MEDICAL VULNERABILITY IN NATURAL DISASTERS:
THE ETHICS OF RESPONSIBILITY AND RESPONSE

BY

RACHEL DARE CROXTON

A Thesis Submitted to the Graduate Faculty of
WAKE FOREST UNIVERSITY GRADUATE SCHOOL OF ARTS AND SCIENCES
in Partial Fulfillment of the Requirements
for the Degree of
MASTER OF ARTS

Bioethics

December 2018

Winston-Salem, North Carolina

Approved By:

John C. Moskop, PhD, Advisor

Ana S. Iltis, PhD, Chair

Ramon Velez, MD
DEDICATION AND ACKNOWLEDGEMENTS

This thesis is dedicated to my brilliant and caring mother, Vada Agnes Davidson, who has maintained tremendous love and concern for others through more than thirty years of chronic illness and disability. Her value of higher education motivated me to pursue this graduate program and her example of resilience in the face of medical vulnerability led to my initial interest in this thesis topic. She is my inspiration.

I extend sincerest thanks to the following individuals for their support:

To my thesis advisor, John Moskop, for his guidance from the planning stages of this thesis to the final product, for his extensive knowledge of clinical ethics and emergency medicine, and for teaching me how to write with better clarity and thoughtfulness.

To Ana Iltis, for dedicating time to serve on my committee and providing valuable insights on ethical issues in global health during class discussions.

To Ramon Velez, for contributing his time to serve on my committee, for providing a physician’s perspective to this work, and for sharing stories about his family’s experience in Puerto Rico following Hurricane Maria.

To my professor Nancy King, for thoughtfully reviewing early drafts of my thesis proposal and for leading class discussions on issues of justice, public health, and vulnerability that significantly guided my approach to this topic.

To my colleague Mysha Sissine, for encouragement throughout the writing of this thesis, for stories about her previous work with Floating Doctors in Panama, and for her passion for global health that inspired much of this work and my future career goals.

To my supervisors Pamela Duncan and Heidi Munger Clary in Neurology at Wake Forest Baptist Health, for teaching me to appreciate the importance of assessing social and functional determinants of health in patients with chronic conditions and for supporting my professional development throughout the writing of this thesis.

To my father, Thomas Croxton, for never ceasing to make me laugh in times of stress, for offering a reassuring voice when needed, and for consistently supporting my education and development.
# TABLE OF CONTENTS

List of Illustrations and Tables | iv
---|---
Abstract | v
Introduction | vi
Chapter One: The Disaster Context | 1
Chapter Two: Medically Vulnerable Populations | 14
  Vulnerability in Bioethics | 14
  Medical Vulnerability | 17
  Population One: Manageable Chronic Conditions | 18
  Population Two: The Elderly | 29
  Population Three: Mental Illness | 30
  Population Four: Children | 34
Chapter Three: Vulnerable Health Systems | 38
  What Is Vulnerable? | 38
  Comparison One: Hurricanes in New Orleans and Puerto Rico | 39
  Comparison Two: Earthquakes in Haiti and Chile | 49
  Implications for Disaster Relief: Example of the USNS Comfort | 57
  Summary | 60
Chapter Four: Ethics in Disaster Relief | 61
  Overview | 61
  Responders | 62
  Responsibility | 64
  Clinical Ethics Applied to the Disaster Context | 69
  Public Health Ethics Applied to the Disaster Context | 73
  Ethics of Medical Volunteerism Applied to the Disaster Context | 76
  Proposed Ethical Considerations for Disaster Relief | 77
  Extension of Ethical Considerations to Global Health | 81
  Challenges to Ethical Conduct in Disasters | 84
Chapter Five: Planning Care for the Medically Vulnerable: A Predictive Model For Essential Heart Failure Medications in Natural Disasters | 87
  Responsibility to Plan | 87
  Proposed Predictive Model to Plan Care for Heart Failure Patients in Natural Disasters | 89
  Cost of Implementation: Is It Worth It? | 101
  Applications Beyond the Disaster Context | 102
Chapter Six: Human Resilience in Nature’s Misfortunes | 103
  Summary | 103
  Limitations and Future Work | 105
  Vulnerability and Resilience | 111
Endnotes | 114
Curriculum Vitae | 129
**LIST OF ILLUSTRATIONS AND TABLES**

<table>
<thead>
<tr>
<th>Table/Equation</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1-1.</td>
<td>Comparison of similar disaster events and respective death tolls</td>
<td>13</td>
</tr>
<tr>
<td>Table 3-1.</td>
<td>Hurricanes that affected representative health systems</td>
<td>40</td>
</tr>
<tr>
<td>Table 3-2.</td>
<td>Comparison of health insurance rates and select health-related characteristics in Puerto Rico and the 50 US States</td>
<td>43</td>
</tr>
<tr>
<td>Figure 3-1.</td>
<td>Mortality by year from 2003 to 2007 in six Louisiana parishes surrounding New Orleans</td>
<td>47</td>
</tr>
<tr>
<td>Figure 3-2.</td>
<td>Variation in the mortality by various causes in the New Orleans area by year from 2003 to 2007 using data from CDC Wonder</td>
<td>48</td>
</tr>
<tr>
<td>Table 3-3.</td>
<td>Earthquakes that affected representative health systems</td>
<td>50</td>
</tr>
<tr>
<td>Equation 3-1.</td>
<td>Quantitative estimate of post-disaster functional capacity of health care systems after natural disasters</td>
<td>55</td>
</tr>
<tr>
<td>Table 4-1.</td>
<td>Types of organizations involved in response to natural disasters</td>
<td>63</td>
</tr>
<tr>
<td>Figure 4-1.</td>
<td>The overlap of ethical considerations in clinical care, public health and medical volunteerism that are relevant to disaster relief</td>
<td>78</td>
</tr>
<tr>
<td>Table 5-1.</td>
<td>Essential medications for the outpatient treatment of heart failure</td>
<td>91</td>
</tr>
<tr>
<td>Table 5-2.</td>
<td>Heart failure prevalence and potential explanatory variables for 15 countries</td>
<td>93</td>
</tr>
<tr>
<td>Table 5-3.</td>
<td>Explanation of variables used in Table 5-2</td>
<td>93</td>
</tr>
<tr>
<td>Table 5-4.</td>
<td>Regression formula coefficients calculated using Microsoft Excel software</td>
<td>94</td>
</tr>
<tr>
<td>Equation 5-1.</td>
<td>Heart failure prevalence as a function of a country’s population over age 65, GDP in thousands of dollars per capita, and percent of population smoking</td>
<td>94</td>
</tr>
<tr>
<td>Figure 5-1.</td>
<td>Predicted versus actual heart failure prevalence for countries identified in Table 5-1</td>
<td>95</td>
</tr>
<tr>
<td>Table 5-5.</td>
<td>Typical usage of medication classes for the outpatient treatment of heart failure</td>
<td>97</td>
</tr>
<tr>
<td>Equation 5-2.</td>
<td>Formula for estimating need for particular drugs</td>
<td>97</td>
</tr>
<tr>
<td>Table 5-6.</td>
<td>Prevalence of heart failure in representative countries based on percentage of population above age 65, GDP in thousands of dollars per capita, and smoking rates (%)</td>
<td>98</td>
</tr>
</tbody>
</table>
ABSTRACT

Disaster relief organizations and workers often exhibit some of the most noble of human qualities, including concern for others, generosity, dedication, and even bravery in the face of extreme circumstances. Perhaps because of our admiration, disaster relief activities have largely escaped the scrutiny of bioethics; there are relatively few publications dealing with the ethics of disaster relief. Recent experiences, however, indicate that there is a need to evaluate disaster relief efforts from an ethical perspective. The thousands of “excess deaths” in Puerto Rico in the months following Hurricane Maria in 2017 demonstrate that generosity is not helpful if the aid that is provided does not match the actual needs of affected communities. In addition, the persistent cholera epidemic in Haiti, caused by United Nations personnel after a 2010 earthquake, illustrates that well-intentioned interventions can have serious adverse consequences. Based on analyses of these and other natural disasters, I argue that a key concept in disaster ethics is that of medical vulnerability. Both specific populations and health systems are vulnerable to natural disasters, and addressing these vulnerabilities is essential for effective and ethical disaster relief. I draw from published ethical considerations in three other contexts – clinical care, public health, and medical volunteerism – to propose a set of six ethical considerations that are essential in disaster relief. These are (1) Community-level beneficence and nonmaleficence, (2) Respect for communal autonomy, (3) Collaboration, (4) Evidence-based prevention, (5) Need-based response, and (6) Sustainability. Application of these considerations requires detailed planning by disaster relief organizations – planning that should occur well in advance of the disaster and be tailored to the resources and vulnerabilities of the specific affected communities. To illustrate that type of planning, I develop and present a predictive model that can be used to estimate the amounts of particular medications needed to provide care for one exemplary vulnerable population – those with heart failure. The ethical framework and approach to preparation described in this thesis can be used by disaster relief organizations and workers to ensure that responses to future natural disasters are more effective in caring for the medically vulnerable.
INTRODUCTION

HURRICANE MARIA AND PUERTO RICO

On September 19, 2017, heart disease was the leading cause of death in Puerto Rico, as it is in many countries of the world.\textsuperscript{1,2,3,4} On September 20, 2017, Hurricane Maria made landfall on the territory, and official reports placed the death toll at 64.\textsuperscript{5,6,7,8} In the following months, a number of investigations concluded that the death toll in Puerto Rico after Hurricane Maria was actually much higher. In May 2018, a study from the Harvard T. H. Chan School of Public Health was published as a New England Journal of Medicine special article. The aim of the study was to estimate mortality in Puerto Rico in the months following Hurricane Maria – beyond the initial 64 deaths reported. Investigators surveyed more than 3000 Puerto Rican households and estimated that there were 4645 “excess deaths” from the time of the hurricane’s landfall to December 31, 2017.\textsuperscript{9} A similar study from the Milken Institute School of Public Health at George Washington University compared mortality patterns before and after the hurricane to quantify “excess mortality” in the months following the disaster. This study reported 2975 excess deaths in Puerto Rico after Hurricane Maria, reflecting the numbers of deaths above what would be predicted by past trends, and accounting for emigration and other factors.\textsuperscript{10} Puerto Rican Governor Ricardo Rossello later accepted this estimate of 2975 as the official death toll in the territory following Hurricane Maria.\textsuperscript{11} Notably, the vast majority of these excess deaths were not obviously attributable to the hurricane itself. There were not 2975 people crushed under walls blown over by the high winds, and 2975 people did not drown in flooded homes and streets. A few certainly did, but not thousands. Instead, most people died from hypertension, diabetes, heart disease, and respiratory illness. The disaster event did not remove the preexisting chronic disease
burden on the country. Heart disease did not stop being the leading cause of death in Puerto Rico. Perhaps its lead even grew.\textsuperscript{12} The excess deaths came mainly from an interaction between the storm itself and the medical vulnerability of certain populations.

The health consequences of Hurricane Maria in Puerto Rico inspired this thesis, but the lessons learned from that experience are applicable to the general disaster context. In this thesis, I apply the concept of medical vulnerability to certain populations and health systems to explain why those populations and communities are at increased risk of poor health in the aftermath of natural disasters. In Chapter One, I provide an overview of the disaster context, distinguishing natural disasters from other events like emergencies and catastrophes, and describing the importance of considering community contexts in disaster relief. In Chapters Two and Three, I identify certain populations and health systems that are especially vulnerable to poor health outcomes in natural disasters. Then, in Chapter Four, I discuss various ethical considerations in the provision of disaster relief, drawing from the frameworks of clinical ethics, public health ethics, and ethics in medical volunteerism. Based on these three frameworks, I propose a set of ethical considerations for disaster relief, including an argument that the most effective relief includes care for medically vulnerable populations. In Chapter Five, I develop a predictive model to estimate what quantities of medications would be needed to respond to specific disasters in specific locations. This model takes into account the size and characteristics of the community’s population and its pre-disaster rates of disease burden to predict needs in a variety of domains, and it provides an actionable way of addressing the disaster responder’s moral responsibility to care for the medically vulnerable. Lastly, I provide a final summary and propose broader applications of this topic in Chapter Six.
CHAPTER ONE: THE DISASTER CONTEXT

UNDER THE WEATHER

The phrase ‘under the weather’ originated as a term used by sailors to describe feelings of queasiness during storms at sea. When a sailor or traveler felt nauseated during a storm, he or she would retreat below the ship’s deck in an attempt to avoid seasickness. In moving below, the sailor would quite literally move under the unpleasant weather felt by those on deck. This phrase is now used by a broader audience, evolving over time to simply mean that one feels ill. The common phrase ‘under the weather’ shows an important connection between weather and health. That linkage is supported by both qualitative and quantitative data that reveal associations between adverse weather and poor health. For instance, transmission of dengue fever in a major Sri Lankan city was positively associated with rainfall, temperature, and other weather-related phenomena. A more common example is the seasonal flu, with influenza epidemics often varying significantly with weather factors such as humidity and temperature.

Weather itself is a combination of five natural phenomena: temperature, wind, humidity, precipitation, and atmospheric pressure. These parameters are constantly changing at each particular place on Earth, with some locales swinging between extremes in these categories and others having more consistent conditions. Weather changes with the seasons in response to the incident angle of sunlight, and the typical weather in a place over a long period of time constitutes the climate of that place.

Weather typically changes gradually and within expected bounds – in a rather non-disruptive way – getting colder as autumn fades to winter, and warmer as spring
welcomes summer. But occasional disruptions, such as hurricanes in the South Atlantic, can be extreme. Due to the frequency of such events, Miami, Florida instituted strict building codes for developers that require new buildings to use impact-resistant glass and other modifications to reduce the damaging effects of wind. Yet even with risk-reduction efforts such as mandated building codes and more accurate weather prediction, severe weather-related events continue to have adverse effects on human health. The connection between weather and health is clearest when a specific weather event significantly disrupts a community. In fact, this relationship holds for all natural disasters, which include not only weather-related phenomena but also certain geological and hydrological phenomena. All are associated with poor health outcomes.

Natural disasters present unique challenges to communities. One challenge is that these events are typically unpredictable or unexpected. Even when anticipated – like earthquakes in California – they may be greater in magnitude than what is typical. In addition to affecting particular individuals, natural disasters can pose significant challenges for health care systems, often causing great influxes of patients who have sustained injuries due to the disaster event. Disasters may also impair travel, communications, and utilities, disrupting the ability of hospitals and other health care facilities to transfer patients or to receive more supplies or personnel. These are important challenges to mitigate.

Most of the literature on the effects of natural disasters on human health and health systems focuses on the short-term challenges: how to triage patients, how to ration care, and how to deal with acute conditions that arise during the disaster event. Less literature exists on the long-term health effects of disasters. Yet there are
many long-term effects, especially for those with certain chronic conditions. In this thesis, I explore the question of how patients with type 2 diabetes, heart failure, chronic obstructive pulmonary disease, hypertension, and other medical conditions, are affected by disasters that devastate the health care systems in their communities. I argue that those with chronic conditions, as well as the elderly, children, and the mentally ill, should be considered vulnerable populations in the context of natural disasters, and that providers of disaster relief have a conditional ethical responsibility to respond to their needs if they decide to provide care in the affected community.

NATURAL DISASTERS

What is a disaster, and what makes it natural? Disasters are defined as events that are of sufficient magnitude to overwhelm the capacity of affected communities to respond, thus necessitating outside assistance from state and national governments, and, in some cases, international relief organizations. Natural disasters are physical events caused by geological, meteorological, or hydrological phenomena that exceed a community’s ability to cope with the event. Examples include earthquakes and tsunamis, hurricanes and typhoons, volcano eruptions, tornadoes, wildfires not caused by human action, floods, mudslides, and avalanches. Natural disasters are not initiated by human action, and they are characterized by the affected community’s inability to recover without external intervention. Not all devastating events caused by natural phenomena qualify as natural disasters. On a spectrum of event magnitude and breadth, these events lie between emergencies and catastrophes. Emergencies are defined as events that require immediate intervention on a small scale but are manageable on an individual or local
level. On the other extreme, catastrophes are events that affect entire regions – beyond the community level – and are characterized by long-term disruption of the social order.\(^3\)

Natural disasters are distinguished from “man-made disasters,” or disasters of human agency, which include bombings, mass shootings, terrorist attacks, oil spills, stampedes, and radiation leaks. Recent literature has added a new category to the types of disasters – a type called “unnatural disasters.” These can include some of the weather-related events described above as natural disasters, such as hurricanes and floods, but with the distinction that they have been influenced by human action. Because the size and magnitude of certain weather events is arguably affected by climate change, the line between what is “natural” and what is “unnatural” or man-made is blurred. Climate change will be discussed in greater depth in Chapter Six, and this thesis will use the traditional definition of natural disasters, since its primary focus is on the effects of disasters, not their causes.

**PERSON, PLACE, OR THING**

*Category Four Hurricane, Magnitude Seven Earthquake, EF-3 Tornado, Intensity Nine Tsunami*: these are some of the designations that modern civilization gives to natural disasters. We rate them – “rewarding” them according to their strength. In the case of hurricanes, we even name them, with some – *Katrina, Maria, Mitch* – becoming household names remembered for decades after the events have ended and the affected communities have been rebuilt. Just as we associate our distant relatives with the places where they live – Aunt Sue in Little Rock, Uncle Joe in Tallahassee – we associate these storms with the places they ravaged: Katrina and New Orleans, Maria and Puerto Rico, Mitch and Honduras. Natural disasters live on like persons with names, locations, and
legacies. To many, great storms inspire doubt and faith, fear and resilience, division and unity. Many see these physical events as rife with spiritual meaning. Following an Asian tsunami, the Archbishop of Canterbury described this event as a challenge to faith: “Of course, this makes us doubt God’s existence.”33 Some attempt to justify storms as “divine justice” against those they regard as sinful: “I believe that the Hurricane Katrina was, in fact, the judgment of God...” stated televangelist Reverend John Haggee in 2006, referencing a gay pride parade that was scheduled to take place in New Orleans on the day of the storm’s landfall.34 Others urge people to reaffirm and act upon their convictions in a disaster’s wake: “[Hurricane Katrina] may be the greatest opportunity to demonstrate God’s love in this generation,” urged evangelist Billy Graham.35 Love, justice, doubt, and faith are all forefront themes in discussions of the world’s recent and devastating disasters.

Perhaps it is the untamable power of disasters that sparks these questions, judgments, and calls to action. Perhaps it is the level of destruction they bring. They certainly remind us of our limits – that there are winds, waves, and quakes more powerful than any walls, bunkers, and levees we build in defense. Whatever the reason, and whatever metaphysical and moral significance disasters may have to individuals and groups, the physical reality of these storms is that they are often unpredictable, unstoppable, and difficult to manage.

What should natural disasters mean to us? Ought they be viewed as personified entities, or the handiwork of some metaphysical agent? Perhaps for some, but for the purpose this thesis, natural disasters will be evaluated solely as physical events.36 The ethics of disaster relief must be judged on the basis of its benefits and harms to the
community, and not confused by the attribution of a metaphysical meaning to the event. Regardless of their names, magnitudes, and likely causes, disasters are physical phenomena with large-scale, often devastating physical consequences in affected locations. These consequences are many, as disasters may devastate a community’s housing, water and sewage systems, schools, places of worship, transportation services, roads, and other public works. Importantly, disasters may also significantly affect health systems, with numerous effects on human health and wellbeing.

LIGHTS, CAMERA, ACTION

The current media culture in the United States sensationalizes disasters. Over 150 films and television shows have been produced over the past 80 years with settings in a world ravaged by natural disasters. Plots of these films nearly always center on the lives of a few human survivors of large-scale disasters and catastrophes. Fictional stories that wipe out all but a select few are popular because they touch on the emotions of fear, suspense, and resilience. Such “survivor narratives” effectively raise questions about (1) the limits of the human race, and (2) the consequences of unwise innovation or inadequate protection of the environment.37

While these films and television shows are entertaining and serve an important role in reminding us of our limits, they distort the reality of natural disasters – often transitioning rapidly from “life as usual” to the “end of the world” through only a single event or day. This dramatization of disasters provides the public with an inaccurate image of what natural disasters are, and, more importantly, what effects they actually have on the people in the disaster area.
DISASTERS AND HEALTH

Beyond the varied perceptions of the metaphysical causes of natural disasters and dramatized narratives about their survivors, the physical events themselves do have major consequences for human health. The health effects of disasters are numerous, ranging from acute to chronic, and affecting individuals at all life stages, from neonates to the elderly. Natural disasters can affect both acute and chronic health conditions – causing the onset of certain conditions and exacerbating the symptoms of many existing conditions.

Onset of New Conditions

Communicable disease. One of the most frightening consequences of a natural disaster is an infectious disease epidemic. Severe flooding, loss of electricity and clean water supplies, damaged sewage systems, and other factors common in the disaster context may contribute to the spread of disease. While all individuals in an affected community are at risk of infection by communicable disease, certain populations have heightened risk. The elderly are especially at risk of infection in the disaster context, as they generally have a (1) higher prevalence and severity of chronic conditions, (2) increased susceptibility to infection, (3) increased dependency on others for activities of daily living and transportation, and (4) increased dependency on health care providers for efficient and routine care. Certain communities, including some that are highly prone to disasters, tend to have larger populations of the elderly, such as Puerto Rico, which in recent years has experienced significant migration of the younger population to the continental United States in search of employment. Other populations, including children, also have heightened susceptibility to infection and dependency on others.
Toxic Exposure. The conditions that increase the transmission of communicable diseases in disaster-ravaged communities may also pose another hazard – that of exposure to toxins. A common pathway by which toxins enter the human body is through the respiratory tract. Disasters that destroy buildings, disturb soil, and facilitate the movement of particles through high wind speeds may cause humans to inhale toxic contaminants. The flooding of sewage systems and streams may also lead to the widespread distribution of toxins throughout a community. Direct contact with these contaminants, such as could be caused by wading through floodwaters, or drinking unclean water, can also introduce harmful biological and chemical contaminants into the human body.

Mental Illness. In addition to the increased risk of infection and exposure due to the physical effects of natural disasters on a community’s infrastructure, disasters may also cause psychological disturbances that may lead to longer-term, more serious mental illnesses. One common mental illness that is often seen in individuals who live through natural disasters is post-traumatic stress disorder, or PTSD. Mental illnesses are common for those who experience traumatic events, including combat veterans, survivors of concentration camps, rape victims, and those who have been through disasters, both natural and man-made. Observing and experiencing extreme loss, devastation, and pain that are beyond an individual’s ability to control or avoid can lead to anxiety and depression, disturbed sleep patterns, guilt feelings, and impaired concentration. Retrospective studies reveal that certain individuals may be more vulnerable to psychological trauma. Those who experience the traumatic event or setting have an increased risk of PTSD, especially those who are in negative emotional states prior to the
traumatic experience.\textsuperscript{41} Disaster psychiatrists may be able to assist individuals at risk of developing PTSD, as well as other physio-psychological conditions such as chronic stress, anxiety, depression, and suicidal ideation – all of which are common among those who experience disasters. The symptoms felt by those suffering psychological trauma following a disaster often overlap, and this complicates the ability of disaster psychiatrists to make accurate diagnoses. A non-responsive patient may be impaired due to alcohol or drugs, may be catatonic or cataleptic, may simply be disoriented, or may have suffered a brain injury that requires a different type of care. Disaster mental health providers may be overwhelmed by the sheer number of patients who pose a danger to themselves or others, thus prolonging the time it takes to address those with other serious, but not imminently life threatening symptoms.\textsuperscript{42}

\textit{Exacerbation of Existing Conditions}

\textbf{Chronic disease.} Chronic diseases are, by definition, long-term. They are not cured with a week-long medication regimen or a one-time surgery. Rather, people can live for decades with conditions such as heart failure and diabetes. The key to achieving this longevity is management of the diseases. Diabetes is commonly managed with adherence to a healthy diet and use of oral medications or insulin injections, depending on the form of the condition. Heart failure is commonly managed by adherence to a low-salt diet, close weight monitoring, and medication adherence. Other chronic conditions such as hypertension and chronic respiratory illnesses are managed in similar ways.

Because these conditions are both long-term and common, they are not what one generally thinks of as urgent needs in the wake of a natural disaster. A hurricane hits, an earthquake occurs, a tornado lands, and the images we see are acute traumas. A young
boy loses a leg, a family is burned in a house fire, an elderly couple drowns. Such images are real, sad, and important, but they ought not be viewed as the complete story. The worst health consequences of a disaster may actually result from interruption of routine but essential medical care for chronic conditions.

In communities where patients have access to health care facilities and services, the management of their conditions is largely perceived as their responsibility. A hospital will provide heart failure patients with education about how to control their symptoms and improve their health, then following discharge it is the patient’s responsibility to follow his providers’ advice. Similarly, a pharmacist will give a diabetic patient her monthly supply of insulin, and it is the patient’s responsibility to remember to take her medicine and to continue to take it even when she may feel better or feel worse. One of the most common reasons for hospital admission and readmission for chronic conditions such as these is non-adherence – patients did not follow the medical advice they were given or did not take their prescribed medications. The responsibility to manage the patient’s condition is placed on the patient, and so patients are blamed for failure to care for themselves.

This usual way of thinking may not apply in the aftermath of a disaster. Natural disasters reveal the great dependency that patients have on their community health systems. While patients generally recognize that they are responsible for managing their diabetes, heart failure, or hypertension, a disaster that has devastated their health system will often show the importance of a well-functioning health system. When the pharmacy’s power fails, patients cannot get the refrigerated insulin they need. Patients are left on their own to manage their conditions – a task that is normally within their ability
when they have resources and support from physicians, pharmacists, and other providers. But without the tools to manage their conditions in the aftermath of a natural disaster, even the most responsible patients may find it difficult to control their chronic disease symptoms.43

**Pre-Existing Mental Illness.** Mental illness is common, with anxiety and depression affecting over 18% and 7% of adults in the United States, respectively.44 Though there are limited data available about the prevalence of these conditions in other countries, they likely affect a similar portion of those populations. These conditions can be treated with psychotropic medications or psychiatric or psychologic therapy and counseling. The disaster context interrupts the availability of therapeutic services, as pharmacies may be forced to close or may experience delays in obtaining medications, and the personnel and facilities that provide psychiatry and psychology services may be unavailable. In addition, mental illnesses may themselves be exacerbated in disasters due to disaster-related stressful and devastating situations.

**Community Characteristics**

The prevalence of particular conditions differs among communities. As such, the predominant health care needs in disasters are context-dependent. Disaster responses should be informed by an accurate understanding of a community’s physical needs, a great number of which are related to health conditions or the health-related infrastructure. In this thesis, I explore the implications of disasters for acute and chronic health needs – both of individuals and communities – with a focus on how those responding to such needs should seek to achieve “the greatest good” in situations where needs outstrip the available physical and human resources.
THE IMPORTANCE OF CONTEXT

A disaster event opens a Pandora’s Box of questions. Who should respond? What are the needs? When will help arrive? Will life ever be the same? Are my loved ones alright? Why did this happen? The questions of *what* good can be done during and after a natural disaster, *how* such good can be achieved in potentially resource-limited situations, *when* specific goods ought to be prioritized, and *who* ought to provide and receive those goods are quite complex, and answering such questions requires a case-by-case analysis. Each natural disaster has its own type, cause, affected population, community structure, and resources available for response in the short and long term. The implications of each event are very context-dependent and sensitive to a host of cultural, political, economic, religious, social, psychological, and clinical factors. Many have argued that there is no “one-size-fits-all” ethical approach to disaster medicine.\(^{45,46,47}\)

Evidence relating to morbidity and mortality rates and standards of care in different communities affected by natural disasters supports the claim that there is likely no universal approach or plan for disaster response. A comparison of standards of care and mortality rates in different communities and health systems affected by similar disasters can be used to support this claim. The data below provide a brief overview of the effects of two natural disaster types on health systems. Table 1-1 contrasts pairs of locales whose health systems faced the same type of disaster, revealing how similar events can have very different outcomes on health in affected communities. Even for disasters of the same type and similar magnitude, the death tolls may be vastly different for different communities and countries. This is likely due in large part to differences in the quality and capacity of health systems. The characteristics of the health systems in
these communities and how those characteristics influence health outcomes will be further explored in Chapter Three.

<table>
<thead>
<tr>
<th>Disaster</th>
<th>Strength</th>
<th>Location</th>
<th>Death Toll</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005 Hurricane Katrina</td>
<td>Category 3</td>
<td>New Orleans, USA</td>
<td>1833</td>
</tr>
<tr>
<td>2017 Hurricane Maria</td>
<td>Category 4</td>
<td>Puerto Rico, USA</td>
<td>2975</td>
</tr>
<tr>
<td>2010 Chile Earthquake</td>
<td>Magnitude 8.8</td>
<td>Chile</td>
<td>525</td>
</tr>
<tr>
<td>2010 Haiti Earthquake</td>
<td>Magnitude 7.0</td>
<td>Haiti</td>
<td>100,000 – 316,000</td>
</tr>
</tbody>
</table>

Table 1-1. Comparison of similar disaster events and respective death tolls

These comparisons reveal that context is a crucial consideration in preparing for and executing disaster responses. Even for disasters of similar magnitude and intensity, specific communities may experience vastly different outcomes. There appear to be telling correlations between the baseline quality of the health care infrastructure in communities and their health outcomes after a disaster – these will be explored in Chapter Three.

In summary, the “disaster context” is best characterized as unpredictable, highly variable, and complex. A generalizable approach to responding to the health care needs of those affected by natural disasters is impossible, or at best incomplete. Each community is different, as is each disaster event. Effectively responding to specific disasters must begin with a knowledge of who is affected. This is difficult to ascertain before a disaster event takes place, but the question of who is most likely to be affected by the event may be informed by an understanding of vulnerable populations. Chapter Two will provide an overview of four populations that ought to be considered vulnerable to natural disasters.
CHAPTER TWO: MEDICALLY VULNERABLE POPULATIONS

VULNERABILITY IN BIOETHICS

The concept of vulnerability is familiar to the field of bioethics. Some even refer to vulnerability as being “at the heart” of bioethics.\(^\text{48}\) An emphasis on vulnerability in bioethics first appeared in the 1979 Belmont Report, which argued that some populations are more at risk of harm than others in the research context and ought to be protected.\(^\text{49}\) Similarly, Article 8 of the Universal Declaration on Bioethics and Human Rights, adopted by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 2005, includes a principle of “respect for human vulnerability and personal integrity.”\(^\text{50}\) Scholarly interest in vulnerability is relatively new and growing, with PubMed searches placing the number of journal publications using “vulnerability” as a keyword at 10 in 1967\(^\text{51}\), 101 in 1978, and 4189 in 2017. The UNESCO Declaration also extended the concept of vulnerability from the research context to the clinical context.\(^\text{52}\) Protection of “vulnerable populations” is now an aim of all branches of the field of bioethics, including the ethics of research,\(^\text{53}\) clinical practice, and public health.\(^\text{54}\) But what is vulnerability, to whom or what does this concept apply, and what follows after a person, population, or something else has been classified as vulnerable?

The concept of vulnerability

Commentators offer a variety of definitions and descriptions of vulnerability, including the following:

I. “[Vulnerability is an] increased risk of harm, and/or having a decreased capacity to protect oneself from harm.”\(^\text{55}\)

II. “Vulnerable individuals and groups are subject to exploitation.”\(^\text{56}\)
III. “Vulnerability is diminished autonomy… special measures by other persons are required to assist and protect the vulnerable.”57

IV. “[The vulnerable are] at increased risk by virtue of belonging to a particular group.”58

V. “Vulnerable people are relatively or absolutely incapable of protecting their own interests.”59

Most of these definitions equate vulnerability with a heightened risk of harm. If vulnerability were a disease, it would have many risk factors, with some individuals and populations more predisposed to the condition of being at greater risk than others. One factor that may lead to vulnerability is restricted choice. The poor woman has fewer choices for what house to buy compared to the rich woman, and may be forced to live in an unsafe neighborhood or in a house without a security system due to her lack of money. The rich woman, in contrast, has more options for housing; she can afford the same houses as the poor woman and more expensive houses in safer neighborhoods, perhaps with security systems. The poor woman is thus at greater risk of harm than the rich woman due to the lack of choices available to her because of her poverty. A second factor that may lead to vulnerability is lack of awareness. A child may approach a stray dog on the street, assuming that the animal is similar to his family’s obedient, friendly pet dog. He is not aware that the animal may carry diseases or be aggressive, because he has not experienced or been taught about the potential dangers of approaching stray dogs. His lack of awareness that dogs may be dangerous puts him at a greater risk of harm than the informed adult walking down the same street. Finally, although vulnerability is often discussed as a constant characteristic of an individual or group, when a person or population is vulnerable may also vary with time or situation. Hence, the concept of vulnerability can be classified into different types, as described below:
Types of vulnerability

Scholars identify and describe a number of different types of vulnerability, as follows:

I. **Universal Vulnerability**: An increased risk of harm that is “inherent and inevitable.” Populations in this category are vulnerable at all times, regardless of the particular situation. Examples of these groups are children, pregnant women, prisoners, and the mentally disabled, who are labeled as “vulnerable populations.”60 These populations are appropriately labeled as vulnerable because the characteristics of these groups that make them vulnerable – being a child, pregnant, in prison, and mentally handicapped – apply in all contexts, and thus they are vulnerable in all contexts.

II. **Contextual Vulnerability**: Certain individuals or groups may experience heightened vulnerability and risk of harm in particular situations or environments.61,62 For instance, Individual A may not be vulnerable in Situation B, but is vulnerable in Situation C. In the same vein, Individual X may be more vulnerable in Situation Y and less vulnerable in Situation Z. The degree of vulnerability experienced by these individuals is context-dependent. Relevant contexts might include participation in a particular research study63 or being in a location affected by a natural disaster.

III. **Physical Vulnerability**: Certain infrastructures or locations may produce heightened risk of harm due to factors such as population density, remoteness, and building design.64

IV. **Social Vulnerability**: An increased risk of harm due to the “inability of people, organizations, and societies to withstand adverse impacts to hazards due to characteristics inherent in social interactions, institutions and systems of cultural values. It includes aspects related to literacy and education, peace and security, basic human rights, systems of good governance, social equity, positive traditional values, customs and ideological beliefs, and collective organizational systems.”65

V. **Economic Vulnerability**: An increased risk of harm due to an individual or group’s economic status. Those of lower economic status are generally more vulnerable to harm in situations such as natural disasters because they are unable to access the same resources (e.g. transportation, food, safe housing) as those of higher economic status.66

VI. **Environmental Vulnerability**: An increased risk of harm due to environmental conditions such as natural resource depletion and resource degradation.67

VII. **Medical Vulnerability**: An increased risk of experiencing poor health outcomes. This may be a form of universal or contextual vulnerability and is often the result of dependence on others to meet certain health-related needs.
MEDICAL VULNERABILITY

In health care, the concept of vulnerability can be applied to describe individuals or populations that have an increased risk of poor health outcomes compared to others. It may be universal or contextual, and it may be associated with certain forms of physical, social, economic, and environmental vulnerability, as the “risks of harm” related to those vulnerabilities often have health consequences. In the clinical context, it is generally accepted that efforts should be made to protect the rights and preferences of medically vulnerable individuals, and to promote their welfare in interactions with health care providers, as well as in clinical research.\(^6\)

**Who is medically vulnerable in natural disasters?** Natural disasters can affect individuals, families, groups, and entire communities and nations. Major health-related effects are common in the disaster context. Disaster events may directly cause health-related problems – such as traumatic injuries or exposure to toxins due to flooding. Disasters may also have severe *indirect* effects on human health due to the event’s devastation of community health systems.

This chapter describes four populations that should be classified as medically vulnerable in the disaster context. First are those with chronic diseases, especially four common chronic conditions: hypertension, type 2 diabetes, heart failure, and chronic obstructive pulmonary disease; second are the elderly; third are those with mental illnesses such as anxiety or depression; and fourth are children. These populations are especially relevant to this thesis because their medical vulnerability is strongly contextual, as it greatly increases in the aftermath of a natural disaster. While the medical needs of these populations are typically manageable under normal circumstances, control
of these conditions may be lost in the hours, days, or months following a disaster. Several mechanisms contribute to this medical vulnerability. The natural disaster may directly affect health by aggravating pre-existing chronic diseases, causing infections among the elderly and children, and triggering or worsening mental illnesses. In addition, the natural disaster may devastate the local health system and interrupt the provision of essential medical care. Finally, the natural disaster may interfere with needed support provided by family or other personal caregivers. In combination, these consequences of a natural disaster may have a devastating effect on health outcomes in the four groups identified above.

POPULATION ONE: MANAGEABLE CHRONIC CONDITIONS

Overview

The U.S. National Center for Health Statistics defines a chronic disease as “a disease lasting three months or longer.” Chronic diseases are long-term conditions that are typically manageable, though not curable, with medications, lifestyle modifications, and routine visits with health care providers. Individuals can live for many years with chronic diseases that are well managed. These conditions are major problems globally, and in fact, the burden of chronic disease is felt more heavily in lower income countries than in richer nations like the United States. Mortality by non-communicable chronic diseases is strongly associated with income, with 78% of all non-communicable disease (NCD) deaths in 2016 occurring in low- and middle-income countries. In addition to being a global problem, chronic disease is a growing problem. Predictions are that the number of Americans with chronic disease will rise from 133 million in 2014 to 157 million by year 2020.
The risk factors for most common chronic diseases – heart failure, stroke, chronic obstructive pulmonary disease, hypertension, diabetes, and others – are similar. All of these conditions can be prevented or delayed by regular physical activity, a healthy diet, and abstaining from smoking and excessive alcohol use. Yet strategies to prevent chronic diseases are often unsuccessful for many reasons. Some individuals may live in food deserts without easy access to grocery stores that sell healthy foods. Some may not be able to afford health insurance and decide not to incur the out-of-pocket cost of routine doctor’s visits. Others may resort to cigarette smoking as a form of short-term stress relief. Still others who may have sufficient resources for a healthy diet, exercise, and medical care simply choose to live less healthy lifestyles. Whatever the root causes of failed prevention are, the consequence is that many people are affected and must manage chronic diseases.

Chronic disease management is feasible for individuals who can afford prescriptions, doctor’s appointments, and time spent exercising and eating well. However, disease management does lead to dependency, because the chronically ill rely heavily upon their physicians, pharmacists, caregivers, and other health care providers. The availability of these health care personnel and resources is often disrupted in natural disasters, which may devastate hospitals and pharmacies due to loss of electricity, water shortages, and even infrastructure destruction. Such disruptions may be so long lasting that the chronically ill run out of needed medications or oxygen and miss regularly scheduled follow-up visits with physicians, dialysis centers, or other providers on which they depend for disease management. Thus, critical needs of the chronically diseased are
often unmet in the disaster context. This is especially true for the four chronic disease populations described below.

**Hypertension**

**Disease Description**

*Medical Perspective.* Hypertension is a condition in which an individual’s blood pressure is greater than normal levels. Individuals with hypertension are at enhanced risk of cardiovascular disease, stroke, and premature death. While some contributing factors to hypertension are not modifiable (such as genetics, age, gender, and race), there are many modifiable factors that enable those with hypertension to manage their disease effectively. Modifiable risk factors of hypertension include physical inactivity, a high sodium diet, obesity, excessive alcohol consumption, sleep apnea, high cholesterol, diabetes, smoking, and stress. Hypertension can usually be controlled well with diet modifications and safe and relatively inexpensive medications.

*Epidemiological Perspective.* Hypertension is common, affecting 33% of the adult population in the U.S. and a similar fraction of the population in other countries, both high- and low-income. It is generally more prevalent in males and among African-Americans and tends to worsen with age.

**Hypertension in the Disaster Context**

Individuals with hypertension often experience poorer health in the aftermath of a natural disaster. Disasters can interfere with ongoing treatments and also involve physiological stressors that can have direct effects on blood pressure. Increases in blood pressure are associated with chronic stress. The stressors brought by the effects of a disaster on individuals and communities are often long-lasting, as people may lose their
homes, jobs, loved ones, and access to community resources. These stressors, coupled with the potential inability to obtain medications from closed pharmacies and health centers, can lead to increases in blood pressure for those with pre-existing hypertension.

**Puerto Ricans with Hypertension after Hurricane Maria**

66 days after Hurricane Maria hit Puerto Rico, 76-year-old Mariano Fonseca Rivera died from primary hypertension. According to an online survey of his family members, “They didn’t have money for a generator and his condition deteriorated because he couldn’t use his apnea machine.”

Rivera’s story illustrates that the problems associated with poverty often get worse in the aftermath of natural disasters. The loss of electricity caused by Hurricane Maria left Rivera in need of electrical power – something that had been generally available to him, but which he would need money to replace. Dependent on electricity to power his continuous positive airway pressure (CPAP) machine for the management of his sleep apnea, he was left with few options. One possibility would be to buy a generator, but he could not afford one. The other option would be to hope for power to be restored. Perhaps he did, but many areas in Puerto Rico still lacked power until early summer 2018. By the end of December 2017, only 65% of power had been restored to the territory. That was unfortunately not soon enough for Rivera, who died two months after the hurricane. It is common for patients with sleep apnea to also have high blood pressure, or hypertension, and regular use of CPAP machines can reduce blood pressure levels. His inability to use the CPAP machine likely inhibited his ability to control his blood pressure levels, this putting him at increased risk of death.
Rivera was not alone. The problem of hypertension in the disaster context is illustrated by a report that more than 45% of patients seen at a community clinic in Puerto Rico in the four months following Hurricane Maria presented with hypertension. While a priority of many relief organizations is to provide food for those living in devastated communities after natural disasters, much of the food provided is very high in calories – intended to help prevent starvation. The food is also often high in salt, which may be a death sentence for those with hypertension whose conditions are already worsened due to the physical and psychological stressors of the disaster, and the infrastructure damage that may occur – causing some, like Rivera, to lose electricity, and others to lose access to health care facilities.

**Type 2 Diabetes**

*Disease Description*

*Medical Perspective.* Type 2 diabetes is first recognized clinically as an increase in fasting blood glucose levels. If not well controlled, it causes widespread dysfunction of small blood vessels, leading to heart disease, neuropathy, skin ulcers, blindness, and kidney failure. Like many chronic conditions, diabetes has many modifiable risk factors, which include physical inactivity, obesity, and smoking. In mild cases, type 2 diabetes can be managed effectively with diet modifications. In moderate cases, oral medications are effective. The most severe cases require regular insulin injections. Severe diabetes leads to kidney failure, requiring dialysis or kidney transplant for survival.

*Epidemiological Perspective.* In 2016, diabetes caused 1.6 million deaths, representing 3% of all global deaths. Diabetes is more common in higher income nations and has increased in prevalence in recent generations.
Diabetes in the Disaster Context

Management of existing, severe diabetes presents special challenges in the context of natural disasters. First, many diabetics need to adjust their treatment, especially insulin dosage, with variations in stress, exercise, and food intake. Monitoring by a physician is often essential, since both undertreatment and overtreatment can have serious consequences. Second, severe diabetes can transform rapidly into life-threatening conditions: either ketoacidosis if undertreated or hypoglycemic shock if over-treated. Third, many preparations of insulin must be refrigerated. With loss of electrical power, there may be unpredictable degradation and loss of potency for insulin that is kept at ambient temperatures for more than a few hours. Fourth, individuals whose diabetes has caused severe kidney damage may require several dialysis treatments each week to avoid coma and death. Because of these issues, management of diabetes can be very difficult in the aftermath of a natural disaster.

Puerto Ricans with Diabetes after Hurricane Maria

24 days after Hurricane Maria hit Puerto Rico, 84-year-old Cerelda Rodríguez Olmeda died. An interview with her family described her story:

*I think it was a combination of factors. I saw her the day before and she was fine. She lived with my brother who always left her some food when he went to work. When he returned, he found her dead. I believe stress, lack of medical care... and her schedules were changed. We don't know if she had her insulin at the right time.*

*Before* Hurricane Maria, one out of every seven adults in Puerto Rico had been diagnosed with diabetes, with approximately 6000 dependent on regular dialysis. Many others depended on regular insulin injections to manage their diabetes. *After* Hurricane Maria, widespread outages in power and water forced many dialysis centers to close. Although nearly all of Puerto Ricans on dialysis had the chance to communicate with
their dialysis providers prior to the storm,\textsuperscript{86} that communication did little more than inform patients that the dialysis centers might close. While knowledge of how a hurricane may affect them is important, it does not replace the need for resources. Many of these patients were left unable to access resources on which they depended for life. For those dependent on insulin injections, the widespread lack of electricity in Puerto Rican homes made it impossible to keep insulin vials cool at recommended temperatures.\textsuperscript{87}

\textbf{Heart Failure}

\textit{Disease Description}

\textit{Medical Perspective}. Heart failure is any condition associated with inadequate pumping of blood by the heart. It can be fatal when severe. The primary symptoms of chronic heart failure are weight gain, shortness of breath, and exercise intolerance. These are mainly due to inadequate perfusion of the kidneys with fluid accumulation throughout the body, including pulmonary edema, or fluid accumulation in the lungs. Heart failure often involves a decrease in the fraction of blood ejected by the left ventricle when it contracts. However, it is now recognized that a sizable percentage of patients with heart failure – particularly older women – have a normal left ventricular ejection fraction. The cause of the heart failure for these patients may be inadequate filling of the heart in its relaxation phase. Both forms of heart failure are managed by routine weight monitoring, restrictions in salt consumption and fluid intake, abstaining from smoking and excessive alcohol consumption, and diuretic medications that remove excess fluid from the body.

\textit{Epidemiological Perspective}. In 2016, cardiovascular disease caused 17.9 million deaths, representing 31\% of all global deaths, the leading cause of death worldwide.\textsuperscript{88} A large fraction of those were due to chronic heart failure. Heart failure is strongly associated with age. In the United States, approximately half a million people are newly
diagnosed with heart failure each year – 50% of whom are predicted to die within five years.\textsuperscript{89}

Heart Failure in the Disaster Context

Self-management of heart failure as described above is usually highly effective, and variations in this condition tend to occur slowly enough for patients to recognize them and adjust treatments. Nevertheless, management of heart failure without the careful supervision of a health professional requires high levels of understanding, cognitive ability, and physical ability for self-care. Hence, heart failure patients who rely on family, friends, or visiting nurses for disease management are particularly vulnerable to the interruptions in transportation that often occur in the context of a natural disaster. In addition, changes in diet and fluid intake that are common when relying on disaster aid for these essentials can have substantial effects on health status in those with heart failure. The inability to obtain diuretic medications if pharmacies close due to a disaster may also lead to worsening of heart failure symptoms, and even death.

Puerto Ricans with Heart Failure after Hurricane Maria

Six days after Hurricane Maria hit Puerto Rico, 56-year-old Gerardo Rojas Cruz died. The excerpt below from an interview with his family tells his story:

\textit{Stress worsened and altered his condition. The incident happened six days after hurricane Maria. He was getting ready to report to work when he told me he couldn't breathe. I immediately took him to the hospital, but when we got there, his condition worsened and he died.}\textsuperscript{90}

Although Cruz had a willing and able caregiver available to take him to the hospital and had a hospital to go to, he still succumbed to what is typically a stable condition less than a week following Hurricane Maria. Presenting with shortness of
breath at the hospital is common for patients with heart failure, and these patients are generally stabilized with oxygen or intubation to increase the oxygen saturation of the blood, with aspirin for those at risk of heart attack. ECGs should also be performed on those over age 50. Perhaps the hospital Cruz visited lacked electricity to power ventilators or other devices. Perhaps they were operating at capacity and had no physicians available to see Cruz in time to help his case. Perhaps he was seen by a physician, but developed an infection due to exposure to an unclean environment or from other patients.

Cruz was not alone. Though most common in older adults, even younger Puerto Ricans were affected by adverse outcomes in heart health after the hurricane, as heart attacks were one of the leading causes of death for those between ages 30 and 44 after the disaster. Deaths due to diseases of the heart, such as heart failure and heart attack, significantly increased in the nine months following Hurricane Maria, compared to predicted rates.

**Chronic Obstructive Pulmonary Disease**

**Disease Description**

*Medical Perspective.* Chronic obstructive pulmonary disease (COPD) is a progressive disease of the lungs that may manifest itself as emphysema, chronic bronchitis, or a combination of the two. The symptoms of COPD are shortness of breath and exercise intolerance, and these may seriously worsen with minor viral or bacterial respiratory infections. Symptom relief can usually be achieved with inhaled bronchodilator drugs, but these are expensive and do little to slow the progression of the
disease. Modest extension of life can be obtained in end-stage COPD with oxygen treatment.\textsuperscript{94}

\textit{Epidemiological Perspective.} In 2016, chronic respiratory diseases caused approximately 3.8 million deaths, representing 7\% of all global deaths.\textsuperscript{95} COPD is strongly associated with a history of cigarette smoking, but approximately 15\% of cases occur in never-smokers. In low-income nations, non-smoking women who use biomass fuel for cooking indoors are at substantial risk of developing COPD. Like cigarette smoking, COPD is strongly associated with poverty and lower education attainment.

COPD in the Disaster Context

Empirical data related to how patients with COPD fare in the disaster context are limited. One study at a medical center in Ishinomaki, Japan following the 2011 Great East Japan Earthquake analyzed health outcomes from one hundred COPD patients in the months after the disaster event. Following the earthquake, this health center experienced a significant increase in hospitalizations for patients with exacerbated COPD.\textsuperscript{96} Respiratory conditions were some of the most common reasons for hospitalization after Hurricane Maria, alongside diabetes, hypertension, and heart disease.\textsuperscript{97}

Puerto Ricans with COPD facing Hurricane Maria

Four days after Hurricane Maria hit Puerto Rico, 92-year-old Carlos Luis Irizarry Lugo died. An interview with his family revealed factors that contributed to his passing:

\textit{After the hurricane passed, they could no longer provide oxygen therapy to the patient because there was no electricity. They also needed to split the oxygen among several patients. They didn't provide the patient the proper care that was provided at the beginning, when we arrived.}\textsuperscript{98}
For those with respiratory illness that makes breathing more difficult, oxygen therapy may assist with getting the enough oxygen to the patient’s blood and body. Lugo’s story shows that oxygen therapy was beneficial – helping him stay alive towards the beginning of his hospitalization. Hurricane Maria severely disrupted his care due to the limitations it placed on the hospital’s resources coupled with the increases in the number of patients presenting to the hospital with respiratory distress. What was enough oxygen for one had to be shared with many – leading those at great risk of respiratory distress not to receive sufficient care. Like the effects of electricity loss on those dependent on CPAP machines, respirators, refrigerators, and other technologies, those receiving oxygen were similarly left with urgent, unmet needs after the hurricane.

**Poverty as a Predictor of Medical Vulnerability**

Poverty and chronic illness are positively associated. The poor are more likely to have at least one chronic medical condition. Unlike other risk factors such as genetic predisposition to disease, poverty is a major contributing factor to both the development of chronic illnesses and an individual’s ability to manage them. When an individual lacks basic resources such as food, clean water, and safe housing, self-management of his or her disease becomes much more difficult. Impoverished individuals are also less able to purchase goods and services that might help them adapt to adverse conditions. Social factors such as poverty affect a patient’s chronic disease, regardless of the presence of a natural disaster or its aftermath. But natural disasters typically worsen existing social limitations, and this can greatly exacerbate health outcomes in those who are already on the margin of being able to manage their existing disease effectively.
POPULATION TWO: THE ELDERLY

Overview

The elderly are at increased risk of many chronic conditions. In addition to the previously discussed conditions of hypertension, type 2 diabetes, heart failure, and COPD, the elderly are also at increased risk of developing arthritis, pneumonia, and stroke. Weakening of immune function with aging makes the elderly more susceptible to both infections and cancer. The elderly also show general frailty, often requiring assistance with activities of daily living. Strong caregiver support networks are important for the well-being of the elderly. The elderly are very heavy users of health care resources because of their susceptibility to multiple diseases.

The Elderly in Natural Disasters

All of these factors combine to make the elderly particularly vulnerable to health effects of natural disasters. They are more likely to have chronic illnesses and are generally less able than younger people to compensate for disruptions in communication, transportation, and access to food and water. They also have less biological resilience than the young and are more likely to die from an acute worsening of their diseases. Their dependence on caregivers for support with activities of daily living (ADLs) and independent activities of daily living (IADLs) also contribute to this group’s increased likelihood of experiencing poor health outcomes in the disaster context compared to non-disaster situations.

Elderly Puerto Ricans after Hurricane Maria

74 days after Hurricane Maria hit Puerto Rico, 76 year old Aurea Encarnacion Fernández died. Her story, according to a family member, is described below:
A day after the hurricane my mom fell and broke her hip. Surgery was not possible until nine days later. She caught a bacterial infection in her wound and died from sepsis. She was transferred to a hospital in Hato Rey, after trying to transfer her to other hospitals. During the surgery we were told that she could catch bacteria because the operating room could be not completely disinfected. And so, she caught bacteria. All her organs stopped working. Eventually she had a respiratory arrest.100

Of all of the populations described in this chapter, the elderly experience perhaps the greatest vulnerability in natural disasters. This is due to their increased susceptibility to multiple conditions, which may combine with the general frailty that results from aging to make both activities of daily living such as bathing, cooking, and dressing and independent activities of daily living such as driving, medication management, and housework more difficult. Fernández’s story exemplifies many aspects of the elderly population that lead to their increased vulnerability in the disaster context. She likely fell due to general frailty, was dependent on a child for transportation to the hospital, and was at high risk of developing an infection. These risks became realities, thus hastening her death. Although every demographic group in Puerto Rico experienced “excess mortality” after Hurricane Maria compared to predicted rates, the elderly – particularly males above the age of 65 – experienced increased risks of death through February 2018.101

POPULATION THREE: MENTAL ILLNESS

Overview

Mental illness encompasses a wide range of disturbances in thought, emotion, and cognition. Severe forms, including schizophrenia, major depression, and bipolar disorder, can cause psychotic episodes. These affect a relatively small fraction of the population, about 1% each. But there are also more common forms of mental illness. For instance, symptoms of depression and anxiety affect over 7% and 18% of adults in the United
States, respectively. The ethical duties to care for these populations that will be discussed in Chapter Four likely apply to all mental illness, but in this section, I focus on the more common forms – anxiety and depression.

**Anxiety and Depression**

**Disease Description**

*Medical Perspective.* Symptoms of generalized anxiety disorder (GAD) may be both physiological and emotional. Those with GAD feel extreme nervousness, worry, trouble relaxing, difficulty sitting still, or paranoia. These feelings often interfere with the ability of those with GAD to carry out everyday tasks. While GAD can be hereditary, that is not always the case. Treatments for GAD include counseling with a mental health specialist, cognitive behavioral therapy, psychotropic medications, and relaxation therapies. Symptoms of depression may likewise be both physiological and emotional. Clinically depressed individuals may feel persistent sadness, emptiness, longstanding guilt, disinterest in activities, and difficulty concentrating and finding energy to complete everyday tasks. Experiencing these feelings for at least two weeks indicates that an individual may be clinically depressed. Treatments for depression are similar to those with GAD, including counseling with mental health specialists and psychotropic medications. There are many types of depressive disorders, including major depression, psychotic depression, postpartum depression, seasonal affective disorder (SAD), and bipolar disorder. Factors that influence the onset of depression include genetics, brain chemistry, situational events or circumstances, and life stressors. Without treatment, depressed individuals may experience increased suicidal ideation, and may be more likely to attempt suicide.
Epidemiological Perspective. There is substantial variation among nations in the prevalence of diagnosed mental diseases. A 2017 report by the World Health Organization (WHO) revealed that the “treated prevalence” of mental disorders varies greatly among low income, middle income, and high income nations; the high-income nations had 319.7 out of 100,000 individuals receiving mental health services, while those in the low income group had only 18.8 per 100,000 receiving care. Nevertheless, it seems likely that these differences are due almost entirely to differences in capacity for diagnosis and treatment of mental illness, rather than to a real difference in prevalence.

The same WHO study reported that there are 1.6 mental health workers per 100,000 population in low income countries, but 71.7 mental health workers per 100,000 in high income countries. Even greater disparity is seen in the number of psychiatrists, with low income nations having 0.1 psychiatrists per 100,000 individuals and high income nations 12.7 psychiatrists per 100,000. These data show that there are strong associations between access to mental health care and economic status.

Anxiety and Depression in the Disaster Context

Data from the World Health Organization in 2005 on the prevalence of certain mental disorders in adults before and after emergencies (including disasters) indicate that the prevalence of “severe” mental disorders increases from 2-3% to 3-4% across countries in the year following an emergency. A similar change is seen in the prevalence of “mild or moderate” mental disorders when comparing the year before to the year following an emergency event, with increases from 10% to 15-20% across countries. Disasters may act in many ways to worsen mental illness: they generate stressors that can produce symptoms of anxiety and depression even in those without mental illness, they
can compromise access to needed medications and counselors, and they can worsen pre-existing disparities in receipt of mental health services by those in need.

Populations in low-income countries may be even more vulnerable to mental illness in the disaster context because of lower baseline rates of diagnosis and treatment, as well as more severe societal disruption due to the disaster event and its aftermath. Because mental illnesses are generally underdiagnosed and undertreated in poorer nations, it is likely that the effects of natural disasters on those with mental illnesses in low income countries are much greater than has been recognized.

**Puerto Ricans with Anxiety and Depression after Hurricane Maria**

30 days after Hurricane Maria hit Puerto Rico, 47-year-old Alejandro González Vázquez took his own life:

*As a result of the social crisis created by the effects of Hurricane Maria, Alejandro's mental illness deteriorated to the point of threatening his own life. He had gone to the United States two months before the hurricane. He decided to return to Puerto Rico because he knew nothing of his family and wanted to help after hurricane. After coming back to the island, he spent two weeks without taking his medications. The night he was supposed to return to the United States, he committed suicide. I think he was very affected by everything he saw here after the hurricane.*

Following Hurricane Maria, many doctors reported seeing an increase in suicides and suicide attempts, and the need for mental health care in affected communities is growing. Vázquez’s story is important in that it reveals that the devastation brought by natural disasters persists even after the event itself has ended. As he was in the United States during the hurricane, he did not directly experience the event. Yet his return to Puerto Rico after Maria led him to experience its aftermath – a situation of great stress, images of great suffering, and settings of great need. There are many potential contributors to his medication noncompliance. Perhaps he did not have a pharmacist in
Puerto Rico that had his needed antidepressants in stock. Perhaps the stress related to not knowing about his family distracted him and disrupted his medication management routine. Perhaps the medications were stolen, sold, or given to another person. Whatever the reason, the disaster’s aftermath worsened his existing mental illness due to disruption in his treatment schedule, leading him, like many others, to commit suicide.

POPULATION FOUR: CHILDREN

Overview

In this thesis, I use the term ‘children’ to refer to human beings who have not yet reached the legal age of majority. Children are a unique population in that they are considered vulnerable in nearly all contexts – possessing a form of universal vulnerability due to their general dependency on caregivers for physical and social support, and for decision-making in the clinical, research, and legal contexts. There is universal recognition of paternalistic duties to care for children through physical protection, education, discipline, and nurturing. In the research context, children are considered a “special population” due to their lack of capacity to consent to participation in research, as well as their vulnerability to coercion or undue influence. Regulations provide specific guidelines for research with children – requiring parental consent and child assent for participation in research studies and placing strict restrictions on when research involving greater than minimal risk and no potential for direct therapeutic benefit may be conducted. Similar legal guidelines exist in the context of clinical care, where parental consent is typically required for the treatment of children.

There is also a strong biological basis for the medical vulnerability of children. During the rapid growth phase of early life, children are highly susceptible to
environmental factors, including both toxins and infectious agents. As a result, the very young experience a mortality rate that is exceeded only by the elderly. About 6 million children die each year, mainly from preventable causes; the vast majority of these deaths occur before age 5. There has been a 50% decline in early life mortality over the past 30 years, but the rate in certain regions, such as Sub-Saharan Africa, remains approximately 10 times that in North America.\textsuperscript{114}

Leading causes of death in early childhood worldwide are pneumonia and diarrheal illnesses. Most deaths before age 5 are preventable with vaccination, adequate nutrition, safe drinking water, sanitation, appropriate antibiotic usage, and access to basic health care.\textsuperscript{115} Other infections such as malaria and HIV are also serious problems globally. Although the rates of childhood mortality are much lower in high-income countries than in the rest of the world, they nevertheless show the same qualitative patterns of vulnerability with regard to age and susceptibility to infections and environmental toxins as are seen in poorer nations.

\textbf{Children in the Disaster Context}

The factors that are associated with excess mortality in children are quite similar to those that are typical of natural disasters. Disasters are often associated with disruptions involving supplies of water and food, sanitation, and access to medical care. Like the elderly, children are much more likely than young adults to experience poor health outcomes under these conditions. Furthermore, certain rarely fatal conditions that are common among the children of affluent nations (such as asthma) are highly sensitive to environmental factors (such as molds and dusts) that can greatly increase after certain natural disasters. Hence, children in both low-income and high-income countries are a
highly vulnerable population that needs special attention in the context of planning for disaster relief.

**Children in Puerto Rico after Hurricane Maria**

Seven-year-old Yadriel Hernandez was living in Puerto Rico at the time of Hurricane Maria. He did not die in the disaster’s aftermath, but his health took a turn for the worse due to the event. Hernandez had been diagnosed with asthma years prior to the hurricane – a condition that was well-controlled with an inhaler. After Hurricane Maria, he experienced an increase in the frequency of his asthma attacks, facing at least two a month, and requiring higher doses of allergy medication to control his symptoms.\(^{116}\) Asthma rates increased after the hurricane across age groups due to airborne mold and pollen circulating after the disaster event.\(^{117}\) Fortunately, Hernandez’s condition was not fatal. Yet this was not the case for all younger Puerto Ricans, as death rates for those between age 15 and 19 increased by almost 10% in the final four months of 2017.\(^{118}\)

**SUMMARY**

In this thesis, I argue that, to respond appropriately to the health care needs of communities affected by natural disasters, providers and aid agencies should be prepared not only to treat the traumas and acute conditions directly caused by the disaster event but also to provide care for those with pre-existing medical and mental health conditions. Natural disasters that devastate health systems impair patients’ ability to obtain the resources – medications, routine care, and technologies – that they need to manage their chronic conditions. Large natural disasters that damage or destroy health systems in affected communities compromise health for many different groups, including those with chronic or mental illnesses, the elderly, and children. These groups are especially
vulnerable in the days and months following a natural disaster, and care for such groups ought to be planned for and provided by those responding with aid to the disaster community.

Planning for the care of these four populations in natural disasters begins with a recognition of their increased vulnerability in the disaster context. This recognition should be followed by an analysis of (1) why protection of the medically vulnerable is morally required in natural disasters, (2) who is responsible for responding to the needs presented by these populations, (3) who is responsible for providing care to these populations, (4) when is response most ethically appropriate, (5) what ethical considerations apply in the care of these populations in the disaster context, and (6) what are the extent and boundaries of an ethical duty to provide care for the medically vulnerable in natural disasters. This analysis will be provided in Chapter Four, where the frameworks of clinical ethics, public health ethics, and the ethics of medical volunteerism will be used to define the responsibilities of health care providers involved in disaster relief to care not only for immediate needs posed by the disaster event, but also for the long-term needs of populations whose medical vulnerability is increased in the disaster context.

In preparation for this analysis, the concept of medical vulnerability will be expanded in Chapter Three. While Chapter Two addressed the question of who is vulnerable, Chapter Three will consider what is vulnerable, expanding the concept of medical vulnerability to apply not only to populations, but also to health systems.
CHAPTER THREE: VULNERABLE HEALTH SYSTEMS

WHAT IS VULNERABLE?

The English word ‘vulnerable’ stems from the Latin noun ‘vulnus’ and verb ‘vulnerare.’ These translate to ‘wound’ and ‘to wound.’ The first known uses of the term ‘vulnerability’ in the English language were in the early 1600s, when the term was used to describe something’s proneness to being physically wounded. Modern English now uses the term to describe a more general susceptibility to being wounded, including harms that may be physical, emotional, economic, or environmental. The term may be used to describe persons, places, or things, as, for example, in the following statements: “Albert is vulnerable to the seasonal flu,” “Albuquerque is vulnerable to drought,” and “computer software systems are vulnerable to hackers.” ‘Vulnerable’ is thus a very general term in modern English. In bioethics, however, the term is typically used to describe individuals and groups of people that are at heightened risk of harm in research and clinical settings. A more general sense of the term may also be useful to the field of bioethics because the vulnerability of things – objects, technologies, and places – can have important implications regarding the well-being of persons. Hence, the concept of vulnerability, and specifically of medical vulnerability, may be extended beyond individuals and populations to describe other entities such as health care infrastructure and systems.

This chapter analyzes the vulnerability of something inanimate – health care systems – in the context of natural disasters. Some health systems are at heightened risk of harm from disaster events, and this increased risk can lead to excess harm to populations that are reliant on these health systems for routine care.
In this thesis, I use the term ‘health care system’ to refer to the available facilities, personnel, and resources that provide for the health care needs of a community. Such systems may be vulnerable because their various components are at risk of harm. In disasters, for instance, hospitals and other facilities may lose power, flood, or sustain structural damage; doctors may leave the affected community or die; and resources such as medication stockpiles may be depleted if suppliers cannot reach affected communities. Insight into the vulnerability of health systems to natural disasters can be gained through comparisons of health care systems that faced similar disaster events, but experienced significantly different outcomes in human mortality. Such analyses will be presented in this chapter. The first comparison will be between 2005 Hurricane Katrina in New Orleans and 2017 Hurricane Maria in Puerto Rico. The second comparison will be between the 2010 earthquakes in Haiti and Chile.

**COMPARISON ONE: HURRICANES IN NEW ORLEANS AND PUERTO RICO**

**Hurricanes**

According the U.S. National Oceanic and Atmospheric Administration, hurricanes, also known as tropical cyclones, are storms that form over tropical or subtropical bodies of water and that have sustained winds of at least 74 miles per hour.\(^{121}\) The Saffir-Simpson Hurricane Wind Scale is used to categorize hurricanes on a scale of 1 to 5, based on the maximum speed of the storm’s sustained winds. High category hurricanes, and the high sustained winds they bring, can cause severe damage to structures upon landfall.\(^{122}\) Yet even hurricanes of similar size can have vastly different effects on specific communities. This section compares the effects of two similar hurricanes – Hurricane Katrina in 2005, and Hurricane Maria in 2017 – that had
significantly different outcomes on the communities of New Orleans, Louisiana, and Puerto Rico. Table 3-1 below gives an overview of disaster size and death toll for the two events:

<table>
<thead>
<tr>
<th></th>
<th>New Orleans 2005</th>
<th>Puerto Rico 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disaster Event:</td>
<td>Category 3</td>
<td>Category 4</td>
</tr>
<tr>
<td>Hurricane Deaths</td>
<td>123</td>
<td>1833</td>
</tr>
</tbody>
</table>

Table 3-1. Hurricanes that affected representative health systems

NEW ORLEANS, Louisiana, USA – 2005

Health System and Population Characteristics

The state of Louisiana is divided into 64 districts called parishes. The Orleans Parish is coterminous with the city of New Orleans. Before Hurricane Katrina, the health system in the Orleans Parish consisted of nine acute care hospitals, serving approximately 437,186 residents. The ratio of available hospital beds to residents was 4:1000, well above the national average at the time of 2.8:1000. Availability of hospital care for the overall population was thus not a major issue for New Orleans. Yet availability of health care services for the city’s poor was somewhat more problematic. Although the average hospital bed occupancy rate was approximately 56% overall, it was higher for safety net hospitals serving the city’s poor. The health system in New Orleans had more available beds per person compared to other systems in the United States, but access to the system was limited for some residents. Those with health insurance could afford care at any of the New Orleans community hospitals, but those without insurance were largely limited to receiving care from the public safety net hospitals. The major provider of safety net hospital services to the New Orleans poor before Hurricane Katrina was Charity Hospital, part of a charity care system run by Louisiana State University. Thus, access to hospital care in New Orleans depended more on the characteristics of the patient.
population – i.e., whether individuals and families could afford hospital care – and less on the number of local facilities.

What characteristics of the New Orleans patient population affected their interactions with the city’s health system? In 2005, approximately 1 in 5 residents of New Orleans did not have health insurance, constituting one of the highest uninsurance rates in the United States at the time.\(^{129}\) Twenty-three percent of residents lived in poverty.\(^{130}\) Employer-sponsored health insurance rates were similarly low, because the city’s many small business were not mandated to provide health insurance under the Affordable Care Act. Approximately 95\% of firms in Louisiana had fewer than 50 workers, with New Orleans having a large number of small businesses.\(^{131}\) In 2004, only 29 percent of residents of Orleans Parish were covered by Medicaid.\(^{132}\) Thus, many residents – especially the poor and African Americans – relied on the Charity Hospital system run by Louisiana State University.\(^{133}\) Before Hurricane Katrina hit New Orleans, the city faced high rates of heart disease, diabetes, and AIDS.\(^{134}\)

*Effect of Hurricane Katrina on New Orleans Health Care System*

Word of the coming storm led to a mass exodus from affected areas, with approximately 1.5 million people evacuating before the hurricane hit Louisiana.\(^{135}\) While evacuees had many struggles due to crowded shelters and travel delays, the nearly 200,000 people who remained in affected areas faced life-threatening circumstances.\(^{136}\) Two days after Hurricane Katrina made landfall in New Orleans, at least 80\% of the city was affected by flooding.\(^{137}\) This had significant implications for individuals and for the city’s infrastructure. On the individual level, close to 300 deaths, or 33\% of deaths attributed to the storm in New Orleans, were due to drowning, with older individuals
having much higher risk of drowning in flooded facilities or areas. On the infrastructure level, the storm destroyed 200,000 homes and 18,700 business sites, and it damaged 850 schools. On the hospital level, most of the nine acute care hospitals in the New Orleans area were forced to close, including Charity Hospital. Twelve months after the hurricane, only three of the nine hospitals were open and fully functioning. In Orleans Parish, hospital bed capacity plummeted from 2269 before the hurricane to 479 by summer 2006. Drastic reductions in the number of physicians in New Orleans were also seen, with approximately 4500 dislocated by the storm, and only 25% of the pre-hurricane physician workforce returning to the area seven months after the hurricane. Supporting the medical vulnerability of patients with chronic disease in the disaster context, one study found that 47% of all deaths in New Orleans were attributed to acute and chronic conditions that potentially could have been prevented if patients had ready access to care after the storm.

**PUERTO RICO, USA – 2017**

*Health System and Population Characteristics*

In September 2017, the territory of Puerto Rico had 93 community health centers (CHCs) that provided primary care services to residents of both urban and rural areas. What characteristics of the Puerto Rican patient population affected their interactions with the territory’s health system? The interplay of poverty and little funding from the United States government produced stark differences between the health of Puerto Ricans and residents of US states, as revealed in the following comparisons:
Table 3-2. Comparison of health insurance rates and select health-related characteristics in Puerto Rico and the 50 US States

As shown by the statistics in Table 3-2, the overall health of the Puerto Rican population is poorer than that of the rest of the United States, based on self-reported information from citizens of the territory and country, respectively. Insurance rates are similarly low compared to US states, due in part to Puerto Rico’s “statutory cap” on Medicaid support – meaning that the territory does not receive additional Medicaid funds after explicitly appropriated federal funds are depleted. There is also a high incidence of many chronic diseases in Puerto Rico, especially diabetes.

Effect of Hurricane Maria on Puerto Rican Health Care System

Following Hurricane Maria, Puerto Rico faced what is arguably the “largest blackout in American history,” with power lacking in some areas until summer 2018, approximately nine months after the storm. This widespread loss of power had significant effects on hospitals – most of which lacked electricity. Only three major hospitals were functional three days after the hurricane. This was a particular problem for individuals with certain highly prevalent chronic diseases, and those patient populations were severely affected by the loss of electricity. For instance, nearly all 47 dialysis centers in the territory lost power, with many reliant on backup generators for months, and some ultimately closing due to failed generators. Every age and social subgroup of Puerto Rico’s population of 3,327,917 was affected by the hurricane, though some groups experienced greater rates of excess mortality in the months following the hurricane,
particularly those of low socioeconomic status (with a 45% greater risk of death) and males over the age of 65. Hurricane Maria also affected the availability of health care personnel to meet the level of need in the country, with only 2% of the need for physicians met in November 2017, the month after the hurricane.

**Comparative Vulnerability to Hurricanes of the New Orleans and Puerto Rico Health Systems**

*Days versus Months*

Hurricanes Katrina and Maria had death tolls of 1833 and 2975 in New Orleans and Puerto Rico, respectively. Although both storms had severe effects on the communities they encountered – with devastating flooding in New Orleans and long-term power outages in Puerto Rico – there was a notable difference in the time it took for each affected community to recover from the storm. In New Orleans, the most severe effects of the storm on health subsided after a few *days*, with the majority of casualties and infrastructure devastation taking place during the week of the hurricane. In contrast, Puerto Rico’s recovery took *months*, and higher than expected mortality was experienced for certain groups at least six months after the storm. While each health system has strengths and weaknesses, the types of vulnerability of the health systems and populations in New Orleans and Puerto Rico appear to be quite different.

*Body Counts and Doubts*

Conversations about Hurricanes Katrina and Maria often focus on numbers. For Katrina, these numbers captured a 50% reduction in the New Orleans population after the storm. As of 2017, the population had still not returned to previous levels. Other stories reported the number of evacuees seeking refuge at overcrowded shelters and the amount of federal aid given to support immediate relief from the disaster and recovery after the
storm. In Puerto Rico, much attention was given to the number of deaths, and in the months after the storm debate ensued about how to count deaths after a disaster and what kinds of deaths should be attributed to the hurricane. Proposed death tolls for Puerto Rico ranged from 16 to 8500.\textsuperscript{149}

A few weeks after Hurricane Maria hit Puerto Rico, U.S. President Donald Trump visited the territory and addressed its people, saying, “Sixteen versus in the thousands… you can be very proud of all of your people, all of our people working together. Sixteen versus literally thousands of people.”\textsuperscript{150} Referencing the then-reported death toll of “sixteen,”\textsuperscript{151} President Trump compared this count to the nearly 2000 hurricane-related deaths in New Orleans 12 years prior. President Trump may have spoken far too soon, as later studies from Harvard and George Washington University placed the death toll in the months following Maria in the thousands. This was substantially more than were killed in Katrina-ravaged New Orleans, which until 2017 was the most deadly hurricane in the United States since the 1900 Great Galveston Storm.\textsuperscript{152} The question of how many deaths may be attributed to a specific disaster event is complex; an event like a hurricane may cause deaths both immediately and later, as a consequence of the event’s effect on community infrastructure, including the functionality of health systems. How many deaths did these storms cause? Can deaths by conditions such as unmanaged heart failure and diabetes be attributed to natural disasters? Analyzing these questions through comparison of hurricanes in New Orleans and Puerto Rico suggests some answers to these questions, as well as posing new questions regarding the relationship between natural disasters and human mortality. The analysis below provides a quantitative comparison of mortality in both contexts.
Functional Vulnerability

Although Hurricanes Katrina and Maria were of similar magnitude and caused thousands of deaths, the patterns of death in New Orleans and Puerto Rico were drastically different. In Puerto Rico, relatively few of the deaths were directly related to the storm itself. Rather, the vast majority occurred months later, and these appear to have been mainly due to medical causes. This conclusion is supported by an analysis of the Milken School of Public Health at George Washington University that estimated “excess mortality” in Puerto Rico was 2975 between September 2017 and February 2018, a 6-month period after the hurricane.¹⁵³ “Excess mortality” represents the difference between the number of deaths that occur in a particular community after a disaster event (observed mortality) and the number of deaths that would have been expected in the community, based on previous trends and population characteristics, in the absence of a disaster (predicted mortality).¹⁵⁴

Unlike Maria, the vast majority of deaths due to Hurricane Katrina occurred in the month of the storm, August 2005 (see Figure 3-1 below). Although mortality rates remained somewhat elevated for 6-8 months, most of the excess deaths occurred during or immediately after the hurricane. Furthermore, an analysis of the causes of mortality in the area of New Orleans during 2005 shows that the increased mortality that year was largely due “external causes” (see Figure 3-2 below). There appear to have been only minor increases in deaths due to respiratory conditions, infections, neurological diseases, and mental health conditions, with either decreases or no apparent increase in mortality due to cardiovascular disease, neoplasms, or other medical conditions. Even though the immediate impact of Katrina was much greater than that of Maria, the sustained effects
Mortality in Six Louisiana Parishes Surrounding New Orleans

Data from CDC Wonder

**Figure 3-1.** Mortality by year from 2003 to 2007 in six Louisiana parishes surrounding New Orleans
Why was the Puerto Rican health system so vulnerable? An obvious contributor was interrupted access to medical care.\textsuperscript{155} Other likely reasons include the generally poor health of many Puerto Ricans, coupled with weak medical infrastructure and poorly funded programs.\textsuperscript{156} Although Puerto Ricans are citizens of the United States, they do not have the same access to individual health insurance subsidies that the Affordable Care Act provides to states, and the territory receives less funding for Medicaid than its state counterparts.\textsuperscript{157}

While Hurricane Katrina certainly devastated the health systems in New Orleans in 2005, the city had much greater access to federal aid to kick-start the recovery process in the days following the storm – a process that Puerto Rico continued to struggle with nearly a year following the hurricane. In addition, the medical insurance infrastructure
was relatively stable, electricity was quickly restored, and some hospitals in the New Orleans area remained operational through the storm. Compounding Puerto Rico’s issues related to health care financing were the hurricane’s effects on that health care system’s ability to provide care. The health system following Maria did not recuperate quickly following the storm – taking nearly a year in some areas for electrical power to be restored. During this time, many people were not able to get to the doctor, clinics were not able to open, and patients with kidney failure could not get dialysis because facilities were closed. While the health care infrastructure was generally intact after the storm, it did not function properly in the months after Maria.

**COMPARISON TWO: EARTHQUAKES IN HAITI AND CHILE**

**Earthquakes**

Earthquakes are the movement of certain areas of the earth caused by the sudden release of energy that builds up between two tectonic plates that press against each other but have not moved, due to the force of friction. When the force of the plates’ movement becomes greater than the friction holding them together, spontaneous sliding occurs, with one plate passing over another.\(^{158}\) Scientifically, the strength of an earthquake is measured with a seismograph, which quantifies the energy of the shock wave. The effects of earthquakes on populations and communities depend not only on the magnitude and duration of the quake, but also on certain characteristics of the populations and communities. This section compares the outcomes of two similar earthquakes – the 2010 earthquakes in Haiti and Chile – that had significantly different outcomes in the affected communities. Table 3-3 below gives an overview of disaster size and death toll for the two events:
Table 3-3. Earthquakes that affected representative health systems

<table>
<thead>
<tr>
<th>Haiti 2010</th>
<th>Chile 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disaster Event: Magnitude 7.0 Earthquake</td>
<td>Disaster Event: Magnitude 8.8 Earthquake</td>
</tr>
<tr>
<td>Deaths: 100,000 – 316,000</td>
<td>Deaths: 525</td>
</tr>
</tbody>
</table>

HAITI in 2010

**Health System and Population Characteristics**

The health care system in Haiti is largely a private, for-profit enterprise, with the highest standard of care provided in cities to those who can pay. In 2010, 47% of the Haitian population lacked access to even basic health care. Women were most severely affected by this lack of access to health care, with over 50% of women not having access to basic services.\(^{159}\) Only 17% of the population had access to appropriate sanitation, and only 47% received the measles vaccine. The population of 2.3 million had high rates of certain chronic infectious diseases, such as a 9% prevalence of HIV, and low literacy rates, with only 50% of the population having the ability to read and write.\(^{160}\) As might be expected given Haiti’s high poverty rate, there was little consideration of seismic risk in the design and construction of buildings, including hospitals.\(^{161}\)

**Effect of 2010 Earthquake on Haitian Health Care System**

According to a Post-Disaster Needs Assessment (PDNA) sponsored by the Haitian government, more than 50 hospitals and health centers physically collapsed or were so structurally damaged that they were unusable after the 2010 earthquake.\(^ {162}\) In the most affected area, 30 out of 47 hospitals (64%) were destroyed or damaged.\(^ {163}\) The majority of patients presenting to the remaining functional hospitals faced injuries directly related to the earthquake – 48% presenting with fractures and 16% needing amputations - yet most of the health care facilities destroyed or severely dysfunctional were those that the provided secondary and tertiary care services needed for these
patients. The few hospitals that remained operational faced “a very daunting task” as they received a massive influx of needy patients, noted John Walton, a board chairperson for the Albert Schweitzer hospital 40 miles outside of the capital.

CHILE in 2010

Health System and Population Characteristics

Citizens of Chile have the option of opting for public health coverage through the National Health Insurance Fund, or private insurance from any number of available programs. In 2008, 86% of the population received health insurance coverage from either public or private insurers. Notable differences in the quality and type of health care services provided by public versus private insurers, such as the greater coverage of primary care under public programs, and significant differences in the services covered by the public and private insurance programs led Chile in late 2004 to initiate a period of health care reform. These reforms included passage of the Regime of Explicit Guarantees in Health law, which guarantees universal health care coverage for all Chilean citizens under the AUGE Plan. By 2010, coverage for 66 health conditions was provided for all Chileans.

In 2001, nine years before the 2010 earthquake, Chile had 187 hospitals, 146 rural clinics, and 1102 “rural health posts” that provided care to populations in remote areas. Important characteristics of the Chilean population include a literacy rate of 95%, life expectancies of 80 years for women and 73 for men, and an infant mortality rate of 8.6 per 1000 live births. The country’s emphasis on preventive care, attention to improving living conditions for its population, and good overall level of socioeconomic
development all contributed to the good health of the population relative to other countries.\textsuperscript{171}

\textbf{Effect of 2010 Earthquake on Chilean Health Care System}

On February 27, 2010, one of the strongest earthquakes ever recorded – a magnitude 8.8 event – was triggered off the coast of Chile.\textsuperscript{172} The death toll of 525 persons was extremely low for an earthquake of this magnitude. The recovery effort was likewise very quick for what would be predicted for a disaster of this size. The major factor contributing to the low death toll was the structural integrity of Chilean buildings, a result of mandated building codes and laws placing responsibility on building owners for all deaths that occur in their facilities for 10 years following the building’s construction. Other important factors included well-coordinated disaster response efforts among various actors, including emergency management, fire services, and law enforcement. Arguably, the root cause of this success was that the country was knowledgeable about and prepared for earthquakes as a result of a 1960 Chilean earthquake that had caused over 2000 deaths.\textsuperscript{173} The 2010 earthquake in Chile affected at least 100 hospitals in the country, across six provinces.\textsuperscript{174} Out of these 100 hospitals, however, 86 were not significantly affected by the earthquake.

\textbf{Comparative Vulnerability to Earthquakes of Haitian and Chilean Health Systems}

\textit{Months versus Years}

The 2010 earthquakes in Haiti and Chile had magnitudes of 7.0 and 8.8, and death tolls of 100,000-316,000 and 525, respectively. The lessons to be learned from why an earthquake over 60 times more powerful in Chile had less than 1\% of the mortality of the earthquake in Haiti are numerous, and this comparison shows the wide variation in the effects of natural disasters on communities, as well as the need for very context-specific
response efforts. Consistent with their significant variation in earthquake mortality, the
two countries had huge differences in the time it would take them to recover from the
disaster event. While it took Chile *months* to recover from a magnitude 8.8 earthquake, it
took Haiti *years* to recover from a magnitude 7.0 event. This difference in outcomes
between the 2010 quakes in Haiti and Chile is arguably influenced by numerous factors.
Differences in the poverty rates between the two countries are perhaps the most apparent
factor, but it was not the poverty of the Haitian population that led directly to the greater
mortality, but rather the effects that poverty had on the country’s physical infrastructure.
It was not low income that directly devastated Haiti, but rather the implications that
widespread low income had on the quality of building construction. The root cause of the
differential mortality was poverty, but the direct cause was Haiti’s poorly built and
maintained buildings, and conversely Chile’s well-reinforced buildings and strict
construction codes. The differences are in the specific features of these two nations.

*It’s in the (Concrete) Details*  
“Details,” by definition, are not always obvious when one looks at an object.
Museum visitors may observe a captivating painting from 10 feet away, but such distance
makes it difficult to appreciate the artist’s intricate brush strokes. Details are always
present, though not always noticed. Yet while the attention to detail may be a *choice* in
art appreciation and analysis, they appear to be *imperative* for those analyzing the root
and secondary causes of vulnerability in the disaster context. Each community has
general characteristics that are widely available – the size of the population, the number
of houses, the incidence rates of certain diseases, the number of citizens registered to
vote. Yet there are also very particular, context-specific characteristics that influence the
effect of the disaster on that community. These “details” may be more difficult to find or identify, but they can have significant influences on how a community’s capacity to cope with a disaster event. Attention to both the broad community characteristics as well as the context-specific “details” is essential for understanding how natural disasters affect a specific community. For the comparison of the 2010 earthquakes in Haiti and Chile, the “detail” that was arguably most relevant to the different effects of the disaster events was the presence and implementation of building codes in the two countries. Specifically, the quality of the concrete used in the construction of buildings was a major contributor to the different mortality and morbidity rates in the two contexts.

Concrete is the most common building material in the world, yet the material itself is simply a mixture of cement and aggregates that vary in quantity, chemical composition, method of preparation, and level of reinforcement with other materials such as metal rebar. A look at the “concrete” details of Chile and Haiti in 2010 reveals some significant differences. Chile is significantly richer than Haiti and, following a large earthquake in 1960, instituted building design codes to account for seismic activity. Buildings in Haiti, in contrast, were largely built using poorer quality cements and were constructed with the purpose of having the structures be heavy and rigid enough to withstand hurricanes and high magnitude storms, but not earthquakes. In 2010, Haiti did not enforce building codes as consistently as did Chile. Following the earthquake, Haitian President René Préval pointedly stated, “Port-au-Prince was not well built.”

**Structural Vulnerability**

What does concrete have to do with health systems? Many homes, hospitals, and other buildings in Haiti were built using poorly reinforced, low quality, low-cement
content, weakly-aggregated concrete. In contrast, structural damage in Chile was minimal, and only four of 100 hospitals (4%) in the country were completely destroyed by the quake. In contrast, a large number of Haitian hospitals were severely damaged. Unlike the situation in Puerto Rico, where the health system was physically intact but dysfunctional, the primary problem in Haiti was physical destruction of its health care facilities. Thus, Haiti represents a form of vulnerability I call *structural* vulnerability. I propose the following equation to provide a rough quantitative measurement of the functional capacity of health care systems following natural disasters, which serves as a retrospective measure of the health care system’s pre-disaster structural vulnerability, where HCF stands for “health care facilities” in affected areas:

\[
Post\ -\ Disaster\ Functional\ Capacity
\]

\[
= \frac{(Total\ pre\ -\ disaster\ HCF) - (destroyed\ HCF) - \left(\frac{partially\ damaged\ HCF}{2}\right)}{(Total\ pre\ -\ disaster\ HCF)}
\]

**Equation 3-1.** Quantitative estimate of post-disaster functional capacity of health care systems after natural disasters

*Explanation of Equation 3-1.* This formula provides a rough quantitative estimate of the functional capacity of a health care system in a community that has faced a recent natural disaster. The product represents the ratio of health care facilities functionally capable of providing care to patients after a disaster event. Values can range from 1 to 0, where 1 represents a fully functional health care system, where no health care facilities have been destroyed or partially damaged. A product of zero represents a completely destroyed health care system (i.e. “destroyed HCF” = “total HCF”). It is important to note that this formula provides only a rough measure functional capacity. The category of “partially damaged HCF” is intentionally broad, representing a range of hospitals that
have faced a level of damage between complete destruction and full functionality. Hospitals in this category may therefore be damaged but largely operational (perhaps 80% operational) or severely affected and minimally operational (perhaps 20% operational).

*Application of Equation 3-1 to Haitian Health Care System after 2010 Earthquake.* The data in the equation below are from an analysis by the Pan American Health Organization, which reported that out of 49 hospitals in the most earthquake-affected area, 30 were damaged or destroyed by the event. Of these, eight hospitals were completely destroyed, and the remaining 22 were damaged and experienced limitations in functional capacity.\(^\text{181}\)

\[
\text{Post – Disaster Functional Capacity in Haiti} = \frac{(49) - (8) - \left(\frac{22}{2}\right)}{(49)} = 0.61
\]

*Application of Equation 3-1 to Chilean Health Care System after 2010 Earthquake.* The data in the equation below are from the Chilean Ministry of Health, which found that out of 100 hospitals in affected areas in Chile, 4 were “uninhabitable” after the earthquake, 12 lost over 75% of functional capacity, 8 lost less than 75% of functional capacity, and the remainder maintained the pre-disaster level of functionality. In the equation below, the number of hospitals operating at greater than and less than 75% functional capacity are combined in the “partially damaged” category.\(^\text{182}\)

\[
\text{Post – Disaster Functional Capacity in Chile} = \frac{(100) - (4) - \left(\frac{20}{2}\right)}{(100)} = 0.86
\]
Comparing the ratios of destroyed and partially destroyed hospitals to the hospital functionality prior to the 2010 earthquakes in Haiti and Chile, we see that Haiti’s hospital system following the earthquake was roughly 61% operational, while the system in Chile was approximately 86% operational using the equation given above. Thus, the health system in Haiti was much more severely affected than that of Chile, due primarily to its structural vulnerability.

IMPLICATIONS FOR DISASTER RELIEF: EXAMPLE OF THE USNS COMFORT

The ship. The United States Naval Ship (USNS) Comfort, commissioned by the US Navy as a hospital ship in 1987, serves as a floating medical facility for the US military and for the victims of natural disasters. Within the hulls of the ship are 12 operating rooms and 1000 hospital beds, including 80 intensive care beds. The ship was designed to be stable enough when harbored to allow surgeries to be performed safely onboard, in addition to other invasive medical procedures. In its over 30-year career as a floating hospital, the USNS Comfort has responded to some of the most devastating natural disasters in the Western Hemisphere. It responded to both the 2010 earthquake in Haiti and the 2017 hurricane in Puerto Rico.

Response to Haiti. Seventy-seven hours after the 2010 earthquake in Haiti, the USNS Comfort left its port in Baltimore, Maryland, and traveled to earthquake-devastated Haiti. In Haiti, the ship reached full operational capacity – a first in the ship’s then 23 years as a hospital ship. During the ship’s month-long anchorage in Haiti, medical personnel onboard the ship treated 871 patients and performed 843 surgeries. Within the first ten days of the relief mission, the ship cared for over 540 patients who
had sustained critical injuries.\textsuperscript{187} The trip was arguably a success – providing needed and timely care to a multitude of critically ill Haitian patients following the 2010 earthquake.

\textit{Response to Puerto Rico.} Nine days after Hurricane Maria devastated Puerto Rico, the USNS Comfort left its port in Norfolk, Virginia, and traveled to the battered territory to begin what would be a nearly two-month trip.\textsuperscript{188} While the ship’s medical staff treated 1899 patients and performed 191 surgeries, the mission was criticized because the ship’s facilities were under-utilized during the crucial time period in the weeks following the hurricane.\textsuperscript{189} This was largely due to confusion regarding how to transfer patients to the Comfort and about what level of care the Comfort would provide – confusion that resulted in the utilization of only 13\% of beds on board the ship in its first two weeks of anchorage off Puerto Rico.\textsuperscript{190,191} The ship had the capacity to provide care for 200 patients each day, but the ship averaged only 6 patients per day.\textsuperscript{192,193} The majority of those cared for on the ship were outpatients – 1625 out of the 1899 total cases.\textsuperscript{194} Though there was great need for health care services in Puerto Rico that the ship could provide, the official protocol from the Federal Emergency Management Agency (FEMA) was for patients to first seek care at the medical facility closest to them.\textsuperscript{195} If the closest facility could not provide care, doctors at those facilities were instructed to contact the medical coordinating center in the territory’s capital San Juan, which would then decide where to transfer the patients for care. At this point in the protocol, one option was to transfer patients to the USNS Comfort, but that rarely happened except for patients in critical condition in need of specialized care.\textsuperscript{196}

\textit{Caring for the Medically Vulnerable.} The health systems in both Haiti and Puerto Rico were especially vulnerable to natural disasters, but in different ways. In Haiti, the
health system was *structurally vulnerable*, in that many of the hospital facilities were unusable, leaving patients without access to care. For Puerto Rico, the health care system was *functionally vulnerable*, in that many hospitals remained physically intact after the Hurricane Maria, but due to the lack of electricity and supply shortages were unable to provide proper care for those presenting to their facilities. Medical ships such as the USNS Comfort have great potential to provide needed medical care to the suffering in natural disasters. Yet these ships are simply floating facilities with operating rooms, clinics, and health care providers – they are separate resources that are not intended to help address the functional needs of existing health care facilities in the communities they visit. The USNS Comfort thus appears very effective at responding to situations of *structural* vulnerability of health systems, but less useful in situations of *functional* vulnerability. In Puerto Rico, the ship arrived offshore, but received few patients at a time when needs were high. This is because the problem – the vulnerability – in Puerto Rico was functional. The health care facilities in the territory were not physically devastated by the hurricane, but were unable to treat patients effectively within their facilities due to other effects of the hurricane, which included disruption of the communications and transportation systems needed to make good use of both the island’s facilities and the ship. Thus, it is important that relief agencies think in terms of what kind of vulnerability the communities they assist actually face. Analyses of vulnerability should guide what form the disaster response efforts take for specific disasters. For Haiti, a medical ship was useful. For Puerto Rico, there may have been a better alternative.
SUMMARY

The examples discussed in this chapter illustrate two different problems with health systems: their baseline deficiencies and their vulnerability to disasters. Both of these problems contribute to poor health outcomes in the disaster context, and they are closely related, since weak health systems are less able to respond to the challenges associated with disasters and, hence, tend to be vulnerable. These problems with health systems are distinguishable, however, and they require different approaches. For example, crowding of emergency departments under normal circumstances might require construction of additional hospitals, creation of new medical schools, and greater investment by the nation in health care. On the other hand, crowding of emergency departments following a disaster might best be dealt with by pitching tents in the parking lot, bringing in temporary workers, and evacuating some patients by helicopter to hospitals in less affected areas. Although remediation of deficiencies of health systems and dealing with their vulnerabilities are both important public health goals, the focus of this thesis is specifically on vulnerabilities. I consider in Chapters 4 and 5 certain steps for disaster planning that should be taken by relief organizations to address vulnerabilities of health care systems. While the ideal way of dealing with vulnerabilities might be to eliminate them beforehand, that is often not possible because of limitations in resources, knowledge, and political will. Hence, those recommendations will deal, not with the elimination of vulnerabilities, but with how a well-informed understanding of existing local health system vulnerabilities is important in planning, preparing for, and carrying out disaster relief efforts.
CHAPTER FOUR: Ethics in Disaster Relief

OVERVIEW

Natural disasters are prime examples of non-ideal and uncontrolled situations. Needs are heightened and resources are limited, at least in the short term. Disaster events and their outcomes are often unpredictable. The balance between health-related needs and the resources needed to meet them may be especially disrupted, as the disaster setting causes both the onset of new health conditions (trauma, infectious disease, and heat exhaustion, among others), and the exacerbation of chronic conditions (cardiovascular disease, diabetes, chronic respiratory disease, anxiety, and depression, among others) – all of which require care from medical professionals. The resources required to address these health-related needs may be limited by disruption of communications, transportation systems, and manufacturing capacity, by damage to medical facilities, and by limitations on the storage and shelf life of certain drugs. The demand for medical care after natural disasters often exceeds the availability of physicians, nurses, pharmacists, hospital beds, and supplies such as medications, oxygen, and wheelchairs. Beyond these supply and demand issues are the complex challenges of particular disasters – power outages in Puerto Rico and generator failures due to flooding in New Orleans after hurricanes, for instance. Such challenges linked to specific disasters and faced by specific communities add layers of complexity to the already difficult situations of high demand and limited health care resource and personnel supply. Common consequences of natural disasters include:
1. Significant immediate harm to persons and property
2. Limited immediate-response resources
3. Increased risk of ongoing harm
4. Limited longer-term capabilities of health systems

These common consequences of disasters raise many questions about moral responsibility, duty, harm reduction, and resource allocation. What are the health-related needs in the disaster context, and who is responsible for responding to those specific needs? Is there a duty to care for the medically vulnerable in disasters? Who bears this responsibility, and for how long? What ethical framework and considerations should guide those responsible for disaster response? This chapter begins with a brief overview of the many actors who typically respond to disasters and the traditional roles they assume. After identifying the various actors, I address the question of which actors are responsible for responding to which needs. I then provide an overview of three ethical frameworks (clinical ethics, public health ethics, and the ethics of medical volunteerism) and discuss their relevance to natural disasters and the limitations of each. Finally, I adapt features of these ethical frameworks to develop and propose a composite ethical framework specifically for health care in disaster relief.

**RESPONDERS**

Individuals, local and national governments, and private organizations frequently respond to natural disasters. The specific types of responders include public, governmental organizations and private, nongovernmental organizations, including charities and nonprofits. Some examples of public and private disaster response organizations are summarized in the table below:
PUBLIC SECTOR

International Organizations
United Nations - Office for the Coordination of Humanitarian Affairs (OCHA): “Responsible for bringing together humanitarian actors to ensure a coherent response to emergencies.”\(^{198}\)

National Organizations
Federal Emergency Management Agency (FEMA): “To lead America to prepare for, prevent, respond to and recover from disasters.”\(^{199}\)

Regional Organizations
The Regional Disaster Fund of the San Diego Foundation: “Makes grants to nonprofit organizations that demonstrate impact in disaster response, recovery, rebuilding and preparedness [for the San Diego region].”\(^{200}\)

Local Organizations
Community Emergency Response Team (CERT) in Winston-Salem, North Carolina: “Educates people [in the Winston-Salem area] about disaster preparedness for hazards that may impact their area and trains them in basic disaster response skills.”\(^{201}\)

PRIVATE SECTOR

Médecins Sans Frontières: “[Provides] medical assistance to people affected by conflict, epidemics, disasters, or exclusion from healthcare.”\(^{202}\)

Salvation Army: “[Their] disaster assistance includes providing food, water, and shelter to victims, lending a hand with cleanup, and putting people in touch with their loved ones.”\(^{203}\)

International Red Cross and Red Crescent Movement: “A global humanitarian network of 80 million people that helps those facing disaster, conflict and health and social problems.”\(^{204}\)

Table 4-1. Types of organizations involved in response to natural disasters

The organizations listed in Table 4-1 above are just a sample of the many organizations that respond to natural disasters. In fact, the availability of personnel in disaster response is rarely a major issue. Instead, the major issues deal with how to deploy responders, how best to coordinate groups, and how to use the influx of responders to provide appropriate care for persons in affected communities. Some organizations are small, others large; some are staffed primarily by volunteers, others by paid employees; some have ties to governments or governmental alliances, others are
purely nongovernmental; some rely heavily on donations from individuals for funding, while others receive financial support from governments or other sponsors. Organizations differ in their response times to specific disasters, the type and quantity of their available resources, and the duration of support that they may provide. Some organizations respond to specific needs, such as Habitat for Humanity’s focus on housing and reconstruction. Other organizations provide for a more holistic set of needs. This great variety in the types of disaster relief responders makes the development of one set of ethical guidelines problematic. The ethical considerations for an organization solely providing dental care may be quite different from those of an organization helping with water purification or with the provision of psychiatric care. The general goal of these organizations, however, is the same: to help individuals and communities affected by natural disasters. This “help” comes in many forms, and most of these organizations respond even without a moral imperative to do so.

RESPONSIBILITY

The types of organizations described in the previous section respond to natural disasters with the intention of providing aid to affected communities. It is generally accepted that relief personnel and resources should be sent to disaster-devastated communities, but there is no clear rule on who should respond. Is there a moral responsibility to respond to natural disasters, and who bears it? In the next two sections, I evaluate the moral responsibility of disaster relief organizations to respond to natural disasters, making a distinction between the duties of governments and public organizations and those of private, nongovernmental organizations.
Public Organizations

Public organizations are those controlled or funded by governments that deliver public programs, goods, or services.\textsuperscript{206} Examples of public organizations involved in disaster relief in the United States are the Federal Emergency Management Agency (FEMA) and the Citizen Corps.\textsuperscript{207} Other countries have similar national programs, such as the European Commission’s Humanitarian and Civil Protection (ECHO) department in the European Union\textsuperscript{208} and the National Disaster Management Authority (NDMA) in India.\textsuperscript{209}

*General responsibility.* Public disaster relief organizations help fulfill a government’s responsibility to protect its citizens from harm and to promote their welfare.\textsuperscript{210} Natural disasters may inflict severe harm on a country’s citizens and communities, thus posing a threat to their welfare. Governmental responsibilities to protect its citizens include disaster relief, and all governments are arguably responsible to provide at least some measure of relief to their citizens who are victims of natural disasters within national borders.

*Ability.* The duty of a government to respond to natural disasters and other threats to a country’s citizens may be limited by the government’s ability to respond. This ability varies greatly among governments. Limiting factors may include the size of a government’s disaster relief organizations, the public funds available for and allocated to disaster relief, the number of responders (physicians, engineers, volunteers) available to respond to a disaster, and internal political divisions, among others. Many nations, especially poorer countries, have limited ability to respond to disasters and so must rely on private, nongovernmental organizations for major support.
Private Organizations

Private disaster relief organizations are not affiliated with or under the control of governments. Examples include the World Health Organization (WHO), the International Red Cross, World Vision, and Relief International. Private organizations do not have the same ethical responsibility to respond to natural disasters as public organizations. Nevertheless, these organizations have made it their mission and purpose to respond to the great need for assistance posed by natural disasters.

Opportunity. It would be difficult to argue that private disaster relief organizations must respond to natural disasters. They do not have the same responsibility to provide for the welfare of populations that describes the duties of governments to their citizens. Are natural disasters and their implications for affected communities unfortunate or unfair? Certain disaster events, such as mass shootings, are influenced or initiated by human actions and target certain individuals or groups. These events are unfair, in the sense that harm is inflicted by the intentional, immoral actions of an aggressor. Natural disasters, in contrast, are arguably unfortunate – not unfair – because the disaster event is an inanimate force of nature that itself does not have the capacity to intend harm to specific populations or individuals. Some areas of the world may be more severely affected by natural disasters than others, but that is due to geological, meteorological, and ecological factors, not human action, and thus it is unfortunate, but arguably not a failure of moral responsibility, that those communities are more affected by natural disasters than others. Because disasters that are purely natural in their cause are unfortunate, it is difficult to argue that private disaster relief organizations – that are not bound by a general
responsibility to protect a specific citizenry – must respond to them, though many of these private organizations do respond.

Disaster response and other forms of humanitarian assistance are morally praiseworthy endeavors, and the global community relies heavily on voluntary organizations whose chosen mission is to assist the victims of natural disasters. As exemplified by the large number of disaster relief organizations, many are willing and able to respond. For private organizations, ethics in disaster relief is less about a moral imperative to respond to natural disasters than about how relief ought to be provided by those who choose to respond. This is a conditional responsibility – those who choose to respond are bound by certain obligations to the communities they serve because of their choice to enter the disaster setting. This conditional responsibility is somewhat analogous to that of being a physician. No one is obligated to provide medical care to others, but anyone who does choose to enter the medical profession incurs significant moral obligations and responsibilities to other people. In a similar way, those who choose to provide aid following a disaster assume ethical obligations to respond in a way that best serves the affected community.

Conditional Responsibility. I argue in this chapter that if an individual, group, or organization that is not affiliated with an affected community’s government chooses to respond to a natural disaster, then they incur certain ethical responsibilities regarding the relief they provide to affected communities. These conditional responsibilities are different for the different types of organizations, but there are general ethical considerations that apply to all disaster responders. For those involved in caring for the health care needs of those affected by disasters, these considerations include the
provision of care that does not cause further harm to patients, that provides significant benefits for patients, and that recognizes both short-term and long-term health needs caused or made worse by the disaster event. These conditional responsibilities extend to care for medically vulnerable individuals, since they are particularly affected by natural disasters – sometimes in greater numbers than patients with acute needs. I argue that both public and private organizations involved in disaster relief should provide not only for acute needs such as traumas caused by the disaster event, but also for the needs of those with chronic diseases, such as diabetes, heart failure, hypertension, and chronic respiratory diseases that are worsened by the disaster. Furthermore, responders should anticipate the needs of other groups that are vulnerable in the disaster setting, such as the elderly, children, and those with needs for mental health care.

Although relief organizations are admirably altruistic and generally effective, their activities do not relieve all of the problems related to human health in disasters. There is room for improvement, especially with regard to the chronic care of vulnerable populations who may suffer from excess mortality for months or years following a disaster event. To lay a foundation for recommendations for how disaster relief organizations may more effectively meet the needs of vulnerable populations in disasters, I consider a number of ethical considerations that should guide relief efforts. The key question I address is:

**What are the moral obligations of organizations that respond to natural disasters to care for medically vulnerable populations after natural disasters?**

Three areas of bioethics are highly relevant to disaster relief – clinical ethics, especially as it relates to care in emergency settings, public health ethics, and the ethics
of medical volunteerism. The next three sections will review these ethical frameworks and highlight the relevance of each to disaster relief. I then draw from these three frameworks to develop a set of principles to guide the medical care planned for and provided by disaster relief organizations in the disaster setting.

CLINICAL ETHICS APPLIED TO THE DISASTER CONTEXT

Beneficence and Nonmaleficence

The phrase “First, do no harm” is familiar to health care providers, as it is a widely cited maxim of clinical ethics. This maxim is commonly, but perhaps incorrectly, attributed to Hippocrates. Regardless of its origin, it is a valuable principle that obligates health care providers to be aware of the consequences of their actions and to make conscious efforts not to cause preventable harm to patients. ‘Do’ refers to agency, including both intentional and unintentional consequences of one’s actions. “No harm” means not causing or increasing the injury experienced by another. And the dual meaning of “First” serves as a valuable reminder that initial actions (first in time) are often foremost (first in importance) in determining long-term outcomes. Hence, these four words summarize the bioethical principle of nonmaleficence.

Although “First, do no harm” is very familiar to health care providers, those who participate in disaster relief are more likely to be guided by the principle of beneficence. Beneficence describes a natural desire to help others, especially those in need. Beneficence resonates with the altruism of disaster responders and the optimism of volunteers. Nevertheless, when guided by beneficence alone, there is a risk that well-intentioned short-term actions can lead to eventual harm. One of the clearest examples of
this in 21st century natural disasters is the introduction of cholera in Haiti by United Nations Stabilization Mission workers from Nepal. The good intention of providing disaster relief to Haiti in the months after the 2010 earthquake led to the unforeseen consequence of a long-term cholera epidemic that arguably has caused more harm than the responders prevented in the disaster’s aftermath. In the provision of health care services in the disaster context, a strong emphasis on nonmaleficence may be needed to balance disaster relief workers’ natural interest in beneficence.

Yet nonmaleficence is difficult to apply in the context of natural disasters, where great needs may evoke a sense of urgency for intervention that overrides the caution and carefulness required to truly “do no harm.” In fact, it is often necessary to risk some harm in order to achieve a greater benefit, such as with the use of powerful chemotherapeutic agents to treat cancer. The disaster event, be it a hurricane, tornado, landslide, or earthquake, clearly causes harm to the affected community. Less predictable, but highly relevant, is how the response to a disaster may also cause harm. In the hours, days, and weeks following a disaster, the affected community typically receives an influx of personnel and resources to help alleviate suffering and to give “relief” from the devastation caused by the disaster. But while the motivation behind the provision of “disaster relief” is commendable, the magnitude and scope of the damage of some disasters are much greater than what the individual responders are able to remedy. In the wake of most large natural disasters, not all suffering can be relieved and not all individuals in need can be helped or saved. In efforts to help some, others may be neglected or harmed.
In the clinical context, the principles of beneficence and nonmaleficence are usually applied to interactions between individual physicians and their individual patients. These interactions typically take place when patients seek care from a doctor. In the disaster context, however, there are typically populations in need that may not be able to seek medical care. These may include medically vulnerable patients with chronic disease, the elderly, the mentally ill, and children. These populations, which may be at greatly increased risk of poor health outcomes in the aftermath of natural disasters, might be ignored under the predominant clinical medical ethics approach since they are not in a traditional doctor-patient relationship with a provider of disaster relief. There is a great opportunity to “do good” and prevent increased harm to the medically vulnerable in the disaster context, but this requires a heightened sensitivity to community needs, not just those of patients presenting for care.

Respect for Autonomy

Health care providers are trained to honor the principle of respect for autonomy when providing clinical care to patients. Respect for individual values and preferences can be the predominant consideration for health care in the absence of resource limitations, and many physicians emphasize autonomy in their moral decision-making. In the context of a natural disaster, however, treatment needs are great, resources may be highly limited, and confusion abounds. In this context, making the best use of available resources to benefit as many patients as possible may justifiably overshadow attention to individual preferences. These situations may permit exceptions to informed consent for treatment, require that some patients’ wishes are not honored in order to provide care for others, and allow relaxation of patient privacy and confidentiality protections. Respect for
patient preferences for care and the need to consult with surrogate decision-makers for incapacitated patients may be of secondary importance when there is great need for immediate treatment and the situation is complicated by language and cultural barriers. Thus, respect for autonomy plays a limited role in ethical considerations in the disaster context, with relatively greater emphasis placed on the interests of the community at large.

The focus of clinical ethics on respect for individual autonomy reveals its limited applicability to issues of disaster relief where informed consent may be difficult to obtain, and the needs for medical care may be so urgent as to prompt physicians to proceed with the provision of care before offering all treatment options to patients or considering the patient’s individual preferences for care. Hence, the bioethical principles of beneficence, nonmaleficence, and respect for autonomy do not provide sufficient ethical guidance in the context of disaster relief. Additional moral guidance is needed to identify responders’ moral obligations to care for the medically vulnerable in natural disasters.

There is, however, a community-level analogue to the concept of respect to autonomy, which I refer to as respect for communal autonomy. This includes respect for cultural values and norms, attainment of community consent for intervention, affirmation of the role of local governments, and support for local health care systems and infrastructure. The focus of clinical ethics on interactions between medical providers and individual patients makes it an imperfect framework for the ethics in the disaster context, where the best medical outcomes are often achieved by attention to community-level needs and resources. Disaster relief must also consider the influence of the disaster event on communities as a whole, and this makes a second branch of applied ethics, public
health ethics, especially relevant. The application of public health ethics to the disaster context is discussed in the next section.

PUBLIC HEALTH ETHICS APPLIED TO THE DISASTER CONTEXT

The major focus of public health ethics is on how best to promote the health and well-being of communities, groups, or populations, and on government’s responsibility to protect the health and well-being of the communities it governs. This field differs from other areas of bioethics, such as clinical ethics and research ethics, due to its emphasis on the community instead of on individual patients or research subjects. Compared to clinical ethics, public health ethics is relatively new. Its formal history began with sanitation efforts in the nineteenth and early twentieth centuries, championing clean water and sewage systems, but it is also associated with forced sterilization of those with mental illness and certain disabilities. These efforts reflect an underlying utilitarian aim to promote “the greatest good for the greatest number.” Utilitarianism is a doctrine that evaluates decisions based on their consequences, specifically on their effect on the overall wellbeing of individuals. The most appropriate decisions, for a utilitarian, are those that maximize welfare, thus producing the greatest good. Examples of maximizing good in the disaster context may be for a doctor to triage patients in a clinic so that the greatest number are saved, or more generally for disaster relief providers to reduce “excess mortality” as much as possible in a community following a disaster. Knowing how to anticipate the consequences of actions of various actors on communities is central to public-health interventions, which often involve the use of population-level data on health outcomes and disease prevalence to guide public policy and program decisions. The notion of what is “good” in these examples is controversial and can change with
time; there is, for example, now agreement that the good of the public is not furthered through forced sterilization. In fact, arguments from public health ethics are now used to justify why such sterilizations are wrong, as they harm certain populations that ought to be protected.

Public health policies and interventions are concerned with promoting the overall health of communities. At times, this is done at the expense of individual interests. There remains tension within the field of public health between those who champion individual rights to make decisions regarding interventions related to health – such as in the receipt of vaccines or fluoridated water – and those who believe that the government should protect the health of its population through these measures. This tension between achieving the collective good and protecting individual liberty is at the heart of public health. Yet achieving the “greatest good” is often the best goal for those providing health care in the disaster context, because of the inability to meet all health needs due to resource limitations. Large natural disasters devastate communities, often causing an influx of patients in dire need of care to hospitals that are likely short on the resources and personnel needed to manage the needs of all. In disasters, needs outweigh resources, and health care providers must triage patients and inevitably can only treat some, not all.

An ethical perspective that focuses on the community, such as that underlying the public health framework, fits well with the disaster context, where situations arise in which not everyone can be saved or helped. Disaster contexts require health care providers to work both in doctor-patient relationships and in a doctor-community relationship. But what should these doctor-community and relief organization-community relationships involve? Because public health interventions are usually administered at a
community level, they often focus on prevention of future harms instead of response to current needs and are justified using statistical data. One example is evidence that fluoridated water reduces dental cavities by approximately 25% across age groups, which is the basis for fluoridation of drinking water in the United States. In contrast, needs in the disaster context may be immediate and life-threatening, but those needs are nevertheless shared by and specific to particular affected communities. Some communities may have very poor living conditions that make the risk of infection or toxic waste exposure more likely than in richer communities. Other communities may have a high incidence of certain chronic conditions, or a high proportion of elderly residents, which may increase the likelihood of exacerbation of chronic disease in those locations. To increase their effectiveness, disaster relief organizations should consider characteristics of the affected community, responding not only to the immediate needs of individual patients, but also anticipating the effects of the disaster event on the specific community’s population.

While public health ethics can inform disaster relief, like clinical ethics it provides an incomplete ethical framework for effective and appropriate disaster response because it does not adequately address the role and involvement of external groups. External relief organizations do not have the same responsibilities to affected communities as local governments do, so the use of public health ethics to justify the responsibilities of these relief organizations to affected communities is limited. Ethical considerations in the provision of health services by external parties to communities in need are, however, addressed by ethical analyses of medical volunteerism. This third perspective on the ethics of disaster relief will be discussed in the next section.
ETHICS OF MEDICAL VOLUNTEERISM APPLIED TO THE DISASTER CONTEXT

Medical volunteerism, or participation in short-term medical trips to resource-poor locations, shares many features with disaster relief efforts. Most of these trips involve the engagement of a foreign organization in a community perceived as being in need. It is well appreciated that medical volunteerism – sometimes called “medical voluntourism” – is fraught with ethical hazards, many arising from an imbalance of resources and power between providers and the community being served, from language barriers that make the exchange of information and the process of informed consent difficult or impossible, and from the transient nature of the efforts. Commentators have proposed ethical considerations that ought to guide the conduct of these trips. A basic assumption of these proposed guides is that the primary goal of humanitarian medical efforts should be to address the health needs of local communities rather than serving the egos or training needs of the providers. The Sphere Project, for example, identified seven key principles of a Core Humanitarian Standard: mission, partnership, preparation, reflection, support, sustainability, and evaluation. The American College of Physicians identified the following five “positions” on the ethics of short-term global health care programs:

Position 1: “Physicians’ primary ethical obligation in short-term global health experiences is to improve the health and well-being of the individuals and communities they visit.”

Position 2: “The ethical principle of justice requires partnering with local leaders to ensure that the potential burdens participants can place on local communities abroad are minimized and preparing for limited material resources.”

Position 3: “The ethical principle of respect for persons, including being sensitive to and respectful of cultural differences, is essential to short-term global medical experiences.”

Position 4: “Predeparture preparation is itself an ethical obligation. It should incorporate preparation for logistical and ethical aspects of [short-term
experiences in global health], including the potential for ethical challenges and moral distress.”

**Position 5:** “Physicians should participate with organizations whose [short-term experiences in global health] are consistent with ethics and professionalism as exemplified in these positions.”

These ethical guidelines are generally applicable to international disaster relief efforts as well. Positions 1, 2, and 4 are especially applicable; these can be restated as addressing the needs of populations in a holistic and effective way (Position 1), collaborating with local governments and institutions (Position 2), and preparing in advance for disaster relief efforts (Position 4).

**PROPOSED ETHICAL CONSIDERATIONS FOR DISASTER RELIEF**

**If, Then**

I offer the following general moral proposal: If an individual, group, or organization voluntarily chooses to respond to a natural disaster and aims to provide health care services and resources to an affected community, then they ought to be guided by a number of ethical considerations. These responsibilities are conditional, in that they apply to those who voluntarily choose to respond to natural disasters. The responsibilities are drawn from clinical ethics, public health ethics, and the ethics of medical volunteerism described above – all of which have certain strengths and limitations in the disaster context. In combination, various considerations from these three areas address the range of issues involved in disaster relief. The complementary perspectives and contributions from these fields are illustrated in Figure 4-1, below.
Clinical ethics has well-developed principles for guiding the delivery of medical care and informing the responsibilities of health care providers, but it is highly focused on the individual. The disaster setting includes health care needs that extend beyond the individual level to the community level, and the harmful effects of natural disasters on the health of communities cannot be effectively addressed by individual doctor-patient interactions. Thus, clinical ethics is limited in the disaster context due to its focus on individual interactions.

An emphasis on the community is found in public health ethics, where the principles of beneficence and nonmaleficence are applied at the population level, sometimes at the expense individual liberty. Yet governments are generally the parties responsible for implementing public health initiatives for their populations. Although

Figure 4-1. The overlap of ethical considerations in clinical care, public health, and medical volunteerism that are relevant to disaster relief.
many public health needs are present in the disaster setting, the responsibility to respond to public health needs is generally placed on governments, not on external organizations. The United States Department of Health and Human Services, for instance, classifies many natural disasters as “public health emergencies,” but these declarations are limited to states and territories governed by the United States. Such a declaration was made for Puerto Rico after Hurricane Maria on September 17, 2017, and was renewed on March 16, 2018. The United States does not make such declarations for natural disasters affecting countries outside of its governance, suggesting that it does not recognize a responsibility to respond to public health needs in other locations. This limits the considerations of public health ethics in the disaster context because it does not address the relationship of a voluntary disaster relief organization (which is often external to the affected community) to the community.

The ethics of medical volunteerism explores how external groups should interact with host communities, emphasizing principles of sustainability, collaboration, and respect for cultural values. Medical volunteerism efforts have many similarities to disaster relief, as both involve external groups providing medical care to communities in need. The main differences are the immediacy and overwhelming magnitude of needs in the disaster context. Medical volunteerism targets communities lacking resources due to poverty, while disaster relief targets communities facing immediate harms due to disaster events, as well as resource limitations. Other differences may include the types of personnel responding – medical volunteerism often includes a large number of medical students and health care providers in training, while disaster relief is provided primarily by practicing physicians, nurses, and other health care providers. There may also be
differences in whether the providers’ services were requested by host communities (common in disaster relief), or the host community was selected by the providers (common in medical volunteerism). Despite these potential differences between disaster relief and medical volunteerism, many of the ethical considerations applied to the latter are also highly relevant to the former. Drawing from clinical ethics, public health ethics, and the ethics of medical volunteerism, I propose below six ethical considerations for disaster relief:

1. **Community Level Beneficence and Nonmaleficence** (from clinical and public health ethics)
   a. Relief efforts should minimize immediate and long-term harms to the community.
   b. Relief efforts should maximize immediate and long-term benefits to the community.

2. **Respect for Communal Autonomy** (from medical volunteerism and clinical ethics)
   a. Relief organizations should obtain community consent for involvement.
   b. Relief workers should respect cultural values of the community.

3. **Collaboration** (from medical volunteerism and public health ethics)
   a. Relief organizations should partner with and affirm local health systems.
   b. Relief activities should minimize interactions and interventions that create dependency of the local community on external providers and organizations.
   c. Disaster relief organizations should coordinate to maximize effectiveness of efforts, minimize redundancy in the services provided, and best distribute personnel throughout communities in need.

4. **Evidence-Based Prevention Strategies** (from medical volunteerism and public health ethics)
   a. Relief efforts should include preventive strategies in addition to the treatment of current needs.
   b. Preventive strategies should be informed by evidence of their effectiveness in preventing post-disaster adverse health consequences.

5. **Need-Based Response Strategies** (from medical volunteerism and public health ethics)
   a. The type of relief provided should address the actual needs of host communities.
   b. Relief efforts should extend beyond access to water, food, sanitation, and housing to include medical care for vulnerable populations.
c. Relief organizations should anticipate local needs, so that activities and resources can be effectively planned and tailored to the affected community.

d. Needed care and resources should be accessible to affected populations, i.e., response efforts should ensure that populations in need have access to relief provided.

6. **Sustainability** (from medical volunteerism and public health ethics)
   a. Relief work should address both immediate and long-term consequences of the disaster.
   b. Aid-giving should include capacity-building of the local infrastructure to allow for transfer of services from relief organizations to local personnel.

Consideration 5 articulates a broad responsibility assumed by relief organizations to provide medical care to vulnerable populations in communities with devastated health systems. To provide effective care, these organizations should determine what supplies and resources will be needed to respond to a disaster in a specific community, develop plans of action, and stockpile supplies, such as medications. In Chapter Five, I illustrate how this planning might be accomplished by developing a predictive model for the resources that would be needed to care for patients with heart failure in a variety of disaster scenarios. Consideration 6 extends that responsibility in time to cover the months or years of excess morbidity and mortality caused by the disaster.

**EXTENSION OF ETHICAL CONSIDERATIONS TO GLOBAL HEALTH**

The ethical considerations described above were developed in the specific context of disaster relief, but they may apply as well to global health activities in the absence of disasters. Impoverished communities experience many of the same health problems that communities facing disasters do, including challenges with chronic disease management and access to health care services. The characteristics of the vulnerable populations described in Chapter Two that make these groups more at risk of poor health outcomes in disasters are universally present – those with chronic medical conditions are always
dependent on medications, the elderly and children are always more susceptible to
disease and dependent on others for care, and those with mental illness are always at risk
of their conditions worsening due to specific events. Natural disasters simply increase
these existing vulnerabilities – serving as a trigger that increases the likelihood that
vulnerable individuals will experience worsened health. Poverty itself is a context quite
similar to the disaster context – as it produces situations where needs are great and the
resources available to meet those needs are limited.

Natural disasters differ from the chronic health problems of poorer nations
primarily by the presence of an immediate crisis. The disaster worsens the plight of
vulnerable populations, but it also creates awareness and generates interest from groups
that may provide aid. After a natural disaster, millions of eyes are glued to television
programs describing the devastation and providing updates on death tolls and relief
efforts. Natural disasters have a “shock factor” that attracts the attention of audiences
worldwide. In contrast, endemic poverty and its effects on communities, especially
globally, are not newsworthy and are more easily ignored. Poverty is not a one-time
disaster that devastates a community overnight. It is gradual – causing progressive and
long-lasting devastation to communities. While disasters are like flash floods – occurring
quickly and causing severe damage on impact – poverty is like a flood that takes years to
rise, but rises nonetheless. But overall, the effects of natural disasters and poverty on
communities are much the same – the difference is that the former is short-term and
attention-grabbing, while the latter is long-term and often neglected. Even the responses
to disasters and chronic poverty are similar and involve many of the same challenges.
Both typically involve interactions between medical personnel from advanced wealthy
nations and impoverished communities, problems with communication, and difficult
decisions regarding allocation of limited resources.

Just as the problems associated with disasters and poverty are similar, the ethical
issues that arise in these situations are much the same. Therefore, the ethical
considerations described above can easily be applied to the more general field of global
health. The needs of communities are often the same, the actors intervening to meet these
needs are similar, and the populations that are vulnerable in disasters are also vulnerable
in any setting where resources are limited and conditions are substandard. Four of these
ethical considerations deal with relationships between outside groups and local
communities – namely community level beneficence and nonmaleficence, respect for
communal autonomy, collaboration, and need-based strategies. These are of obvious
relevance and importance in a wide range of situations related to global health that
involve interactions between wealthy and poorer nations. As in disasters, effective
international efforts to improve global health must bridge a wide gap between visiting
foreign health care providers and local communities in need, and it can be difficult for
providers to coordinate with the local health care systems and to direct outside assistance
to the real needs of the local population. These similarities make the ethical
considerations for disaster relief equally applicable to the ordinary challenges of global
health. For example, the need to have community assent and to affirm the role of local
health care providers is the same regardless of whether one is providing emergency
medications after a disaster or giving routine childhood immunizations.

The remaining two ethical considerations for disaster relief – evidence-based
prevention strategies and sustainability – are likewise central to the aims of global health.
These considerations focus on long term outcomes and are essential to any effective global health intervention. Just as it is important in the disaster context to anticipate and minimize the harmful consequences of an unpredictable future disaster, it is essential for those working in global health to anticipate and minimize the easily predictable consequences of poverty, illiteracy, and lack of medical resources. If sustainability of relief is applicable to the disaster context, it is even more relevant in the context of chronic needs.

Application of these ethical principles in global health can be illustrated by a simple example. Epidemic cholera is often fatal but can be controlled with sanitation, proper nutrition, and basic medical care. The ethical considerations described above could be used as a blueprint for action against cholera in the following ways:

1. Community Level Beneficence and Nonmaleficence would identify cholera control as a major goal of foreign policy.
2. Respect for Communal Autonomy would foster trust between local populations and external organizations.
3. Collaboration would lead to relationships among physicians of different countries and better education of local health care providers.
4. Evidence-Based Prevention Strategies would address underlying problems of sanitation.
5. Need-Based Response Strategies would stockpile fluids for oral replenishment in areas of potential need.
6. Sustainability would encourage long-term interactions of physicians with health systems in countries at risk, not short-term visits by medical students to observe diseases that are uncommon in high-income nations.

CHALLENGES TO ETHICAL CONDUCT IN DISASTERS

Providing health care in disasters is much more difficult than in the usual clinical setting. There is unpredictability, as exemplified by the cholera epidemic in Haiti, where some presumably well-intentioned disaster relief personnel caused more harm than good to the communities they aimed to serve. Individuals who need non-urgent medical
attention in disasters, such as the medically vulnerable populations described in Chapter Two, may be difficult to identify, locate, or contact in certain disaster settings. Medical resources are limited, there are often more patients in need than providers can adequately care for, and other services – such as electricity, refrigeration, transportation, and sanitation – may be lacking. These factors present unique challenges to the ability of health care providers to make morally sound choices and to implement those choices effectively. A qualitative study conducted by investigators at the Shahid Beheshti University of Medical Sciences in Iran, published in the Journal of Medical Ethics and History of Medicine, describes these and other challenges faced by responders to a variety of disasters. Such challenges include:

1. **Unfamiliar settings.** The health care facilities in affected communities may differ in size and resources when compared to the settings in which the disaster responders work and were trained. Unfamiliar settings may result in providers not knowing how to adapt to the local situation.

2. **Communication difficulties.** There may be language barriers between patients and providers or between providers from different relief groups. Some settings may lack electricity or cell towers, making communication between relief personnel and their organizational sponsors difficult.

3. **Non-ideal selection of responders.** The assumption that *more help is more helpful* is incorrect in some contexts. Attempting to provide the maximum possible number of responders may lead to the enlistment of personnel with inadequate training.

4. **Insufficient training.** Health care providers often exemplify great altruism, but may lack thorough preparation for dealing with complex ethical dilemmas due to insufficient training in the ethics of disaster relief.

5. **Multiplicity of leadership.** The presence of personnel from local institutions and multiple disaster relief organizations can lead to confusion regarding who is in authority, how to provide care, and who is responsible for certain tasks. Each group may also have distinctive codes of conduct that differ from those of other groups.
6. **Environmental and social factors.** Disaster responders may experience conflicting motivations if they fear for their personal safety – such as from exposure to communicable disease, looting of supplies, and harm from external parties – and these concerns may prevent them from providing effective care to patients.

7. **Psychological stress.** Similar to the social factors described above, the disaster setting is often highly stressful, both for patients and responders. In the days and weeks following a disaster event, health care providers may feel overwhelmed by the sheer number of patients in need, especially if those in need exceed their treatment capacity. Long hours, difficult clinical cases, and images and stories of devastation may contribute to psychological stress experienced by providers. Such stress may affect providers’ ability to reason through complex clinical or ethical situations that may arise.

To provide effective relief services, organizations must recognize and be prepared to address each of these challenges. The ethical principles I have proposed above are tailored to the disaster context and implicitly deal with most of these difficulties. However, it is critically important to note that ethical conduct of disaster relief organizations and workers cannot be an afterthought. Ethics cannot become a consideration only after relief efforts are underway. Rather, ethical responses to disasters demand planning and preparation. While preparation may be especially difficult due to the unpredictability of disaster occurrence, magnitude, location, and effects, available information and calculation tools can estimate some of the post-disaster care needs of vulnerable populations. The predictive model presented in the next chapter not only illustrates the type of tool that a relief organization might use for planning, it also highlights how relief efforts may be substantially altered if proper attention is paid to the long-term medical needs of vulnerable populations. For example, providing high calorie, high salt meals designed for soldiers in combat may be inappropriate for heart failure patients with comorbid diabetes and hypertension.
CHAPTER FIVE: PLANNING CARE FOR THE MEDICALLY VULNERABLE – A PREDICTIVE MODEL FOR ESSENTIAL HEART FAILURE MEDICATIONS IN NATURAL DISASTERS

RESPONSIBILITY TO PLAN

Natural disasters often occur with little or no warning. Earthquakes and volcanic eruptions are notoriously unpredictable, and even hurricanes and typhoons, which can sometimes be tracked for days before landfall, often change course unexpectedly and cause their greatest damage to communities that did not anticipate these storms. Because of this unpredictability, disaster relief organizations must quickly assess each disaster scenario and adjust their activities to the immediate needs of that unique situation, and there is a general expectation that disaster relief efforts will be reactive rather than proactive.

Nevertheless, a review of the ethical considerations for disaster relief that I outlined in Chapter 4 reveals a substantial need and obligation of relief organizations to plan for disasters. To provide the most beneficial aid, it is necessary for a relief organization to both anticipate and prepare. For example, the critical requirement for collaboration (Consideration 3) is very difficult to accomplish in the immediate aftermath of a natural disaster. Collaborations will be strongest and most effective if they are developed before the disaster occurs. Larger relief organizations should act before disasters occur to develop relationships with key players in disaster-prone countries, including leaders of government, public safety agencies, the military, and health care systems.

In a similar way, the ethical consideration of evidence-based prevention (Consideration 4) presumes a detailed knowledge of both local populations and best
practices for preventive interventions. This may require systematic study of communities that may someday require aid and the prior development of plans. Otherwise, when a disaster does occur, the immediate needs of the population are likely to distract from thoughtful consideration of potential risks. The time to prevent cholera in Haiti was before the earthquake, when the U.N. might have anticipated importation of the infection from Nepal and developed a simple procedure for screening aid workers for disease before transporting them to the disaster region.

In this chapter, I consider at greater length the demands for planning imposed by another ethical consideration – the call for need-based response strategies (Consideration 5). Clearly, strategies can be “need-based” only if the needs of the affected communities are clearly understood. In caring for medically vulnerable populations, the needs are highly predictable, because they closely resemble the needs of these patients in the absence of a disaster. What a disaster typically does is disrupt the existing health care system and generate environmental conditions that may exacerbate certain medical conditions (e.g. asthma). Both of these effects can be anticipated in a highly quantitative manner. For example, with disruption of a local health care system, there may be a need for relief organizations to substitute for that health system, in part or in whole. The magnitude of that demand for services can be estimated from knowledge of the number of patients in the affected region who have the disease or condition being considered.

For this analysis, I have chosen as an example a single medical condition – chronic heart failure. Cardiovascular disease is the leading cause of death in the vast majority of countries, and those with existing disease are at heightened risk of complications and death if their ongoing treatments are interrupted. Heart failure is a
good choice for this illustration because it is common (often affecting 1-2% of a nation’s population), is serious (involves risk of death), and requires ongoing therapy according to well-established clinical practice guidelines. Given the standardization of care for heart failure, it is possible to develop quantitative estimates of the amounts of particular drugs that might reasonably be needed in a particular community in the aftermath of a specific disaster.

PROPOSED PREDICTIVE MODEL TO PLAN CARE FOR HEART FAILURE PATIENTS IN NATURAL DISASTERS

The first few minutes, hours, and days after a major natural disaster are characteristically chaotic. Loved ones may be missing, electricity may be out, and buildings may be flooded. This chaos and uncertainty is added to the typical challenges of everyday life – feeding one’s family, showing up for work and doctor’s appointments, protecting one’s home and possessions, bathing and clothing oneself, and meeting a multitude of other responsibilities. While dealing with all of these issues, individuals with heart failure have the added challenge of reliance on medications to manage their condition. Closed pharmacies, lost medications, reductions in the physician workforce, and devastated health systems may make it difficult or impossible for patients like those with heart failure to fill prescriptions and obtain needed care. Worsening of heart failure is thus common in the disaster context due to these factors, and patients may experience difficulties obtaining care not only in the first few chaotic days after the disaster, but for months or perhaps even years, until the community’s health system is restored.

Disaster relief organizations have a unique opportunity to provide for the health care needs of individuals in affected communities, and it is important that they do so.

This care may require organizations to stockpile or rapidly acquire an appropriate amount
of medications, such as those that are essential to treat heart failure, and to send them with responding personnel for distribution to heart failure patients in affected communities. To anticipate the quantity of medications that would be needed, the following model may be useful.

What drugs are needed? The first step that relief organizations would need to take in planning care for heart failure patients would be to determine what medications are needed, and in what amounts. Clinical practice guidelines provide recommendations for how to treat heart failure – these include different approaches for stable heart failure (such as for outpatients who take oral medications for condition management) and acute exacerbations (such as for inpatients who are given intravenous medications). Patients with stable heart failure are those most likely to face condition worsening because they are not hospitalized under the care of health care providers. For this group that is reliant on oral medications, many different drugs are available, though these generally fall into a few drug classes. These classes are beta-blockers, diuretics, and drugs that target the angiotensin system (angiotensin converting enzyme (ACE)-inhibitors and angiotensin receptor blockers (ARBs)). Drugs within a class are usually interchangeable, and thus relief organizations may only need to stockpile one or two of the drugs of each class to care for the health failure population in a particular community. The World Health Organization (WHO) has prepared a list of “Essential Medications” that includes drugs for heart failure. These include the following oral medications:
<table>
<thead>
<tr>
<th>Generic Drug Name</th>
<th>Representative Formulation</th>
<th>Typical Monthly Dose</th>
<th>Cost per tablet (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bisoprolol</td>
<td>5 mg tablets</td>
<td>30 tablets</td>
<td>0.229</td>
</tr>
<tr>
<td>Enalapril</td>
<td>5 mg tablets</td>
<td>30 tablets</td>
<td>0.145</td>
</tr>
<tr>
<td>Losartan</td>
<td>50 mg tablets</td>
<td>30 tablets</td>
<td>0.064</td>
</tr>
<tr>
<td>Furosemide</td>
<td>40 mg tablets</td>
<td>30-60 tablets per month</td>
<td>0.031</td>
</tr>
<tr>
<td>Spironolactone</td>
<td>25 mg tablets</td>
<td>30 tablets</td>
<td>0.072</td>
</tr>
</tbody>
</table>

Table 5-1. Essential medications for the outpatient treatment of heart failure

The WHO list of “Essential Medications” also includes hydrochlorothiazide, a less potent but possibly less expensive alternative diuretic. Because heart failure patients can reasonably be managed in the disaster context without the use of hydrochlorothiazide, it has not been included in Table 5-1. Patients are typically prescribed 1-4 of the 5 drugs listed above for outpatient treatment of chronic heart failure.

*How many people need the drugs?* The second step needed to plan care for heart failure patients in disaster relief is to determine the number of people in need of these medications. This depends on two factors: (1) how many heart failure patients there are in a particular community, and (2) how many of these patients would be dependent on external relief services. For planning purposes, it may be appropriate to begin by planning for the worse-case scenario, i.e., for situations where all heart failure patients in an affected community are reliant upon external support. Heart failure affects patients in all populations of the world, but the prevalence of the condition varies widely among countries and communities. The fundamental challenge here is knowing how many individuals have heart failure in a particular community – the one that is affected by a disaster event. Unfortunately, heart failure prevalence data are available for only a small
fraction of countries, and the data that are available show tremendous variation. For instance, it has been estimated that less than half a percent of the population of India suffers from heart failure, but in Malaysia the prevalence is 6.7%. Thus, there is no one-size-fits-all answer to how many people are affected by heart failure across communities. Fortunately, mathematical models may be useful in predicting prevalence.

**Estimating Heart Failure Prevalence**

In order to predict the prevalence of heart failure in *any* country, I chose to develop a predictive equation that would give an estimate of heart failure prevalence based on demographic data that are generally available for all countries. It is known that heart failure is associated with certain factors, such as poverty, smoking, obesity, diet, aging, family history, availability of health care, education, socioeconomic status, and other forms of cardiovascular disease such as hypertension. I chose to use a variety of variables that capture these characteristics of a population as potential predictive variables in the model. These potential explanatory variables are given in Table 5-2 for 15 countries for which the prevalence of heart failure has been reported. Readily available data sources provide values of these variables for any country.
<table>
<thead>
<tr>
<th>Country</th>
<th>HF Prev</th>
<th>HTN</th>
<th>65+</th>
<th>Life</th>
<th>Phys</th>
<th>Obesity</th>
<th>School</th>
<th>GDP</th>
<th>Smoking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal</td>
<td>1.50</td>
<td>37.1</td>
<td>19.40</td>
<td>79.4</td>
<td>4.43</td>
<td>20.8</td>
<td>17</td>
<td>30.4</td>
<td>21.6</td>
</tr>
<tr>
<td>Spain</td>
<td>2.10</td>
<td>40.5</td>
<td>17.98</td>
<td>81.8</td>
<td>3.87</td>
<td>23.8</td>
<td>18</td>
<td>38.3</td>
<td>24.7</td>
</tr>
<tr>
<td>Germany</td>
<td>1.70</td>
<td>34.9</td>
<td>22.06</td>
<td>80.8</td>
<td>4.19</td>
<td>22.3</td>
<td>17</td>
<td>50.4</td>
<td>22.3</td>
</tr>
<tr>
<td>Sweden</td>
<td>2.00</td>
<td>39.4</td>
<td>20.26</td>
<td>82.1</td>
<td>4.19</td>
<td>20.6</td>
<td>18</td>
<td>51.5</td>
<td>13.6</td>
</tr>
<tr>
<td>Italy</td>
<td>1.44</td>
<td>40.9</td>
<td>21.53</td>
<td>82.3</td>
<td>4.02</td>
<td>19.9</td>
<td>16</td>
<td>38.1</td>
<td>22.3</td>
</tr>
<tr>
<td>USA</td>
<td>1.70</td>
<td>31.5</td>
<td>15.63</td>
<td>80.0</td>
<td>2.57</td>
<td>36.2</td>
<td>17</td>
<td>59.5</td>
<td>15.3</td>
</tr>
<tr>
<td>China</td>
<td>1.30</td>
<td>34.0</td>
<td>10.81</td>
<td>75.7</td>
<td>3.63</td>
<td>6.2</td>
<td>14</td>
<td>16.7</td>
<td>24.9</td>
</tr>
<tr>
<td>Japan</td>
<td>1.00</td>
<td>41.9</td>
<td>27.87</td>
<td>85.3</td>
<td>2.37</td>
<td>4.3</td>
<td>15</td>
<td>42.8</td>
<td>21.3</td>
</tr>
<tr>
<td>India</td>
<td>0.28</td>
<td>27.5</td>
<td>6.24</td>
<td>68.8</td>
<td>0.76</td>
<td>3.9</td>
<td>12</td>
<td>7.2</td>
<td>12.6</td>
</tr>
<tr>
<td>Malaysia</td>
<td>6.70</td>
<td>25.8</td>
<td>6.10</td>
<td>75.2</td>
<td>1.53</td>
<td>15.6</td>
<td>13</td>
<td>29.0</td>
<td>19.1</td>
</tr>
<tr>
<td>Singapore</td>
<td>4.50</td>
<td>23.9</td>
<td>9.63</td>
<td>85.2</td>
<td>2.28</td>
<td>6.1</td>
<td>13</td>
<td>93.9</td>
<td>13.1</td>
</tr>
<tr>
<td>Australia</td>
<td>1.50</td>
<td>33.8</td>
<td>16.14</td>
<td>82.3</td>
<td>3.50</td>
<td>29.0</td>
<td>20</td>
<td>50.3</td>
<td>16.3</td>
</tr>
<tr>
<td>UK</td>
<td>1.60</td>
<td>30.8</td>
<td>18.19</td>
<td>80.9</td>
<td>2.83</td>
<td>27.8</td>
<td>18</td>
<td>44.3</td>
<td>20.1</td>
</tr>
<tr>
<td>Poland</td>
<td>4.30</td>
<td>37.8</td>
<td>17.47</td>
<td>77.9</td>
<td>2.29</td>
<td>23.1</td>
<td>16</td>
<td>29.6</td>
<td>27.2</td>
</tr>
<tr>
<td>Oman</td>
<td>0.52</td>
<td>23.7</td>
<td>3.55</td>
<td>75.9</td>
<td>1.92</td>
<td>27.0</td>
<td>14</td>
<td>46.0</td>
<td>9.1</td>
</tr>
</tbody>
</table>

Table 5-2. Heart failure prevalence and potential explanatory variables for 15 countries

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTN</td>
<td>% of Adult Population</td>
<td>Prevalence of hypertension among adults</td>
</tr>
<tr>
<td>65+</td>
<td>% of Population</td>
<td>Percent of population over age 65</td>
</tr>
<tr>
<td>Life</td>
<td>Years</td>
<td>Average life expectancy at birth for population</td>
</tr>
<tr>
<td>Phys</td>
<td># of physicians per 1000 population</td>
<td>Number of physicians available for every 1000 persons</td>
</tr>
<tr>
<td>Obesity</td>
<td>% of Population</td>
<td>Percent of population obese</td>
</tr>
<tr>
<td>School</td>
<td>Age</td>
<td>Average age at completion of schooling across population</td>
</tr>
<tr>
<td>GDP</td>
<td>Thousands of dollars per capita</td>
<td>Gross domestic product in thousands of dollars per capita</td>
</tr>
<tr>
<td>Smoking</td>
<td>% of Population</td>
<td>Percent of population reporting use of cigarettes</td>
</tr>
</tbody>
</table>

Table 5-3. Explanation of variables used in Table 5-2
Using the data tabulated above, I next performed a multivariable regression to mathematically determine which of these variables would be useful for predicting the prevalence of heart failure for a particular country. This regression produces a coefficient for each independent variable, together with a P-value that reflects the confidence that this coefficient is significantly different from zero. I then eliminated the variable with the least significant coefficient and repeated the regression analysis. That process was continued until all coefficients had a P-value less than 0.1. This step-wise process yielded a model with only three independent (explanatory) variables: 65+, GDP, and smoking. The regression results for the final model are shown in Table 5-4. This model is represented in Equation 5-1, which requires only three variables to estimate the heart failure prevalence for any country, even those without published prevalence data.

<table>
<thead>
<tr>
<th></th>
<th>Coefficients</th>
<th>t Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.923174764</td>
<td>-0.92688</td>
<td>0.37387908</td>
</tr>
<tr>
<td>65+ (X Variable 1)</td>
<td>-0.176750332</td>
<td>-2.42699</td>
<td>0.03358852</td>
</tr>
<tr>
<td>GDP (X Variable 2)</td>
<td>0.050578112</td>
<td>2.209561</td>
<td>0.04925631</td>
</tr>
<tr>
<td>Smoking (X Variable 3)</td>
<td>0.248263315</td>
<td>2.462365</td>
<td>0.03154606</td>
</tr>
</tbody>
</table>

Table 5-4. Regression formula coefficients calculated using Microsoft Excel software

**HF Prevalence** = \(-1.923 + (-0.177)(\text{% of Population over 65}) + (0.0506)(GDP) + (0.248)(\text{% of Population Smoking})\)

**Equation 5-1.** Heart failure prevalence as a function of a country’s population over age 65, GDP in thousands of dollars per capita, and percent of population smoking

Plots of predicted HF prevalence vs. reported HF prevalence (see Figure 5-1) changed very little as the number of independent variables was reduced from 8 to 3. While there are substantial deviations from the line of identity for some countries, some of this discrepancy may be due to errors in the reported prevalence data, rather than inadequacy of the predictive model. Overall, the model generally distinguishes countries with lower or higher heart failure prevalence from those with a more typical prevalence.
of 1-2%. I conclude that this simple model is probably useful for estimating the prevalence of heart failure in countries for which those data are unavailable.

**Figure 5-1.** Predicted versus actual heart failure prevalence for countries identified in Table 5-1

**Estimating Need for Essential HF Medications**

The magnitude of a disaster’s effect on a community and its health system are highly variable. The effect may be very minor, with health care systems functioning as well as they were before the disaster event. In this case, it may be unnecessary for external relief agencies to provide medications to care for heart failure patients, as the needs for these medications would already be met by the community. It is more common, however, that the effect of large natural disasters on communities is severe, leaving health systems devastated and patients reliant on external support. In this case, quantifying the needs present and the resources required to meet them is important. This can be done in a straightforward way once the heart failure prevalence in a particular
community is known. First, an estimate of the number of heart failure patients in the affected area can be obtained by multiplying the prevalence of heart failure (percentage/100) by the community’s population. Next, a correction for the severity of the disaster can be applied by multiplying by a factor that reflects the extent to which the local health system is affected. This factor ranges from 0 to 1 with 0 representing no effect of the disaster and 1 representing total destruction or dysfunction. For example, if a health system in the affected community is operating at half of its usual capacity, relief organizations would need to provide the other 50% of care.

In the case of stockpiling and distributing heart failure medications, it is necessary to recognize that not all heart failure patients take the same specific drugs. However, substitutions are possible within classes, allowing relief agencies to focus on only the five drugs listed in Table 5-1. Furthermore, information on the percent of heart failure patients who typically take drugs of a particular class is known (see Table 5-5). These percentages of drug usage by class are likely less than what would be recommended for guideline-based care, and these data from Canada may reflect under-treatment. However, similar usage rates of ARBs, ACE inhibitors, and diuretics were reported for a US population of Medicaid beneficiaries with congestive heart failure. Data on typical usage allow calculation of the anticipated needs for particular drugs.
### Table 5-5. Typical usage of medication classes for the outpatient treatment of heart failure

<table>
<thead>
<tr>
<th>Drug Class</th>
<th>Representative Drug</th>
<th>% of Patients on Drug of Class based on subset of patients in Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta blocker</td>
<td>Bisoprolol</td>
<td>27.4 – 33.1</td>
</tr>
<tr>
<td>ACE inhibitor</td>
<td>Enalapril</td>
<td>35.8 – 36.7</td>
</tr>
<tr>
<td>ARB</td>
<td>Losartan</td>
<td>12.4 – 15.3</td>
</tr>
<tr>
<td>Loop diuretic</td>
<td>Furosemide</td>
<td>36.5 – 37.1</td>
</tr>
<tr>
<td>K⁺-sparing diuretic</td>
<td>Spironolactone</td>
<td>4.8 – 5.4</td>
</tr>
</tbody>
</table>

Equation 5-2. Formula for estimating need for particular drugs

For example, if a community has a population of 300,000, the heart failure prevalence is estimated to be 2.5%, and the disaster is estimated to have impaired the local health system by 75%, the monthly need for bisoprolol could be estimated as:

\[
\text{Monthly need for bisoprolol} = (0.025) \times (300,000) \times (0.75) \times (0.30) \times (30) = 50,625 \text{ tablets (5 mg) per month}
\]

**Hypothetical Examples**

In this section I consider examples of how the modeling described in this chapter could be used by relief organizations to inform disaster relief aid that would include provision of medications for treatment of chronic heart failure. As described previously,
the first step in this exercise is to estimate the prevalence of heart failure in the affected country. Examples of that calculation are shown in the table below.

<table>
<thead>
<tr>
<th>Countries</th>
<th>Population(^{236})</th>
<th>65+</th>
<th>GDP</th>
<th>Smoking</th>
<th>Estimated HF Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>329,256,465</td>
<td>15.63</td>
<td>59.5</td>
<td>15.3</td>
<td>2.1</td>
</tr>
<tr>
<td>Haiti</td>
<td>10,788,440</td>
<td>4.21</td>
<td>1.8</td>
<td>7.1</td>
<td>0*</td>
</tr>
<tr>
<td>Indonesia</td>
<td>262,787,403</td>
<td>0.77</td>
<td>12.4</td>
<td>30.2</td>
<td>6.1</td>
</tr>
<tr>
<td>Peru</td>
<td>31,331,228</td>
<td>7.61</td>
<td>13.5</td>
<td>11.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Chile</td>
<td>17,925,262</td>
<td>11.13</td>
<td>24.6</td>
<td>28.6</td>
<td>4.5</td>
</tr>
<tr>
<td>Ireland</td>
<td>5,068,050</td>
<td>13.32</td>
<td>73.2</td>
<td>24.3</td>
<td>5.5</td>
</tr>
</tbody>
</table>

*The HF prevalence in Haiti is noted as zero because a negative value was calculated using Equation 5-1. Prevalence cannot be negative, so this value was reset to zero.*

Note that the prevalence of heart failure is predicted to be very low in Haiti and Peru. The combination of low GDP, low percentage of population over age 65, and low rates of smoking would be expected to make heart failure less of a problem in those places. Relief efforts in those countries might better focus on other diseases. However, heart failure is expected to be highly prevalent in Indonesia, Chile, and Ireland. Disaster relief efforts in those areas should be prepared to address the medical needs of that vulnerable population.

As a particular example, consider the hypothetical case of a Chilean earthquake that causes substantial destruction to Santiago, a city of 6.3 million people. Within that population, I estimate that there are approximately 280,000 individuals with heart failure. Using data from Tables 5-1 and 5-5, and assuming that the health system in Santiago is
60% destroyed (thus 0.60 dysfunctional), I estimate that providing heart failure medications for the individuals in need would require the following drugs:

<table>
<thead>
<tr>
<th>Drug</th>
<th>Quantity</th>
<th>Calculations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bisoprolol</td>
<td>1.5 million</td>
<td>$280,000 \times 0.30 \times 0.60 \times 30 = 1.5$ million 5 mg tablets per month</td>
</tr>
<tr>
<td>Enalapril</td>
<td>1.8 million</td>
<td>$280,000 \times 0.36 \times 0.60 \times 30 = 1.8$ million 5 mg tablets per month</td>
</tr>
<tr>
<td>Losartan</td>
<td>0.7 million</td>
<td>$280,000 \times 0.14 \times 0.60 \times 30 = 0.7$ million 50 mg tablets per month</td>
</tr>
<tr>
<td>Furosemide</td>
<td>2.8 million</td>
<td>$280,000 \times 0.37 \times 0.60 \times 45 = 2.8$ million 40 mg tablets per month</td>
</tr>
<tr>
<td>Spironolactone</td>
<td>0.3 million</td>
<td>$280,000 \times 0.05 \times 0.60 \times 30 = 0.3$ million 25 mg tablets per month</td>
</tr>
</tbody>
</table>

Clearly, advance planning and stockpiling of essential medications would be necessary if organizations are to quickly mount relief efforts of this magnitude.

**Duration of Response**

Determining the duration of response that is appropriate is the final step of planning care for the heart failure patients described above. Knowing how long care will be needed informs the required total cost and total amount of support. Unfortunately, it is unlikely that a relief organization will know how long relief will be needed when first responding to a disaster. The duration of a disaster’s effect on a community may be highly variable; an affected community’s reliance on foreign aid may last for days, months, or even years. Very severe disasters that affect communities with weak health systems may require two years or more of support, while disasters of smaller magnitude that affect communities with little structural vulnerability may require support for only a few weeks. The choice of how long to sustain disaster aid is a critical decision for relief organizations. On the one hand, withdrawing support too soon could result in substantial excess mortality in medically vulnerable populations. On the other hand, with prolonged aid there is depletion of resources for emergency relief efforts that may be needed elsewhere, and there is a real danger of fostering dependency of the affected community on external organizations. This is particularly true for medical assistance, since the
resources and standards of care of medical relief workers may greatly exceed those of the affected health system. Transition of responsibility back to the local health system on an appropriate timeline is critically important for ethical disaster relief, but it may be difficult to know when it is appropriate to withdraw.

I suggest that relief organizations should (1) respond quickly with sufficient resources for a short duration, (2) be prepared to sustain aid for a longer time, and (3) actively monitor the situation and withdraw in an orderly manner as rapidly as possible. In this context, “short” may be the time frame of one month, and “longer” may mean two years. Hence, I suggest that when stockpiling the medications according to the steps above, relief organizations should prepare for at least one month. During the initial days and weeks of response in the affected community, the responders ought to monitor the heart failure community’s needs, their success in meeting these needs, and the status of rebuilding of the health system. Additional medications can be then be purchased and transported to the disaster region at a rate based on the initial estimate of need and adjusted by the actual experience of the relief organizations on site. Communication and collaboration with local health authorities is important for ensuring that relief organizations do not leave the affected community too soon while there are still needs that the community’s health system is unable to meet but also do not stay too long and create a dependency of the community on the responders that inhibits the ability of local health care system to sustain the community. Periodic monitoring should take place as care is being provided so that responders properly judge the appropriate time to leave.
COST OF IMPLEMENTATION: IS IT WORTH IT?

Although individuals with chronic conditions may be severely affected by natural disasters, and the analyses above provide an example of how their needs for essential medications may be met by relief organizations, is it cost effective to provide care for these needs? Using the bisoprolol example given above for a hypothetical community of 300,000 persons, approximately 50,625 tablets of 5 mg bisoprolol would be needed to care for the heart failure population taking this medication for one month. The cost of one tablet of bisoprolol is $0.229, using data in Table 5-1. Thus, the cost to meet the need for bisoprolol in this community in US dollars would be (0.229) multiplied by (50,625), or $11,594 per month. Without factoring in costs of transportation of the supplies to the community, this is approximately $390 per day. By comparison, operating the USNS Comfort medical relief ship cost $180,000 per day.\textsuperscript{237} Although bisoprolol is only one of several heart failure medications that would need to be provided, the total cost of providing the needed amounts of these medications would be only a few thousand dollars per month, which pales in comparison to the cost of operating a relief ship such as the USNS Comfort, which arguably was not the appropriate response for caring for the actual needs of the Puerto Rican population after Hurricane Maria. In that disaster, exacerbation of chronic conditions was a much greater problem than trauma. Disaster relief is a costly endeavor, but it is important that relief provided effectively meets the actual needs of the affected community. Stockpiling medications for chronic conditions, and perhaps other needs of these populations, appears to be both an ethical and practical way to do so.

Considering all drugs for all common conditions, the cost of providing these drugs could be substantial. Because providing this care has not been a traditional responsibility of disaster relief organizations, consideration is needed of who should pay for these drugs
and services. As with other aspects of disaster relief, there may be roles for payment from public (government funds), charitable contributions, and foreign aid contributions from other nations. The responsibility to fund these initiatives may depend on the size of the relief organizations and the location of the disaster. Consideration of funding for medical care of vulnerable populations should become a routine component of disaster planning.

APPLICATIONS BEYOND THE DISASTER CONTEXT

Predictive models are of value for quantifying the anticipated needs of specific vulnerable populations after disasters, but these models may also be useful in other contexts in which populations are vulnerable. Some groups, such as pregnant women, prisoners, and children, possess universal vulnerability, or vulnerability in all settings. Other groups are more vulnerable in some situations than in others, giving them a contextual vulnerability that is setting-dependent. In this thesis, I identify and describe four populations that are contextually vulnerable in the disaster setting. However, all of the chronic conditions and medically vulnerable groups I address exist everywhere, and there is potential to apply this model and extensions of it to the needs of groups outside of the disaster context. Models such as the one I describe in this chapter could be used to plan care to address a nation’s chronic public health needs. In fact, a discrepancy between actual drug utilization and the need for a drug predicted by my model might suggest an underlying deficiency in that country’s health care system. Thus, predictive models like the one developed in this chapter may have applications far broader than disaster planning.
CHAPTER SIX: HUMAN RESILIENCE IN NATURE’S MISFORTUNES

SUMMARY

**Medical Vulnerability in Natural Disasters**

In the last three decades, the frequency and intensity of natural disasters have increased, and projections are that these trends will continue. With more common and stronger disasters worldwide, it is important that disaster responders from both governmental and nongovernmental organizations know how best to respond and care for affected populations. Although natural disasters can have severe immediate effects on the health of populations, they also pose threats to the long-term health of certain groups if disaster relief does not restore local health systems and health-related resources quickly enough to maintain ongoing care for these patients. In this thesis, I apply the concept of medical vulnerability to argue that certain populations are at risk of poorer health outcomes after natural disasters. These populations include patients with chronic medical conditions, the elderly, the mentally ill, and children. Health systems may likewise be vulnerable to structural damage and functional derangement following natural disasters, and this vulnerability can have serious implications for vulnerable populations in need of care. I argue that effective disaster relief must include care for the medically vulnerable in addition to those with acute trauma and immediate needs after disasters, and I propose a set of ethical considerations for those providing disaster relief.

The first three chapters describe aspects of the disaster context that contribute to poor health outcomes, both acute and chronic, for people in affected communities. These chapters demonstrate the complexity of the disaster context and the many factors that affect human health, from physical infrastructure of hospitals to access to medications to availability of electricity. These resources are required for routine clinical care, and they
are often compromised by disasters that destroy components of the health system and disrupt interactions between providers and individual patients. The fourth chapter analyzes ethical considerations in disaster response, focusing both on moral responsibilities to respond to natural disasters and on conditional moral obligations incurred by those who do respond voluntarily to natural disasters. That chapter proposes a set of ethical principles that are especially relevant to disaster responders and that would serve to ensure that disaster responses are appropriate and effective. A key element of these principles is the need for planning and preparation, and that aspect is illustrated in Chapter 5 by a proposed method of effectively planning care for the medically vulnerable. In that chapter, I develop a predictive model to estimate demand for essential medications for heart failure patients in specific communities affected by disasters.

Drawing from the experience of the Puerto Rican population after Hurricane Maria in the year following the storm’s landfall, my aim in writing this thesis was to identify populations and health systems that are vulnerable in natural disasters and to explore, from an ethical perspective, the obligations of disaster relief workers to deal with these vulnerabilities. I suggest that many of the estimated 2975 “excess deaths” in the six months after Maria could have been prevented by better planning and more effective disaster relief activities. To prevent a repeat of the Puerto Rican experience, I argue that aid following future disasters should be tailored to the affected community’s actual needs and unique population and that particular attention should be paid to medically vulnerable groups.
LIMITATIONS AND FUTURE WORK

Human Influence on Natural Disasters

One limitation of this thesis is that I focused solely on “natural disasters,” without evaluating the potential human influences on these disaster events. The defining characteristic of natural disasters is that they are caused by forces of nature, not by human action. However, there is some evidence that human choices do influence certain disasters that are classified as natural disasters, such as hurricanes, flash flooding, and heatwaves. Just as forest fires can be both natural and caused by humans, the line between “natural” and “unnatural” disasters is sometimes blurred, especially with growing evidence of the impact of anthropogenic greenhouse gas emissions on global climate change and weather-related disasters. The relationships between weather, climate, and human health were described in the section “Under the Weather” in Chapter One, where I argued that major disruptions in the weather or climate of a location, including those caused by certain natural disasters, are associated with poor health outcomes. Humans can do little to control the weather in a location, beyond predicting it through short-term forecasts. But there is increasing evidence that humans do influence the climate – that greenhouse gases emitted in our burning of fossil fuels and in our clearing of forests for agriculture increase climate variability and extreme weather. Climate change has the potential to influence natural disasters that are meteorological, or weather-related, such as hurricanes, floods, tornadoes, blizzards, droughts, heat waves, and hailstorms.

Small increases in the average summer temperature increase the probability that major heat waves will occur, and heat waves can have devastating impacts on medically vulnerable populations, especially the elderly. This was seen in the 2003 summer heat
wave in Europe, which caused over 22,000 deaths, with the elderly population taking the greatest hit. In areas such as the Caribbean and Atlantic where hurricanes are common, it is suspected that climate change has been associated with greater intensity of the storms. Stronger storms, with higher sustained wind speeds and more rainfall, cause more immediate damage to physical infrastructure in affected communities, which then leads to longer-term consequences for medically vulnerable populations, such as those seen in Puerto Rico following Hurricane Maria. For instance, the intensity of hurricanes originating in the Atlantic had been rising annually since 1995, and arguably the 2005 hurricane season, and particularly Hurricane Katrina, may have been a product of this trend – a trend that is arguably rooted in global climate change. Perhaps Hurricane Katrina and other disasters I evaluate were not entirely “natural.”

If human action can influence natural disasters, this may have implications regarding moral responsibility for disaster response. For instance, if certain countries are responsible for the greatest greenhouse gas emissions in a certain area of the world, they may be more responsible than other countries for causing, and by extension for responding to natural disasters that occur in those areas. These questions and concepts, and analysis of ethical responsibilities in disaster response in light of human influence on natural disaster frequency and intensity, would be interesting and useful extensions of this work.

Prediction and Response

Although knowing how best to respond to natural disasters is important for ensuring the most appropriate and effective care for those in disaster-affected communities, there are situations where the most effective action is that which takes
place before the disaster event occurs. In some cases, maximizing good outcomes in natural disasters is more a matter of prediction and prevention than of response. This is evidenced in a comparison between tsunamis in Indonesia and Japan. In December 2004, a magnitude 9.1 earthquake occurred off the west coast of the Indonesian island of Sumatra. This earthquake triggered a tsunami in the Indian Ocean that devastated many countries in Southeast Asia.\textsuperscript{246} Often referred to as the “Boxing Day” tsunami, this disaster killed 230,000 people in 14 countries.\textsuperscript{247} Over half of those casualties – at least 128,858 – occurred in Indonesia, the country closest to the epicenter of the 9.1 magnitude earthquake that triggered the tsunami.\textsuperscript{248} In March 2011, a similar magnitude 9.0 earthquake occurred near the coast of Japan, triggering a tsunami in the Pacific Ocean, which impacted the coastal regions of Japan and caused approximately 4000 deaths.\textsuperscript{249} Over 30 people died in the Indonesian tsunami for every one person who died in the Japan tsunami, even though both were triggered by similar magnitude earthquakes. One reason proposed for why the death toll following the Indonesian tsunami was much greater than that of the Japanese tsunami was that the latter had an effective tsunami warning system in place, and residents of coastal areas of Japan knew how to react to such a warning, while the former lacked such a system.\textsuperscript{250} Many of those residing on the coasts of the Indonesian island of Sumatra on the day of the earthquake were not aware of the oncoming wave or of how to respond appropriately once it was visible. Some, particularly tourists, even walked out onto the beaches as the tsunami approached – curious and not aware of its great potential to inflict harm on those in its path. Japan in 2011, in contrast, had both an earthquake warning system and a tsunami warning system of buoys in the Pacific Ocean that were in place at the time of the disaster event and that
sent warning messages that allowed those in areas in the tsunami’s path to evacuate and move to higher ground.  

In the case of these tsunamis in Indonesia and Japan, *anticipation* of the disaster event is perhaps more important than planning *response* to the event in affected communities. While I focus primarily on the response stage of disaster relief, there is great opportunity for extensions of the work on moral responsibility and ethical considerations in anticipating disaster events, as well as the effects of appropriate anticipation on health outcomes in affected communities.

**Other Medically Vulnerable Populations**

The term ‘medically vulnerable’ refers to populations that have increased risk of poor health outcomes, either in general (universal vulnerability), or in specific settings (contextual vulnerability). In this thesis, primarily in Chapter Two, I identify four populations that are medically vulnerable in natural disasters: patients with chronic conditions, the elderly, those with mental illnesses such as anxiety and depression, and children. There are likely other populations that may have similar levels of vulnerability in the disaster context, including pregnant women, those with other mental illnesses or cognitive impairments, and the functionally and intellectually disabled. The scope of this thesis was limited to the four populations described in Chapter Two, but there is great opportunity for extensions of this work to analyze the vulnerability of other populations in the disaster context. Extensions may even expand upon the groups I identify, such as evaluating other chronic conditions (beyond hypertension, type 2 diabetes, heart failure, and chronic obstructive respiratory disease), such as stroke, cancer, and asthma. The root causes and potential implications of vulnerability for these populations would be
extensions of this work that would serve to inform disaster relief efforts more completely, as well as patients and health care providers in disaster-affected areas.

**Predictive Modelling**

*Limitations of Proposed Model.* The predictive model developed in Chapter 5 was intended to show the type of planning that could and should be done by disaster relief organizations to prepare and respond more effectively to the health needs of vulnerable populations in affected communities. Since it was intended to be illustrative, this model was limited to a single condition, heart failure, and it further focused on the need for medications.

The development of my model revealed gaps in knowledge that may hamper its extension to other conditions. Despite the fact that cardiovascular disease is the most common cause of death worldwide, data on the prevalence of heart failure are available for only a handful of countries, mainly from affluent nations of North America and Europe. Some of these data have large uncertainty and some (e.g., from India) are suspected to be inaccurate. The lack of reliable data on prevalence limits the confidence for estimates of prevalence in other countries, particularly low- and middle-income countries. This limitation is probably not important in the case of heart failure, since my model appears to be correct within a factor of two, which is arguably less uncertainty than that of many other factors related to natural disasters, such as the amount of food needed in a community, or the percent of hospitals closed. Nevertheless, predictive modeling for other chronic conditions is likely to be both more difficult and less accurate than for heart failure, since the epidemiological data for less common conditions is probably more sparse and less reliable. Additional research is needed to better estimate
the prevalence of disease globally and the associated needs for drugs and supplies. This research might employ population surveys or, alternatively, could develop models based on mortality data or health care utilization data.

Another limitation of existing epidemiological data is its geographic resolution. The demographic data used by my model are generally available for countries as a whole, but not for particular regions or communities. Because of this, I chose to ignore possible regional variations in disease prevalence, assuming that all communities within a country have the average characteristics of that country. Extensions of this approach could attempt to better model the characteristics of particular communities by considering local characteristics in the estimates. Such an extension is probably needed most in situations where there is physical proximity between communities that differ widely in wealth. In such a case, it is likely that natural disasters would have disparate effects on the health of these communities.

Extension of Proposed Model. The proposed predictive model estimates amounts of certain medications that would be needed to care for patients with heart failure after a natural disaster in their community. Possible extensions of the model include similar predictive measures of medication needs for other populations with chronic diseases. Full implementation of this type of planning would require extensions of this methodology to a fuller range of chronic conditions (hypertension, asthma, diabetes, COPD, kidney failure, cancer, depression, psychosis, anxiety, arthritis, HIV, etc.), to a more complete listing of the materials, supplies, and personnel needed for outpatient treatment of these conditions (disposable supplies, durable medical equipment, etc.), and to the facilities required for inpatient management of associated exacerbations. Perhaps the other chronic
conditions identified in Chapter Two – hypertension, type 2 diabetes, anxiety, depression, and chronic respiratory obstructive disorder, would be highest priority for development of similar predictive models. Other high priority groups may be those for whom interruption of drug supply can have catastrophic consequences, such as survivors of ischemic stroke who are dependent on anticoagulants and anti-hypertensives to prevent recurrent cerebrovascular events.

Heart disease → diuretic and anti-hypertensive medications
Ischemic stroke survivors → anticoagulants and anti-hypertensives
COPD → home oxygen therapy
Diabetes → insulin
Kidney failure → hemodialysis

These extensions can be guided by existing clinical practice guidelines and should be straightforward. Less obvious but perhaps equally important is the need for disaster planners to anticipate non-medical resources that are needed for health, such as low-salt meals for those with heart failure.

Another useful extension of this work would be to develop other materials, such as educational booklets on how those with specific chronic diseases are affected by natural disasters. Educational materials could be used to help health care providers and patients, as well as responders, prepare for natural disasters.

VULNERABILITY AND RESILIENCE

Lisbon to Maunabo

“It was hardly nature who assembled there twenty-thousand houses of six or seven stories. If the residents of this large city had been more evenly dispersed and less densely housed, the losses would have been fewer or perhaps none at all... For me, I see everywhere that the misfortunes nature imposes upon us are much less cruel than those we please to add.”

253
The quotation above comes from a letter from Jean-Jacques Rousseau to Voltaire dated August 18, 1756. In discussing a poem Voltaire had written on the Lisbon Disaster, a major earthquake that devastated the city of Lisbon in 1755, Rousseau asserts that the devastation it caused – between 10,000 and 100,000 people died, an entire city lay in ruins – was exacerbated by human choices, not merely the unfortunate result of natural causes.254

“Lourdes! Lourdes!” These were the last words of 77-year-old Natalio Rodriguez Lebron – a cry for help to his daughter Lourdes Rodriguez on January 6, 2018, 108 days after Hurricane Maria made landfall in Puerto Rico.255 Natalio had many chronic conditions that required ongoing care, including diabetes, lung disease, sleep apnea, and congestive heart failure. In the months after Maria, his condition worsened. He could not use his sleep apnea machine due to electric power outages in his neighborhood in Maunabo, Puerto Rico, that lasted for months. Three months after the storm, a generator was donated to the family to help power the CPAP, but they struggled to afford gasoline to keep it running. Early on January 6th, 2018, the generator failed and the CPAP fell silent. Lourdes entered her father’s room in response to his call for help, finding her father clutching his chest and unable to breathe. She tried to restart the generator, but was unsuccessful. Natalio never regained his breath.

Perhaps the many deaths caused by the Lisbon Disaster could have been prevented had the disaster occurred in a less populated area, or if the city of Lisbon had been less heavily developed, as Rousseau points out. Bigger buildings and more people provide more opportunities for physical destruction and human injury. Yet the factors that led to deaths in Puerto Rico following Hurricane Maria appear quite different. What
would have prevented Natalio Rodriguez Lebron’s death was unrelated to the population density and sheer number of buildings in his neighborhood. It was his ability to use his CPAP machine – his ability to access a working generator. For others like him, it was lack of access to essential medications for heart failure, or access to refrigeration for insulin. It was not that Puerto Rico communities were physically vulnerable to major storms, but rather that they were functionally vulnerable – at greater risk of being unable to meet the needs of those affected by the storm in the months after Maria, even though clinics and hospitals and ships full of relief supplies and personnel were sent to their shores. Before the next disaster, how will we prepare to care for those who are not crushed under fallen buildings and not immediately affected by the disaster event? How can we foster resilience instead of worsening existing vulnerabilities in communities affected by natural disasters? What will we do to help the next Natalio Rodriguez? This thesis proposes an initial approach to answering these serious questions.
ENDNOTES


19 Ram-Tiktin, E. “Ethical Considerations of Triage Following Natural Disasters: The IDF Experience in Haiti as a Case Study.” *Bioethics* (2017); 31(6): 467-475.


41 Ibid.
56 Macklin, R. “Bioethics, vulnerability, and protection.” *Bioethics* (2003); 17(5-6):472-86.
60 Kwek, A. “The indispensability of labelling groups to vulnerability in bioethics.” *Bioethics* (2017); 31:674-682.
65 Ibid.
66 Ibid.
67 Ibid.
70 Ibid.


80 Ramphal, Lilly. “Medical and psychosocial needs of the Puerto Rican people after Hurricane Maria.” Baylor University Medical Center Proceedings (July 2018); 31(3): 294-296.


“Mental Health Atlas 2017.” World Health Organization (2018). License: CC BY-NC-SA 3.0 IGO, Table 3.2.2.


“Mental Health Atlas 2017.” World Health Organization (2018). License: CC BY-NC-SA 3.0 IGO, Table 3.2.5.


“Mental Health Atlas 2017.” World Health Organization (2018). License: CC BY-NC-SA 3.0 IGO, Table 3.2.5.

Ibid.


127 Ibid.

128 Ibid.

129 Ibid.

130 Ibid.

131 Ibid.

132 Ibid.

133 Ibid.

134 Ibid.


136 Ibid.


140 Ibid.

141 Ibid.

142 Ibid.

143 Ibid.


146 Ibid.


151 Initial death tolls varied based on the source, most commonly referenced is 64.


154 Ibid., 1-42.


157 Ibid.


160 Ibid.


Santiago, L., Simon, M. “There’s a hospital ship waiting for sick Puerto Ricans – but no one knows how to get on it.” *CNN Health*. October 17, 2017. Available at: https://

196 Ibid.


Data on percent of patients on particular drugs obtained from: Murphy, G et al. “Cardiovascular Medication Utilization and Adherence Among Heart Failure Patients in Rural and Urban Areas: A Retrospective Cohort Study.” Canadian Journal of Cardiology (2015); 31: 344.


Ibid.


Ibid.

Ibid.


Ibid.


CURRICULUM VITAE

Personal Data

Name: Rachel Dare Croxton  
Address: 303 Timber Lane, Falls Church, Virginia 22046  
Telephone: (703) 220-0104  
Email: rachel.croxton@gmail.com  
Date of Birth: March 24, 1995  
Place of Birth: Baltimore, Maryland

Education

Graduate:  
Master of Arts, Bioethics  
Wake Forest University  
Thesis: “Medical Vulnerability in Natural Disasters: The Ethics of Responsibility and Response”  
Winston-Salem, North Carolina  
Anticipated Graduation December 2018

Undergraduate:  
Bachelor of Science, Chemistry with Biochemistry  
Wake Forest University  
Winston-Salem, North Carolina  
Graduation May 2017

Work Experience

Research Specialist II  
Wake Forest Baptist Medical Center  
Department of Neurology  
Winston-Salem, North Carolina  
November 2017 – Present

Revenue Cycle Intern  
Wake Forest Baptist Medical Center  
Department of Admissions and Registration  
Winston-Salem, North Carolina  
June 2017 – August 2017

Chemistry Research Fellow  
Wake Forest University Department of Chemistry  
Winston-Salem, North Carolina  
June 2016 – August 2016

Research Assistant  
Ameritox, Ltd.  
Research & Development  
Greensboro, North Carolina  
## Research Experience

*FRET-based fluorescence assay for microRNA detection*
- Advisor: Christa Colyer, PhD
- Presentations: 2016 Southeastern Regional Meeting of the American Chemical Society (SERMACS); 2016 Wake Forest University Undergraduate Research Day
- June 2016 – August 2016

*Fluorescence-based assay employing graphene quantum dots for tricyclic antidepressants*
- Advisor: Christa Colyer, PhD
- Presentation: 2015 Wake Forest University Undergraduate Research Day
- May 2015 – August 2016

*Validation of a 6-monoacetylmorphine (6-MAM) repeat assay by LC/MS/MS*
- Advisor: Erin Strickland, PhD

## Volunteer Experience

<table>
<thead>
<tr>
<th>Role</th>
<th>Organization</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>President</td>
<td>Baptist Student Union</td>
<td>May 2016 – May 2017</td>
</tr>
<tr>
<td></td>
<td>Wake Forest University</td>
<td></td>
</tr>
<tr>
<td>Pharmacy Client Assistant</td>
<td>Crisis Control Ministry Pharmacy</td>
<td>February 2016 – May 2017</td>
</tr>
<tr>
<td></td>
<td>Winston-Salem, North Carolina</td>
<td></td>
</tr>
<tr>
<td>English Language Tutor</td>
<td>Wake Forest University</td>
<td>January 2015 – May 2015</td>
</tr>
<tr>
<td></td>
<td>Professional Development Center</td>
<td></td>
</tr>
<tr>
<td></td>
<td>International Student Language Workshop</td>
<td></td>
</tr>
<tr>
<td>Pastoral Care Coordinator</td>
<td>Baptist Student Union</td>
<td>August 2014 – May 2016</td>
</tr>
<tr>
<td></td>
<td>Wake Forest University</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Satun, Thailand</td>
<td></td>
</tr>
<tr>
<td>Dental Assistant</td>
<td>Christian Emergency Relief Teams International</td>
<td>June 2011, June 2012</td>
</tr>
<tr>
<td></td>
<td>Puerto Maldonado, Peru</td>
<td></td>
</tr>
<tr>
<td>Awards and Honors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
<td>-----------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Provost Merit Scholarship</td>
<td>Wake Forest University</td>
<td></td>
</tr>
<tr>
<td></td>
<td>August 2017 – December 2018</td>
<td></td>
</tr>
<tr>
<td>Bioethics Scholarship</td>
<td>Wake Forest University</td>
<td></td>
</tr>
<tr>
<td></td>
<td>August 2017 – December 2018</td>
<td></td>
</tr>
<tr>
<td>Wake Forest Research Fellowship</td>
<td>Wake Forest University</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Department of Chemistry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>June 2016 – August 2016</td>
<td></td>
</tr>
</tbody>
</table>