PART II

CONCEPTUAL FRAMEWORK OF DISASTERS

Chapter Three

OVERVIEW AND CONCEPTS

ABSTRACT

It is not possible for persons within and between the many disciplines involved in disasters to communicate with each other without clear definitions of the specific terms that are used. In many instances, the same terms have different meanings in different disciplines. Thus, a standardized set of definitions is provided in this chapter and in the associated Glossary of Terms. Some definitions discussed in this Chapter include: (1) disaster; (2) medical disaster; (3) hazard; (4) risk; (5) prevention; (6) modification; (7) event (including onset, duration, amplitude, intensity, scale, and magnitude); (8) impact; (9) mitigation; (10) preparedness; (11) damage; (12) vulnerability; (13) resilience; (14) absorbing capacity; (15) buffering capacity; (16) disaster management; (17) response; and (18) recovery. An annotated, comprehensive set of definitions is provided in the *Glossary of Terms* in these Guidelines.

Keywords: absorbing capacity; amplitude; buffering capacity; damage; definitions; disaster; duration; event; hazard; impact; intensity; magnitude; management; medical disaster; mitigation; modification; onset; preparedness; prevention; recovery; resilience; response; risk; scale; vulnerability

TFQCDM/WADEM: ***Health Disaster Management: Guidelines for Evaluation and Research in the "Utstein Style".*** **Chapter 3: Overview and concepts.** ***Prehosp Disast Med*** **2002;17(Suppl 3):31–55.**

IT IS NOT POSSIBLE to discuss disasters without clear definitions of specific terms that are used within this document. In the development of these Guidelines, it became clear that terms used in discussing disasters and the responses to them often are unclear and the meanings given were not adequate to facilitate understanding of the discussion. In many instances, the same terms have different meanings in different disciplines. Thus, for the sake of clarity, many of the definitions used in this document are included in this Chapter or in the Glossary of Terms. It is an objective of these Guidelines to establish a standardized vocabulary for future research and evaluations that utilize these Guidelines for the conduct and reporting of such studies. There is no assumption that the manner in which the terms as used in this document, will be accepted universally by the entire disaster community. However, for consistency and reproducibility, and hence, external validity, any future studies that use these Guidelines and their Templates should adhere to the definitions as presented in this document.

DISASTER

There are many definitions of a disaster, and these definitions have been discussed in detail by Al-Mahari and Keller.[1] The definitions used seem dependent upon the discipline using the term. No definition of "disaster" is accepted universally. In the course on Disaster Management published in *Prehospital and Disaster Medicine,* Cuny defined a disaster as: "a situation resulting from an environmental phenomenon or armed conflict that produced stress, personal injury, physical damage, and economic disruption of great magnitude."[2] Perez and Thompson in their series on *Natural Disasters*, define a disaster as: "the occurrence of widespread, severe *damage, injury, or loss of life or property*, with which the community cannot cope, and during which the affected society undergoes severe disruption."[3] Both of these definitions note that a disaster disrupts the society stricken by the event. Furthermore, Cuny stresses that the event resulting in a disaster does *not* comprise the disaster: it is what results from the event that comprise the disaster, not the precipitating event itself.[2]

The definition of a disaster adopted by the World Health Organization and the United Nations as established by Gunn is: "the result of a vast ecological breakdown in the relationships between man and his environment, a serious and sudden (or slow, as in drought) disruption on such a scale that the stricken community needs extraordinary efforts to cope with it, often

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

with outside help or international aid."[4] This definition also indicates that it is the damage that results from the impact on society that constitutes the disaster, not the event that is the disaster.

Medical Disaster/Health Disaster

The most common medical definition of a disaster is an event that results in casualties that overwhelm the healthcare system in which the event occurs. A health disaster often is considered a medical disaster. A *health disaster* encompasses impaired public health and medical care to individual victims. A *medical disaster* relates to the healthcare or break in healthcare to individuals as a result of an event. The Task Force broadened the definition of a health disaster to include: *a precipitous or gradual decline in the overall health status of a community with which it is unable to cope adequately*. Evaluating the changes that have occurred as part of a disaster is dependent upon the baselines established for the pre-event status of the society impacted.

The use of this definition requires an assessment of the *pre-disaster event health status* of the affected community. By definition, *the disaster begins when it first is recognized as a disaster, and is overcome when the health status of the community is restored to its pre-event state.* Responses to disaster aim to:

(1) Reverse adverse health effects caused by the event;

(2) Modify the hazard responsible for the event (reducing the risk of the occurrence of another event);

(3) Decrease the vulnerability (increase the resiliency) of the society to future events; and

(4) Improve disaster preparedness to respond to future events.

Number (1) falls under the definition of disaster response whereas (2), (3), and (4) are defined as development. All responses, however, encompass both the health and the medical responses to a disaster.

Other terms often are used interchangeably with disaster. An event that results in a large number of casualties (mass casualties) may or may not constitute a disaster. If local resources are unable to cope with the numbers and/or types of casualties and outside medical help is requested, then the event has created a disaster. Examples of events that may generate mass casualties include transportation accidents, tornadoes, terrorist bombers, avalanches in inhabited areas, etc. The impact of such events depends upon the ability of the affected society to cope with the circumstances: whether the society remains intact and mechanisms can be developed within the infrastructure to cope with the circumstances. Many consider events that produce multiple or mass casualties as a disaster, since the immediately available local resources transiently may be overwhelmed; but if such events rapidly are brought under control, and the effects on the medical community are short-lived, without a need for outside assistance, there is no disaster.

Some of the definitions that follow are used as the results of the action verbs from which they are derived. In particular, this applies to words such as prevention, mitigation, and modification. Many of the definitions are accompanied by graphical representations of the definition and the relationships of the term being defined to other terms used in this document. These figures are hypothetical and are used only as examples of possible relationships between the variables. They are postulated to be relationships defined by generic s-shaped curves, but the exact shape and slopes are not meant to be quantitative. Multiple representations of the relationship are suggested to provoke thought about the relationships between the variables. Future research will help to characterize these relationships. These relationships will be discussed in detail in the presentation and discussion of the Conceptual Framework that follows. Figure 3.1 is provided to facilitate the understanding of the relationships between the different components that lead to damage and possibility to disaster.

HAZARD (H)

All disasters are related to a specific hazard or combinations of hazards whether of a natural phenomenon or a result of human actions. A hazard is *anything that may pose a danger;* thus, it is used in this discussion to mean *a natural or manmade phenomenon or a mixture of both that has the potential to adversely affect human health, property, activity, and/or the environment.* Often, a hazard can be described as contained energy.

Hazards are classified as to type. A specific arm of science is dedicated to the identification of hazards. Known hazards can be classified according to the scheme in Table 3.1 The specific hazards to which we are exposed vary in space and time. They also may vary between different populations: what is recognized as a hazard in one community may not be so in another. A hazard that has not converted into an event, cannot become a disaster. Because of the absence of a disaster, in many settings, a hazard may not be recognized. Consequently, *hazard identification* is important in the development of preventive or mitigating measures. Preventive measures are directed at the

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

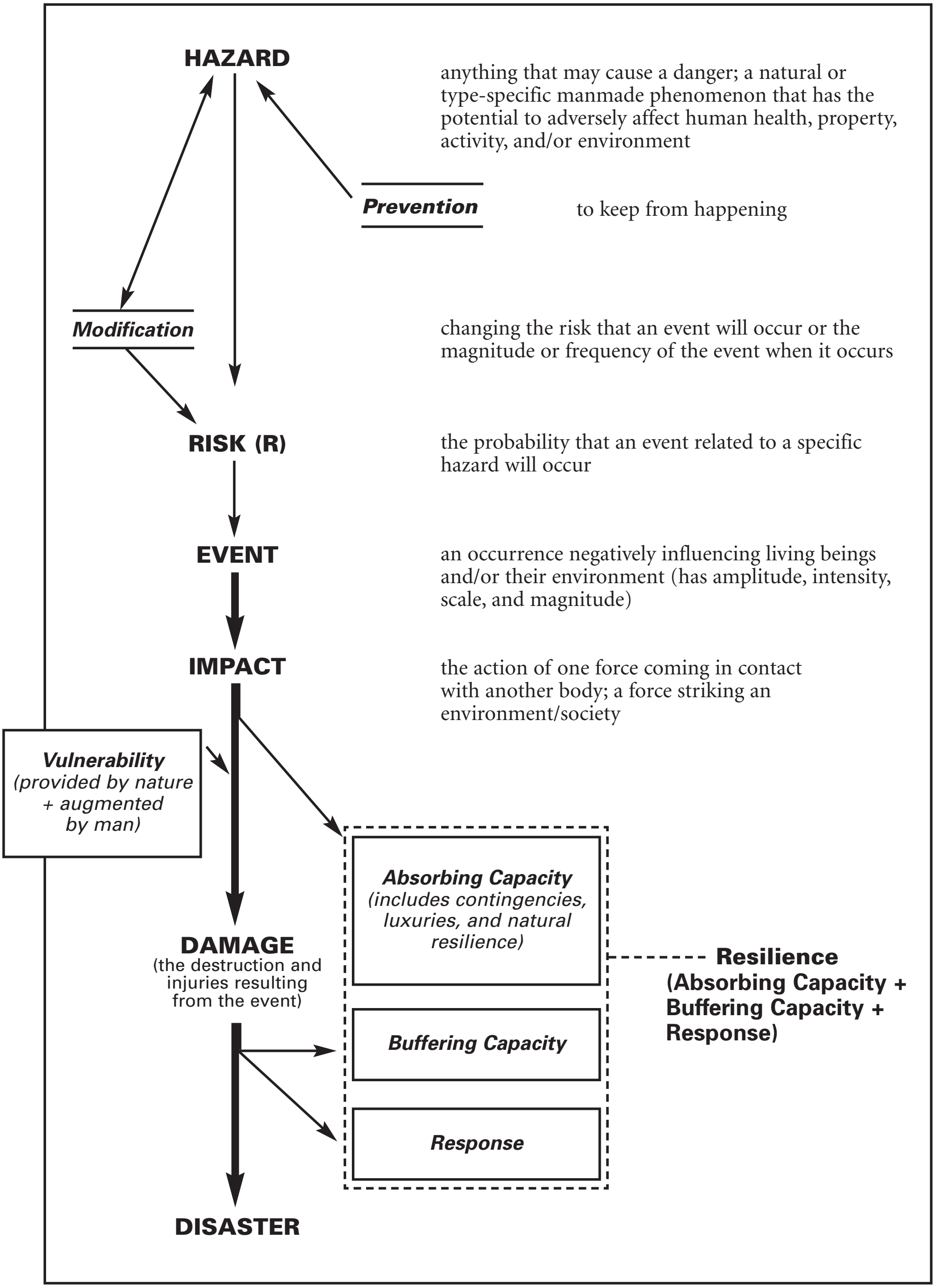

Figure 3.1—Diagrammatic representation of definitions

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

I. NATURAL
- ***I.1. Seismic***
  - **I.1.1. Earthquake**
  - **I.1.2. Volcanic eruption**
  - **I.1.3. Tsunami**
  - **I.1.4. Celestial collision**
- ***I.2. Climatic: Meteorological***
  - **I.2.1. High winds**
    - **I.2.1.1 Gale**
    - **I.2.1.2 Storm**
    - **I.2.1.3 Tropical cyclone/Hurricane/Typhoon**
    - **I.2.1.4 Tornado**
  - **I.2.2. Precipitation**
    - **I.2.2.1 Rain**
    - **I.2.2.2 Snow**
    - **I.2.2.3 Ice (Ice storm, hail)**
  - **I.2.3. Lightning - fire**
  - **I.2.4. Temperature extremes**
    - **I.2.4.1. Heat**
    - **I.2.4.2. Cold**
  - **I.2.5 Erosion**
  - **I.2.6 Drought**
  - **I.2.7 Desertification**
  - **I.2.8 Floods**
  - **I.2.9 Avalanches**

II. MIXED: NATURAL + HUMAN-CAUSED
- ***II.1. Drought***
- ***II.2. Desertification***
- ***II.3. Floods***
- ***II.4. Erosion***
- ***II.5 Landslides/mudslides***
- ***II.6. Fire***
- ***II.7. Health-related***
  - **II.7.1. Epidemic of infectious disease**
  - **II.7.2. Genetic**
  - **II.7.3. Other**

III. MAN-MADE (HUMAN-CAUSED)
- ***III.1. Technological***
  - **III.1.1. Release of substances**
    - **III.1.1.1. Chemicals**
    - **III.1.1.2. Biological**
    - **III.1.1.3. Nuclear**
  - **III.1.2. Transport**
  - **III.1.3. Structural failure**
  - **III.1.4. Explosions**
  - **III.1.5. Fire**
  - **III.1.6. Environmental interference**
  - **III.1.7. Other**
- ***III.2. Conflict (inter-human)***
  - **III.2.1. Armed Conflict**
    - **III.2.1.1 Conventional war (armed forces)**
    - **III.2.1.2 Armed conflict/civil strife**
    - **III.2.1.3 Complex human emergency**
    - **III.2.1.4 Terrorism**
    - **III.2.1.5 Other**
  - **III.2.2. Unarmed Conflict**
    - **III.2.2.1 Sanctions**
    - **III.2.2.2 Embargo**

Table 3.1—Classification of known hazards

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

elimination of the hazard (making the risk of an event related to the hazard equal to zero) or by gaining complete control of the potential release of energy that brings the risk that a hazard may produce an event down to zero (0) without actually eliminating the hazard. Mitigating measures are directed towards increasing a society's properties to withstand the forces (absorb them or buffer them), thereby decreasing the probability that such an event will produce extensive damage.

RISK (R)

Risk is the *objective (mathematical)* ***or*** *subjective (inductive)* ***probability*** *that something negative will happen.* For example, the probability of an earthquake occurring in the northern Europe is quite low compared to such a hazard becoming realized in California or Turkey. The probability of a cyclone becoming realized in India or Central America is huge compared to the probability that such an event will occur in Canada. The likelihood (probability) of an industrial release of toxic substances is greater in an area without strict codes compared to those with strict codes. Thus, the risk of an event occurring largely determines the drive for preparedness to cope with such an event or efforts to eliminate the hazard (Figure 3.1). *Risk applies only to one specific hazard.*

Thus, factors (risk factors) can be identified that may provide the means to modify this probability. Even though less obvious, certain natural hazards and their risk factors can be modified.[i]

In relation to health issues, such *risk factors* may constitute personal behaviors, life-styles, cultures, environmental factors, and inherited characteristics that are known to be associated with health-related questions. Some of these factors may determine the probability that an event will occur and to what extent it will affect a specific population or populations. Such risk factors are denoted as markers (risk markers). A *risk marker* is an attribute of the hazard that is associated with an increased probability that an event *may* occur, and can be used as an indicator of an increased or increasing risk that an event will materialize.[5] Exceptionally heavy snow accumulations serve as a marker that avalanches are imminent or that floods are likely to occur when the snow melts. Some observations indicate that changes in animal behaviors may be a risk marker for an impending earthquake. Falling

[i] In most hilly and mountainous countries exposed to heavy snowfalls, artificial release of snow through aimed detonations is a common method used to control both the risk and thereby the accentuated hazard of landslides. Also, landslides may be prevented through reinforced concrete alongside roads.

pressures in a gas pipeline may constitute a risk marker that a leak has occurred in the pipeline and that leaking gas could result in an explosion as happened near the city of Ufa in the former Soviet Union in 1989.[6]

Also, it is important to recognize that many societies are willing to accept a very low risk posed by a known hazard in turn for a perceived very great benefit ("acceptable" risk). For example, the building of a nuclear power plant carries with it a very low probability that an event will occur, and the society in need of inexpensive electrical power will condone the construction and operation because the risks are minute. Often, this type of action is called a "calculated" risk.

Assessing to what extent a specific hazard may become actuated as an event, is accomplished through: (1) surveillance; (2) investigation; (3) analysis; (4) information; (5) integration; and (6) dissemination. Ongoing *surveillance* may be directed to identification of changes in the risks that a particular known hazard will become an event. For example, identification of the development of a tropical cyclone using a weather satellite and ongoing analysis of its potential track and strength may modify the risk for the known hazard to create damage. Environmental surveillance in an area in which a known industrial hazard exists may detect changes in the likelihood of such an event occurring. Analysis and information are the processes of collating and analyzing those data collected during the investigation, and then, the conversion of the data into information (knowledge). *Integration* of knowledge about a hazard into operations may result in modification of the risk and dissemination of knowledge pursuant to the hazard may change the likelihood of the hazard becoming realized. The latter two elements apply primarily to manmade hazards. The information then must be disseminated to all of the stakeholders, generally in the form of community education or warnings.

Lastly, every hazard places a specific population at risk. The size and the nature of the population at risk is an important characteristic of the risk. The *population-at-risk* is the location and number of persons likely to be affected if the hazard becomes actualized into an event. Decisions may not only take into account the probability of the event occurring, but also include the size and nature of the population likely to be affected if the hazard becomes realized. Higher risks may be acceptable in areas in which the population is sparse compared to risks in densely populated areas.

PREVENTION

To prevent means to keep the event from happening, and thus, prevention is *the aggregate of approaches and measures taken to ensure that human actions or natural phenomena DO NOT cause or result in the occurrence of an event related to the identified or unidentified hazard.* It does NOT mean decreasing the amplitude, intensity, scale, and/or magnitude of the event.

Prevention can, in principle, occur only by eliminating the hazard. It would be difficult and probably impossible to prevent a natural hazard from occurring. However, some manmade hazards could be eliminated.[ii]

MODIFICATION

To modify is to change the external character of, to vary or to alter in some respect.[7] Modification of the event does not mean that the event will not occur. Modification can change either the nature of the hazard or the risk that the hazard will evolve into an event. In terms of the hazard, it is *the aggregate of all approaches and measures taken to modify the amplitude, intensity, magnitude, scale and/or the probability of the actuation of the event that would have occurred without human intervention.* Thus, through human activities, the resulting event either may be augmented (increased) or attenuated (decreased) both in magnitude and frequency.

Risk management involves human actions that are directed towards *modification of the probability* that an event will become realized. Such management measures are directed towards decreasing the probability for occurrence. They may include the development and implementation of standards and/or codes of practice at local, regional, national, and/or international levels, education (curriculum design, graduate/post-graduate training), distribution of information, and/or the development of preventive services. Often community action is required for implementation of such programs. All such programs have the requisite knowledge about the hazard, the setting, and the circumstances. Risk management only is possible if appropriate risk markers can be identified. Currently, risk management applies mainly to manmade and mixed hazards.

This does not mean that we are in complete control of all elements and

---

[ii] Theoretically, all manmade hazards can be eliminated. This will, however, deprive society of commodities, structures, and processes that are considered essential for a modern life, and would be counter-productive if it was rigorously executed. For some manmade hazards, however, elimination is a feasible and advisable option.

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

especially not the basic causative element that produces that specific hazard. We cannot stop rain from falling to prevent flooding or provoke rain to end a famine. But we can control the timely release of avalanches and landslides. We may mitigate flooding through a well-constructed dam system. Also, we may modify in the wrong directions and increase the risk (deforestation, for example, increases the risk of flooding, landslides, and erosion). The floods and mudslides that occurred in Honduras following Hurricane Mitch in 1998 were augmented by deforestation prior to the hurricane.

In this respect, a thorough understanding of what are the dependent and independent variables is important. An example of the relationships between variables is illustrated in Table 3.2. In this table, the precipitating event is the absence of rain that results in the secondary event of drought. Drought negatively impacts food production, and impairment of food production results in famine, which ultimately is responsible for the increase in crude mortality rate. The absence of rain is the precipitating event, and drought, decreased food production, and famine all are secondary events to the absence of rain, with the increase in the crude mortality rate (CMR) as the outcome. In this case, it may be possible to influence the famine, but not through creation of rain. We also should be capable of recognizing the lack of rain before the CMR starts to increase.

EVENT

An event occurs when the hazard is realized or becomes manifest. For the current discussion, it means *an occurrence that has the potential to negatively affect living beings and/or their environment.* Such occurrences have a characteristic type of onset, intensity, duration, scale, and magnitude. Temporally, events may be sudden, gradual, slow, or delayed in onset (Figure 3.2). *Sudden-onset* events include those with onsets lasting seconds to hours (e.g. earthquakes, tsunamis, cyclones, fire, etc.). *Gradual-onset* events have an onset over days to weeks (e.g. floods, climate changes, epidemics, armed conflict), and may or may not present with warning of several days to weeks. *Slow-onset* events have a prolonged and gradual onset (famine, drought, epidemics, nuclear contamination, etc.). *Delayed* onset events occur some time after the discovery of the likelihood that the hazard will become realized. Such events usually allow for warnings to the population that potentially will be impacted by the event (cyclones, tsunamis, burst of weakened dams, famine). Events with the preceding types of onset (sudden, gradual, slow) also may be delayed in onset.

The *duration* of events may be brief, short, intermediate, or prolonged. Events of *brief duration* last only seconds to minutes, and therefore, necessarily must correlate with a sudden mode of onset (earthquake, tsunamis, avalanches, landslides, volcanic eruption [may go on to be prolonged], etc.). Events of *short* duration continue in some form, for hours to days. Examples

If variable is:	Dependent Variable or Parameter could be:
Rain	Drought
Drought	Food Production
Food Production	Famine
Famine	Crude Mortality Rate

Table 3.2—Relationships between a precipitating event (absence of rain) and outcome (crude mortality rate)

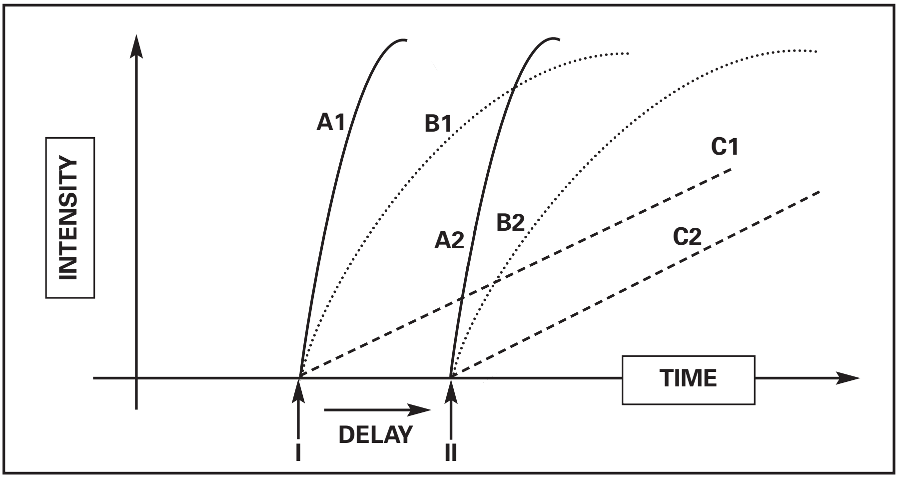

Figure 3.2—Graphic representation of the time course of sudden (A), gradual (B), and slow (C) onset events. At time point I, discovery of the event is simultaneous with its onset. Time point II represents a delay from discovery or identification of the likelihood of occurrence to time of onset. The character of the onset (A2, B2, and C2) is the same as for the events with a simultaneous onset.

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

include tropical cyclones and floods. Events of *intermediate* duration may include epidemics, toxic or nuclear contamination, fires, etc. Intermediate duration events last days to weeks. Events that last for *prolonged* periods (months to years) include drought, famine, epidemics, complex emergencies, nuclear contamination, etc. Some events cross over into more than one of these categories (Table 3.3). It is important to distinguish between the onset and duration of an event. Not all sudden-onset events have a short duration. However, most events that have a slow onset also have a long duration. Also, it is useful to distinguish between the duration of the event, which can be short, and the disaster that results from the event that can become chronic (earthquakes).

The scope of an event includes its: (1) amplitude; (2) intensity (amplitude / time interval); (3) scale (intensity x area impacted); and (4) magnitude (scale x total duration). The *amplitude* is the degree of departure from the point of equilibrium (pre-event state).[8] Examples of amplitude include a flood crest, storm surge, and wave height. The *intensity* consists of the ampli-

	ONSET		
DURATION	**Sudden** (seconds to hours)	**Gradual** (days to weeks)	**Slow** (months to years)
BRIEF (seconds to hours)	earthquake, tsunami volcanic eruption, structural failure, avalanche, landslide		
SHORT (hours to days)	high winds, infestations	floods, temperature extremes	
INTERMEDIATE (days to weeks)	volcanic eruption, armed conflict, epidemics	epidemics	epidemics
PROLONGED (months to years)	armed conflict	armed conflict	drought, desertification, armed conflict, famine

Table 3.3—Differences in the definitions between types of onset and the duration of an event. Some events have dominant characteristics that readily fit into one position in the matrix, while others have varying time frames that fit into one or more of the positions (note: no attempt has been made to fit all types of events into the matrix).

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

tudes integrated over a given period of time. Examples of intensity include the amount of rain falling in an hour and the quantity of ash falling in a specific location per hour. The *scale* of an event is the intensity of the event in the geographical area involved.[9] Examples include the incidence of a specific infectious disease in a country, the depth of rain that accumulated in a specific city in a given period of time, and the number of hectares under an accumulation of water due to flooding. *Magnitude* is the total energy encompassed by the event, the combination of the integral of the amplitudes, the area involved (being studied), and total duration of the event. Examples include the kiloton explosive equivalent of a nuclear bomb explosion, and the total rainfall accumulated over an area during the entire course of a storm.

In addition, events may be precipitating (primary) or secondary. *Precipitating events* are those responsible for initiating the damage, and *secondary events* occur as a result of the impact of the precipitating event. Human actions may result in an increase in the magnitude of the damage and/or may be the nidus for the development of secondary events. Numerous examples can be identified in which rainstorms of a relatively moderate intensity, previously perceived as insignificant, have become significant as a result of deforestation. Specifically, this proved true following Hurricane Mitch in which most of the deaths were not related directly to the hurricane, but instead were due to the mudslides associated with the rainfall.[10] Actions such as deforestation may be classified as *vulnerability augmentation*, but, in certain settings, they are responsible for the creation of new hazards. Secondary events may be delayed in onset and prolonged in duration (mudslides, complex emergencies, floods, etc.). In some situations, the event may be discovered first by the appearance of damage. In these cases, management may be required not only to deal with the damage, but may be required to terminate the ongoing event. This is true particularly for events of intermediate or prolonged duration, e.g., epidemics, famines. In other situations, an impending event may be discovered before it impacts upon a society (hurricane, avalanche, flood).

IMPACT

Impact is defined as *the actual process of contact between an event and a society or a society's immediate perimeter*. The impact refers to both positive and negative influences produced by the event on the environment. The degree of damage produced by the energy impacting on to the environment is

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

dependent upon the vulnerability and preparedness of the environment and the society for the specific event. The impact is the precipitating cause of the damage that may result from an event. The damage that results from the impact not only is a function of the magnitude of the event, but also depends on the resilience of the society and environment towards the impact including the preparedness of the society for such an event. Examples include the landfall of a tropical cyclone, drought extending to an expanded area, and refugees arriving in a new area.

MITIGATION

For the purpose of this discussion, *to mitigate* means *to lessen or decrease the seriousness of the process* to which the word is applied. Mitigate is the action verb and mitigation is the result of this action. To avoid confusion in the use of the Guidelines, *mitigate,* in this context, will be reserved for any process that is undertaken to reduce the immediate damage otherwise being caused by a destructive force on the society.

PREPAREDNESS

Preparedness is the *aggregate of all measures and policies taken by humans* ***before*** *the event occurs that reduces the damage that otherwise would have been caused by the event.* Preparedness is comprised of the ability to mitigate the immediate result of the impact of an event and our ability to alleviate suffering and accelerate recovery. It consists of measures that a locale /region/ country maintains, at a particular time, to combat the deleterious effects of situations to which it may be exposed (hazard); and a complex of measures, specific for each local community, that provides the community with the *capacity* to withstand a forthcoming event, provide for effective response, and assist expedient rehabilitation and reconstruction.[11]

Preparedness includes warning systems, evacuation, relocation of dwellings (e.g., for floods), stores of food, water, and medical supplies, temporary shelter, energy, response strategies, disaster drills and exercises, etc. *Contingency plans* and responses are included in preparedness as used in this document and are part of overall disaster management. Such measures are aimed at meeting the increased demands during and following an event (conditional functions) or to compensate for destruction and damage to the societal infrastructure and organizational functions by the event, or both. Preparedness consists of actions taken before an event occurs. For example

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

the training and preparation of the disaster managers affects the way in which the persons function during and after the event. As preparedness increases, the ability of the society to absorb the event and mitigate the damage is augmented as a dependent variable of the level of preparedness. Some aspects of preparedness may be event specific, while others may apply to mitigate the damage sustained from a host of potential events.

DAMAGE

Damage is defined *as harm or injury impairing the value or usefulness of something, or the health or normal function of persons.*[12] Damage is the ***negative*** result of the impact of an event on the society and environment. Damage may manifest in multiple ways and forms. Events may produce damage that may or may not be of sufficient magnitude to result in a disaster. It is the amount and characteristics of the damage that result from an event, tempered by the place of occurrence, society and culture, level of development, and degree of preparedness that determine whether an event results in a disaster. Damage may involve humans, other creatures, and/or the environment. The severity of the damage is a function of the magnitude of the event buffered by the resilience of the society and the environment impacted (including actions taken by the society impacted before the occurrence of the event (preparedness)). For example, the damage created by rising waters is buffered by the construction of dykes and the strategic placement of sandbags and other protective measures, movement of human settlements off of the flood plain, placement of housing onto stilts, etc. Each of these is an element of preparedness.

All events, regardless of their type, mode of onset, and magnitude have an impact on the population. Figure 3.3 outlines some of the potential aspects of damage that may result from an event and the cause-effect relationships involved in creating damage. The event, directly or indirectly, may result in the death of some of the humans exposed to the event, some may be missing, and others may be injured, while the health of others may be unaffected by the event. While some of the persons affected by the event may not be injured, they may be placed at increased risk by the event, i.e., those who become isolated, those who are unable to care adequately for themselves, and for those who are dependent on medication, medical devices, or require external support.[13] In addition, some of those not directly affected by the precipitating event may be placed at great risk for secondary events, such as

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

flooding and/or mudslides following the impact of a tropical cyclone or from other cause-effect relationships like impairment of logistics, etc. Traditionally, it is the dead, injured, and missing that have received the greatest attention from the media. Certainly, in the setting of a sudden-onset disaster, immediate attention is directed toward search and rescue and the identification, assessment, and provision of emergency treatment to the injured.

In some slow-onset types of disasters, once recognition that the event has occurred, the main response by the affected society may be, if possible, to meet the deficits of available resources with increased supplies. Thus, additional supplies of specific resources will be consumed to provide the *conditional* functions. Such functions depend upon the type of supplementation required to meet the increased consumption required to provide the increased function. When the condition responsible for the augmented needs ends, so do the conditional functions and the need for additional resources. The nature of the resources required to provide the conditional

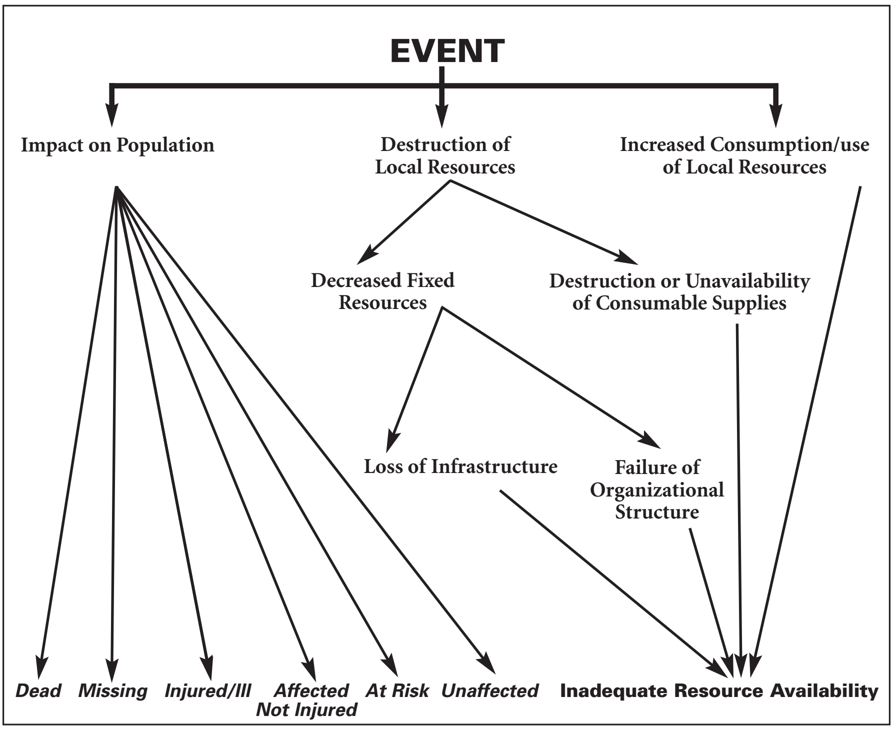

Figure 3.3—Flow chart illustrating some of the pathways for damage to occur related to a destructive event

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

function may be event-specific. The augmented resources required to provide for the conditional functions are *conditional needs* and are over and above those needs required for the daily function of the society. For example, when it is predicted that a tropical cyclone will impact a population, preparedness measures may dictate that the region be evacuated; the consumption of fuel increases, and the consumption of lumber and other expendable supplies will be augmented as people prepare for the more damaging aspect of the delayed-onset event. If a drought is predicted, relevant storage of food and water may be established to meet requirements for that period.[14]

In addition, local resources (supplies and personnel) may be destroyed or damaged by the event (either primary or secondary). Moreover, the possibility to supply resources may be profoundly compromised by damage to the societal infrastructure and other basic functional components of the affected society (e.g., destruction of bridges, transport capabilities, etc.). Importantly, societal functions are interdependent upon one another. The availability of resources, both human and material, may be compromised further by failures in the performance of coordination and control of the multifaceted problems associated with the damage. It has become clear that a major failure responsible for inadequate resources being improperly directed, is an inadequate coordination and control. Failure of organizational structure has occurred at all levels.[10]

Generally, attention is focused upon the effects of the event in the area directly impacted by the event. However, consideration also must be given to the possibilities that effects may be realized far from the area directly impacted. For example, rupture of a dam produces immediate destruction in the area below the dam, even sometimes far downstream from the event. But, if the dam was the principal production resource for electrical power, the impact of the event may have far-reaching effects hundreds of kilometers from the site of the event. Drought may produce famine in areas and populations at a far distant from the area in which the drought has occurred

Damage has two major components: (1) reparable; and (2) non-reparable. Some damage to humans and the environment can be repaired, while other elements are destroyed and must be replaced (some are beyond both repair and replacement (lost lives, etc.)). Therefore, response is directed at the delivery of repair and for replacement of the damage directed at returning the society and the environment to their respective pre-event states. The effects of the damage on a society can be attenuated by good response and vice versa, and good response is a function of the level of preparedness of the society for the event.

VULNERABILITY AND RESILIENCE

In the survey of all of the participants involved with the development of these Guidelines, "vulnerability" had the greatest variation in definitions. Definitions ranged from the "degree of loss" to "liability to attack or injury" to "the extent a society is susceptible to the forces thrown upon them". Vulnerability represents the susceptibility of an individual or population to injury or contagion;[15] or "the degree of possible/potential loss to a given element at risk resulting from a given hazard at a given intensity".[16] For this discussion, vulnerability means *the susceptibility of the population and environment to the type (nature) of the event*. The degree of vulnerability depends upon the resilience of the society for the event.

$$\textbf{Vulnerability} = \textbf{1} - \textbf{Resilience}$$

Equation 3.1

The *resilience* of the population/environment against the event is its *pliability, flexibility, or elasticity to absorb the event*. Resilience as used in this document is a counteracting component of vulnerability. Resilience has two components: (1) that provided by nature; and (2) that provided through the actions of humans. It is comprised of: (1) the absorbing capacity; (2) the buffering capacity; and (3) response to the event and recovery from the damage sustained.

Equation 3.1 is a mathematical expression and Figure 3.4 is a graphical expression of the relationship between vulnerability and resilience. Since the exact relationship is not known, the equation is not intended to be quantitative and is provided for conceptual purposes (otherwise the equation would produce a straight line). Vulnerability is a dependent variable on resilience. The important aspect of this relationship is that the greater the resilience, the less will be the vulnerability of the society, its basic functions, or their sub-functions for that specific event. If the resilience is sufficiently high (complete) for the specific event, then the society is not vulnerable to the event. No disaster can occur when there is no vulnerability to the event, should one occur.

Natural resilience includes forests that are able to withstand large

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

amounts of rainfall without succumbing to erosion and mudslides, the composition of the earth upon which human structures have been constructed, resistance of humans and other creatures to infections, etc. Examples of increased resilience due to human actions include the building of dykes to control floods from rising water, implementation of strict building codes to minimize the destruction caused by an event (earthquake resistant), etc. Examples of human actions that affect resilience negatively (increase vulnerability) include deforestation (e.g., to use the wood for other purposes) thereby decreasing the ability of the land to resist erosions, building human settlements on a floodplain, etc. Thus, *both resilience and vulnerability have a natural and manmade component.*

In summary, for conceptual consistency and for the purpose of structured analysis, we separate natural resilience from human actions. Consequently, natural resilience cannot be modified by human actions. Where the resilience of the environment and society is high, vulnerability to a given event is low. For example, the mudslides that resulted in Honduras from the

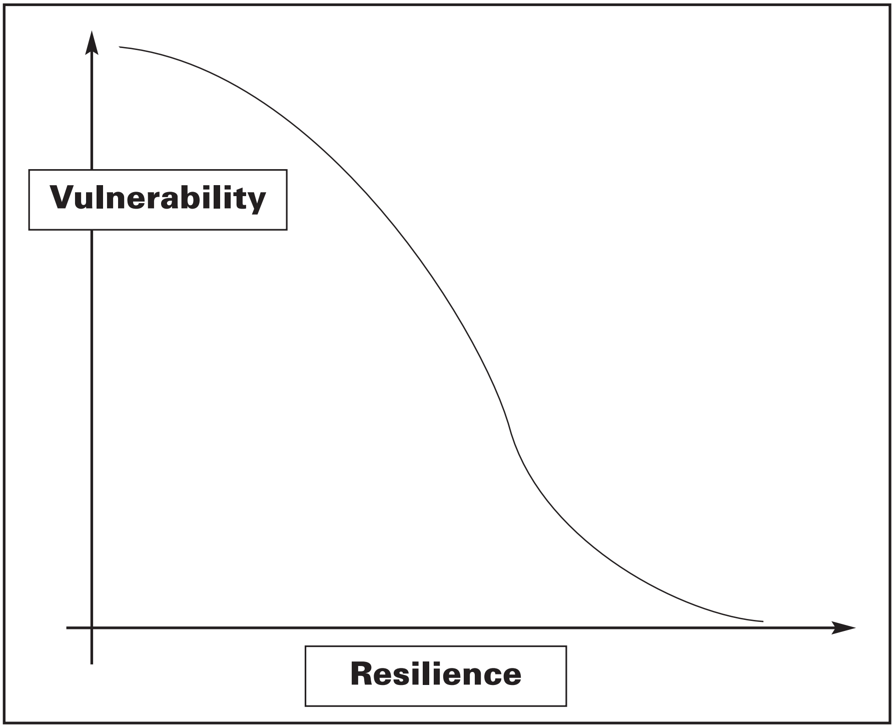

Figure 3.4—Relationship between vulnerability and resilience

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

rain and floods associated with Hurricane Mitch, in large part, were due to the deforestation of the area imposed by man.[10,17-20] Thus, their vulnerability increased as did the probability for damage and disaster to occur.

ABSORBING CAPACITY

The *absorbing capacity* is the ability to absorb the free energy of an event without sustaining a loss of essential functions of the affected society. Absorbing capacity is a part of the overall resilience of a society. The absorbing capacity consists of the natural resilience of the society and its environment and the surplus amount of available goods and services. This surplus of available goods and services may be consumed before any impairment of societal functions occurs. The surplus also may be used for building contingencies to prepare for an event, if one occurs, and for luxuries.

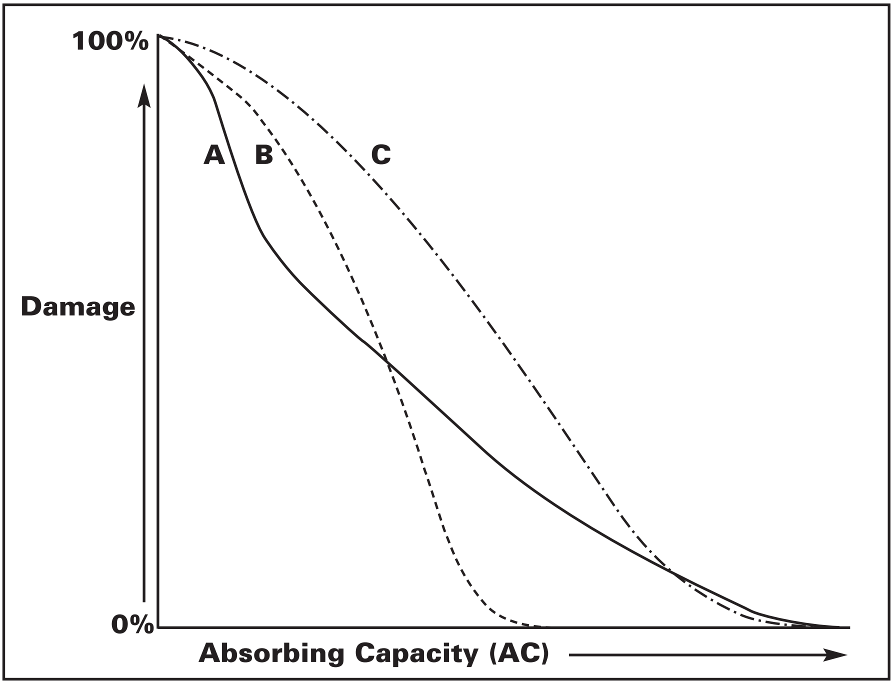

Figure 3.5—The relationship between damage produced by a specific event and the absorbing capacity of the society struck by the event. When the absorbing capacity = 0, damage produced by the event is maximum; when the absorbing capacity is total, the event produces no damage. The shape and position of a curve (A, B, or C) representing the relationship for a specific event in a specific society is unknown.

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

The absorbing capacity can be affected by human actions before an event occurs. Such actions could improve (preparedness) or impair the absorbing capacity for an event. For example, deforestation may decrease the absorbing capacity for torrential rains with the result of flooding and mudslides. The absorbing capacity of the society may be strengthened by or through improved planning, the development of contingencies, construction and building codes, stockpiling of equipment and supplies, training of personnel for response, distribution of protective equipment, education, etc.

As illustrated in Figure 3.5, as the absorbing capacity of a society increases, the likelihood of sustaining damage from a specific event decreases. Since natural resilience cannot be changed, the absorbing capacity of a society to a specific event only can be modified by human actions.

BUFFERING CAPACITY

Buffering capacity is the ability of a society to minimize the change in an essential function or functions for a given change in available resources (goods and/or services) (Equation 3.2). The concept is identical to the principles of chemical buffering of free hydrogen ions (H^+) in a chemical buffer system; in a buffered system, there is less change in pH for a given addition or removal of free H^+ ions. The principle is illustrated in Figure 3.6. The slope

$$\textbf{Buffering Capacity} = \frac{\mathbb{S}\ \textbf{Function}}{\mathbb{S}\ \textbf{Available Resources}}$$

Equation 3.2

of the relationship of Function/Available Supplies for Society A is less steep than it is for Society B. Thus, for a given change of available supplies, a much smaller change in the functional status will occur in Society A than in Society B. This is the case especially in the steep portions of the slope. As pictured in Figure 3.6, Society B is very efficient (cost-efficient); it uses a smaller amount of a given resource to provide a specific function needed in daily life. However, this slope reflects also how much a society has made itself dependent upon that specific commodity; a computerized, automated society is equally as vulnerable to a decrease in supplies as it is cost-efficient in getting the level of function. Examples include computerized, automated society, building codes, regulations for the use of water, regional planning, coordina-

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

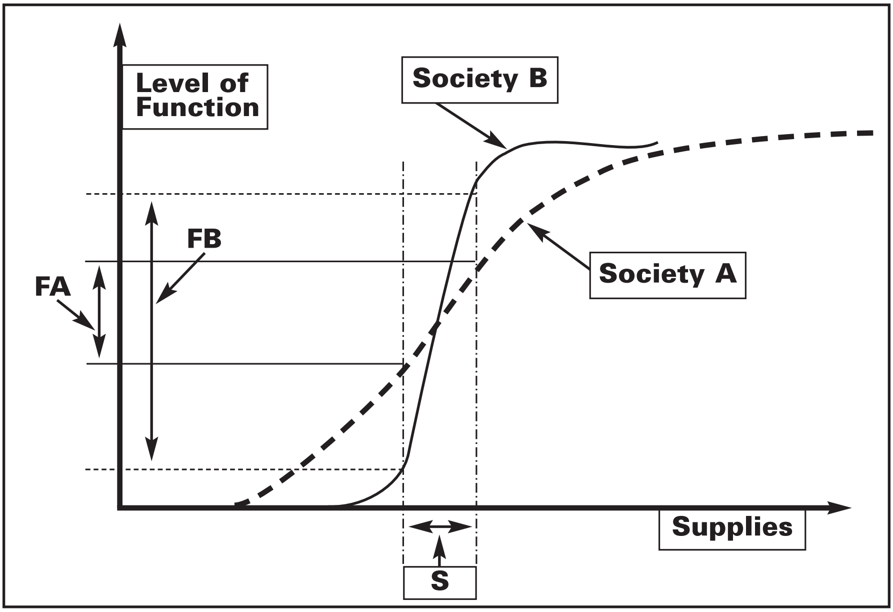

Figure 3.6—Buffering Capacity of a function in two different societies (A and B) illustrating the differences in change of function (FA and FB) for a given change in available supplies (S)

tion and control, etc. The greater the buffering capacity, the less likely a disaster will result from the impact of the precipitating event or secondary event(s).

DISASTER MANAGEMENT

Disaster Management is the *aggregate of all measures taken to reduce the likelihood of damage that will occur related to a hazard(s), and to minimize the damage once an event is occurring or has occurred and to direct recovery from the damage.* The effectiveness of disaster management determines the final result of the impact of the event on the environment and society impacted. Management of the damage/disaster either may be productive in minimizing the damage or it may be negative and, as such, contribute to the damage.

The training of medical response personnel, as part of preparedness, and the actual responses of medical personnel to the persons injured by the event are both parts of management.

DISASTER RESPONSE

Disaster Response is the *aggregate of all measures taken to cope with the dam-*

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

age sustained. The effectiveness of disaster response is part of disaster management that determines the final result of the impact of the event on the environment and society impacted. Response to the damage/disaster either may be productive in minimizing the results of the damage or it may be negative and, as such, contribute to the damage.

The principal tools for responses to damage are interventions and are parts of overall disaster management. Whereas, the stockpiling of medical supplies for use in case of a massive increase in the demand for these supplies is part of preparedness, the use of these supplies for treatment of the increased numbers of casualties is part of response. The training of medical response personnel is part of preparedness while the actual intervention of medical personnel to the persons injured by the event is part of response.

DISASTER

The occurrence of an event may result in the destruction of resources and may mandate an increased consumption of some resources in the affected area (local). Resources affected by the event may include consumable supplies as well as fixed resources and people. The latter may involve damage to the infrastructure as well as to the functions of the organizational structure in the affected area. Damage to the infrastructure may contribute further to impairment of the function of the organizational structure (process) of the affected society. In the context of this document, infrastructure encompasses all societal structures including buildings, roads, bridges, sanitary facilities, railroads, waterways, water facilities, and other essential societal structures *and* functions. An important example of increased consumption is the use of medical supplies and equipments in the treatment of those injured as a result of the event.

The occurrence of an event *may* produce a disaster. As noted earlier, a disaster happens when the damage rendered by an event becomes so great that the local mechanisms for response become overwhelmed and outside assistance is required to cope with the damage. The ability of a society to absorb the impact and to buffer the consequences of the damage created, is determined by many factors described above. These factors are influenced by the stage of development and culture of the society, the economics of the region, the natural and built environments, the preparedness for the event, and the ability of the society to manage the damage. What constitutes a disaster in one setting may not generate one in another.

https://doi.org/10.1017/S1049023X00700033 Published online by Cambridge University Press

RECOVERY

Recovery occurs when all of the damage from an event has been repaired or replaced. Thus, in the context of a disaster, recovery means bringing all of the societal components back to their pre-event status. All of the responses (interventions) to the damage sustained must have goals that contribute to the recovery of the society affected. Responses that carry the specific level of function to levels that are greater than it was before the event occurred (pre-event status) constitute development. Development is affected profoundly by disaster.

SUMMARY

A disaster occurs when the damage sustained by a society is so great that the local resources are insufficient to cope with the magnitude of the damage, and hence, resources from outside the area are required to deal with the damage. The multiple components that lead from the discovery of a hazard to damage to recovery offer many avenues for the application of interventions that can affect subsequent steps in the continuum. A structured approach to each of the components is provided in the Conceptual Framework and discussions that follow.

REFERENCES

1. Al-Mahari AF, Keller AZ: Review of disaster definitions. *Prehosp Disast Med* 1007;12(1):17–21.
2. Cuny FC: Introduction to disaster management. Lesson 1: The scope of disaster management. *Prehosp Disast Med* 1992;7(4):400–405.
3. Perez E, Thompson P: Natural hazards: Causes and effects. *Prehosp Disast Med* 1994;9(1):80–88.
4. Gunn SWA: *Multilingual Dictionary of Disaster Medicine and International Relief*. Boston: Kluwer Academic Publishers, pp 23–24.
5. Last JM (Ed.): *A Dictionary of Epidemiology*. New York, Oxford, Toronto: Oxford University Press, 1995, p 149.
6. Krymsky VG, Akhmedjanov FM, Suslov AS, Yunusov AR: *Regional Management of accidents risk level: Strategy based on effective feedbacks.* Society for Risk Analysis - Europe 1998 Annual Meeting. Abstract.
7. Thatcher VS, McQueen A (eds): *The New Webster Dictionary of the English Language*. Chicago: Consolidated Book Publishers, 1971, p 542.

8. Thompson D (ed): *The Concise Oxford Dictionary of Current English.* 9th ed, Oxford: Oxford University Press, 1995, p 43.

9. *Ibid.*, p 1230.

10. Pan American Health Organization/World Health Organization: Evaluation of preparedness and response to Hurricanes Georges and Mitch: Conclusions and recommendations. *Prehosp Disast Med* 1999;14(2):21–33.

11. Group 4: Invitational Workshop on Quality Control of Health Disaster Management: Nordic School of Public Health, Gothenburg, Sweden 1997. Unpublished data.

12. Thompson, *Dictionary,* p 338.

13. Sareen H, Shoaf KI: Impact of the 1994 Northridge earthquake on the utilization and difficulties associated with prescription medications and health aids. *Prehosp Disast Med* 2000;15(4):173–180.

14. First Book of Moses. *The Bible*, Chapter 41, verses 1-57.

15. Taylor EJ (ed): *Dorland's Illustrated Medical Dictionary*. Philadelphia: WB Saunders Co., Hartcourt Brace Jovanovich, Inc., 1988, p 1849.

16. Group 1: Invitational Workshop on Quality Control of Health Disaster Management: Nordic School of Public Health, Gothenburg, Sweden 1997. Unpublished data.

17. Guill CK, Shandera WX: The effects of Hurricane Mitch on a community in northern Honduras. *Prehosp Disast Med* 2001;16(3):166–171.

18. Goenjian AK, Molina L, Steinberg AM, Fairbanks LA, Alvarez ML, Goenjian HA, Pynoos RS: Posttraumatic stress and depressive reactions among Nicaraguan adolescents after hurricane Mitch. *American Journal of Psychiatry* 2001;158(5):788–794.

19. Caldera T, Palma L, Penayo U, Kullgren G: Psychological impact of the hurricane Mitch in Nicaragua in a one-year perspective. *Social Psychiatry & Psychiatric Epidemiology* 2001;36(3):108–114.

20. Balluz L, Moll D, Diaz Martinez MG, Merida Colindres JE, Malilay J: Environmental pesticide exposure in Honduras following hurricane Mitch. *Bulletin of the World Health Organization* 2001;79(4):288–295.