Natural Disasters and the Impacts on Health

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1. INTRODUCTION

A natural disaster is defined as an event of nature, which overwhelms local resources and threatens the function and safety of the community. Generally, disasters are the ultimate test of a community's emergency response capability. A thoughtful and well-organised emergency strategy will be able to quickly adjust and adapt to unforeseen situations and complications. (1) An emergency strategy that is myopic and static in nature is doomed to fail as the disaster situation grows, becoming both complex and unpredictable. Disasters are difficult to plan and anticipate because they are innately different from common emergency events. While it is true that both can lead to large amounts of casualties and property damage, the difference between a disaster and a common emergency event is more than one of magnitude alone. A disaster challenge cannot be overcome by mobilising more personnel or materials. In order for a community to survive a catastrophe scenario, a disaster plan that is adaptable to multi-disciplinary and multi-jurisdictional situations is needed. (2) Large scale disasters can have a multitude of effects upon a community: from economic to social, from physical to psychological. This report will attempt to catalogue and briefly discuss the immediate medical and long-term health effects of a natural disaster. Other topics such as the disruption of a community's critical infrastructure, vulnerable groups within populations, and common misconceptions in disaster response will also be reviewed. Finally, mitigation and loss reduction strategies will be introduced in the context of injury prevention and promotion of health benefits.

2. THE IMMEDIATE EFFECTS OF NATURAL DISASTERS – TRAUMA AND INJURY

Natural disasters are complicated events within which people are subjected to a multitude of risks and dangers. Every disaster scenario is unique in its own way and presents new and unusual challenges to victims and rescue emergency personnel alike. On one hand, each disaster must be evaluated independently of past events in order to recognise the special features of the situation at hand. In this manner, one avoids the common mistake of preparing for the last disaster situation as opposed to anticipating the next one. On the other hand, certain disaster situations do follow general patterns and develop along similar paths. It is vital to appreciate these subtle patterns in order to provide community planners and allied health professionals with a foundation to design a comprehensive emergency response plan. (3) A fine balance must be maintained between learning from the mistakes and lessons of the past, and resisting the temptation of simply approaching a situation 'the way it has always been done'. (4)

Generally speaking, certain disasters lead to certain types of injuries more than others. This can be an important fact to bear in mind when planning an emergency response, taking stock of available medical supplies, or estimating the needs of a community or geographical area. (4) It is crucial, however, to be conscious that injury types are not exclusive to any one situation. Indeed

the sheer scale and complexity of a natural disaster may lead to many smaller disaster situations; each one with its own individual characteristics and challenges. (5) An example of a large scale catastrophe causing many smaller emergencies situations is a large scale flood which in turn causes a chemical spill from a water logged factory, a landslide burying several homes, drinking water reservoir contamination, and the collapse of a downtown building. As a basis for planning, it is nevertheless useful to consider the types of injuries the majority of the victims will incur in order to evaluate the immediate needs of the disaster response team.

Droughts

The immediate emergency effects of a drought are subtle when compared to those brought on by natural disasters such as tornadoes or hurricanes. In a region that has been severely affected by a drought, mortality may increase sharply due to protein malnutrition (kwashiorkor) or calorie malnutrition (marasmus). Certain vitamin deficiencies, such as a lack of Vitamin A, can lead to specific consequences such as xerpohthalmia and child blindness. Long standing malnutrition can easily lead to increased rates of disease and mortality, and limit the general population's functionality. (6) In some cases, mass movements of people spurred by long-standing drought and food shortages can lead to over-crowding and collectively poor hygiene. Over-crowding can easily lead to an increase in the transmission rates of communicable diseases such as tuberculosis or gastro-intestinal infections. (7)

Earthquakes

Earthquakes induce a high level of mortality due to crush injuries from falling objects. The greatest risk of injury from an earthquake is either indoors or in close proximity to buildings and other structures. The risk of injury in open areas such as fields or in the countryside is very low. (4) Furthermore, injury severity is inversely related to the distance from the epicentre of the earthquake. Injuries and deaths are generally increased with the magnitude of the earthquake, increased ground motion, and structural damage. (8)

If an earthquake occurs at night, there is a greater incidence of trauma to the pelvis, thorax, and spine. This is because most victims are lying down in bed at the time of the disaster. These injuries commonly lead to severe damage to internal organs coinciding with severe internal bleeding. If the earthquake occurs during the daytime, it is more common to see injuries of the extremities with comorbid lacerations, severe external bleeding, and crush injuries including rhabdomyolysis and compartment syndrome. Additionally, since most victims are standing or sitting down, most injuries during a diurnal earthquake occur to the skull and the collarbone because of falling debris. (4)

Victims that have been trapped in fallen rubble for hours or possibly days run the risk of having infected wounds and/or gangrene. Common trauma procedures that need to be urgently addressed include amputations, vascular stabilisation, faciotomies, orthopedic stabilisation, and debridement and/or dressing of severe open wounds. It is important to note that patients who suffer from crush injuries also run a high risk of developing hypovolemic shock, hyperkalemia, renal failure, and have a greater chance of having a fatal cardiac arrhythmia or myocardial infarct. (3) While most of the trauma in an earthquake is a direct result of falling debris or collapsing structures, fire is another major concern within the first 'golden' 24 hours after the disaster. Depending on the size and extent of the fires, burn injuries, as well as respiratory problems due to smoke inhalation can quickly become a major strain on the medical system after an earthquake. (3)

Fires

While ninety percent of the forest fires in the United States are caused by human action, 'natural' forest fires most often occur due to lightening strikes in dry and windy conditions. The greatest health impact of a forest fire is, its effect on the surrounding air quality. Due to opportune local conditions, many smaller fires can contribute to poor air quality of one particular area. At the very best, the build up of smoke and pollutants in the air decreases visibility, and at the very worst it leads to new respiratory problems or exacerbates existing conditions. (7) Burn injuries from forest fires are uncommon but not unheard of. Burn injuries are most likely associated with members of the forest fire fighting crew who are commonly called upon to be in close proximity of large and unpredictable fires. Depending on existing wind conditions, forest fires are able to spread rapidly and change direction quickly which can lead to the entrapment of fire fighters and, less commonly, private citizens. (7)

Occasionally, within the context of a large forest fire animal attacks and/or bites also increase. Depending on the proximity of a forest fire to a population center, many wild animals, who have been forced to take flight, come into greater contact with humans. (9) This phenomenon, which is also seen in large floods, can lead not only to trauma from animal attacks, but more commonly increases the risk of zoonotic infections (infection passed from animals to humans). (10)

Great fires that rage through urban areas are less common in developed countries due to the advent of a trained and equipped fire department. However, large-scale urban fires are still possible in the developing world, as well as secondary to other natural disasters such as an earthquake. In 1906, a magnitude 8.7 earthquake in the San Francisco area triggered major fires that eventually destroyed over 25,000 buildings and left 250,000 homeless. (11) Injuries in a large-scale urban fire are more commonly burn injuries and deaths associated with asphyxiation. Common complications of burn injuries include hypovolemic shock as well as massive infection and sepsis.

Floods

The greatest risk of mortality from a flood is predictably drowning. In North America, floods account for more yearly weather deaths than all other natural disasters, with the exception of heat illnesses. The greatest number of deaths and injuries occur when there is little to no warning of an impending flood. This can occur in the case of flash flooding, the collapse of a dam, or from the action of a tidal wave due to a distant or even sub-oceanic earthquake. (12) Consistently, individuals underestimate the power of moving water leading to what could have been many preventable deaths and injuries. In the best of times, it is difficult to estimate the average depth of opaque and fast moving water; and it can be next to impossible at dusk or in the middle of the night. It takes less than two feet of moving water to float a large vehicle such as a school bus, and only between three and six inches of fast moving water to sweep a large man off of his feet. (13)

Second only to drowning, exposure to the elements accounts for a large percentage of the deaths and critical injuries that occur in floods. In many cases, individuals who are caught in rising floodwaters wait for rescue in any refuge that can be found including trees, tops of buildings and automobiles. Depending on the extent of the flooding and the availability of rescue personnel, people may spend hours to days openly exposed to inclement weather. (14) The lower the ambient temperature falls below 15ºC, the greater the risk of accidental hypothermia. (3)

Blunt trauma injuries are not uncommon in floods due to the amount of debris that may be caught in the moving floodwaters along with the unsuspecting victims. (4) Injuries in this case resemble projectile injuries and commonly include extremity and torso fractures, lacerations, and severe bruising.

Heat Waves

Heat waves are known as the silent natural disaster. Between 1979 and 1999, over 8,000 people in the United States died from hyperthermic illness. This represents more deaths than earthquakes, tornadoes, hurricanes, lightening, and floods combined. The immediate health effects of a heat wave are first noticeable among vulnerable populations within an affected area. The elderly, the very young, and the sick are all especially vulnerable to heat stress, which can eventually convey a patient from heat exhaustion to the potentially fatal heat stroke. (15) It is important to note however that the young and healthy are also susceptible to heat illness if the proper precautions are not taken.

Heat illnesses are preventable by remaining in the hot weather for only short periods at a time. Maintaining body fluid status by drinking plenty of liquids and abstaining from alcoholic or caffeinated beverages also help prevent heat illnesses. Treatment of later stages of heat illness, such as heat stroke, includes rapid cooling of the body and urgent fluid and electrolyte replacement. When cooling is initiated, the core body temperature must be monitored in order to guard against rebound hyperthermia or inadvertent hypothermia. (15) The mortality rate for heat stroke is directly related to the duration and severity of the hyperthermia as well as timeliness of diagnosis and treatment.

Hurricanes, Typhoons, and Cyclones

In recent years, sustained population growth in conjunction with aggressive development of vulnerable coastal areas has lead to an increase in hurricane related deaths, injuries, and economic costs. (16) In a hurricane (cyclones in the Indian Ocean and typhoons in the western Pacific Ocean), the greatest mortality originates from the secondary disasters that have been triggered such as small tornadoes, flash flooding, and storm surges. In coastal regions (within 30 miles of a salt-water coast), the level of a hurricane's storm surge is one of the strongest predictors of mortality. Historically, nine out of ten deaths form a hurricane can be directly accounted to the preceding storm surge. (9) Individuals in the storm path consistently underestimate a hurricane's ability to cause coastal flooding and many are caught unprepared for the consequences. On the eastern seaboard of the United States, storm surges can increase the mean water level by as much as fifteen feet in the right front quadrant of the storm. (9) (The right front quadrant is the area of landfall where the hurricane's movement combines with onshore winds to create the area of greatest storm surge.) This effect can be exacerbated by superimposing wind waves upon the storm tidal height in combination with the possibility of a hurricane achieving land fall during high tide. (3)

Winds are the second deadliest aspect of a hurricane. The wind of a hurricane often causes property damage along with the collapse of houses and other wooden structures. Breaches in windows or doors of a structure due to flying objects or wind pressure are common precursors to major damage to a building. (17) Once the stable envelope of a structure has been ruptured, wind is able to freely enter the structure where pressure builds until the walls collapse in an effort to

allow the expanding mass of air to escape. (17) Crush injuries, such as those seen in an earthquake, are common in severe storms or in areas with substandard construction practices. (4) In a hurricane, many additional trauma incidents are caused by large objects which can become airborne in the severe winds. The most common non-fatal traumatic injury in a hurricane is superficial lacerations from flying glass and other debris. (18) In many instances, however, addressing traumatic injuries after a hurricane is not considered a pressing public health concern when compared against the daunting necessity of providing potable water, nutritious food, and adequate shelter for all residents concerned.

Tornadoes

Due to the lack of warning, a tornado offers a community little time to prepare or seek shelter, and hence the morbidity and mortality is proportionally higher compared to other disasters. (12) In the United States, the leading cause of death and critical permanent injury in a tornado is cranio-cerebral injury due to projectiles accelerated by tornado winds. Crush injuries due to collapsing structures or extremely large airborne debris are also frequent. Common non-fatal injuries include fractures, penetrating trauma, lacerations, and other soft tissue injuries. (3)

Lacerations, contusions, abrasions, punctures, and musculoskeletal strain account for over half of the total injuries seen in local emergency rooms. Most victims suffer from multiple wounds and many of the soft tissue injuries occur in areas of exposed skin such as the head and neck. Tornado victims also exhibit a characteristic abrasion pattern on exposed skin that is due to fine particles of soil, mud, sand, and even water which strike the body at highly accelerated speeds. (19)

Wound contamination, and subsequent infection, appear to be a major contributor to post operative sepsis leading to an increased need of aggressive wound care and surgical debridement. One fifth of fracture injuries in the aftermath of a tornado can be expected to be open, contributing to the infection rates among patients. (19) Studies have shown that due to a high proportion of projectile injuries, one half to two thirds of tornado victims who require surgery will exhibit signs of early bacteremia and sepsis. A possible fatal outcome of sepsis infection is multiple organ dysfunction syndrome which then leads to multiple system failure. (3)

Volcanoes

Volcanic eruptions have immediate life threatening health effects as they eject tonnes of airborne pollutants into the atmosphere. Like smoke from large forest fires, the airborne pollutants may cause new respiratory diseases or exacerbate existing conditions. With volcanoes, however, the sheer magnitude of a large eruption can literally fill the atmosphere with tonnes upon tonnes of ash and lethal gases. If caught within close proximity to an eruption, even individuals with no respiratory illnesses will find it hard to breath. Common effects of toxic volcanic gases such as carbon dioxide, carbon monoxide, and sulphuric acid include acute respiratory distress syndrome, pulmonary edema, irritant conjunctivitis, joint pain, muscle weakness, and cutaneous bullae. (3) Burns due to superheated steam or from secondary fires started by the eruption are also common. In many instances mudslides occur in conjunction with volcanic eruptions as the topographical contour of the hillside is changed rapidly. Mudslides, which are commonly seen in flooding situations as well, can lead to crush injuries, severe internal bleeding, multiple organ dysfunction syndrome, and asphyxiation.

Winter Storms

The immediate effect of a severe winter storm is usually felt in disruption of traffic patterns and a severe spike in automobile accidents. Trauma from traffic collisions can vary from orthopedic injury, to severe vascular compromise, to life threatening bruising to the thorax and abdomen. Head injuries, fractures, and bruising are also caused by falls in icy walking conditions and are more common among the elderly. (20)

Exposure to the elements is also of great concern in a winter storm. Individuals may incur frostbite from extended exposure to the unusual cold. Severe cases may require amputation. Since power lines and phone systems are commonly disrupted in a severe winter storm, death from carbon monoxide poisoning and hypothermia is also a large concern as individuals frequently use inappropriate heaters indoors in an attempt to stay warm. (21) Additionally, death and injury from fires are increasingly common in winter storms as individuals leave candles, fireplaces, and heaters burning throughout the night as sources of both heat and light. (21) Furthermore, as previously sedentary individuals venture out into the winter storm in order to effect repairs or clear snow from driveways and roofs, the incidence of unstable angina and acute myocardial infarctions increase dramatically.

3. INDIRECT MEDICAL CONSEQUENCES OF NATURAL DISASTERS – STRESS EFFECTS AND SECONDARY ILLNESSES

In addition to the immediate trauma and injuries suffered by the victims of natural disasters, studies have shown that several secondary medical conditions have a higher incidence in the critical hours and days of the assessment and recovery period. In many cases, these secondary medical conditions can be attributed, at least in part, to the immense stress that is placed on individuals during a disaster situation. Disaster stress varies from situation to situation and each individual is vulnerable to different types and levels. (22) Commonly mass evacuation of communities leads to total disruption of an individual's personal coping mechanisms. Families and neighbourhoods find themselves tossed from their homes, possibly billeting in massive temporary shelters. As shelters are usually places of last resort, individuals remain vulnerable to the lack of information and control that are awarded them. The weight of the situation is compounded by the lack of privacy and even by the isolation of natural support groups within a specific community. (20)

In the aftermath of a major natural disaster such as an earthquake where structural damage is common, an increase in acute myocardial infarctions (AMI) is not uncommon. (23, 24) In the Taiwan Chi-Chi Earthquake of 1999, the sudden increase of heart attacks were limited to mostly male patients and was attributed mainly to formerly sedentary individuals becoming suddenly and intensely active throughout the rescue period. (25). It has also been suggested that the physiological 'fight or flight' response that is initiated during times of perceived personal danger such as an earthquake or other natural disaster, is in of itself contributory to the increase of post catastrophe AMIs. The fight or flight response, which is a hallmark of systemic sympathetic nervous system activation, leads to an increased vulnerability to myocardial attacks in individuals with pre-existing heart disease. (26) Along with outright heart attacks, other cardiovascular complications are increasingly seen after natural disasters such as unstable angina and potentially fatal arrhythmias. In many instances, the affect of the increased stress load is compounded with the interruption of regular medical services for pre-existing conditions such as diabetes and high cholesterol.

In some instances, respiratory conditions such as allergies and asthma are aggravated after a natural disaster. This is especially true if there has been large-scale ejection of pollutants into the atmosphere as with a volcanic eruption or forest fire. Interestingly, this seems to be limited to individuals with pre-existing asthmatic or bronchial conditions, and heavily exposed rescue and recovery workers. (27) In many studies, there was little to no appearance of *de novo* respiratory conditions among the general populace who received minimal to medium amount of exposure to the airborne irritants. (27, 28) Furthermore, it has been found that in the immediate aftermath of some disasters, the actual occurrence of severe asthmatic or allergic attacks is actually decreased. (28)

After an initial decrease in incidence, respiratory illnesses start to show a substantial increase in the days to weeks after a disaster. This apparent shift in illness is attributed more to the transmission of communicable diseases such as influenza or even tuberculosis in crowded temporary shelters. Likewise, respiratory illnesses have been noted to particularly increase in the extended aftermath of a flood. As the floodwater recedes and victims reclaim their former living areas, the concentration of allergens such as dust mites climb dramatically within washed out homes, schools, and offices. (29)

Disaster stress has also been attributed to making current disease processes worse and reducing victims' abilities to fight off infection. One study of rheumatoid arthritis (RA) patients showed that after an earthquake the incidence of RA activity (pain, stiffness, and swelling) increased dramatically. (30) It has also been shown that due to the common occurrence of dehydration, malnutrition, break down of public health safe guards, and stress and anxiety in the aftermath of natural disaster, an individual is more prone to serious infection from a familiar vector. Including disease vectors which under normal circumstances would be non-pathogenic. (11)

In many cases, while the stress of a natural disaster is felt immediately by the victims, the impacts upon their health take days to weeks to surface. This is common with the psychological impacts of catastrophes. In the weeks and months following a disaster event, many patients will suffer from such psychological disorders such as post-traumatic stress disorder (PTSD) or general anxiety disorder (GAD). (12) In many instances victims and survivors complain of some of the following symptoms: night terrors, sudden phobias, grief, depression, guilt, insomnia, loss of appetite or flashbacks and hallucinations. (31) It is common for many behavioural responses - to disasters and catastrophic events - to remain subtly buried within a victim's coping mechanisms, surfacing only under close observation of key health related habits such as sleeping, eating, smoking, or alcohol consumption. Psychological recovery from lapses in mental health, brought on by catastrophic circumstances, is dependent upon the timely recognition of faint symptoms and the availability of the appropriate resources which can be used to promote healing. (31)

As populations in high-risk areas begin to increase in density, the potential for mass casualty natural disasters rises. In the event of a catastrophe with perhaps thousands of victims, the sheer volume would overload local response mechanisms. This would compound any existing stresses and pressures that surviving victims would face after an emergency. Scarce essential resources would now have to be shared between a greater number of victims. Volunteers and health professionals would have less time to spend on each individual. (1) Generally, the severity of secondary medical conditions, many of which can be in part attributed to stress, is directly dependent on the size of the disaster and the community's ability to cope with, and recover from the devastation.

4. THE RESCUE STAGE – DISRUPTION OF THE INITIAL EMERGENCY RESPONSE

In the hours following a major natural disaster, the immediate rescue effort originates from the affected community itself. Local resources are quickly recruited and reorganised to suit the obvious needs at hand. In many instances, this is done on a case-by-case basis, and medical response measures may be initiated before the complete picture is considered. Within the first 24 hours the focus must remain on ensuring that the most critically ill and accessible patients receive the appropriate medical attention and care. However, with many natural disasters, the situation is further complicated by the massive disruption of critical infrastructure which prevents an appropriately organised and comprehensive medical response.

Health infrastructure may be broadly defined as 'traditional lifeline systems within a given community or geographical area'. Some systems contribute directly to the health of the community such as hospitals, clinics, emergency response units, and water treatment plants. Other systems such as shelter, power, fuel, and communication, are not directly labelled as "medical care systems," but still contribute to the public health and safety of the affected populace. (32)

In the worst case scenario, the very core of the health infrastructure, the hospital, could be disrupted. A review of many of the recent major natural disasters in United States revealed that damage or collapse of a hospital is quite rare. Yet, many of the disaster response protocols which were redesigned in the 1970s account for this possibility, even though loss of power or water is more common than structural damage. Hence, most hospitals in North America are equipped with at least one, if not two, backup systems to ensure that a moderate degree of functioning can occur in even the worst situation (although in severe disasters even the backup systems have been known to fail.) (20, 33) However, the situation is vastly different in developing countries. In many underdeveloped emergency care systems, power failures or even structural damage are a real possibility in a serious disaster. In many cases, hospitals and clinics have received no additional disaster protection over the rest of the community, leaving the area at risk to a major catastrophe. (34)

A powerful natural disaster may also directly damage other medical resources such as fire trucks and ambulance vehicles. Damage to emergency vehicles would be most disruptive in the early stage of the rescue operation as many victims seek transportation to medical centres. However, studies have shown that in large-scale disasters, many victims are brought to medical centres in taxis and private vehicles in the absence of ambulances. Thus, damage or destruction of emergency vehicles would acutely affect the critically ill patients who require specialised care at the scene or en route to a designated medical centre. (34) Disruption of transportation routes also interfere with the initial medical emergency response. Natural disasters such as earthquakes, hurricanes, or flooding can render roads, bridges, and tunnels impassable. Inclement weather from hurricanes, cyclones, or tornadoes can ground rescue helicopters and "medi-vac" aircraft. As emergency vehicles are prevented from reaching critically ill victims, it is important to note that patients in private vehicles are equally prevented from reaching hospitals and clinics. In a study of patients caught in flooding caused by Hurricane Floyd in North Carolina in September of 1999, almost one fifth reported difficulty reaching required medical care. (14)

Just as hospitals and emergency vehicles are easily damaged or destroyed by natural disasters, so are medical supply depots and storage facilities. The damage or destruction of essential medical stores carrying medications, dressings, IV lines etc., can compound an already desperate

situation. In the aftermath of any disaster, hospitals and clinics will require additional supplies in order to account for the increase in admissions. The number of victims may overwhelm the medical system's ability to provide for everyone. In addition, certain natural disasters may require specialised supplies in order to treat the presenting specific injury patterns. (20) In some instances, a deficiency in medical supplies may contribute to a "secondary disaster" whereby victims, who would have survived with timely medical care, succumb to their injuries.

Furthermore, in natural disasters, where injuries and loss of life are widespread, prompt medical care may be prevented by the loss of medical personnel. Many disaster plans require that off-duty health workers are called upon in the event of a major catastrophe. A prevailing assumption is that a department may double or even triple their available work force by activating off-duty personnel. In large-scale disasters however this is not necessarily the case. A review of medical practices after the Taiwan Chi-Chi earthquake in 1999 shows that many medical personnel will only respond to the community's needs after they feel that their own family's safety and well being is assured. (25) Combined with the loss or injury to other health care professionals, authorities in Taiwan were faced with a medical work force one half the predicted size. Finally, it was observed that many physicians and nurses that were "off-shift" at the time of the disaster were prevented from reaching hospitals and clinics due to disrupted transportation systems.

A sign of a mature emergency care system is the specific development of disaster protocols and medical sub-specialities, such as trauma medicine, in order to deal with disaster injuries and challenges. Within the context of a developed emergency plan, large tertiary hospitals take a central role in providing care for victims and even act as a central point of organisation for the community as a whole. Commonly, hospitals are structurally reinforced with the forethought of the role that they will play in the disaster recovery operation. With underdeveloped emergency care systems common to developing countries, medical care in a disaster situation is usually given by physicians and health care workers who are not specifically trained in emergency medicine. In these circumstances, there is usually a diffuse response to the disaster with no centralised point of organisation. (34) Here the hospital's role rarely extends beyond providing medical care and community or regional organisation is sporadic at best.

5. THE RESCUE STAGE – DISRUPTION OF THE INFRASTRUCTURE CRITICAL TO PUBLIC HEALTH AND WELFARE

The critical infrastructure of a community is vital to both the well being and public health of its members. As mentioned above, the critical infrastructure constitutes a variety of systems including shelter, power grids, fuel lines, the supply of potable water, transportation networks, and communication systems. (32) Disruption of these services can have immediate effects, as well as long-term consequences.

After providing appropriate and timely emergency medical care, the next priority for the survivors of a natural disaster is shelter. (3) Shelter is a basic human need that protects individuals against the elements, and secondly allows for the restoration of proper public health practices that will protect against long-term health consequences. (12) Finding appropriate shelter for all victims usually becomes a priority around the 48-hour mark after a disaster. At this stage the rescue operation is most likely continuing. For the survivors, however, the recovery and even the reconstruction stage must begin. Loss of shelter is one of the most common consequences of a natural disaster. (35) While different types of natural disasters disrupt the community in different ways, a common thread is their ability to force people from their homes.

In an earthquake, tornado, fire, or a severe winter storm, loss of shelter due to collapsed or unsafe structures leaves victims homeless until other permanent structures can be completed. In disasters such as a hurricane or flood, many displaced victims may be able to return to their homes after the disaster has passed. (3) The type and longevity of the shelter that needs to be provided depends on the particular situation at hand.

Damage to power grids and fuel lines can have far reaching consequences. As exemplified in the severe winter storm to hit the eastern United States and Canada in 1998, an extended disruption in the power grid can leave homeowners vulnerable to the extreme cold as well as disrupt most forms of communication. (36) As days without power turns into weeks, many public health issues arise. Many individuals not only loose their ability to heat or cool their homes, but they also loose the ability to adequately refrigerate or prepare food. The spoilage of food can exacerbate existing food shortages leading to possible large-scale malnutrition. Additionally, in a power outage many households use candles at night and portable kerosene or gas heaters. This increases the risk of fire and/or carbon dioxide poisoning dramatically. (20, 21) In other disasters, such as a tornado or a hurricane, the loss of power can also disable automatic warning systems, thereby increasing a community's vulnerability to the disaster's destructive affects (12). Finally, many communities require an adequate electricity supply in order to properly treat or pump their drinking water. With an extended complete power outage, drinking water that is able to reach homes runs the risk of becoming contaminated. This is compounded with the fact that individuals lack the ability to conveniently boil the water that they do receive. (37)

The loss of a potable water supply is one of the most devastating long-term effects from a natural disaster. As mentioned above, water supplies can be contaminated due to a failure of treatment facilities. However, in earthquakes, the water supply can additionally become contaminated due to damaged water mains. In floods and hurricanes, filtration systems can become overwhelmed and water basins can be rendered impure by floodwaters containing debris and toxins. In volcanic eruptions, acid rain formed from ash clouds can pollute the entire water cycle. (10) The lack of drinkable water in a community quickly leads to water borne illness and dehydration. As personal hygiene decreases, disease can become more frequent and more difficult to contain. (10) Finally, a lack of water due either to pump failure or broken water mains can lead hinder fire fighting efforts, allowing small fires to get out of control and devastate an entire urban centre.

An interruption of an area's transportation network not only hinders emergency vehicle response time, but can also delay or prevent the delivery of food, medicine, external aid and other essential reconstruction supplies. Island communities are extremely vulnerable to isolation as bridges and tunnels connecting to the mainland represent high value access points, which if closed can leave a large population stranded. Additionally, severe weather that commonly accompanies a natural disaster may prevent safe passage over water or by air. (35, 38) Likewise, remote communities which are only accessible through key mountain passes or long jungle roads are vulnerable to isolation from external aid in the event of a severe natural disaster such as land slides, flooding, or earthquakes.

A final aspect of a community's critical infrastructure that a natural disaster may disrupt is the area's communication network. An organised response and revitalization effort needs a stable and comprehensive communication network in order to be both effective and efficient. In order to facilitate a quick recovery, specific sites within the disaster area need to be able to request re-supply in response to the needs they are faced with. As a disaster situation changes and matures, the site needs will develop as well. (33) A suitable communication system is vital to the proper

integration of a multi-organisational response with the relay of information to and from field command posts to an emergency operations centre. Note that field command posts are usually located at the disaster and are responsible for the emergency rescue operations that occur on site. Meanwhile, an emergency operations centre is usually located distant to the actual disaster site, near governmental offices or supply stockpiles. An emergency operation centre is concerned with the accurate and efficient distribution of rescue supplies to all areas of the disaster in order to save the most lives and minimise any subsequent damage. (33) During a communication disruption, the loss of the ability to call for emergency aid will have an obvious effect of postponing appropriate medical care to many individuals. (39) Additionally, the isolation that stems from a lack of communication and information transfer can also have psychological effects as family groups find themselves without direction or reassurance from authorities. (40)

6. THE RECOVERY STAGE – SHORT TERM AND LONG TERM PUBLIC HEALTH CONCERNS

After a catastrophe, as days turn to weeks, the rescue period gradually transforms into the recovery and reconstruction period. The focus of the volunteers and emergency health personnel turns from stabilising patients and treating immediate traumatic injuries to assessing and addressing public health concerns. Survivors turn their attention from searching for other victims to restoring communities and rebuilding lives. The most pressing public health concerns include quickly establishing adequate hygiene protocols, controlling the outbreak of endemic diseases, and re-establishing routine health activities. (4)

The resumption of common medical practice in the shadow of major destruction from a large natural disaster can be accomplished through the utilisation of outside medical aid, or the establishment of several temporary hospital and clinics in suitable locations. (4) The application of any medical system to a disaster region depends heavily upon the local conditions, availability of equipment, prevailing cultural practices, and the number of victims on hand. (5)

One of the primary goals of local health officials in the wake of a major disaster is to resume the normal health practices of the region. This includes the normal operations of all local hospitals and clinics, disease monitoring systems, and all public health programs. Additionally, any disease control programs that were in operation before the disaster must continue. Despite common misconceptions, most outbreaks following a natural disaster are not exotic or rare diseases. Public health officials should instead be vigilant of endemic and common illnesses. (12) Vector control programs are the single most effective method of controlling diseases such as malaria, while vaccination programs are extremely effective for preventing outbreaks of illnesses such as measles, whopping cough, and poliomyelitis. (11).

As survivors may find themselves without access to clean running water, personal hygiene conditions may quickly deteriorate. Disaster victims may allow their personal hygiene to depreciate due to the traumatic psychological effect of the surrounding destruction, the possibility of extremely low standards of living before the disaster, and simple ignorance to the use and maintenance of provided sanitary installations. (5) In many cases, sanitary education is needed to ensure that victims properly dispose of refuse, maintain the cleanliness of temporary shelters, and do not waste or contaminate potable water. (5) Education should also be provided indicating what food reserves are safe and how food should be prepared considering the resources that are available. (18)

A community's overall sanitation may be compromised by shattered water and sewer lines or

malfunctioning filtration plants which can lead to an increase in diseases such as dysentery and cholera. (38) It is vital to note that children are especially vulnerable to dehydration as a consequence of chronic diarrhoea. The lack of refuse removal can increase the amount of contact that individuals may have with disease vectors such as rodents and insects. Consideration must be given to removing preferential vector breeding grounds, such as stagnant water, that are in close contact with population concentrations. Furthermore, vector control should be initiated with pesticide spraying and rat eradication programs. Note, however, that all pesticides in sufficient quantities are toxic to humans and thus a balance between vector management and pesticide toxicity must be sought. (5)

Crowding and unsanitary conditions at temporary shelters is a major contributor to increased disease transmission in the aftermath of a natural disaster. As individuals find themselves in close proximity to one another, an outbreak of a communicable disease can quickly evolve into a mass epidemic. All precautions should be taken to ensure that a basic minimum of sanitation is kept in all shelters. In the event of an infectious disease outbreak, the affected individuals should be quarantined as best can be from individuals with no apparent symptoms. (21) Diseases that commonly affect shelters include influenza, measles, whooping cough, tuberculosis, and scabies and other skin infections.

Mass population movements by victims may also influence the transmission patterns of certain diseases. Displaced people may introduce new and unusual diseases into an area affecting the indigenous population. Likewise, the displaced population could also be infected by locally endemic diseases, which are not common in their homeland. (41) Additionally, the presence of mass numbers of refugees can also place an insurmountable burden upon local resources such as water, leading to an increased incidence of illness among the total population. (11)

As local supplies dwindle, the risk of large-scale malnutrition also increases. Food shortages may arise due to the destruction of food stocks or the disruption of distribution networks from food storage centres. The risk of population wide malnutrition is heavily dependent on the community's nutritional status before the disaster. Populations who were experiencing food shortages or famines in the pre-disaster period are almost certain to experience nutritional problems during the recovery and reconstruction phases. (35) The nutritional status of a population not only affects its functionality, it also contributes to an individual's ability to recover from disease or resist infection entirely. It has been observed that feeding malnourished victims leads to a greater survival rate from diseases such tuberculosis and malaria, especially among children. (11)

It is crucial to consider that when a community's health services fail, certain populations are at greater risk to illness or death than others. In the aftermath of a catastrophe, when medical aid is basic and uncoordinated at best, patients with pre-existing medical conditions run an immense risk of either developing co-morbid conditions or exacerbating their present situation. (21) Individuals with regular health care needs such as dialysis patients can be prevented from reaching a medical facility due to disruption of transportation networks. Furthermore, hospitals, which are inundated with disaster victims, shift their focus to more immediate trauma injuries and away from non-urgent cases. (14)

Both the very old and the very young have a disproportionately higher risk of health problems during the recovery and reconstruction period of a catastrophe. The elderly are less able to recover from physical injuries sustained during the natural disaster and appear to be more

susceptible to stress related illnesses, such as myocardial infarct. (42) Children on the other hand appear to be more disposed to infections and severe diarrhoea. In addition, the poor and homeless of a community are extremely vulnerable to the health effects of a natural disaster. In many cases, the poor are suffering from previous medical conditions such as malnourishment or respiratory infections, which reduce their ability to cope with the further reduction of available resources.

In a large-scale disaster, thought must be given to the collection and transport of the deceased. In order to properly protect the community's health and well being, disaster workers must arrange for the proper transport, storage, and disposal of human corpses. Health workers should attempt to discretely and quickly remove all bodies from the disaster scene to an area where they are to be prepared for burial or cremation. Every possible effort should be made to identify the deceased and notify the next of kin and other relatives. An official register of deaths should be drawn up which should indicate where the body was located, the most likely cause of death, and other identification particulars. Personal belongings should be returned to relatives if possible. (4) In many cases, a balance must be found between burying or cremating the body as soon as possible for health reasons, or waiting to facilitate identification and notification of family.

7. COMMON MISCONCEPTIONS OF DISASTER RESPONSE AND EFFECT ON HEALTH

When a major disaster strikes, people are often motivated to donate aid and time. Perhaps due to misrepresentation in the media, many individuals have misconceptions as to what form of aid is the most beneficial in the aftermath of most natural disasters. If requests for specific supplies are not heeded, or little forethought has been given to what is actually needed within the disaster area, external assistance can actually cause a great deal of disruption and consume precious internal resources. It is essential to bear in mind that any and all external assistance will require both storage space and manpower at the disaster site in order to effectively catalogue, assign, and distribute supplies equitably. In the early rescue period after a disaster, experience has shown that the local governments and citizens are masters at improvisation in order to meet the challenges of the first 72 hours. In many cases it is best to postpone large donations of supplies until the local authorities request specific items or a representative may be sent to the disaster site on a fact finding mission to assess the community's needs. (10)

Another common misconception in the aftermath of a disaster is that any and all medical assistance is needed immediately. This often manifests itself with every individual with first aid training rushing to a disaster scene leading to a sporadic and uncoordinated rescue effort. Again, it has been observed that the local population is largely capable of providing initial rescue needs. (10) It is true that some communities may lack the ability to provide certain medical specialities. In this case, external assistance would be required and greatly appreciated. It is thus important for disaster stricken areas to quickly and concisely request what medical services and aid is needed. (4) Common inappropriate medical assistance include medications unsuitable for trauma care, generally trained health workers unfamiliar with the special needs of disaster victims, and extremely sub-specialized surgical teams whose skills are applicable only to a small patient load. In these situations the external aid does not correspond with true local needs but rather represents either a convenient surplus on hand or the remote appreciation that donors have of the actual situation. (4)

In the aftermath of a large scale natural disaster, rumours quickly abound regarding epidemics of

uncommon and exotic diseases. While it is true that poor sanitary conditions and inadequate personal hygiene increases the risk of illness, post disaster epidemics occur only if the pathogens are common to the local area. (12). Furthermore, by diverting valuable medical resources in order to prevent the occurrence of a low risk event, both the care of urgent patients and the public health of the community may be unnecessarily compromised. Any mass vaccination programs that are initiated in the post disaster phase should be based upon epidemiological observation of local risk factors and not on hearsay nor public alarm. In many cases, the most effective method of controlling and preventing disease outbreaks in the aftermath of a catastrophe, is to quickly rejuvenate community health programs that were ongoing before the disaster struck. (3)

Despite frequent media coverage of widespread looting after a large disaster with dazed and confused victims, studies show that individuals rarely panic or engage in anti-social behaviour. (7) Observation reveals that in many different cultures, survivors of a major catastrophe are able to quickly organise into community groups in order to actively participate in the rescue phase. It has been shown that where search and rescue remains the primary focus of the first 24 hours, the bulk of the work is usually performed by local volunteers. During the initial rescue and recovery operations, it has been observed that increased interaction and co-operation occurs across previously impenetrable class and social barriers. In many cases, local volunteers develop an instant camaraderie and tend to distrust or even ostracise external groups. (7) Finally, in managing a disaster site or in organising the recovery operation, research as far back as the 1940s show that the public deals best with the entire truth. Individuals are able to more efficiently cope with a problem only if they have a complete understanding of the situation at hand. (22) Despite this, governments and authorities consistently and unilaterally decide to withhold fragments of information or downplay risks in order to avoid mass panic. This serves only to perpetuate the urban legend that in an emergency, people are helpless and dependent only on external handouts.

8. MITIGATION AND LOSS REDUCTION

In disaster research and analysis, the vulnerability of a community is defined as the "characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard". (43) It is important to note that some groups within society are more vulnerable to the destructive effects of natural disasters as compared with others. Within certain societies, factors of gender, wealth, culture, ethnicity, or education can all contribute to the risk that certain individuals tolerate on a daily basis. Risk is generally defined as a community's vulnerability factored with the nature of the impending hazard. In order to safeguard against the inherent risk of a natural disaster, the only method in which a community can lower its risk is to decrease its vulnerability. In order to effectively prepare for a natural catastrophic event a society must establish and adequately practice a "Health Disaster Management Program". (10)

An effective disaster mitigation program must include aspects of public education, professional training, and multi-discipline collaboration. Programs, which educate the public and promote personal disaster safety, are the backbone to a successful disaster response. In order for the public to be prepared even to a minimal standard, the specific disasters that the community may face must be common knowledge. Additionally, the community must be made aware of simple actions that can reduce an individual's personal vulnerability. (20) Professionals in many different fields must also possess specific skills relevant to a large-scale disaster response. This includes specialised training for paramedics, doctors, nurses, engineers, and even police officers and military personnel. Health care professionals need catastrophe training in order to modify

daily triage protocols to handle the possible deluge of victims. Engineers need training and equipment, which enable them to quickly assess the structural stability of varying homes and buildings. Police and military personnel may be called upon to control crowds and enforce civil order, and must be specifically trained in how to manage expanded levels of authority in relation to civil rights during times of crisis. (20) Governments must be lobbied in order to improve building codes and to properly fund enforcement. Adequate search and rescue resources in relation to the community's population must be in place as well modernised and "disaster-proof" infrastructure such as highways, bridges, hospitals, and fire halls. Disaster plans must also account for the possibility of mass evacuation and should also provide a basic stockpile of medical supplies.

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