigger than the chance of getting one specific disease. As a result, we are not able to explain how the specific categories of diseases are affected as a long term effect of natural disasters. Nonetheless, what we can conclude is that we found evidence for our main theses (natural disasters have a negative long-term effect on health). In addition we found two other significances, which is great. Let us discuss the three significances one by one.

Total large

Though not the most significant, we found that the total large disasters are related to the difference in DALY between 2002 and 2004. This is an encouraging result, as it confirms our expectation that natural disasters are indeed having long term effects on human health. This is the conformation of our main hypotheses. This outcome is quite surprising, as in our overview of expected outcomes, we did not even included outcomes for the category total disasters. We expected that the outcomes would only work through the specific categories, and not trough the total values. The coefficient is 1.204. This value can be explained as the increase in DALY (in percentages) when one extra disaster would have occurred. As we have controlled for country area, this would mean that one additional disaster per 1000 square km will result in 1.204% increase of DALY.

Hydrological disasters

<u>Hydrological</u>	Events caused by deviations in the normal water cycle and/or overflow of bodies of water caused	<u>Flood</u>, Mass Movement (wet)

	by wind set-up	

The significance of 0.000 is very high. With great confidence we can say that floods (and recurrent flooding) has a negative effect on long-term health. Unfortunately we cannot say anything about the specific category of diseases that is responsible for this effect. In our literature study we already described the effects of floods on diseases. There are direct effects as people are wounded or killed directly by the flood (though most of the time this number is minimal). But there are also multiple indirect effects, as sanitation can be affected, mold can stay in houses, sick/elderly people can face aggravated complaints, due to temporary lack of health services. The swampy soil that remains after a flood, can become the perfect habitat for several types of diseases. In addition, a flood can distributed all kinds of toxic materials, and pathogens into houses, schools, irrigation systems, sanitation systems etcetera. Although floods are very similar to storms, the big difference is that floods endure for a much longer period (Kunii et al, 2002) which might be explaining why storms are not significant and floods are.

The coefficient is 5.790. Which is much higher than the increase among the all disaster category. This means that one additional hydrological disaster per 1000 square km will result in 5.790% increase of DALY.

Geophysical disasters

Geophysical	Events originating from solid earth	Earthquake, Volcano, Mass Movement, (dry),Tsunami

It is not surprising that we found significance among geophysical disasters, as this is the only disaster where some relation was expected in all three categories (of the DALY data). Geophysical disasters are not predictable, which makes it very difficult to be prepared. Especially when the timing of an earthquake is bad (in the evening or during the night). Earthquakes are generally the only type of disaster that cause an overwhelming number of injuries. These injuries, when not treated well (or not soon enough) can evolve into immense long term health effects. In addition the destructive power of earthquakes is enormous, the economic consequences (for the economy as a whole, but also for single households) from the devastation can be enormous and can ruin someone's total property/business. This can have great consequences for someone's coping mechanisms and the ability to overcome the effects of the disaster.

The coefficient is 18.732. Which is extremely high. Especially when we compare them with the other coefficients. One extra geographical disasters per 1000 square km would increase DALY with 18.732%.

3.2 INCOME GROUPS

We found significance among two of the five types of disasters, which is very convenient as a bonus upon our main finding, that we found proof for our main thesis. Though we are curious whether we can find significances, or differences in significances when we divide our data according to income level of countries. We will use three categories, OECD countries, least developed countries and developing countries. The first two groups are relatively small (less than 40 countries), while the last group is quite big (more than 100 countries). The group of least developed countries is also included in developing countries.

Table 8: OECD countries

	All diseases		Communicable		Non-communicable		Injuries	
Total large	.0091358	0.989	-3.072475	0.163	-.0087655	0.990	4.140643	**0.022**
Hydro large	4.439286	0.551	21.72576	0.304	7.412815	0.273	-25.76431	0.200
Meteo large	1.032481	0.571	27.47279	**0.003**	.8273581	0.664	6.016336	0.233
Clim. Large	-.1848084	0.791	-3.595446	0.115	-.2097326	0.777	4.000236	**0.049**
Geo large	-3.713434	0.763	198.6156	**0.000**	-2.758386	0.823	-23.50899	0.500

Table 9: Least developed countries

	All diseases		Communicable		Non-communicable		Injuries	
Total large	2.403672	0.206	2.452794	0.297	-1.352249	0.338	2.048028	0.289
Hydro large	2.173281	0.598	5.662411	0.227	-2.495949	0.405	2.574257	0.469
Meteo large	7.069218	0.714	13.91975	0.514	.5979949	0.966	.5477161	0.974
Clim. large	2.61871	0.300	1.214831	0.714	-1.646554	0.405	3.120159	0.204
Geo large	2.847844	0.994	-	-	-	-	-	-

Table 10: Developing countries

	All diseases		Communicable		Non-communicable *		Injuries*	

Total large	1.892091	**0.004**	.2673512	0.834	.087235	0.927	-.4732145	0.836
Hydro large	4.653363	**0.000**	.7364557	0.792	-.5535086	0.618	3.57316	0.408
Meteo large	.8452086	0.589	.0014444	1.000	.2176696	0.883	-3.152564	0.454
Clim. large	1.778487	0.128	.5448272	0.841	.7056923	0.517	-1.055431	0.742
Geo large	-1.568339	0.909	-4.367472	0.680	-.1198557	0.977	-16.64957	0.652

If we look at the above results, we see quite familiar outcomes. Among the least developed countries sample, we have no significances at all. Which can be due to the small sample size. Among developing countries (in which least developed are included) we have a significance among total disasters and hydrological disasters for the category all diseases. The only difference with the 'normal' dataset is that we do not find a significance under geophysical disasters. But apart from that, there are no different outcomes.

The outcomes for OECD countries are much more interesting (though we must keep in mind that the sample size is quite small). The interesting fact is that we find significances among diseases and among injuries. The fact that meteorological and geophysical disasters are significant among communicable diseases is not surprising, as this is also what we expected based on our literature study. In addition, meteorological and geophysical disasters are unstoppable. It is impossible to prevent them from happening, while other (floods, epidemics and malnutrition) are highly preventable. The fact that these two types of disasters are significant specifically among OECD countries (were institutions and prevention mechanisms are state of the art) might be explained by this property. Injuries are significant among the 'all countries' group as well as with climatological disasters. The first outcome is understandable as disasters are generally known for their devastating effects. The second outcome is surprising as droughts are the only type of disaster that are not destructive in the way that they directly cause injuries. It thus must be explained by an indirect effect or a third factor. A third factor might be war, but in the case of OECD countries, this is not a logical explanation.

Table 11: Overview expected and found relationships

Expected	All diseases	Communicable	Non-communicable	Injuries
Geophysical		X	X	D
Meteorological		X	X	D
Hydrological		X		D
Climatological		X		
Results	All diseases	Communicable	Non-communicable	Injuries
All countries	A, D			O
Geophysical	A	O		
Meteorological		O		
Hydrological	A, D			
Climatological				O

Only significance above 0.05

A = All countries

D = Developing countries
L = Least developed countries
O = OECD countries
X = Based on literature study, a relation is expected.

3 CONCLUSION/DISCUSSION

3.2 CONCLUSION

Conclusion 1: There are long term effects of natural disasters on human health.

Conclusion 2: These long-term effects are at least working through geophysical and hydrological disasters.

We have studied the long term effects of natural disasters on health. We have studied this with quantitative analysis, using robust regression. For health we used an artificial indicator (DALY). In addition we used 21 control variables and data on disasters from the University of Louvain.

The outcomes of our analysis acknowledges our main theses, which is; natural disasters have (a negative) long term effect on human health. With a P value of 0.026, we found evidence that overall, great disasters between 2002 and 2004, can be used as an explanation for the increase of DALY in the same period. In addition we found evidence that geophysical disasters as well as hydrological disasters have a negative effect on long term health (both with a P-value of 0.000!). We thus can conclude that (based on our analysis) natural disasters have a long term effect on health. This works through geophysical and hydrological disasters. There are possibly more relations between disasters and specific diseases, we aimed to find these, but we did not (at least not with all countries included in our sample). Unfortunately the results won't let us do this. Though it reminds us of the fact, that we are the first researchers to use quantitative analysis to research the long-term effects of natural disasters. We must be very glad that we can conclude that our general theses can be acknowledged.

3.3 DISCUSSION

We are the first (for as far as we know) to study the long-term effects of natural disasters on health (through quantitative analysis). We do not intend to claim full proof evidence for the (negative) long term effects of natural disasters. We only found some significances and we cannot thoroughly explain why we only found significances among the 'all diseases' category. In our research set-up we believed that we would rather find significances among specific diseases in combination with specific disasters. This did not happen, but we still believe that these relations could be found. This would also be very beneficial for future policies, as this would be a fundament for more targeted policies.

Most outcomes were not surprising, only one outcome was surprising as we found a significance between climatological disasters and injuries (among OECD countries). This result is surprising and we are not able to give a thorough explanation of this outcome. Among another country group a war would be the perfect explanation, but in the case of OECD countries, this is not likely. As such we are not able to explain all outcomes. The outcomes were somewhat different than we hoped, but the most essential part, our main theses, has been proved.

The main difference between our study and other studies on this theme is that we are the first to use quantitative analysis. This made it possible for us to compose a baseline study (which was significance). In addition it made it possible to study all types of diseases as well as all (great) disasters. This made it easier to generalise our findings, as we are not bound to local circumstances. Other studies usually focus on mental health, we have been able to take into account all types of diseases which is a great improvement. As such our study is a valuable application to existing studies. But more researchers should do the same as we have done to attain more and better insights.

3.4 LIMITATIONS

Our research has got its limitations. We will mention the most important limitations that we have come across.

- The period of research, which is only three years (2002-2004) is not very long, and possible not long enough to find differences in health levels.
- Our indicator for health (DALY) is an artificial indicator, it is based upon actual data, but it is not a perfect reflection of the actual health.
- The disaster data is based upon reported disasters, which makes it possible that some disasters have not been taken into account.
- The disaster data is selected (by EM-DAT) on amount of people deadly affected, people affected and damage. These criteria are often difficult to measure. As we selected only the biggest we have tried to cope with these problems, but even with the biggest disasters there are problems, it is very plausible that not all big disasters in our period of research have been included in our research.
- We work with control variables that are not always available. Especially smaller states (often islands) were excluded while preparing our dataset. In addition STATA left out almost 50 countries due to missing values.
- We used our data in such a way that we listed our data per country. With somewhat more than 200 countries in the world (of which we had to drop the small ones), we started our analysis with 182 counties. Which are a lot of countries, but not very much data entries for such a regression. Another research set-up might tackle this problem.

There are more limitations off course, but we will only want to mention the biggest ones.

3.5 RECOMMENDATIONS:

Our research set-up made it possible to analyse disasters on a broader level. The outcomes are more generalizable than existing qualitative studies that have a more local scope. With our research set-up it will be very possible to give advice on policy level. But it must be criticised by other researchers first. It must be redone by different researchers as well. They can use other types of regression, a longer study period and possibly another way of presenting the data in order to have more data entries. It might also be interesting to do a similar study on country or regional level. Though a lot of data would be necessary for separate provinces or areas, it might not be possible to find this data.

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APPENDIXES

DEFINITIONS

Daly: The sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability

Disaster: Situation or event, which overwhelms local capacity, necessitating a request to national or international level for external assistance (definition considered in EM-DAT); An unforeseen and often sudden event that causes great damage, destruction and human suffering. Though often caused by nature, disasters can have human origins. Wars and civil disturbances that destroy homelands and displace people are included among the causes of disasters. Other causes can be: building collapse, blizzard, drought, epidemic, earthquake, explosion, fire, flood, hazardous material or transportation incident (such as a chemical spill), hurricane, nuclear incident, tornado, or volcano (Disaster Relief). (EM-DAT, 2012c)

EM-DAT differentiates disasters into natural and technological disasters. This research focuses only on natural disasters. There are five sub-categories, with several sub-types. See table 2 for a summary of the categories (EM-DAT, 2012a).

For a disaster to be entered into the EM-DAT database, at least one of the following criteria must be fulfilled:

- Ten or more people reported killed.
- Hundred or more people reported affected.
- Declaration of a state of emergency.
- Call for international assistance.

(EM-DAT, 2012a)

Tornado: A tornado is a rotating column of air (vortex) that emerges out of the base of a cumulonimbus cloud and has contact to the Earth's surface. Typically it forms during a severe convective storm in so-called super cells and is often visible as a funnel-shaped cloud. Tornadoes are usually short-lived, lasting on average no more than 10 minutes. They can generate wind speeds above 400 km/h and are considered the most destructive weather phenomenon. The intensity of tornadoes is assessed using the Enhanced Fujita Scale. Other names for this weather phenomenon are twister, waterspout (over open water). (EM-DAT, 2012c)

Tropical Cyclone: A tropical cyclone is a non-frontal storm system that is characterised by a low pressure centre, spiral rain bands and strong winds. Usually it originates over tropical or sub-tropical waters and rotates clockwise in the southern hemisphere and counter-clockwise in the northern hemisphere. The system is fuelled by heat released when moist air rises and the water vapour it contains condenses ("warm core" storm system). Therefore the water temperature must be >27 °C. Depending on their location and strength, tropical cyclones are referred to as hurricane (western Atlantic/eastern Pacific), typhoon (western Pacific), cyclone (southern Pacific/Indian Ocean), tropical storm, and tropical depression (defined by wind speed; see Saffir-Simpson-Scale). Cyclones in tropical areas e.g. hurricanes, typhoons, tropical depressions etc. (names depending on location). (EM-DAT, 2012c)

Volcanic eruption: All volcanic activity like rock fall, ash fall, lava streams, gases etc. Volcanic activity describes both the transport of magma and/or gases to the Earth's surface, which can be accompanied by tremors and eruptions, and the interaction of magma and water (e.g. groundwater, crater lakes) underneath the Earth's surface, which can result in phreatic eruptions. Depending on the composition of the magma eruptions can be explosive and effusive and result in variations of rock fall, ash fall, lava streams, pyroclastic flows, emission of gases etc. (EM-DAT, 2012c)

Earthquake: Shaking and displacement of ground due to seismic waves. This is the earthquake itself WITHOUT secondary effects. An earthquake is the result of a sudden release of stored energy in the Earth's crust that creates seismic waves. They can be of tectonic or volcanic origin. At the Earth's surface they are felt as a shaking or displacement of the ground. The energy released in the hypocentre can be measured in different frequency ranges. Therefore there are different scales for measuring the magnitude of a quake according to a certain frequency range. Those are: a) surface wave magnitude (Ms); b) body wave magnitude (Mb); c) local magnitude (ML); moment magnitude. (EM-DAT, 2012c)

Drought: Long lasting event; triggered by lack of precipitation. A drought is an extended period of time characterised by a deficiency in a region's water supply that is the result of constantly below average precipitation. A drought can lead to losses to agriculture, affect inland navigation and hydropower plants, and cause a lack of drinking water and famine. (EM-DAT, 2012c)

Affected: 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. Appearance of a significant number of cases of an infectious disease introduced in a region or a population that is usually free from that disease. (EM-DAT, 2012c)

Great disaster: Definition (in line with the United Nations Definition criteria)

The affected region's ability to help itself is distinctly overtaxed if:

- Interregional or international assistance are necessary
- Thousands of people are killed
- Hundred thousands of people are made homeless
- Substantial economic losses
- Considerable insured losses

Munich Re (2006) classifies disasters into several categories. A *small-scale loss event* involves fewer than 10 fatalities and no damages. A *moderate loss event* involves fewer than 20 deaths and damage to buildings and other property. A *severe catastrophe* involves more than 20 deaths (but fewer than 100) and damages worth in excess of $50 million. A *major catastrophe* involves more than 100 deaths (but fewer than 500) and damage of more than $200 million. A *devastating catastrophe* involves more than 500 deaths and damage in excess of $500 million. Finally, a *great natural* *catastrophe* involves thousands of deaths and extreme insured losses. Since we are interested in estimating the impact of large-scale disasters on international trade, we decided to confine our empirical analysis to disasters that meet any of the following criteria which represent an adaptation of Munich Re's *great natural catastrophe* category: (i) number of killed is no fewer than 1000; (ii) the number of injured is no fewer than 1000; (iii) number of affected is no fewer than 100,000; or (iv) the amount of damages is no less than $1 billion.3 In order to make estimates of damage comparable over time, we have converted dollar values into constant 2000 dollars using the US GDP deflator. The adoption of this decision rule reduces the number of disasters for analysis to 1589 (1548 of which are classified as natural disasters and 41 of which are technological disasters).

(Gassebner et al., 2010)

LIST OF USED DATA

	Indicator name	Source
Education	Percentage of secondary schooling attained in population (25+)	Barro LEe
GDP per capita	GDP per capita (constant 2000 US$)	World Bank
Improved water source		World Health Organisation
Improved sanitation facility	Improved sanitation facilities (% of population with access)	World Health Organisation
Life expectancy	Life expectancy at birth, total (years)	World Bank
Continent		Google/Wikipedia/UN stats
Child mortality	Mortality rate, under-5 (per 1,000 live births)	World Bank
Population density	Population density (people per sq. km of land area)	FAO/World Bank
Rural population	Rural population (% of total population)	World Bank
Ethnic heterogeneity	Ethnic heterogeneity and ethnic conflicts 2003-2010	Finish social science data archive
Latitude	Latitude (average)	https://opendata.socrata.com/
Openness of trade	Own calculation: Exports of goods and services (% of GDP) + Imports of goods and services (% of GDP)	World Bank
Age dependency	Age dependency ratio (% of working-age population)	World Bank
Net ODA received	Net ODA received (% of GNI)	Wold Bank
Hospital beds	Hospital beds (per 1,000 people)	WHO/ World Bank
Physicians (per 1,000 people)	Physicians (per 1,000 people)	WHO/ World Bank
Health expenditure per capita	Health expenditure per capita (current US$)	WHO
Health expenditure, total (% of GDP)	Health expenditure, total (% of GDP)	WHO
Fertility rate	Fertility rate, total (births per woman)	World Bank
Prevalence of undernourishment	Prevalence of undernourishment (% of population)	FAO
Depth of hunger	Depth of hunger (kilocalories per person per day)	FAO
Inequality	Estimated Household Income Inequality Data Set	University of Texas
Democracy	Polity II	Polity IV Project

OVERVIEW DALY DATA

DALY data 2002-2004, by category

	2004		2002	
Total population	6.425.275		6.213.869	
All causes	1.521.022	100%	1.488.687	100%
Communicable diseases	603.464	39,67%	611.464	41.07%
Non-communicable diseases	730.346	48,02%	695.754	46.74
Injuries	187.212	12,31%	181.469	12.19%

RELATION BETWEEN NCD'S AND CD'S

List of non-communicable diseases (NCDs) and their known or probable infectious risk factors.

Copied from Ogoina & Onyemelukwe, 2009

Disease	Infection
Cardiovascular	
Atherosclerosis and ischemic heart disease	Chlamydiab, CMVb, Herpes Virusb, Dental infectionsb
Hypertension	Chlamydiab
Peripartum cardiac failure	Coxsackie B virusb, Toxoplasmosisb, Chlamydiab
Endomyocardial fibrosis	Loa loab, Toxoplasmosisb, Trichinellab, Ascarisb, Hookwormb, Schistosomab
Rheumatic fever/rheumatic heart disease	Group A ˇ hemolytic Streptococcus
Dilated cardiomyopathy	Virusesa, Toxoplasmosisa, Chaga'sa, HIVa, Lyme diseasea, etc.
Neurology/pyschiatry	
Stroke	Chlamydiab
Tropical spastic paraparesis	Human T lymphotrophic virus type 1a (HTLV1)
Dementia	HIVa
Alzheimer's disease	Herpes virusb, Chlamydiab

Multiple sclerosis	EBVb, Corona virus
Creutzfeldt-Jakob, Kuru, Familial insomnia	Prionsa
Subacute sclerosing panencephalitis (SSPE)	Measles virusa
Gullian Barre Syndrome	Campylobacter Jejunia
Schizophrenia	Intrauterine influenzab
Motor neuron disease (MND)	Virusesb
Chronic fatigue	HTLV1b, EBVb
Tics, Obsessive compulsive disorder	Group A Streptococcus Agalactiaeb
Autoimmune/endocrine	
Type 1 DM	Enterovirusesb—–Coxsackie, Mumps, etc.
Graves Disease	Yersinia enterolyticab
Sjogren's disease	Helicobacter pylorib
Rheumatoid arthritis/SLE	Epstein Barr Virus, Parvovirus, Mycobacterium species, Human endogenous retroviruse
Polyarteritis nodosa	Hepatitis B Virusa
Mixed cryoglobulinaemia	Hepatitis C Virusa
Obesity	Adenovirus 36b
Reiter's arthritis	Chlamydiaa, Salmonellaa, Shigellaa, Campylobacter Jejunia, Yersiniaa
Gastrointestinal diseases	
Peptic ulcer, Gastritis	Helicobacter pyloria
Chronic hepatitis, Liver cirrhosis	Hepatitis B Virusa, Hepatitis C Virusa
Primary biliary cirrhosis	Helicobacter pylorib
Crohn's disease	Mycobacterium paratuberculosisb
Whipple's disease	Tropheryma whippleia
Malnutrition	Several infectionsa
Renal	
Nephrotic syndrome/chronic glomerulonephritis	Malariaa, Hepatitis B Virusa, Hepatitis C Virusa, Salmonellaa, Schistosomiasisa, Syphilisa, Leprosy a, Tuberculosisa, etc.
Acute glomerulonephritis	Post _ hemolytic streptococcusa
Respiratory	
Asthma	Chlamydiac, Mycoplasmab, Aspergillusa, Dermatophagiodesa, Parasitesb Disease
Chronis obstructive pulmonary	Chlamydiab, Mycoplasmab, Haemophilusb, Streptoccocusb
Sarcoidosis	Mycobacterium speciesb
Cancers	
Primary liver cell carcinoma	Hepatitis B Virusa, Hepatitis C Virusa, Aflatoxin B1 from

	Aspergillus flavusa
Burkitt's lymphoma	Malaria and Epstein Barr Virusa
Malt lymphoma, gastric lymphoma	Helicobacter pyloria
Bladder cancer	Schistosoma haematobiuma
Cervical cancer, anal, laryngeal, penile, vulva cancers	Human Papilloma Virusa
Adult T cell leukemia	Human T lymphotrophic virus 1a
Kaposi's sarcoma	Human herpes virus 8a
Hodgkin's lymphoma, nasopharyngeal cancer, B cell lymphoma in HIV	Epstein barr virusa
Bile duct cancer	Opisthorchis viverrrinia, Chlonorchis sinensisa
Others	
Blindness	Trachomaa, Onchocerciasisa, Measlesa, etc.
Eclampsia	Infectionb [118]? Type
Dental caries	Several bacteria infectionsa
Hemolytic uremic syndrome	Escherichia Coli 0157a
Anemia, arthritis	Parvovirus B19a
Bacillary angiomatosis	Bartonella henselaea
Chronic lyme arthritis	Borrelia Burgdoferia
Acne	Propionbacterium acnea

[a] Known infectious risk factor.
[b] Probable infectious risk factor.