“The connection between natural disasters and epidemics of infectious diseases in 2005-2015”

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## Table of contents

Abstract................................................................................................................................. 3

Chapter 1: Introduction................................................................................................................................................................................. 4-10

  1.1. Background and rationale......................................................................................... 4-8
  1.2. Research objectives..................................................................................................... 8
  1.3. Research design and methodology............................................................................. 8-9
  1.4. Sampling....................................................................................................................... 9
  1.5. Utility.......................................................................................................................... 10

Chapter 2: Literature review................................................................................................................. 11-61

  2.1. Introduction.................................................................................................................. 11
  2.2. Selection criteria and framework................................................................................ 11-13
  2.3. Definitions.................................................................................................................... 13-17
  2.4. Health effects.............................................................................................................. 17-21
  2.5. Risk factors.................................................................................................................. 21-29
  2.6. Epidemic-prone diseases following a natural disaster.............................................. 29-61
    2.6.1. Water-related diseases.......................................................................................... 30-43
    2.6.2. Vector-borne diseases.......................................................................................... 43-54
    2.6.3. Acute respiratory infections............................................................................... 54-60
    2.6.4. Wound infections.................................................................................................. 60-61

Chapter 3: Results.......................................................................................................................... 62-74

  3.1. Literature review.......................................................................................................... 62-71
    3.1.1. Connection confirmed............................................................................................ 62-67
    3.1.2. No outbreaks.......................................................................................................... 67-71
  3.2. Analysis of the databases............................................................................................ 71-74

Chapter 4: Discussion....................................................................................................................... 75-79

Conclusion......................................................................................................................................................... 80-81

References................................................................................................................................................. 82-99

Annex.......................................................................................................................................................... 100-105
Abstract

Natural disasters have always had adverse effects on humanity, however, lately their frequency and intensity have increased and their consequences on various spheres of people’s lives, including health, have become more severe. Natural disasters are often associated with epidemics of communicable diseases, although opinions on the necessary connection vary. By conducting literature review and analyzing the EM-DAT, ReliefWeb and WHO databases the present study found that although, the risk of an infectious disease outbreak in the aftermath of a natural disaster is not very high, it does exist and should be taken into consideration when planning a humanitarian response.
Chapter 1: Introduction

1.1. Background and rationale

In their 2006 paper Floret et al., found no correlation between natural disasters and the occurrence of epidemics between 1995 and 2004. This is a surprising and counterintuitive finding that stands in contrast to the classical believe that such a correlation exists. Natural disasters are an integral part of nature. They have existed since before life emerged on our planet and have had an adverse effect on humanity. Since the start of the twenty-first century, the frequency and intensity of disasters has increased due to factors such as climate change (Petrazzi et al., 2013). Moreover, natural disasters have increased mortality across the world (Kim et al., 2013). According to the Centre for Research on the Epidemiology of Disasters (CRED), the number of victims from natural disasters in 2010 was the highest in a decade (CRED, 2011). In the period 2005-2015, 4418 natural disasters occurred across the world and affected approximately 1.848 billion people. (“Disaster list,” n.d.) In addition, natural disasters are expected to increase in frequency and intensity in the next decades (Petrazzi et al., 2013).

Natural disasters can strike quickly, without warning, disturbing the normal order of life in any society (Petrazzi et al., 2013). These catastrophic events destroy infrastructures and damage livelihoods, lead to numerous deaths and injuries and population displacement, and collapse health systems and facilities impacting public health (Kouadio et al., 2012). In contrast to the findings of Floret et al, it has been commonly thought that one of the main concerns in the days and weeks following a natural disaster is outbreaks of communicable diseases (Babaie et al., 2015). Ivers and Ryan found that natural disasters can lead to outbreaks of various infectious diseases, especially when they result in substantial population displacement, unsafe water and exacerbate risk factors for disease transmission (2006). During a 7-month period after the 2010 earthquake in Haiti, all diseases diagnosed in a primary healthcare clinic were recorded. Among the patients studied, 42.6% cases presented with an infectious disease, also high rates of malaria and dengue fever were reported (Neuberger et al., 2012). Infectious disease during an emergency condition can raise the death rate 60 times comparing to other causes including trauma. Over 40% of deaths in emergency
conditions occur due to diarrheal illness with 80% of those involving children less than 2 years of age (Ameli, 2012). After natural disasters, transmission of water- and vector-borne diseases and outbreaks of acute respiratory diseases are the primary disease threats related to the change in the environment due to the disaster (Guha-Sapir & van Panhuis, 2009).

Natural disasters have often been followed by fear of outbreak of communicable diseases, bringing up a debate on avoiding the risk of epidemics. Tsiamis et al. found that, while natural disasters often do not result in the outbreak of new infections, they may increase disease transmission and prevalence of preexisting infections (2013). For instance, the transmission of malaria is influenced by changes in the environment due to natural disasters. People, living in improperly protected temporary shelters, are more likely to be bitten by mosquitoes. In Ecuador in 1983, a large-scale flooding caused by an earthquake was the primary cause of a seven times increase in malaria’s incidence (Pinault & Hunter, 2012). Similarly, 61 cases of malaria were diagnosed between November 2010 and February 2011 after a 7.0-magnitude earthquake in Haiti (Feng et al., 2015). After an earthquake in 2003, there were 124 malaria cases in two months in Bam, Iran (Zhang et al., 2013).

With regard to water-borne diseases, such as cholera, despite the fear of its outbreaks after natural disasters, especially when followed by population displacement, critical sanitation conditions, and increased risks to water resources, a necessary connection is under question. For instance, Sumner et al. found no evidence of such a correlation (2013).

Epidemics of acute respiratory infections have often been reported at evacuation shelters following natural disasters, causing significant health burdens on victims of the disaster (KAWANO et al., 2015). After the earthquake and tsunami occurred in Japan on 11 March 2011, the incidence of the infections in patients in the disaster-affected area increased sharply during the first month compared to the rate during the same period in 2012 (Aoyagi et al., 2013). During post-disaster periods, epidemics of acute respiratory infections at shelters consume additional healthcare resources (KAWANO et al., 2015). Besides that, natural disasters can increase the concentrations of environmental particulate matter that are likely to contribute to respiratory health
CONNECTION BETWEEN NATURAL DISASTERS AND EPIDEMICS OF INFECTIOUS DISEASES

problems, including infectious diseases (ROBINSON et al., 2011). In the USA, states with the highest number of pulmonary cases, such as California, Florida, Louisiana, and Hawaii, are also those with a high number of natural disasters (Honda et al., 2015). Likewise, within 3 weeks after the earthquake and tsunami in Japan in 2011, a rapid increase in pneumonia hospitalisations and related deaths was reported (Daito et al., 2013).

Typically, a lot of attention is drawn to natural disasters and their possible health impacts. Immediately after the Japan earthquake and tsunami occurred 2011, the World Health Organization (WHO) cautioned that people at shelters in a disaster-affected area may be at risk of increased transmission of infectious diseases including acute gastroenteritis, hepatitis A and E, leptospirosis, acute respiratory infection, and scabies (Kawano et al., 2014). Another example is the 2015 earthquake in Nepal, when the WHO raised concerns about the transmission of infectious diseases across Nepal. As it was stated in its May 26 report, “population displacement, crowding, limited quantities of safe water, inadequate hygiene and toilet facilities, and unsafe practices in handling and preparing food are all associated with disease transmission. There is a risk of an increase in communicable diseases, including diarrhea, respiratory infections, and mosquito-borne diseases, particularly with the rainy season approaching soon” (Bagcchi, 2015, p. 1). A similar situation happened after the earthquake and tsunami struck South Asia on December 26, 2004. Although by 3 January the WHO had received no reports of major epidemics, the organisation warned that millions of people were under serious threat of disease outbreaks as a result of disrupted water and sanitation systems, sea water contamination, and the crowded conditions of the displaced people (WHO, 2015b). The reason for those announcements was the experience of outbreaks after previous disasters (Moszynski, 2005).

However, there are examples that have led to debates on whether the risk of disease outbreaks is genuine. For instance, an 8.0 - magnitude earthquake shook Wenchuan County, China in May 2008 and resulted in more than 80,000 deaths (Zeng, 2008). The potential risk for epidemic after the disaster posed a serious threat to the health of more than 14 million people. However, no major epidemic outbreaks have been reported in the affected areas, which cover more than 100,000 km², in the first weeks after the disaster (Zeng, 2008).
Moreover, many experts believe that the risks of infectious disease outbreaks following natural disasters have been overemphasized by health officials and the media and have led to unnecessary and potentially harmful public health activities (Wilder-Smith, 2005). Media reports almost always point out the risk for epidemics. The news industry which has an influence on donations, political decisions by governments and NGOs tends to emphasize more dramatic and simplistic information and unjustified warnings mostly based on an approximate assessment of risks. It often leads to panic and confusion among the affected population (Watson et al., 2007). In addition to the media, other institutions draw attention to the risk for epidemics. Similar to the examples given above, in a letter published three weeks after the earthquake in Bam, Iran, in December 2004, WHO warned that potential outbreaks of cholera, typhoid fever, malaria, and leishmaniasis were a major concern (Floret et al., 2006). WHO also issued a warning about the risk for epidemics that could develop after the 2004 tsunami: “There is an immediate increased risk of waterborne diseases, i.e., cholera, typhoid fever, shigellosis and hepatitis A and E…. Outbreaks of these diseases could occur at any moment” (WHO, 2012d). The high risk for epidemics in areas affected by the tsunami was also pointed out by several papers published during the weeks after the disaster (Moszynski, 2005). Responding to WHO warnings, humanitarian agencies collected and invested money, effort, time, and personnel to prepare for potential epidemics (Floret et al., 2006). Spiegel et al. wonder if this was really necessary and if large-scale epidemics do commonly occur following large natural disasters (2007).

The present study aims to give an answer to this question. Regarding the rationale for this research and its academic value, there are several supporting points to be made. Firstly, the goal of emergency health is to prevent epidemics and improve deteriorating health conditions among the population affected (Waring & Brown, 2005). So the role played by natural disasters in causing outbreaks of diseases must be identified so that priorities can be defined and resources can be appropriately allocated which is vital, especially during the first stage of response. Secondly, according to the WHO, every year natural disasters result in over 60,000 deaths, mainly in developing countries and the number of disasters is anticipated to increase (Floret et al., 2006). That is why it is important for humanitarian agencies to know what to be prepared for to be able to respond in the most efficient way. Thirdly, despite the fact that it is of paramount importance to be aware of risks for diseases outbreaks, there is, unfortunately, a lack of
empirical studies on this question. The results of the research conducted by Floret et al., which includes a systematic review of the information about the disasters and epidemics occurred in 1995-2004, provides support to the epidemiologic evidence that no high, short-term risk for epidemics follows a natural disaster (specifically geophysical) (2006). But after that there is a research gap of systematic reviews related to the topic of the study: a few similar analyses have been done on earlier periods but little has been researched after 2011. Also, the results of the studies are various and there is no certain conclusion on the relation between the two phenomena, whereas it is extremely important to understand the relationship between natural disasters and epidemics, especially in the past decade. So the research question of this study: Is there a connection between natural disasters and epidemics of infectious diseases?

1.2. Research objectives

The overall objective of the study is to examine the existence of a connection between natural disasters and epidemics of infectious diseases. To achieve the overall objective, the specific objectives have been set up:

1) To identify possible natural disasters’ health effects as well as epidemic-prone diseases and risk factors of their outbreaks
2) To analyse data on natural disasters and epidemics occurred in the world during 2005-2015
3) To analyse the existing hypotheses and experiences with regard to the correlation between natural disasters and epidemics

1.3. Research design and methodology

The study adopted a mixed research strategy for a couple of reasons. Firstly, it ensures triangulation which, in turn, increases reliability, validity, and objectivity of the results (Sarantakos, 2005). Secondly, different research objectives require different methodology. The first objective implies identification of possible health impacts, description of epidemic-prone diseases and analysis of risk factors which demands a qualitative strategy because it focuses on processes and structural characteristics of a specific phenomenon/object (Sarantakos, 2005) and enables the researcher to explore and get a deeper understanding of underlying factors that have an impact on a particular phenomenon (Bryman, 2012). Also, a qualitative approach suits better for the
achievement of the first objective due to the fact that data which needs to be analysed cannot be quantified. To achieve the second objective, it is necessary to analyse statistics, therefore a quantitative approach was used. Besides that, when the sample size is large it is recommended to use a quantitative strategy (Bryman, 2012). The third objective requires a qualitative approach since theories and information about previous experiences, which needs to be analysed, is mostly qualitative in nature.

Regarding research design, cross-sectional type was used to conduct the study since it is the most appropriate type when more than one case is going to be examined and data can be quantified (Bryman, 2012). Since the target area of the research is not one region, but the whole world, and the study aims to identify general trends with regard to the relationship between natural disasters and epidemics, cross-sectional design is the most suitable way for conducting this research.

In terms of methods, literature review was conducted in order to learn what hypotheses on the current topic exist, identify possible health effects of natural disasters and factors which impact the risk of an epidemic, and describe epidemic-prone diseases. The main sources are National Library of Medicine National Institutes of Health, specifically PubMed database, and the databases of University of Groningen and University College Dublin. Another method used is analysis of secondary data that was conducted to achieve the second and the third objectives (computer software such as Excel was used). The main sources of information are the websites of WHO and ReliefWeb and Emergency Disasters Data Base.

1.4. Sampling

Sampling frame of the research is determined by a period of time which is from 2005 to 2015 for the present study. All natural disasters occurred in the world in that period of time and available in Emergency Disasters Data Base were chosen for the present research. In the given database an event is considered a natural disaster if it resulted in 10 or more people deaths and 100 or more affected/injured/homeless people. Similarly, epidemics found in the WHO database and ReliefWeb which broke out in a particular area after a natural disaster were included in the analysis.
1.5. Utility

It is hoped that the research presents an informed discussion on the relationship between natural disasters and epidemics and provides an insight into these phenomena. It also raises awareness of the worldwide tendencies, risk factors of epidemics’ occurrence due to natural disasters, and diseases which are most likely to break out which can allow humanitarian organisations to be better prepared and design a more effective strategy of humanitarian response to the health effects of natural disasters (for example, provide efficient allocation of time and resources when meeting people’s health needs in an emergency). Finally, as there appears to be a lack of research that focuses on the links between natural disasters and epidemics in the period of 2005-2015, the research can fill the gap, contribute to the overall knowledge and understanding of the topic, and provide a baseline for further research to be carried out on the given topic.
Chapter 2: Literature review

2.1. Introduction

This chapter reviews the relevant literature surrounding the topic of natural disasters and epidemics of infectious diseases. Particularly it intends to explore the current debates on the relationship between the two concepts. Firstly, the chapter will introduce key concepts crucial to the research and provide definitions of specific terms mentioned further in the paper. Secondly, an overview of possible health effects of natural disasters, including diseases which are most likely to break out, will be presented. Thirdly, factors that influence the probability of disease outbreaks in the aftermath of natural disasters will be discussed. Finally, expert opinions based on academic knowledge and data from previous assessments with regard to the correlation between natural disasters and epidemics of infectious diseases will be reviewed. This chapter will help to give proper context of this study in relation to the subjects of the research.

2.2. Selection criteria and framework

To ensure the reliability of the information, only peer-reviewed articles were used for the study. Only articles in English, published from January 2005 through December 2015 were selected. The database of PubMed library was screened and the following search terms were used: (natural disaster* OR seism* OR earthquake* OR volcano* OR tsunami*) AND (infectious disease* OR communicable disease* OR epidemic* OR outbreak* OR vector-borne disease* OR arboviruses OR cholera OR malaria OR dengue OR West Nile virus OR Rift Valley fever OR hepatitis OR leptospirosis OR typhoid fever OR measles OR shigellosis OR scrub typhus OR plague OR diarrhea).

The same terms were used in the study done by Floret et al. in 2006. From this, 580 articles were found. Further selection was conducted based on the principles of the framework called “Critical Appraisal of Research Evidence”.

Critical appraisal is “the process of carefully and systematically examining research to judge its trustworthiness, and its value and relevance in a particular context.” (“Critical appraisal,” 2008, p. 4). It is of paramount importance to critically evaluate research evidence in order to facilitate evidence-based practice (“Critical appraisal”, 2008). With relation to public health it implies the process of systematically finding, appraising, and using latest clinical and community research findings as the basis for decisions in public
health. Critical appraisal helps to distinguish the best available evidence, what means that it is not the quantity but the quality what matters. In order to assess the quality of the articles the following steps were taken:

- Formulating a clear question from a public health problem
- Searching the literature
- Appraising the evidence
- Selecting the best evidence
- Linking evidence with public health experience, knowledge and practice

More specifically, the following questions were answered and necessary actions were taken:

- Is the article relevant to the topic? Reading abstracts helps to find out if the article addresses the related topic and what findings were obtained. Then reading the introduction and discussion sections allows to have a more detailed look at the objectives and context of that study and identify the key concepts, goals, subjects, and themes of the research. Also, the discussion can explain the limitations of the research. Finally, consulting the method section gives an idea about where the study was done, what kind of data was collected (primary or secondary) and how.

- What are the results? To determine if a study’s findings are trustworthy, the methods section should be reviewed more thoroughly. It includes comparing the results with findings from other studies, looking at the quality of the data and the appropriateness of the methods given the nature of the data.

- Are the results valid? Reading the methods and results sections allows to find out if the relevant factors were included in the research and how important are the factors that may have been left out. With relation to validity, it is necessary to understand if the measures accurately reflected what the researcher was trying to measure and how clear and appropriate they are. Also, attention should be paid to the sample size, matching the methods and the purpose of the study and the amount of missing data.

After reading the abstracts, 100 articles were selected. After that, the introduction, discussion and method sections of those 100 articles were read and appraised.
Eventually, 60 articles turned out to be of high quality and relevant to a greater or lesser extent.

### 2.3. Definitions

First of all, the key concepts and specific terms should be clearly defined in order to avoid any misinterpretation of the main notions throughout the study. There are a number of definitions used in the reviewed articles and mentioned in a number of dictionaries which have both similarities and differences. The table below presents the definitions found during the research process. One definition for each concept was adopted for the present study.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epidemic</td>
<td>a sudden outbreak of infectious disease that spreads rapidly through the population, affecting a large proportion of people.</td>
<td>(Martin, 2010)</td>
</tr>
<tr>
<td>Epidemic</td>
<td>a sudden increase in the number of cases of a disease above what is normally expected in that population in that area.</td>
<td>(CDC, 2012)</td>
</tr>
<tr>
<td>Epidemic</td>
<td>the occurrence of more cases of disease than expected in a given area or among a specific group of persons over a particular period of time.</td>
<td>(Floret et.al., 2006)</td>
</tr>
<tr>
<td>Epidemic</td>
<td>an unusual increase in the number of cases of an acute infectious disease which already exists in the region or population concerned or the appearance of an infection previously absent from a region.</td>
<td>(Spiegel et al., 2007)</td>
</tr>
<tr>
<td>Epidemic</td>
<td>a temporary prevalence of a disease; a rapid spread or increase in the occurrence of something (e.g. riots)</td>
<td>(Dictionary, 1900)</td>
</tr>
<tr>
<td>Epidemic</td>
<td>the appearance of a particular disease in a large number of people at the same time</td>
<td>(Cambridge Dictionary, 2016)</td>
</tr>
<tr>
<td>Disease outbreak</td>
<td>the occurrence of cases of disease in excess of what would normally be expected in a defined community, geographical area or season. An outbreak may occur in a restricted geographical area, or may extend over several countries. It may last for a few days or weeks, or for several years.</td>
<td>(WHO, 2013a)</td>
</tr>
<tr>
<td>Disease outbreak</td>
<td>in epidemiology, outbreak is the occurrence of</td>
<td>(Farlex, 2003)</td>
</tr>
<tr>
<td></td>
<td>Definition</td>
<td>Source</td>
</tr>
<tr>
<td>-------</td>
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<td>-------------------------------</td>
</tr>
<tr>
<td>Natural disaster</td>
<td>a disruption of human ecology which exceeds the community’s capacity to adjust, so that outside assistance is needed.</td>
<td>(Floret et.al., 2006)</td>
</tr>
<tr>
<td>Natural disaster</td>
<td>any event or force of nature that has catastrophic consequences, such as avalanche, earthquake, flood, forest fire, hurricane, lightning, tornado, tsunami, and volcanic eruption</td>
<td>(Dictionary, 2016a)</td>
</tr>
<tr>
<td>Natural disaster</td>
<td>a natural event such as a flood, earthquake, or hurricane that causes great damage or loss of life.</td>
<td>(Oxford, 2016)</td>
</tr>
<tr>
<td>Communicable disease</td>
<td>an illness that arises from transmission of an infectious agent or its toxic product from an infected person, animal, or reservoir to a susceptible host.</td>
<td>(Babaie et al., 2015)</td>
</tr>
<tr>
<td>Communicable or Infectious disease</td>
<td>an illness caused by another living agent, or its products, that can be spread from one person to another.</td>
<td>(“The Johns Hopkins”, n.d.)</td>
</tr>
<tr>
<td>Communicable disease</td>
<td>a disease that is transmitted through direct contact with an infected individual or indirectly through a vector.</td>
<td>(Dictionary, 2016b)</td>
</tr>
<tr>
<td>Communicable disease</td>
<td>an illness caused by an infectious agent or its toxins that occurs through the direct or indirect transmission of the infectious agent or its products from an infected individual or via an animal, vector or the inanimate environment to a susceptible animal or human host</td>
<td>(CDC, 2010)</td>
</tr>
</tbody>
</table>

Table 1. The author

Regarding the term “epidemic”, since there are different versions of the definition, it should be clearly stated which one was used for the present study. Considering that the research is focused on epidemics which can occur following a natural disaster in a particular area and population, the concept “epidemic” should be understood as a sudden outbreak of infectious disease that spreads rapidly in a given area or among a specific group of persons over a particular period of time.

A similar to the concept of epidemic such as disease outbreak should also be defined. According to WHO, it is “the occurrence of cases of disease in excess of what would normally be expected in a defined community, geographical area or season. An outbreak may occur in a restricted geographical area, or may extend over several countries. It
may last for a few days or weeks, or for several years” (WHO, 2013a). Also, a single case of a communicable disease long absent from a population, or caused by an agent not previously recognised in that community or area, or the emergence of a previously unknown disease, may become an outbreak (WHO, 2013a). Generally, the terms “epidemic” and “disease outbreak” are often used as synonyms. For example, epidemic refers to an increase, often sudden, in the number of cases of a disease above what is normally expected in that population in that area; outbreak carries the same definition of epidemic, but is often used for a more limited geographic area, according to CDC (CDC, 2012). Similarly, in literature the term outbreak is synonymous with epidemic and is sometimes preferred because it may not cause too much media attention and panic in a society associated with the word epidemic (Floret et al., 2006). In this study the two concepts should also be understood as synonyms.

It should also be noted that there are organisations that do not use “natural disaster” as a term at all. Instead, “natural hazard” is the preferable expression which International Federation of the Red Cross (IFRC) defines as “a naturally occurring physical phenomena caused either by rapid or slow onset events which can be geophysical (earthquakes, landslides, tsunamis and volcanic activity), hydrological (avalanches and floods), climatological (extreme temperatures, drought and wildfires), meteorological (cyclones and storms/wave surges) or biological (disease epidemics and insect/animal plagues)” (“Types of disasters,” 2016). Also, according to WHO, in the 2005 Secretary-General Report “Relief to Development”, the term “natural disaster” was purposely not used, as it implies that disasters occurring as a result of natural hazards are fully “natural”, and therefore inevitable and cannot be controlled (WHO, 2014a). Instead, disasters happen when the capacity of a community to anticipate, respond, cope with and recover from a hazard event is overwhelmed (“Acceptable risk,” 2007). In other words, it is not an inevitable event but the result of the way individuals and societies relate to threats originating from natural hazards. The risks for disasters associated with natural hazards are largely determined not only by the exposure to a hazard, but also by measures taken to prevent, mitigate and prepare for disasters. Thus, disasters, to a great extent, depend on human action, or lack thereof. Therefore, the expression “disasters associated with natural hazards” should be used (WHO, 2014a).
Natural hazards, in turn, comprise phenomena such as earthquakes, volcanic activity, landslides, tsunamis, tropical cyclones and other severe storms; tornadoes and high winds; river floods and coastal flooding; wildfires and associated haze; drought, sand/dust storm, and infestations (WHO, 2014). However, it should be noted that some of these natural hazards can be manmade in origin (for instance, wildfires). Similarly, The United Nations Office for Disaster Risk Reduction (UNISDR) prefers to use the terms “natural hazard” and “disaster” separately. There is no such thing as a 'natural' disaster, only natural hazards. Disasters often follow natural hazards. It depends on how much impact a hazard has on society and the environment (“What is disaster risk reduction?,” n.d.). UNISDR defines natural hazard as a “natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage” (“What is disaster risk reduction?,” n.d.). With regard to disaster, it is “a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources” (“What is disaster risk reduction?,” n.d.).

Although, some use the term natural hazard rather than natural disaster, in this paper the term “natural disaster” will be used instead in order to avoid any confusion since this term is the one that is commonly used in the literature with relation to epidemics. Also, considering that the present study does not tackle capacity building and is not focused on long-term effects of catastrophic events, but tries to analyse the relationship between them and epidemics along with their health impacts, the following definition was adopted: \textit{natural disaster is a natural event that may cause loss of life, injury or other health consequences, and may involve social, economic or environmental losses and impacts.}

Natural disasters can be classified in several groups:

- **Geophysical** - a hazard originating from solid earth (earthquake, mass movement, volcanic activity).
- **Meteorological** - a hazard caused by extreme weather and atmospheric conditions that last from minutes to days (extreme temperature, fog, storm).
• Hydrological - a hazard caused by the occurrence, movement, and distribution of surface and subsurface water (flood, landslide, wave action).
• Climatological - a hazard caused by long-lived atmospheric processes related to climate variability (drought, wildfire).
• Biological - a hazard caused by the exposure to living organisms and their toxic substances or vector-borne diseases that they may carry (epidemic, insect infestation, animal accident).
• Extraterrestrial – a hazard caused by asteroids, meteoroids, and comets as they pass near-earth, enter the Earth’s atmosphere, and/or strike the Earth, and by changes in interplanetary conditions that effect the Earth’s magnetosphere, ionosphere, and thermosphere (“Main menu,” 2009).

2.4. Health effects of natural disasters

Natural disasters have multiple environmental consequences on public health, depending on their severity and a country’s exposure and capacities. The usual outcomes of disasters are the destruction of infrastructure and health facilities, mortality, injuries, environmental degradation, increasing vector feeding areas, mass displacement of the population, poor personal hygiene, and lack of access to safe drinking water (Ardalan, 2013). In addition to physical damage, disasters disrupt health programs, such as regular vaccinations and vector control (Babaie et al., 2015). Consequently, the disaster-stricken areas are prone to communicable disease (CD) outbreaks (Babaie et al., 2015). However, some experts say that deaths associated with natural disasters are overwhelmingly due to blunt trauma, crush-type injuries, or drowning, while deaths from communicable diseases after natural disasters are less common (Watson et al., 2007).

Generally, it is said that most infections following natural disasters typically develop from indigenous microbes; that is, infections are rarely the result of imported microorganisms. Infections that develop 24 to 48 hours after natural disasters are usually opportunistic, acquired as a direct result of trauma. Infections that arise 1 to 4 weeks after the event are mostly due to food, water, and airborne transmissions. Acute respiratory infections are also frequent, especially in conditions where overcrowding develops (Honda et al., 2015). Natural disaster survivors may also be at higher risk for
nontuberculous lung infections caused by inhalation or aspiration of contaminated water, soil, or amoebae infected with nontuberculous mycobacteria (NTM) (Honda et al., 2015). Diseases that cause a visible impact if they break out on a large scale, such as measles, cholera, dysentery and malaria, are usually considered the top threats in humanitarian relief operations (Connolly et al., 2004).

Health consequences of natural disasters can also depend on the type of a disaster and timing. For example, flood disasters are the most common (40%) natural disasters worldwide which immediate health effects include drowning, injury, acute asthma, skin rashes and clusters, outbreaks of gastroenteritis, and respiratory infections (1, 810) (Kouadio et al., 2012). Previous studies of the health effects of floods divided the health aspects into direct effects caused by the floodwaters (such as drowning and injuries) and indirect effects caused by other systems damaged by the flood (such as waterborne infections, acute or chronic effects of exposure to chemical pollutants released into flood waters, vector-borne diseases, and food shortage. The greatest risk of mortality from a flood is drowning (Kim et al., 2013). Also, standing water provides an ideal environment for mosquitoes to breed. Although the first mosquitoes to appear likely will be little more than a nuisance, the potential for outbreaks of diseases such as dengue exists (Ligon, 2006). Acute respiratory infections (ARI) account for 20% of all death in children less than 5 years of age, with the majority of deaths resulting from pneumonia (Kouadio et al., 2012). Also, floods might facilitate the proliferation of rodents and the spread of leptospires in a human community which might lead to an outbreak of leptospirosis (Kouadio et al., 2012). Also, a slight increase in deaths from snakebites has been reported, but not fully confirmed (Pan American Health Organization, 2000). The mid-term effects of flooding are infected wounds, complications of injury, poisoning, poor mental health, and starvation. Flooding can also be followed by the proliferation of mosquitoes resulting in an upsurge of mosquito-borne diseases such as malaria (Kouadio et al., 2012). In the long-term, chronic disease, disability, poor mental health, and poverty-related diseases including malnutrition are the potential issues. Another concern of a prolonged flooding is the risk of communicable disease outbreaks because of the deterioration of living conditions and the interruption of basic public health services (Pan American Health Organization, 2000).
Earthquake disasters are found to be the second most reported natural disaster. Compared to other ecological events (floods, landslides, avalanches, cyclones, volcanic eruptions and droughts), earthquakes are currently the most unpredictable and potentially severe of all the natural disasters and are much more harmful in terms of health and material damage (Petrazzi et al., 2013). They mostly occur in regions with high seismic activity such as Central and South America and Asia (southeast and central parts). Similar to floods, the impact of earthquakes varies according to the power, intensity, population density of the area and level of development of the affected country (Kouadio et al., 2012). The direct cause of death as a result of an earthquake is mainly because of dwelling destruction that may cause many deaths and injure large numbers of people. Although little information is available about the kinds of injuries result from earthquakes, a lot of people are likely to be injured with minor cuts and bruises, a smaller group suffering from simple fractures, and a minority with serious multiple fractures or internal injuries requiring intensive treatment (Kouadio et al., 2012). Despite that, trauma is not always the main concern after the occurrence of an earthquake. For example, after a magnitude-7.0 earthquake, which struck Sichuan province in China on April 20, 2013, the common diseases and injuries observed ten days after the earthquake were also respiratory tract infection, diarrhea, dermatosis, and infectious diseases (Ding et al., 2015). The following diseases were also observed in children: acute upper respiratory tract infection; pneumonia; diarrhea; and urinary tract infection. Trauma mainly involved accidental injury and was not considered as the most serious problem during this earthquake. Instead, diseases of the respiratory, skin, and digestive systems as well as infectious and other pediatric diseases were prevalent (Ding et al., 2015). Also, after an earthquake, public health is compromised due to limited access to clean water, lack of food and malnutrition, and an increase in direct contact between humans and infected reservoir animals and vectors (Pourhossein et al., 2015). Additionally, earthquake disasters often result in substantial population displacement into unplanned and overcrowded shelters with limited access to food and safe water (Kouadio et al., 2012). In such situations, outbreaks of vector-borne and zoonotic diseases such as malaria, plague, tularemia, and cutaneous leishmaniasis have been reported (Pourhossein et al., 2015).

Volcanic eruptions also affect the population and infrastructure in many ways. A contact with volcanic material and falling rocks and stones may result in different types
of trauma injuries. The heated ash, gases, rocks, and magma can cause so severe burns that they can kill immediately. Breathing the gases and fumes can cause respiratory distress. Health facilities and other infrastructure can be destroyed or disrupted (Pan American Health Organization, 2000). Contamination of the environment, including water and food with volcanic ash also can disrupt environmental health conditions; this effect is a particular challenge when the population must be evacuated and housed in temporary shelters. Also if the eruptive phase is prolonged, other health effects, such as increased stress and anxiety, become important. Long-term inhalation of volcanic ash also can result in pulmonary silicosis after some years (Pan American Health Organization, 2000).

Landslides usually cause high mortality, although injuries are few. If there are health facilities in the path of the landslide, they can be damaged or destroyed (Pan American Health Organization, 2000).

Flash floods, hurricanes and tsunamis may cause many deaths, but leave relatively few severely injured in their wake. Deaths result mainly from drowning and are most common among weaker members of the population (Pan American Health Organization, 2000). Among the diseases identified by the CDC as potential developments after disasters such as a tsunami or hurricane are cholera, diarrhea, Hepatitis A, Hepatitis E, leptospirosis, parasitic diseases, rotavirus, shigellosis, and typhoid fever (Ligon, 2006). Animal bites, usually those of bats or skunks, poses a potential risk for the development of rabies and other infections. Also, natural phenomena such as tsunamis after earthquakes can result in flooding and destruction of critical infrastructure (Ameli, 2015). Such events can increase the risk of soft tissue, respiratory, diarrheal, and vector-borne infectious diseases as a result of the direct inoculation of pathogenic organisms (tetanus, wound infections, aspiration pneumonia), the destruction of shelters and resultant crowding of surviving displaced individuals (influenza, measles, meningitis, tuberculosis), the elimination of potable water supplies (shigella, cholera), and altered vector breeding grounds or zoonotic reservoirs (malaria, dengue, arboviral encephalitis) (Ameli, 2015).

Generally, gastrointestinal diseases following natural disasters are a common scenario. They can be caused by various viruses, bacteria, and protozoa and are more likely to
occur in developing countries (Watson et al., 2007). Also people who work with dead bodies are at higher risk of gastrointestinal illnesses because transmission of pathogens can occur after direct contact with dead bodies and clothing through the fecal-oral route (Watkins, 2011). However, the risk for transmission is low since enteric pathogens do not survive long in the environment, especially when bodies have decayed or have been in water. To reduce the risk of gastrointestinal illness workers should follow certain precautions, such as wearing gloves when handling bodies, wash hands, and disinfect equipment and vehicles used for transportation (Watkins, 2011).

In this part, general information about possible health consequences of natural disasters was given. More detailed description and classification of epidemic-prone diseases will be presented further in the paper.

2.5. Risk factors

The types and symptoms of disaster-related diseases vary depending on the cause of the disaster, the season of occurrence, and the hygienic conditions of the disaster-affected area (Tominaga et al., 2013). Increases in infectious disease outbreaks following natural disasters are associated with prolonged after-effects of the disaster. The post-disaster risk assessment identified a number of these indirect effects including displaced populations, environmental changes, increasing vector breeding sites, disruption of basic public utilities, high exposure to and proliferation of disease vectors (rodents, flies, mosquitoes), compromised sources of water, unplanned and overcrowded shelters, poor water and sanitation conditions, food shortage, low levels of immunity to vaccine-preventable diseases or insufficient vaccination coverage, and limited access to healthcare services (Kouadio et al., 2012). All of the factors play an important role in aggravating the devastation. The social environment might also add compromise for relief and recovery efforts (Waring & Brown, 2005).

An epidemic or outbreak can occur when several aspects of the agent (pathogen), population (hosts), and the environment create an ideal situation for spread (Ameli, 2015). Another important aspect is the level of development of a disaster-stricken country. Developing countries are disproportionately affected because they may lack resources, infrastructure, and disaster-preparedness systems (Watson et al., 2007). In
resource-poor nations, large outbreaks of infectious diseases, such as cholera, typhoid, acute respiratory infections, and leptospirosis, following a natural disaster are not rare (Ivers & Ryan, 2006). Whereas in rich countries with adequate public health infrastructure, post-disaster infectious disease surveillance has only occasionally detected increases in diseases outbreaks after natural disasters. For instance, the 2011 Nepal earthquake resulted in serious destruction of 392 health facilities and 531 were partially damaged. Their functioning, in turn, was also severely compromised. The disruption of the health programs (diseases prevention and control activities, immunisation, vector control) was an additional risk factor to an increase of infectious diseases transmission and outbreaks (Marahatta, 2015). The risk of the disease outbreak was also associated with the prolonged after-effects of the disaster which were mentioned above. As a result, the situation required extra efforts, resources, and measures in order to prevent outbreaks of infectious diseases (Marahatta, 2015).

**Displacement: Primary Concern**

The risk for communicable disease outbreaks after disasters is primarily associated with the size and characteristics of the population displaced, specifically population density, the proximity of safe water and functioning latrines, the nutritional status of the displaced people (malnutrition increases the risk for death from communicable diseases), the level of immunity to vaccine-preventable diseases, and the access to healthcare services (Watson et al., 2007). Moreover, displacement of wild or domesticated animals near human settlements brings additional risk of zoonotic infections (Pan American Health Organization, 2000). Although outbreaks after flooding have been better documented than those after any other natural disaster, disease outbreaks are rarely associated with natural disasters (regardless of its type) that do not result in population displacement. Historically, the large-scale displacement of populations resulted from natural disasters is not common, which contributes to the low risk for outbreaks overall and to the opinion that risks for epidemics might also depend on the type of a disaster (Watson et al., 2007).

**Armed conflicts** may also be an important contributory factor of a natural disaster and often of a disease outbreak (Ferris & Solís, 2016). There are cases where natural disasters occur in places where conflict has already disrupted the lives of people, such as the Philippines, Iraq, Somalia, Kenya, Colombia, and Haiti. Conflicts weaken a
society’s capacities, so countries with ongoing conflicts are less likely to be able to respond to and cope with the effects of a natural hazard, and it will most likely result in a natural disaster (Ferris & Solís, 2016). For example, the Somali government is extremely weak as a result of prolonged conflict and thus unable to respond to the natural hazards that occurred in Somalia. If it was not the case, it is more likely that the state and community institutions would be able to cope with the natural hazards and avoid disasters (Ferris & Solís, 2016). Armed conflict can also exacerbate the already challenging situation caused by a natural disaster. For instance, it might lead to increased flow of displaced people. For example, in Somalia, agriculture was disrupted by flooding in 2009 and it was already a challenge to grow sufficient food for their communities (Ferris & Solís, 2016). Thus the arrival of people displaced by the fighting in Mogadishu posed an additional burden on these communities. Such situations may result in further food shortage or malnutrition, which, in turn, increases a risk of communicable disease transmission (Ferris & Solís, 2016). Malnutrition is generally more common in conflict-affected populations, especially if their displacement is related to long-term conflict (Watson et al., 2007). In the case of Pakistan, millions of internally displaced people moved away from the war-torn north-eastern regions, bringing with them an increase in infectious disease, thereby sharply increasing the risk of transmission (Haider et al., 2015).

Armed conflict also influences relief operations, in particular, access of relief agencies to affected communities. This constitutes additional difficulties when governments are unwilling to provide access to humanitarian actors. For example, after the 1990 devastative earthquake in Iran which killed 50,000 people and destroyed entire villages, the government initially insisted that the country would handle the crisis on its own and did not let international assistance in. By the time the government was willing to receive aid from the outside, a significant proportion of the affected people had died from deaths that could have been prevented, including communicable diseases (Ferris & Solís, 2016).

So, it seems fair to conclude that conflicts might increase the risk of natural disasters and their effects, such as communicable disease outbreaks and transmission, by weakening state, community and individual capacity to respond (Ferris & Solís, 2016).

Flooding is usually associated with contamination of water sources with fecal material and toxic chemicals, which might cause infectious disease outbreaks, and with mosquito
breeding (Kouadio et al., 2012). However, the relationship between the two phenomena is complex. In general, flooding and rainfall often lead to standing water that may serve as breeding sites for mosquitoes thereby increasing mosquito densities. The theory is that increased vector mosquito populations increase the risk for human disease when people are exposed after a disaster (Chang et al., 2014). However, increased mosquito population itself does not necessarily lead to a disease outbreak. Instead, outbreaks may be the result of disruptions of the basic water supply and use of water storage containers that serve as breeding sites; interruptions of mosquito control programs; crowding of infected and susceptible hosts; and increased exposures to mosquitoes while sleeping outside (Chang et al., 2014). Nevertheless, rainfall may affect the level of contamination of drinking water. There is evidence of the effect of extreme rainfall on water-borne outbreaks of infectious diarrhea, even in highly developed countries (Curriero et al., 2001).

Besides that, although water is an essential component of the mosquito environment, the characteristics of water matter too. Whether it is running or standing, shaded or sunlit, clean or polluted, fresh or brackish, are the main factors determining which species of mosquito breed in it. Transient, polluted salt water generated by a tsunami will not sustain most species related to transmission of dengue fever and malaria (Floret et al., 2006). Quality of water and level of sanitation also affect the incidence of infectious diarrhea, the likelihood that extreme precipitation will lead to contamination of water sources, and the types of agents that cause infectious diarrhea (Kim et al., 2013).

Weather conditions also play an important role in determining the risk of infectious disease outbreaks. Cold winter weather might affect people’s health and cause serious respiratory disease, such as bronchitis, influenza, or pneumonia (Alexander, 1982). The risk of ARI may be increased due to overcrowding, poor ventilation and poor nutrition, and in crowded shelters specifically in cold weather (Kouadio et al., 2012). Extremely warm weather might also have an impact on the risk of epidemics. For example, in 2008 a devastating magnitude 7.9 earthquake occurred in China and brought huge losses in people’s lives and health (Wang et al., 2008). The earthquake occurred in summer, when warm and wet weather was beneficial for insect breeding and spread. It contributed to insect-borne infectious diseases transmission and becoming epidemic (Upadhyayula et al., 2012).
As mentioned above, after a natural disaster an increased risk of infectious diseases among survivors is often an immediate concern. However, the degree to which an epidemic might occur also depends on the regional endemcity of specific diseases, the level of public health infrastructure in place, and the level and efficacy of disaster response (Ivers & Ryan, 2006). For example, in countries such as India, Ethiopia, Nigeria, Haiti, the Democratic Republic of the Congo, Tanzania, Kenya, and Bangladesh cholera is considered an endemic disease and the risk of its outbreak is always higher in a particular season or under certain weather conditions even without exacerbation caused by natural disasters (Ivers & Ryan, 2006).

Dead bodies
The risk for outbreaks is often presumed to be high after natural disasters largely because of fear associated with dead bodies and epidemics (Watson et al., 2007). Media often emphasize the “fact” that dead bodies are a potential cause of epidemics after a natural disaster (Kouadio et al., 2012). However, this “fact” is a myth, since there is no evidence proving that dead bodies constitute a risk in areas that are not endemic for certain diseases. Although, the myths about corpses are unfounded, they have become ingrained in people’s minds largely due to distortions of religious norms or superstition. When a disaster strikes, authorities prioritize their actions to address the immediate concerns such as the injured, the displaced, and the dead. Little time has been devoted to documenting the fact that dead bodies do not pose a significant threat of infectious disease outbreaks following a natural disaster (Pan American Health Organization, 2004).

The common assumption about dead bodies resulted in confusion among authorities and the general population. This situation has often led to incorrect prioritization and misuse of resources in crisis situations that have caused more deaths and illnesses than caused by the disaster itself. (Pan American Health Organization, 2004)

Although, in disease endemic areas dead bodies can be carriers of the etiologic agent (for example, cholera), they themselves do not cause epidemics. In the case of Zaire, the 1994 cholera epidemic most likely occurred due to factors such as overcrowding, poor sanitation measures, and the lack of drinking water. The presence of dead bodies in the camp proved to be only a cofactor, owing mainly to the nonobservance of necessary
standards of hygiene (Pan American Health Organization, 2004). The role that the presence of dead bodies plays in areas with endemic diseases requires a critical assessment of whether the following can be verified:

- The area is endemic for the disease in question;
- The disease can survive in a dead body for a considerable period of time;
- The confluence of the two factors, together with the local environment and a potential event, such as a disaster, make the presence of dead bodies a greater hazard than in usual conditions (Pan American Health Organization, 2004).

Instead, the source of acute infections is more likely to be from the survivors, especially when death is directly due to the natural disaster (Kouadio et al., 2012). Moreover, even in disease endemic areas, with a higher risk of an infectious disease outbreak, no reason exists to deprive families from honoring their loved ones who died due to a disaster if they follow certain precautions when dealing with dead bodies (Floret et al., 2006). Recovering the dead is more important for people for psychological reasons than for any consideration of sanitation (Guha-Sapir & van Panhuis, 2009).

In the management of dead bodies, care should be taken with certain endemic diseases (for example, cholera, tuberculosis) and certain vectors that can transmit microorganisms harbored in the corpse, such as typhus or plague. Nevertheless, it is worth mentioning that even in these cases dead bodies pose a limited health threat because when a corpse desiccates, the body temperature drops quickly. Even the most resistant bacteria and viruses die quickly in an animal that has died recently. This makes it extremely difficult for them to transfer from dead bodies to vectors, and from vectors to human populations (Pan American Health Organization, 2004).

There are several recommendations for proper management of dead bodies in disease endemic areas:

- Strengthen personal hygiene measures both of the affected population and humanitarian workers;
- Disinfect bodies with a chlorine-based solution;
- Monitor transport vehicles;
- Prevent direct contact between the corpse and family members. Bodies can be delivered to the family members in airtight boxes so that they can be buried rapidly;
Avoid exposure of the dead bodies to animals. The best way to avoid this is to bury the body (Pan American Health Organization, 2004).

The role of dead bodies in infectious disease outbreaks after natural disasters still induces a lot of debates among health institutions. WHO has repeatedly pointed out that the risk is minimal. In a document published in 2002, WHO stated that: “Dead or decayed human bodies do not generally create a serious health hazard, unless they are polluting sources of drinking-water with faecal matter, or are infected with plague or typhus, in which case they may be infested with the fleas or lice that spread these diseases.” (Wisner & Adams, 2002). According to scientists from the Water, Engineering and Development Centre (WEDC) of the United Kingdom, corpses rarely contaminate water sources and are not associated with the transmission of vector-borne infectious diseases. They also state that many of the hurried disposals pose a greater threat for public health than the corpses themselves. For example, mass cremations produce a lot of smoke with airborne dioxin, resulting in significant respiratory problems (Pan American Health Organization, 2004). Another study also states that despite the vast number of deaths caused by the 2010 earthquake in Haiti and the 2011 earthquake and tsunami, no outbreaks resulting from corpses has been reported (Kouadio et al., 2012). However, in case of Ebola virus, human corpses are potentially dangerous. The WHO warns that levels of Ebola virus remain high after death, thus bodies of people infected with the virus must be buried immediately and the procedure should be handled by trained and properly equipped burial teams. Animal corpses are also dangerous since Ebola virus can be transmitted to people through close contact with the blood, secretions, organs or other bodily fluids of infected animals, including chimpanzees, fruit bats, monkeys and others found ill or dead (WHO, 2016q). Having said all this, the role of bodies for epidemics has clearly changed when it comes to Ebola virus.

Although human body is a natural home to hundreds of species of microorganisms, the organisms involved in putrefaction (mostly anaerobic flora) are not usually considered pathogenic without a large inoculum and exposure occurrence (Conly et al., 2005). There are many pathogens that may be associated with human cadavers and these pathogens reflect the organisms that may be transmitted from living humans. With the death of a host comes the loss of the living environment for these microorganisms;
ultimately, without a host, these organisms cannot sustain their growth. The time after which these pathogenic organisms would no longer be considered transmissible, due to their diminution or ultimate demise, depends on the host and other factors, and may be measured in hours or days (Conly et al., 2005). Organisms traditionally associated with transmission from cadavers include bloodborne viruses (HIV, hepatitis B, hepatitis C, human T-lymphotropic virus 1), enteric bacteria (Salmonella, Shigella, Campylobacter, Yersinia, Vibrio cholerae, Vibrio vulnificus, Escherichia coli, Leptospira), viruses (rotavirus, norovirus, hepatitis A virus and enteric adenovirus), parasites (Giardia, Cryptosporidium) and airborne agents (mycobacterium tuberculosis) (Conly et al., 2005). Although there is a risk of carriage among disaster victims, this risk is no greater than the risk of carriage in the general population. Most of the deaths in a natural disaster are due to trauma, drowning or fire, and there is no opportunity for any amplification of the pathogens that the victims may have been harbouring (Conly et al., 2005). Severe diseases, such as cholera or typhoid, do not typically break out after hurricanes and floods in areas where such diseases do not naturally occur (Conly et al., 2005). A risk of gastroenteritis may be present for the general public if corpses have contaminated the water supply. This risk usually occurs in the later phases of a natural disaster (Conly et al., 2005).

Animal corpses

Many of the assumptions about human corpses correspond to those relating to animal corpses. Myths have been developed about animal corpses as well, without any reliable evidence. It is true that animal vectors do spread a number of diseases among humans, but a lot of people believe that animals as disease vectors are dangerous regardless of whether alive or dead (Pan American Health Organization, 2004).

In most cases, the bodies of dead animals constitute as little risk to humans as human bodies. An animal that has lived through its life cycle or has died from injuries does not pose any health threat for humans. Similarly, massive animal deaths directly resulted from natural disasters are not a health hazard for people. However, it should be noted that animals that die from exposure to a disaster or as a consequence of injuries, and that have had a specific communicable disease, may pose a risk to the affected population (Pan American Health Organization, 2004).
Zoonoses are becoming an increasing threat to human populations. However, like diseases that survive in the corpses of humans, zoonotic diseases from animal corpses must occur in an endemic area for that disease to present any risk. If the area is not endemic for the disease, the probability of corpse-to-human transmission is very low. Generally, there are two specific situations in which the animal bodies can be a risk for humans: the presence of specific infectious agents and the contamination of water by feces and substance from lesions (Pan American Health Organization, 2004).

Although animal corpses constitute a minimal health risk, the proper disposal of bodies of dead animals is important. Methods of animal disposal vary from country to country, mostly depending on the infrastructure and available manpower. In general, it is difficult to bury or cremate large animal corpses due to the lack of resources. First, animal corpses are sprayed with oil and then covered with soil to protect them from predators until they can be destroyed or buried. The same approach is used when parts of animals numerous small animals are found. Another recommendation is to use quicklime, thereby delaying the decay and decreasing the number of bacteria that might pose a risk for zoonoses (Pan American Health Organization, 2004).

Final disposal requires burying the dead animals where there is no possibility of contaminating surface or ground water. This is particularly important in the case of flooding when it is more appropriate to bag the corpses until they can be cremated or buried (Pan American Health Organization, 2004).

2.6. **Epidemic-prone diseases following a natural disaster**

Communicable diseases that have been reported in post-disaster settings will be discussed in this part of the chapter. These diseases should be considered when post-disaster risk assessments are implemented.

The diseases can be categorized into four groups: water-related diseases, vector-borne diseases, acute respiratory infections, and infections as a result of wounds or injuries (Kouadio et al., 2012).
2.6.1. Water-related diseases

Flooding is associated with an increased risk of infection, but, in fact, this risk is low unless there is large-scale population displacement and/or water sources are compromised. The only epidemic-prone infection which can be transmitted directly from contaminated water is leptospirosis, a zoonotic bacterial disease (WHO, 2012a). However, there is a high risk of disruption of access to safe water as a result of a natural disaster, which can lead to outbreaks of acute watery diarrhea, cholera, paratyphoid fever, acute jaundice, and norovirus can also be caused by flooding. Hepatitis A and E are also transmitted in association with lack of access to safe water and sanitation (Watson et al., 2007).

Cholera outbreaks were found directly or indirectly associated with natural disasters. Cholera is one of the most prevalent water-related infections, especially in South Asia, sub-Saharan Africa, and Latin America. The majority of cholera outbreaks occur in coastal regions, indicating a strong association between environment and the disease (Jutla et al., 2013). Cholera is an acute diarrheal disease caused by infection of the intestine called Vibrio cholera, serogroups O1 or O139, which produce cholera toxin (Ligon, 2006). Researchers have estimated that there are 1.4 to 4.3 million cases, and 28000 to 142000 deaths worldwide due to cholera every year. (WHO cholera) Cholera can be transmitted by drinking water or eating food contaminated with the cholera bacterium or feces of already infected persons and spread rapidly in areas with inadequate treatment of sewage and drinking water (Ligon, 2006). Incubation period of 2 hours to 5 days, is an important factor that triggers cholera epidemics (WHO, 2016a).

Vibrio cholerae strains

Two serogroups of V. cholera – O1 and O139 – cause outbreaks. V. cholera O1 causes the majority of outbreaks, while O139 is only present in South-East Asia. Non-O1 and non-O139 V. cholera can cause mild diarrhea but do not lead to epidemics. Other strains have been detected in several parts of Asia and Africa which can cause more severe cholera with higher mortality rates. The main reservoirs of V. cholera are people and aquatic sources such as brackish water. (WHO, 2016a)

Symptoms

About 80% of people infected with V. cholera do not develop any symptoms. Among people who develop symptoms, 80% have mild or moderate symptoms, while around
20% have acute watery diarrhea with severe dehydration. (WHO, 2016a) It might lead to acidosis, hypovolemic shock, renal failure, and even death if left untreated. (Ameli, 2015) Vomiting and leg cramps can also be symptoms of cholera. (Watkins, 2011)

**Treatment**

Cholera is an easily treatable disease. The principles of treatment include restoring fluid losses with oral or intravenous hydration and administering antibiotics. Up to 80% of people can be treated with oral rehydration salts. (WHO cholera) Cases of severe dehydration can be managed with intravenous fluids. These patients might also need antibiotics to diminish the duration of diarrhea, reduce the volume of rehydration fluids needed, and shorten the duration of V. cholera excretion. Doxycycline is the most commonly used antibiotic, alternatives include trimethoprim sulfamethoxazole, erythromycin, furazolidone, ciprofloxacin, or azithromycin (Ameli, 2015) Mass administration of antibiotics is not recommended, as it has no effect on the proliferation of cholera and contributes to increasing antimicrobial resistance. (WHO, 2016a)

**Risk factors and disease burden**

Cholera transmission is closely linked to inadequate environmental management. The consequences of a humanitarian crisis, such as disruption of water and sanitation systems, or the displacement of populations to overcrowded camps, where basic infrastructure is not available, can increase the risk of cholera transmission. (WHO, 2016a) Global warming also creates a favourable environment for the bacteria. The number of cholera cases continues to be high and the disease remains a global threat to public health and a key indicator of lack of social development. (WHO, 2016a)

**Prevention and control**

In order to reduce cholera outbreaks and control cholera in endemic areas, a multidisciplinary approach is needed.

The long-term solution for cholera control both in epidemic and endemic areas is related to economic development and universal access to safe drinking water and adequate sanitation. (WHO, 2016a) In a short-term period isolation of infected persons is not important although hygiene and washing hands is crucial. (Ameli, 2015) A number of actions targeting environmental contamination are also needed. They include the development of piped water systems, water purification, and construction of systems for sewage disposal and latrines. (WHO, 2016a)

Also, surveillance system should be set up. Local capacities for improving diagnosis and for collecting and analysing data need to be strengthened so that vulnerable
populations living in high-risk areas can be identified. (WHO, 2016a) During epidemics, cholera should be presumed after the first batch of confirmed cases, by history and exam alone, and money should not be spent confirming every case of cholera thereafter. (Ameli, 2015)

Besides that, health education campaigns should promote the appropriate hygiene practices such as hand-washing with soap, safe preparation and storage of food and breastfeeding. Also awareness campaigns during outbreaks should encourage people with symptoms to seek immediate health care. (WHO, 2016a)

**Oral cholera vaccines**

Vaccination of populations against cholera is an effective strategy, especially in regions prone to natural disasters. Currently there are two WHO pre-qualified oral cholera vaccines (OCVs) - Dukoral and Shanchol). Both of them have been used in mass vaccination campaigns. Their use has made it possible to collect evidence on the effectiveness and feasibility on implementation of oral cholera vaccination campaigns as a tool in protecting high-risk populations from cholera. OCV can be a part of health campaigns in areas experiencing an outbreak or preventive measure among populations at high risk for cholera, or at heightened vulnerability during a humanitarian crisis. No serious adverse effects of oral vaccines have been reported so far. (WHO, 2016a)

An OCV stockpile of 2 million doses was established in 2013 for outbreak control and emergencies. It was justified by the role of the vaccines in the prevention and control of cholera when used together with accessible healthcare and improvements in water and sanitation. In November 2013, a contribution to the global cholera vaccine stockpile for epidemic and endemic conditions for 2014-2018 was approved. (WHO, 2016a)

**Hepatitis A**

**Key information**

Hepatitis A is a viral liver disease that can cause mild to severe illness. (WHO, 2016c)

The causative agent of Hepatitis A is hepatitis A virus (HAV), a picornavirus (Kouadio et al., 2012).

Like Hepatitis E, hepatitis A is usually self-limiting. However, a very small proportion of people infected with hepatitis A could die from fulminant hepatitis.

Viral hepatitis A and E are common in areas with inadequate sewage disposal and sanitation system and poor personal hygiene.
Hepatitis A is found worldwide and can occur sporadically and in epidemics, with a tendency for cyclic recurrences. Epidemics can lead to significant economic and social consequences in communities. It can take weeks or months for people to recover from the illness and return back to daily life (WHO, 2016c).

**Transmission**
The virus is primarily spread when an uninfected (and unvaccinated) person ingests food or water that is contaminated with the feces of an infected person (fecal-oral route) (WHO, 2016c). After it is ingested, subsequent replication in the liver occur, after which the virus is excreted in bile in high concentrations (Kouadio et al., 2012). In families, this may happen through dirty hands when cooking for family members. The virus can also be transmitted through direct person-to-person physical contact, although casual contact does not spread the virus (WHO, 2016c).

**Symptoms**
The incubation period of hepatitis A is usually 14–28 days and approximately 10 percent of cases have relapses (Kouadio et al., 2012). Symptoms are similar to those of Hepatitis E but abdominal discomfort, malaise, enlargement of liver or spleen, and myalgia may also be present. Adults have signs of illness more often than children and the severity of disease is higher in older age groups (WHO, 2016c).

**Diagnosis**
Similarly to Hepatitis E, cases of hepatitis A are not clinically distinguishable from other types of acute viral hepatitis. Diagnosis can be made by the detection of HAV-specific IgM antibodies in the blood. Additional tests can be done in order to detect the hepatitis A virus RNA, and usually require specialised laboratory facilities (WHO, 2016c).

**Treatment**
There is no specific treatment for hepatitis A, rest is recommended during the acute phase (Ligon, 2006). Recovery from the disease’s symptoms may be slow and take several weeks or months. Most important is the avoidance of unnecessary medications. For instance, acetaminophen/Paracetamol and medication against vomiting should not be given. However, therapy aimed at maintaining comfort and adequate nutritional balance should be provided. Hospitalization is necessary only in case of acute liver failure (WHO, 2016c).

**Prevention**
Hepatitis A is a vaccine-preventable disease and several vaccines are currently available (Ligon, 2006). Generally, proper disposal of sewage, food safety, adequate supplies of safe drinking water, personal hygiene practices, and immunization are the most effective ways to reduce the spread of and/or combat hepatitis A (WHO, 2016c).

**Hepatitis E**

**Key facts:**

- Hepatitis E is a liver disease caused by hepatitis E virus (HEV).
- Every year, there are an estimated 20 million HEV infections worldwide, leading to an estimated 56,600 deaths.
- Hepatitis E is usually self-limiting and resolves within 2–6 weeks but some cases may develop into acute liver failure (fulminant hepatitis). It occurs more frequently in cases of pregnancy (WHO, 2016b).

Hepatitis E virus has at least 4 different types: genotypes 1, 2, 3 and 4. Genotypes 1 and 2 have been found only in humans. Genotype 3 and 4 viruses have been found in several animals (for example, pigs and deer) without causing any disease, and occasionally infect humans (WHO, 2016b).

Hepatitis E is found worldwide, but is more prevalent in East and South Asia. The disease is common in resource-limited countries with limited access to water, sanitation, hygiene and health services. In these areas, the disease occurs both as outbreaks and as sporadic cases. The outbreaks are usually caused by faecal contamination of drinking water supplies. Some of these outbreaks have occurred in areas of conflict and humanitarian emergencies where sanitation and safe water supply are disrupted (WHO, 2016b).

**Transmission**

The hepatitis E virus is spread by eating or drinking contaminated food or water due to faecal contamination of the supplies as the virus is shed in the stools of infected persons (Ligon, 2006). Other ways of transmission have been identified, but appear to account for a much smaller number of cases. These routes of transmission include:

- Ingestion of undercooked meat derived from infected animals may cause sporadic cases in endemic areas
- Transfusion of infected blood products
- Transmission from a pregnant woman to her fetus (WHO, 2016b).

**Symptoms**
The incubation period following exposure to the hepatitis E virus ranges from 2 to 10 weeks, with an average of 5–6 weeks. Typical symptoms of hepatitis include:

- mild fever, fatigue, reduced appetite, nausea and vomiting, lasting for a few days; sometimes abdominal pain, itching, skin rash, or joint pain
- jaundice, with dark urine and pale stools
- a slightly enlarged liver.

These symptoms often cannot be distinguished from those of other liver illnesses and usually last between 1–6 weeks (WHO, 2016b).

**Diagnosis**

It is very hard to distinguish Hepatitis E from other types of acute viral hepatitis. Definitive diagnosis is usually based on the detection of specific IgM antibodies to the virus in a person’s blood. This is usually required in endemic areas (WHO, 2016b). There are also additional tests detecting the virus RNA in blood and/or stool, which is particularly needed in areas where hepatitis E is infrequent, and in cases with chronic HEV infection. However, these tests require specialised laboratory facilities, which are often not provided in areas affected by natural disasters or conflicts (WHO, 2016b).

**Treatment**

There is no specific treatment of acute hepatitis E, it can only be supportive. As the disease is usually self-limiting, hospitalization is usually required only for people with fulminant hepatitis and, sometimes, pregnant women. The state of immunosuppressed people with chronic Hepatitis E can be improved by specific treatment using ribavirin (antiviral drug) and sometimes interferon (WHO, 2016b).

**Prevention**

Prevention is the most effective approach against the disease. Transmission of HEV can be reduced by maintaining quality standards for public water supplies and establishing proper disposal systems for human feces (WHO, 2016b). Individuals can also reduce the risk by following standard recommendations about personal hygiene, for example, washing hands with safe water, and also avoiding consumption of water from unknown sources (WHO, 2016b).

If an outbreak of Hepatitis E has already been suspected, there are a number of actions that should be done, including verification of the diagnosis and confirmation of existence of an outbreak; determination of the mode of transmission, and identification of the population at risk; improvement of sanitary and hygienic practices; and elimination of the source of infection (WHO, 2016b).
Diarrheal disease

Key facts:

- Diarrheal disease is the second leading cause of death in children under five years old. It kills around 760,000 children under five annually.
- The disease is treatable and preventable.
- Globally, there are nearly 1.7 billion cases of diarrheal disease every year.
- Diarrhea is a leading cause of malnutrition in children under five years old (WHO, 2016d).

Diarrhea is the passage of 3 or more loose or liquid stools per day, or more frequently than is normal for the individual. It is usually a symptom in the intestinal tract, which can be caused by a number of bacterial, viral and parasitic organisms. Infection is spread through contaminated food or water, or from a direct human-to-human contact as a result of poor hygiene. In severe cases, diarrhea leads to fluid loss and may be life-threatening, especially in young children and people who suffer from malnutrition or have a weak immune system as well as those who live with HIV (WHO, 2016e).

There are three clinical types of diarrhea:

- acute watery diarrhea – lasts several hours or days, and includes cholera;
- acute bloody diarrhea – also called dysentery; and
- persistent diarrhea – lasts 14 days or longer (WHO, 2016e).

Risk of diarrhea

People in areas with limited access to clean water and sanitary facilities, are particularly vulnerable to acute diarrhea. Generally, diarrheal epidemics are frequently reported in the aftermath of natural disasters, especially in developing countries (Kouadio et al., 2012). For example, after the earthquake in Pakistan in 2005, where infrastructure was severely disrupted, 23,405 cases of acute watery diarrhea with three related deaths have been reported (Ligon, 2006). Greater than 40% of deaths in emergency conditions occur secondary to diarrheal illness with 80% of those involving children under 2 years old (Ameli, 2015).

Dehydration

The most severe threat posed by diarrhea is dehydration. During the course of the disease, water and electrolytes (sodium, chloride, potassium and bicarbonate) are lost through liquid stools, vomit, sweat, urine and breathing. Dehydration occurs when these losses are not replaced and might lead to death (WHO, 2016d).

There are three stages of dehydration:
1. Early dehydration – no signs or symptoms.
2. Moderate dehydration which causes symptoms such as thirst, restless or irritable behavior, sunken eyes, and decreased skin elasticity.
3. Severe dehydration: at this stage symptoms become more severe and might also include shock, lack of urine output, cool, moist extremities, a rapid and weak pulse, low or undetectable blood pressure, and pale skin (WHO, 2016d).

**Causes**

There are a number of causes of diarrhoeal disease. Firstly, diarrhea can be a symptom of infections caused by a host of bacterial, viral and parasitic organisms, most of which are spread by feces-contaminated water. Infection is more common when sanitation and access to safe water are compromised. Cholera is one of the most common causes, which can spread rapidly and lead to very high mortality rates (Waring & Brown, 2005). Rotavirus, Escherichia coli, and dysentery (Shigella) are other common agents of diarrhea in developing countries. Secondly, diarrhea can result from malnutrition which particularly affects children and makes them more vulnerable to diarrhea. Each diarrhoeal episode, in turn, makes their malnutrition even worse. Thirdly, water sources contaminated with human or animal feces might cause diarrhea. Also, there are other causes, such as person-to-person transmission, aggravated by poor personal hygiene; food, prepared or stored in unhygienic conditions (WHO, 2016d).

**Prevention**

Key preventive measures include:

- food hygiene and access to safe drinking-water
- improved sanitation
- good personal hygiene, including hand washing with soap
- exclusive breastfeeding for the first six months of life
- health education about how infections spread
- rotavirus vaccination (WHO, 2016d).

**Treatment**

Key measures:

- Rehydration: with oral rehydration salts (ORS) solution. It is a mixture of clean water, salt and sugar. ORS helps to replace the water and electrolytes lost in the faeces. In case of severe dehydration or shock, intravenous fluids are recommended.
Zinc supplements reduce the duration of a diarrhea episode by 25% and stool volume by 30%.

In order to prevent/treat malnutrition caused by diarrhea, nutrient-rich food, including breast milk should be given to patients (WHO, 2016d).

Dysentery is bloody diarrhea usually caused by Shigella species, two types of which are most prominent: Shigella sonnei and Shigella flexneri (WHO, 2016d). The bacteria are especially prevalent where hygiene is poor, so any natural disaster that causes contamination of food and water supplies can cause a Shigella epidemic. It is transmitted through fecal-oral route (Watkins, 2011). The incubation period may last from 12 hours to several days and is usually followed by diarrhea, fever, and stomach cramps. During the first 48 hours, high volume diarrhea, often bloody or mucous, may occur. Bacillary dysentery usually resolves without therapy in 5 to 7 days. In cases of severe diarrhea, hospitalization is needed. Treatment of the disease includes oral hydration and antibiotics, such as ampicillin, trimethoprim, nalidixic acid and others (Ligon, 2006). However, antibiotic resistance has been spreading in Shigella, limiting treatment options (Watkins, 2011).

Leptospirosis

Key facts:

- Leptospirosis an epidemic-prone zoonotic bacterial disease caused by bacteria of the genus Leptospira.
- It affects humans and animals.
- Leptospirosis occurs worldwide, but is most prevalent in tropical and subtropical regions.
- Outbreaks of leptospirosis have been reported following natural disasters such as flooding. Floods or excessive rainfall facilitate the proliferation of rodents and can cause an outbreak of leptospirosis, especially in developing countries (Ligon, 2006).

Transmission

Leptospirosis can be transmitted by direct contact with water, food, or soil containing urine from infected animals through cuts of the skin, or through the mucous surfaces of the eyes, nose and mouth (Ligon, 2006). Besides rodents, there are a number of animals that are also considered common reservoirs of Leptospira, such as cattle, buffaloes,
horses, sheep, goat, pigs and dogs (WHO, 2016f). Occasionally, the disease can be transmitted through the drinking of water or ingestion of contaminated food. Human-to-human transmission occurs extremely rarely (WHO, 2016f).

**Symptoms**

The incubation period is usually 5–14 days, but can also be 2–30 days (WHO, 2016f). In humans, the disease causes a wide range of symptoms, including fever, abdominal pain, severe headache, red eyes, chills, muscle pain, vomiting, and occasionally jaundice, diarrhea, or a rash; some patients may have no symptoms. If the disease is not treated, it can lead to kidney damage, meningitis, liver failure, and respiratory distress (Ligon, 2006). 5-15% of untreated cases can progress to a more severe and even fatal stage (WHO, 2016f).

**Diagnosis**

Leptospirosisis is often difficult to diagnose, as symptoms can be very similar to other diseases such as dengue, typhoid and viral hepatitis (WHO, 2016f). The disease is usually confirmed by laboratory testing of a blood or urine sample (Ligon, 2006).

**Treatment**

Leptospirosis can be treated with antibiotics, such as doxycycline or penicillin that should be given at the early stage of the course of the disease. Clinicians should never wait for the results of laboratory tests before prescribing antibiotics (WHO, 2016f).

**Prevention**

Risk of infection can be minimized by avoiding contact with infected and dead animals and/or a contaminated environment. Other preventive measures include the following:

- Wearing protective clothing and covering skin lesions with waterproof dressings.
- Limiting access to water source known or suspected to be contaminated.
- Maintaining good personal hygiene.
- Washing and cleaning wounds.
- Avoiding or preventing urine splashes and aerosols, avoiding touching ill or dead animals, or assisting animals in giving birth.
- Where possible, disinfecting contaminated areas.
- Consuming clean drinking-water.
With regard to vaccination, although a number of vaccines have been used in some countries with varying degrees of success, WHO has not approved any vaccines yet (WHO, 2016f).

**Typhoid Fever**

**Key facts:**

- Caused by the bacterium *Salmonella Typhi*. A similar but often less severe disease, paratyphoid fever, is caused by *Salmonella Paratyphi* A, B or C serotype.
- The bacterium lives only in humans, who carry the bacteria in their bloodstream and intestinal tract.
- Even after recovery infected people continue to carry the bacteria (Ligon, 2006).
- Approximately 21 million cases and 222 000 typhoid-related deaths occur annually worldwide (WHO, n.d.).

Areas where typhoid fever is endemic are particularly prone to outbreaks following natural disasters, as they typically have poor sanitation and very limited access to clean drinking water. It has been found that after the 2004 tsunami in Indonesia, outbreak of typhoid fever occurred among internally displaced people due to the lack of clean water and bacterial contamination of drinking water (Watkins, 2011).

**Transmission** occurs by fecal contamination of food or water (Watkins, 2011). Once the bacteria are ingested, they multiply and spread into the bloodstream (Ligon, 2006).

**Symptoms** usually develop within 1–3 weeks and may be mild or severe. They include high fever, malaise, headache, loss of appetite, constipation or diarrhea, and enlarged spleen and liver (WHO, n.d.). In some cases, patients have a rash of rose-coloured spots on the chest (Ligon, 2006). Symptoms are often clinically non-distinguishable from other febrile illnesses (WHO, n.d.).

**Treatment**

The disease is usually treated with antibiotics, such as ampicillin, trimethoprim-sulfamethoxazole, or ciprofloxacin. Persons who do not get treatment may continue to have fever for weeks or months, and the disease may lead to serious consequences or even death, especially in poor water and sanitation conditions (Ligon, 2006). However, the bacteria are becoming more and more resistant to commonly used drugs, which is the major concern with regard to treatment (WHO, n.d.).
Prevention
Typhoid fever is a preventable disease. Two vaccines exist and are currently recommended for use:

- an injectable polysaccharide vaccine based on the purified Vi antigen for persons aged two years and above;
- an oral Ty21a vaccine in capsule formulation for people over five years of age (WHO, 2015a).

It also should be possible to eliminate the disease through improved sanitation. However, its wide prevalence and lack of resources for water and sanitation facilities in resource-poor countries makes eradication nearly impossible (Watkins, 2011).

Protozoan parasites
Amebiasis is caused by either Entamoeba histolytica or Entamoeba dispar. The former can cause symptomatic diseases. The disease has been reported worldwide, but is more common in areas or countries with poor sanitation, particularly in the tropics (WHO, 2012b). Transmission occurs via the faecal–oral route, either directly by person-to-person contact or by eating or drinking contaminated food or water. The course of the disease ranges from asymptomatic infection to fulminant colitis and peritonitis (WHO, 2012b). The most common manifestations of acute amoebiasis are diarrhea and dysentery. Chronic amoebiasis can present with abdominal pain and/or distention, also fatigue, tachypnea, weight loss and occasional fever. Extraintestinal amoebiasis can occur if the parasite affects other organs, most commonly the liver where it causes amoebic liver abscess and often causes high fever (WHO, 2012b). The disease can be treated with various medications, depending on the severity of the disease. Therapy should also include rehydration with fluid and electrolytes (Pearson, 2016). The disease can be prevented by practicing good hygiene, proper food preparation, and avoiding drinking contaminated water. No vaccine is available so far (WHO, 2012b).

Cryptosporidiosis is a diarrheal disease caused by a microscopic parasite Cryptosporidium that infects the gastric and respiratory epithelium. Both the parasite and the disease are commonly known as "Crypto." Cryptosporidium is a leading cause of waterborne disease (CDC, 2015a). Transmission occurs by the fecal-oral route; ingestion of contaminated water or food is the most common way to spread the parasite (Ligon, 2006). Diagnosis of cryptosporidiosis is made by examination of stool samples (CDC, 2015a). Symptoms of the disease generally begin 2 to 10 days (average 7 days)
after the exposure. The most common symptom is watery diarrhea, others may include stomach cramps or pain, dehydration, nausea, vomiting, fever, or weight loss. Some people have no symptoms at all (CDC, 2015a). Symptoms usually last about 1 to 2 weeks (with a range of a few days to 4 or more weeks) in persons with strong immune systems, while people with weakened immune systems may develop serious, chronic, and sometimes fatal illness (CDC, 2015a). People with healthy immune systems do not need treatment, except for rehydrating measures. However, immunosuppressed individuals will most likely need specific medications. Cryptosporidiosis can be prevented by taking same measures as in the amebiasis case, no vaccine is currently available too (CDC, 2015a).

Cyclosporiasis is caused by the microscopic parasite *Cyclospora cayetanensis* that infects the Watkins, 2011 tract (Ligon, 2006). Similarly to other protozoan diseases, transmission occurs by the fecal-oral route as a result of consuming contaminated food or water. Cyclospora infection is diagnosed by examining stool specimens (CDC, 2016a). Cyclosporiasis is characterized by a rapid onset of watery diarrhea, which may be accompanied by malaise and myalgia. Also, symptoms such as low-grade fever, vomiting, abdominal cramping, heartburn, and indigestion may be present. The disease is self-limited in people with strong immune systems and may last for a few days to a month or longer (Ligon, 2006). People who have weakened immune systems may be at higher risk for severe or prolonged illness. In that case, medication is needed. With regard to prevention, avoiding food or water that may have been contaminated with feces is the best option because no vaccine for cyclosporiasis is available (CDC, 2016a).

Giardiasis is caused by infection with the protozoan parasite *Giardia lamblia* that has been found worldwide. Transmission usually occurs by the fecal-oral route, so the level of sanitation plays a crucial role in the spread of the disease. The disease is often asymptomatic (Ligon, 2006). In other cases, symptoms are mainly intestinal and normally begin 1 to 3 weeks after becoming infected (CDC, 2016a). Symptoms vary from mild abdominal discomfort, fatigue, and diarrhea to severe cramping, bloating, and weight loss. Disruption of digestion by bile and proteases may lead to malabsorption, diarrhea, and, as a result, malnutrition (Ligon, 2006). Diagnosis of giardiasis is made by examination of stool samples. Regarding treatment, many drugs are currently available and rehydration is also recommended as an additional measure. In order to prevent spread of the infection, simple actions such as practicing good hygiene, and not eating
food and drinking water that might have been contaminated can be taken (WHO, 2012c).

**Enterotoxigenic Escherichia Coli**

Escherichia coli is a bacterium that normally lives in the intestines of humans and other animals. Most types of E. coli are harmless, but some of them (like ETEC) can produce special toxins which cause the intestines to secrete excessive fluid, thereby producing diarrhea (CDC, 2014a). Infections caused by Enterotoxigenic Escherichia coli (ETEC) range from asymptomatic carriage to severe diseases similar to cholera (Watkins, 2011). It is one of the most important cause of bacterial diarrheal illness. ETEC is transmitted by food or water contaminated with animal or human feces (CDC, 2014a). Incubation period lasts 1-3 days after exposure and the course of the disease usually lasts 3-4 days. Symptoms of the disease may include watery diarrhea, abdominal cramping as most common; also fever, nausea with or without vomiting, chills, loss of appetite, headache, muscle aches and bloating can also be present. ETEC is diagnosed by examination of stool samples (CDC, 2014a). Most patients recover with supportive measures, like rehydration, within a few days and do not require hospitalization or antibiotics. Infection can be prevented by proper preparation of food and beverages as well as washing hands with soap. Vaccines for ETEC are being developed, but none are available yet (CDC, 2014a).

### 2.6.2. Vector-borne diseases

Natural disasters, particularly cyclones, hurricanes, and flooding, can affect vector-breeding sites and, consequently, vector-borne disease transmission. Standing water caused by heavy rainfall or flooding can create new breeding sites (WHO, 2012a). Generally, a lag time is up to 8 weeks before the onset of vector-borne diseases, depending on the local mosquito vector species and its preferred habitat (Waring & Brown, 2005). Overcrowding of populations, increased exposure to mosquitoes while sleeping outside, a weakened public health infrastructure, and interruptions of ongoing control programs are all risk factors for vector-borne disease transmission (Watson et al., 2007). As literature review showed, vector-borne diseases which are likely to result in a large outbreak following a natural disaster include malaria, dengue, rabies, chaga’s disease, chikungunya, and West Nile Fever.
**Malaria** epidemics after flooding are a well-known phenomenon in malaria-endemic areas that represent serious public health emergencies (Kouadio et al., 2012). An epidemic of malaria usually occurs 4 to 8 weeks after the disaster’s strike and is characterized by several weeks duration before its peak (Waring & Brown, 2005). In 2015 there were 214 million new cases of malaria worldwide, 438 thousand of which resulted in deaths. The African Region accounted for most cases and deaths (88% and 90% respectively), followed by the South-East Asia Region and the Eastern Mediterranean Region (WHO, 2016g).

**Cause and transmission**
Malaria is a curable disease caused by species of Plasmodium and is transmitted by the infective bite of malarial female Anopheles mosquitoes. The incubation periods vary from 7 to 30 days, depending on which organism is involved (WHO, 2016g). Transmission also depends on species of mosquito, preferred breeding habitats, and prevalence of the parasite. Usually, the mosquitos breed in stagnant fresh or brackish water (Waring & Brown, 2005).

**Symptoms**
The first symptoms of malaria are fever, headache, chills and vomiting. They usually appear between 10 and 15 days after the mosquito bite (Ligon, 2006). With uncomplicated malaria, the attack lasts 6 to 10 hours and is characterized by cold and shivering followed by a hot stage that comprises fever, headaches, vomiting, and seizures in young children. The final stage is sweating that includes sweats, return to normal temperature and tiredness (Ligon, 2006). The attacks might occur every second or every third day depending on the type of parasite. The typical attack involves a combination of fever, chills, sweats, headaches, nausea and vomiting, body aches, and general malaise. Physical findings may include high temperature, enlarged spleen and/or liver, mild jaundice, and increased respiratory rate (Ligon, 2006). Without prompt treatment, malaria can progress to severe illness, which is often complicated by serious organ failures or abnormalities in the patient’s blood or metabolism and may lead to death (WHO, 2016g).

**Treatment**
Artemisinin-based combination therapies (ACTs) are highly effective against P. falciparum, the most prevalent and lethal malaria type affecting humans. Severe malaria is a medical emergency and should be treated urgently (Ligon, 2006). Clinical diagnosis is based on the patient’s symptoms and physical findings at examination and then needs
to be confirmed by laboratory blood test. Drugs that are active against the parasite forms in the blood include chloroquine, sulfadoxine-pyrimethamine, mefloquine, atovaquone-proguanil, quinine, doxycycline (Ligon, 2006).

**Prevention and control**

Key interventions in order to prevent, control and eliminate malaria include the use of insecticide-treated mosquito nets and indoor spraying and diagnostic testing. These measures have dramatically decreased the malaria burden in many settings. Also, WHO recommends diagnostic testing for all people with suspected malaria before treatment is administered. Rapid diagnostic testing (RDTs), introduced widely in the last ten years, has made it easier to distinguish between malarial and non-malarial fevers, ensuring timely and appropriate treatment (WHO, 2016g).

**Insecticide and drug resistance**

In many countries, progress in malaria control is threatened by the rapid development of anti-malarial drug resistance. By now, parasite resistance to artemisinin has been detected in 5 countries in Southeast Asia. Mosquito resistance to insecticides used in nets and indoor spraying is another growing concern (WHO, 2016g). As a result, malaria is becoming more difficult to control.

**Risk factors**

The prevalence of vector-borne diseases in the region before the disaster, the identity and ecology of the vectors (for example, type of water they are likely to breed in), and the impact of control programmes and preventive measures play a significant role in determining the risk of malaria epidemics (Feng et al., 2015). Other important factors include damage to critical infrastructure such as basic utilities, transport, communication, and health care as a result of the disaster; warm and wet weather. Also, poor awareness of methods to control mosquito populations often leads to greater opportunities for mosquitoes to transmit malaria (Feng et al., 2015).

**Dengue**

**Key features:**

- Dengue is a mosquito-borne viral infection that can be found worldwide but is prevalent tropical and subtropical countries mostly in urban and semi-urban areas (WHO, 2014b).
- It is caused by one of four distinct serotypes (dengue 1-4) (WHO, 2016h).
• Sometimes it causes a life-threatening complication called severe dengue (also known as dengue hemorrhagic fever). Today it affects mostly Asian and Latin American countries and has become a leading cause of hospitalization and death in these areas (WHO, 2014b).

• The incidence of dengue has increased 30-times over the last 50 years. Up to 50-100 million infections are occur annually in over 100 endemic countries, resulting in 40% of the world’s population living population at risk (WHO, 2014b).

**Transmission**

Dengue viruses are transmitted to humans via the bite of infected female mosquitoes of the Aedes genus (Kouadio et al., 2012).

**Symptoms**

Symptoms appear between 3 and 14 days after the infective bite (WHO, 2016i). They vary according to the age of the patient. Infants and young children usually have only a febrile illness with a rash that can hardly be distinguished from other viral illnesses, whereas older children and adults often have a rapidly rising temperature (39°C) that lasts approximately 5 to 6 days (Ligon, 2006). During the febrile period, patients may have severe headache, myalgia, arthralgia, nausea, and/or vomiting. Also, minor hemorrhagic manifestations such as petechiae, epistaxis, and gingival bleeding may occur (Ligon, 2006).

Generally, non-severe dengue illness is often characterized by high fever, severe headache, pain behind the eyes, muscle and joint pains, nausea, vomiting, swollen glands, or rash. In turn, severe dengue may cause severe abdominal pain, persistent vomiting, rapid breathing, bleeding gums, fatigue, restlessness, and blood in vomit, and may be fatal due to plasma leakage, fluid accumulation, respiratory distress, severe bleeding, or organ impairment (WHO, 2016h).

**Treatment**

There is no specific treatment for dengue. Generally, patients recover after having 7 to 10 days of illness. The main feature of management is maintenance of fluid circulation (Ligon, 2006). People who have dengue fever should drink plenty of fluids, rest and reduce the fever using paracetamol (WHO, 2016i). Appropriate supportive care has reduced the mortality rate to 1% which, otherwise, could be 20% (Ligon, 2006).

**Factors and risks**
CONNECTION BETWEEN NATURAL DISASTERS AND EPIDEMICS OF INFECTIOUS DISEASES

Dengue disproportionately affects the poor (Chang et al., 2014). The transmission is influenced by weather conditions such as rainfall and humidity, however, the disease is not directly associated with them. In endemic areas, such events may coincide with seasonal periods of high risk for transmission and may be exacerbated by increased availability of the vector’s breeding sites (such as water storage containers) caused by disruption of basic water supply (Watson et al., 2007). The risk for outbreaks can be increased by other factors, including population movement from dengue-non-endemic to -endemic areas, interruptions of mosquito control programs; crowding of infected and susceptible hosts; increased exposures to mosquitoes while sleeping outside; or changes in the habitat that promote mosquito breeding (landslide, deforestation, river damming, and rerouting of water) (Chang et al., 2014).

Prevention
The first dengue vaccine, Dengvaxia (CYD-TDV), was licensed in December, 2015, in Mexico. It has been registered for use in individuals 9-45 years of age and is recommended for use in areas where epidemiological data indicate a high burden of disease (WHO, 2016h). However, there is no universal dengue vaccine yet. Several vaccine candidates are in clinical or pre-clinical development. Regarding preventive measures, WHO recommends using methods that target mosquitoes directly such as mosquito habitat removal and use of insecticides (WHO, 2016h).

Rabies
Key facts:
- Rabies is an infectious viral disease that is almost always fatal once symptoms start to appear (WHO, 2016j).
- It is a vaccine-preventable disease which occurs in more than 150 countries and causes 55,000 deaths annually, 95% of which occur in Asia and Africa (WHO, 2016j).
- Any mammal can get rabies, including raccoons, skunks, bats, foxes, and coyotes. However, dogs are the most popular source, contributing up to 99% of all rabies transmissions to humans (Ligon, 2006).
- Immediate wound cleansing with soap and water after contact with a potentially infected animal can be life-saving (WHO, 2016j).

Transmission
Rabies affects domestic and wild animals, and is spread to people via bites or scratches or direct contact with human mucosa or fresh skin wounds. Human-to-human transmission by bite is possible in theory but has never been confirmed. Rarely, the infection can be transmitted by inhalation of virus-containing aerosol or via transplantation of an infected organ (WHO, 2016j).

**Symptoms**

The incubation period is typically 1–3 months, but may vary from 1 week to 1 year, depending on the location of rabies entry and the viral load (WHO, 2016j). This acute phase typically ends after 2 to 10 days. After infection occurs, the virus enters an eclipse phase and can hardly be detected; the phase may last for days or months. During that period, the host immune system may develop cell-mediated immunity against the infection. Progression of infection occurs when the virus reaches peripheral nerves. Once it happens, the virus is transported to the central nervous system via retrograde axoplasmic flow (Ligon, 2006). The initial symptoms of rabies may be nonspecific flu-like signs such as fever, malaise, headache, but also discomfort or tingling or burning sensation (paraesthesia) at the site of the bite. As the disease progresses, more symptoms such as anxiety, confusion, and agitation, followed by delirium, abnormal behavior, hallucinations, and insomnia appear (Ligon, 2006). With the virus spread through the central nervous system, fatal inflammation of the brain and spinal cord develops (WHO, 2016j). However, symptoms also depend on the form of the disease. In case of furious rabies, people have signs of hyperactivity, excited behavior, hydrophobia and sometimes aerophobia. After a few days, death occurs due to heart failure (WHO, 2016j). In case of paralytic rabies (about 30% of all cases), the course of the disease is usually less dramatic and longer. The symptoms include gradual paralysation of muscles followed by coma and eventually death. The paralytic form of rabies is often misdiagnosed, contributing to the under-reporting of the disease (WHO, 2016j).

**Diagnosis**

Diagnosis of rabies is very difficult unless the specific signs of hydrophobia or aerophobia are present. Human rabies can be confirmed by various tests aimed at detecting the virus, viral antigens or nucleic acids in infected tissues (brain, skin, urine or saliva) (WHO, 2016j).

**Treatment**
CONNECTION BETWEEN NATURAL DISASTERS AND EPIDEMICS OF INFECTIOUS DISEASES

As an immediate treatment, post-exposure prophylaxis can be done. It helps to prevent rabies from entering the central nervous system which would result in imminent death. This measure consists of local treatment of the wound, a course effective rabies vaccine, and the administration of rabies immunoglobulin, if indicated. Effective treatment soon after infection can prevent the onset of symptoms and death (WHO, 2016j). Without post-exposure prophylaxis, rabies becomes a fatal disease after the infection (WHO, 2013b).

**Prevention**

- Vaccinating dogs is the most cost-effective preventive strategy.
- Pre-exposure immunization in people, especially children since they are considered at higher risk because they tend to play with animals, may receive more severe bites, or may not report them (WHO, 2016j).

Overall, prevention of human rabies must involve both veterinary and public health officials. If the virus is not eliminated, expenses related to prevention of the disease in both humans and animals are likely to increase dramatically in developing countries (WHO, 2013b).

**West Nile virus**

**Key facts:**

- West Nile virus is a member of the *Flavivirus* genus and belongs to the Japanese encephalitis antigenic complex of the family *Flaviviridae* (Ligon, 2006).
- West Nile virus can cause a fatal neurological disease and in humans.
- Birds are the natural hosts of West Nile virus.
- The virus can be found in Africa, Europe, the Middle East, North America and West Asia (WHO, 2016k).

**Transmission**

West Nile virus is most commonly transmitted to humans by mosquitoes (Ligon, 2006). Mosquitoes become infected when they feed on infected birds. The virus may also be transmitted through contact with other infected animals, their blood, or other tissues (WHO, 2016k). Humans and other animals are thought to be dead-end hosts which means that they cannot transmit the virus further (Ligon, 2006). A very small proportion of human infections have occurred via organ transplant, blood transfusions, exposure in
a laboratory setting, and from mother to baby during pregnancy, delivery, or breastfeeding (CDC, 2016b).

**Symptoms**

The incubation period is usually 3 to 14 days (WHO, 2016k). Around 80% of people who become infected with West Nile virus do not have any symptoms (CDC, 2016b). However, in some cases the virus can lead to West Nile fever (about 1 in 5 people infected) or severe West Nile disease (around 1 in 150 persons infected) (WHO, 2016k). In case of the former, patients might have symptoms such as fever, headache, fatigue, body aches, joint pains, nausea, vomiting, diarrhea, skin rash, or swollen lymph glands. Most people with this type of the disease recover completely, but fatigue and weakness can last for weeks or months (CDC, 2016b). The symptoms of severe disease (also known as neuroinvasive disease, such as West Nile encephalitis or meningitis or West Nile poliomyelitis) may include headache, high fever, neck stiffness, disorientation, coma, muscle weakness, tremors, stupor, seizures, or paralysis (WHO, 2016k). Serious illness can occur in people of any age. However, people over 60 years as well as people with certain medical conditions, such as cancer, diabetes, hypertension, kidney disease, and people who have received organ transplants, are at greater risk for serious illness. Recovery from severe disease may take several weeks or months. Some of the neurologic effects may be permanent. About 10 percent of people who experienced the severe form of West Nile virus die (CDC, 2016b).

**Treatment**

No effective treatment exists for WNV infection (Ligon, 2006). Treatment can only be supportive to reduce fever and relieve symptoms (CDC, 2016b). In severe cases, patients often need to be hospitalized to receive treatment, such as intravenous fluids, respiratory support, painkillers, and prevention of secondary infections nursing care (WHO, 2016k).

**Prevention**

No vaccine is available for humans (WHO, 2016k). The most effective way to avoid West Nile virus disease is to prevent mosquito bites (CDC, 2016b). Prevention includes personal protection such as minimising outdoor activity from dusk to dawn, wearing protective clothes, and using mosquito nets and insect repellents (Ligon, 2006). Blood and organ donation restrictions and laboratory testing should be considered at the time of the outbreak in the affected areas in order to reduce the risk of transmission through blood transfusion and organ transplant (WHO, 2016k). Also, the establishment of an
active animal health surveillance system to detect new cases in birds and horses as well as vaccination of the latter are essential in preventing further spread of the virus (WHO, 2016k).

**Chaga’s disease**

**Key facts:**
- Chaga’s disease is a potentially life-threatening zoonotic disease caused by *Trypanosoma cruzi* parasite (Ivers & Ryan, 2006).
- About 6 million to 7 million people all over the world, mostly in Latin America, are estimated to have experienced the disease (WHO, 2016l).
- Chagas disease is endemic in 21 Latin American countries.
- The cost of treatment for Chagas disease including medications and insecticide sprays remains substantial (WHO, 2016l).
- Poor housing conditions often cause the spread of triatomine bugs, so in endemic countries people living in rural areas are at greatest risk for getting infected (CDC, 2016c). Also, rainfall, temperature, and humidity are found to be important predictors of the increased proliferation of the infection (Ivers & Ryan, 2006).

**Transmission**
The parasites are mainly transmitted by contact with faeces/urine of infected blood-sucking triatomine bugs. However, infection can also occur from mother-to-baby during pregnancy or childbirth, blood transfusions, organ transplantation, laboratory accident, consumption of food or drink contaminated with the parasite (CDC, 2016c).

**Signs and symptoms**
Chagas disease has an acute and a chronic phase. If untreated, infection is permanent. Acute phase occurs immediately after infection and may last from a few weeks to two months after infection (CDC, 2016c). During the acute phase, a high number of parasites circulate in the blood but in most cases infection is mild or asymptomatic. In less than 50% of cases symptoms such as skin lesion or swelling around the site of inoculation are present. Additional symptoms include fever, headache, enlarged lymph glands, pallor, muscle pain, difficulty in breathing, and abdominal or chest pain (WHO, 2016l). Rarely, acute infection may result in severe inflammation of the heart muscle or the brain and lining around the brain (CDC, 2016c).
Following the acute phase, most infected people enter into a prolonged asymptomatic form of disease during which few or no parasites are found in the blood since they are mainly hidden in the heart and digestive muscles. Many people may remain asymptomatic for life and never develop any specific symptoms (CDC, 2016c). However, up to 30% of patients suffer from cardiac disorders and up to 10% suffer from digestive (such as enlargement of the oesophagus or colon), neurological or mixed alterations. Later on the infection can lead to sudden death or heart failure caused by progressive destruction of the heart muscle and its nervous system (WHO, 2016l).

**Treatment**

Chagas disease can be treated with benznidazole and nifurtimox. Both medicines proved to be effective if given soon after the onset of the acute phase including the cases of congenital transmission (WHO, 2016l). The medicines are recommended for all people diagnosed with an acute infection, congenital infection, and for those with suppressed immune systems, and for patients of all age groups during the early chronic phase (CDC, 2016c). However, Benznidazole and nifurtimox should not be taken by pregnant women or by people with kidney or liver failure. Nifurtimox should also not be given to people with neurological or psychiatric disorders (WHO, 2016l). For cardiac or gastrointestinal manifestations resulting from Chagas disease, specific treatment may be required (CDC, 2016c).

**Control and prevention**

There is no vaccine for Chagas disease. Vector control is the most useful method to prevent Chagas disease (WHO, 2016l). In endemic areas of Latin America improved housing and spraying insecticide to eliminate triatomine bugs has significantly decreased the spread of Chagas disease (CDC, 2016c). Therefore, WHO recommends the following measures of prevention and control:

- spraying of houses and surrounding areas with insecticides
- house improvements to prevent infection
- use of bed nets
- good hygiene practices in food preparation, transportation, storage and consumption
- screening of blood donors
- testing of organ, tissue or cell donors and receivers
- screening of newborns and other children of infected mothers to provide early diagnosis and treatment (WHO, 2016l).
Chikungunya virus

Key facts:
- Chikungunya is a mosquito-borne viral disease caused by a virus that belongs to the alphavirus genus of the family Togaviridae.
- The disease has similar to dengue clinical signs, and can be misdiagnosed in areas where dengue is common.
- The proximity of mosquito breeding sites to human habitation is a significant risk factor.
- Chikungunya has been identified in over 60 countries in Asia, Africa, Europe and the Americas. The disease used to occur only in Africa, Asia and the Indian subcontinent. However, in recent decades it has spread to Europe and the Americas (WHO, 2016m). Since then, local transmission has been identified in 45 countries of the Americas with more than 1.7 million suspected cases (CDC, 2016d).

Transmission
The virus is transmitted by the bites of infected female mosquitoes. Most commonly, the mosquitoes involved are *Aedes aegypti* and *Aedes albopictus*. These two species can also transmit other mosquito-borne viruses, including dengue (WHO, 2016m). Rarely, chikungunya virus can be transmitted from mother to newborn around the time of birth (CDC, 2016d).

Signs and symptoms
The incubation period of the disease usually lasts from 4 to 8 days but can range from 2 to 12 days (WHO, 2016m). The most common symptoms are fever and joint pain (CDC, 2016e). Other signs include muscle pain, headache, nausea, joint swelling, fatigue and rash. Often symptoms are mild and the infection may go unrecognized, or be misdiagnosed in areas where dengue occurs (WHO, 2016m). Most patients feel better within a week and recover fully. However, in some cases the joint pain may persist for months (CDC, 2016e). Hence the virus can cause acute, subacute or chronic disease (WHO, 2016m). Rarely, eye, neurological, gastrointestinal and heart complications may be present. Also, older adults, newborns and people with medical conditions such as high blood pressure, diabetes, or heart disease are at risk for more severe disease (CDC, 2016e). It is also worth mentioning that once a person has been infected, he or she is likely to be protected from future infections (CDC, 2016e).

Treatment
There is no specific treatment for chikungunya (WHO, 2016m). Treatment is aimed at relieving the symptoms and may include acetaminophen or paracetamol to reduce fever and pain, plenty of fluids to prevent dehydration, and rest (CDC, 2016e).

**Prevention and control**

No vaccine exists to prevent chikungunya disease (WHO, 2016m). In order to prevent further spread of the disease during outbreaks, insect repellents and mosquito bed nets should be used; wearing long-sleeved shirts and long pants during daytime (the peak of the vectors’ activity) is also recommended (CDC, 2016f).

**2.6.3. Acute respiratory infections**

Acute respiratory infections (ARI) can be a major cause of morbidity and mortality in post-disaster emergencies due to factors such as population displacement, overcrowding and malnourishment. Also, floods may result in cases of near-drowning, immersion, and aspiration. Direct contact with marine and soil debris may cause serious respiratory and systemic infections (Ivers & Ryan, 2006). In addition, moulds may contaminate buildings following flood damage, causing respiratory diseases in susceptible individuals (ROBINSON et al., 2011). ARI account for up to 20% of all deaths in children younger than 5 years, with the majority of deaths resulting from pneumonia (Connolly et al., 2004).

ARI may be classified into upper (AURI) and lower (ALRI) acute respiratory infections, depending on the main organs affected (nose, sinuses, middle ear, larynx and pharynx versus trachea, bronchi and lungs). AURI are generally mild and self-limiting, whereas ALRI, such as bronchitis and pneumonia, are more severe and may even result in deaths (Bellos et al., 2010). Generally, the combination of factors such as overcrowding, susceptibility, malnourishment, and poor ventilation in temporary shelters increase the risk for pneumonia (Waring & Brown, 2005). Children under 5 years old, the elderly and immunocompromised individuals are at increased risk of ARIs infection (Bellos et al., 2010).

According to the literature reviewed, other main respiratory infections that may break out in the aftermath of a natural disaster include pneumonia, influenza, and measles. These diseases are described in detail further in this section.
**Pneumonia**

**Key facts:**
- Pneumonia is a respiratory disease that affects lungs.
- It is the largest infectious cause of death in children worldwide and accounts for 15% of all deaths of children under 5 years old, with a number of 920,136 deaths in 2015.
- The disease has been reported worldwide but predominantly in South Asia and sub-Saharan Africa (WHO, 2016n).

**Causes**
Pneumonia can be caused by viruses, bacteria and fungi. The most common are *Streptococcus pneumonia* (bacterial), *Haemophilus influenzae* type b (bacterial), respiratory syncytial virus, and *Pneumocystis jiroveci* (fungus) that largely affects infants infected with HIV (WHO, 2016n).

**Transmission**
Transmission can occur in a number of ways. The viruses and bacteria that are commonly found in a person’s nose or throat can infect the lungs if they are inhaled. Another way of spread is via air-borne droplets. In addition, pneumonia may be transmitted through blood, especially during and shortly after birth (WHO, 2016n).

**Symptoms and signs**
Symptoms can vary from mild to severe, depending on the type of pneumonia, patient’s age and health. The most common symptoms of pneumonia include cough (sometimes with mucus, or even bloody mucus), fever, shaking chills, and shortness of breath. In addition, such symptoms as chest pain that gets worse when breathing or coughing, headache, excessive sweating and clammy skin, loss of appetite, fatigue, confusion, especially in older people, and sometimes blueness of the lips and/or nailbeds (American Lung Association, n.d.). Very severely ill infants may be unable to feed or drink and even experience unconsciousness, hypothermia and convulsions. Generally, the symptoms of viral pneumonia may be more numerous than the symptoms of bacterial pneumonia. Wheezing is also common in case of viral infection (WHO, 2016n).

**Treatment**
Pneumonia caused by bacteria can be treated with antibiotics. However, pneumococcal bacteria have become resistant to some of the antibiotics used to treat these infections (3 out of every 10 cases) (CDC, 2015b). All viral pneumonia patients must receive
supportive treatment with oxygen, rest, antipyretics, analgesics, nutrition, and close observation (Mosenifar et al., 2016). In case of fungal pneumonia, patients must be treated with a special medicine (trimethoprim sulfamethoxazole) that must be taken for three weeks (CDC, 2014b). Hospitalisation is recommended only for severe cases of pneumonia (WHO, 2016n).

**Risk factors**

Risk factors include cigarette smoking; recent viral respiratory infection; difficulty swallowing and/or impaired consciousness (due to some neurological conditions); chronic lung disease; cerebral palsy; other serious illnesses, such as heart disease, liver cirrhosis, or diabetes; recent surgery or trauma; a weakened immune system (due to HIV infection, malnutrition and other factors) (American Lung Association, n.d.). Also, environmental factors such as indoor air pollution and living in crowded homes may increase the susceptibility to pneumonia (WHO, 2016n).

**Prevention**

Pneumonia can be prevented by immunization, adequate nutrition, and by addressing environmental factors. In children infected with HIV, the antibiotic cotrimoxazole can be given daily to decrease the risk of pneumonia infection (WHO, 2016n).

**Influenza**

**Key facts:**

- Influenza is an acute viral infection that can affect the nose, throat, bronchi and, occasionally, lungs. There are 3 types of seasonal influenza viruses – A, B and C.
- Influenza viruses have been found worldwide and can affect anybody in any age group.
- Among many subtypes of influenza A viruses, influenza A(H1N1) and A(H3N2) subtypes are currently circulating among humans. Type C influenza cases occur much less frequently than A and B. That is the reason why only influenza A and B viruses are included in influenza vaccines (WHO, 2016o).

**Transmission**

The viruses spread mainly by droplets made when infected people cough, sneeze or talk. Less often, transmission occurs via touching a surface or object that has the virus on it and then touching their own mouth, eyes or nose (CDC, 2016g).

**Symptoms**
Incubation period lasts from one to four days, normally it is about two days. Symptoms vary from mild to severe. Generally, they may include a sudden onset of high fever, cough, headache, muscle and joint pain, severe malaise, sore throat and runny or stuffy nose (WHO, 2016o). Some people may have vomiting and diarrhea, though this is more common in children (CDC, 2016g). Cough can be severe and can last for weeks. Most people recover within a week without requiring medical attention. However, influenza can cause severe illness or even death. Possible complications of influenza can include bacterial pneumonia, ear infections, sinus infections, dehydration, and worsening of chronic medical conditions, such as congestive heart failure, asthma, or diabetes (CDC, 2016g).

Treatment

There are influenza antiviral drugs that may reduce severe complications and deaths. The medicines may be given in the form of pills, liquid, an inhaled powder, or an intravenous solution (CDC, 2016g). Ideally, they need to be given within 48 hours since the appearance of symptoms. Some influenza viruses develop resistance to the antiviral drugs, limiting the effectiveness of treatment (WHO, 2016o).

Risk factors

Anyone can get infected, but children under 2 years old, adults aged 65 years or older, pregnant women, and people with certain medical conditions, such as chronic heart, lung, kidney, liver, blood or metabolic diseases, or weakened immune systems are at a higher risk of being infected (WHO, 2016o).

Prevention

The most effective preventive measure is annual vaccination. Safe and effective vaccines are available worldwide and have been used for more than 60 years (WHO, 2016o). With regard to everyday preventive actions, simple measures such as staying away from people who are sick, covering coughs and sneezes, and frequent hand washing are also recommended (CDC, 2016g).

Measles

Key facts:

- Measles is a highly contagious disease caused by a virus in the paramyxovirus family.
- It is one of the leading causes of death among young children (WHO, 2016p).
Measles is one of the MSF ten top priorities with regard to the emergency phase (Médecins Sans Frontières, 2010).

The virus infects the mucous membranes, then spreads throughout the body.

Measles outbreaks can result in large-scale epidemics that cause heavy human toll, especially among young, malnourished children (WHO, 2016p).

Transmission
Transmission occurs via coughing and sneezing, close personal contact or direct contact with infected nasal or throat secretions. The virus remains contagious in the environment for up to 2 hours (WHO, 2016p). If people breathe the contaminated air or touch the infected surface, and then touch their eyes, noses, or mouths, they can become infected. The virus can be transmitted by an infected person from 4 days before the onset of the rash to 4 days after the rash appears (WHO, 2016p). Measles is so contagious that if one person has it, 90% of the people close to that person who are not vaccinated will also become infected (CDC, 2015c).

Signs and symptoms
The symptoms of measles generally appear from seven to fourteen days after exposure to the virus. The first symptom is usually a high fever, which begins about ten to twelve days after the infection, and lasts four to seven days (WHO, 2016p). A runny nose, a cough, red and watery eyes, and small white spots inside the cheeks are also amongst initial signs. After several days, a rash erupts, usually on the face and upper neck. Over about 3 days, the rash spreads, eventually reaching the hands and feet (WHO, 2016p). Three to five days after symptoms begin, a rash breaks out. It usually starts with the face at the hairline and then spreads downward to the neck, trunk, arms, legs, and feet. When the rash appears, fever may become even higher (CDC, 2015d). The rash lasts for 5 to 6 days, and then fades the fever subsides. On average, the rash occurs 14 days after exposure to the virus (within a range of 7 to 18 days). People who recover from measles are immune for the rest of their lives (WHO, 2016p).

Most measles-related deaths are caused by complications caused by the disease. The most serious complications include blindness, encephalitis, severe diarrhea, ear infections, or severe respiratory infections such as pneumonia (WHO, 2016p).

Treatment
No specific treatment exists for measles virus. Only supportive treatment for symptoms can be used. It may include good nutrition, adequate fluid intake and treatment of dehydration. Antibiotics should be prescribed to treat eye and ear infections, and
pneumonia if present (WHO, 2016p). All children in developing countries diagnosed with measles should be given two doses of vitamin A supplements to help prevent eye damage and blindness. It has been shown that vitamin A supplements reduce the number of deaths from measles by 50% (WHO, 2016p).

Who is at risk?
Severe measles is more likely to affect malnourished young children, especially those with lack of vitamin A, or with immune systems weakened by HIV/AIDS or other diseases. Pregnant women are also at risk of severe complications and the pregnancy may end in miscarriage or preterm delivery. Generally, unvaccinated persons, especially those living in developing countries are also more likely to have complications caused by measles (WHO, 2016p). The overwhelming majority (more than 95%) of measles deaths occur in low-income countries and weak health infrastructures. Also, measles outbreaks can be very serious in countries exposed to or recovering from a natural disaster or conflict due to the disruption of health services and immunization programmes, and overcrowding in residential camps (WHO, 2016p).

Prevention
Vaccination is the best way to prevent measles infection. Sometimes the measles vaccine is incorporated with rubella and/or mumps vaccines in countries where these illnesses are endemic. One dose of such vaccine is about 93% effective at preventing measles if exposed to the virus (WHO, 2016p). Despite the availability of the vaccines, measles is still common in some countries. Worldwide, an estimated 20 million people get measles and 146,000 people die from the disease annually (CDC, 2015d).

Also, outbreaks of meningitis have been reported in the aftermath of natural disasters, although very occasionally. Briefly, meningitis is inflammation of the meninges of the brain and spinal cord most often caused by bacteria, virus, or fungal, but can also be produced by specific medical conditions (for example, cancer) (WHO, 2014c). Meningitis is a major cause of morbidity and mortality in childhood especially in Africa and Asia. The disease easily spreads from person to person, particularly in situations of crowding (Watson et al., 2007). Meningitis outbreaks have been reported after only a few natural disasters including the 2005 Pakistan earthquake and the 2004 Indonesian Tsunami. Factors such as crowded residential camps, poor hygiene, and limited access to medical care as well as living alongside infected persons pose a major risk to the spread of the disease (Kouadio et al., 2012).
Besides that, the risk of outbreak of tuberculosis is another concern of public health authorities (ROBINSON et al., 2011) The transmission of tuberculosis is facilitated by population displacement, poor access to healthcare services, poor nutritional status, and interruption of on-going treatment or control programs, especially with regards to children (Kouadio et al., 2012). In the case of hurricane Katrina, 195 persons in the most directly affected regions were receiving treatment for tuberculosis when the hurricane struck (Ligon, 2006).

2.6.4. Wound infections

Wound infections after natural disasters are widespread. Destruction of health infrastructure, the inability to wash wounds due to lack of access to clean water, and the disruption of health services can lead to a large number of severe wound infections, even if the causative trauma was relatively minor. Wounds may be contaminated with concrete, wood, metal, soil, and water (Ivers & Ryan, 2006). Anaerobic bacteria can enter the body through wounds, thereby causing tetanus, gas gangrene, and other infectious diseases (Neuberger et al., 2012). Most wound infections are caused by staphylococci and streptococci. Recommended initial antimicrobial treatment of infected wounds consists of proper washing and special antibiotics. Wounds that have been contaminated with water can develop infections caused by waterborne organisms, although these infections are uncommon, even after floods (Ligon, 2006).

After the tsunami in Indonesia in 2004, until May 2005, a total of 1458 injured victims in the affected area, Aceh, were reported. Wound infections accounted for 16.9% of that number. The personnel confirmed the involvement of highly resistant and unusual pathogens in wound infections (Guha-Sapir & van Panhuis, 2009). Wound contamination involved a mixture of sea and fresh water as well as soil. Polymicrobial infection was present. Infections included both marine and enteric pathogens. Inoculation with soil pathogens resulted in cases of anaerobic infection, mucormycosis and melioidosis (Ivers & Ryan, 2006). After hurricane Katrina in 2005, 18 cases of Vibrio wound infections were found among people in the affected area. The infections may progress rapidly and five of the 18 patients with wound-associated vibrio infections died (Ivers & Ryan, 2006). Wound infections can be prevented by prompt wound cleaning. Also, a physician should assess the wound immediately for further treatment and prevention of the development of other wound infections (Ding et al., 2015).
Tetanus

Despite being preventable, tetanus remains a significant source of morbidity and mortality worldwide. The majority of cases occur in third-world countries (Sutiono et al., 2009). Tetanus is caused by the bacterium *Clostridium tetani*. The disease is caused by a neurotoxin, released by the bacteria when they grow in the absence of oxygen (for example, in dirty wounds) (WHO, 2013c). Then the toxin is distributed from the infection site to the bloodstream, thereby spreads throughout the body and reaches the central nervous system resulting in muscular spasms (Pascapurnama et al., 2016). The incubation period from the time of injury until the first symptoms ranges from 2 to 50 days. However, symptoms usually occur within 5 to 10 days. The early appearance of symptoms increases the risk of death and the overall mortality rate is approximately 10%–50% (Sutiono et al., 2009). Initially, spasms occur in the jaw muscles, possibly followed by seizures which might cause serious complications and eventually death if the disease is untreated (WHO, 2013c). Death is usually caused by spasms, hypoxia, and pain (Sutiono et al., 2009). People of all ages can get tetanus but the disease is particularly common and severe in newborn babies. So-called “neonatal tetanus” is mostly fatal; it is common in rural areas where deliveries are at home without adequate sterile conditions (WHO, 2013d). Tetanus can be prevented through vaccination. Therefore it is critical that besides surgical and medical care of open wounds, injured people receive tetanus immunization (Waring & Brown, 2005). Also, it is recommended to vaccinate children as well as women of childbearing age either during pregnancy or outside of pregnancy. Also, people who recover from tetanus do not have natural immunity and can be infected again and therefore need to be vaccinated too (WHO, 2013d).

Generally, tetanus infections are common in disaster-affected areas. It was a serious public health problem in the aftermath of the 2004 tsunami in Indonesia. The tetanus mortality rate rose up to 18% in the affected area. Cases were also reported after the 2005 Pakistan earthquake (Kouadio et al., 2012). Likewise, tetanus cases were recorded by Australian humanitarian assistance 13 days after the tsunami of 26 December, 2006 (Sutiono et al., 2009).
Chapter 3: Results

3.1. Literature review

After reading the abstracts, 94 articles were selected. Eventually, 56 articles were considered of high quality and relevant to the present study to a greater or lesser extent. 25 of the articles confirm that an outbreak of a certain disease(s) was caused by a natural disaster or its after-effects; 23 articles conclude that there is no direct connection between natural disasters and epidemics of infectious diseases; 8 articles neither prove nor disprove the correlation between these two phenomena due to various reasons. For more detailed information about the articles, see Annex 1.

3.1.1. Connection confirmed

There are a large number of studies that confirm the connection between natural disasters and epidemics of infectious diseases in one way or another. A study conducted on health effects of earthquakes states that respiratory tract infections from dust clouds, diarrheal diseases from contaminated water, malaria from the increased mosquito population, and tetanus and measles are the commonly reported infectious diseases among those that could be prevented by vaccination (Asokan & Vanitha, 2016). After the 2005 earthquake in Pakistan, an increase in the incidence of acute respiratory infections, diarrheal diseases, tetanus, 400 cases of measles, outbreak of meningitis, and more than 1200 cases of hepatitis A and E were reported among the displaced population in areas where access to safe water was limited (Asokan & Vanitha, 2016). After a landslide in 2010 in Eastern Uganda, there was a significant burden of infectious diseases where malaria and respiratory infections were most prevalent (Asokan & Vanitha, 2016). Infectious diseases also significantly increased as well as cardiovascular diseases after the L’Aquila earthquake that stroke Italy on 6 April 2009. Although, the decrease of gastroenterological diseases was reported, it related to the admission diagnoses only and so seemed a less reliable result (Petrazzi et al., 2013).

Infections were also the most common reason for patients who needed primary health care in Leogane, Haiti after the 2010 earthquake (42.6% of all patients). All diseases diagnosed in a primary healthcare hospital in the affected area were recorded during a 7-month period. Respiratory infections were found to be the most common issues (33.5% of all patients diagnosed with infectious diseases) possibly because of overcrowding in
camps, followed by skin and soft tissue infections (12.8%) (Neuberger et al., 2012). Also, cases of tetanus (however, it was endemic in Haiti) and vector-borne diseases were reported among which malaria was the most common followed by filariasis and dengue fever. Again, a large proportion of these infections are preventable (Neuberger et al., 2012). Moreover, after the earthquake in Yogyakarta, Indonesia which occurred on May 27, 2006, 71 cases of tetanus were reported. Tetanus outbreak also emerged following the earthquake in Pakistan in 2005 (Pascaupurnama et al., 2016). After the earthquake and tsunami in Aceh, Indonesia occurred on 26 December 2004, an outbreak of 106 cases of tetanus was reported during the first month following the tsunami. According to the article, it reflects the extremely high number of injuries caused by the tsunami, low immunisation level, and inadequate public health response (Group, 2006). Generally, more than 70% of patients with injuries resulted from natural disasters infected with tetanus (Sutiono et al., 2009).

In late 2010 and early 2011, the state of Queensland in Australia experienced heavy rainfall which resulted in widespread flooding. During 12 months after the disaster, there were 154 confirmed cases of leptospiral infections. The majority of infections for the year occurred immediately following the floods in January and the cyclone in February. The observed increase in the incidence of leptospirosis was consistent with previous studies reporting an increase in leptospirosis after flooding (Wynwood et al., 2014). Leptospirosis was one of the diseases that also increased sharply after the landslides in Brazil in 2011. Nova Friburgo was one of the most severely affected counties, where 3,000 landslides were recorded, along with severe destruction of infrastructure. Between January and March 2011, 177 cases of leptospirosis were reported (Pereira et al., 2014). The disaster is believed to have caused an environmental imbalance that changed the leptospirosis behavior previously observed in the area. Therefore, all cases recorded until March 2011 were attributed to the disaster. Dengue fever was another disease associated with the landslides (Pereira et al., 2014). Another study about leptospirosis was conducted in New Caledonia where an outbreak of leptospirosis occurred in 2008 after heavy rainfalls and floods. The disaster resulted in 135 cases of leptospirosis. Generally, climate is considered to be responsible for the occurrence of infectious diseases such as leptospirosis, which is sensitive to climate change and extreme events (Pereira et al., 2014).
Generally, acute respiratory infections constitute a large proportion of the diseases increasing in the aftermath of natural disasters. According to one study carried out on Aceh following the 2004 tsunami, by week 12, 62% of the 184,864 documented consultations were for cases of respiratory infections (Kamigaki et al., 2014). Children are often more prone to be infected in these situations: 6,599 cases were children less than 5 years of age and 18,613 were children over 5 years of age. An increase in the incidence of pneumonia also occurred after the earthquake (Kamigaki et al., 2014). Besides that, clusters or outbreaks of tetanus, hepatitis A and E, and measles were also reported in the aftermath of the disaster (Kawano et al., 2014). A similar situation was recorded in Sri Lanka following the tsunami (ROBINSON et al., 2011).

Health workers may also be at increased risk of ARI. For example, after the 2008 earthquake in China, the rate of ARI among the victims and rescuers that lived in temporary shelters with crowded conditions and poor ventilation was very high, particularly acute upper respiratory infections (ROBINSON et al., 2011). ARI was also one of the two predominantly observed diseases among the displaced population after the 2011 Japan Earthquake and tsunami. Approximately 28% of people who stayed at a shelter were infected with ARI (Kawano et al., 2014). According to the study, the incidence of ARI was 10 times higher than previously measured in Japan under normal conditions. Acute gastroenteritis was second most frequently occurred disease, however with a big difference in the number of cases - 3% of people who stayed at a shelter for 3 weeks were infected with gastroenteritis (Kawano et al., 2014). These observations are said to be consistent with infectious disease outbreaks after other natural disasters.

Outbreaks of ARI and gastroenteritis have been reported following natural disasters in both industrialised and developing countries. For instance, after Hurricane Katrina in the USA in 2005, surveillance reported that ARI and acute gastroenteritis were common among the affected population (Kawano et al., 2014). Overcrowding in shelters forces close contact between people infected with ARI or acute gastroenteritis and others. In addition, lack of safe water and poor personal hygiene can increase the spread of these diseases (Kawano et al., 2014).

In addition to respiratory tract infections, there is another study on the 2004 Asian tsunami which states that the epidemic peak of pneumonia in the affected area was strongly associated with the tsunami (so-called “tsunami lung”) (Wiwanitkit, 2005).
Also, at the beginning of April 2011, around three weeks after the earthquake, a significant increase in pneumonia hospitalisations was reported in northern Miyagi Prefecture, Japan. During the study period (1 March 2010 to 30 June 2011), 550 pneumonia cases were identified (Daito et al., 2013). There was a sharp increase in the weekly number of pneumonia hospitalisations soon after the disaster. During the three and a half months after 11 March, the weekly rate of pneumonia hospitalisations increased by 5.7 times compared to the level before the disasters (Daito et al., 2013). The study finds these hospitalisations attributable to the earthquake and the tsunami; another finding is that the pneumonia burden becomes substantial for elderly population (Daito et al., 2013).

A study performed by Shibata et al. on the disasters occurred in Japan in 2011 found that wound infection and aspiration pneumonia were major infectious diseases occurred after the tsunami (2016). The risk of pneumonia death was increased by the disasters. A number of studies suggested that factors such as lack of appropriate nutrition, disruption of health services, psychological stress and cold temperature contributed to pneumonia death. Additionally, the accident at the atomic power plant in Fukushima led to a high population density in the shelter and might have increased the risk of pneumonia death. The study also confirms the connection between the disasters and pneumonia deaths (Shibata et al., 2016). Indeed, the number of deaths caused by pneumonia increased during first three months after the earthquake and tsunami. In inland areas, pneumonia there was less than 100 deaths before the earthquake and increased to 120 after the disasters (Shibata et al., 2016). In coastal municipalities, pneumonia deaths were less than 50 before the earthquake and the number increased to 90 afterwards. The study hypothesises that “tsunami lung”, which involves aspiration of the tsunami, was responsible for the increased pneumonia death risk. Aside from the Japan earthquake, after the Kashmir Earthquake of 2005, infectious diseases accounted for at least 65% of all illness of which respiratory infections, including pneumonia, were the most common cause of health care seeking (Shibata et al., 2016).

Coming back to the disasters occurred in Japan in 2011, a study done by Namiki et al. reports that 8 patients were diagnosed with influenza A (H3N2) by March 27 (2013). Another study reports two outbreaks of influenza A in different evacuation centers in Miyagi Prefecture. According to the study, the first outbreak occurred in the period from 21 March to 30 March 2011 (25 patients were diagnosed with influenza); the
second outbreak occurred between 4 April and 18 April 2011 (twenty cases of influenza at Tatekoshi Elementary School) (Hatta et al., 2011). In addition, a study carried out by Kamigaki et al. confirms the outbreak of influenza A in Japan in 2011 (2014). It also says that at that time influenza was circulating in Japan, therefore the possibility of an influenza outbreak was increased. Although an exact transmission route was not identified, the findings suggested that the influenza virus was introduced into the area through search and rescue activities (Kamigaki et al., 2014).

It is plausible that the increasing incidence of natural disasters and severe weather conditions may also contribute to the observed rise in pulmonary nontuberculous mycobacteria infections (NTM) (Honda et al., 2015). The study concludes that after natural disasters NTM infections are more likely to occur as a result of the disruption of water and soil ecosystems normally inhabited by NTM; due to which the risk of NTM infection may remain for weeks, months, or years following a natural disaster (Honda et al., 2015). The suggested link between natural disasters and NTM infections is consistent with the geographic overlap observed between US states such as California, Florida, Louisiana, and Hawaii with a high prevalence of NTM lung disease and states with high occurrences of natural disasters (Honda et al., 2015). The study provides evidence from Louisiana regarding a potential link between natural disasters and rise in NTM lung disease. A study carried out 4 years after Hurricane Ike (2008) and 7 years after Hurricanes Katrina and Rita (2005) reported that the risk of pulmonary NTM disease in residents of the affected area in Louisiana was the highest in the US (Honda et al., 2015).

Besides that, the findings of the study conducted on impacts of the 2008 flood in Vietnam on health revealed higher proportions of pink eye and dermatitis in severely affected communities. Almost all pink eye cases were diagnosed among people who had suffered from the disease before (Bich et al., 2011). Outbreaks of hepatitis A and E, and scabies have also been reported after natural disasters (Kawano et al., 2014). Cases of skin and soft tissue infections that develop weeks to months after natural disasters have also been reported (Tominaga et al., 2013).
Furthermore, a study conducted on natural disasters and gastrointestinal diseases found that incidences of diarrhea-causing diseases such as infectious enteritis, which, in turn, was caused by norovirus, increased after the earthquakes that occurred on March 25, 2007 in Japan and in Haiti on January 12, 2010. Moreover, after Hurricane Katrina in 2005, 1,169 (18 %) of approximately 6,500 patients had symptoms of acute gastroenteritis (Tominaga et al., 2013). In addition, a large outbreak of norovirus occurred among people staying in a temporary shelter in Houston, Texas (Watkins, 2011).

In addition to diarrheal diseases, a large epidemic of cholera (97,934 cases) was reported in India after a massive flooding in 2007 which demonstrates that areas where cholera is endemic are susceptible to outbreaks after natural disasters (Watkins, 2011). Higher incidence (86%) of V. cholerae was observed in water bodies during the flood. This confirms the conclusions of the reports regarding the incidence of cholera in various areas of Bangladesh, with seasonal peaks of the disease associated with annual monsoon (Schwartz et al., 2006). There is an opinion that the secondary effects of flooding such as crowding and subsequent fecal-oral spread of gastrointestinal pathogens may contribute to spread of diarrheal diseases even more than contamination of water caused by disruption of water supply systems (Schwartz et al., 2006).

After the 2010 earthquake, Haiti also experienced a large outbreak of cholera. The same year, Pakistan also reported a cholera epidemic associated with major floods (Bhuyan et al., 2016). Also, a study done on impacts of typhoon and heavy rain disasters in South Korea found that the disasters were associated with increases in infectious diarrhea hospitalization and mortality (Kim et al., 2013).

3.1.2. No outbreaks

Despite the large number of studies that confirm the connection between natural disasters and epidemics of communicable diseases, there are many studies that support a different point of view. First of all, there is a belief that natural disasters themselves do not import diseases. It is not possible for diseases that are not endemic or imported in the disaster affected areas to occur naturally (Kouadio et al., 2012). Moreover, even in areas where a given disease is endemic, the worst-case scenario such as an epidemic does not always occur (Floret et al., 2006). Diseases such as malaria and dengue are unlikely to break out in areas where they were not already present. No serious outbreaks
of those diseases had been reported by the beginning of February after the 2004 Asian tsunami that occurred on December 26, 2004 (Orellana, 2005).

Also, the research carried out by Sutiono et al., found that frequent large-scale cholera outbreaks after earthquake disasters are not particularly common (2010). Besides, cholera epidemics as well as dysentery outbreaks do not always occur even after large-scale floods. In the period from 1980 to 2010, epidemics of water-borne diseases have been uncommon after floods and other natural disasters (Van Rooyen & Leaning, 2005). However, they are quite common, in large displacement camps. Indeed, it is not the disaster but the artificial, crowded communities resulted from the disasters that increase the risk of the spread of infectious diseases (Van Rooyen & Leaning, 2005). For instance, about 400 measles cases were found following the earthquake in Pakistan in 2005, mostly in communities living in crowded shelters with low vaccination coverage conditions; measles cases were also reported in unplanned and crowded camps created after the 2004 tsunami disaster in Banda Aceh (Kouadio et al., 2012). Generally, the risk depends on the alignment of various factors including local disease prevalence, scale of population displacement, and environmental vulnerability (Sumner et al., 2013). For example, major risk factors associated to the spread of meningitis include crowded camps, poor hygiene, limited access to medical care as well as living close to infected persons (Kouadio et al., 2012). Similarly, a study done by Floret et al. concluded that the risk for communicable diseases transmission after natural disasters is low and not directly related to the disasters and dead bodies, but primarily associated with population displacement and disease endemicity. This belief also states that there is a need for rapid but accurate assessment of health status, risk, and needs prior to the implementation of relief activities such as communicable diseases surveillance, early warning, and rapid response to epidemic-prone situations or outbreaks (Michel et al., 2007).

In addition, there are other studies that state that the risk for outbreaks after natural disasters is low, especially when the disaster does not result in substantial population displacement (Watson et al., 2007). There have been few reports describing outbreaks of influenza in disaster settings despite the potential for increased influenza transmission. (Hatta et al., 2011) Meningitis outbreaks have been documented after only a few natural disasters including the 2005 Pakistan earthquake (Kouadio et al., 2012).
Despite being prone to communicable diseases, there was no increase in the incidence of these diseases in the East Azerbaijan province of Iran after the occurrence of the twin earthquakes on August 11, 2012. Only 3 cases of diarrheal cases were reported, which were controlled (Babaie et al., 2015). Within the first month after the earthquake, no positive cases of cholera, salmonella, shigella, or Escherichia coli were reported. In one of the affected cities, some cases of influenza-like syndrome were reported, which were promptly examined and were found to be negative. During this period, a suspected malaria case was reported, which was not confirmed either (Babaie et al., 2015). Similarly, in spite of disrupted access to safe water, serious destruction of houses and sanitation system, and, in some areas, the presence of dead bodies caused by the earthquakes occurred in Nepal in April-May, 2015, no unusual increase in the number of infectious diseases had been reported by May 26, 2015 (Bagcchi, 2015). After the 2004 South Asian tsunami no risk for outbreaks of vector-borne diseases was present in Nagapattinam district of Tamil Nadu state, India by March, 2005 (Balaraman et al., 2005). Likewise, another study found that although in the following weeks after the South Asian tsunami diseases such as diarrhea, cholera, dysentery, and typhoid were the main flood-related health impact, no large disease outbreaks were reported (Morgan et al., 2005). In addition, health facilities were under surveillance during six months after a 7.9 magnitude earthquake struck off the western coast of Peru on 15 August 2007. It was found that tuberculosis rates were similar to those seen before the earthquake (Chapin et al., 2009). Also, a literature review done by Khan et al. did not find any examples of increase of tuberculosis incidence following natural disasters (2010).

Longnan City, China suffered serious damage caused by the 2008 Wenchuan earthquake. Generally, the city has a subtropical climate that is warm, wet, and rich in insects and the earthquake occurred in summer so mosquito populations typically increased. Also, many houses were damaged by the earthquake, a factor which increased the risk for people to be bitten by mosquitoes (Zhang et al., 2013). Furthermore, Japanese encephalitis, a common insect-borne infectious disease, is widely distributed both in Longnan City and in China in general. However, there was no significant difference in the Japanese encephalitis incidence after the 2008 Wenchuan earthquake compared with the year 2005 and 2007 (Zhang et al., 2013). Similarly, from 2005 to 2011, only seven malaria cases were found in the affected area, showing a low incidence of this disease. Likewise, there was no significant difference in the number of
cases of Kala-azar, the most severe form of a zoonotic disease called leishmaniasis, in the following years after the earthquake (Zhang et al., 2013).

The finding of Bompangue et al. is in agreement with the 2006 study conducted by Floret et al., showing that geophysical disasters were not usually followed by epidemics (2006). Bompangue et al. states that from 1989 to 2009 not a single cholera outbreak was recorded in the aftermath of geophysical disaster, even after the tsunami in Asia in 2004 (2009). The finding shows that even in a place where cholera outbreaks are common during the rainy season and a very devastative disaster occurred, cholera epidemics can be avoided (2009).

Also, there is one case of study with mixed results. A magnitude 7.7 earthquake occurred on April 20, 2013 in Sistan and Baluchestan Province, Iran, (the same region where the outbreak of tularemia occurred in 2007). Due to the possibility of an outbreak of zoonotic disease, a research team was dispatched to this area in order to assess the presence of plague and tularemia among rodents in this region. No evidence of the plague cycle was found, but evidence of tularemia infection was found in rodents (Pourhossein et al., 2015).

There are also a number of examples when natural disasters were not followed by infectious disease outbreaks possibly due to preventive and control measures. Except for a cluster of cases of rotaviral diarrhea, no major infectious disease outbreak occurred in the Andaman Islands in the year after the 2004 South Asian tsunami (Roy et al., 2009). Furthermore, the incidence of acute diarrhea among children of the Andaman Islands decreased within months after the disaster. However, due to the previous experience of cholera outbreak that followed the disaster in the Andaman and Nicobar Islands in 2002, public health and sanitation measures were taken promptly after the tsunami. These actions might be the reason why no communicable disease outbreak occurred in the aftermath of the disaster (Roy et al., 2009). Similarly, despite the fact that malaria did not increase in Sri Lanka after the tsunami, the effect of the disaster cannot be accurately assessed due to the presence of control measures (Briët et al., 2006). There was also prediction of possible disease outbreak after the 2015 earthquake in Nepal. However prompt disease surveillance and preventive activities took the situation under control. The activities included water safety, medical services, early warning system, vector- control and health promotion measures (Marahatta, 2015).
Moreover, as the 2014 earthquakes occurred in Yunnan Province, China in the favourable for malaria season, mosquito populations typically increased. However, the government and health departments took effective measures to prevent infectious disease epidemics after the disaster. As a result, no locally acquired malaria cases were reported in the affected areas after the earthquakes (Feng et al., 2015).

### 3.2. Analysis of the databases

From 2005 to 2015, 2235 natural disasters were identified in the Em-Dat database. The number includes 180 droughts, 161 earthquakes, 905 floods, 126 landslides, 484 storms, 51 cases of volcanic activity, 72 wildfires, and 220 other events such as extreme temperature, insect infestations, animal accident, and mass movements. Most of the events were also reported on the ReliefWeb site. Also, 274 cases of epidemics, which occurred from 2005 to 2015, were identified in the Em-Dat database, 65 of them were not included in the subsequent analysis since they did not happen after the occurrence of a recent natural disaster.

After that, epidemics identified in the Em-Dat database were checked in the database of WHO and on the ReliefWeb. It was done in order to find out what diseases broke out and set the chronological order of the occurrence of epidemics and natural disasters in a particular year in order to exclude unrelated cases of the outbreaks. As a result, 114 epidemics turned out to be unrelated to any natural disasters due to the time of their occurrence and/or their nature (for instance, epidemics of HIV/AIDS were considered unrelated as they could not be caused by environmental events). There are also a number of epidemics which were identified in the Em-Dat database but there was no confirming information about such cases both in the WHO database and on the ReliefWeb. The total number of those cases is 82 and they are marked as “no information”. Eventually, in 13 out of 209 cases natural disasters were followed by epidemics (Figure 1). More detailed information is presented below.
1) During the night 5 to 6 August 2006 heavy rains caused flooding in the region of Dire Dawa, Ethiopia (OCHA, 2006). After that, on the 28th of September 2006, The Ministry of Health of Ethiopia reported a total of 22,101 cases and 219 deaths from acute watery diarrhoeal syndrome (WHO, 2006). Five regions out of nine and one subdivision (Addis Ababa) were affected. Ongoing flooding affected seven of Ethiopia’s nine regions and displaced many people. Amhara, the region severely affected by floods, has a CFR of 10% (WHO, 2006).

2) Heavy rains experienced in October and November, 2006 in the western, northeastern and coastal parts of Kenya had a devastating impact on the country. Later on, northeastern Kenya experienced more heavy rains on Saturday, 18th November, which caused flash floods in the area (OCHA, 2006). As a result, 12 cases with 11 deaths of Rift Valley Fever occurred in the North Eastern province which was reported on the 21st of December 2006 by the Ministry of Health of Kenya (WHO, 2006). The same wave of rains affected Somalia at the end of November which resulted in the outbreak of the same disease and led to 114 cases including 51 deaths (from 19 December 2006 to 20 February 2007) (WHO, 2007).
3) Due to the flood occurred as a result of heavy rains in August 2007 (OCHA, 2007), Rift Valley Fever broke out in Sudan. On 18 October 2007, the Federal Ministry of Health of Sudan requested WHO support to investigate and control a suspected haemorrhagic fever outbreak and by November 2, 125 cases including 60 deaths had been reported (WHO, 2007).

4) On the 17th of April 2008, the Ministry of Health of Madagascar reported 418 suspected cases of Rift Valley fever including 17 deaths (WHO, 2008). Two months earlier, tropical cyclone Ivan, with extremely strong wind (230 kilometer per hour), caused landfall in Madagascar on 17 and 18 February 2008. Rainfall continued for several days after the cyclone which made conditions even worse and caused major destruction to electricity, water and sanitation and communication networks (WHO, 2008).

5) As of 3 October 2010, 40,468 cases of cholera and 1,879 deaths had been reported in Cameroon, Chad, Niger and Nigeria. The rainy season with flooding, which started in June, alongside with poor hygiene conditions and population movements in the area contributed to the unusually high level of cholera (WHO, 2010).

6) Heavy rains and melting snowfall led to an enormous rise of river levels in Afghanistan and Pakistan in June, 2005 (OCHA, 2005). By June 16, the Ministry of Health of Afghanistan reported 3245 cases of acute watery diarrhea in Kabul city, 777 of them were hospitalised for severe dehydration. Cholera virus was laboratory confirmed in 30 stool samples out of 44 (WHO, 2005).

7) As a result of heavy rains on 11 April 2010, flooding occurred and affected 18 villages in Tajikistan. Besides the 18 affected villages, more than 10 villages were under the risk of flooding and landslide (IFRC, 2010). Later on, as of 21 April 2010, 120 cases of Acute Flaccid Paralysis (AFP) had been reported from Tajikistan. By the 23 of April 2010 poliovirus had been detected in diagnostic samples from cases of AFP from Tajikistan (WHO, 2010).

8) The earthquake that hit Haiti on 12 January 2010 affected almost 3.5 million people, including the entire population of Port-au-Prince (2.8 million). The Government of Haiti estimated that the earthquake killed 222,570 and injured another 300,572
people. Such a devastative disaster also seriously damaged infrastructure and disrupted facilities that provided people with their basic needs, mainly water and sanitation (United Nations, 2011). The disaster resulted in the outbreak of cholera. As of 25 October, the Ministry of Health of Haiti had reported 3,342 confirmed cases including 259 deaths (WHO, 2010).

9) A cholera outbreak started in Burundi at the beginning of August 2011. In general, cholera is endemic there, but because of the early start of the rainy season, the number of cholera cases increased up to 423, including two lethal cases. By the end of August, the Burundi Red Cross managed to take the situation under control and declared an end to the epidemic (IFRC, 2012).

10) In August 2011, more than 13,000 people were affected by floods in the regions of Tillabéry, Zinder, Tahoua and Agadez, Niger (“Niger: Floods,” 2012). Later on, a cholera outbreak occurred in seven regions along the Niger River. Although the first confirmed cases were reported in March 2011, the flooding in August made the situation worse and resulted in 2,130 cases and 50 deaths by October 2011 (IFRC, 2011).

11) On the night of 17-18 Nov 2012, heavy rains hit Pointe Noire, the second largest city in the Republic of Congo, causing severe flooding which caused five deaths and displacement of over 2,000 people. Severe destruction of the drainage system, overflowed wells and latrines as well as stagnant water caused an outbreak of cholera; 59 cholera cases had been reported (IFRC, 2013).

12) Heavy seasonal rainfall caused flooding in Tillabéry (the most affected), Dosso, Maradi and Tahoua regions of Niger in August 2014. By October, the number of affected people reached 68,483 and more than 8,100 houses had been destroyed (“Niger: Floods,” 2015). In September 2014, cholera cases began to increase drastically, especially in Tahoua and Maradi regions. By the beginning of December, 1,750 cases, including 64 deaths, had been reported. By the end of March, no more cases had been reported, but cholera remained a threat due to the lack of access to clean water and poor hygiene conditions (“Niger: Cholera outbreak,” 2015).
Chapter 4: Discussion

One of the objectives of the study was to identify natural disasters’ health effects as well as epidemic-prone diseases and risk factors of their outbreaks. Review of the literature related to the topic showed that there is a range of factors that determine the risk of an epidemic in the aftermath of a natural disaster. The factors include the type of the disaster as well as its power, intensity and the season of occurrence; population density and the hygienic conditions of the affected area; and level of development of the country (Tominaga et al., 2013). Developing countries may lack resources, infrastructure, and disaster-preparedness systems which altogether increase the risk of a disease outbreak as it happened in Nepal after the 2011 earthquake (Marahatta, 2015). Also, increases in infectious disease outbreaks following natural disasters are associated with prolonged after-effects of the disaster. These effects comprise population displacement, environmental changes, disruption of public utilities, high exposure to and proliferation of disease vectors, overcrowded shelters, poor water and sanitation conditions, low levels of immunity to vaccine-preventable diseases or insufficient vaccination coverage, and limited access to healthcare services (Kouadio et al., 2012).

Talking about the risk factors more specifically, population displacement is one of the most influential ones. However, the extent to which it influences the risk of disease outbreaks also depends on its size, population density, the proximity of safe water and latrines, and the nutritional status of the displaced people (Watson et al., 2007).

Another important contributory factor is armed conflicts. Conflicts weaken a society’s capacities to respond to and cope with the effects of a natural disaster and it will most likely aggravate its consequences. Armed conflict can also exacerbate the already difficult situation caused by a natural disaster. For instance, it might lead to increased flow of displaced people like in the case of the 2009 flood in Somalia (Ferris & Solís, 2016). In the case of Pakistan, millions of internally displaced people moved away from the war-affected regions bringing with them an increase in infectious disease and, as a result, the risk of transmission sharply increased (Haider et al., 2015). Armed conflicts also influence relief operations through provision or denial of access of relief agencies to affected communities (Ferris & Solís, 2016). Besides that, malnutrition is generally more common in conflict-affected populations, especially if their displacement is long-term, thereby increasing the risk of disease outbreaks (Watson et al., 2007).
Weather conditions also play an important role in determining the risk of infectious disease outbreaks. Cold weather might cause serious respiratory disease such as bronchitis, influenza, or pneumonia (Alexander, 1982). Extremely warm weather might contribute to increased mosquito breeding and insect-borne infectious diseases transmission as it happened after the 2008 earthquake in China (Upadhyayula et al., 2012). However, increased mosquito population itself does not necessarily lead to a disease outbreak. Instead, disruptions of the basic water supply and mosquito control programs; use of water storage containers that serve as breeding sites; and increased exposures to mosquitoes while sleeping outside are more likely causes of a vector-borne disease outbreak (Chang et al., 2014).

The risk of an epidemic also depends on the regional endemicity of specific diseases (Ivers & Ryan, 2006). For example, in countries such as India, Ethiopia, Nigeria, Haiti, the Democratic Republic of the Congo, Tanzania, Kenya, and Bangladesh cholera is considered an endemic disease and the risk of its outbreak is always higher in a particular season or under certain weather conditions even without aggravation caused by natural disasters (Ivers & Ryan, 2006). Although, as it was found, human and animal dead bodies do not cause an epidemic, proper management is essential, especially in areas where infectious diseases which are likely to break out are endemic (Pan American Health Organization, 2004).

With regard to diseases that are more likely to increase in post-disaster settings, they can be categorized into four groups: water-related, vector-borne, acute respiratory infections, and infections resulted from wounds or injuries (Kouadio et al., 2012). As the literature review showed, possible disruption of access to safe water caused by a natural disaster can lead to outbreaks of acute watery diarrhea, cholera, typhoid fever, acute jaundice, leptospirosis, protozoan parasites, Escherichia Coli, Hepatitis A and E and norovirus can also be caused by flooding (Watson et al., 2007). Besides that, the risk factors mentioned above might lead to outbreaks of a number of vector-borne diseases including malaria, dengue, rabies, chaga’s disease, chikungunya, and West Nile Fever (Watson, et al., 2007).

Similarly, acute respiratory infections can be a serious public health issue in post-disaster emergencies due to the after-effects of natural disasters, especially lower acute respiratory infections such as bronchitis and pneumonia (Ivers & Ryan, 2006). They are generally more severe than upper acute respiratory infections and may even result in
CONNECTION BETWEEN NATURAL DISASTERS AND EPIDEMICS OF INFECTIOUS DISEASES

deaths (Bellos et al., 2010). Other main respiratory infections that may break out following a natural disaster include influenza, measles and rarely meningitis. Another type of diseases which level is likely to increase in the aftermath of a natural disaster is wound-related. The overall destruction, the inability to wash wounds due to lack of access to clean water, and the disruption of health services can lead to a large number of infections such as tetanus and gas gangrene (Ivers & Ryan, 2006).

Regarding the correlation between natural disasters and epidemics, there are a large number of studies that confirm the connection between the two phenomena in one way or another. The examples include an increase in the incidence of a number of infectious diseases after the 2005 earthquake in Pakistan in areas where access to safe water was limited; a significant burden of malaria and respiratory infections after a landslide in 2010 in Eastern Uganda (Asokan & Vanitha, 2016); tetanus outbreaks after the 2006 and the 2004 earthquakes in Indonesia; a sharp increase in leptospirosis infections after the heavy rainfall in Australia in 2011 and in Brazil after the 2011 landslides (Pereira et al., 2014). Also cases of increased levels of acute respiratory infections and gastrointestinal diseases after natural disasters are known such as the 2008 earthquake in China; the 2011 Japan Earthquake and tsunami; Hurricane Katrina in the USA in 2005 (Kawano et al., 2014). In addition, a large epidemic of water-related diseases such as cholera was reported in India after the 2007 flood which demonstrates that areas where cholera is endemic are susceptible to outbreaks after natural disasters (Watkins, 2011). At the same time, there are also a number of studies that do not confirm the connection between natural disasters and epidemics of communicable diseases. The general idea is that it is not the disaster but the crowded shelters resulted from the disasters that increase the risk of the transmission of infectious diseases (Van Rooyen & Leaning, 2005). Examples of measles outbreaks after the earthquake in Pakistan in 2005 and the 2004 tsunami disaster in Banda Aceh support the statement. Also, according to the literature, it is not possible for diseases that are not endemic or imported in the disaster affected areas to occur naturally (Kouadio et al., 2012). And even if a disease is endemic, an outbreak of it does not occur necessarily. For instance, Japanese encephalitis, a vector-borne disease which is widespread both in the affected area did not change significantly after the 2008 Wenchuan earthquake compared with the year 2005 and 2007 (Zhang et al., 2013). Other examples of natural disasters that did not result in infectious disease outbreaks include the 2012 earthquakes in Iran (Babaie et al.,
CONNECTION BETWEEN NATURAL DISASTERS AND EPIDEMICS OF INFECTIONOUS DISEASES

2015); the 2015 earthquakes in Nepal (Bagcchi, 2015); the 2007 earthquake in Peru (Chapin et al., 2009).

There are a number of possible explanations why some studies did not find any correlation between the two phenomena. Firstly, it might be due to preventive and/or control measures after the occurrence of a natural disaster. For example, although, malaria transmission did not increase in Sri Lanka after the tsunami, the effect of the disaster cannot be accurately assessed due to the presence of control measures (Briët et al., 2006). Moreover, although the 2014 earthquakes occurred in China in the favourable for malaria season, no locally acquired malaria cases were reported in the affected areas since the government and health departments took measures to prevent infectious disease epidemics after the disaster (Feng et al., 2015). Also, due to the previous experience of cholera outbreak that followed the disaster in the Andaman and Nicobar Islands in 2002, public health measures were taken promptly after the 2004 tsunami. As a result, no infectious disease outbreak, except for a cluster of rotavirus, occurred after the tsunami (Roy et al., 2009). Similarly, after the 2015 earthquake in Nepal prompt disease surveillance and preventive activities took the situation under control (Marahatta, 2015). Secondly, in some countries surveillance system is poor or not even in place so even if an outbreak of a communicable disease occurs, it might just not be reported.

With regard to the overall objective of the study, as the introduction says, it is to examine the existence of the connection between natural disasters and epidemics based on the analysis of the databases such as EM-DAT, WHO and ReliefWeb and the findings of the literature review. The analysis of the databases showed that out of 13 disease epidemics related to a natural disaster, the most frequent disease identified was cholera (7 cases) which was followed by Rift Valley Fever Virus (4 cases). Also, 1 case of Polio and 1 case of Acute watery diarrheal syndrome were identified. From the geographical perspective, the relevant cases of diseases outbreaks occurred in different parts of Africa: (10 cases: Ethiopia, Kenya, Somalia, Sudan, Madagascar, Cameroon, Chad, Niger (2010 and 2014), Nigeria), in Asia (2 cases: Afghanistan, Tajikistan), and in the Caribbean (Haiti). The most common type of disaster that caused the epidemics described in the results section is hydrological (heavy rains or floods). 12 cases out of 13 were caused by this type of disaster either resulted from heavy rains or in combination with a landfall or melting snowfall. The number of the related cases
constitutes 7.7% of the total number of disease epidemics occurred in 2005-2015 which allows to say that although, the risk does not seem high, it is not negligible either as the study done by Floret et al. (2006) states. The risk should be considered and might determine the allocation of resources and the priority activities.

Based on the results, a few recommendations can be given. Firstly, in countries with a potentially high risk of cholera outbreaks (for example, where the disease is endemic or which are prone to hydrological disasters, or lack capacities to respond promptly in order to prevent a large-scale outbreak in post-disaster settings) preparedness should be strengthened such as access to safe drinking water and adequate sanitation should be ensured; preventive measures should be taken such as vaccination of populations and information campaigns in order to promote the appropriate hygiene and raise awareness about the disease; and surveillance system should be set up in order to be able to identify infected and/or vulnerable populations. Secondly, considering the geographical distribution of the disaster-related outbreaks, special attention should be paid to the African region since the overwhelming majority of the epidemics occurred in that part of the world. Thirdly, the results show that the type of a natural disaster matters too. Thus, after a hydrological event such as heavy rainfall or flood occurs, a risk of an infectious disease outbreak should be considered more seriously since its likelihood is higher in the aftermath of this type of disasters.

The present study also has some limitations. Firstly, in some cases a prompt and effective response to a natural disaster was provided including preventive measures in order to avoid large-scale disease outbreaks. Therefore, it is not possible to say if the disaster would result in an epidemic had preventive measures not been taken. Secondly, due to the amount of time available for conducting the research, a limited number of the existing articles were reviewed. Also, the chronological framework is limited to ten years for the same reason. Thirdly, the epidemics databases (WHO and ReliefWeb) may not be exhaustive because epidemics handled by national health systems might not be reported there.
Conclusion
The research shows that the risk of epidemics of infectious diseases after a natural disaster does exist. Generally, phenomena such as natural disasters have existed on our planet for ages and have often had deteriorating effects on humanity. Lately, the frequency and intensity of disasters has increased as well as the severity of their consequences, in particular, on health. Health effects, including outbreaks of infectious diseases, depend on a number of various factors related to the environment, regional specificity, socioeconomic development, political situation, a disaster’s characteristics and climate conditions. However, there are certain diseases which are more prone than others to break out in the aftermath of natural disasters. These diseases can be classified in several groups such as water-related, vector-borne, acute respiratory infections and wound-related diseases.

There are multiple opinions on the correlation between natural disasters and epidemics of infectious diseases, but the risk of disease outbreaks is often overemphasized by health officials and the media. The latter has an influence on donations and decisions by governments and NGOs so it tends to point out more dramatic information and unjustified warnings mostly based on an approximate assessment of risks. Other entities such as the WHO also draws attention to the risk of epidemics by issuing warning messages.

The present research presents an informed discussion on the relationship between natural disasters and epidemics of communicable diseases, fills the gap in literature as there appears to be a lack of research on the connection between the two phenomena in the period of 2005-2015, contributes to the overall knowledge and understanding of the topic, and provides a baseline for further research to be conducted on the given topic. It is very important to understand the correlation between natural disasters and infectious diseases and be aware of the risk of outbreaks of the diseases following a natural disaster so that priorities can be determined and resources can be allocated in the most efficient way which is crucial in post-disaster settings, especially in the emergency phase. The overall objective of the present study was to examine the existence of a connection between natural disasters and epidemics of infectious diseases. It has been found that disasters themselves do not import any diseases, instead, communicable disease outbreaks result from after-effects of natural disasters. Although, the risk of an infectious disease outbreak does not seem high, it is still present and should be taken into consideration in order to be able to provide the most effective humanitarian
response, prioritize activities and allocate resources in the most efficient way. In humanitarian action, there is nothing more important than saving people’s lives and alleviation of their suffering by doing as much as we can, and the findings of the present study can help to achieve the top humanitarian priority and make people’s lives better.
CONNECTION BETWEEN NATURAL DISASTERS AND EPIDEMICS OF INFECTIOUS DISEASES

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Connection between natural disasters and epidemics of infectious diseases

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CONNECTION BETWEEN NATURAL DISASTERS AND EPIDEMICS OF INFECTIOUS DISEASES


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CONNECTION BETWEEN NATURAL DISASTERS AND EPIDEMICS OF INFECTIOUS DISEASES


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CONNECTION BETWEEN NATURAL DISASTERS AND EPIDEMICS OF INFECTIOUS DISEASES


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<table>
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<tr>
<th>Connection confirmed</th>
<th>No outbreak</th>
<th>No conclusion</th>
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¹ The article does not have a particular conclusion on the connection between natural disasters and epidemics but it does note that diseases can be imported in disaster-affected areas.

² The article does neither prove nor disprove the connection between natural disasters and epidemics of infectious diseases since it is focused more on climate change as a global issue, contains information about dengue fever, discusses the relationship of climatic factors with population growth, human migration, urbanization, and poverty as well as factors affecting vector biology and potential solutions to mitigate the burden of dengue fever globally.

³ The purpose of this study was to identify infectious diseases and injuries that may be caused by a natural disaster and describe their importance in disaster response activities in order to identify key recommendations for the improvement of control and surveillance of these diseases during and after disasters. Therefore, no particular conclusion on the connection between natural disasters and disease outbreaks was drawn.

⁴ The article is focused on possible flood-associated infectious disease consequences of disastrous natural events and severe weather. It provides a detailed description of possible health consequences but does not have a particular conclusion on the relationship between infectious disease epidemics and natural disasters.
## CONNECTION BETWEEN NATURAL DISASTERS AND EPIDEMICS OF INFECTIOUS DISEASES

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5 The article looks more like a report about the situation right after the earthquake in Iran in 2012. In particular, it provides information on what has been done in terms of disaster response and what else should be done and taken into account with relation to public health. The latter includes information about the infectious diseases that are likely to break out. Since the situation was ongoing, no specific conclusion on the connection between the earthquake and disease outbreaks could be drawn.

6 The focus of this article is on the identification of public hygiene problems in the areas affected by earthquakes, and providing relevant recommendations to local governments about disaster-relief activities. Therefore, no conclusion on the relationship between natural disasters and epidemics of communicable diseases was presented.

7 The article presents a review of some of the major issues relevant to preparedness and response for natural disasters, including surveillance, risk assessment, and description of various diseases. No conclusion on the connection between natural disasters and infectious disease outbreaks was made.
## CONNECTION BETWEEN NATURAL DISASTERS AND EPIDEMICS OF INFECTION DISEASES

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8 The article has mostly predictions of further possible consequences of the Indian Ocean tsunami occurred on December 26, 2004 (two weeks before the article was issued). Also, it provides recommendations about what public health measures should be done and what should be taken and what complications are in place. No specific conclusion on the relationship between the tsunami and epidemics of infectious diseases could be drawn since the situation was ongoing.
<table>
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<tr>
<td>Flood on health: Epidemiologic evidence from Hanoi, Vietnam. <em>Global Health Action</em>, 4(00)</td>
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<td>Authors</td>
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<tr>
<td>Pourhossein, B., Esmaeili, S., Gyuranecz, M., &amp; Mostafavi, E.</td>
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<td>Watkins, R. R.</td>
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104
setting of natural disasters. *Current Infectious Disease Reports, 14*(1), 47–52.
