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## DISASTER RESEARCH AND EPIDEMIOLOGY

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**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."<sup>1</sup> 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.

### 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.<sup>2–8</sup> 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.<sup>9,10</sup> 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.”<sup>11</sup> 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.<sup>12,13</sup>

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.”<sup>11</sup> Researchers compiled the NORC disaster studies into a three-volume report.<sup>14</sup>

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.”<sup>11</sup> 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.<sup>15,16</sup> 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.<sup>17,18</sup>

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<sup>19</sup>

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

**Table 1.1. Milestones in Disaster Research**

<i>Dates</i>	<i>Primary Research Agency/ Funding Source</i>	<i>Primary Disciplines Conducting Research</i>	<i>Research Strategies</i>	<i>Contributions to Disaster Research and Knowledge</i>
1920	Doctoral dissertation	Sociology	Exploratory case/field study	Recognized as first scholarly study of a disaster <sup>9,10</sup>
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 <sup>13</sup>
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 <sup>14</sup>
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 <sup>11,14,65,129–131</sup>
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.
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, <sup>23</sup> <i>Morbidity and Mortality Weekly Report (MMWR)</i> becomes the main source for epidemiological disaster research in the U.S.

**Table 1.1. (continued)**

<i>Dates</i>	<i>Primary Research Agency/ Funding Source</i>	<i>Primary Disciplines Conducting Research</i>	<i>Research Strategies</i>	<i>Contributions to Disaster Research and Knowledge</i>
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
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
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
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 <sup>132</sup>

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.<sup>20,21</sup> 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.<sup>22</sup>

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.<sup>23</sup> 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.”<sup>24</sup> 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*.<sup>25</sup> 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.<sup>26</sup> 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.<sup>27</sup> 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.<sup>28</sup> 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,

**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)
<b>Epidemiology Journals</b>			
<i>American Journal of Epidemiology</i>	6	11	Australia (2), Britain, China, Europe, Iceland, Italy, Netherlands, Vietnam; International (2)
<i>Annals of Epidemiology</i>	10	4	China (2), UK; Asia
<i>Epidemiology</i>	5	7	Bangladesh, Canada, Chile, China, Liberia; 15 European cities; International
<i>Morbidity and Mortality Weekly Report</i>	18	12	Greece, Haiti (3), Kenya, Mexico, New Zealand, Pakistan, Sudan; International (3)
<b>Social Science Journals</b>			
<i>International Journal of Mass Emergencies and Disasters</i>	41	32 <sup>1</sup>	Australia, Bangladesh, Cameroon, Canada (2), Haiti, India, Israel, Japan, Korea, Liberia, New Zealand (2), Sweden, Turkey, UK; Asia (3); International
<i>Environment and Behavior</i>	10	7	China, Japan, Netherlands, New Zealand, UK; International

<sup>1</sup> 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.<sup>29,30</sup>

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.<sup>31</sup> 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 “non-medical 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.<sup>32</sup>

In 2009, Smith et al. published a review of disaster-specific literature from 1977–2009.<sup>33</sup> 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 soci-

ology, 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*.<sup>34,35</sup> 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.<sup>34</sup>

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.<sup>36–38</sup>

### 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.<sup>39</sup> 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.<sup>40</sup> 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.<sup>41</sup> 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.<sup>42</sup> 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.<sup>43</sup>

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



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.<sup>44</sup>

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<sup>45</sup>. 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.

### 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

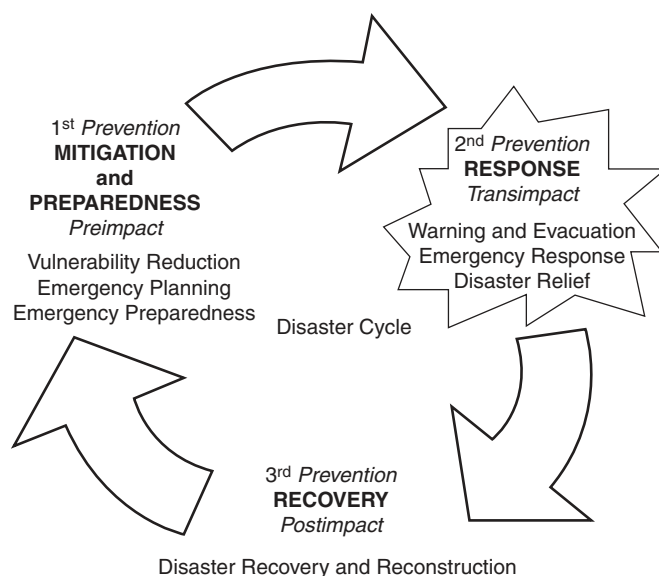


Figure 1.1. The Disaster Cycle.

be measured in terms of pre-disaster exposure to public information campaigns or other preparedness messages.<sup>46</sup> 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.<sup>47</sup> 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.<sup>48,49</sup>

### 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.<sup>50–52</sup> 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.<sup>39</sup> 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.<sup>53</sup> 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.<sup>54</sup> 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.<sup>55</sup> 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