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Disaster ecology: implications for disaster psychiatry

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The nature of disaster from an ecological perspective

When disaster strikes, individuals, families, and entire communities are subjected to powerful forces of harm. Yet, exposure to disaster impact is only the opening salvo. As the disaster unfolds, and far into the aftermath, affected populations grapple with loss and change, consequences that persevere long after the risk for physical harm has dissipated. This trilogy of forces – exposure to hazard, massive personal and societal loss, and profound and enduring life change – characterizes the nature of disaster. Thus we define a disaster as an encounter between a hazard (forces of harm) and a human population in harm's way, influenced by the ecological context, creating demands that exceed the coping capacity of the affected community (Landesman, 2001; Noji, 1997a; Quarantelli, 1985, 1995, 1998; Shultz *et al.*, 2007; Somasundaram *et al.*, 2003; World Health Organization, 1999).

Disasters are population-based phenomena. According to Raphael (2000), "Disasters can have widespread and devastating impact on individuals, families, communities and nations." Disasters are collective, community-wide events, necessitating simultaneous consideration of issues residing within a person, or between persons, or between persons and their community and society. We propose an ecological frame of reference to concurrently consider the interplay of these factors as they pertain to disaster's forces of harm: exposure, loss, and change. Our disaster ecological approach aligns with the tidal shift now occurring within the field of public health that recognizes that human health status is determined not only at the individual level, but just as powerfully by a broad, multi-layered spectrum of factors comprising the social and environmental "context" (Blakely & Woodward, 2000; Kaplan, 1999, 2004; Karpati *et al.*, 2002; Krieger, 1994, 2001; Mackenbach, 1993; McMichael, 1999; Pearce, 1996; Poundstone *et al.*, 2004; Susser, 1994, 1998; Sussser & Susser, 1996; Woodward, 1996). Disaster ecology examines the interrelationships and interdependence of the social, psychological, anthropological, cultural, geographic, economic, and human context surrounding disasters and extreme public health events such as severe storms, earthquakes, acts of terrorism, industrial accidents, and disease epidemics (Kaplan, 1999).

Psychosocial reactions to trauma are recognized to be among the most long-term and debilitating outcomes of disasters (Norris, 2005; Ursano *et al.*, 1994). The extent and extremity of psychosocial responses, ranging from transient fear and distress to chronic psychopathology, relate directly to the nature of disaster itself and to the complex interplay of factors including the exposure of vulnerable human communities to massive forces of harm or widespread perception of imminent threat. Exposure, loss, and change – the forces of harm – represent disaster consequences and powerful stressors (Table 4.1).

Table 4.1 Forces of harm: exposure to hazard, loss, and change

Disaster stressors associated with the forces of harm		
Exposure to hazard	Loss	Change

• Perceived threat of harm
• Disaster warning
• (or) Lack of warning
• Shopping/stockpiling
• Evacuation/sheltering
• Perception of personal threat to life
• Exposure to physical force of disaster
• Personal physical harm
  • injury
  • disease
• Witnessing
  • widespread destruction
  • mass casualties
  • death/injury of others
• Exposure to
  • grotesque scenes
  • noxious agents
• Human causality
	• Bereavement
	• Separation from loved ones
	• Physical harm: pain, debility
	• Loss of function
	• Loss of home, worksite
	• Property damage
	• Lack of basic necessities
	• Loss of personal possessions
	• Loss of social support
	• Resource loss/financial loss
	• Loss of employment, income
	• Loss of independence
	• Loss of control
		• Disruption of services
		• Physical displacement
		• Separation from essential health care, medications
		• Lack of utilities
		• Lack of transportation
		• Unemployment, job change
		• School closure
		• Displacement
		• Financial hardship
		• Disruption of community
		• Personal, community bereavement
		• Shortages, rationing
		• Occupying forces/military rule
		• Refugee conditions
		• Social violence
		• Community poverty
		• Postdisaster disease outbreaks

This chapter describes the evolution of a disaster ecological framework for portraying the impact of disasters on human populations. We begin with a detailed look at exposure to hazards – categorized by type, intensity, time, and place factors – providing the most extensive presentation on this topic within this volume. Issues of loss and change are discussed in detail throughout many chapters and are treated briefly here. We discuss the multiple levels of factors that may influence disaster-related public health outcomes on a proximal to distal continuum, including individual/family, community, and societal/structural levels. Examples of individual/family factors are demographics, family structure, socioeconomic position, disaster-specific behaviors, and response roles. Community context includes community infrastructure and disaster preparedness, social support networks, social environment, civic society, and community socioeconomic status. Societal/structural context includes the physical and built environment, political structure and governance, cultural context, and national or multinational disaster preparedness and response.

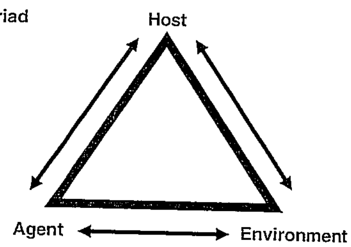
Evolution of a disaster ecology framework

Along the historical path toward a disaster ecology model, two conceptual formulations have provided critical building blocks, the "epidemiological triad" (Fox, 2003; Last, 2001) and the Haddon matrix (Haddon, 1972, 1980). We discuss both prior to outlining our disaster ecology model (Figure 4.1).

Epidemiological triad: causal or exposure pathway models

Epidemiology is defined as "the study of the distribution of a disease or a physiological condition

Epidemiological Triad



Haddon Matrix

	Host	Vector	Environment
Pre-event			
Event			
Post-event			

Figure 4.1 Epidemiological triad and Haddon matrix

in human populations and of the factors that influence this distribution" (Lilienfeld & Stolley, 1994). Epidemiology originated as the study of infectious disease epidemics. The classic "epidemiological triad," consisting of agent, host, and environment, was introduced to explain the spread of disease throughout a community, to identify points of intervention to halt transmission, and to guide field epidemiologic investigations. For example, the influenza virus (*infectious disease agent*) is readily spread to susceptible humans (*host*) through respiratory exposure in communal settings or public gatherings (*environment*). As we comprehended more about the causal or exposure pathway of disease transmission, a fourth element was added to depict intermediaries (i.e., vehicles or vectors) essential for transmission of certain infectious agents through the environment. Some biological agents infect susceptible hosts via such "vehicles" as contaminated water (cholera), food (salmonella), or blood (hepatitis B). Other infectious agents rely upon a living arthropod "vector" (mosquito or tick) to harbor, transport, and mechanically inject the agent when feeding upon an unsuspecting human host. The infectious agents that cause malaria (*Plasmodium* species), West Nile disease (West Nile virus), and Lyme disease (*Borrelia burgdorferi*) are transmitted in this manner (Butler *et al.*, 2003; Reissman *et al.*, 2005; Rundell & Christopher, 2004).

Applying the agent–host–environment triad to the realm of disasters requires bridging the chasm from infectious disease agents to physical forces of harm. Such an analysis was performed to investigate earthquake-related traumatic injuries (Logue *et al.*, 1981; Peek-Asa *et al.*, 2003; Ramirez & Peek-Asa, 2005). Depicting the *agent* as the energy transferred from the earthquake, the *environment* as the buildings and structures in which humans are located at the time of ground shaking, and *host factors* as the demographics, behavioral response, and physiological robustness of individuals, these investigators examined interactions among the three components to elucidate the "causal pathway to injury" (Ramirez & Peek-Asa, 2005).

The Haddon matrix: analyzing the triad factors by event phase

Haddon (1972, 1980) extended the epidemiologic triad to the field of injury prevention and control. In an automobile crash, the motor "vehicle" itself serves as the object for an injurious transfer of kinetic energy (*agent*) to the driver (*host*) with the likelihood and severity of harm strongly influenced by such elements as road conditions, vehicle speed, and use of seatbelt (*environment*). Haddon's primary contribution was to examine the anatomy of a motor vehicle crash, and associated human injury, in time sequence: pre-event, event, and post-event. He considered the interrelation of agent, host, and environment within each phase in order to identify strategies for injury prevention and intervention. His analysis was structured as a two-dimensional table with columns labeled "host," "vehicle," and "environment" and rows representing pre-event, event, and post-event time phases, an elegant formulation that bears his name, the Haddon matrix (Figure 4.1). Runyan (1998) proposed a third dimension to the model, giving a cubic appearance to the matrix.

In 2003, the authors of the Institute of Medicine (IOM) report *Preparing for the Psychological Consequences of Terrorism* (Butler *et al.*, 2003), a landmark publication in the field of disaster psychiatry, extended the Haddon matrix analysis to acts of terrorism – and specifically to psychosocial outcomes. Within their framework, terrorists (*vector*) perpetrate a threat or violent act (*agent*), targeting individuals or populations (*host*), within a "physical and social environment." A more sophisticated analysis might view psychological "terror" as the agent, with terrorists using the threat or overt infliction of harm as the vehicle to incite terror.

The IOM expert panel populated a Haddon matrix to map the psychosocial impact of a terrorist attack. Their 3-by-3 matrix included disaster phase (pre-event, event, post-event) as one dimension and the triad of affected populations, "terrorist and injurious agent," and "physical and social environment" as the others. The same array was also used to map intervention strategies that might be implemented to mitigate the psychosocial impact of a future event.

Others have used the Haddon matrix for public health readiness and response planning, including pandemic influenza preparedness, and have expanded the columns to treat physical and social environments separately (Barnett *et al.*, 2005a, 2005b). The Centers for Disease Control and Prevention (CDC) used modified Haddon matrices to promote strategic planning for public health response and recovery functions and to help map out a comprehensive research agenda. Innovations applied to the model included the concept of "collective efficacy" and community resilience as part of the environmental context to describe pro-active, community-based health protection strategies (Pfefferbaum *et al.*, 2006; Reissman *et al.*, 2005; Ritchie *et al.*, 2005).

Disaster ecology model

To model disaster ecology, we will apply a causal and exposure pathways approach incorporating the elements portrayed in the epidemiologic triad and Haddon matrix. To account for the diverse types of disasters and emergency events, we will use disaster-specific terminology that is applicable across all hazards.

We recast agent in terms of "hazard" or "forces of harm." Host expands to "affected communities and populations," the term used in the IOM report. The physical and social environment acquires multiple dimensions and layers of "ecological context" to account for a variety of socio-cultural relationships and the interdependence within and between communities (Figure 4.2).

Second, we recommend strengthening the emphasis on what historically has been the short stump of the triad's three-legged stool of the epidemiologic triad, the "environment." We propose to expand environment to ecological context and to greatly strengthen the focus on this component. Consider for example, at a time of intensive focus on terrorism, that the socio-cultural context is the dominant determinant of what sets terrorists on their course, while the interaction between the mechanism of harm (an explosive, for example) and persons in harm's way is quite secondary when considering intervention strategies.

Fortunately, the emphasis on ecological context is gaining momentum as increasing numbers of investigations and sophisticated analyses are conducted from the perspectives variously described as eco-social (Krieger, 1994), eco-epidemiological (Susser & Susser, 1996), and social-epidemiological (McMichael, 1999).

To the progressive evolution of the triad and matrix formulations, the disaster ecology perspective offers the prospect of disaster-specific focus and terminology coupled with full appreciation for the co-equal, and sometimes predominant, importance of the ecological context dimension. Also, the simple clarity offered by the Haddon matrix, with its appeal for planning and preparedness, can be supplemented by more in-depth, multi-level analyses being developed by social epidemiologists that will better define points for intervention to diminish disaster likelihood, in the case of human-generated events, and the devastating impact of disasters of all types.

The disaster ecology model, depicted in Figures 4.2 and 4.3, serves as the basis for the remaining discussion that will focus sequentially on hazard factors,

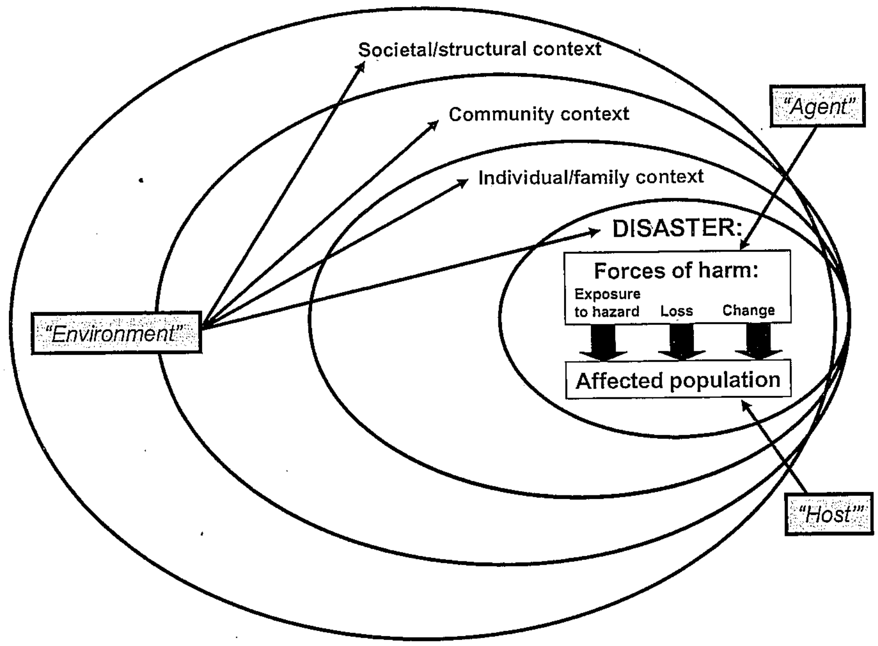


Figure 4.2 Disaster Ecology Model

followed by three levels of ecological context factors: individual/family, community, and societal/structural.

Disaster ecology model: exposure to hazards (the forces of harm)

Exposure to the forces of harm represents the defining disaster event and a strong predictor of adverse medical and psychological effects (Galea & Resnick, 2005). This is represented as the inner circle on the disaster ecology diagram (Figure 4.2). The spectrum of hazards can be described across multiple dimensions of type, magnitude, frequency, and locale; each of these descriptors provides a measure of exposure for human populations encountering these harmful forces. Directly relevant to the field of disaster psychiatry, the degree of psychosocial impact varies by disaster type and generally increases with increasing magnitude and frequency of disaster occurrence (Norris *et al.*, 2002a, 2002b).

Moreover, loss and change associated with disaster are powerful forces of harm that create overt hardship and exacerbate stress, continuing the psychosocial impact of disasters far beyond the period of time when the disaster hazards are exerting their effects (Table 4.1). The protraction of loss and the relative permanence of change partially explain why psychosocial effects are prolonged relative to the time of direct exposure and physical harm. Through loss, many more persons are affected psychologically than physically, extending the reach of the disaster numerically, temporally, and geographically. These forces are integrated into the discussion of the multiple levels of context and are a principal focus of other chapters.

Forces of harm: disaster type

An expansive range of events qualify as disasters, capable of exerting destructive force and causing damage, injury, disease, death, and loss of infrastructure (Noji, 1997a). The universe of extreme events is frequently divided into two broad

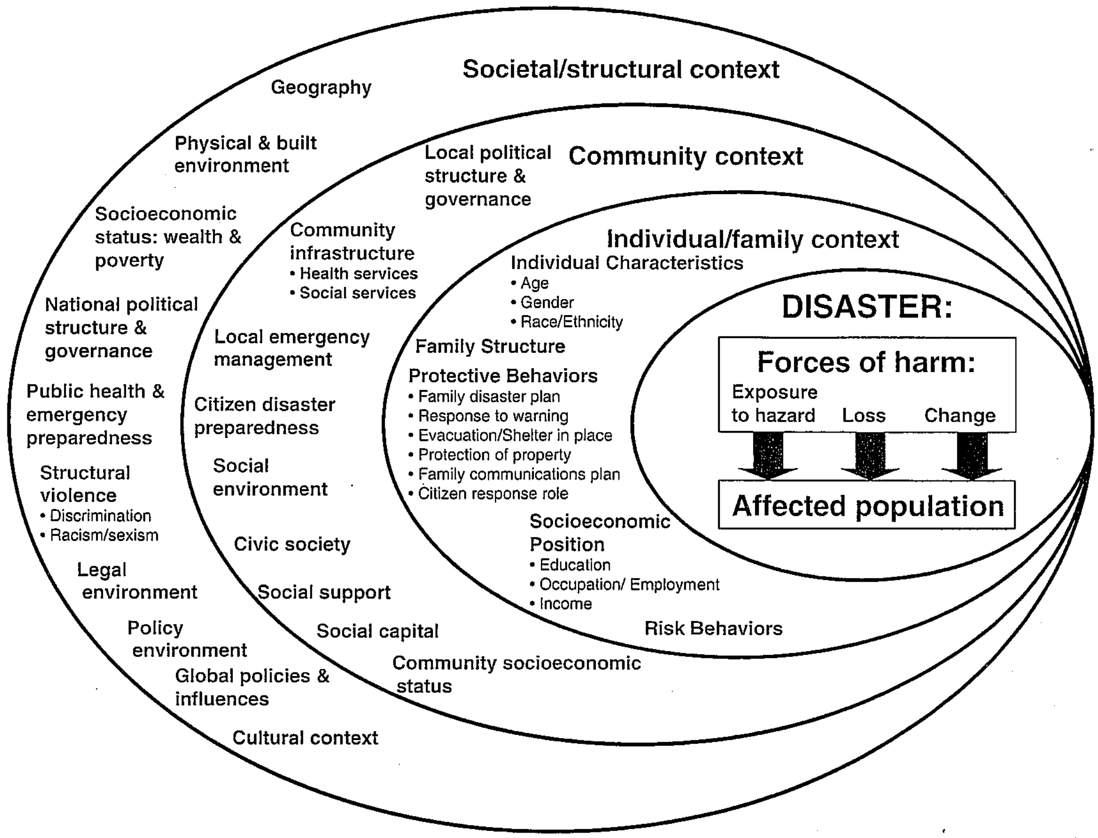


Figure 4.3 Detailed disaster ecology model

categories, natural disasters and human-generated disasters (Rutherford & de Boer, 1983) (Table 4.2). Norris and colleagues determined that disaster type matters (Norris & Kaniasty, 2004; Norris *et al.*, 2002a, 2002b). These reviewers conclude that large-scale, mass-violence events, in which harm is intentionally perpetrated, are associated with more severe psychosocial impairment than are natural disasters and that, within developed nations, technological disasters are more harmful psychologically than are natural disasters.

Natural disasters

Natural disasters, in which harm to human populations is primarily caused by the forces of nature, can be further categorized into hydro-meteorological disasters (typically weather-related) such as floods and windstorms; geophysical disasters such as earthquakes and tsunamis, and volcanic eruptions; droughts and related phenomena; and pandemic waves of disease (Centre for Research on the Epidemiology of Disasters, 2005; Guha-Sapir *et al.*, 2004).

The United Nations Development Program provides a strong statement regarding the impact of natural disasters: "In the last two decades, more than 1.5 million people have been killed by natural disasters. Worldwide, for every person killed, about 3 000 people are exposed to natural hazards. Some 75 percent of the world's population lives in areas affected at least once by earthquake, tropical cyclone, flood or drought between 1980 and 2000. At the global level, and with respect to large- and medium-scale disasters, these four hazard types (earthquakes,

Table 4.2 Disaster classification

Natural disasters
Hydrometeorological disasters (Weather-related)
Floods and related disasters
Floods
Landslides/mudslides
Avalanches
Windstorms
Tropical cyclones (hurricanes, cyclones, typhoons, tropical storms)
Tornadoes
Storms: thunderstorms, winter storms
Geophysical disasters
Earthquakes
Volcanic eruptions
Tsunamis/tidal waves
Droughts and related disasters
Extreme temperatures
Wildfires
Droughts
Famine
Insect infestation
Pandemic diseases
Human-generated disasters
Nonintentional/technological
Industrial accidents
Transportation accidents
Ecological/environmental destruction
Miscellaneous accidents
Intentional
Declared war
Civil strife
Ethnic conflict
Mass gatherings
Terrorism
Complex emergencies

tropical cyclones, floods and droughts) account for approximately 94 percent of total mortality." (United Nations Development Program, 2004).

Human-generated disasters

Disasters caused or exacerbated by human action are subdivided into intentional versus nonintentional events based upon the presence or absence of purposeful human causation. Industrial disasters, transportation disasters, and progressive or precipitous destruction of ecosystems reflect failures or side-effects of human-devised technologies (frequently referenced as "technological disasters"), failures of human judgment, or even flagrant human neglect. However, harm and destruction are not intentionally perpetrated. Several particularly memorable technological disasters are the accidental toxic gas release in Bhopal, India and the nuclear meltdown in Chernobyl, Russia.

In contrast, intentional harm is a defining feature during acts of mass violence including declared war, civil strife, ethnic or religious conflict, and acts of terrorism. Terrorist actions threaten harm, or overtly inflict harm, with the intent of provoking widespread fear that extends beyond those who are directly targeted (Butler *et al.*, 2003; Ursano, 2002). Civilians, rather than soldiers or police, are increasingly targeted, and represent a growing proportion of casualties from all types of mass violence, especially acts of terrorism.

Disasters have been described as "extreme event(s) at the interface of natural and human systems," (Sarewitz & Pielke, 2001). Some extreme events generate compounding consequences and pervasive human suffering on a scale that warrants use of the term "complex emergency." According to the World Health Organization and United Nations, a complex emergency has been defined as:

> a humanitarian crisis in a country, region or society where there is considerable breakdown of authority resulting from internal or external conflict which requires an international response that goes beyond the mandate or capacity of any single agency ... complex emergencies are typically characterized by: excessive violence and loss of life; massive displacements of people; widespread damage to societies and economies; the need for large-scale, multifaceted humanitarian assistance; the hindrance or prevention of humanitarian assistance by political and military constraints; and considerable security risks for humanitarian relief workers in some areas. (United Nations Development Program, 2004; World Health Organization, 2005).

Disaster consequences frequently derive from interaction between both natural and human factors. Tropical cyclones are particularly disastrous when they strike densely populated, low-lying coastal areas where many live in structurally vulnerable, ramshackle housing (Shultz *et al.*, 2005). In the case of Hurricane Katrina in 2005, New Orleans sustained damage but withstood the pummeling storm surge and battering hurricane winds. However, post-storm failure of the human-engineered levee system produced massive flooding which was to become the major hazard, claiming more than 1 000 lives and devastating infrastructure. New Orleans essentially survived the natural disaster, but succumbed to a technological catastrophe.

The reverse pattern was observed following twin explosions at the Chernobyl nuclear reactor on April 26, 1986 (Hatch *et al.*, 2005). Radioactive cesium^{137} was released from the incinerating site for 10 days, a classic human-generated event. However, geographical dispersion of airborne radioactive material extended over much of the former Soviet Union, Scandinavia, and Europe, a function of strong and highly variable winds.

In a similar vein, The United Nations Development Program described the term "hazard" as "a natural or human-made event that threatens to adversely affect human life, property, or activity to the extent of causing a disaster," (World Health Organization, 1999) and offered the following five-fold typology:

Natural-physical	hydrometeorological and geophysical disasters
Natural biotic, biological	pest infestations, epidemics, pandemics
Socio or pseudo natural	human transformation of the natural environment
Man-made technological	contamination, explosions, conflagrations
Social	conflict including war, civil strife, violence.

Forces of harm: magnitude

Globally, the cumulative impact of disasters can be estimated using multiple measures. The public health consequences of disasters can be assessed in terms of mortality, morbidity (injury, disease, psychosocial impact), and disruption of health care infrastructure. During the 1995–2004 decade, cumulative disaster-associated mortality associated with 5 989 registered disasters totaled 901 177 deaths, an average of 150 deaths per disaster (Centre for Research on the Epidemiology of Disasters, 2005) worldwide (Table 4.1). These disasters generated 2.5 billion person-events in which an individual was affected by disaster (physical harm, displacement, property loss), with some individuals affected by multiple disaster events. Injury predominates as the major form of disaster-associated morbidity but disasters may also involve infectious disease outbreaks as the defining event. The precise pattern of morbidity is dependent upon the type and intensity of the event interacting with the vulnerabilities of the affected populations. Disasters are also expensive; Centre for Research on the Epidemiology of Disasters (CRED) has estimated total economic costs associated with the 5 989 disasters occurring during 1995–2004 at $739 billion.

Absolute magnitude

Increased physical magnitude of a hazard is associated with increased physical harm and destruction, and concomitant psychosocial impact. Specifically, severe, lasting, and pervasive psychological effects are likely when a disaster causes extreme and widespread damage to property, serious and ongoing problems for the community, and there is a high prevalence of trauma in the form of injuries, threat to life, and loss of life (Norris *et al.*, 2002a, 2002b).

However, examined from the opposite perspective, Norris and colleagues (2002a, 2002b) offer the following insightful caveat: events (1) that involve few deaths or injuries, (2) that create limited destruction and property loss, (3) during which social support systems remain intact and function well, and (4) that involve no indication of human neglect or malicious intent are likely to have minimal psychosocial impact on the affected population. A high proportion of disaster events fulfill these criteria. Disaster events of such magnitude that they cause great harm, necessitate large-scale response, and generate extensive media attention are relatively few in number; yet these exceptional incidents tend to become the focus for published research studies regarding physical and psychosocial consequences.

Relative magnitude

Events of identical type and equal physical magnitude may pose very different challenges for populations of different sizes, and for communities with ample versus limited response capacity (United Nations Development Program, 2004). Norris and colleagues (2002a, 2002b) noted that the scale of the disaster relative to the size of the community is relevant. Describing this phenomenon as the "impact ratio" the point made is that a disaster that causes harm to 100 persons has a very different level of impact for a community of 500 versus a community of 500 000.

This point finds its way to the very core of disaster terminology. Quarantelli (1985) defined disaster as a "crisis occasion where demands exceed capabilities," and he offered the following continuum of labels for disasters of varying magnitude relative to community resources (Quarantelli, 2006):

Crisis	Capacity exceeds demands – with capacity to spare
Emergency	Capacity meets or somewhat exceeds demands
Disaster	Demands exceed capacity
Catastrophe	Demands overwhelm and may destroy capacity.

Immediately following the extreme damage wrought by Hurricane Katrina along the Gulf Coast, Quarantelli (2005) described six distinctions that place catastrophe in a qualitatively different realm from disaster: (1) much of the built structure of the community is damaged or destroyed including operational headquarters for emergency response organizations; (2) local officials are unable to perform their usual job functions; (3) destruction is frequently so widespread that nearby communities are impacted and unable to offer aid; (4) community functions and vital services are markedly disrupted and shortages may become acute; (5) mass media "socially construct" the event, selectively broadcasting negative consequences, antisocial behaviors, and damaging rumors to a national audience while local coverage is limited or absent; and (6) the expansive magnitude of the event demands attention from national leaders, infusing the catastrophe with political implications of blame and responsibility. While disaster preparedness has become a major theme of homeland security initiatives in developed nations, catastrophe preparedness remains beyond reach by the very nature of the capacity-obliterating destruction that defines such an event (Lakoff, 2005).

Measures of magnitude

The greater the magnitude of the hazard, the greater is the potential for causing harm, but the hazard must impact vulnerable human populations to precipitate disaster. Consider that while more than 500 000 earthquakes are detected by ultra-sensitive instrumentation each year, the majority are of minimal intensity or occur far from human habitation. Less than 1% (3 000) is even perceptible to human populations, among which 7–11 will cause significant loss of life (Alexander, 1996; International Federation of Red Cross and Red Crescent Societies, 1996; Ramirez & Peek-Asa, 2005).

It is apparent that forces of harm come in gradations. Scales have been devised to measure magnitude and intensity. For hurricanes, the Saffir–Simpson Scale classifies tropical cyclones into tropical depressions, tropical storms, and five categories of hurricanes based on specific cut-points of wind speed and central pressure (Shultz *et al.*, 2005). Accompanying the scale are estimates of the height of coastal storm surge and a narrative description of the degree of damage likely to be sustained by physical structures subjected to the full brunt of the storm. Similarly, the Fujita scale provides an intensity assessment for tornadoes, describing the width of the tornado's destructive swath and the distance traveled along the ground, accompanied by wind speed and damage estimates.

Magnitude and intensity are measures of an earthquake's strength. *Magnitude*, measured on the Richter scale, is the total energy from seismic or elastic waves radiating from the epicenter (Alexander, 1993; Ramirez & Peek-Asa, 2005). However, as a single, summary exposure measure for the entire earthquake event, this metric is not useful for predicting harm to individuals who are distributed over a broad geography. Measures of *intensity* such as peak ground acceleration and Modified Mercalli Intensity (MMI) assess the earthquake effect at specific locations (Noji, 1997b) and, where sensors are available, these measures may accurately predict earthquake injury and death (Mahue-Giangreco *et al.*, 2001; Peek-Asa *et al.*, 2000, 2003; Shoaf *et al.*, 1998).

For human-generated events, quantity measures are often used to denote magnitude or dose of exposure. For example, the destructive force of bombs and blast devices is measured as a multiple of the explosive power of a ton of dynamite (trinitrotoluene). The greater the quantity of explosive, chemical, nuclear, or biological agent released, the greater will be the destructive potential.

Forces of harm: the time dimension

Generally, harm, destruction, and psychosocial impact will increase with increasing frequency and duration of disaster events, and subsequent destruction of infrastructure and services leading to prolonged disruption. Multiple simultaneous or serial events will have a more profound, and possibly synergistic, impact than single events. Concatenation and compounding of multiple forces of harm will extend the impact period, expand the magnitude of destruction, and exacerbate the complexity of the recovery process. Multiplicity may come into play with or without hazard impact; the perception of ongoing threat and possible distortion of one's sense of safety may be prompted, for example, by the approach of a series of menacing hurricanes during a highly active tropical storm season, or by sporadic ominous statements released by a terrorist organization.

Lack of warning precludes defensive or protective actions that could mitigate the approaching forces of harm or move citizens from harm's way. In contrast, knowledge that certain types of hazards are rare or that the hazards are cyclical, restricted to specific seasons, or are preceded by ample warning periods, increases predictability and perceived control – and diminishes stress.

Frequency and trends

Disasters are common phenomena. Once every 19 h, a natural disaster is recorded in the international disaster registry located at CRED in Brussels, Belgium (CRED, 2005). Once every 25 h, a human-generated "technological" disaster is registered.

CRED maintains the EM-DAT Emergency Disasters Data Base (CRED, 2005), as the mechanism for compiling and sharing information on disasters worldwide. To be included as a disaster recorded in the EM-DAT data base, at least one of the following four criteria must be met: (1) 10 or more people reported killed, (2) 100 or more people reported affected, (3) declaration of a state of emergency, or (4) request for international assistance. Greater attention to disasters and an increasing sophistication in our ability to detect them produce the appearance of an explosive, exponential increase in disasters (Figure 4.4).

Technological advances and expansion of international communications coupled with enhanced global cooperation have increased the completeness of disaster reporting (Guha-Sapir *et al.*, 2004). Furthermore, a significant trend toward increased reporting of small- and medium-impact disasters has swelled the numbers of disaster records. The largely artifactual upsurge in numbers of disaster events, particularly from the 1960s forward, also coincides with the emergence of the field of disaster management (Kirschenbaum, 2004). Proliferation of governmental, nongovernmental, and university-based disaster management and

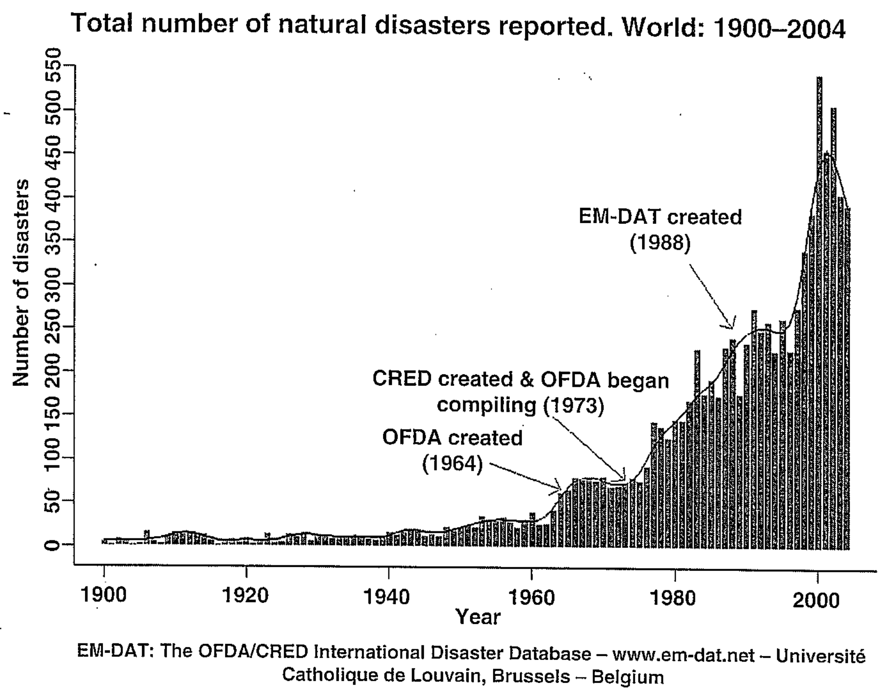


Figure 4.4 Frequency of reported and registered disasters

response services has generated intensive demand for disaster reporting, since the very announcement of a disaster launches these programs into action.

EM-DAT organizes and counts disaster events by country. Thus disasters affecting many nations generate multiple registrations. Hurricane Mitch, a single tropical cyclone that ravaged Central America in 1998, appears in the EM-DAT data base as a collection of seven country-specific disaster records. The tsunami of December 26, 2004, the highest fatality event of its type in recorded history, generated 12 country-specific disaster entries. Approximately one-in-six disasters in the data base is a multi-country event (Guha-Sapir *et al.*, 2004).

It is the aim of EM-DAT to systematically define and routinely report disasters in a timely manner with high fidelity and consistency worldwide. It is anticipated that the number of natural disasters annually will reach something resembling a steady state, or perhaps a gradual upward trend, as increasing numbers of persons continue to migrate and settle in disaster-prone regions. During the 5 years 2000–2004, 3 199 natural disasters and 2 790 technological disasters were registered with CRED. On average, for each of these 5 years, 9 cyclones, 12 hurricanes, 17 typhoons, 11 tornadoes, 32 earthquakes, 154 floods, 20 landslides, 57 industrial accidents, and 225 transportation disasters were recorded. While EM-DAT does not track terrorist events, the recently established U.S. Department of Homeland Security's Counter-Terrorism Center compiles such incidents and reported an average of eight terrorist events per day in 2004.

Seasonality and cyclicity

Many types of natural disasters, particularly the large class of hydrometeorological events, tend to be seasonal. Tropical cyclone seasons are determined by annual fluctuations in ocean temperature (Figure 4.5). Winter storms are seasonal by

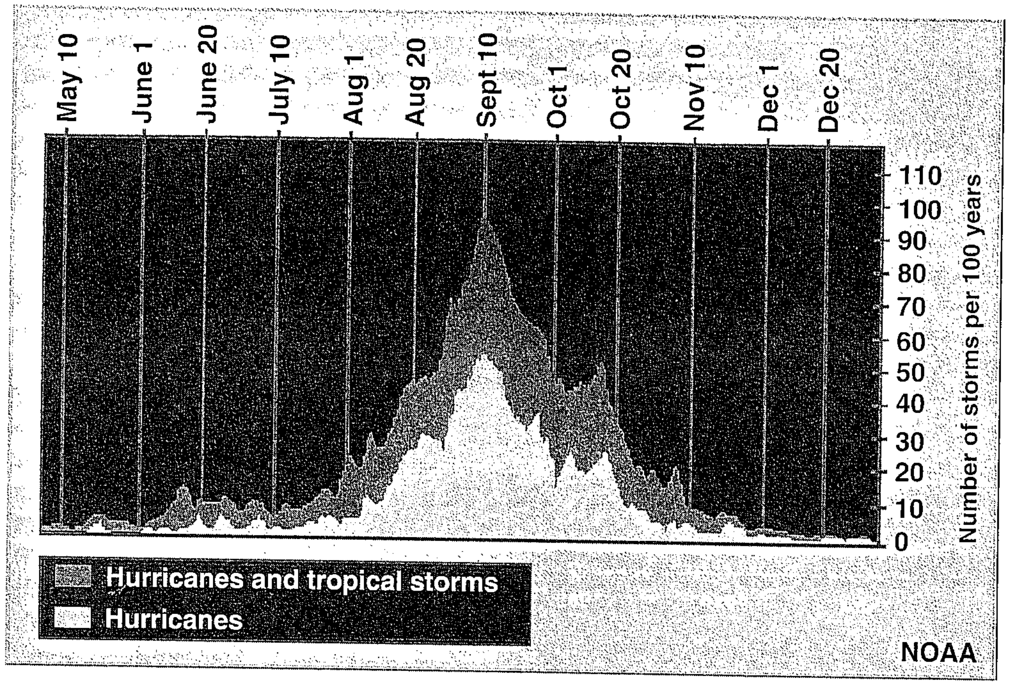


Figure 4.5 Seasonality: Atlantic Hurricane Basin tropical storms and hurricanes

definition and flooding occurs with spring thaws, rainy seasons, or monsoons. Some infectious diseases such as influenza circulate globally, rising and falling on a seasonal basis within a particular geographic area.

Severity of certain forces of harm may also vary over multi-year periods. One notable example is the 20- to 40-year cycle of hurricane frequency and intensity. Increases in numbers of named tropical storms, hurricanes, and major (Category 3 or higher) hurricanes occurred in the Atlantic Hurricane Basin during the 1940s, 1970s, and again during the early 2000s. As another example, influenza causes illness and death on a seasonal basis annually. Influenza viruses periodically emerge from animal reservoirs and mutate in such a fashion to cause infection in humans. When antigenic shift or adaptive mutations result in a highly virulent strain, an influenza pandemic erupts (as no humans have immunity). This has led to deadly flu pandemics three times in the past century; thus highlighting current concerns about the evolving avian flu designated H5N1 from Southeast Asia.

Duration of impact/duration of disruption

Time factors of great import are duration of impact and duration of disruption. Impact varies from seconds (earthquakes and landslides, conventional bomb blasts) to minutes (tornadoes, flash floods, tsunamis) to hours and days (hurricanes) to weeks and months (riverine flooding, volcanic eruption, pandemics and bioterrorist disease outbreaks) to years (famine, drought) to decades and centuries (radioactive contamination). Moreover, the period of disruption of vital services may be protracted if power is disrupted, and schools and businesses are closed due to damage. Population displacement is one of the hallmarks of humanitarian crises and complex emergencies. In some cases persons can never return home due to physical destruction so catastrophic that the area is deemed unsalvageable. Events such as extreme contamination, profound depletion of vital resources, or change in ownership following warfare or ongoing militant threat may displace and dispossess persons in a manner that may be life-long.

Multiplicity

While isolated, discrete disaster events may produce widespread consequences, multiple events exert a greater effect than do single events. This has been explicated in relation to terrorism (Butler *et al.*, 2003; Ursano, 2002). We distinguish three patterns of multiplicity: simultaneous, sequential (consecutive), and cascading (Shultz *et al.*, 2007). Multiple events may occur simultaneously. A signature tactic of the terrorist organization Al Qaeda involves same-time strikes on multiple targets: (1) bombing two American embassies in Kenya and Tanzania in 1998; (2) hijacking four civilian aircraft on September 11, 2001; (3) attacking three hotels in Amman, Jordan in 2005. Another variation on the theme of multiplicity involves repetitive assaults over time, especially when it is difficult to assess the individual risk of being targeted. This was demonstrated with the serial sniper shootings in the metropolitan areas of Washington D.C., Maryland, and Virginia in 2002 (Grieger *et al.*, 2003), and the anthrax bioterrorism in 2001 involving spore-laden envelopes mailed through the US Postal Service (Jernigan *et al.*, 2002) – both events were protracted over several months. In the realm of natural disasters, repeated strikes by the same type of disaster are not uncommon. From August through November of 2004, the State of Florida was struck by a succession of four destructive hurricanes (Centers for Disease Control and Prevention, 2004). Similarly, Guam endured a series of five consecutive typhoons in 1992 (Staab *et al.*, 1996).

Multiplicity may appear as a cascade or concatenation of disaster events. The succession of the forces of harm related to Hurricane Katrina striking the Gulf Coast in 2005 included extraordinary storm surge, inundating rains, powerful hurricane force winds, levee failure, massive flooding, and onshore flow of hazardous materials from damaged oil platforms. These hazards amplified and compounded into overwhelming health concerns and significant doubts about economic and sociocultural recovery.

Predictability

The time factor is also relevant in terms of warning periods. Most types of natural disasters provide minimal warning periods (tornadoes, tsunamis, flash floods, volcanoes) or none at all (earthquakes, slides, tsunamis in areas without warnings systems). Notable exceptions are tropical cyclones, riverine floods, and winter storms, events that provide sufficient warning to prepare and protect lives and property. Acts of terrorism and many acts of warfare are conducted without warning to maximize both the devastation and the terror provoked.

Forces of harm: the place dimension

There are definable geographical boundaries that prescribe where disasters may – and may not – occur and, by extension, which populations may sustain impact. Similarly, terrain and topographic features mark areas of risk for certain types of disasters.

Geography and topography

One of the most distinguishing features of disaster occurrence is geographic distribution. For example, tropical cyclones form seasonally in seven hurricane basins distributed as twin belts just north and south of the equator. Tropical cyclones require multiple simultaneous climatic conditions for cyclogenesis, most fundamental of which is warm ocean water. Human populations susceptible to powerful hurricane strikes are those living in coastal regions at the perimeter of the hurricane basins. Populations living in vast inland areas and along coastal areas that border perennially cool waters are spared from the worst ravages of hurricanes, typhoons, and cyclones (Shultz *et al.*, 2005).

While tropical systems can maintain momentum over considerable distances inland, the destructive

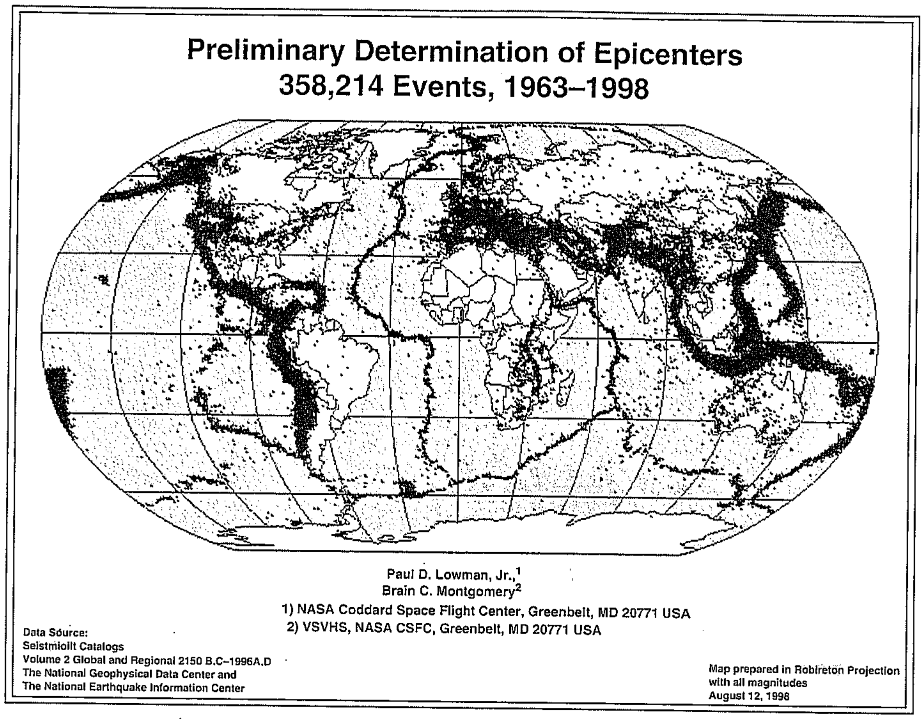


Figure 4.6 Place characteristics: worldwide seismic activity

force of tsunamis is restricted to several miles inland from the coast, yet the affected coastline may extend for thousands of miles along the perimeter of multiple continents. Likewise, earthquakes are concentrated in regions where the tectonic plates that compose the Earth's surface abut and interact (Adams, 1990; Kious & Tilling, 1996; Noji, 1997b; Simkin *et al.*, 2004) (Figure 4.6). Ramirez and Peek-Asa (2005) describe the geospatial dimensions of earthquake risk, "Populations located above plate activity are at greatest risk of earthquake-related morbidity and mortality, such as communities along the Pacific Rim ..., along island chains ..., and boundaries between certain continents."

Tornadoes form at the intersection of unstable air masses and the most active tornado belt on Earth is in the United States Midwest. Landslides and mudslides require steep, mountainous terrain while winter storms and avalanches occur in low temperatures and high elevations. Flash floods and riverine floods, the most deadly of natural disasters, require a combination of meteorological and geographical features for their propagation.

The World Bank's *Natural Disaster Hotspots: A Global Risk Analysis* displays a series of composite maps and corresponding analyses of the worldwide distribution of risk for single and multiple hazards, disaster mortality, and economic loss (World Bank, 2005). Graphical depiction demonstrates that portions of the world's population are at heightened risk and high vulnerability for the onslaught of a variety of disasters while other populations live in zones of nominal risk.

The Asia–Pacific region experiences the greatest absolute and proportional mortality due to earthquakes, tropical cyclones, and floods. The only comparable loss of life is sustained in Africa associated with drought and exacerbated by the dynamics of complex emergency including armed conflict, extremes of poverty and epidemic disease

(United Nations Development Program, 2004). Africa also sustains loss of life from flooding. Latin America and the Caribbean are principally affected by tropical cyclones, flooding, and associated landslides and mudslides.

Currently, wars and civil conflict are raging in multiple venues. Refugee and internally displaced populations frequently reside in makeshift housing at elevated risk for harm, vulnerable to the ravages of natural hazards. Acts of terrorism likewise have geographic foci; much of the world's surface is spared from such atrocities while certain pockets remain hotbeds for frequent acts of terror. Within nations threatened by terrorism, risk for attack varies remarkably by locale; a function of terrorist tactics, target selection, and population concentration.

Extending the previous discussion, topography further defines the boundaries for disaster occurrence. Low-lying areas are susceptible to flooding, while coastal areas are prey to wave action and storm surge. Steep terrain and mountainous areas are prone to landslides and mudslides in response to heavy rains or seismic activity. In northern latitudes and high altitudes, avalanches may occur. Dust storms and sand storms sweep arid plains and deserts. Regarding acts of terrorism, terrain, geology, and topography are all relevant factors in determining availability and choice of targets, availability and choice of weapons materials, and availability of remote and inaccessible hiding places where terrorists may lurk between attacks.

Area and path

The area of impact may be geographically focalized, or may expand to cover a vast area, or may extend over extraordinary linear distances. The September 11 attack on the United States was geographically constrained to several dozen blocks in lower Manhattan, Pentagon City, and a small acreage in Shanksville, Pennsylvania. Hurricane Katrina, in contrast, affected 600 miles of Gulf of Mexico coastline and pierced deep into the southern states before losing force and momentum. The track of destruction of hurricanes and tornadoes can extend for hundreds of miles over land. The tsunami of December 2004 devastated coastlines on multiple continents and the entire circumference of the island nation of Sri Lanka. Drought, such as that in the Darfur area of Sudan, may stretch over large territorial expanses.

Forces of harm: summary

Forces of harm are powerful primary stressors in their own right, and the consequences of disaster impact typically result in disruption of function that creates a cascade of secondary stressors. Hurricane Katrina, striking the US Gulf Coast in 2005, provides a "forceful" example of the hazard or forces of harm dimension (Table 4.3).

Forces of harm associated with a disaster can be considered from many perspectives. The degree and extent of harm are directly related to the type of disaster, the magnitude and intensity of the event, the frequency and duration of exposure to the forces of harm, and the geographic scope and scale – and so too are the psychosocial impacts (Norris *et al.*, 2002a, 2002b; *Science*, 2005).

Disaster ecology model: the ecological context of disaster risk and protective factors

Disaster risk is the product of hazard and vulnerability. We now describe multiple levels of factors that influence disaster risk with the disaster ecology model, providing illustrations of factors that populate each of the layers. Individual and family factors are viewed as relatively proximal. Community context and societal/structural context factors are described in later sections. It is important to understand that many factors come into play at multiple levels. For this discussion, we present a flexible layering of factors; risk and protective factors are richly and dynamically interconnected. For simplicity, we have

Table 4.3 Hazards: forces of harm: Hurricane Katrina, Gulf Coast, USA, 2005

Type	**Definition**	Catastrophe/complex emergency
	Classification	Hurricane (tropical cyclone)
Magnitude	**Intensity**	Florida landfall: Category 1
	Saffir–Simpson Scale	Peak intensity: Gulf of Mexico: Category 5 Louisiana landfall: Category 3–4 Mississippi landfall: Category 3
	Size	Large storm: 500-mile diameter
Time dimension	**Frequency**	No previous strike of this magnitude in recorded history. However, hurricanes repeatedly strike the area
	Multiplicity	Multiple tropical storms and hurricanes have struck Florida and the Gulf Coast each year recently. During 2005, the Gulf Coast was impacted by T. S. Arlene, T. S. Cindy, Hurricane Dennis prior to Hurricane Katrina and by Hurricane Rita later in the season Sequence of impacts: storm surge, rain, wind, eyewall impact, wind, rain, flood from levee break
	Seasonality	Atlantic Basin hurricane season: June 1–November 30
	Cyclicity	Strike occurred during the peak of a 30- to 40-year cycle of increased hurricane frequency
	Predictability	Predictable with days of advanced warning. Unpredicted change of course – striking the Florida coast and moving sharply southwest over Miami-Dade County (forecast track was due west). Track in Gulf of Mexico toward New Orleans held very steady on the middle of the predicted storm path
	Duration of impact	*Florida* Surge: 1 day; wind: several hours *Gulf Coast* Surge: 2 days; wind: 1 day; flood: weeks
	Duration of disruption	*Florida* 1 week *Gulf Coast* undetermined – months to lifetime
Place dimension	**Geography**	Atlantic Basin Hurricane Increasing intensity in Gulf of Mexico due to passing over Northern Loop Current of warm water New Orleans surrounded on all sides by bodies of water
	Topography	Concave shoreline of Gulf of Mexico produces very high storm surge Below water level construction Inadequate construction of levees to contain flooding
	Scale/scope	500-mile diameter storm Impact along 600 miles of Gulf Coast shoreline Total 1000 mile trajectory: Caribbean; Atlantic; Florida peninsula; Gulf of Mexico; landfall in Louisiana; Mississippi and Alabama; continuation of strong storm into northern United States

categorized factors into just three levels – individual/family, community, and societal/structural; other socio-ecological models have created a more detailed set of tiers (Figures 4.2, 4.3).

Ecological context: individual/family factors

Forces of harm – exposure to hazard, loss, and change – are brought closest to home within the realm of individual and family factors. Frequently families weather the storm or battle the pandemic on the home front. Losses are most acute when harm or death comes to a spouse, child, or other close family member. Losses for one family member ripple through the household, the extended family unit, and the neighborhood. Change is also experienced with particular intensity by partners, families, and close gatherings of friends.

Disaster impact on citizens and whole populations varies by individual and family characteristics such as age, gender, race/ethnicity, education, occupation, employment status, and income. Gender and race/ethnicity will be discussed as examples. Also highly relevant are the disaster mitigation, preparedness, response, and recovery activities and behaviors in which individuals and families engage. This includes such protective actions as developing a family disaster plan, stockpiling survival supplies, responding to disaster warnings, evacuating when instructed, sheltering in place, protecting property from harm, and developing a family contact and communications plan. Also included at this level, we consider the opposing risk behaviors that place individuals in harm's way (e.g., failure to heed warnings or evacuate, risk-taking during impact and postimpact periods). A proportion of the community is composed of full-time disaster response professionals. Many other community members will assume emergency response functions within their occupational roles at the time of a disaster. Others will train to develop disaster volunteer skills. Despite ample options for citizen engagement in personal, family, and community preparedness, the stark reality is that few nations have a broadly trained public that can mobilize rapidly in time of disaster.

Gender

Gender inequalities are notable throughout many cultures and contribute to disparities in disaster impacts (Kumar-Range, 2001; World Health Organization, 2002). Women bear a disproportionate burden of disaster vulnerability due to biological and gender role differences. World Health Organization (2002) notes that gender differences are pervasive throughout all aspects of the disaster cycle: "The differential impact of disasters on men and women may be due to socially determined differences in women's and men's roles and status, due to biological differences between the sexes, or due to an interaction of social and biological factors."

Women's heightened vulnerability is related to their lower socioeconomic status, limiting abilities to provide adequately for their families, and access to critical resources. Moreover, a higher proportion of women live in poverty, greatly diminishing their ability to protect themselves against disaster hazards. Within the family, women's control over life decisions for themselves and their children may be severely restricted. Within the community, women lack political influence, a byproduct of disempowerment. Women are more vulnerable in the wake of disaster when care-giving demands increase, and access to resources decrease (Kumar-Range, 2001). Conversely, the care-giving roles (that ironically increase women's susceptibility), and women's ability to establish formal and informal networks are instrumental for household and community recovery following disasters (Morrow, 1997).

While most studies highlight the relative disadvantage for women in disasters, men's "protector" roles may demand considerable risk-taking during rescue and recovery phases placing men at elevated risk at such times (World Health Organization, 2002).

Race/ethnicity

Review of the literature paints a picture of increased vulnerability to and risk of disasters for racial and ethnic communities in the United States. Fothergill *et al.* (1999) contend that, "In terms of racial and ethnic communities, we believe that there are links between racism, vulnerability and economic power in the disaster context." Based on earlier work (Fothergill, 1996), these authors expand "the cyclical framework of the human ecology perspective which uses the following categories: preparedness, response, recovery, and mitigation," to a typology of eight categories based on the stages of a disaster. They reviewed the scientific literature and found mixed results generally trending toward disadvantage for race/ethnic minority populations for each of the disaster stages: (1) heightened perception of personal disaster risk; (2) lack of preparedness; (3) less access and response to warning systems; (4) increased physical impacts due to substandard housing; (5) poorer psychological outcomes; (6) cultural insensitivity on the part of emergency responders; (7) marginalization, lower socioeconomic status, and less familiarity with support resources leading to protracted recovery; and (8) diminished standard of living, job loss, and exacerbated poverty during reconstruction (Fothergill *et al.*, 1999).

Ecological context: community-level factors

When thinking about disasters, the local "environment," or perhaps better put, the local "context" may determine the likelihood of a disaster itself and the rates of disaster consequences. These features of the local context interact with, and shape, one another and may be considered as features of a socioecological model that explains the consequences of disasters. We discuss key features of the local environment that are critical to our thinking about the epidemiology of disasters and its consequences.

Elements subsumed under community context include the local political structure and governance, and related community infrastructure including health and social services and local emergency management. Gaining increasing emphasis in recent years is the concept of citizen training and empowerment to assume disaster response roles through such mechanisms as Community Emergency Response Teams (CERT) and Medical Reserve Corps (MRC). Key elements of community context that will receive expanded discussion are social support, community socioeconomic status, social environment, and civic society.

Social support

Substantial research has demonstrated a central role for social support as a resource influencing risk of psychopathology postdisaster (Kaniasty & Norris, 1993; Norris & Kaniasty, 1996). In a longitudinal study in China, social support was associated with lower prevalence of post-traumatic stress disorder (PTSD) throughout a 1-year follow-up of earthquake victims (Zhao *et al.*, 2000) and social support moderated stress processes after the Three Mile Island disaster (Chisholm *et al.*, 1986). One study showed that although social support was protective for psychiatric disorders after the Three Mile Island disaster, it was not protective for the development of affective disorders (Solomon, 1985). Social support that individuals receive from postdisaster mobilization efforts is thought to counter the diminishing expectations of support often experienced by victims of major life events (Fullerton *et al.*, 1992). One study has suggested that a disaster fortifies social cohesion with a tendency towards perseverance and strengthening of core values (Norris & Kaniasty, 1996). The relation between these factors and others, discussed here, that may predispose groups toward vulnerability or resilience is likely complex.

Community socioeconomic status

Postdisaster evidence has demonstrated an association between individual poverty and lower perception of risk, poorer preparedness, limited warning communication, greater physical and psychological impacts, and more limited access to emergency response and recovery resources after disasters (Fothergill & Peek, 2004). While the disaster literature has focused almost exclusively on *individual* poverty, rather than community deprivation, an abundance of public health research demonstrates that aggregate community socioeconomic status is associated with health, independent of individual socioeconomic position. Community socioeconomic status encompasses multiple domains including high rates of poverty and unemployment (Berkman & Kawachi, 2000), and lower education and income levels (Berkman & Kawachi, 2000; Krieger, 1994).

Empirically, low community socioecological status, frequently also referred to as community deprivation, is a determinant of health outcomes including health-related behaviors, mental health, infant mortality rate, adult physical health, coronary heart disease and mortality; even after accounting for individual level factors (Diez-Roux, 2001; Diez-Roux *et al.*, 1997; Pickett & Pearl, 2001).

Community deprivation may be associated with differential access to quality medical care (Mandelblatt *et al.*, 1999), limited availability of other salutary resources, such as healthy food (Cheadle *et al.*, 1991; Sooman *et al.*, 1993), and psychosocial stress accompanying chronic shortage of essential resources (Williams *et al.*, 1994). These mechanisms influence health in the disaster context. Postdisaster, when both formal and informal resources are limited, societies with *a priori* fewer resources are less likely to have access to health and social services or food reserves. Similarly, postdisaster circumstances are more likely to heighten pre-existing stressors and potentially lead to poor coping and health-compromising behaviors (e.g., substance abuse). An example of these mechanisms at work is provided by the differential response capacities and recovery trajectories of two towns impacted by the 1992 earthquakes in Humboldt County, California; with the less affluent community unable to mount a sufficient response, resulting in a more constrained and prolonged recovery phase (Rovai, 1994).

Social environment

The social environment has been broadly defined to include, "... occupational structure, labor markets, social and economic processes, wealth, social, human, and health services, power relations, government, race relations, social inequality, cultural practices, the arts, religious institutions and practices, and beliefs about place and community" (Barnett & Casper, 2001, p. 465). This definition, by its very complexity, suggests that there are multiple ways in which the social environment may affect health. Limited social cohesion may predispose persons to less adaptive coping and adverse health consequences (Kawachi & Berkman, 2001; McLeod & Kessler, 1990).

Social capital effects are thought to offer general economic and social support on an ongoing basis and also to make specific resources available at times of stress. Social capital has been shown to be associated with lower all-cause mortality (Kawachi *et al.*, 1997; Skrabski *et al.*, 2004), reduced violent crime (Kennedy *et al.*, 1998), and self-reported health status (Subramanian *et al.*, 2002). Persons who live in segregated communities may have disproportionate exposure, susceptibility, and response to economic and social deprivation, toxic substances, and hazardous conditions (Williams & Collins, 2002).

Predisaster community cohesion is a basis upon which postdisaster recovery can be built (Oliver-Smith, 1996; Pfefferbaum *et al.*, 2006; Reissman *et al.*, 2005; Torry, 1986). In addition, pre-existing social stressors, influenced by racial/ethnic and socioecological strains, may influence postcrisis interactions during the recovery phase. Pre-existing social stressors may also influence social interactions between disaster-affected communities and those attempting to provide postdisaster aid. This was evident in the aftermath of Hurricane Katrina in New Orleans in September 2005, as national television captured relief workers repeatedly exacerbating tensions in a racially segregated city. Also, in the context of limited postdisaster resources, some of the social stressors could be mitigated by enforcing or rewarding equitable distribution of resources.

Civic society

Although related to features of the social and cultural environment, civic society frequently plays a distinct role in shaping a context that is salutary for population health. Civic society defines the space not controlled by government or the market where residents interact to achieve common goals. Several participants in civil society influence the health of populations. Community-based organizations (CBOs) or nongovernmental organizations (NGOs) have a long history of working to improve living conditions both in their own home countries and internationally (Halpern, 1995). CBOs such as neighborhood associations and tenant groups who provide services, mobilize populations, and advocate for resources could be re-purposed during a crisis to work in concert with each other to protect the health and safety of the community (Reissman *et al.*, 2005).

Places of worship and faith-based organizations offer social support, a safe space, and political leadership (Lincoln & Mamiya, 1990; Thomas *et al.*, 1994). In many instances, civic society may well be the only formal societal structure standing in the aftermath of a disaster that has the population's respect and trust. Particularly in human-made disasters when public suspicion of formal governmental authority may be high, civic society can serve as an honest broker and cultural ambassador, delivering aid and helping to rebuild the social and physical environments. For example, during the extended conflict between Israel and Lebanon in the 1980s and 1990s, local civic institutions, many predating the conflict, played a central role in providing health and social services to local populations in contested territory.

Ecological context: societal/structural factors

Beyond the community level, broader societal and structural factors influence disaster severity and consequences. Here we revisit geography, discussed previously during the explication of the hazard component of the ecological model, and now viewed as part of the environmental context. The physical, engineered and built environment is an important factor in relation to human settlement patterns. Cultural context, political structure and governance, and health and social services infrastructure resonate across all levels but are discussed here as societal/structural factors. Related factors include the legal and policy environment at national and international levels, socioeconomic status and development, and issues such as structural violence within and across populations.

Geography

Although disasters are a global phenomenon, the impact of disasters remains grounded in local context. As noted earlier in this chapter, geographic factors render specific areas to a particularly high risk of disasters. Areas that are below sea level or close to bodies of water that change levels frequently (e.g., the Gulf Coast region in the US, river Deltas in Bangladesh) are particularly prone to flooding. Similarly, human settlements in arid areas (e.g., Southern Australia) are vulnerable to fires (Gillen, 2005). The threat of disasters in such areas is endemic, and floods, bushfires, and earthquakes are cyclical events, with varying degrees of intensity in different seasons. In some areas, the exigencies of geography dictate the unavoidable risk for recurrent disasters; complete resettlement of human populations into lower risk areas is the sole option for elimination of disaster risk.

Geography also plays an important role in structuring the postdisaster response. News of a disaster event in isolated communities may take far longer to reach aid agencies or the media, as in the case of the Darfur famine of 2004–2005, than in more accessible locations. The ability of agencies to provide aid may be limited in geographically distant or difficult locales. For example, it took more than a week for aid efforts to reach some victims of the devastating 2005 earthquakes in the Kashmir region of Pakistan that killed an estimated 54 000 people (Agence France Presse, 2005).

Physical environment

There are multiple features of the physical environment that are associated with human health, with a vast empiric literature demonstrating links between the physical (human-engineered and natural) environment and well-being, within the physical, psychological, and spiritual realms.

The physical environment is a central feature of context for postdisaster recovery. As an immediate consequence of a disaster, structures such as buildings, bridges, and skyscrapers may be vulnerable to natural or human-made disasters, as recent earthquakes in Japan and Iran and the September 11, 2001 terrorist attacks on New York City demonstrated respectively. Features of the physical environment directly influence disaster outcomes (Daley *et al.*, 2005). The cities of Kobe, Japan and Bam, Iran sustained earthquakes of comparable magnitude in 1995 and 2003, respectively. While the buildings in Kobe were structurally engineered to withstand earthquake tremors, those in Bam collapsed wholesale. Absolute numbers of deaths and mortality rates were substantially higher in Bam. Infrastructure can be damaged after an earthquake or hurricane, straining already taxed systems and contributing to adverse health consequences. Lengthy time periods for reconstruction of the local physical environment may contribute to prolonged community suffering after a disaster, limited job opportunities, and a torrent of other factors slowing, and possibly compromising, the recovery of population physical and mental health.

Cultural context

The impact of culture on health-related beliefs and practices is difficult to describe and quantify, especially in the postdisaster period. "Culture" as a notion lends itself to diverse definitions and interpretations. For the purposes of this chapter we consider culture to be "shared, learned behaviors and meanings that are transmitted socially" (Marsella & Christopher, 2004, p. 529). Social relationships associated with formal civic and religious institutions are elements of the cultural context that may shape health. Similarly, religiously sanctioned or endorsed behaviors and practices have the potential to influence health in the predisaster context. For example, religious prohibition of alcohol use is associated with much lower rates of alcohol dependence among Muslims compared to non-Muslims (Cochrane & Bal, 1990). Evidence suggests that other manifestations of a dominant culture, such as patterns of social congregation in public places, are associated with social transmission of health behavior and norms (Henrich & McElreath, 2003). Complex social security networks, which serve to minimize the risk of resource shortfalls, have also been identified as important informal sources of assistance that are called upon during disasters (Shipton, 1990). Importantly, this "moral economy" of sharing is also linked to community socioeconomic status, which, in turn, influences the efficacy of informal support networks. Less affluent communities may be less able than more affluent communities to mobilize material resources (i.e., instrumental social support) to assist others (Hadley *et al.*, under review, 2006). Strong cultural norms about societal organization, altruism, and diversity may influence social cohesion postdisaster and contribute to communal efforts to restore symbolic structures, social hierarchies, and services to their predisaster state. Conversely, destruction of culturally significant places may be associated with communal grief (Bode, 1989), that has been in turn associated with elevated rates of depression in the aftermath of disasters (Goenjian *et al.*, 2001).

Political structure and governance

Political structures and systems of governance establish the parameters (e.g., taxation, federal–state relations) that shape many of the other contextual factors that have an impact on health. Democratic governance is associated with greater governmental openness and responsiveness to domestic criticism and there is some evidence that such regimes are less prone to state failures. For example, analyses of state failures in Liberia and

Somalia that predisposed their citizens to disasters show that these events are more likely to occur in partial as compared to fully democratic regimes (Esty & Ivanova, 2002). There is also evidence that disasters occurring in alternate political systems are substantially mitigated by effective governance.

A feature of political structures that relates directly to the mitigation of disaster is the *effectiveness* of political structures and governance. At the extreme, there are a few societies worldwide without an effective government of any sort. For example, Somalia has not had a central government since 1993. In its stead, informal organizations established along clan lines provide a loose form of governance and respond to mass disasters such as famines by providing relief for persons in affected communities and brokering international aid. Within well-established national political structures, there have been several recent examples of both effective and ineffective governmental response to disasters. In the US as an example, some environmental and consumer regulations have been loosened, and many previously public services (e.g., sanitation, water, health care) have been privatized (Gans, 1995; Katz, 1989). Limited regulation of municipal water supplies has been considered, at least in part, responsible for water-borne disease outbreaks in different North American cities (Corso *et al.*, 2003; Garrett, 2000; Krewski *et al.*, 2002). Problems with the domestic response to Hurricane Katrina in August/September 2005 have been widely attributed to significant changes within central governmental authority and to poor coordination among federal, state, and municipal levels of government (Nates & Moyer, 2005).

Health and social services infrastructure

Predisaster availability of health and social resources is inextricably linked to postdisaster recovery. Affluent countries and communities are characterized by a broader array of health and social services compared with poorer counterparts (Casey *et al.*, 2001; Felt-Lisk *et al.*, 2002). In the US, even the poorest communities have dozens of social agencies, each with a distinct mission and service package. Many of the public health successes in wealthy countries over the past few decades, including reductions in human immunodeficiency virus (HIV) transmission and tuberculosis control, have depended in part on the efforts of these groups (Freudenberg *et al.*, 2000). In poor communities, or less wealthy countries, social and health services are frequently susceptible to changing national and donor fiscal realities and service reductions frequently coincide with times of greater need in the population (Felt-Lisk *et al.*, 2002; Friedman, 1989).

The scope and magnitude of disasters are associated with the extent of disruption of health and social services. When health and social services continue to function postdisaster, the contribution of these resources to preserving or restoring health in a population is self-evident. However, these pre-existing resources are also relevant in devastating disasters where most formal resources are destroyed because local health and social service practitioners have indigenous knowledge, acceptance by local community members, and are much more likely to be able to provide continuity of care than are services provided by outside aid agencies (Fissel & Haddix, 2004).

Ecological context: summary

The rich complexity of environmental features at community and societal levels interactiong across all phases of disaster mitigation, preparedness, response, and recovery. Consideration of the context is instrumental for disaster psychiatrists and providers of disaster behavioral health support. Context largely determines the extent of disaster impact, and, in turn, the extent of natural supports and community resources that can be tapped in times of disaster.

Concluding comments

Systematic consideration of the defining components of disaster, presented from a socioecological perspective, can guide efforts aimed at mitigating the consequences of these events, diminishing the pervasive psychosocial impacts, and improving the health of populations worldwide. We have advocated for promoting an ecological approach to better understand the avenues of prevention, mitigation, and recovery. Doing so will facilitate the ongoing movement to integrate public health and behavioral health strategies for disaster preparedness and will allow us to identify and leverage other sectors of government and civic life, whose interdependence and interrelatedness are essential in times of disaster such that we can protect and improve community or population-level health and well-being. Understanding the dynamic nature of disasters as the collision between forces of harm – exposure to hazard, loss, and change – and vulnerable human populations in harm's way, richly influenced by the ecological context, is a fundamental underpinning for the effective practice of disaster psychiatry.

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