1

Disaster Research and Epidemiology

Megumi Kano, Michele M. Wood, Judith M. Siegel,
and Linda B. Bourque

OVERVIEW

The effective application of research can deepen understanding of a disaster's impact on health and societies. Such systematic study can inform disaster management across the entire response spectrum: from preparedness and prevention, through the immediate aftermath, to coping and rebuilding. Research allows for the identification of best practices that are subsequently refined and updated through further study. Meaningful improvement in any field is based on sound research. Without this activity, a field becomes stagnant and eventually irrelevant. In addition, thoughtful analysis of research data may demonstrate where accepted practices are no longer appropriate or, in some cases, where assumptions that directed disaster responses are in error. A body of research that continually builds on previous studies is the best tool for guiding practitioners, policymakers, and program planners in their efforts to reduce the impact of disasters on individuals and communities.

This chapter provides an overview of the wide range of disaster research conducted to date across various disciplines and documents changes that have occurred in the last few years. The first section reviews definitions of disaster, provides a historical overview of disaster research, and summarizes the characteristics of recent articles published in major epidemiology journals and some social science journals. The second section reviews the current state of the art, including the methods used, objectives, and settings within which disaster research takes place, and the application of information technology to disaster research. Also included are sections on research ethics, disaster vulnerability, morbidity and mortality, and the consistency of estimation methods used. The chapter ends with recommendations for further research. While the methodology remains largely unchanged, numerous new studies have been conducted indicating sustained development in this field of research.

Defining Disaster

There is no single, agreed-upon definition of disaster either within or across disciplines. Definitions used in practice and research vary widely, reflecting different objectives and interests in regard to the causes, consequences, and processes involved in disasters. The following discussions touch on the broad spectrum of processes involved in disasters, including, but not limited to, the impact on the healthcare system; the short- and long-term effects on people's health and livelihood; and the behaviors of individuals, groups, and organizations in relation to disasters.

Accordingly, a disaster is "any community emergency that seriously affects people's lives and property and exceeds the capacity of the community to respond effectively to the emergency."[1] As an extreme example, the 2011 Tōhoku Earthquake and Tsunami (M9.0) that occurred on March 11, 2011, in the Pacific Ocean off the coast of Japan's northeastern region was the biggest earthquake ever recorded in Japan. It caused powerful tsunami waves 10 to 40 meters high, which reached up to 6 km inland, devastating the coastal areas and leaving over 18,000 people dead or missing. The disaster was further compounded by the loss of power and subsequent meltdown of reactors at a nuclear power station affected by the earthquake and tsunami. Large quantities of radioactive contaminants were released, which led to evacuations of surrounding areas. More than 2 years later, many of the victims of this disaster who lost their homes, neighborhoods, and livelihoods still lived in temporary housing settlements, depending on their savings, disaster compensation, and donations. National and local governments are struggling over reconstruction and redevelopment. This event clearly overwhelmed the response and recovery capacity of the community at the individual, household, and organizational levels. Studies of this disaster legitimately go beyond its impact on people's health and the healthcare system.

The term disaster is often used interchangeably with the terms "emergency" and "hazard," although there are formal distinctions. An emergency is a threatening situation that requires immediate action but may not necessarily result in loss or destruction. If an emergency is managed successfully, a disaster may be averted. A hazard is a possible source of danger that upon interacting with human settlements may create an emergency situation and may lead to a disaster. For the purposes of this chapter, all three terms will be used, and the distinctions in meaning will be maintained.

https://doi.org/10.1017/CBO9781139629317.004 Published online by Cambridge University Press

Historical Overview of Disaster Research

Historically, sociological disaster research has been dominated by exploratory research designs, whereas epidemiological research emphasizes the importance of explanatory designs.[2–8] Exploratory studies usually focus on examining new areas of research or the feasibility of conducting more structured research with an emphasis on developing hypotheses. Descriptive and explanatory studies, in contrast, start with hypotheses and emphasize minimizing bias and maximizing external validity, with explanatory studies also attempting to infer causality. The next section of this chapter (Current State of the Art) provides greater detail on study design.

The perceived need to enter the field immediately after a disaster encouraged disaster researchers to utilize exploratory study designs rather than more structured descriptive designs. Researchers thought they were dealing with perishable data that had a limited time frame for collection. Information was thought to be unavoidably fleeting, vanishing quickly after a disaster because of memory decay, removal of debris, and other activities. Furthermore, it was assumed that disaster-associated in- and out-migrations were rapidly changing the target population and their communities in ways that could not be captured by the research. Consequently, early research on disasters relied on data obtained through semi-structured interviews with selected informants after quick entry into a community immediately post-impact. Over time, this perceived need to enter the disaster area immediately has been referred to as the "window of opportunity" and has been adopted by practitioners and policymakers as well as other research disciplines including engineering, seismology, medicine, and public health.

Disaster researchers trained in the social sciences have been concerned with the applicability of social theory to the study of disasters and, in reverse, the contributions that disaster research can make to the development of theory. References to theory in the early disaster epidemiology literature are oblique, with the exception of concerns about biological plausibility. Contemporary social epidemiological research more frequently incorporates theory, a subject that is discussed more fully later in this chapter, under the heading of Disaster Vulnerability.

Early Disaster Research

Samuel Prince's Columbia University dissertation, which examined the impact of the collision and explosion of two ships in the inner harbor of Halifax, Nova Scotia, in 1917, is recognized as the first scholarly study of a disaster.[9,10] With few exceptions, other systematic studies of disaster were not undertaken until World War II. Table 1.1 organizes the milestones in disaster research linearly by date, initiating agency and funding sources, primary disciplines conducting the research, research strategies, contributions to the field, and key sources for accessing disaster research. In the United States, through 1959, all of the early research was initiated and funded by the federal government, often the military.

The United States Strategic Bombing Surveys (1944–1947) examined the effect of U.S. strategic bombing and the resultant physical destruction on industry, utilities, transportation, medical care, social life, morale, and the bombed population's will to fight in Germany and Japan. Fritz noted, "people living in heavily bombed cities had significantly higher morale than people in the lightly bombed cities," and that "neither organic neurologic diseases nor psychiatric disorders can be attributed to nor are they conditioned by the air attacks."[11] In other words, the problems that were anticipated did not emerge, including social disorganization, panicky evacuations, criminal behavior, or mental disorders. In fact, morale remained high and suicide rates declined. These findings were not widely disseminated and were at variance with prewar expectations and prevailing views on the behavior of people under extreme stress.[12,13]

With the advent of the Cold War, federal government agencies ignorant or unaware of these findings expressed concern about how people might react to new war-related threats. A second set of studies, funded by the U.S. Army Chemical Corps Medical Laboratories and conducted at the National Opinion Research Center (NORC) at the University of Chicago (1949–1954), hypothesized that disasters cause extreme stress, which in turn results in social disorganization, the breakdown of social institutions, and the manifestation of antisocial and psychotic behavior by individuals and groups. Field studies were conducted following disasters, with a major objective being to use these situations as surrogates for what might occur during an invasive war of the U.S. and the Americas. "Comparing the state of knowledge prior to the NORC studies with the new field research findings, it became clear that previous studies . . . were sorely deficient," and that "except for a few notable exceptions, the literature was loaded with gross stereotypes and distortions."[11] Researchers compiled the NORC disaster studies into a three-volume report.[14]

In 1952, the U.S. National Academy of Sciences–National Research Council established the Committee on Disaster Studies (later the Disaster Research Group) at the request of the Surgeons General of the Army, Navy, and Air Force to "conduct a survey and study in the fields of scientific research and development applicable to problems which might result from disasters caused by enemy action."[11] This third set of studies refined theories about human behavior in disasters and improved the methodologies. Exploratory field studies conducted in the immediate aftermath of a disaster focused on how individuals behaved in crisis.

The general theoretical structure brought to this research, although not always explicitly stated, was developed from the theories espoused by Mead and Cooley of symbolic interaction and theories of collective behavior, particularly those specific to crowd behavior and the development of emergent groups.[15,16] It was hypothesized that the norms which determined social interaction might be challenged as a result of a disaster. Different social norms might evolve either temporarily, while the environment stabilized, or permanently, leading to different forms of social organization. Disasters were seen as triggers that disrupted the social order. Of interest was the behavior of individuals, groups, and organizations during either a brief or prolonged period of normlessness.[17,18]

> Societies are composed of individuals interacting in accordance with an immense multitude of norms, i.e., ideas about how individuals *ought* to behave . . . . Our position is that activities of individuals . . . are guided by a normative structure in disaster just as in any other situation . . . . In disaster, these actions . . . are largely governed by *emergent* rather than established norms, but norms nevertheless.
>
> –Drabek as cited by Perry[19]

Consistent with the interests in emergent norms and in behavior during and immediately after a disaster, the research conducted

https://doi.org/10.1017/CBO9781139629317.004 Published online by Cambridge University Press

Table 1.1. Milestones in Disaster Research

Dates	*Primary Research Agency/ Funding Source*	*Primary Disciplines Conducting Research*	*Research Strategies*	*Contributions to Disaster Research and Knowledge*	*Key Sources*
1920	Doctoral dissertation	Sociology	Exploratory case/field study	Recognized as first scholarly study of a disaster[9,10]	
Nov. 1944–Oct. 1947	U.S. War Department, Army and Navy	Civilian and military experts headed by a civilian chair	Exploratory and descriptive research using field observations, archival data, and personal interviews	Countered prevailing views that extreme stress lowers morale, causes mental disorders and social disorganization[13]	U.S. National Archives and Records Administration, Records of the United States Bombing Survey [http://www.archives.gov/research/guide-fed-records/groups/243.html]
1949–1954	National Opinion Research Center at the University of Chicago; funded by the U.S. Army Chemical Corps and Medical Laboratories	Social science; Psychology	Exploratory field studies	Laid the groundwork for the study of human behavior in disasters[14]	
1952–1959	Committee on Disaster Studies (1952–1957), Disaster Research Group (1957–1959), National Academy of Sciences-National Research Council; requested by Surgeons General of Army, Navy, and Air Force; funded by the Armed Forces, Ford Foundation, National Institute of Mental Health, Federal Civil Defense Administration	Social science; Psychology; Medicine	Exploratory and descriptive research involving field studies, experiments, clinical, economic and demographic studies	Showed that routine crises are qualitatively different from large-scale disasters, although there are similarities in human responses across disaster types. Also shed light on the positive outcomes of disasters[11,14,65,129–131]	
1963–present	Disaster Research Center at Ohio State University and later at the University of Delaware; funded by Office of Civil Defense, FEMA and other federal agencies	Sociology	Exploratory field studies during immediate aftermath of a disaster, and descriptive surveys	Generated sociological disaster research over four decades. Remains one of the main academic centers for disaster research in the U.S.	Disaster Research Center [http://www.udel.edu/DRC/] International Journal of Mass Emergencies and Disasters [http://www.ijmed.org/] Mass Emergencies [http://www.massemergencies.org/]
1970–present	Center for Disease Control, and later, the Centers for Disease Control and Prevention (CDC)	Public health, especially epidemiology	Descriptive and some explanatory epidemiology	The first epidemiological study of a disaster is published,[23] *Morbidity and Mortality Weekly Report* (*MMWR*) becomes the main source for epidemiological disaster research in the U.S.	MMWR [http://www.cdc.gov/mmwr/]

(*continued*)

Table 1.1. ***(continued)***

Dates	*Primary Research Agency/ Funding Source*	*Primary Disciplines Conducting Research*	*Research Strategies*	*Contributions to Disaster Research and Knowledge*	*Key Sources*
1973–present	Centre for Research on the Epidemiology of Disasters at the School of Public Health of the Université Catholique de Louvain in Brussels, Belgium	Epidemiology	Descriptive and explanatory epidemiology. Emphasis on applied research	Established an academic center for the study of disaster epidemiology. Maintains database on disasters worldwide and their human and economic impact by country and type of disaster	Bulletin of the World Health Organization [http://www.who.int/bulletin/en/] Disasters [http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1467-7717] Epidemiologic Reviews [http://epirev.oxfordjournals.org/] Lancet [http://www.thelancet.com/]
1976–present	Natural Hazards Center at the University of Colorado; funded by a consortium of federal agencies and the Public Entity Risk Institute	Geography; Sociology; Economics	Various research objectives and strategies. Promotion of interdisciplinary research	Brought together hazard researchers and disaster researchers. Increased interaction across disciplines, and between researchers, practitioners and policymakers both in the U.S. and internationally	Natural Hazards Center [http://www.colorado.edu/hazards/] Natural Hazards Review [http://www.colorado.edu/hazards/publications/review.html]
1976–present	World Association for Disaster and Emergency Medicine	Emergency medicine	Exploratory and descriptive research utilizing case studies and surveys	Marked emergency medicine's entry into disaster research	Prehospital and Disaster Medicine [http://journals.cambridge.org/action/displayJournal?jid=PDM/]
1977–present	Numerous grants awarded by the National Science Foundation, U.S. Geological Survey, National Institute of Science and Technology, FEMA, and the National Oceanic and Atmospheric Administration through the National Earthquake Hazards Reduction Program	Geography; Sociology; Political science; Psychology; Economics; Decision science; Regional science and planning; Public health; Anthropology	Various research objectives and strategies	Expanded the diversity in and quantity of disaster research[132]	

between 1949 and 1960 gradually identified an underlying timeline in the natural history of a disaster, starting with preparedness and proceeding through warning, evacuation, impact, and response and recovery periods. The early studies focused on the middle four stages, with little attention paid to preparedness or recovery. The stages enumerated have changed over time, but an underlying timeline is assumed, whether stated or not, in most contemporary disaster research.

The establishment of the Disaster Research Center (DRC) in 1963 – first at Ohio State University and later at the University of Delaware, by Russell Dynes and Enrico Quarantelli – was a natural extension of this early research. The DRC continued to conduct field studies immediately after disasters, focusing on the behavior of formal, informal, and emergent groups rather than the behavior of individuals. Although primarily studying disasters within the United States, field studies were also conducted in a number of other countries. Most studies were exploratory in design and many continue to be today, but some investigations were conducted using descriptive designs.[20,21] The Defense Civil Preparedness Agency (precursor to the Federal Emergency Management Agency, FEMA) funded most of the research, with the focus on major community organizations involved in disasters, such as police, fire departments, hospitals, and public utilities. Some funding was received from the National Institute of Mental Health and the Health Resources Administration to examine the delivery of medical care and mental health services.[22]

Gilbert White established the Natural Hazards Research and Applications Center (NHRAC) at the University of Colorado in 1976. With primary funding from the National Science Foundation as part of the National Earthquake Hazards Reduction Program agencies, the center served as a catalyst for bringing social scientists, physical scientists, academic researchers, practitioners, and policymakers together in multidisciplinary research projects, yearly workshops, and training programs. It encouraged the merger of disaster and hazard research. Interestingly, it was not until 1990 that the workshops drew participants from medicine, emergency medicine, epidemiology, and public health.

Epidemiology, Public Health, and Emergency Medicine

The first disaster research by investigators who identified themselves as epidemiologists was a study of the East Bengal cyclone of November 1970 by Sommer and Mosley.[23] They showed that death rates were highest for children and the elderly, and that women fared poorly relative to men. A decade later, in the first article published on disaster research in *Epidemiologic Reviews*, Logue and colleagues noted that, "research on the epidemiology of disasters has emerged as an area of special interest."[24] The authors observed that a few university groups in the United States (e.g., DRC and NHRAC) were conducting extensive research on disasters, and also made note of the work by the Center for Research on the Epidemiology of Disasters at the School of Public Health of Louvain University in Brussels, Belgium. They described the efforts as focusing on the immediate post-impact period with emphasis on surveillance for outbreaks of communicable diseases and on increased mortality directly attributable to the disaster. Importantly, they also recognized three "controlled long-term health studies" of the 1968 floods in Bristol, England; the floods in Brisbane, Australia, in 1974; and the 1972 Hurricane Agnes in Pennsylvania, respectively.

In 1990, a discussion of the epidemiology of disasters appeared as a brief update in *Epidemiologic Reviews*.[25] Many of the disasters discussed occurred outside the United States. Notably, the public belief about the high prevalence of communicable diseases post-disaster was countered. Unlike the earlier review, however, there was no cross-referencing to studies conducted by social scientists or others traditionally associated with disaster research. In 2005, *Epidemiologic Reviews* devoted a full issue to the topic "Epidemiologic Approaches to Disasters." Included were original reviews of research conducted following cyclones, floods, earthquakes, and the Chernobyl reactor meltdown, and of the development of posttraumatic stress following disasters.

Disaster epidemiology concentrates on estimating the direct and indirect incidence and prevalence of morbidity or other adverse health outcomes over the short and long term, with the objective of developing surveillance systems, prevention strategies, and estimations of the public health burden caused by the disaster.[26] Ideally, studies would be population based and longitudinal in design. Case-series, cross-sectional, case-control, and cohort designs are all represented in the epidemiological studies of disasters, but where field studies are common in other disciplines, the case series predominates in the epidemiological disaster literature. The U.S. Centers for Disease Control and Prevention (CDC) and others have encouraged and sometimes funded the conduct of post-disaster, rapid-assessment surveys, using modified cluster sampling.[27] However, a substantial number of epidemiological studies are restricted to coroners' reports and the description of persons who present at emergency departments and other points of service. Many of these studies make no effort to describe the denominator population from which the dead, the injured, and the sick were drawn. A further complication is the lack of agreement on what constitutes a disaster-related death, injury, or disease.[28] With the exception of one article, none of the contributions to the aforementioned 2005 special issue of *Epidemiologic Reviews* makes any reference to theory, and most of the articles call for more rigorous methodology in epidemiological studies of disasters.

Epidemiology Publications, January 2007–April 2013

In the first edition of this chapter, the authors conducted systematic, although not exhaustive, searches for disaster-related research articles in the epidemiological literature published between 1987 and 2007. The review that follows covers the period of January 2007 through April 2013. We examine articles published in the *Morbidity and Mortality Weekly Report*, *Prehospital and Disaster Medicine*, and four epidemiologic journals (*American Journal of Epidemiology*, *Annals of Epidemiology*, *Epidemiology*, and *Epidemiologic Reviews*). We identify the location of the disaster, the research team, and the extent to which bibliographies include references to the broad social science literature, in addition to medical and epidemiologic journals. As a means of comparison, we provide a similar review of articles on disasters in two social science journals known for publishing disaster research (*Environment and Behavior* and *International Journal of Mass Emergencies and Disasters*) and determine the extent of cross-reference to the medical and epidemiologic literature (see Table 1.2).

A total of seventy-seven articles were identified with the following distribution: twenty-nine in the *Morbidity and Mortality Weekly Report* (*MMWR*), twenty in the *American Journal of Epidemiology*, fourteen in the *Annals of Epidemiology*, twelve in *Epidemiology*, and two in *Epidemiologic Reviews*. Although our review focuses on journals published in English,

https://doi.org/10.1017/CBO9781139629317.004 Published online by Cambridge University Press

Table 1.2. Number of Disaster-Related Articles Published in Six Selected Journals by Geographic Location of the Index Disaster Event, January 2007–April 2013

Journal	*U.S. Disaster*	*Non-U.S. Disaster*	*Geographic Scope of Non-U.S. Disaster/Event (Number of articles)*
Epidemiology Journals			
American Journal of Epidemiology	6	11	Australia (2), Britain, China, Europe, Iceland, Italy, Netherlands, Vietnam; International (2)
Annals of Epidemiology	10	4	China (2), UK; Asia
Epidemiology	5	7	Bangladesh, Canada, Chile, China, Liberia; 15 European cities; International
Morbidity and Mortality Weekly Report	18	12	Greece, Haiti (3), Kenya, Mexico, New Zealand, Pakistan, Sudan; International (3)
Social Science Journals			
International Journal of Mass Emergencies and Disasters	41	32[1]	Australia, Bangladesh, Cameroon, Canada (2), Haiti, India, Israel, Japan, Korea, Liberia, New Zealand (2), Sweden, Turkey, UK; Asia (3); International
Environment and Behavior	10	7	China, Japan, Netherlands, New Zealand, UK; International

[1] Includes twelve articles, of which six each were published in two special issues of the *International Journal of Mass Emergencies and Disasters* – one on Theory of Disaster Recovery (August 2012, Vol. 30, No. 2) and one on the National Evacuation Conference (March 2013, Vol. 31, No. 1).

thirty-four of the articles report on disasters that occurred outside the United States, and most of those articles were written by non-U.S. researchers. These articles examine the full range of disasters and disaster-associated morbidity, mortality, service delivery, and needs assessments. Topics of study included the 2009 H1N1 pandemic influenza (n = 23, of which 19 were in *MMWR*); other influenza outbreaks including historical events (n = 4); combat and war in both contemporary and historical settings (n = 15); weather events involving extremes of heat and cold (n = 5); the terrorist attacks of September 11, 2001 (n = 3); wildfires (n = 3); floods (n = 3); earthquakes (n = 2); preparedness for disasters (n = 2); a pub fire; a dioxin spill; dust storms; a power outage in the northeast United States; a typhoon; a hurricane; a coal mine disaster; a tornado; school mass homicides; two review articles on global surveillance and humanitarian relief workers; and two historical vignettes on the Halifax explosion and the Johnstown flood.

In contrast to the earlier 20-year period when the *American Journal of Epidemiology* published an average of one disaster article each year, an average of more than three articles was published each year between 2007 and 2013. Most of the studies are atheoretical (not designed to test a hypothesis or theory), and many combine existent cohort studies with a natural experiment. As before, the emphasis has been on mortality, morbidity, injuries, and psychological distress. Like the early field research conducted by social scientists and psychologists, many studies lack denominator data or information about the population they represent.

The journal *Epidemiology*, sponsored by the International Society for Environmental Epidemiology, publishes mostly conference abstracts, but also published twelve disaster-related articles between 2007 and 2013. Of these, five were conducted by U.S.-based researchers, five by research groups outside the U.S., and two by groups comprised of both U.S. and non-U.S. researchers. There were a total of eleven references to social science research. During this same time period, the *Annals of Epidemiology* published fourteen articles on disasters. Data were collected using surveys, registries, and other existent secondary sources of information. Eleven references were made to social science literature in the fourteen studies.

Prior to 2007, in addition to the literature noted previously, *Epidemiologic Reviews* published review articles on psychiatric distress from disasters, pandemic influenza, toxic oil syndrome, and heat-related mortality. Since 2007, two review articles, one on global public health surveillance and the other on trauma-related mental illness, have at least tangential relevance to the study of disaster epidemiology.[29,30]

Since January 2007, the CDC periodical *MMWR* has published twenty-nine articles about disasters throughout the world, with fifteen published in 2009. Most articles combined surveillance with a case series, but articles on school-associated homicides and coal mining included historical reviews of similar events with contemporary surveillance reports. A case-control study in Sudan evaluated an intervention designed to reduce the spread of cholera, and a population-based needs assessment following Hurricane Ike reported on injuries and other health-related needs. Two studies of household preparedness for emergencies and disasters were surveys. There are no references to social science research in any of the twenty-nine articles in *MMWR*. The lack of such references is particularly surprising in the two articles about household preparedness, given that household preparedness and evacuation behavior have been the focus of a substantial amount of social science research dating back to 1950.

Prehospital and Disaster Medicine, January 2007–April 2013

The establishment of the World Association for Disaster and Emergency Medicine by Peter Safar and other leading international experts in resuscitation/anesthesia in 1976 and that of the American Board of Emergency Medicine as a conjoint specialty board in 1979 mark emergency medicine's entry into disaster research.[31] Originally an invitation-only group called the Club of Mainz, membership was eventually broadened in 1997. In 1985, Safar founded the journal *Prehospital and Disaster Medicine* (*PDM*). Much of the disaster research conducted in emergency medicine is published in *PDM*, but in our original review we reported that very few articles contained references to disaster research conducted outside of medicine or to those published before 1985. More of the mainstream emergency medicine

journals are now regularly featuring disaster medicine research but some of these same limitations remain.

Using a broad definition of "disaster research" and "nonmedical citations," twenty-three issues of *PDM* were reviewed for articles on disaster research in the first edition of this chapter. Seventy-one articles were identified, which included a total of ninety-two citations to nonmedical sources; these references were found in only a limited number of articles. Most references were to other emergency medicine or medical journals, including the *Annals of Emergency Medicine*.

This review was repeated for articles published between January 2007 and April 2013. Here we assumed that all articles published in *PDM* were directly or indirectly related to emergency medicine and disasters. During that period, 488 articles were published, with 175 about disasters and emergencies in the United States, 294 focused on non-U.S. disasters, and 19 having an international focus. A few authors of non-U.S.-based articles were from the United States, but the overwhelming majority was not.

PDM publishes a broad range of articles. Some focus on policy issues and editorial commentary. A substantial number of articles are based on case series or retrospective review of records. Some issues are largely devoted to publication of conference proceedings with, for example, Issue 5 in 2007 focused on the First Annual Humanitarian Health Conference convened by the Dartmouth Medical School and the Harvard Humanitarian Initiative. Occasionally case-control studies and evaluations of interventions are reported. Almost all research articles were atheoretical.

Over the period reviewed, there were 118 references to social science research in the 474 articles. When references appeared, they were concentrated in just a few articles, and the plurality of references was to Enrico Quarantelli's articles and chapters. When articles are focused on emergency medical interventions and treatment, such as triaging or crush injuries, lack of references to social science research is logical; however, when articles are focused on crowd behavior or evacuation, the lack of attention to historical social science research can be seen as a critical oversight. Earlier we noted that much of the theoretical interest in studying disasters evolved from theories of collective behavior, particularly those specific to crowd behavior and the development of emergent groups. At least four articles in *PDM* focus on mass gatherings and crowd control but only one editorial comment correctly identifies the origin of such research in social psychology over 100 years ago and its use as a context for studying disasters starting in 1950.[32]

In 2009, Smith et al. published a review of disaster-specific literature from 1977–2009.[33] The authors noted that the formal study of disasters dates to Samuel Henry Prince's dissertation on the 1917 ship explosion at Halifax, Nova Scotia, which was followed by "empirical and theoretical research throughout the 1930s, 40s and 50s," and that, "throughout the 1960s and 1970s, academics from a variety of disciplines began to examine the nature and concepts of disasters." Nonetheless, they make no attempt to include the social science literature in their review.

Social Science Publications, January 2007–April 2013

For a brief comparison, we also examined articles on disasters that were published in two social science journals to see whether authors cited research conducted in medicine or epidemiology. Because traditional disaster research primarily originated in sociology, the number of articles published in traditional sociology journals between 2007 and 2013 was examined first. Over that period, only a total of five articles were published in the *American Sociological Review*, the *American Journal of Sociology*, and *Social Problems* , and a single special issue with seven articles was published in *Social Forces*. The absence of articles in these journals emphasize the extent to which the traditional disaster research paradigm in sociology has become restrictive and unproductive as suggested both by Tierney and in the special issue of *Social Forces*.[34,35] Tierney notes that:

> Disaster researchers must stop organizing their inquiries around problems that are meaningful primarily to the institutions charged with managing disasters and instead concentrate on problems that are meaningful to the discipline. They must integrate the study of disasters with core sociological concerns, such as social inequality, societal diversity, and social change. They must overcome their tendency to build up knowledge one disaster at a time and focus more on what disasters and environmental crises of all types have in common with respect to origins, dynamics, and outcomes. And they must locate the study of disasters within broader theoretical frameworks, including in particular those concerned with risk, organizations and institutions, and society-environment interactions.[34]

As a consequence, disaster researchers have become isolated from mainstream sociology and tend to publish in extreme event and multidisciplinary journals such as *Environment and Behavior*, the *International Journal of Mass Emergencies and Disasters*, *Disasters*, the *Natural Hazards Review*, the *Journal of Contingencies and Crisis Management*, *Risk Analysis*, and *Natural Hazards*. *Environment and Behavior* and the *International Journal of Mass Emergencies and Disasters* were selected as two examples of this broader social science literature.

Environment and Behavior published seventeen articles on disasters between January 2007 and April 2013. Nine articles focused on disasters in the United States and eight on non-U.S. disasters. All articles cited at least one theoretical context for the research being conducted, and data were collected through environmental observation, self-administered and internet questionnaires, in-person interviews, telephone surveys, panel studies, and the combination of multiple sources of data. Across the seventeen articles, there were twenty-one references to medical or epidemiology journals.

The *International Journal of Mass Emergencies and Disasters (IJMED)* – established in 1983 by the International Sociological Association's Research Committee on Disasters – focuses on theory, research, planning, and policy related to the social and behavioral aspects of disasters or mass emergencies. Papers concerned with medical, biological, physical engineering, or other technical matters are accepted if social and behavioral features of disasters are also discussed. Between January 2007 and April 2013, seventy-three articles were published in *IJMED* with forty-five focused on disasters in the United States and twenty-eight on disasters outside the United States. Articles in *IJMED* were less likely than those in *Environment and Behavior* to provide a theoretical context for the study, but all cite previous relevant research. Two special issues were published during this period on Gender and Disasters (August 2010), and the Theory of Disaster Recovery (August 2012). Across the 73 articles there were

119 references to medical journals and 11 to epidemiology journals. Interestingly, the articles focused on the identification of bodies after disasters had only a few references to relevant medical and epidemiologic literature.

Summary

The previous review demonstrates that roughly half of the disaster-related articles published between 2007 and early 2013 in some of the key English-language epidemiology journals, and a few social science journals, are about disasters occurring outside the United States. Articles published in epidemiology and emergency medical journals rarely cite a theoretical context for their analyses or provide cross-citations to the social science research on disasters. In contrast, articles published in the social science journals reviewed here are often placed within a theoretical structure but with limited references to relevant literature in medicine and epidemiology. These findings suggest that the many disciplines engaged in hazard and disaster research remain largely self-contained, with restricted knowledge of research conducted in other areas and disciplines, constraining the diversity of perspectives that could be brought to bear on critical issues.

CURRENT STATE OF THE ART

State of the art is described in regard to three aspects of disaster research: methodology, vulnerability, and estimates of morbidity and mortality. The first portion provides an overview of key methodological issues pertinent to disaster research, ranging from disaster research settings to ethical considerations. The second portion explores the concept of vulnerability, focusing on different approaches to determining who might be most vulnerable to the impact of a disaster. The last section is relevant to the impact and aftermath of a disaster. It reviews the factors that influence estimates of disaster-related morbidity and mortality.

Disaster Research Methods

There are multiple scientific perspectives involved in disaster research, and the methods used to study disasters are equally varied. The appropriateness of one methodological approach over another is determined by the specific question the researcher is trying to answer and the discipline in which the researcher was trained. A number of books provide expert guidance on disaster research methods.[36–38]

Disaster Research Objectives

The objective of disaster research can be exploratory, descriptive, or explanatory. Exploratory studies are the least structured type of research endeavor, often examining new areas of research or the feasibility of conducting more structured research. The emphasis is on developing hypotheses, frequently involving in-depth data collection from a relatively small group of purposively selected research subjects. It should not be assumed that exploratory studies are easier to conduct or less time consuming simply because they tend to be performed on a smaller scale or without the use of large sets of quantitative data.

Descriptive studies, in contrast, start with formal hypotheses or research questions and seek to accurately describe a situation by deriving estimates of important outcome distributions (e.g., disease occurrence by person, place, and time) or associations between variables and theoretical constructs in a population. Like descriptive studies, explanatory studies are driven by hypotheses. The aim, however, is to explain causal relationships. Explanatory research is also referred to as analytic research in epidemiology.[39] In both descriptive and explanatory studies, emphasis is placed on selecting samples that are representative of the population being studied and minimizing bias in data collection.

Disaster Research Settings

The study of disasters can occur in many different physical and temporal contexts. Among disaster health researchers and epidemiologists, data collection activities have been focused largely in high yield areas where disaster victims are likely to congregate, such as emergency departments. Research conducted in these settings captures the numerator, that is, the number of people with different health afflictions who present themselves in these settings. This approach provides no information on the larger community from which these individuals emerged (i.e., the denominator) or the extent to which they represent the range and severity of disaster-related morbidity in a population. It can even lead to misattribution of the cause for morbidity in the absence of a rigorous protocol. As a case in point, Peek-Asa and colleagues examined coroner and hospital records following the 1994 Northridge earthquake in California.[40] They found that, when compared with their systematic, individual medical record review, initial reports overestimated earthquake-related deaths and hospital admissions by misattributing deaths and injuries that presented for care shortly after the earthquake.

Population-based studies, in contrast, enable researchers to estimate the number of individuals in a community who were afflicted in some manner because they focus on the denominator, or the entire community at risk. A study conducted in Iceland after a volcanic eruption in 2010 utilized an existing population registry to identify and survey all adult residents in the municipalities closest to the volcano and an additional sample of demographically matched residents from a non-exposed area in the northern part of the country.[41] This population-based cross-sectional survey was able to estimate the proportion of the population afflicted by symptoms likely related to the volcano eruption and determine that residents living in the exposed area had markedly increased prevalence of respiratory and other physical symptoms compared to non-exposed residents. The dose–response pattern that emerged, with the highest symptom prevalence found in those living closest to the volcano, strengthened the evidence that the symptoms found in the study were caused by exposure to the eruption.

Disaster research may also occur in different temporal contexts. An organizational structure for disaster planning, response, and research conceptualizes disaster events as occurring in a cycle. There are slight variations in the way different researchers divide and label the critical periods, but three phases are common to all schemas.[42] These are the "pre-impact," "trans-impact," and "post-impact" periods, also described as the "disaster mitigation and preparedness," "emergency response," and "disaster recovery" periods. The U.S. National Research Council recommends that cycles typical of hazards on one hand, and disasters on the other, be integrated in recognition of the importance of collaborative cross-disciplinary research.[43]

The pre-impact period is the time frame leading up to a disaster event. This period involves two major activities, hazard

https://doi.org/10.1017/CBO9781139629317.004 Published online by Cambridge University Press

mitigation and disaster preparedness, which help reduce vulnerability to disaster impact. Emergency preparedness planning and research may be conducted during this phase. Baseline information about disaster readiness and emergency planning may be collected as well. The trans-impact period focuses on warning, evacuation, immediate response, and disaster relief activities. The post-impact period revolves around disaster recovery. It is important to note that these divisions serve as an organizational scheme and are neither fixed nor absolute. In fact, they may blend together depending on the outcome of interest.

More recently, studies have been conducted during all phases of the disaster cycle, extending the window of post-impact data collection and using longitudinal designs (comparing data before and after a disaster) when appropriate baseline data are available. The notion that disaster-related memory is stable over time is supported by research conducted in three successive time periods following the 1994 Northridge earthquake in California.[44]

The stages of the "disaster cycle" can be related to the different levels of morbidity and mortality prevention. Within the field of epidemiology, the term "prevention" is broadly used to understand the spectrum of efforts to eliminate or reduce the negative consequences of disease and disability[45]. Traditionally the term has been defined in levels of primary, secondary, and tertiary prevention to help delineate different healthcare foci. Primary prevention involves individual and group efforts to protect health through activities such as improving nutrition and reducing environmental risks. These efforts are made before disease or disability occurs, and they are the main focus of public health. In terms of the health threats posed by disasters, primary prevention efforts represent individual and group disaster mitigation and preparedness activities.

Secondary prevention consists of measures that facilitate early detection and treatment, such as health screening, to control disease or disability and reduce the potential for harm. In terms of disasters and their health consequences, secondary prevention can be likened to early warning systems, evacuation efforts, and immediate disaster response and relief because these efforts are designed to reduce later harm in the face of a newly introduced disaster health threat.

Tertiary prevention strives to reduce the long-term impact of disease and disability by eliminating or reducing impairment and improving quality of life. These efforts are generally the focus of rehabilitation. Tertiary prevention of disaster-related health effects might be understood as disaster recovery efforts, in which the goal is to eliminate impairment caused by a disaster and to rebuild communities and infrastructures. Figure 1.1 integrates the temporal stages of a disaster, levels of prevention, and disaster-related activities.

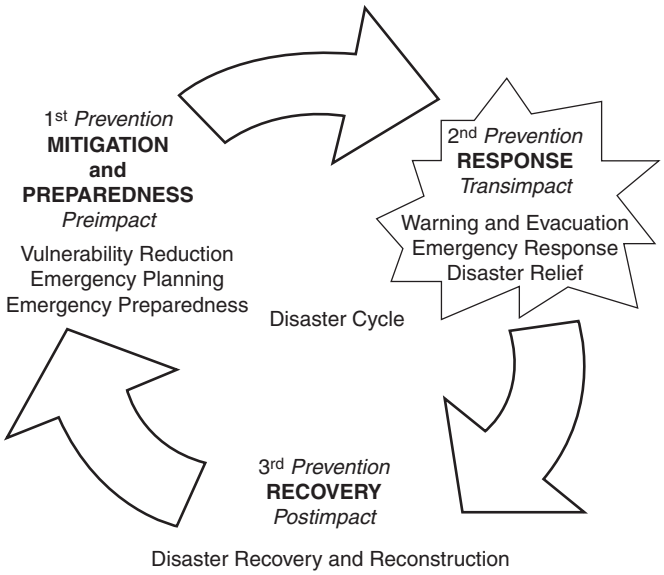

Figure 1.1. The Disaster Cycle.

Disaster Research Variables

Regardless of the phase of the disaster cycle that is being studied, the choice of research variables requires careful consideration. This selection is guided by the researcher's disciplinary or theoretical background as well as by the unit of analysis (i.e., individuals, groups, organizations, or communities). Variables that are expected to have an effect on the outcome of interest are the independent variables. A key independent variable in epidemiologic disaster research is the level or dose of exposure to a disaster. This exposure can be measured in various ways, such as the intensity of shaking experienced in an earthquake or the extent of personal loss due to a disaster. Alternatively, dose can be measured in terms of pre-disaster exposure to public information campaigns or other preparedness messages.[46] Demographic characteristics of the population at risk or those exposed to the disaster are also considered as independent variables or as effect modifiers that influence people's experiences in an event.

The range of possible outcomes or dependent variables in disaster research is extremely wide due to the multidimensionality of the disaster phenomenon and the corresponding multidisciplinary nature of disaster research. The major disciplines involved in disaster research today include geography, geology, engineering, economics, sociology, psychology, public policy, urban planning, anthropology, public health, and medicine.

Geographers and geologists study the relationship between human settlements and hazards (e.g., earthquake faults, hillsides, and floodplains), or the "hazardscape," and engineers examine the extent of structural damage that can be caused by a disaster. Economists assess the economic and financial impact of disasters, sociologists and psychologists study the behavioral responses to disasters and disaster risk, and health professionals are primarily interested in the effect of disasters on people's health and the healthcare infrastructure. Depending on when (i.e., during which part of the disaster cycle) the dependent variables are measured and how the study is designed, researchers can forecast the amount of loss and damage that might be done or prevented, measure the actual impact of a disaster, assess the effectiveness of interventions in reducing disaster impact, and predict the course of long-term recovery, each in terms of the dependent variables of interest to the researcher.

As the number of disasters increases worldwide, the field of disaster research grows, with new disciplines being added or previously minor disciplines becoming more prominent. These changes affect the dependent variables that are studied in disaster research. For example, subsequent to September 11, 2001, the study of terrorism has grown dramatically within this field. Studies have assessed different outcomes of terrorism, including the public's response to terrorism and the health impact of terrorism events.[47] Similarly, the occurrence of SARS and influenza pandemics and their repercussions on a global scale have given

further impetus to public health emergency research in recent years.[48,49]

Disaster Research Study Designs

The appropriate study design depends on the research objective; whether it is exploratory, descriptive, or explanatory/analytic (as described earlier); and the feasibility of the study given available resources. The designs described here are frequently used in the social sciences and in epidemiology to study a wide range of phenomena, including those related to disasters.

Experimental studies involve comparing outcomes between those who receive a certain treatment and those who do not, holding all other known factors constant. A treatment can be any independent variable that is expected to have an effect on the dependent variable. In experiments, the researcher controls the level of the independent variable, or exposure, in an attempt to isolate its effect. Experiments involve random assignment of subjects to treatment groups (i.e., randomization) to increase the likelihood that the groups will be comparable in regard to characteristics other than the main independent variable that may affect the outcomes. Truly experimental designs can offer evidence with the highest internal validity (i.e., evidence of causality) and thus are suitable for explanatory research. As an example, researchers tested the effectiveness of a behavioral treatment for earthquake-related posttraumatic stress disorder by randomizing a group of survivors of the 1999 Turkey earthquake with a clinical diagnosis of posttraumatic stress disorder into treatment and non-treatment groups. This study identified significant effects of the behavioral intervention at weeks 6, 12, and 24, and 1–2 years post-treatment. Experiments might also be conducted in which human subjects are not involved, for example, to test whether certain structural designs mitigate damage in an earthquake. They are not used, however, to investigate how people are affected by or respond to disasters because it is unethical and, in most cases, impossible to manipulate exposure to a disaster.

There are many natural social settings in which the researcher can approximate an experimental design without fully controlling the stimuli (determining when and to whom exposure should be applied and randomizing the exposure) as in a true experiment. Collectively, such situations can be regarded as quasi-experimental.[50–52] Quasi-experiments are frequently used in the social sciences for explanatory research. This includes studies in which a group of individuals who were naturally exposed to a disaster is compared to a group of non-exposed individuals, or to those with varying degrees of exposure, to identify possible differences in the occurrence of key outcomes. In the absence of an actual disaster, level of exposure to disaster "risk" (e.g., distance from a hazard) instead of exposure to the disaster itself can be the exposure of interest in studying certain behavioral responses (e.g., emergency preparation). As will be discussed in a later section, people may also be indirectly exposed to a destructive event, for example, via media reports.

In epidemiology, study designs that are not experimental, including quasi-experimental designs, are called observational studies.[39] Here, subjects are studied under natural conditions without any intervention by the researcher. Only naturally occurring exposures and outcomes are examined in these types of studies. A cohort study is one of the typical designs used in epidemiology in which the researcher identifies a group of exposed individuals and a group of non-exposed individuals, or individuals with varying degrees of exposure, and follows the groups to compare the occurrence of specific outcomes. In disaster research, for example, long-term health outcomes could be compared between groups of residents in the same disaster-affected community based on their level of exposure to the index disaster or between residents of a disaster-affected community and residents of a similar community not affected by a disaster.

Following the 1995 Kobe, Japan earthquake, a cohort of school children were assessed for posttraumatic stress reactions at four points in time over the 2 years after the disaster. Children who lived in areas directly affected by the earthquake were compared with children of the same age group who lived in distant areas that were not directly affected.[53] It was found that greater exposure to the earthquake was associated with more fear, anxiety, and depression or physical symptoms, with younger children exhibiting greater vulnerability. Exposure was defined as the extent of survivors' experiences related to home damage, injuries to oneself, fatalities or injuries among family members, and having to be rescued or to stay in shelters after the earthquake.

Another common study design in epidemiology applied to disaster research is the case-control study. As with cohort studies, this design is appropriate for explanatory research aimed at understanding the association between exposure and outcomes. In contrast with cohort studies, however, instead of determining exposure status first and then observing outcomes, a case-control study begins by identifying groups of people who naturally have or do not have the outcome of interest (i.e., cases and controls, respectively) and then retrospectively determining their exposure status. For example, a matched case-control study was conducted in a village of Southern China where a powerful typhoon struck in August 2006.[54] A census was conducted to determine residents who had died or been injured in the typhoon (i.e., the outcome of interest). A comparison with those residents who had survived without injury led to the identification of risk factors for typhoon-related injury and death. These included proximity of the house to the sea and behavioral factors such as failure to reinforce doors or windows and staying near a door or window during the typhoon.

Quasi-experimental, cohort, and case-control studies can all offer relatively high internal validity. They can also maximize external validity, or generalizability to a larger population, if population-based sampling is used. One of the major challenges to using these designs is defining disaster exposure. For example, one might posit that everyone in the United States was exposed to the September 11, 2001, attacks on the World Trade Center and Pentagon, even though most people were not proximal to the disaster sites. Nonetheless, they may have experienced it vicariously through the media, their friends, or family. A quasi-experimental study conducted in the United Kingdom (UK) compared the responses collected before and after the September 11 terrorist attacks in a longitudinal household panel survey. Investigators demonstrated that a terrorist attack in one country negatively impacted the wellbeing of residents in another country through vicarious exposure.[55] However, the amount of this exposure was not measured or validated in this study. As an example, researchers did not assess whether or how much the respondents had actually viewed or heard any media coverage of the event. Rather, given the extensive and prolonged worldwide media coverage of the disaster, it was assumed that all of the surveyed population had been exposed by the time of the post-9/11 survey. Epidemiologists are often interested in identifying dose–response relationships, that is, the relationship of observed outcomes to varying levels of exposure. A

dose–response relationship strengthens the internal validity (i.e., causal claims) of the research findings.

Observational study designs are also appropriate for descriptive studies, in which the objective is to accurately describe the distribution of variables or associations between variables in a population. Non-experimental designs have low internal validity but can have a high degree of external validity if they are conducted with a probability sample of the population. The greatest challenge in conducting population-based studies in disaster research is identifying the population to which the study results can be generalized, or, in other words, establishing the denominator for population estimates. Catastrophic disasters further complicate this issue because the population from which data is collected may be unstable or different from what it had been before the event due to disaster-associated in- and out-migrations, deaths, and alterations in procedures used to compile administrative records.[56] A study of migration patterns in the wake of Hurricanes Katrina and Rita in the United States found that places characterized by greater proportions of disadvantaged populations, housing damage, and more densely built environments were significantly more likely to experience out-migration following the hurricanes.[57] In this case, surveying only the people who remained in the area will likely underestimate the full extent of physical and socioeconomic damages caused by the storms. Any population-based study conducted post-disaster will need to account for such nonrandom patterns of change in the base population.

A non-experimental observational study design that is suitable for in-depth, exploratory research is the case study (or a case series). In this type of study, cases are deliberately selected for examination without insuring they are statistically representative of a population, thus compromising external validity. Internal validity is also low because systematic comparisons between cases and non-cases are not performed. The main benefit of case studies is that they lead to a better understanding of rare or new phenomena and the development of hypotheses. Much of the early disaster research in the social sciences used case studies (see earlier section on Historical Overview of Disaster Research). Case studies are also used in disaster medicine and epidemiology to describe the unique characteristics of deaths, injuries, illnesses, and other health outcomes associated with disasters.[58]

In addition to the distinction between experimental and observational designs, there is also a difference between methodologies in terms of how frequently data are collected over a study period. When data are collected at only one point in time, it is called a cross-sectional or prevalence study. It is best used to describe the state of a population at a given time. Cross-sectional designs can also be used to identify causal associations between variables, where the evidence for causation is based on the application of theory and inferential logic rather than time sequence.[59] In other words, theoretical models are used to determine whether the hypothesized independent variable logically precedes the dependent variable. Therefore, cross-sectional designs can also be used in explanatory research, although they are most naturally used for descriptive research.

Cross-sectional studies conducted before a disaster occurs can provide valuable baseline data on health status, knowledge of risks, attitudes toward preparedness, and actual preparedness behavior at the individual, organizational, or community level. In reality, most disaster studies using a cross-sectional design are conducted after the event has occurred to assess its impact. Examples of these kinds of studies include the post-disaster, rapid health surveys routinely conducted by the CDC as well as by local public health officials. Results of post-disaster, cross-sectional studies must be interpreted with care, especially when baseline data are not available. Although it is tempting to associate post-disaster observations with the index event, it must be recognized that findings from a post-disaster, cross-sectional study reflect conditions that existed before the event as well as conditions that arose during or afterward. Therefore, not all cases or conditions identified in a post-disaster, cross-sectional study are new (i.e., incident cases). The cases identified in a cross-sectional study, including both old and new, are referred to as prevalent cases.

Even new cases that occur after a disaster may have little or no causal association with the incident itself. Among the prevalent cases identified after an event, errors are frequently made in distinguishing between incident cases (or conditions) caused by the disaster, incident cases unrelated to the disaster, preexisting cases that were exacerbated by the disaster, and preexisting cases that were unaffected by the disaster. Chronic conditions are especially prone to such classification errors, although a carefully designed study can allow researchers to make causal attributions to the index event. As an example, following the magnitude 8.8 earthquake that struck Chile in 2010, the Chilean government re-interviewed a subsample of respondents to a national socioeconomic survey for a longitudinal study of posttraumatic stress symptoms, which had just been completed before the earthquake.[60] This enabled a clear distinction of pre- and post-exposure conditions. The study also employed new statistical methods to match the exposed and unexposed individuals on forty-six covariates to further strengthen internal validity. As a result, this study was able to produce strong evidence of elevated posttraumatic stress symptoms associated with earthquake exposure.

Longitudinal studies collect data more than once over a long period of time. This methodology is used less frequently than cross-sectional designs because it typically requires more resources and a longer-term commitment to the study. It has the advantage, however, of allowing researchers to examine trends and changes over time. It can also provide stronger evidence for causality because temporal ambiguity is reduced or eliminated. In disaster research, longitudinal designs are often used for documenting a community's course of recovery from a disaster, or for observing changes between periods interrupted by a disaster (i.e., pre- and post-disaster).

Examples of longitudinal designs include repeated cross-sectional studies (in which new samples of the population are studied each time) and cohort studies, also referred to as panel studies or repeated-measures studies (in which data are collected at multiple times from the same group of subjects). Repeated cross-sectional designs are especially useful when pre-disaster data are available for a population that was later affected by an incident. To illustrate, a study was conducted to estimate the impact of Hurricane Katrina on mental illness by comparing results of a post-hurricane survey with those of an earlier survey.[61] The populations from which the probability samples were drawn were comparable (although the post-hurricane population frame was limited to survivors) and the measures used to assess outcomes were identical. Results showed that the estimated prevalence of mental illness doubled after the hurricane.

Although repeated cross-sectional studies have the advantage of studying samples that are representative of the population at each time of data collection, cohort studies allow for the examination of change over time within a group. Cohort studies, however,

often suffer from loss of follow-up (i.e., respondents intentionally or unintentionally stop participating in the study). For instance, respondents to a survey conducted after the 1994 Northridge, California earthquake were re-interviewed 4 years later to determine if their prior experience affected their response to another anticipated disaster, a slow-onset El Niño weather pattern.[62] Of the 1,849 households originally interviewed after the 1994 earthquake, 1,353 (73%) agreed to a follow-up interview, but less than half of them could be contacted at the time of the follow-up study. Ultimately, 414 were interviewed, yielding a 22.4% response rate of those interviewed at baseline. Loss of follow-up is expected to be high in areas where the population is very mobile, such as in large urban areas.

A further aspect of study designs is the timing of data collection in relation to the outcome of interest associated with the index disaster. In a concurrent design, both exposure and outcome data might be collected at the time the event occurs, or shortly afterward. In a prospective study, which is only possible using a longitudinal design, exposure data are collected from the target population before the event (in this case, the disaster) has occurred, and outcome data are collected subsequently. In these instances, the study may be initiated for other purposes but can be adapted to the disaster researchers' needs. Lastly, in a retrospective design, data are collected on events or conditions that occurred in the past by using archival or recalled information. An example here is a study based on a review of hospital records after a disaster. Case-control studies are retrospective by design because prior exposure data are collected after cases are identified. Although most observational studies can use any one of these designs, or a combination of them, experiments by definition can only be concurrent or prospective because it is impossible to go back in time to manipulate study variables.

Some study designs have been underutilized in disaster research. Case studies using laboratory simulations were used in early disaster research, but have not been used in recent times, perhaps because of the difficulty of simulating the complexities of a disaster.[63] Moreover, the external validity, or generalizability, of results from laboratory simulation studies might be compromised due to the highly artificial and decontextualized nature of a laboratory setting. It has been noted, however, that disaster simulation exercises in the field, which are routinely conducted to train emergency management personnel, are underutilized opportunities for disaster research.[7] A recent study has also noted that disaster exercises are an opportunity to test and evaluate research protocols.[64]

Retrospective designs are relatively underutilized compared to concurrent or prospective designs because they are not as suitable for research during the immediate post-disaster period, where researchers frequently focus. These include retrospective case studies (which involve the historical analysis and reconstruction of events that occurred in the past), historical cohort studies (which involve the analysis of data on cohorts that were followed up in the past), and case-control studies.[10] Case-control studies are appropriate for studying rare outcomes and thus would be suitable for studying disaster-associated phenomena.

Disaster Research Data Collection

As with most other types of investigations, disaster research utilizes both qualitative and quantitative data. Qualitative data are often collected through field observations, in-depth interviews, focus group discussions, and archival research. They offer very detailed information about a specific individual or group, place, time, and/or phenomenon that is of interest to the researcher. Qualitative data collection methods are frequently used in exploratory or descriptive studies in which the objective is to investigate an issue or describe a phenomenon about which there is little existing information. A historical example of qualitative disaster research is Form and Nosow's 1958 study of community responses to a tornado in Michigan.[65] A more recent study examined the dynamics of existing and emerging social networks among Latino survivors of Hurricane Katrina, which struck the Gulf Coast of the United States in 2005.[66] Data gathered from individual, in-depth interviews brought to light: 1) the role of social networks in gathering information, making decisions, and accessing resources; 2) broader structural constraints, including poverty, a lack of transportation, and marginalized status as immigrants; and 3) the emergence of new, if temporary, social networks based primarily on shared nationality, language, and a sense of collective commitment. These and other examples of well-performed qualitative disaster research demonstrate that despite a common misperception that qualitative studies are less scientifically rigorous than quantitative studies, they are indeed important and have been published in prominent journals.

Quantitative data complement qualitative data by expanding the breadth of knowledge about a particular issue. The most popular and efficient method for collecting quantitative data is the use of surveys based on representative sampling. Surveys can be of individuals, households, institutions, or communities, and data in surveys can be collected with questionnaires and record reviews. Surveys of individuals are typically conducted using questionnaires that are self-administered by the respondent or administered by interviewers over the telephone or in person. For surveys of households, organizations, or communities, a representative of the group can be designated to participate in the survey instead of all members of the group.

Survey topics that are common in social science research include: pre-disaster knowledge, attitudes, and behaviors; immediate emotional and behavioral responses to an event; and the course of post-disaster recovery. Commonly perceived limitations of survey use in disaster research include victims' reluctance to discuss their experiences with investigators and the inconsistent reliability of self-reports, although these concerns have been refuted by several researchers.[44,67,68] Another obstacle to using surveys for disaster research is the recent general decline in participation rates for household surveys.[69]

Surveys of individuals, healthcare providers, and healthcare organizations are heavily utilized in disaster epidemiology to obtain quantitative data about the health status of a population and possible associations between disaster exposure and health outcomes. These data are critical for assessing the immediate and ongoing healthcare needs in a population during and following a disaster. In addition to directly surveying members of the population, epidemiological disaster surveys often collect aggregated data from healthcare providers, emergency response agencies, coroners, and other relevant sources, either prospectively or retrospectively. Public health officials might survey emergency shelters on a weekly basis by reviewing medical records to enumerate shelter residents diagnosed with acute respiratory and gastrointestinal illnesses to detect possible outbreaks of infectious disease.

Standardization of the data collection method is especially important with quantitative data in order to allow comparisons across different events, populations, settings, and times.

In this respect, post-disaster rapid health surveys frequently suffer from inconsistencies in sampling methods, data reporting periods, criteria for establishing whether health outcomes are disaster-related, and completeness of data collection for identifying disaster-related injuries and medical conditions. Lack of standardized definitions and survey instruments is one of the major challenges to quantitative data collection in disaster research.

While qualitative and quantitative methodologies complement each other, use of both together in a single investigation (referred to as mixed methods) has yet to become an established approach in disaster research. Mixed methods is broadly defined as research in which the investigator collects and analyzes data, integrates the findings, and draws inferences by using both qualitative and quantitative approaches in a single study or program of inquiry.[70]

The Multihazard Mitigation Council of the National Institute of Building Sciences in the United States conducted a mixed method research study to determine the future savings gained from investments by FEMA in hazard mitigation activities.[71] FEMA funded hazard mitigation projects to reduce loses from earthquakes, high winds, and floods. Future savings from these endeavors were measured in two interrelated studies by using different methods to address the common question: What is the ratio of hazard mitigation benefit versus cost? The first study component used benefit/cost ratio analyses and a statistically representative sample of FEMA mitigation grants so that findings in the sample could be applied to the entire population of these FEMA grants. In the second study component, eight communities were selected using purposive sampling to examine if, why, and how mitigation activities percolate through communities. Field studies were conducted in each community by using semi-structured telephone interviews with informants, field visits, and the review of documents. Findings suggest that natural hazard mitigation activities funded by the three FEMA grant programs between 1993 and 2003 were cost effective and reduced future losses from earthquakes, wind, and floods; yielded significant net benefits to society as a whole; and represented significant potential savings to the federal treasury. Specifically, the quantitative benefit/cost analysis found that on average, every dollar spent on natural hazard mitigation saves society approximately $4. The community studies suggest that the 1:4 cost/benefit ratio may be an underestimate because federally funded hazard mitigation often leads to an increase in non-federally funded mitigation programs.

Information Technology Applications in Disaster Research

The application of information technology (IT) in both disaster management and disaster research has remarkably advanced in recent years. The use of Geographic Information Systems (GIS) technology is a prime example. Dash, Thomas, and colleagues have written on the use of GIS technology in disaster management and research.[72,73] There have also been discussions on the utility of GIS-based spatial analysis in health research and epidemiology.[74,75] The main strength of GIS technology is its ability to integrate geographical data with other information, such as demographic data, extent of physical damage caused by a hazard, morbidity and mortality rates, and access to resources. It also has the capability to analyze data as well as to generate maps and other visual summaries of the data.

FEMA has developed a software program, HAZUS-MH, which uses GIS technology to map and display hazard data and also to produce estimates of potential losses (i.e., physical damage, economic loss, and social impact) from earthquakes, floods, and hurricane winds. GIS-based risk assessment tools such as these are extremely useful to disaster management officials and policymakers who are responsible for developing and implementing disaster mitigation, preparedness, and response strategies for geographically defined areas.

The most common application of GIS technology in disaster epidemiological research is to facilitate post-disaster rapid assessment surveys, which frequently use cluster–random sampling. The cluster–random sampling design, which was originally developed to estimate immunization coverage in a population, allows investigators to obtain expedient and accurate population-based information at relatively low cost.[76] GIS is used to aid the random selection of households, field navigation, data management and analysis, and presentation of results. For example, less than 3 weeks after Hurricane Katrina struck Hancock County, Mississippi, the CDC was asked to conduct a rapid assessment of public health needs. Using GIS, they cluster–random sampled 200 households. Using global positioning system technology to navigate to those locations, they physically surveyed 197 households and completed interviews with 77 of them in 2 days.[77] The results of the assessment, which indicated a need for water, trash/debris removal, and access to health services, were provided to the state health department and emergency management to guide relief and recovery operations.

There are other applications of GIS in disaster epidemiology that involve more extensive data collection and spatial referencing. Peek-Asa and others used GIS to link separate data elements derived from studying the 1994 Northridge, California earthquake. These included geophysical characteristics (i.e., shaking intensity, strong ground motion, and soil type), individual characteristics of people who were injured in the earthquake (i.e., physical address and demographics), and building data (i.e., damage state, year of construction, structure type), each obtained from a different source.[78] Their analyses indicated that a person's age and sex, intensity of ground motion, and multiunit building structures independently predict heightened risk for injuries in an earthquake.

GIS has the potential to facilitate data collection, analysis, and presentation for describing or predicting the geographical distribution of various disaster-relevant variables. The usefulness of GIS to disaster research, and especially disaster health research, depends on the quality and availability of spatial data. Health data generally lack spatial attributes (i.e., geocodes) unless they were collected specifically for use in GIS. In addition, there is a legitimate concern about preserving individual confidentiality within spatial information. Researchers have shown, for instance, that a map of Hurricane Katrina-related mortality locations in Orleans and St. Bernard Parishes published in a local newspaper could be reengineered to reveal the actual addresses associated with the points, even though the original map included very little secondary spatial data.[79]

Examples of relatively novel applications of IT include tracking population movements with mobile phone network data; real-time monitoring of calls made to a disaster communication hub (e.g., 211 calls for community information and referral services in the United States and Canada); crowd-sourced online mapping services; geo-targeted imminent threat alerts and warnings delivered to cell phones and other mobile devices; and use of

social media for tracking events and distributing alert and warning messages.[80–85] While not without limitations, these applications may pave the way for further innovations in the use of IT to improve the efficiency of rapid assessments and the coverage of disaster relief services, as well as facilitate research-related activities.

Ethics in Disaster Research

As with any study, ethical considerations are integral to disaster research. The central concern is whether the investigational activity could, directly or indirectly, harm the research participants and the wider community. For example, field observations and interviews of evacuees and emergency responders during or immediately after the disaster might impede the progress of relief operations. Likewise, interviewing disaster victims about their experiences has the potential to cause emotional stress and pain, compounding that already caused by the event. Such an investigation might not be justified by the expected benefits of the study. Other ethical considerations include the ability of researchers to maintain a neutral stance. This situation might emerge when grave human suffering seemingly is attributable to social injustice and an incompetent response by the organizations responsible for protecting people's welfare. Despite a sense of urgency to deploy post-impact, disaster researchers must consider these and other ethical issues in designing their study and before having contact with research subjects. Readers are referred to Chapter 7 of this book, as well as to writings by Stallings, Fleischman et al., and Collogan et al. for further discussion about the ethical issues involved in disaster research.[4,86,87]

Disaster Vulnerability

There is a general consensus within the disaster community that vulnerability interacts with the physical hazard agent to produce disaster risk.[88–90] Vulnerability is conceptualized as, "the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist, and recover from the impact of natural hazards."[90] Thus, greater vulnerability of an individual or group is associated with increased risk from a given level of disaster exposure. In many instances, estimations of who might be most vulnerable to a disaster can be formulated before an event occurs, although disasters often function to bring attention to underserved segments of the population.

Health professionals may be most familiar with conceptualizing vulnerable populations as those that are physiologically susceptible because of age and/or physical and mental health conditions. Examples include children, the elderly, pregnant women, and people with disabilities. Physiological vulnerability can indeed affect people's ability to withstand external shock (such as the physical force of an earthquake, tornado, or hurricane) and survive trauma injuries. Also at risk is their capacity to cope with short- or long-term disruptions of access to basic resources, including food, shelter, and healthcare. It is widely recognized, however, that disaster vulnerability is multidimensional; there are many other factors that contribute to people's capacity to anticipate, cope, and recover from the impact of hazards.

The most commonly mentioned dimensions of vulnerability in disaster research are physical, economic, political, social, and psychological.[91–94] The social epidemiologic theory of fundamental cause is relevant to several of these dimensions, although the theory does not address disasters directly.[95] The central notion is that one's socioeconomic position shapes exposure to health risk factors and the individual's capacity to respond to those risk factors. The measured components of socioeconomic position are occupational prestige, educational attainment, and income, while the construct itself is thought to encompass political power and other forms of social stratification. The inverse relationship of social class with mortality and almost every measure of morbidity is consistent and strong. In fact, other predictors of health outcomes are often considered provisional until it can be shown that relationships exist independently of socioeconomic position, viewed as the fundamental cause.

Physical vulnerability refers to an individual's proximity and/or inadequate physical and structural resistance to a hazard.[94,96,97] Physical vulnerability is important for high physical force disasters, such as earthquakes and tornadoes, in which the potential for damage to physical structures is increased.

Economic vulnerability can be conceptualized at the macro level, in terms of international and national economic practices and conditions. However, it is more often conceptualized at the micro, or household level, in terms of employment conditions (e.g., income opportunities and job characteristics).[98] The nature of economic vulnerability is different for disasters with a rapid onset and short duration, such as earthquakes, than for those of a slow onset and/or long duration, such as droughts. In rapid-onset disasters, economic vulnerability is defined by the ability to withstand short-term social and economic disruption and the ability to finance reconstruction and repairs of structural damages. In contrast, economic vulnerability to slow-onset/chronic disasters depends on the flexibility of the economy to adjust to prolonged disaster situations (e.g., importing food stock, creating jobs for farmers), the availability of assets at the household level, and the diversity of income-producing opportunities.[99] Extended exposure to adverse conditions, including food scarcity, mass population movement, and psychological stress, can lower immunity levels and increase risk for infectious diseases, as well as exacerbate any preexisting health conditions. Although the risk for communicable diseases is actually quite low for any major disaster, these concerns are relevant in chronic disaster situations, like droughts and famines.[100]

Political vulnerability encompasses having little or no political power, representation, or autonomy.[91,93,101,102] Political values and priorities determine which hazards will be addressed, the degree of emphasis and support placed on hazard mitigation, and the willingness to meet the needs of divergent groups in the aftermath of a disaster. Political vulnerability, like psychological vulnerability described later, is relevant to any type of disaster. Political power affects the likelihood that an individual or a community will receive government support to ensure a safe environment or have the resources and resilience to take self-protective measures. Those who are marginalized in society tend to live in the least safe areas and have the greatest exposure to hazardous conditions. Political vulnerability is particularly relevant for disasters in conflict situations, where political or military motivations by warring parties determine who receives the most aid and protection.[103] The philosophy that increasing political influence is the key to reducing overall vulnerability, including vulnerability to disasters, underlies individual and community empowerment efforts.[102]

Social vulnerability includes the formal institutional structures that marginalize certain groups and individuals based on their socioeconomic characteristics, such as gender, race, or

ethnicity.[94,97,104,105] Informal social relations with friends, family, and others are included here as well.[91] A community is socially vulnerable when people feel victimized, fatalistic, or dependent, often resulting in apathy and a low sense of personal responsibility.[92,93,101] This global sense of alienation can become immersed in a broader cultural system of beliefs and customs and may manifest itself in disaster-relevant behaviors, such as low levels of motivation and/or knowledge about implementing preparedness measures.

In an effort to quantify social vulnerability, the Social Vulnerability Index was developed, using factor analytic techniques to reduce thirty community-level variables (e.g., percent below poverty threshold) to a few factors that group similar data items together.[106] The index provides a score for each county in the United States and is envisioned as a tool for policymakers and practitioners. Consistent with predictions from fundamental cause theory, the variables of race (Black), class, poverty, and wealth contribute heavily to scores on the Social Vulnerability Index. The concept is a promising one and research on indices that attempt to quantify social vulnerability should be expanded.

Psychological vulnerability is studied at the level of the individual in terms of the psychological characteristics that influence coping skills with disaster stress and the likelihood of experiencing an emotional injury or distress.[107] In the extant literature, previous mental health problems are the most robust and consistent predictors of post-disaster distress.[108] Contrary to popular belief, psychological effects of non-terrorist disasters tend to be mild and transitory in the general population, rarely resulting in psychopathology.[109–111] Severe levels of psychological impairment are more likely to occur in disasters involving mass violence compared with other types of disasters.[112] Thus, psychological vulnerability is a more prominent factor in exposure to intentional disasters, with high exposure and loss of significant others as risk factors, in addition to previous mental health problems.[113]

The dimensions of vulnerability concept is a convenient schematic but it should be recognized that these dimensions mutually interact, and the distinctions among them are often blurred. For example, the 2010 earthquake in Haiti, which killed more than 220,000 people and injured another 300,000, occurred in a country where 80% of the population lived in poverty (economic and social vulnerability).[104] Lack of a clean water supply (physical vulnerability), both before and after the quake, contributed to a cholera epidemic that broke out later in 2010. Deforestation (physical vulnerability) and long-term political instability (political vulnerability) enhanced the impact of the quake and the government's ability to respond. In a country with a low priority on mental health, the earthquake magnified the inadequacy of mental health services (psychological vulnerability). Recovery continues to be slow, with some of the aid intended for rebuilding diverted to other projects (political vulnerability). The sharp reduction in foreign aid and focused attention may foster feelings of abandonment, futility, and hopelessness (psychological vulnerability). Focusing on the interplay among the dimensions of vulnerability is compatible with an ecological approach that emphasizes the mutuality of nature and human activity.[114–117] According to this approach, disasters occur when the social and cultural systems of a population fail to provide adequate adaptation to the environmental conditions that surround it or when these systems themselves produce a threat to the population.[116]

Disaster Morbidity and Mortality

The discussion of disaster morbidity and mortality describes how these estimates are derived, as well as the many factors that can influence their accuracy and introduce variability across studies.

Patterns of Morbidity and Mortality by Disaster Type

The health impact of a disaster varies by: 1) the physical characteristics of the hazard that triggers an abnormal event; 2) the physical, social, and political environment in which the hazard event occurs; and 3) the characteristics of the population that is affected. For instance, the number of people who die or suffer from physical or mental health problems as a result of an earthquake depends on multiple factors. These include: 1) the intensity of the ground shaking, the duration of shaking, the soil type, and the intensity and frequency of aftershocks (hazard characteristics); 2) the population density and proximity of human settlements to the areas where the greatest shaking occurs; 3) common types of building construction; 4) the emergency response and health-care infrastructure in place (physical environment); 5) cultural norms regarding earthquake awareness and preparedness, common human activity at the time of the earthquake occurrence, and political will and capacity to mitigate against and respond to earthquake disasters (social and political environment); and 6) the age, preexisting health conditions, and socioeconomic status of the population (population characteristics).

This is why earthquakes of a similar magnitude, as measured on the Richter scale, result in vastly different outcomes in regard to human casualties. To illustrate, official reports indicate that the 2001 Seattle/Nisqually, Washington earthquake (M6.8) resulted in one death and 407 injuries; the 1994 Northridge, California earthquake (M6.7) 57 deaths and 1,500 injuries (Note: A thorough county-wide screening of hospital admission records and a review of relevant medical records and coroner's reports in Los Angeles County verified 33 fatalities and 138 hospital admissions); the 1988 Armenian earthquake (M6.8) 25,000 deaths and 130,000 injuries; and the 2003 southeastern Iran earthquake (M6.6) 26,200 deaths and 30,000 injuries.[40,118]

Differences in reports of morbidity and mortality also reflect variability in the methods used to estimate the health impact. These methods are reflective of the infrastructure for systematic data collection that exists before the event, and the extent to which damage and disruption caused by the event interfere with post-disaster data collection. Thus, it is important to recognize this multifactorial nature of both the actual and reported morbidity and mortality in disasters. When possible, researchers should attempt to put the numbers into context by accounting for the various factors that could have influenced estimates of morbidity and mortality.

Hazard type is a common classification scheme for disaster-associated morbidity and mortality.[28,119] The CDC, through their publication *MMWR*, is the main source for disaster-attributable morbidity and mortality data in the United States. The amount of knowledge or research that is available about the health effects of a particular hazard depends on several factors. These include: 1) how frequently events involving that hazard occur; 2) whether there is a clear beginning and end point to the hazard event, thus making causal attributions less ambiguous; 3) whether the hazard tends to cause multiple human casualties; and 4) whether there have been especially devastating or dramatic events that surround the disaster.

As an example, there is an accumulation of literature and knowledge about the health impact of hurricanes (and floods associated with them) and tornadoes, especially in the United States. Both types of events are seasonal hazards that occur annually. Earthquakes also have been well studied internationally, even though they are irregular events, because there is little ambiguity about when an earthquake begins and ends, and because large earthquakes have caused numerous deaths. In comparison, relatively little research has been devoted to the health impact of volcanoes, wildfires, tsunamis, and droughts, due to one or more of the reasons noted. These limiting characteristics include infrequent event occurrence, ambiguous event thresholds, and low human impact. Concomitant with recent interest in the effects of global warming, there has been a recent rise in the number of heat-related health consequence studies, with a greater willingness to conceptualize extreme temperatures as a disaster.[120] The occurrence of a catastrophic event can re-energize or completely change the research activity in these areas. The Indian Ocean tsunami in December 2004 and the 2011 Tōhoku Earthquake and Tsunami in March 2011 have spawned an unprecedented amount of research on the physical and psychological morbidity and mortality associated with tsunamis.

Among the hazards that are not "environmental," unintentional releases of hazardous materials caused by industrial accidents have been studied the most. In regard to intentional events, the effects of terrorism, usually involving explosive devices, have also been well documented. This is especially true for the 1995 Oklahoma City and 2001 New York City bombings. In contrast, there have been very few studies on the intentional use of biological, radiological, or chemical agents. Nonetheless, the medical or physical health consequences of direct exposure to these hazards are perhaps better known than those resulting from exposure to other hazards, partly because exposure can be defined more clearly.

The psychological morbidity resulting from disasters is less differentiated by the type of hazard and more affected by whether a disaster was due to unintentional or intentional causes. The latter type causes greater psychological distress to victims who are aware it is intentional. Posttraumatic stress disorder is by far the most common malady studied, followed by depression, anxiety, and panic disorders.[121,122] Most studies reveal a significant drop in symptoms over time.[122,123]

Consistency of Estimation Methods

Lack of consensus on what constitutes a disaster, exposure to disaster, and a disaster-related death, injury, or disease complicates disaster research. One focus of disaster research is classifying types of disasters by types of health outcomes. Although a number of schemes for classifying health outcomes do exist, there is no standard method for classifying exposure to a disaster. Despite efforts to develop standardized procedures, disaster researchers continue to develop and use their own definitions and classification protocols, often with little regard for prior research. The sprawling disciplinary landscape of disaster research contributes to this tendency.

The definition of what constitutes a death or injury caused by a disaster varies not only within, but also across disaster types. The CDC has attempted to develop a protocol for classifying outcomes attributable to disasters based on the time the death or injury occurs relative to the event, and also based on whether the event is directly or indirectly related to the disaster. According to the authors, "disaster-attributed deaths [are] those caused by either the direct or indirect exposure to the disaster. Directly related deaths are those caused by the physical forces of the disaster. Indirectly related deaths are those caused by unsafe or unhealthy conditions that occur because of the anticipation, or actual occurrence, of the disaster."[124] Although strong in theory, the schema is difficult to apply in practice, especially when estimating indirect effects.

Estimates of morbidity are harder to ascertain than those of mortality. In many cases, assessments of U.S. disaster-related morbidity are based on the best guesses of a public health employee who contacted the Red Cross and local hospitals for their number estimates of the injured and ill individuals served in emergency departments. It has been established that most of the injured and sick do not utilize emergency departments, and persons staffing emergency departments are not necessarily aware of, or knowledgeable about, which injuries are attributable to a given disaster.[40] Thus, morbidity estimates often include a fairly substantial margin of error, including both under- and over-reporting. Careful review of emergency department logs and admission records is essential and will improve estimates but cannot eliminate ambiguity in every case.[28,108]

RECOMMENDATIONS FOR FURTHER RESEARCH

The key message that underlies this chapter is captured well in the following quote from Lurie et al.: "The knowledge that is generated through well-designed, effectively executed research . . . is critical to our future capacity to better achieve the overarching goals of preparedness and response: preventing injury, illness, disability, and death and supporting recovery."[125] Research is essential in generating the evidence base for policy development and decision-making to help ensure that fewer people and societies suffer from the devastating impact of disasters in the future. This final section offers some recommendations on the way forward for research on disasters.

In the first edition of this book, we had recommended the following: 1) facilitating closer collaborations between disciplines as well as between researchers and practitioners; 2) enhancing capacity in disaster research; 3) strengthening the validity of research findings through the use of population-based and longitudinal designs; 4) improving consistency of methods and measurements, with specific reference to the guidelines recommended by an international task force for the reporting of disaster medical research; and 5) improving access to disaster research strategies and findings.[126] These recommendations are still relevant today.

However, despite the fact that interdisciplinary and multisector collaborations have become common approaches in most research fields, it remains quite limited in practice when it comes to disaster research. Given how disasters are become increasingly complex within such contexts as climate change, urbanization, and population dynamics (e.g., ageing, racial/ethnic diversity, migration), multidisciplinary approaches to research are needed to understand the various factors and interactions that determine the causes and sequelae of disasters. Urban settings would be especially ideal for such research because these factors tend to converge in heavily populated areas. In addition, researchers, practitioners, and institutions from multiple disciplines and sectors can be found in urban centers. Research on urban disasters is also important because local city governments are frequently responsible for the first level of official preparedness, mitigation,

and response to a disaster. In view of the fact that over half of the world's population lives in urban areas (a proportion which continues to grow) and that the most populous cities in the world are at risk of major disasters, we should expect more urban disaster research in the future.[127]

Access to reliable health and medical data remains a significant challenge. One approach to improving data collection is to classify injuries and illnesses that arise from officially declared disasters as reportable diseases. Identifying these outcomes as reportable will facilitate efforts by public health personnel to obtain critical information on disaster victims. The public health community has a long history of obtaining such information effectively while protecting the confidentiality of those exposed to the disaster. This approach will facilitate research across disciplines and make analyses more efficient, in that each group of researchers will not be repeating the process of independently collecting data. In addition, the recommended change will improve rapid access to data that may be lost over time or difficult to obtain, secondary to various governmental regulations.

With regard to enhancing training and capacity building in disaster research, increased efforts should be directed toward the developing regions of the world. Statistics show that 90% of all deaths caused by disasters over the past two decades have occurred in developing countries.[127] Even though the majority of the world's disaster-related human suffering occurs in these countries, much of the disaster research continues to be conducted in more developed regions. Disasters that affect developing countries are not limited to just rare, sudden-onset, catastrophic events. They also include recurrent, slow-onset events, such as floods and droughts. Improving the understanding of disasters in developing countries is in everyone's best interest in this increasingly interdependent, globalized world. Building capacity for research in these areas of the world can be realized through traditional cooperation between more resourced and less resourced countries, as well as through interactions between less developed countries which share common challenges and perspectives. Such initiatives have been shown to be successful in other fields of research, like mental health.[128] Funding initiatives are also important. In June 2013, a new collaboration between the UK government's Department of International Development and the Wellcome Trust was established to support world class research examining public health interventions during humanitarian disasters. The first *Call for Proposals for Research for Health in Humanitarian Crises Programme* was launched with a series of town hall meetings held in Delhi, Nairobi, London, and New York. Participants included those interested in applying for funding or seeking to build research partnerships. It is anticipated that initiatives like this can provide the impetus and funding necessary for building disaster research capacity in areas with limited resources.

The sustained frequency of disaster events should be utilized appropriately to improve the quality of disaster research. It is an unfortunate fact that disasters have continued to occur with such regularity around the globe. The year 2011 was one of the worst disaster years in history, with more than 300 disasters recorded, nearly 30,000 people killed, and over 350 billion U.S. dollars in losses.[127] Some of the same places are struck repeatedly, such as China by earthquakes, the Philippines by floods, and the United States by hurricanes and tornadoes. However, the frequency and predictability of these events should allow researchers to plan and conduct well-designed studies that could potentially yield strong evidence of causality with a high degree of generalizability. Furthermore, it is important to generate greater knowledge about effective interventions that limit secondary effects over the course of recovery from a disaster.[26] While social science research has extensively studied pre-disaster preparedness and evacuation behavior, and health research has focused on immediate health consequences of disasters, societies could benefit from more multidisciplinary research analyzing longer-term impacts. Such topics include the indirect, medium- to long-term effects on individuals and communities, and how these impacts can be effectively addressed through interventions. Population-based, longitudinal designs would be ideal for capturing such effects.

We have previously advocated for improved consistency across studies and better access to completed research. The importance and relevance of these two recommendations has not changed. Some activities, if implemented and funded, have the potential to increase mechanisms that integrate disaster research at both the national and global level. For example, in 2011, an advisory committee to the U.S. Department of Health and Human Services (HHS) issued an endorsement to include scientific investigations as an integral component of disaster planning and response. It further recommended that the HHS develop infrastructure for strengthening the research response to emergencies.[125] At the same time, however, the CDC's funding and support for academic centers on public health preparedness and research has been inconsistent and, in fact, declining. How these contrasting approaches by the U.S. government to support health sciences research on disasters will evolve is open to speculation.

Finally, researchers are encouraged to explore new domains, such as the role of emerging technological and social innovations in the context of disasters. This may include research on entirely new topics, such as the efficacy of wireless emergency alerts, or on "old" topics with a new twist, such as disaster volunteerism through the use of social networking. It is through a continuous process of both learning from the past and staying abreast of new developments that the field of disaster research can further mature and generate critical knowledge toward building sound public policy and more resilient societies.

REFERENCES

1. Noji E. Public health consequences of disasters. *Prehosp Disaster Med* 2000; 15: 147–157.
2. Cisin IH, Clark WB. The methodological challenge of disaster research. In: Baker G, Chapman D, eds. *Man and Society in Disaster.* New York, Basic Books, 1962; 23–54.
3. Gordis L. *Epidemiology.* 3rd ed. Philadelphia, Elsevier Saunders, 2004.
4. Stallings RA. Methodological issues. In: Rodríguez H, Quarantelli EL, Dynes RR, eds. *Handbook of Disaster Research.* New York, Springer, 2006; 55–82.
5. Killian LM. An introduction to methodological problems of field studies in disasters. In: Stallings RA, ed. *Methods of Disaster Research.* International Research Committee on Disasters, Xlibris Corp., 2002; 49–93.
6. Quarantelli EL. The Disaster Research Center (DRC) field studies of organized behavior in the crisis time period of disasters. In: Stallings RA, ed. *Methods of Disaster Research.* International Research Committee on Disasters, Xlibris Corp., 2002; 94–126.

7. Drabek TE. Following some dreams: Recognizing opportunities, posing interesting questions, and implementing alternative methods. In: Stallings RA, ed. *Methods of Disaster Research.* International Research Committee on Disasters, Xlibris Corp., 2002; 127–153.
8. Guetzkow H. Joining field and laboratory work in disaster research. In: Baker GW, Chapman DW, eds. *Man and Society in Disaster.* New York, Basic Books, 1962; 337–355.
9. Prince SH. *Catastrophe and Social Change: based upon a Sociological Study of the Halifax Disaster.* ADD 1920. Proquest Dissertations and Theses, 1920.
10. Scanlon TJ. Rewriting a living legend: Researching the 1917 Halifax explosion. In: Stallings RA, ed. *Methods of Disaster Research.* International Research Committee on Disasters, Xlibris Corp., 2002; 266–301.
11. Fritz CE. Disasters and mental health: therapeutic principles drawn from disaster studies. 1996. http://dspace.udel.edu:8080/dspace/handle/19716/1325 (Accessed June 20, 2013).
12. Ikle F. The effects of war destruction upon the ecology of cities. *Soc Forces* 1951; 29: 283–291.
13. United States Strategic Bombing Survey. *Reports.* Washington, DC, Government Printing Office, 1947.
14. Marks ES, Fritz CE. *Human Reactions in Disaster Situations.* Vols. 1–3. Unpublished report, Chicago, IL, National Opinion Research Center, University of Chicago, 1954.
15. Morris CW, ed. *Mind Self and Society from the Standpoint of a Social Behaviorist.* Chicago, University of Chicago Press, 1932.
16. Cooley CH. *Social Organization.* New York, Charles Scribner's Sons, 1909.
17. Perry RW. What is a disaster? In: Rodríguez H, Quarantelli EL, Dynes RR, eds. *Handbook of Disaster Research.* New York, Springer, 2006; 1–15.
18. Turner RH, Killian LM. *Collective Behavior.* 1st ed. Englewood Cliffs, NJ, Prentice-Hall, 1957.
19. Perry RW. Evacuation decision-making in natural disasters. *Mass Emergencies* 1979; 4: 25–38.
20. Connell R. *Collective Behavior in the September 11, 2001 Evacuation of the World Trade Center.* Preliminary Paper #313. Newark, University of Delaware Disaster Research Center, 2007.
21. Taylor VA. *The Delivery of Mental Health Services in the Xenia Tornado: a Collective Behavior Analysis of an Emergent System Response.* DAI-A 37/02, Proquest Dissertations and Theses, 1976.
22. Quarantelli EL, Dynes RR. Editors' introduction. *Am Behavior Sci* 1973; 16: 305–311.
23. Sommer A, Mosley WH. East Bengal cyclone of November, 1970: epidemiological approach to disaster assessment. *Epidemiol Rev* 2005; 27: 13–20.
24. Logue JN, Melick ME, Hansen H. Research issues and directions in the epidemiology of health effects of disasters. *Epidemiol Rev* 1981; 3: 140–162.
25. LeChat MF. The epidemiology of health effects of disasters. *Epidemiol Rev* 1990; 12: 192–198.
26. Dominici J, Levy JI, Louis TA. Methodological challenges and contributions in disaster epidemiology. *Epidemiol Rev* 2005; 27: 9–12.
27. Noji EK. Disasters: introduction and state of the art. *Epidemiol Rev* 2005; 27: 3–8.
28. Bourque LB, Siegel JM, Kano M, et al. Morbidity and mortality associated with disasters. In: Rodríguez H, Quarantelli E, Dynes R, eds. *Handbook of Disaster Research.* New York, Springer, 2006; 97–112.
29. Castillo-Salgado C. Trends and directions of global public health surveillance. *Epidemiol Rev* 2010; 32: 93–109.
30. Connorton E, Perry JJ, Hemenway D, et al. Humanitarian relief workers and trauma-related mental illness. *Epidemiol Rev* 2012; 34: 145–155.
31. Srikameswaran A. Dr. Peter Safar Renowned Pitt physician called 'father of CPR.' Obituary. *Pittsburgh Post-Gazette.* August 5, 2003.
32. Ammar A. Role of leadership in disaster management and crowd control. *Prehosp Disaster Med* 2007; 22: 527–528.
33. Smith E, Wasiak J, Sen A, et al. Three decades of disasters: A review of disaster-specific literature from 1977–2009. *Prehosp Disaster Med* 2009; 24: 306–311.
34. Tierney K. From the margins to the mainstream? Disaster research at the crossroads. *Annu Rev Sociol* 2007; 33: 503–525.
35. Brunsma D, Picou JS. Disasters in the twenty-first century: modern destruction and future instruction. *Soc Forces* 2008; 87: 983–991.
36. Norris F, Galea S, Friedman MJ, Watson PJ. *Methods for Disaster Mental Health Research.* New York, Guilford Publications, 2006.
37. Rodríguez H, Quarantelli E, Dynes R, eds. *Handbook of Disaster Research.* New York, Springer, 2006.
38. Stallings RA, ed. *Methods of Disaster Research.* International Research Committee on Disasters, Xlibris Corp., 2002.
39. Kelsey JL, Whittemore AS, Evans AS, Thompson WD. *Methods in Observational Epidemiology.* 2nd ed. New York, Oxford University Press, 1996.
40. Peek-Asa C, Kraus JF, Bourque LB, Vimalachandra D, Yu J, Abrams J. Fatal and hospitalized injuries resulting from the 1994 Northridge earthquake. *Intl J Epidemiol* 1998; 27: 459–465.
41. Carlsen HK, Hauksdottir A, Valdimarsdottir UA, et al. Health effects following the Eyjafjallajökull volcanic eruption: a cohort study. *BMJ Open* 2012; 2: e001851.
42. Tierney KJ, Lindell MK, Perry RW. *Facing the Unexpected: Disaster Preparedness and Response in the United States.* Washington, DC, Joseph Henry Press, 2001.
43. National Research Council. *Facing Hazards and Disasters: Understanding Human Dimensions.* Washington, DC, The National Academies Press, 2006.
44. Bourque LB, Shoaf KI, Nguyen LH. Survey research. In: Stallings RA, ed. *Methods of Disaster Research.* International Research Committee on Disasters, Xlibris Corp., 2002; 157–193.
45. Last JM. *A Dictionary of Epidemiology.* 4th ed. Oxford, Oxford University Press, 2001.
46. Wood MM, Mileti DS, Kano M, Kelley MM, Regan R, Bourque LB. Communicating actionable risk for terrorism and other hazards. *Risk Anal* 2012; 32: 601–615.
47. Kano M, Wood MM, Bourque LB, Mileti DS. Terrorism preparedness and exposure reduction since 9/11: the status of public readiness in the United States. *Journal of Homeland Security and Emergency Management* 2011; 8.
48. Bensimon CM, Smith MJ, Pisartchik D, et al. The duty to care in an influenza pandemic: A qualitative study of Canadian public perspectives. *Soc Sci Med* 2012; 75: 2425–2430.
49. Fang LQ, Wang LP, de Vlas SJ, et al. Distribution and risk factors of 2009 pandemic influenza A (H1N1) in mainland China. *Am J Epidemiol* 2012; 175: 890–897.
50. Cook TD, Campbell DT. *Quasi-experimentation: Design and Analysis Issues for Field Settings.* Boston, Houghton Mifflin, 1979.
51. Campbell DT, Stanley JC. *Experimental and Quasi-experimental Designs for Research.* Boston, Houghton Mifflin, 1963.
52. Rothman KJ, Greenland S. *Modern Epidemiology.* 2nd ed. Philadelphia, Lippincott-Raven Publishers, 1998.
53. Uemoto M, Asakawa A, Takamiya S, et al. Kobe earthquake and post-traumatic stress in school-aged children. *Int J Behav Med* 2012; 19: 243–251.

54. Shen J, Feng Z, Zeng G, et al. Risk factors for injury during Typhoon Saomei. *Epidemiology* 2009; 20: 892–895.
55. Metcalfe R, Powdthavee N, Dolan P. Destruction and distress: using a quasi-experiment to show the effects of the September 11 attacks on mental well-being in the United Kingdom. *The Economic Journal*, 2011; 121: F81–F103.
56. Smith SK, McCarty C. Demographic effects of natural disasters: a case study of Hurricane Andrew. *Demography* 1996; 33: 265–275.
57. Myers CA, Slack T, Singelmann J. Social vulnerability and migration in the wake of disaster: the case of Hurricanes Katrina and Rita. *Popul Environ*, 2008; 29: 271–291.
58. U.S. Centers for Disease Control and Prevention. Deaths associated with Hurricane Sandy, October–November 2012. *MMWR* 2013; 62: 393–397.
59. Aneshensel CS. *Theory-based Data Analysis for the Social Sciences*. 2nd ed. Los Angeles, CA, Sage, 2013.
60. Zubizaretta JR, Cerdá M, Rosenbaum P. Effect of the 2010 Chilean earthquake on posttraumatic stress reducing sensitivity to unmeasured bias through study design. *Epidemiology* 2013; 24: 79–87.
61. Kessler RC. Mental illness and suicidality after Hurricane Katrina. *Bull World Health Organ* 2006; 84: 930–939.
62. Siegel JM, Shoaf KI, Afifi AA, Bourque LB. Surviving two disasters: does reaction to the first predict response to the second? *Environ Behavior* 2003; 35: 637–654.
63. Drabek TE, Haas JE. Laboratory simulation of organizational stress. *Am Sociol Rev* 1969; 34: 223–238.
64. Legemaate GAG, Burkle FM Jr., Bierens JJLM. The evaluation of research methods during disaster exercises: Applicability for improving disaster health management. *Prehosp Disaster Med* 2012; 27: 18–26.
65. Form WH, Nosow S. *Community in Disaster*. New York, Harper, 1958.
66. Hilfinger MDK, Barrington C, Lacy E. Latino social network dynamics and the Hurricane Katrina disaster. *Disasters* 2012; 36: 101–121.
67. Beckett M, Da Vanzo J, Sastry N, Panis C, Peterson C. The quality of retrospective data: an examination of long-term recall in a developing country. *J Hum Resources* 2001; 36: 593–625.
68. Norris FH, Kaniasty K. Reliability of delayed self-reports in disaster research. *J Trauma Stress* 1992; 5: 575–588.
69. Curtin R, Presser S, Singer E. Changes in telephone survey nonresponse over the past quarter century. *Public Opin Q* 2005; 69: 87–98.
70. Tashakkori A, Creswell JW. The new era of mixed methods [Editorial]. *J Mixed Meth Res* 2007; 1: 3–7.
71. Multihazard Mitigation Council. *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities*. Washington, DC, National Institute of Building Sciences, 2005.
72. Dash N. The use of geographic information systems in disaster research. In: Stallings RA, ed. *Methods of Disaster Research*. International Research Committee on Disasters, Xlibris Corp., 2002; 320–333.
73. Thomas DSK, Kivanç E, Kemeç S. The role of geographic information systems/remote sensing in disaster management. In: Rodríguez H, Quarantelli E, Dynes R, eds. *Handbook of Disaster Research*. New York, Springer, 2006; 83–96.
74. Moore DA, Carpenter TE. Spatial analytical methods and geographic information systems: use in health research and epidemiology. *Epidemiol Rev* 1999; 21: 143–161.
75. Rushton G. Public health, GIS, and spatial analytic tools. *Ann Rev Public Health* 2003; 24: 43–56.
76. Malilay J, Flanders WD, Brogan D. A modified cluster-sampling method for post-disaster rapid assessment of needs. *Bull World Health Organ* 1996; 74: 399–405.
77. U.S. Centers for Disease Control and Prevention. Rapid community needs assessment after hurricane Katrina–Hancock County, Mississippi, September 14–15, 2005. *MMWR* 2006; 55: 234–236.
78. Peek-Asa C, Ramirez M, Seligson HA, Shoaf KI. Seismic, structural, and individual factors associated with earthquake-related injury. *Injury Prevent* 2003; 9: 62–66.
79. Curtis AJ, Mills JQ, Leitner M. Spatial confidentiality and GIS: Re-engineering mortality locations from published maps about Hurricane Katrina. *Intl J Health Geographics* 2006; 5: 44. http://www.ij-healthgeographics.com/content/5/1/44 (Accessed June 11, 2013).
80. Bengtsson L, Lu X, Thorson A, et al. Improved response to disasters and outbreaks by tracking population movements with mobile phone network data: a post-earthquake geospatial study in Haiti. *PLoS Med* 2011; 8: e1001083.
81. Bame SI, Parker K, Lee JY, et al. Monitoring unmet needs: using 2–1–1 during natural disasters. *Am J Prev Med* 2012; 43: S435–S442.
82. Zook M, Graham M, Shelton T. Volunteered geographic information and crowdsourcing disaster relief: a case study of the Haitian earthquake. *World Medical & Health Policy* 2010; 2: 7–33.
83. Nagele DE, Trainor JE. Geographic specificity, tornadoes, and protective action. *Weather, Climate, and Society* 2012; 4: 145–155.
84. National Research Council. *Public Response to Alerts and Warnings on Mobile Devices: Summary of a Workshop on Current Knowledge and Research Gaps*. Washington, DC, The National Academies Press, 2011.
85. National Research Council. *Public Response to Alerts and Warnings Using Social Media: Report of a Workshop on Current Knowledge and Research Gaps*. Washington, DC, The National Academies Press, 2013.
86. Fleischman AR, Collogan L, Tuma F. Ethical issues in disaster research. In: Norris FH, Galea S, Friedman MJ, Watson PJ, eds. *Methods for Disaster Mental Health Research*. New York, Guilford, 2006.
87. Collogan LK, Tuma F, Dolan-Sewell R, Borja S, Fleischman AR. Ethical issues pertaining to research in the aftermath of disaster. *J Trauma Stress* 2004; 17: 363–372.
88. Dilley M, Boudreau TE. Coming to terms with vulnerability: a critique of the food security definition. *Food Policy*. 2001; 26: 229–247.
89. Maskrey A. *Disaster Mitigation: A Community Based Approach*. Oxford, Oxfam, 1989.
90. Wisner B, Blaikie P, Cannon T, Davis I. *At Risk: Natural Hazards, People's Vulnerability, and Disasters*. 2nd ed. London, Routledge, 2004.
91. Morrow BH. Identifying and mapping community vulnerability. *Disasters* 1999; 23: 1–18.
92. Anderson MB, Woodrow PJ. *Rising from the Ashes: Development Strategies in Times of Disaster*. Boulder, CO, Lynne Rienner Publishers, 1998.
93. Aysan YF. Keynote paper: Vulnerability assessment. In: Merriman PA, Browitt CWA, eds. *Natural Disasters: Protecting Vulnerable Communities*. London, Thomas Telford, 1993; 1–14.
94. Cardona OD. The need for rethinking the concepts of vulnerability and risk from a holistic perspective: a necessary review and criticism for effective risk management. In: Bankoff G, Frerks G, Hilhorst D, eds. *Mapping Vulnerability: Disasters, Development and People*. London, Earthscan, 2004; 37–51.

95. Phelan JC, Link BG, Tehranifar P. Social conditions as fundamental causes of health inequalities: theory, evidence, and policy implications. *J Health Soc Behav* 2010; 51**:** S28–S40.
96. Horlick-Jones T, Jones DKC. Communicating risks to reduce vulnerability. In: Merriman PA, Browitt CWA, eds. *Natural Disasters: Protecting Vulnerable Communities*. London, Thomas Telford, 1993; 25–37.
97. McEntire DA. Tenets of vulnerability: An assessment of a fundamental disaster concept. *J Emerg Manage* 2004; 2: 23–29.
98. Cannon T. A hazard need not a disaster make: vulnerability and the causes of 'natural' disasters. In: Merriman PA, Browitt CWA, eds. *Natural Disasters: Protecting Vulnerable Communities*. London, Thomas Telford, 1993; 92–105.
99. Ezra M, Kiros G-E. Household vulnerability to food crisis and mortality in the drought-prone areas of northern Ethiopia. *J Biosoc Sci* 2000; 32: 395–409.
100. Morgan O. Infectious disease risks from dead bodies following natural disasters. *Pan Am J Public Health* 2004; 15: 307–312.
101. McEntire DA. Triggering agents, vulnerabilities and disaster reduction: towards a holistic paradigm. *Disaster Prevent Manage* 2001; 10: 189–196.
102. Heijmans A. From vulnerability to empowerment. In: Bankoff G, Frerks G, Hilhorst D, eds. *Mapping Vulnerability: Disasters, Development, and People*. London, Earthscan, 2004; 115–128.
103. Jaspars S, Shoham J. Targeting the vulnerable: a review of the necessity and feasibility of targeting vulnerable households. *Disasters* 1999; 23: 359–372.
104. Horton L. After the earthquake: gender inequality and transformation in post-disaster Haiti. *Gend Dev*, 2012; 20: 295–308.
105. Saito F. Women and the 2011 East Japan Disaster. *Gend Dev*, 2012; 20: 265–279.
106. Cutter SL, Boruff BJ, Shirley WL. Social vulnerability to environmental hazards. *Soc Sci Q* 2003; 84: 242–261.
107. Gerrity E, Flynn BW. Mental health consequences of disasters. In: Noji EK, ed. *The Public Health Consequences of Disasters*. New York, Oxford University Press, 1997; 101–121.
108. Bourque LB, Siegel JM, Kano M, Wood MM. Weathering the storm: the impact of hurricanes on physical and mental health. *Ann Am Acad Politic Soc Sci* 2006; 604: 129–151.
109. Bravo M, Rubio-Stipec M, Canino GJ, Woodbury MA, Ribera JC. The psychological sequelae of disaster stress prospectively and retrospectively evaluated. *Am J Community Psychol* 1990; 18: 661–680.
110. Lindell MK, Prater CS. Assessing community impacts of natural disasters. *Natural Hazards Rev* 2003; 4: 176–185.
111. Thompson MP, Norris FH, Hanacek B. Age differences in the psychological consequences of Hurricane Hugo. *Psychol Aging* 1993; 8: 606–616.
112. Norris FH, Friedman MJ, Watson PJ, Byrne CM, Diaz E, Kaniasty K. 60000 disaster victims speak, Part I: An empirical review of the empirical literature, 1981–2001. *Psychiatry* 2002; 65: 207–239.
113. Neria Y, DiGrande L, Adams BG. Posttraumatic stress disorder following the September 11, 2001, terrorist attacks: a review of the literature among highly exposed populations. *Am Psychol* 2011; 66: 429–446.
114. Hilhorst D. Complexity and diversity: Unlocking social domains of disaster. In: Bankoff G, Frerks G, Hilhorst D, eds. *Mapping Vulnerability: Disasters, Development, and People*. London, Earthscan, 2004; 52–66.
115. Oliver-Smith A. Global changes and the definition of disaster. In: Quarantelli EL, ed. *What is a Disaster? Perspectives on the Question*. New York, Routledge, 1998; 177–194.
116. Bates FL, Pelanda C. An ecological approach to disasters. In: Dynes RR, Tierney KJ, eds. *Disasters, Collective Behavior, and Social Organization*. Cranbury, NJ, Associated University Presses, 1994; 145–159.
117. Oliver-Smith A. Theorizing vulnerability in a globalized world: a political ecological perspective. In: Bankoff G, Frerks G, Hilhorst D, eds. *Mapping Vulnerability: Disasters, Development and People*. London, Earthscan, 2004; 10–24.
118. Kano M. Characteristics of earthquake-related injuries treated in emergency departments following the 2001 Nisqually earthquake in Washington. *J Emerg Manage* 2005; 3: 33–45.
119. Noji EK, ed. *The Public Health Consequences of Disasters*. New York, Oxford University Press, 1997.
120. Bey T, van Weizsaecker E, Koenig KL. Global warming: polar bears and people – implications for public health preparedness and disaster medicine: a call to action. *Prehosp Disaster Med* 2008; 23: 101–102.
121. Norris FH, Friedman MJ, Watson PJ. 60000 disaster victims speak, Part II: *Summary and implications of the disaster mental health literature*. Psychiatry 2002; 65: 240–260.
122. Vlahov D, Galea S, Resnick H, et al. Increased use of cigarettes, alcohol, and marijuana among Manhattan, New York, residents after the September 11th terrorist attacks. *Am J Epidemiol* 2002; 155: 988–996.
123. Briere J, Elliott D. Prevalence, characteristics, and long-term sequelae of natural disaster exposure in the general population. *J Trauma Stress* 2000; 13: 661–679.
124. Combs DL, Quenemoen LE, Parrish RG, Davis JH. Assessing disaster-attributed mortality: development and application of a definition and classification matrix. *Intl J Epidemiol* 1999; 28: 1124–1129.
125. Lurie N, Manolio T, Patterson AP, et al. Research as part of public health emergency response. *N Engl J Med* 2013; 368: 1251–1255.
126. Sundnes KO, Birnbaum ML, eds. Health disaster management: guidelines for evaluation and research in the Utstein style. *Prehosp Disaster Med* 2003; 17: Suppl. 3.
127. Maurice J. Mitigating disasters – a promising start. *Lancet* 2013; 381: 1611–1613.
128. Siriwardhana C, Sumathipala A, Siribaddana A, et al. Reducing the scarcity in mental health research from low and middle income countries: A success story from Sri Lanka. *Int Rev Psychiatry* 2011; 23: 77–83.
129. Chapman DW. Issue editor introduction. *Journal of Social Issues, Human Behavior in Disaster: A New Field of Social Research*. 1954; 10: 2–4.
130. Moore HE. *Tornadoes over Texas*. Austin, University of Texas Press, 1958.
131. Williams HB. Fewer disasters, better studied. *Journal of Social Issues, Human Behavior in Disaster: A New Field of Social Research*. 1954; 10: 5–11.
132. Committee on Disaster Research in the Social Sciences: Future Challenges and Opportunities, Division on Earth and Life Studies, National Research Council. *Facing Hazards and Disasters, Understanding Human Dimensions*. Washington, DC, The National Academies Press, 2006.
133. Basoglu M, Salcioglu E, Livanou M, Kalender D, Acar G. Single-session behavioral treatment of earthquake-related posttraumatic stress disorder: a randomized waiting list controlled trial. *J Trauma Stress* 2005; 18(1): 1–11.