Natural Disasters and Medication Interruption: A Systematic Literature Review

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Abstract

Background: Natural disasters often cause both structural and non-structural damage to healthcare buildings. They can disrupt supply chains, limit hospital capacities, reduce access to healthcare providers, and force the evacuation of healthcare facilities. These disruptions have a particular significance in relation to an increasing number of individuals around the world living with non-communicable diseases who require ongoing medical treatment.

Objective: The aim of this systematic literature review is to identify the impact of natural disasters on the continuity of care for pre-existing conditions during natural disasters, including the impact of medication loss and medical aid loss on individuals displaced during disasters, and the difficulties of providing continued care by medical relief teams following extreme weather events and other natural hazards.

Methods: Key health journal databases (Medline, AGRICOLA, Global Health, PsycInfo) were searched via the Ovid SP search engine. Search terms were identified by first consulting MeSH terms and then by using other key terms as part of a secondary review. Journal articles, meta-analyses, and systematic reviews published from January 2000 to December 2020, that were written in English and contained an abstract, were included in this review. Book chapters, clinical trials, abstracts for conferences or dissertations, and articles written in a language other than English were excluded. 87 articles were screened first by title, and then by abstract eligibility. The remaining articles (n = 36) were screened based on their full text, and a secondary screening via

citation searching was conducted which resulted in an additional 20 articles. From these articles, 7 were rejected for not fulfilling the inclusion criteria, and 14 were literature review articles.

Results: A total of 35 articles which fulfilled the inclusion criteria were included in this systematic review. A substantial number of individuals experienced a period of medication interruption following natural disasters, and current recommendations for personal preparedness have proved ineffective in most countries. Additional barriers to reestablishing continued care for individuals with pre-existing conditions include a lack of patient knowledge regarding their own medical history, and inadequate availability of essential medications.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

ADD	Action on Disability and Development
ART	Antiretroviral Therapy
CBO	Community Based Organization
CBM	Christian Blind Mission
CBR	Crude Birth Rate
CDD	Centre for Disability in Development
CRED	Centre for Research on the Epidemiology of Disasters
CSO	Country Support Offices
DPO	Disabled People's Organization
DRR	Disaster Risk Reduction
DRRA	Disabled Rehabilitation & Research Association
EM-DAT	CRED's Emergency Event Database
HIV	Human immunodeficiency virus
IDMC	Internal Displacement Monitoring Centre
IDP	Internally displaced person(s)
IDU	Intravenous drug users
LAC	Local Assistance Centers
NGO	Nongovernmental organizations
PEP	Post-exposure prophylaxis
STI	Sexually Transmitted Infections
TB	Tuberculosis
UNICEF	United Nations Children's Fund
UNDRR	United Nations Office for Disaster Risk Reduction

USAID	United States Agency for International Development
WHO	World Health Organization

Preface

I would like to take a moment to commend the bravery and selflessness of the first responders who have assisted in rescue and recovery of the populations affected by the natural disasters discussed in this paper. Many of them have sacrificed their time, health, and in some cases their lives, to help others.

I would also like to say that the purpose of this paper is not to undervalue the efforts of emergency medical personnel and disaster response volunteers, nor to devalue the necessity of triage systems in the event of large-scale disasters requiring extreme rescue efforts. This paper seeks to highlight ways in which the medical care of individuals at evacuation sites who are not suffering from severe acute injuries can be improved.

1.0 Introduction

Traditionally, emergency responses to natural disasters have focused on immediate healthcare needs such as the control of infectious diseases and storm-related injuries. Initial disaster risk reduction (DRR) efforts are generally aimed towards providing individuals with shelter, food, and water (4). However, researchers and public health experts have begun to recognize the need for emergency response teams also to prioritize the creation of services and resources in order to provide continuity of care to vulnerable displaced populations with pre-existing conditions in disaster settings (5). These individuals are more likely than the general population to experience adverse health events due to an inability to access healthcare services or medication. Additionally, the two main goals of disaster medicine have always been "to reduce the number of disaster-related deaths" and to "restore the normal medical system" (6). These goals cannot be accomplished without increasing the attention given to, and resources directed towards , providing care relevant to pre-existing conditions, particularly as an increasing percentage of disaster-related deaths are correlated with the worsening of pre-existing respiratory and cardiovascular conditions (6).

One of the most common, and least studied aspects of natural disasters is the disruption of medical services for individuals with pre-existing conditions, in particular the interruption of medications and medical treatment. Medication interruption during natural disasters can be influenced by a variety of factors, both at an individual level and a systems level. Individual level examples of this include a lack of preparation by individuals or households to ensure that they are ready in the event of an emergency, or that patients have adequate knowledge of their own medical history including their current prescriptions and drug allergies. At a systems level, medication

interruption may occur when emergency shelters and pharmacies are not prepared adequately by healthcare professionals and emergency response centers. Structural damage to hospitals and medical facilities often leads to delays in providing care. An inability to gain access to medical histories or past treatment information can make it difficult for pharmacists and emergency medical teams to reliably determine what medication they should be providing to individuals seeking prescription refills or follow up care. Additionally, this structural damage often extends to the wholesale supply of medications and medical equipment, which may lead to largescale shortages of medical supplies if contingency plans are not in place to restock supplies in the event of an emergency. Delays in medication distribution or cessations following an extreme weather event, can further exacerbate chronic conditions and enable the transmission of infectious diseases within local communities and shelters. The interruption of medication for non-communicable diseases (NCDs) is of particular importance, considering that NCDs account for seven of the world's top ten causes of death globally, and there has been a sharp increase in the prevalence of these diseases over the past two decades (7). The leading global cause of death is heart disease and it represents 16% of total deaths from all causes (8). Deaths attributed to diabetes also increased by 70% between 2000 and 2019 (8). Additionally, while the global average life expectancy has increased from 67 years-of-age in 2000 to 73 years-of-age in 2019, there has also been a subsequent increase in the number of adults living with disabilities (7). Natural disasters can further exacerbate chronic health conditions and the trauma of these events can increase the severity of mental illness symptoms in individuals with pre-existing mental illnesses (9). The aim of this systematic literature review is to identify the extent and implications of medication interruption and/or loss on individuals with pre-existing medical conditions following natural disasters and extreme weather events.

2.0 Background

2.1 Natural Disasters

The WHO defines a 'disaster' as "an occurrence that disrupts the normal conditions of existence and causes a level of suffering that exceeds the capacity of adjustment of the affected community." (10) A storm, cyclone, or "natural event" is not classified as a 'disaster' unless it overwhelms the capacity of the municipal or national authorities to respond effectively to the event (11). The WHO further differentiates disasters into those that occur via human causes vs. natural causes (10). Additionally, in order for an extreme weather event or hazard to be categorized as a disaster by EM-DAT, the event must meet at least one of the following criteria; 1) ten or more fatalities 2) 100 or more people affected by the event 3) declaration of a state of emergency 4) there must be a call for international assistance (12). This paper focuses on disasters caused by natural causes such as geophysical, meteorological, climatological, and/or hydrological events.

Natural disasters and extreme weather events can decimate local and national healthcare systems leading to a major loss of life, and morbidity. The 2004 tsunami that hit Aceh, Indonesia killed 131,000 individuals, and displaced over 400,000 people. In some villages, more than 70% of the community died (13). In 2005, an earthquake in Pakistan and India left over 80,000 dead and 3.5 million people displaced (14). In the United States, Hurricane Katrina (2005) affected over 15 million people and killed over 1600 individuals (15). An estimated 273,000 people ended up in emergency shelters and 114,000 were housed in FEMA trailers. More recently, in 2018, Hurricane Maria killed an estimated 1139-4645 individuals living in Puerto Rico (16).

The scale of mortality following a natural disaster is influenced in large part by the wealth and existing infrastructure within countries. Poor and marginalized communities are more likely to be disproportionally affected by disasters, these countries often have a higher level of vulnerability to disasters. Vulnerability to natural disasters is defined as a the circumstances or aspects of a community, system, or asset that make it more susceptible to the damaging effects of a disaster (17) . Developing nations are more vulnerable to natural disasters because more individuals live in areas of high risk, housing structures are more likely to be informal or poorly built, developing countries may lack early warning systems, and individuals are less likely to have substantial assets or a strong social network capable of supporting them after a disaster (18). For example, in 1988, Armenia experienced an earthquake registering 6.9 on the Richter scale. This event led to the death of 55,000 individuals and displaced over 500,000 individuals. When this event is compared to an earthquake the following year that hit San Francisco, California, measuring 7.1 on the Richter scale, that led to the death of only 62 individuals and displaced 12,000, a remarkable difference is noted. Despite the increased severity of the earthquake in California, mortality was much lower due in large part to better infrastructure compared to some of the poorly constructed informal housing seen in Armenia's poorer neighborhoods (19). Individuals living in California in 1989 received more effective early warnings, lived in stronger housing structures, and were less likely to struggle to find safe drinking water, food, or medical aid when compared to Armenia in 1988. In the years between 1991 and 2005, approximately 90% of disaster-related deaths and 98% of people affected by natural disasters were in developing nations (20). Additionally, natural disasters pose a much greater financial burden in low-income countries compared with richer industrialized countries. Snel (2002) and Raddatz (2009) both found that natural disasters in low-income countries cost a higher percentage of GDP than in rich

countries, and that low-income countries saw a 1% decline in per capita GDP compared to the loss sustained by middle- and high-income countries (0.25-0.5%) (18,21). It is unlikely that this trend will change substantially in the next decades as climate change has been shown to have a much more substantial impact on poorer countries when compared to rich ones, and as more individuals migrate out of rural agricultural areas damaged by natural disasters to urban areas seeking better paying jobs and opportunities (22,23). It is estimated that by the year 2030, over 325 million individuals living in poverty will reside in the 49 countries most exposed to the full range of natural disasters (24).

Table 1. 10 most significant natural disasters worldwide by mortality from 2000-2019

Country	Year	Disaster type	Estimated Deaths
Indonesia, Thailand, and other Indian Ocean countries	2004	Earthquake / Tsunami	226,408
Haiti	2010	Earthquake	225,570
Myanmar	2008	Cyclone	138,366
China	2008	Earthquake	87,476
Pakistan	2005	Earthquake	73,338
Central Europe	2003	Heat wave, drought	72,210
Russia	2010	Heat wave	55,736
Iran	2003	Earthquake	26,716
India	2001	Earthquake	20,005
Somalia	2010	Drought	20,000

Natural disasters often cause both structural and non-structural damage to healthcare buildings; they can disrupt supply chains, limit hospital capacities, result in the loss of healthcare staff, and force the evacuation of health care facilities (2,3). In addition to damage to healthcare systems, during extreme weather disasters, the accumulation of debris and stagnant water can lead to an acceleration of infectious outbreaks including leptospirosis, dengue, zika, and chikungunya

(16). The consequences of these disaster events can cost governments a large portion of their annual operating budgets, and the WHO approximates that the average annual cost of natural and technological hazards is US$300 billion (3). Furthermore, the annual economic cost of disasters can go much higher in the face of a disaster that causes massive damage to infrastructure. For example, the 2011 earthquake and tsunami that hit Japan resulted in over US$239 billion in economic losses (12).

The economic losses from natural disasters include both the short-term or direct costs such as the immediate loss of life, lost workforce and wages, destruction of goods and property, damage to natural ecosystems, and the long-term indirect costs that occur far beyond the disaster event itself. Areas hit by largescale natural disasters often see an increase in poverty and an increase of inequality amongst those affected (25). The recovery costs can be extremely high. For example, the recovery following Hurricane Katrina is estimated to have cost more than $100 billion in US federal aid alone (15). The average annual cost of natural disasters globally is likely to continue to increase as the number of natural disaster events increases over time, an increase attributable in large part to global warming.

2.2 Classification of Disasters

Overall, natural disasters can be classified into four types of events; geophysical, meteorological, hydrological and climatological (26,27). The main type of geophysical events are earthquakes, which are caused by seismic waves caused by the buildup of friction between tectonic plates beneath the earth's surface. These events lead the ground to shake, and the intensity of the effects can vary. The impact of an earthquakes is measured with the Modified Mercalli Intensity

Scale which ranges from "I," meaning no damage, to "XII," which is complete or total damage, meaning there are no surviving structures. Earthquakes occur predominantly along the Pacific Rim, with over 81% of the world's largest earthquakes occurring in that region. Earthquakes can also lead to tsunamis, which are seismic sea waves caused by a geophysical event (28). Over the past twenty years, earthquakes and tsunamis have been responsible for 58% of the total global mortality from natural disasters (12). A literature review conducted by Doocy et al. (2013) on the historical impact of earthquakes found that earthquakes impacted over 61 million individuals between 1960 and 2009 and were responsible for over 370,000 casualties globally. During that time period, they also rendered over 16 million individuals homeless. While the studies of these events detailed the acute injuries and deaths from earthquakes, few if any reported on the long-term health impacts of individuals who suffered interrupted medical treatment (29).

Meteorological events including storms, hurricanes and cyclones are the second deadliest type of disaster and are responsible for the deaths of an estimated 200,000 individuals between 2000 and 2019 (12). Hurricanes or cyclones cause high winds, flooding, heavy rain, and storm surges. Island states and coastal regions are the most vulnerable to these types of natural disasters, and Southeast Asia is the highest affected region in the world. Cyclone Nargis hit the coast of Myanmar in 2008 resulting in over 138,000 deaths, making it the deadliest storm worldwide since the 1990's. It is also important to note that the number of storm events is increasing exponentially. Between 1980 and 1999 there were a documented 1457 storm-related disaster events, compared to 2043 in the twenty years following (2000-2019) (12). This almost doubling of storm events suggests that it is necessary and not just prudent for countries to invest in the infrastructure and disaster preparation to withstand these events. An investment in storm preparation is also economically prudent when you consider that meteorological events were responsible for over

49% of the total economic losses from disasters between 2000-2019 compared with the 22% of total economic losses from geophysical events (12).

Hydrological disaster events can be linked to meteorological disasters, and both pose some of the same overlapping challenges for countries. Floods account for 44% of all disaster events globally and are the most common type of disaster event (12).

The two major types of climatological events are droughts and wildfires. Droughts are events brought on by a lack of rainfall, and while they account for only 5% of all disaster events, they can impact millions of people. In 20016 and 2017, a drought in Eastern Africa caused by El Niño events affected over 20 million people (12). Wildfires can occur during both droughts and heat waves and can be due to both human and natural causes. The vast majority of naturally-caused wildfires are ignited by lighting hitting a tree or other fuel source (30). In the past 20 years, 26% of wildfire events and 69% of the economic losses due to wildfires occurred in the United States (12).

Table 2 Classification of natural disaster events

Natural Disaster Groups	Natural Disaster Subgroups
Geophysical A hazard originating from solid earth (geological hazard).	Earthquakes • *Ground movement* • *Tsunami* Mass Movement (dry) • *Rock fall* • *Landslide* Volcanic Activity • *Ash fall* • *Lahar* • *Pyroclastic flow* • *Lava Flow*
Meteorological A hazard caused by short-lived, micro- to meso-scale extreme weather and atmospheric conditions that last from minutes to days.	Storms • *Extra-tropical storm* • *Hurricanes / Cyclones* • *Tropical Storm* • *Convective Storm* Fog Extreme Temperature • *Cold wave* • *Heat wave* • *Severe winter Conditions*
Hydrological A hazard caused by the occurrence, movement, and distribution of surface and subsurface freshwater and saltwater.	Floods • *Coastal floods* • *Riverine floods* • *Flash floods* • *Ice jam floods* Landslides • *Avalanches (snow, debris, mudflow, rockfall)* Wave action • *Rogue wave* • *Seiche*
Climatological A hazard caused by long-lived, meso- to macro-scale atmospheric processes ranging from intra-seasonal to multi-decadal climate variability.	Wildfires • *Forest Fire* • *Land fire (Brush, bush, pasture)* Droughts Glacial Lake Outburst

2.3 Internally Displaced Persons (IDPs)

Displacement from disasters has been acknowledged by the UN General Assembly through the Sendai Framework for Disaster Risk Reduction (Sendai Framework) as one of the most devasting aspects of natural disasters (31). Disaster displacement occurs when people are forced to leave their homes or residences as a result of a natural disaster or hazard (32). The two main causes of human displacement are conflict and natural disasters. The Internal Displacement Monitoring Centre (IDMC) estimates that 22.7 million people were displaced annually between 2009-2019 by natural disasters. This number is three times the number of people displaced by conflict and violence (32). Between 2008-2018, an estimated 87% of all disaster displacement was weather-related and 13% was caused by geophysical hazards (33). One of the major differences between human displacement from conflict vs. natural disasters is that the displacement from natural disasters is generally temporary and remains within the borders of the affected country (19). These populations are often referred to as internally displaced persons (IDPs). One of the major challenges facing IDPs following disasters is that while most attempt to return home, they often find that basic infrastructure and social services have been damaged to such an extent that it can take years to rebuild. This means that many IDPs return to areas with damaged homes that are unsafe, lack clean water, and lack adequate healthcare facilities. Individuals with pre-existing conditions and disabilities are likely to be overrepresented as IDPs. This is due in part to the higher poverty rates among individuals with disabilities and the increased risk of inadequate or safe housing to individuals with disabilities (34). India, the Philippines, Bangladesh, and China all reported over 4 million people displaced by natural disasters in 2019 alone. The main causes of displacement in South Asia were floods triggered by the monsoon in India and Bangladesh, and cyclones Fani and Bulbul. Cyclone Fani alone led to the evacuation of over 1.7 million people

from the coastal districts in Bangladesh. The United States reported over 916,000 displaced individuals, the majority of whom were displaced by storms and wildfires. In 2019, Hurricane Dorian led to the evacuation of more than 450,000 individuals from North and South Carolina, Florida, Georgia and Virginia, and wildfires displaced over 400,000 Californians (33). While evacuation efforts have greatly decreased the mortality rates from disaster events, more needs to be done to ensure that IDPs returning home have access to clean drinking water, healthcare facilities including on-going access to necessary medication and stronger infrastructure capable of withstanding extreme weather events.

2.4 Infectious Disease Outbreaks

While the purpose of this paper is to evaluate the impact of natural disasters on the disruption of treatment for pre-existing conditions, it is important to recognize the impact of infectious diseases on populations in post-disaster settings. Reported illnesses and pathogens have included sporadic cholera outbreaks, *Cryptosporidium hominis,* leptospirosis, anthrax, *Escherichia coli, Campylobacter jejuni, Giardia lamblia,* norovirus, and *Salmonella enterica* outbreaks (35,36). Diarrheal diseases are a leading cause of death in evacuation camps due in large part to polluted water sources and the contamination of shared water containers and food preparation tools (37). A study conducted in Calang, Indonesia, after the 2004 tsunami found that over 85% of survivors in the city experienced diarrheal illnesses (38).

The impact of natural disasters on infectious disease prevalence within countries can be long-lasting. For example, following the Wenchuan earthquake in 2008, the Sichuan Centre for Disease Control and Prevention reported 2414 cases of infectious diseases within 90 days of the

earthquake. Sichuan province saw an increase in the incidence of highly infectious diseases including measles, hepatitis, influenza, meningitis, and encephalitis two years after the earthquake, suggesting that these major disaster events can have a lasting impact on the risk of infectious disease acquisition within affected regions (39). Similarly, the earthquake in L'Aquila Italy (2009) led to an almost 20% increase in hospital admission rates from infectious diseases in the two months following the earthquake (40). An increase in preventable infectious diseases is common following disasters, and likely attributable to the structural damage to healthcare facilities and healthcare systems, disruption of surveillance and health programs including immunization programs, interruption of ongoing treatment of infectious diseases including tuberculosis and HIV, and the use of unprescribed medications (37).

2.5 Need for Additional Research

As the prevalence of individuals living with chronic diseases or non-communicable diseases increases, and as natural disasters continue to increase in frequency, there is need for further research into the impact of disaster events on those living with pre-existing conditions. This literature review provides an initial effort to summarize the existing research on how natural disasters impact individuals with complex healthcare needs, and attempts to identify the successes and failures of both NGOs and government emergency efforts to prepare populations for disasters, in order to make recommendations for future prevention campaign efforts. The primary focus of this literature review was on medication interruption during disasters and evacuations and on the length of time it took individuals to become reconnected with medical treatment or care for these pre-existing conditions. This literature review did not attempt to look at acute injuries or medical

conditions caused by exposure to a natural disaster, as there is already substantial research on that topic. Instead, this literature review hoped to identify the ways in which these events could worsen existing health conditions, and which populations were most likely to be vulnerable to medication and medical treatment interruption.

3.0 Methods

3.1 Identification

The key health journal databases (Medline, AGRICOLA, Global Health, PsycINFO**)** were searched via the Ovid SP search engine. Search terms were identified by consulting MeSH terms. The first pilot search did not identify many articles, so a second search was conducted using key words related to disaster and medication as shown in Table 1 to increase the chances that relevant articles would be identified.

Table 3 Search terms used and limitations

Search Area	Term Category	Terms
MeSH terms	Disaster	Disasters Disaster medicine Disaster planning Earthquakes Hurricanes Natural Disasters Tsunami Wildfires
	Medication	Drugs Drug prescriptions Drug utilizations Medic Medical Medicalization(s) Medications Medication Interruption Pharmaceutical preparations Prescriptions or medications

3.2 Eligibility Criteria

1. **Inclusion Criteria:** Peer-reviewed journal articles were eligible for inclusion if they were published between the years 2000 to 2020, were written in English, and included an abstract. The search was limited to a twenty-year period because technology and recommended medical treatment evolve quickly over time. If too long a time had been included, data from natural disasters pre-dating current medical treatments, like dialysis may have been included which could have skewed results. Additionally, due to the nature of the review's topic, the period of time had to be long enough to capture several individual natural disaster events since all studies evaluating the impact of medication interruption or loss on individuals occur retrospectively. Eligible articles described the following:
    i. Evacuee's medical preparedness
    ii. Burden of prescription refills or prescription of medication for chronic conditions within relief activities after disasters, and/or
    iii. Disruption of medications due to evacuees not bringing their medication upon relocation
2. **Exclusion Criteria:** Articles and papers were excluded if they were:
    i. Abstracts for conferences or dissertations, chapters of books, clinical trials
    ii. Articles written in a language other than English
    iii. Literature review articles
    iv. Articles that focused on disaster management and COVID-19
    v. Articles that addressed only population displacement, conflict-related disasters and medication interruption; papers related to natural disasters that did not discuss

medication loss or interruption or interruption of medical services; and papers that discussed mental health disorders that began after a disaster or health conditions caused by disaster effects (title exclusion criteria).

3.3 Study Selection

The search was conducted from February to April 2021 and generated 87 results. Out of these records 30 were classified as irrelevant when screened by title exclusion criteria. Therefore, the initial screening by title identified 57 records as relevant. For these remaining articles, abstracts were read and reviewed using the eligibility criteria, which led to the exclusion of another 21 articles.

A secondary snowballing search methodology was used, which yielded 20 results. Overall, a total of 56 articles were identified. Eligibility screening of the full-text articles identified seven as not fulfilling the inclusion criteria**,** and fourteen were literature review articles. The excluded studies either didn't discuss an interruption of medical care, focused on the treatment of conditions acquired during natural disasters, or looked at continuation of COVID-19 vaccination and screening programs. A total of 35 research studies were identified as fulfilling the inclusion criteria and included in this analysis. Figure 1 shows the breakdown of this process. The thirty-five studies included in this analysis were research papers addressing continuity of medical care for pre-existing conditions during and after a natural disaster. Articles included those that focused on medication interruption and cessation following a natural disaster, individual disaster preparedness efforts as it pertained to medication and medical documents, and access to medical aids and devices.

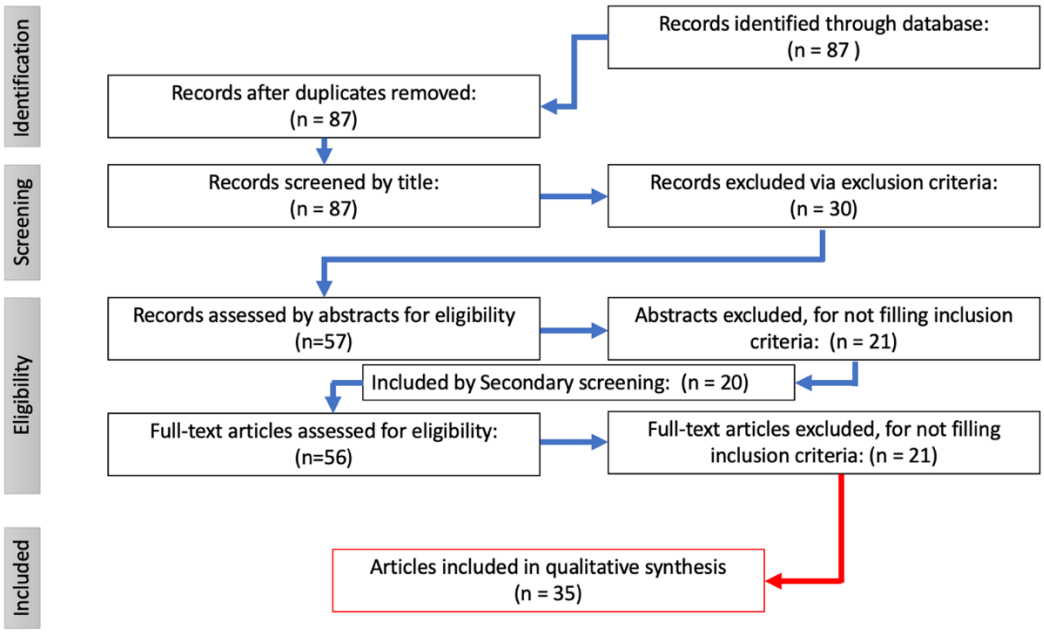

Figure 1 Article review process for determining eligibility

4.0 Results

This systematic review addressed the topic of continuity of care for preexisting conditions during natural disasters and extreme weather events. It focused specifically on medication interruption and cessation following natural disasters and extreme weather events. It also reviewed research on individual preparedness as it pertains to medication and medical histories.

From the MeSH terms, 35 papers were identified that fell within the inclusion criteria. The extreme weather events documented in these 35 papers included hurricanes, tsunamis, floods and any other, and these events ranged from 1995 to 2017. An overview of the events referenced by the included studies can be found in Table 2. Of these articles, 13 (37.1%) reported on the impacts from the 2005 Hurricane Katrina. Additionally, research from 10 countries was included and 68.6% percent of these studies occurred in the United States of America (USA) and/or Puerto Rico. The results of this literature review are provided below in detail, and inform the recommendations made at the end of this study to inform public health officials and emergency medical professionals to improve disaster preparation efforts.

Table 4 Chronological list of the reviewed events

Year	Month	Name of Events	Type of Event	Country	No. of articles
1995	January	Hyougo Earthquake	Earthquake	Japan	1
1999	August	Marmara Earthquake	Earthquake	Turkey	1
2004	September	Hurricane Ivan	Hurricane / Tropical Cyclone	United States	1
2004	December	Asian Tsunami	Tsunami	Indonesia & Sri Lanka	2
2005	August	Hurricane Katrina	Hurricane / Tropical Cyclone	United States	13
2005	September	Hurricane Rita	Hurricane / Tropical Cyclone	United States	1
2005	October	Hurricane Wilma	Hurricane / Tropical Cyclone	United States	1
2006	July	Flash Flood	Floods	Japan	1
2007	October – November	California Wildfires	Wildfires	United States	1
2008	May	Wenchuan Earthquake	Earthquake	China	1
2008	September	Hurricane Ike	Hurricane / Tropical Cyclone	United States	1
2011	March	Great East Japan Earthquake	Earthquake	Japan	1
2012	October-November	Super Storm Sandy	Hurricane / Tropical Cyclone	United States	3
2015	March	Tropical Cyclone Pam	Hurricane / Tropical Cyclone	Vanuatu	1
2017	September	Hurricane Maria	Hurricane / Tropical Cyclone	Puerto Rico	2
2017	September	Hurricane Irma	Hurricane / Tropical Cyclone	Puerto Rico	1
2018-2019	--	Bushfires	Wildfires	Australia	1
2020	May	Cyclone Amphan	Hurricane / Tropical Cyclone	Bangladesh & Indonesia	1
Total	--		5 disaster types	10 countries	35 articles

4.1 Medication Interruption or Cessation

The majority of studies analyzed for this systematic literature review reported a significant prevalence of medication interruption. The importance of medical interruption and/or an inability to receive necessary medical services was emphasized. Kishore et al. (2018) found that the primary cause of sustained high mortality rates in the months following Hurricane Maria was the interruption of medical care.

The percentage of individuals affected by natural disasters with NCDs and/or chronic conditions during disasters varied across studies, disasters, and countries. Some of this variance is likely due to the sociodemographic differences between areas affected by natural disasters and by national and local disaster response policies. However, almost all studies reported that a percentage of individuals affected by natural disasters with chronic conditions and NCDs experienced a period of medication interruption. Chan and Kim reported that 46% of patients seen in rear hospitals following the Wenchuan Earthquake were seeking non-surgical treatment and that many of these individuals were seeking support in managing their chronic diseases (41). A study conducted in partnership between the CBM, ADD International, CDD and DRRA found that approximately 50% of the immediate medical needs following Cyclone Amphan (2020) were for the treatment of pre-existing conditions (42). During Hurricane Katrina (2005) 48.5% of individuals arrived at shelters lacking their medication (43) and 32% of individuals went without their prescription medicines for a period of time which could be as long as several weeks (44). Greenough et al. (2008) found that out of study participants they interviewed, 19.8% of individuals still did not have prescription medications two weeks after Hurricane Katrina. This is similar to what Jenkins et al. (2009) found when surveying households displaced by the California wildfires in 2007. They found that 12.4% of households reported that they were unable to obtain necessary prescription

medications after evacuation and that 20% of this group had not received necessary prescriptions within 10 days of evacuation (45).

One factor of importance that was noted in several studies in determining the extent of medication interruption was the preparedness of community pharmacies (9). Community pharmacies are often heavily relied upon by individuals following natural disasters, regardless of medication availability at shelters (9)**.** Local pharmacists are often the most accessible healthcare providers following a natural disaster, and policymakers should be encouraged to include them in emergency planning discussions.

Medications are not the only medical equipment individuals may require following disasters, as many individuals need assistance replacing hearing aids, glasses, assistive devices and glucose monitors following disasters. Following the Great East Japan Earthquake in 2011, a mobile vision clinic treated over 3380 patients. The majority of these evacuees were coming to the clinic for lost or broken eyeglasses and for the treatment of preexisting conditions which included cataracts, contact lens replacement, glaucoma, conjunctivitis/allergies, dry eye/eye strain, diabetic retinopathy, and branch and central retinal veins (46). Individuals receiving dialysis are also particularly vulnerable during natural disasters, and extreme weather events are often classified as 'kidney failure disasters' due to decreased availability of dialysis care for individuals (47). Dialysis facilities often close in preparation for a disaster, and prolonged loss of electrical power can keep these facilities closed for long periods of time (48). Anderson et al. (2009) found that 44% of hemodialysis patients missed one or more sessions in the aftermath of Hurricane Katrina compared to the 5-9% who missed treatments prior to the disaster. They also found that 17% of patients reported missing 3 or more dialysis sessions following Hurricane Katrina (49). These prolonged closures could create a need to move patients to other states or provinces to access care in different

cities, which may also be difficult to coordinate in the wake of a disaster and within countries who lack universal healthcare systems. In addition to patients who had previously relied upon maintenance dialysis, natural disasters often lead to an increase in AKI cases from crush injuries further stressing the system (47). Over 40% of the patients with crush syndrome from the Wenchaun Earthquake (2008) in Sichuan developed acute kidney injury within 3 days of the event (35).

Additionally, natural disasters can disproportionally impact people living with HIV/AIDS (PLWHA), who are particularly vulnerable due in part to the need for continued complicated medical care, particularly in light of the fact that evacuation centers often do not stock ARTs and that many evacuation center pharmacies are underequipped for the number of evacuees they receive (50,51). As anti-retroviral therapy (ART) becomes more commonplace, there is both an increase in the number of individuals dependent on continued ART drugs and an increase in the resources that should be devoted towards ensuring that evacuation sites and emergency shelters can address the complex health needs of PLWHA. This is particularly true considering that prolonged medication interruption can lead to an increase in drug resistance within a short period of time. For example, in 2012 when Super Storm Sandy hit New York State, it had the highest HIV/AIDS prevalence in the United States with an estimated 130,000 people living with HIV (52). In a retrospective study of the experiences of HIV/STD providers in NY, over 80% of those surveyed reported resource shortages and 18% reported programs that took over 12 weeks to resume normal operations (53). There has been very little research to date looking at the impact of natural disasters specifically at PLWHA, however, the little research that does exist following Hurricane Katrina, showed that displaced individuals had substantially CD4 counts up to 18 months after the disaster (54).

Additionally, there was consistent reporting of increased mortality and morbidity in populations with pre-existing chronic diseases (55). There are a variety of explanations for this increase: inability to access medication, increased stress and anxiety, exposure to toxins, and lack of access to clean food and/or drinking water. Many of the studies found that there was an increase in the prevalence of chronic diseases following natural disasters due to the impact of extreme stress or injury on the body leading to the development of new conditions.

4.2 Interrupted Access to Appropriate Nutrition

In addition to medication interruption, some of the studies reported that changes to medication regimes and food availability worsened patient health conditions. Following Hurricane Ike, more than one in four households (26.8%) reported needing assistance obtaining food within 5-6 days of the storm (56). Additionally, dietary changes due to food scarcity can greatly impact patients with diabetes and high-blood pressure by making it more difficult to stick to a prescribed diet and continue to practice exercise therapies (57). The inability to source appropriate food led to a substantial deterioration in glycemic and BP controls in individuals who were directly impacted by the Great East Japan Earthquake and Tsunami when compared to those who were not hit directly by the tsunami and did not face food shortages (57). Similarly, Sengül et al. (2004) found that individuals with type 1 diabetes experienced both short- and long-term physiological changes following the Marmara earthquake in 1999. They found that out of the 88 individuals interviewed, the majority experienced increased HbA_{1c} levels and insulin requirements 3-months post-earthquake, and that while HbA_{1c} levels eventually returned to baseline, insulin requirements remained elevated a year after the disaster (55). They postulate based on their QOL interviews that

the increase in insulin requirements were due to the acute stress of the event and inadequate access to food and/or insulin during and immediately after the event.

4.3 Vulnerable Populations

Natural disasters tend to impact vulnerable populations including the elderly, homeless, disabled, people who inject drugs (IDUs) and impoverished communities more acutely than other populations (58). The populations are generally more housing insecure before disasters and can be particularly vulnerable to becoming displaced. Natural disasters can affect people with disabilities in a multitude of ways. Individuals with disabilities may be more likely to become injured during natural disasters, leading to more acute injuries. For example, during Tropical Cyclone Pam, people with disabilities were 2.45 times more likely to suffer an injury during the cyclone (59) than able-bodied individuals. The loss or damage of hearing aids, glasses and mobility devices can compound existing transportation difficulties, making it harder for these individuals to evacuate to safety. Following Great East Japan Earthquake of 2011, people with disabilities were twice as likely to die in an earthquake compared to the general population (60). Individuals with disabilities are also less likely to be included in early warning systems and evacuations, which hinders their ability to take care of themselves and stockpile medication, food, and other necessary supplies prior to a disaster. Following Cyclone Amphan (2020), 71% of persons with difficulty hearing and 66% of persons with difficulty seeing reported that early warning systems were inaccessible to them (42).

Additionally, sheltered populations have been shown to have worse morbidity and mortality rates, and following the 1995 earthquake in Japan, the morbidity rates were five times

higher among persons residing in shelters than those who remained in their own homes (61). Similar findings were reported following the 2018-2019 Tasmanian wildfires in Australia, where evacuated individuals experienced more severe health challenges when compared to non-evacuated individuals (9). The elderly in particular are at high-risk for being relocated, particularly those living in nursing homes or residential care facilities. Hurricane Sandy forced over 4500 older adults to evacuate after 31 nursing homes were forced to close (62). They often face increased mortality and worse physiological and mental health outcomes following natural disasters compared to younger adults (63). A retrospective chart review following the Hyougo Earthquake in Japan found that the average age of patients admitted to hospitals following the event was 60 years of age, and that hospitalization rates for persons over 50-years old increased with age (61).

Poverty and household income has also shown to be correlated with lack of disaster preparedness. Clay et al. (2020) found that greater income and greater education were protective against inadequate recovery following Super Storm Sandy (2012). This may be due in part to the costs associated with the creation of an emergency kit and the ability to obtain extra medication doses that are stored in case of an emergency. Bethel et al. (2011) conducted a survey of households in six states in the United States had contradictory findings. They found that individuals with poorer health, disabilities, and multiple chronic diseases were generally less likely to have all four recommended preparedness items stocked than those without chronic conditions (64). However, in contrast, these individuals were more likely to have a 3-day supply of medication for all household members requiring them (87.4%). Updated recommendations are now suggesting that a 3-5 day supply of medication may not be sufficient and that individuals should aim to have at least 7-days of medication on hand for emergencies (56,65). This is in part to help reduce medication demand which can often overwhelm pharmacies, many of whom are facing wholesale

supplier delays, and the reality that it often takes more than three days to rebuild damaged medical infrastructure (9). For example, following Hurricane Ike, 11.1% of surveyed households reported needing prescription medication less than a week after the storm hit Houston (56). Additionally, following the California Wildfires in 2007, 20% of evacuated individuals still had not received needed prescriptions 10 days after they evacuated which suggests that even when individuals reach an emergency shelter, they may not be able to receive new medication as quickly as necessary to avoid missed doses (45).

People who inject drugs (PWID) are particularly vulnerable to the impact of natural disasters and extreme weather events. Following Hurricane Katrina (2005) and Superstorm Sandy (2012) individuals reported increases in shared drug injection and/or preparation equipment, and an inability to receive sufficient doses of opioid maintenance therapy (66,67). Following Superstorm Sandy (2012) 27.9% of individuals reported sharing syringes, 35.6% shared drug preparation equipment, and 17.4% "backloaded/piggy-backed" (used an individual syringe to withdraw drugs from a common syringe containing drugs prepared for more than one person), and 14% reported exchanging sex for money, drugs or other goods (66). Only 30.1% were able to obtain sufficient take-home doses of medication to prevent withdrawal (66).

4.4 Operational Preparedness and Utilities

Natural disasters can increase housing insecurity and displacement, make it more difficult to access water, food, or electricity, and increase unemployment within the regions they hit (34). In the Minamisanriku, Miyagi prefecture in Japan, it took over three months for water to be restored following the Great East Japan Earthquake in 2011, and some individuals spent up to five

months living in temporary housing (6). Cyclone Amphan devastated existing infrastructure and 81% of individuals surveyed reported partial or complete damage to shelter facilities, and over 50% of respondents reported that their primary drinking water sources and sanitation facilities had been destroyed (42). Following Hurricane Maria, Puerto Rican households averaged 84 days without electricity, 68 days without water and 41 days without cellular telephone service (68). Prolonged difficulty accessing electricity can greatly impact individuals relying on respiratory equipment, and lack of cell service can make it impossible for households to reach emergency services to request medical assistance. Interrupted services and an inability to access basic supplies such as food, clean water, and medication are one of the primary motivations for evacuation into shelters where populations often face worsened outcomes. Economists have also found that the prolonged loss of utility services was the main reason households were forced to move after a disaster and had a major impact on household asset losses (25).

Many studies reported a lack of power and/or phone services as being a major barrier to providing continued or ongoing care to patients following a natural disaster. Following Hurricane Sandy (2012), HIV/STD providers reported that 86% of the information they provided during the disaster was via phone calls or through text (51%) (53). Limited access to phone communication can prove to be a huge barrier for individuals in-need of continued care, particularly when paired with inadequate or non-existent access to transportation and can leave these individuals completely isolated from medical care, or unable to reach their primary care doctors for their medical histories. In the event of emergency, the reestablishment of phone networks can greatly aid emergency response teams. This was accomplished with an adaptation of a mobile-phone reporting system following the Wenchuan earthquake, which helped to overcome the destruction of computer networks within destroyed or damaged healthcare facilities. During the Wenchuan disaster,

messages were sent via mobile phones to health care works outside of the disaster area to track disease numbers. It eventually became the primary method of reporting infectious disease outbreaks and medical needs within the disaster zone (35).

5.0 Discussion

Appendix I summarizes the articles related to medication interruption and loss during natural disasters. It lists the country of the event, the name of the disaster and year, the type of research conducted, the sample size of the research, and key findings regarding medication interruption or lack of access to healthcare. Two consistent themes were noted in the majority of articles focused on disaster preparedness and delays in obtaining medical treatment.

5.1 Disaster Preparedness

The first was the need to quickly reestablish medical care and enable prescription refills in the absence of complete medical or patient records (69). For example, following the Great East Japan Earthquake (2011) all medical data stored at the hospital was lost in the tsunami which made it difficult to replicate pre-disaster prescriptions (57). Following the Wenchuan Earthquake (2008) an estimated 80% of medical institutions within Sichuan were damaged and 67.5% of medical buildings within the disaster zone collapsed which led to a massive shortage of both medical facilities and loss of medical records (35). Medical practitioners were forced to make educated guesses to attempt to determine what treatment was the best option for their new and returning patients without being able to review their past medication histories, laboratory results or ongoing care history. In a survey of health experts five major health information elements were identified based on their importance to continued treatment and health care retrieval. These included biomarkers, universal identification, alternative languages, history of communicable diseases, and

mental illness (69). A lack of medical history also presents a challenge to pharmacists who are often unable to provide more than short-term medication refills legally without proof of a prescription (9). Pharmacists are thus faced with both logistical and legal barriers to providing medical care to their patients. The inclusion of pharmacists in discussions regarding individual disaster preparation could be invaluable towards ensuring that individuals have the correct documentation with them in the event of an emergency or natural disaster to enable themselves to obtain ongoing medical care.

The second major theme noted was the importance of individual preparedness and self-sufficiency, to ensure that individuals are prepared in the event of a disaster. Emergency preparedness is generally defined as "actions taken prior to disasters to improve response and recovery efforts" by individuals, emergency response teams, and/or communities (70). Emergency preparedness actions help to moderate the impact of natural disasters by lowering preventable mortality, but also help to improve the macroeconomic resilience of the economy after the disaster, by limiting the extent of loss of income (25). The most studied natural disaster discussed in this literature review, Hurricane Katrina, was preceded by the 'Ready' campaign, launched by the Federal Emergency Management Agency (FEMA) in February 2003. Ready was a national campaign designed to improve individual disaster preparedness and to increase public awareness about challenges they may face in the event of a natural disaster. Despite this campaign, and subsequent campaigns that came after it, communities still struggle to prepare themselves (71). In 2009, the National Hurricane Survival Initiative found that 66% of people living in Atlantic and Gulf coastal states had no survival kit and 55% had no family disaster plan (72). This research aligns with the work done by Witvorapong et al. (2015) which found that only 36.80% of individuals in Thailand had emergency kits or an emergency plan despite prior disaster experiences

(73). In a preparedness study conducted by Clay et. (2020) only 43.3% of individuals reported having an extra supply of medication in their disaster supplies prior to Super Storm Sandy (2012). In households surveyed after Hurricane Ike, over 26.8% reported having run out of food 5-6 days following the storm suggesting a lack of preparation prior to the event despite government produced preparedness advisements (56). One of the flaws of programs like the 'Ready' campaign is that they do not address the financial burden that stockpiling supplies can pose to families. While the Ready Campaign can help inform individuals of what they should include in their disaster kit, it does not provide any financial support for families who are already struggling to afford their daily expenses. Additionally, many insurance providers do not allow individuals to receive more than a certain amount of medication at one time making it difficult to stockpile additional drugs. Lastly, preparedness campaigns like the Ready campaign require a large amount of individual planning that may be overwhelming for some individuals.

The lack of success seen after these programs may be due in part to the lack of empirical evidence in creating preparedness messages and their effectiveness in conveying information to the general public (71). Another barrier to success for these programs is a lack of health literacy and an inability for governments and NGOs to communicate disaster risk and preparedness strategies to at-risk individuals. In Vanuatu, 43% of adults are unable to read an SMS message on a mobile phone and 29% of adults never attended school (59). An estimated 77 million Americans have basic or below basic health literacy and struggle with common health tasks, like following prescription label directions or reading vaccination tables (74). This lack of health literacy likely transfers over to a lack of understanding for emergency preparedness and may influence the medical documents and materials individuals believe to be important to bring with them in the event of an emergency evacuation. There has been little progress towards finding effective ways

to communicate risk across diverse populations and more research needs to be done to evaluate potential methods that can effectively prepare households. There is a clear need for improved pre-disaster preparedness programs since the unpredictable nature of natural disasters mean that governments are limited to the extent that they can prevent these occurrences through either structural measure, like improved building codes, or non-structural measures, such as through land use planning or legislation. Household preparedness initiatives help to decrease the immediate demand for emergency disaster response services, likely decreasing mortality and morbidity resulting from an inability to deliver adequate care to all affected individuals in a timely manner.

6.0 Conclusion

This literature review describes the current research on natural disasters and their impact on medication interruption and related challenges faced by those with chronic health conditions. While the international community has made great strides towards improving the management of healthcare systems and society following natural disasters, it is clear that more needs to be done to prepare individuals at risk of being displaced during natural disasters, particularly those with pre-existing conditions and disabilities. The majority of reviewed studies show that individuals face significant unmet health needs in the face of natural disasters, irrespective of country or type of disaster. In the face of climate change, and an increased likelihood of certain natural disasters, it is more important than ever that countries work to reduce their citizens' vulnerability to natural disasters. This literature review aims to provide recommendations based on the existing research to improve disaster response for key groups experiencing chronic health conditions. It highlights the need for increased availability of prescriptions and improvements in individual disaster preparedness, as well as key populations that should be targeted preventively to ensure that families have the necessary medical supplies available to them in the event of a natural disaster.

7.0 Recommendations

I. **Creation of Affordable Emergency Healthcare Coverage that includes treatment for pre-existing conditions**

   I. Creation of a short-term public insurance coverage plan to ensure that those without medical insurance or who are struggling financially can afford additional medication, or the replacement of medical devices. This short-term public insurance coverage program would help to ensure that individuals receive post-disaster support to help reduce the long-term negative impact of the event. (44) The reduction of medical costs will also help improve the financial resilience of communities by eliminating a source of debt allowing households to reinvest their money back into rebuilding their homes, businesses and communities (25).

II. **Medication and Medical Aid Stockpiling for Chronic Diseases**

   I. Healthcare institutions should stockpile drugs for common conditions to avoid exacerbation of morbidity. These drug stockpiles for chronic diseases should be readily available for emergency dispatchment in the event of a natural disaster to ensure shelter residents needs can be met quickly during a disaster response, in order to minimize the length of medication interruption (43).

   II. The most common requests for medications were for cardiovascular diseases and for pre-existing mental health issues. These medications should be stocked and distributed with priority in the event of a disaster (13,51,75,76)

   III. Opioid maintenance therapy and clean injection materials should be stockpiled at emergency shelters for distribution by qualified healthcare workers in order to

reduce the incidence of relapses, and to prevent the transmission of blood-borne infections among IDUs (66).

IV. Pharmacists should be included in conversations regarding developing better strategies for stockpiling medications and ensuring that local pharmacies are prepared in the event of a natural disaster.

III. **Mental Health Assistance**

I. Emergency medical workers should be trained to provide mental health assistance. Additionally, psychiatrists and counselors should be integrated into disaster response teams from the outset. These teams can help to provide support for patients and individuals suffering with mass grief and loss, while allowing physicians to focus on major physical complaints (13). This is of particular importance since many individuals with pre-existing mental illness diagnoses may be experiencing severe side-effects from medication interruption.

IV. **The creation of Emergency Preparedness Programs with a focus on vulnerable populations, and involve gender and ethnically diverse populations, and communities with various disabilities and medical conditions as active participants in planning disaster preparedness literature.**

I. Health professionals and those working with at-risk populations should create Emergency Preparedness Programs that help ensure individuals are prepared for natural disasters and extreme weather events. These can include education regarding creating of 'personal emergency packs', that include extra medication and copies of their current prescription information. Additionally, programs could include information on how to update and store medical information on phones,

or what to share with family members to ensure that in the event of an emergency individuals are able to correctly answer questions regarding their medications and ongoing medical treatment (71).

II. Further research should be conducted to analyze current recommendations for medication preparedness. The current recommendations are for individuals to "expect to be on your own for three days". However, some studies have found that individuals are often stranded without medical supplies for much longer, and additionally that shelters may be underprepared for the dispensation of medical supplies following a disaster when they exceed their intended capacity (77).

III. Emphasis should be placed on ensuring that vulnerable populations with pre-existing conditions are targeted for these programs, particularly PLWHA. Preparedness programs for PLWHA should include the creation of a "patient passport" that contains current and previous HAART treatment regimens so that care can be obtained at other health centers (78). Additionally, efforts should be made to include Disabled People's Organizations (DPOs) to help inform and develop plans and tools to address disability-specific evacuation needs (59). A study conducted in 2013 across 137 countries found that 85% of disabled individuals had never participated in DRR processes (79). This lack of representation needs to be addressed to improve the outcomes of disabled individuals following a natural disaster.

V. **Increase health professional and medical staff disaster response training to better prepare responders for disaster situations.**

I. Health professionals and medical staff are more likely to participate or volunteer in disaster care if they feel like their organization has a plan and can adequately support and prepare them. This includes the support and protection of HCWs through education, adequate PPE, vaccinations, transportation and access to information (80).

8.0 Limitations

There are several barriers to accurately collecting data from natural disasters, particularly in lower income countries with poor or limited healthcare infrastructure. Certain types of natural disasters are also more likely to receive academic and global attention than others. For example, most of the studies included in this systematic review focus on the United States, and none of the studies focused on Sub-Saharan Africa, or several hard-hit Southeast Asian countries, despite the high number of disasters that have impacted that region, including four of the ten most deadly disasters in the past two decades. The lack of international representation in this study may be partially due to the exclusion of any research published in a language other than English, however the CRED reports that between 2000-2019, only 34% of extreme temperature events such as heat waves reported the total number of people affected which suggests that there is a general lack of research in this area. The studies that have captured mortality rates are predominately in European countries with better reporting systems (12). The IDMC has also reported that most data collected during disasters does not include the number of displaced people and thus it is difficult to get an accurate idea of the scale of these disasters, as well as difficult for researchers to locate people who have migrated to different regions following a disaster event. The year 2019 was the first year in which a substantial effort was made to record the number of people displaced specifically from disasters, challenging the research community's ability to look retrospectively at the impact of disasters on populations (33).

This is particularly important to note when considering that the majority (19) of studies captured in this literature review utilized surveys or interviews, and many of these were conducted using convenient sampling groups which may not have been representative, which means that

individuals who were displaced to areas outside of the study location likely were not surveyed. Additionally, many of these studies used telephone surveys and would have excluded individuals that could not afford or did not have access to telephone services. Systematic nonresponse, including high survey refusal rates, and systematic nonreporting were also commonly reported limitations for survey research. Since most of the research was conducted retrospectively, and some studies were conducted a significant period after the natural disaster of interest, individual-level imprecision regarding diagnoses and treatment may have impacted results.

Most of the captured studies were surveys or interviews and may have suffered from selection bias and consent bias. Additionally, many individuals who suffer from pre-existing conditions are poor, disabled and elderly. These individuals were also more likely to suffer an acute or fatal injury during a natural disaster that would eliminate them from any survey or interview group. Lastly, in studies with control groups, many older adults with disabilities or chronic conditions did not have suitable age and sex matched controls who did not also have a disability. Despite these limitations, the large number of studies included in this literature review from a variety of countries provide enough collective data for the identification of key trends in DDR programs.

Appendix A Literature Review Summary

Appendix A.

Summary of research articles related to medication loss and interruption during or following an extreme weather event, country, research type and outcomes

Articles listed by author and year of publication	Country(s)	Disaster	Type of research	Sample type (size=n)	Outcome
(49)	United States	Hurricane Katrina (2005)	Interviews	386 patients	- 44% of patients reported missing at least one dialysis sessions - 17% reported missing 3 or more dialysis sessions - The adjusted OR of hospitalization among patients who missed 3+ dialysis sessions vs. those who did not miss any was 2.16 (95% CI: 1.05-4.43)
(59)	Vanuatu	Tropical Cyclone Pam (2015)	Rapid Assessment of Disability & Interviews *Mixed Methods*	1836 adults and 1330 children (ages 5-17)	- People with disabilities were 2.45 times more likely to be injured during Tropical Cyclone Pam

(64)	United States	General preparedness	BRFSS[1] Survey	37, 303 respondents collected from 2006 through 2008 in six states (Delaware, Georgia, Louisiana, Montana, Nevada, and Tennessee)	- 87.4% of respondents lived in households in which each member requiring medication had a 3-day supply - Respondents reporting fair/poor perceived health were less likely to have all four preparedness items, evacuation plans, but more likely to have a 3-day supply of prescription medication
(44)	United States	Hurricane Katrina (2005)	Survey / Interviews	608	- 32% went without prescription medicines - 25% went without medical care
(42)	Indonesia	Cyclone Amphan	Interviews	161	- 67% of respondents did not have access to appropriate primary health care if they needed it - Approximately 50% of respondents reported immediate needs for medical care for pre-existing conditions - Over 20% of respondents needed maternal and/or child health primary care

[1] Behavioral Risk Factor Surveillance System (BRFSS) is an ongoing random-digit-dialed telephone survey of the non-institutionalized U.S. civilian population aged >= 18 years conducted by state health departments.

(41)	China	Sichuan, China earthquake (2008)	Descriptive cross-sectional study	182	- 30% of patients required chronic noncommunicable disease (NCD) management - NCDs constituted 77% of immediate health needs post-earthquake - 47% of patients with an NCD had hypertension, only 5% of these individuals had medication - 24% of patients with an NCD had diabetes mellitus, only 3% of these individuals had medication
(81)	United States	Hurricane Wilma (2005)	Survey	547 initial +105 follow-ups	- Subjects after hurricane missed fewer doses of medication than at other times (3.4% vs. 6.7%) - Subjects missed significantly more doctors' appointments after the hurricane (11.6% vs 0.1%)
(56)	United States	Hurricane Ike (2008)	Interviews	440 households	- 24.7% of surveyed households reported evacuating despite not being in the official evacuation zone for at least one day because of the storm - 23.2% of households reported that they were sheltering members of other households in their residence - 13.8% of households reported that some of their own family members had not returned to the residence 5-6 days after the storm had passed - 11.1% of households reported that they needed prescription medication and/or access to medical care 5-6 days after the storm - 26.8% of households reported needing

					assistance obtaining food
(82)	United States	Super Storm Sandy (2012)	Cross-sectional retrospective study design	1114 households	- 45.8% (n=510) reported having all 4 preparedness supplies (food, water, flashlight, battery powered radio) - 43.3% n=482) had an extra supply of medication - 25.3% (n=282) had an evacuation plan
(83)	United States	General preparedness for disasters	Self-reported survey	96,137	- Women were less likely to report household preparedness (PR 0.81) and a 3-day supply of medication (PR 0.89) than men - Divorced, separated, or widowed women were less likely to report household preparedness (PR 0.84) - Women living in a household with children were less likely to report household preparedness (PR 0.84)
(84)	United States	Hurricane Katrina (2005)	BRFSS[1] Survey	1681	- 9% of adult population within New Orleans-Metairie-Kenner had diabetes - 4.6% of adult population within New Orleans-Metairie-Kenner had angina or coronary heart disease - 29% of adult population within New Orleans-Metairie-Kenner had hypertension
(43)	United States	Hurricane Katrina (2005)	2-stage 18-cluster sample survey	- 499 evacuees - 30 adult households	- 48.4% of those who arrived at shelters with a chronic disease lacked medication

					- Two weeks later 19.8% of individuals still did not have access to medications
(85)	United States	General disaster preparedness	Survey	28,167	- Veteran men were more likely to have emergency medical supplies (81.9%) when compared to nonveteran women (74.8%) and veteran women (81.1%) - Only 67.2% of nonveteran men and 60.1% of nonveteran women said they could obtain a two-week supply of medication in the event of an emergency
(86)	United States	Hurricane Katrina (2005)	Retrospective Chart Review	465	- 21% of urgent care services at a health clinic post-Katrina were for medication refills - 52% of medication refill requests were for cardiovascular conditions - Donations of certain classes of medications were more useful than others.
(69)	NA	General disaster preparedness	Mixed Methods: Expert panels, surveys, and examinations of past efforts	NA	- Defined 29 health information elements from phase III met the defined “minimum and essential” criteria
(51)	United States	Hurricane Katrina (2005)	Retrospective Syndromic surveillance system	4229	- 15% of healthcare encounters were for the care of chronic medical conditions - 68% of all medications dispensed to evacuees were for the treatment of chronic diseases - 39% of medications were for cardiovascular conditions

(16)	Puerto Rico	Hurricane Maria (2017)	Descriptive Cross-sectional design	65	- 77% of respondents reported problems related to their medications - 47.7% reported having trouble either contacting or getting to their pharmacy following the hurricane
(45)	United States	California wildfires (2007)	Survey	161 households (573 household members)	- 29.2% of households reported needing health care at some point during evacuation - 29.2% of households needed prescription medication - 12.4% of households needing medications did not believe that their need for prescription medication was met at some point during the evacuation
(13)	Indonesia	Asian Tsunami (2004)	Retrospective Chart Review	483 patient charts	- 39% of patients consulting a mental health clinic established after the Tsunami had pre-existing mental health conditions
(15)*	United States	Hurricane Katrina (2005)	Survey	1043	- 20.6% of respondents reported disrupted treatment of at least 1 condition after the hurricane
(87)	United States	Hurricane Katrina (2005)	Mixed-Methods: National Comorbidity-Survey Replication and two-survey comparisons (pre- and post-Katrina)	826	- 6.1% of surveyed individuals reported a serious mental illness prior to Hurricane Katrina - 9.7% of surveyed had a mild-moderate mental illness prior to Hurricane Katrina - 15.7% estimated to have any mental illness pre-Katrina

(68)	Puerto Rico	Hurricane Maria (2018)	Survey	3299 households	- 14.4% of households unable to access medications - 9.5% of households had respiratory equipment that required electricity (average households spent 84 days without electricity) - 6.1% reported absent doctors and 8.6% reported that issues due to medical facility closures - 8.8% of remote households were unable to reach 911 services by telephone
(88)	United States	Hurricane Katrina (2005)	Survey	55	- 17% reported needing health care but were not able to obtain it within 6 months of Hurricane Katrina - 40% had not used birth control - 31% had trouble getting their birth control method - Women surveyed were more concerned about their ability to receive healthcare (4.2) compared to housing (4.0), employment (4.0), access to schooling (3.7) or feeding family or self (3.4)
(89)	United States	General Preparedness	BRFSS Survey from 2006 - 2010		- 82.9% have a 3-day supply of food - 53.6% have a 3-day supply of water - 89.7% have a 3-day supply of prescription meds - 21.1% have an evacuation plan - Only 25.3% believe they are well-prepared in the event of an emergency and 19.1% are not prepared at all - 8.2% of individuals have cardiovascular disease

					- 8.7% of individuals have diabetes - 8.5% of individuals have asthma
(61)	Japan	Earthquake – Hyougo (1995)	Retrospective Chart Review	6107 patient charts	- Average age of patients admitted for illness was 60 years-old - Hospitalization rates for persons over 50-years increased with age - 8% of the population in the affected area were forced to live in shelters and the morbidity rate among those living in the shelters was five times higher than among persons who remained in their own dwellings
(57)	Japan	Great East Japan Earthquake (2011)	Retrospective chart review	63	- Glycemic and BP controls deteriorated more in patients with tsunami exposure - Chief reason for the worsening of glycemic and BP controls after the incident was probably due to the changes in the drugs administered
(66)	United States	Super Storm Sandy (2012)	Interviews	300 people who inject drugs in New York City	- 60% experienced withdrawal - 27% shared drug injection or preparation equipment, or injected with people they normally would not inject with - 70% of those on opioid maintenance therapy could not obtain sufficient doses - 43% of HIV-positive participants missed HIV medication doses

(90)	Sri Lanka	Asian Tsunami (2004)	Cross-sectional household survey	3,533 individuals from 859 households	- 9.6% of individuals had pre-existing health problems
(91)	United States	Hurricane Katrina (2005)	Survey	124 families	- 25% of families had difficulty accessing care for hematology / oncology services - 13% could not find a hematology/oncology provider for follow-up - 25% did not have access to medical records - 71% of families given "Hurricane Action Plan" intervention following Katrina had a 2-week medication supply on hand for emergencies and 36% had roadmap/treatment plan with them
(76)	United States	Hurricane Katrina (2005)	Survey	373 persons from 197 households	- 56% of adults and 21% of children reported having at least one chronic disease - 14% of adult evacuees reported a mental illness that required medication pre-hurricane - 41% reported no health insurance or public assistance (out of 189 who responded to questions about health insurance)
(55)	Turkey	Marmara Earthquake (1999)	Mixed Methods: Interviews & DQOL surveys	88	- HbA_{1c} levels (9.5%) and insulin requirements significantly increased when surveyed 3 months post-earthquake and while HbA1c levels returned to base levels, insulin requirements remained increased at the 1 year follow up - 13.6% of those interviewed reported having problems obtaining insulin supply in the first days

					following the earthquake - 59.1% of those interviewed reported having problems with their food supply in the first days following the earthquake
(92)	Israel	General Disaster Preparedness	Mixed Methods: qualitative semi-structured interviews and survey	16 interviews 179 surveyed	- 57% of participants kept a 3-day supply of prescription drugs - 23% kept copies of their prescriptions
(93)	United States	Hurricane Katrina (2005)	Retrospective surveillance data	21,673	- 24.3% of health care visits were for chronic diseases and related conditions - 7.2% were for medication refills and 5.7% were for follow up care - Subsequent hospitalization occurred among 28.7% of people presenting with chronic diseases and related conditions compared to 10.9% of those with non-CDRC
(9)	Australia	Summer Bushfires (2018/2019)	Semi-structured telephone interviews	4	- Pharmacists were left out of planning discussions - Medication delays from wholesalers was a reported common problem - Pharmacists reported difficulties in supplying medications to patients presenting without prescriptions
(94)	Japan	Flash Flood (2006)	Cross-sectional study using questionnaire	810	- 9% of all surveyed individuals experienced interruption of medication - 23% of evacuated subjects experienced interruption of medication

(53)	United States	Super Storm Sandy (2012)	Mixed methods study: focus groups, interviews, survey	31	- 68% of the 31 HIV/STD providers surveyed reported moderated to severe impact on offered programs - 84% of respondents reported HIV/STD outreach and education interruptions, 76% reported HIV-related support service interruptions, and 64$ reported HIV/STD testing interruptions - 18% of programs took 12 weeks to resume - 83% of surveyed individuals reported resource shortages
(4)*[2]	United States	Hurricane Katrina (2005)	Telephone survey	1043	- 22.9% of respondents with preexisting mental disorders reported experiencing a reduction in or termination of treatment after Hurricane Katrina

[2] These two studies utilized the same cohort and analyzed different objectives from the same sample population

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