KOENIG AND SCHULTZ'S

# Disaster Medicine

*Comprehensive Principles and Practices*

EDITED BY KRISTI L. KOENIG AND CARL H. SCHULTZ

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# KOENIG AND SCHULTZ'S DISASTER MEDICINE: COMPREHENSIVE PRINCIPLES AND PRACTICES

As societies become more complex and interconnected, the global risk of catastrophic disasters is increasing. Demand for expertise in mitigating the human suffering and damage these events cause is also high. A new field of disaster medicine is emerging, offering innovative approaches to optimize disaster management. Much of the information needed to create the foundation for this growing specialty is not objectively described or is scattered among multiple sources. Now, for the first time, a coherent and comprehensive collection of scientific observations and evidence-based recommendations from expert contributors from around the globe is available in *Koenig and Schultz's Disaster Medicine: Comprehensive Principles and Practices*. This definitive work on disaster medicine identifies essential subject matter, clarifies nomenclature, and outlines necessary areas of proficiency for healthcare professionals managing mass casualty crises. It also describes in-depth strategies for the rapid diagnosis and treatment of victims suffering from blast injuries or exposure to chemical, biological, and radiological agents.

Dr. Kristi L. Koenig, Professor of Emergency Medicine and Director of Public Health Preparedness at the University of California, Irvine, is an internationally recognized expert in the fields of homeland security, disaster and emergency medicine, emergency management, and emergency medical services. During the U.S. terrorist attacks of 9/11, she served as National Director of the Emergency Management Office for the Federal Department of Veterans Affairs. With a strong health policy and academic background, including more than 80 peer-reviewed publications and more than 300 invited lectures in more than a dozen countries, she is widely sought for presentations at regional, national, and international forums.

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*I dedicate this book to*
*The people of the world who have suffered from disasters*
*The frontline disaster workers*
*The visionaries who are crafting a new science of disaster medicine*
*My students, residents, fellows, and colleagues*
*My mother*

*Kristi L. Koenig, MD, FACEP*

*In appreciation and gratitude, I would like to acknowledge*
*The pioneers of our specialty who envisioned and helped create disaster medicine*
*Robert Bade, MD, and Robert Kingston, MD, who provided courage, guidance, and mentorship*
*My colleagues in disaster medicine who continue to pursue the dream*
*My children, Arielle and Eric, who motivate and inspire*
*My wife, Janet, whose love and incalculable support enabled me to complete this work*

*Carl H. Schultz, MD, FACEP*

# Koenig and Schultz's Disaster Medicine: Comprehensive Principles and Practices

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Every effort has been made in preparing this publication to provide accurate and up-to-date information that is in accord with accepted standards and practice at the time of publication. Although case histories are drawn from actual cases, every effort has been made to disguise the identities of the individuals involved. Nevertheless, the authors, editors, and publisher can make no warranties that the information contained herein is totally free from error, not least because clinical standards are constantly changing through research and regulation. The authors, editors, and publisher therefore disclaim all liability for direct or consequential damages resulting from the use of material contained in this publication. Readers are strongly advised to pay careful attention to information provided by the manufacturer of any drugs or equipment that they plan to use.

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# Foreword

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17th Surgeon General of the United States
Distinguished Professor of Public Health, Mel and Enid Zuckerman College of Public Health, University of Arizona
Vice Chairman, Canyon Ranch
CEO, Canyon Ranch Health
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The concept of disaster medicine has been in evolution for decades. Its requisite components were buried within disparate, often apparently unrelated disciplines and specialties. Today, we know these diverse disciplines must work seamlessly together and are essential for disaster preparedness, response, mitigation, and recovery. Events such as the tsunami in Indonesia, Hurricane Katrina in the United States, the cyclone in Myanmar, and the Novel H1N1 (2009) pandemic have served to reinforce our interdependence on one another and the globalness of our interconnected responsibilities. As we view the challenge of "all-hazard" preparedness, we are forced to recognize that our geopolitical borders are meaningless and sometimes a barrier to the public's health. In this new millennium, our nation and the globe must now reflect on contemporary threats that are truly international in scope, such as emerging infections, terrorism, weapons of mass destruction, and other disaster events.

From the late 1960s through today, I have had a unique vantage point to observe and contribute to our ever-expanding knowledge base in the fields of disaster and emergency management, as well as in public health and disaster medicine. As a medic, police first responder, registered nurse, physician, professor, trauma surgeon, and Surgeon General of the United States, I have been a witness and participant in this history.

As our knowledge base has exploded in depth and breadth, we have struggled with our own nomenclature and definition of terms. Such rapid growth has made achieving consensus on many complex issues extraordinarily difficult. Acknowledging the lack of international consensus on disaster nomenclature and other key issues, Koenig and Schultz have adopted a unique philosophical approach. They are moving the science of disaster medicine forward by describing its essential concepts and laying the academic foundation for this emerging specialty. Gathering experts from around the globe, the book reaches beyond state-of-the-art discussions to identify important areas that require immediate attention, hence laying the research agenda for the future. There is a focus on science and outcomes rather than opinions and anecdotes.

The "holy grail" of disaster management and care is the ability to surge as needed into a seamless, efficient, multiagency, and multidisciplinary force, united within an incident command system, addressing any and all hazards that may affect our communities, the nation, or the world. Although initial disaster response is local, disasters do not respect borders, and management approaches vary with available resources and existing infrastructures. The successful recruitment of disaster experts from around the globe to share knowledge from multiple perspectives is a key feature of this book.

Drs. Koenig and Schultz, as editors, have assembled a global force of experts to address the complex, interrelated topics and disciplines needed to create the end product that our nation and the world desperately need. The editors are well respected in the field of disaster medicine and have been promoting an academic approach to research and teaching since the very beginning of the specialty, long before it became popular after the tragic events of September 11.

With this publication, we are another increment closer to understanding the elements necessary to define our global interconnectedness during disasters.

# Preface

Kristi L. Koenig

## SETTING THE STAGE: *A PERSONAL PERSPECTIVE*

The specialty of disaster medicine has grown substantially since the terrorist attacks of 9/11 in the United States. In support of this growth, a number of disaster-related textbooks have been published. In some cases, however, these treatises have been authored by the 9/12'ers – people who suddenly gained interest and "expertise" in disasters once the topic became popular and U.S. federal funding flowed freely. As a result, much of the subject matter in these works was covered ineffectively. The challenge remained to create the definitive book written by nationally and internationally respected authors. We have considered editing such a book for the last dozen years; however, the timing never seemed right, and there was that ever-present thought that it would not be possible to "do it right" because we did not know exactly what "it" was.

Complicating the situation is the absence of a standard definition of disaster, much less a uniform concept for an academic discipline of disaster medicine. The need to codify this emerging discipline and create such standards is becoming increasingly clear. For example, the president of the United States issued a Homeland Security Presidential Directive (HSPD) on October 18, 2007 entitled "Public Health and Medical Preparedness." HSPD-21 "establishes a National Strategy for Public Health and Medical Preparedness, which builds upon principles set forth in Biodefense for the 21st Century (April 2004)." It further emphasizes that "the Nation must collectively support and facilitate the establishment of a discipline of disaster health. The specialty of emergency medicine evolved as a result of the recognition of the special considerations in emergency patient care, and similarly the recognition of the unique principles in disaster-related public health and medicine merit the establishment of their own formal discipline. Such a discipline will provide a foundation for doctrine, education, training, and research and will integrate preparedness into the public health and medical communities."

A definitive text is one of the requisites for crafting a scholastic foundation for disaster medicine and for proving its existence as a unique academic discipline. Yet it will be challenging to write a text when standardized nomenclature is lacking. We acknowledge this challenge but believe we can meet it by providing a conceptual framework and including a lexicon of the various terminologies without insisting that one depiction is "right" or "wrong." In addition, we suggest a future research agenda by gathering the top experts from across the globe as authors and asking them to include a section in each chapter discussing directions for future academic inquiry.

The use of established national and international experts results in individuals representing multiple disciplines. Depending on your specialty, you may not recognize some of the authors. Therefore, we have included a brief biography on each contributor to provide insight into the vast amount of expertise and activities that exist around the globe in the emerging field of disaster medicine.

## DISASTER NOMENCLATURE

What then is a disaster? There are multiple definitions. The World Health Organization definition is a "sudden ecological phenomenon of sufficient magnitude to require external assistance." Conceptually, at the most basic level, we are describing a scenario in which the need exceeds the available resources at a given moment. It is not the event itself that defines a disaster; rather it is the functional effects of that event on the system of reference at the time. For example, if an airplane crashes, is this a disaster? From the perspective of the regional trauma hospital, if everyone is uninjured or if everyone dies, there may be absolutely no effect on hospital operations, and thus this might not be considered a disaster. From the perspective of the first responders or the mortuary teams, if the crash does generate mass fatalities, baseline operations would likely need to be augmented, and this event would require the implementation of disaster protocols.

In an attempt to assist with the concept of disaster, one approach is to discard the term "disaster" – which is ill-defined – and replace it with the acronym PICE: potential injury/illness-creating event. PICE is a concise and precise phrase that immediately characterizes the incident and communicates the need for outside assistance. Although this method has not been validated or widely embraced, it has been described in major emergency medicine textbooks and referenced in the world literature and in the U.S. Joint Commission standards. Descriptive modifiers surround this root word "PICE" and account for all possible scenarios. The description is time sensitive and may be modified over the course (or life cycle) of the event. The model is useful for disaster planning, management, and research.

Sometimes the term "emergency management" is used in lieu of "disaster," for example by the U.S. Joint Commission and in the social science literature. Comprehensive emergency management has four phases – mitigation, preparedness, response, and recovery – that describe the life cycle of a disaster. Although clearly described, studied, and well known to some audiences, others – even "experts" in disaster medicine – may be unfamiliar with the term.

Several words or phrases have crept into the disaster lexicons that simply do not make sense. The term, "lessons learned" is an example. After an incident, it is common to prepare an "after action report" and provide a list of "lessons learned." This list is typically similar from event to event despite the variety or time course (e.g., "volunteers will converge at the scene" and "communications are a problem"). "Lessons learned" may be a term more suitable to describe an individual who "learns" from a personal experience. Everyone may need to touch a hot stove once to incorporate the experience into memory and "learn" not to do so. What we need is actually "sustainable knowledge," not merely individual experience. Although it is true that in some systems there is a robust continuous quality improvement process that incorporates lessons from prior events to improve preparation and responses to future events (e.g., in the country of Israel), the term "lessons learned" is often a misnomer and should be used with caution if at all. Rather scientific "findings" should be used to form the basis for continuously expanding the body of academic knowledge.

Another example is the word "preplanning." Why should we plan before we plan? Are we not in fact simply planning? Likewise, do we "pre-position" supplies, or are we actually positioning them? Let us keep the terminology simple and descriptive and discard these words from the lexicon. More logical terminology could include "pre-event planning" and "pre-event positioning" of supplies.

Additional disaster descriptors, commonly applied to healthcare facilities, are "internal" and "external." Although it is true that an event can sometimes occur completely within or outside a facility, the real question is the functional impact on the organization's operations and not its location. Furthermore, many incidents are internal and external simultaneously, for example, an earthquake that causes both citywide and hospital internal disruptions.

Sometimes the etiology of a disaster is the focus of the terminology. This is the case with the terms "natural" and "manmade." The literature is replete with the phrase "natural and manmade disasters." Yet there are in fact few if any differences in the management of an event based on etiology. There are also many instances in which it is initially unknown whether the event is "natural" or "manmade." For instance, the deliberate spraying of salad bars with salmonella in the state of Oregon in an attempt to sicken voters and sway an election was probably the first known bioterrorism attack in modern times in the United States, but it was thought to be a "natural" occurrence until many years later. Another example would be a wildfire disaster that is determined to be the result of arson. Although some might term the wildfire a "natural" disaster, the arsonist created it and, depending on the intent, it could even be classified as a type of "manmade" terrorism.

It is also insufficient to classify an event merely via its etiological agent. For example, an anthrax letter attack, although "biological," is managed more like a traditional "chemical" event. That is, there is a discrete "scene" and time of the occurrence. This scenario has been described as a "sudden impact, defined scene" event to distinguish it from a more classic bioterrorism attack (e.g., aerosolized release of weaponized inhalational anthrax) that would be managed as an evolving public health emergency.

The use of acronyms is also problematic. One can sit in a room with a group of "experts" and fail to communicate. Take "MCI" as an example. Does this mean "mass casualty incident" or "multiple casualty incident" or "multi-casualty incident?" In addition, are there a certain number of victims needed to qualify the event as an "MCI?" Is the point not really whether the volume and/or type of casualties exceed our current ability to manage them rather than an absolute number? The very same number of casualties could lead to a "business as usual" response or a full activation of a disaster plan. Furthermore, what is a "casualty?" There is no consistency as to whether the word "casualty" means "death" or "injury or illness" caused by the event. There is a huge difference in managing patients with potentially treatable injuries and illnesses versus those who are deceased. For the purposes of this book, we will define casualty as anyone incurring an injury or illness or dying as a direct result of the event. In addition, there may be secondary or delayed casualties (e.g., patients with exacerbations of chronic medical conditions due to lack of access to routine healthcare or medications). Types of casualties (e.g., deceased) can be further subdivided for analysis.

Even the same word can mean different things to different experts. For example, "surveillance" has a very different connotation for the intelligence or law enforcement communities than it does for a public health audience. Whatever terminology we use to describe "disaster," there is currently a tendency to "send all you have" to a disaster scene (if a discreet "scene" even exists) rather than analyze the needs and tailor the response. More work is needed on methods to determine the exact nature of the event and match the response to these needs via techniques such as resource typing.

## CONCEPT OF DISASTER PREPARATION

During my tenure as National Director of the Emergency Management Office in the U.S. Federal Department of Veterans Affairs, the most common question from the Deputy Secretary to me after September 11 was, "Are we prepared?" Interestingly, while preparing for congressional hearings, I noted that within a 24-hour period the Secretary of the Department of Homeland Security was quoted in the lay press as saying "yes," whereas a *New York Times* article quoted university researchers as saying "no." How do we reconcile these apparently contradictory statements? We do so by recognizing that they are incomplete responses to the fundamental question – *prepared for what?* Although some work has moved us toward an answer, there remains a lack of standardized and well-accepted benchmarks or performance measures to assess true preparedness. The field of disaster medicine is in its infancy, yet world events are forcing us to operationalize preparedness measures concurrent with their development.

If we consider the idea that a "disaster" requires resources beyond current capacity, an issue related to preparedness is the concept of "surge capacity." Although "capability" refers to a fixed competence (e.g., the hospital has an angiography suite and is therefore "capable" of performing cardiac catheterizations), "capacity" implies a time-sensitive, current ability (e.g., at this very moment, there exists equipment, staff, and infrastructure such as electricity to operate the angiography suite). When something is preventing current capacity (i.e., lack of staff, supplies and equipment, a building, or organizational management structure), surge capacity is needed. This is a relatively new term that needs further definition and discussion. In addition, there is an urgent need to develop a "crisis standard of care" appropriate to the situation in which resources are insufficient at a certain point in time. Triggers to shift from standard operations to this crisis mode should be developed and key personnel must be educated in their use. We must also build resiliency into our emergency management systems.

## FORMAT OF THE BOOK

This book is unique in many ways. We are taking a multidisciplinary approach and collaborating with well-respected academicians and researchers from around the world. In some cases, there is lack of agreement on how to describe or approach the challenges of disaster medicine. Rather than present only one view, we provide a balanced approach with the best science to support each perspective. Within this construct, to the extent possible, we present global (rather than U.S.-centric) perspectives and use a comprehensive emergency management, all-hazard approach philosophy to include a hazard vulnerability analysis. We do not include chapters about every conceivable type of event (e.g., stampedes, wildfires, civil unrest, and so forth); rather, there should be something unique about the topic for it to warrant a separate section. In addition, we emphasize the multidisciplinary nature of the emerging field of disaster medicine and draw heavily from the sociology literature (e.g., the concept of "disasters by design") in addition to other relevant fields.

Chapters are divided into three sections: Overview, Current State of the Art, and Recommendations for Further Research. Hence, we not only provide current information but also look to the future and lay the research agenda for this emerging field, much of which could be considered "translational research" – an area receiving strong emphasis from the U.S. National Institutes of Health, or "transformational research" as promoted by the U.S. National Science Foundation.

## THE TIME IS RIGHT

In 2006, the Disaster Medicine Certification Board was formed. Although visionary, it is perhaps premature to offer a certification in a field in which we have not yet proven a unique body of knowledge. To quote an esteemed colleague, "Our teaching must be based on *knowledge*, not on what we *believe*." Too many times, in the early days of disaster medicine, presentations and publications dealt with personal observations and perceptions, and well-meaning presenters showed photographs of the most recent disaster response and told the audience what happened and what they did. Although a beginning, this is not true science. I am convinced that there is a unique body of knowledge that underlies the discipline of disaster medicine, but we do not yet have the data to support this belief.

Too often, a major disaster must occur before a responsible entity begins to provide sufficient resources toward improving medical and health outcomes. Disaster grant money frequently represents a government's reaction to a devastating event and the need to "do something." The interest of healthcare providers in preparing wanes as time passes after a catastrophic event. With global warming and the effects of climate change, we can only expect an increase in worldwide disasters. Developing a formalized academic specialty is an important step in providing resiliency with sustainable interest, funding, and readiness.

The time is now right, and Cambridge University Press is the right publisher to give the appropriate academic credibility to the project. In addition, I can think of no one more qualified and committed to join me as coeditor than Dr. Carl Schultz. Please enjoy this book and use it as a springboard to further academic discussion and debate as we move forward together to create and codify the rapidly emerging field of disaster medicine.

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# Part I

# Conceptual Framework and Strategic Overview

# 1

# Disaster Research and Epidemiology

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## OVERVIEW

### 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 differing objectives and interests in regard to the causes, consequences, and processes involved in disasters. In the Preface, Koenig presents a terminology for describing disasters that focuses on the functional impact of disasters to the healthcare system. This chapter discusses research methods and findings in the context of the broader 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 livelihoods, 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] For instance, Hurricane Katrina was a category 5 hurricane at its peak, which made landfall as a category 3 hurricane in the Gulf Coast region of the United States on August 29, 2005. Its accompanying storm surge overwhelmed the local flood protection system, flooded entire communities, led to mass evacuation, caused multiple human casualties, and significantly disrupted people's livelihoods. It overwhelmed the response capacity of the community at the individual, household, and organizational levels. Thus, studies of this disaster legitimately go beyond its impact on 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, 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, often with qualitative methods of data collection. 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. (State of the Art section II of this chapter 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 semistructured interviews with selected informants after quick entry into a community, immediately postimpact. 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, primarily sociological theory. References to theory in the early disaster literature are oblique, however, and often are a statement about why theory cannot be applied or that it will emerge inductively from the research. In contrast, and with the exception of concerns about biological plausibility, epidemiological research is largely theoretical. One popular introductory epidemiology textbook contains no reference to theory in its index.[3]

### *Early Disaster Research*

Samuel Prince's Columbia University dissertation,[9] 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.[10] With a 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[11] 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.'" 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 United States and the Americas. "Comparing the state of knowledge prior to the NORC studies with the new field research, it became clear that previous studies . . . were sorely deficient [and], 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[15] and Cooley[16] of symbolic interaction and theories of collective behavior, particularly those specific to crowd behavior and the development of emergent groups. It was hypothesized that the norms that 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 between 1949 and 1960 gradually identified an underlying time line 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 time line 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. 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. Early disasters studied included the Indianapolis Coliseum explosion (1963), the Baldwin Hills (Los Angeles) dam collapse (1963), a nuclear weapons accident in San Antonio, Texas (1963), and the Alaskan earthquake (1964). Although primarily studying disasters within the United States, field studies were also conducted in a number of foreign countries.

Most studies were exploratory in design and continue to be today,[20–23] but some investigations were conducted using descriptive designs, including those following the Wilkes-Barre floods (1972) and the Xenia tornado (1974).[24] 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 physical and mental health services.[25]

Gilbert White established the Natural Hazards Research and Applications Center (NHRAC) at the University of Colorado in 1976. With primary funding by 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,

**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[9,107] | |
| 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[108–110] | 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[111] | |
| 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[11,14,57,112–114] | |
| 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[26] *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://www.blackwellpublishing.com/journal.asp?ref = 0361–3666&site = 1] *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 policy makers 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://pdm.medicine.wisc.edu/] |
| 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[115] | |

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 the last decade 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.[26] They showed that death rates were highest for children and the elderly and that females fared poorly relative to males. A decade later, in the first article published on disaster research in *Epidemiologic Reviews*, it was noted, "research on the epidemiology of disasters has emerged as an area of special interest."[27] The authors observed that a few university groups in the United States were conducting extensive research on disasters (e.g., DRC and NHRAC) and that there was the Center for Research on the Epidemiology of Disasters at the School of Public Health of Louvain University in Brussels, Belgium. They described the work being done as focusing on the immediate postimpact period, with emphasis on surveillance for outbreaks of infectious and communicable diseases and on increased mortality directly attributable to the disaster. Importantly, they also recognized three "controlled long-term health studies," the 1968 floods in Bristol, England; the 1974 Brisbane, Australia, floods; and the 3- and 5-year follow-up of the 1972 Hurricane Agnes floods in Pennsylvania.

In 1990, a discussion of the epidemiology of disasters appeared as a brief update in *Epidemiologic Reviews*.[28] Many of the disasters discussed occurred outside the United States. Notably, the public belief about the high prevalence of communicable diseases postdisaster 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 "Epidemiologic Approaches to Disasters." Included were original reviews of research conducted following cyclones, floods, earthquakes, and the Chernobyl disaster and of the development of posttraumatic stress following disasters.

Disaster epidemiology concentrates on estimating the short- and long-term, direct and indirect incidence, and prevalence of morbidity or other adverse health outcomes, with the objective of developing surveillance systems and prevention strategies and estimating the public health burden caused by the disaster.[29] Ideally, studies would be population based and longitudinal in design. Case-series, and 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 postdisaster, rapid-assessment surveys, using modified cluster sampling,[30] but 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.[31] With the exception of one article, none of the contributions to the special issue of *Epidemiologic Reviews* makes any reference to theory, and most of the articles end by describing a need for more rigorous methodology in epidemiological studies of disasters.

The authors of this chapter conducted systematic, although not exhaustive, searches for disaster-related research articles in the epidemiological literature published between 1987 and 2007 in the *Morbidity and Mortality Weekly Report* (*MMWR*), *Epidemiology*, *Epidemiologic Reviews*, and *American Journal of Epidemiology*. Not surprisingly, the majority (more than a hundred since 1987) of epidemiological disaster studies were published by the CDC in the *MMWR*. These articles examine the full range of disasters and disaster-associated morbidity, mortality, service delivery, and needs assessments. Like the early field research conducted by social scientists and psychologists, the majority of studies are case series or field studies, which lack denominator data or information about the population they represent.

In contrast, *Epidemiology*, the journal of the International Society for Environmental Epidemiology, published fewer than 40 disaster-related articles between 1987 and 2007, with most published since 2000, and the majority of which were conference abstracts rather than full articles. 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. Fewer than 20 articles on disasters have been published in the *American Journal of Epidemiology* during the same time period, where the emphasis has been on mortality, morbidity, injuries, and psychological distress.

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 the establishment of the American Board of Emergency Medicine as a conjoint specialty board in 1979 mark emergency medicine's entry into disaster research.[32] 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*. Much of the disaster research conducted in emergency medicine is published in *Prehospital and Disaster Medicine*, but very few articles contain references to disaster research conducted outside of medicine or before 1985.

Using a broad definition of "disaster research" and "nonmedical citations," 23 recent issues of *Prehospital and Disaster Medicine* were reviewed for articles on disaster research. Seventy-one articles were identified, which included a total of 92 citations to nonmedical sources; extra-medicine references are found in only a limited number of articles. Most references are to other emergency medicine or medical journals, including the *Annals of Emergency Medicine*.

These findings suggest that the many disciplines engaged in hazard and disaster research remain self-contained, with limited knowledge of research conducted in other areas and minimal contact across disciplines.

## CURRENT STATE OF THE ART

This discussion of the state of the art focuses on 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 just as varied. The appropriateness of one methodological approach over another is determined by the specific question that 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.[4,33–35]

### *Disaster Research Objectives*

The objective of a disaster research study 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 obtain accurate estimates of the distribution of variables (e.g., disease occurrence by person, place, and time) or associations between variables and theoretical constructs in a population. Like descriptive studies, explanatory studies start with formal hypotheses or research questions. The goal of explanatory studies is to explain the "true" causal relationship between variables. Explanatory research is also referred to as analytic, as opposed to descriptive, research in epidemiology.[36] 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 "hot spots" 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 (denominator) or the extent to which they represent the range and severity of disaster-related morbidity. For example, Peek-Asa and colleagues[37] examined coroner and hospital records following the 1994 Northridge earthquake and found that when compared with their systematic, individual medical record review, initial reports overestimated disaster-related deaths and hospital admissions by overattributing deaths and injuries that presented for care during the disaster window. 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. For example, following the 1994 Northridge earthquake, three waves of population-based data collection provided information about the proportion of the population affected by disaster, levels of community preparedness, physical and emotional disaster-related injuries within the community, utilization of healthcare and other disaster relief services, and the cost of damages to physical structures, among other things.[38]

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.[39] These are the "preimpact," "transimpact," and "postimpact" periods, also described as the "disaster 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.[40]

The preimpact period is the time frame leading up to a disaster event. Vulnerability reduction, hazard mitigation, and emergency preparedness planning and research may be conducted during this phase. Baseline disaster data and information about disaster readiness may be collected as well. The transimpact period focuses on warning, evacuation, immediate response, and disaster relief activities. The postimpact 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 postimpact 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.[41]

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.[42] 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 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 health threat, that is, disaster. 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 rebuild communities and infrastructures. Figure 1.1 integrates the temporal

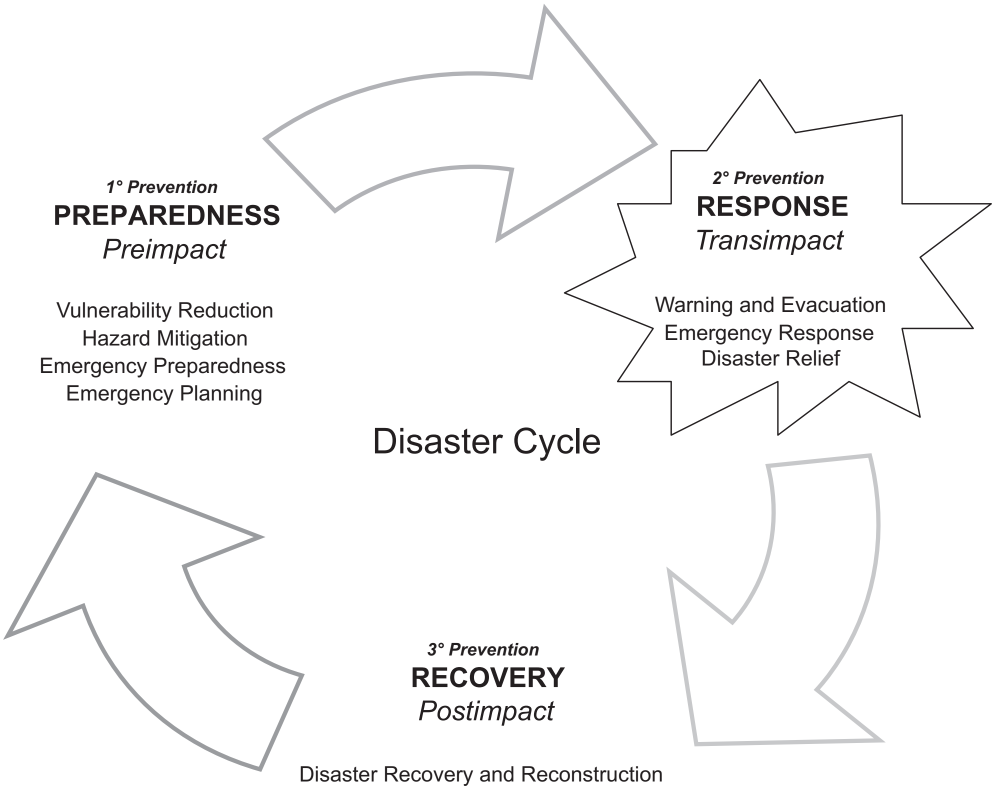


Figure 1.1. The disaster cycle.[39,40,42]

stages of 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. For example, demographic characteristics are often considered independent variables that affect people's experiences in disasters. Another key independent variable that is studied in disaster research is the level or dose of exposure to a disaster. Disaster exposure can be measured in various ways, such as the intensity of shaking experienced in an earthquake, the extent of personal loss due to a disaster, or the amount of information about a disaster that a person received through the media.

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 mitigating 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, since 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. Similarly, bioterrorism, pandemics, and public health preparedness (or lack thereof) are emerging as critical areas of study.

### *Disaster Research Study Designs*

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

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 levels 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 nontreatment groups.[43] This study identified significant effects of the behavioral intervention at weeks 6, 12, and 24, and 1–2 years posttreatment. 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.

Quasiexperiments are frequently used in the social sciences for explanatory research. 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 quasiexperimental.[44–46] In the absence of an actual disaster, the independent variable can be exposure to disaster "risk" instead of exposure to the disaster itself. For example, researchers conducted a study of the causal sequence of risk communication and preparedness behavior in response to an earthquake prediction in three central California communities with varying degrees of earthquake risk:[47] a community 25 miles from the predicted epicenter that had experienced a devastating earthquake in 1983, a community also 25 miles from the predicted epicenter but with no recent earthquake experience, and a community 75 miles from the predicted epicenter with no recent earthquake experience. Results showed that the relationship between information seeking and earthquake mitigation and preparedness behavior was essentially the same in all three communities, regardless of their levels of "risk exposure."

In epidemiology, study designs that are not experimental are called observational studies.[36] That is, 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 nonexposed individuals, or individuals with varying degrees of exposure, and follows the groups to compare the occurrence of outcomes of interest. In disaster research, for example, long-term health outcomes could be compared between groups of residents of 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.

Another common study design in epidemiology that could be 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) and then retrospectively determining their exposure status. For example, researchers would first identify the cases (e.g., people who exhibit certain symptoms of psychological distress), match them with controls (e.g., people without symptoms but who are comparable to the cases in other respects), and compare the extent to which cases and controls were exposed to the index disaster.

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 of the research findings. Quasiexperiments, 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. Rather, they may have experienced it vicariously through the media, their friends, or family.

Observational study designs are also appropriate for descriptive studies, in which the objective is to describe accurately the distribution of variables or associations between variables in a population. Nonexperimental 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. This is not a major problem when a disaster does not result in large demographic shifts. In fact, very few disasters in the United States have resulted in mass casualties or population displacements. Catastrophic disasters, however, complicate population-based sampling because the population from which data can be collected after a disaster is likely to be unstable or different from what it had been before the disaster due to disaster-associated in- and out-migrations, deaths, and alterations in procedures used to compile various types of administrative records.[48,49]

A nonexperimental, 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 purposively selected for the study and are not statistically representative of a population, thus compromising external validity. Internal validity is also low because systematic comparisons between cases and noncases 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.[50]

In addition to the distinction between experiments, quasiexperiments, and observational designs, there is a difference in study designs in terms of the frequency of data collection 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. For that reason, the analogy of taking a snapshot is often used to describe the nature of cross-sectional studies. 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.[51] That is, because all variables are measured at the same time, theoretical models determine whether the hypothesized independent variable logically precedes the dependent variable. Thus, although cross-sectional designs are most naturally used for descriptive research, they are also used in explanatory designs.

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 a disaster has occurred to assess the impact of a disaster. Examples of these kinds of studies include the postdisaster, rapid health surveys routinely conducted by the U.S. CDC as well as by local public health officials. Results of postdisaster, cross-sectional studies must be interpreted with care, especially when baseline data are not available. Although it is tempting to associate postdisaster observations (such as elevated blood pressure) with the index disaster, it must be recognized that findings from a postdisaster, cross-sectional study reflect conditions that existed before the disaster as well as conditions that arose during or after the disaster. Not all cases or conditions identified in a postdisaster, cross-sectional study are new (i.e., incident cases). Rather, some may have existed before the disaster. 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 disaster itself. Among the prevalent cases identified after a disaster, 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 disaster. For example, a nested case-control study, which is a case-control study conducted within a cohort study, was used to assess the long-term mortality and morbidity associated with exposure to the 1988 earthquake in Armenia.[52] New cases of heart disease and other chronic conditions were matched with controls within a cohort of earthquake survivors that had been followed for 4 years since the earthquake. The analyses revealed a dose–response relationship between exposure to the earthquake (i.e., loss of material possessions and family members in the earthquake) and the risk of developing heart disease within 4 years after the earthquake.

When data are collected more than once over a longer period of time, the studies are called longitudinal. This design 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 postdisaster).

Examples of longitudinal designs include repeated cross-sectional studies, in which *new samples* of the population are studied each time, and cohort studies, which are 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 predisaster data are available for a population that was later affected by a disaster. To illustrate, a study was conducted to estimate the impact of Hurricane Katrina on mental illness by comparing results of a posthurricane survey with those of an earlier survey.[53] The populations from which the probability samples were drawn were comparable (although the posthurricane 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 being able to study samples that are representative of the population at each time of data collection, panel studies allow for the examination of change over time *within* a group. For instance, respondents to a survey conducted after the 1994 Northridge, California earthquake were reinterviewed 4 years later to determine if their prior experience affected their response to another anticipated disaster, a slow-onset El Niño weather pattern.[54] This study found that emotional injury experienced as a result of the earthquake both facilitated preparedness, in terms of number of hazard mitigation activities performed, and predisposed people to a subsequent emotional injury. Cohort studies, however, often suffer from loss to follow-up (i.e., respondents who intentionally or unintentionally drop out of the study). In the El Niño study, of the 1,849 households originally interviewed after the earthquake, 1,353 (73%) agreed to a follow-up interview, but less than half of them, 632, could be contacted at the time of the follow-up study. Ultimately, 414 agreed to participate in the follow-up study, yielding a 22.4% response rate of those interviewed at baseline. Loss to 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 design, which is only possible in 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 afterward. In these instances, the study may be initiated for other purposes but can be adapted to the disaster researchers' needs. Last, in a retrospective design, data are collected on events or conditions that have occurred in the past by using archival data or recalled information. An example here is reviewing hospital records after an index 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,[55,56] but have not been used in recent times, perhaps because of the difficulty of simulating the complexities of a disaster. Moreover, the external validity, or generalizability, of results from laboratory simulation studies might be compromised because of 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]

Retrospective designs have generally been disregarded especially because of the emphasis on the "window of opportunity" immediately following a disaster. These include retrospective case studies, which involve the historical analysis and reconstruction of events that occurred in the past,[10] historical cohort studies, which involve the analysis of data on cohorts that were followed up in the past, and case-control studies. Case-control studies are appropriate for studying rare outcomes and, thus, would be suitable for studying disaster-associated phenomena.

### *Disaster Research Data Collection*

Disaster research, as with most other types of 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 response to a tornado in Michigan.[57] A more recent study examined the experiences of hospital evacuation after the 1994 Northridge, California, earthquake by using structured interviews with physicians, nurses, administrators, and other staff who were on duty during the evacuation.[58] 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 predisaster knowledge, attitudes and behaviors, immediate emotional, and behavioral responses to a disaster, and the course of postdisaster recovery. Commonly perceived limitations of the use of surveys in disaster research include disaster victims' reluctance to discuss their experiences with researchers and the lack of reliability of self-reports, although these concerns have been refuted by several researchers.[41,59,60] Another obstacle to using surveys for disaster research is the general decline in participation rates in household surveys in recent years.[61]

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 direct surveying of 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 among sheltered evacuees.

Standardization of the data collection method is especially important with quantitative data because researchers want to compare data across different events, populations, settings, and times. In this respect, postdisaster rapid health surveys frequently suffer from inconsistencies in sampling methods, data reporting periods, the use of different criteria for establishing disaster-relatedness of health outcomes, and incomplete information in records for determining if an injury or medical condition is disaster related. Lack of standardized definitions and survey instruments is one of the major challenges to quantitative data collection in disaster research.

### *Mixed Method Disaster Research*

With increased awareness that qualitative and quantitative methods and data complement each other, a mixed methods approach might become more popular 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 or methods in a single study or a program of inquiry.[62]

The Multihazard Mitigation Council of the National Institute of Building Sciences recently concluded a mixed method disaster research study[63] to determine the future savings gained from FEMA's investments in hazard mitigation activities. Future savings based on losses avoided because of earthquake-, wind-, and flood-related hazard mitigation activities funded by FEMA through three large hazard mitigation grant programs 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 FEMA mitigation 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 semistructured telephone interviews with informants, field visits, and the collection and 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 dollars. 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 nonfederally funded mitigation programs.

***Geographical Information Systems and Disaster Research***

The application of Geographic Information Systems (GIS) technology is growing in the field of disaster research. Dash[64] and Thomas and colleagues[65] have written chapters on the use of GIS technology in disaster management and research. There have also been discussions on the utility of GIS-based spatial analysis in health research and epidemiology.[66,67] 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 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 postdisaster 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.[68] 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, and, 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.[69] 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, which involve more extensive data collection and spatial referencing. Peek-Asa and others[70] used GIS to link data on the geophysical characteristics of the 1994 Northridge, California earthquake (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. 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 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.[71]

So far, GIS has primarily been utilized as a decision-making tool for disaster management or for applied disaster research. Its application to theory-oriented disaster research has been very limited, such as in studying the spatial patterns of social vulnerability to disaster.[72] GIS has yet to be widely used in scientific disaster research for the advancement of theory.

***Ethics in Disaster Research***

As in any research, ethical considerations are integral to disaster research. The central concern is whether the research 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 disaster, which 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 that are responsible for protecting people's welfare. Despite a sense of urgency to get into the field postimpact, 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 5 of this book, as well as to writings by Stallings,[4] Fleischman et al.,[73] and Collogan et al.[74] for further discussion about the ethical issues involved in disaster research.

## Disaster Vulnerability

There is a general consensus within the disaster community that vulnerability interacts with the physical hazard agent to produce disaster risk.[75–77] 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."[77] Thus, greater vulnerability of an individual or group is associated with more risk for a given level of disaster exposure. In many instances, estimations of who might be most vulnerable to a disaster can be formulated before a disaster, 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 vulnerable because of their age and/or physical and mental health conditions, such as 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), survive trauma injuries, and cope with short- or long-term disruptions in regular living conditions, including food, shelter, and access to healthcare. It is widely recognized, however, that disaster vulnerability is multidimensional, in that there are many other factors that contribute to people's capacity to anticipate, cope with, resist, and recover from the impact of hazards. The most commonly mentioned dimensions of vulnerability in disaster research are physical, economic, political, social, and psychological.[78–81]

Physical vulnerability refers to the physical proximity to the hazard and/or inadequate physical and structural resistance to hazards.[81–83] Physical vulnerability is important for high physical force disasters, such as in 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, but is more often conceptualized at the micro, or household level, in terms of livelihood conditions (e.g., income opportunities, job characteristics).[84] 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.[85] 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,[86] these concerns are relevant in chronic disaster situations, like droughts and famines.

Political vulnerability encompasses having little or no political power, representation, or autonomy.[78,80,87,88] Political values and priorities determine which hazards will be addressed, the relative emphasis on and support for hazard mitigation, and the ability 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 social protection from governments or have the resources and resilience to take measures to protect themselves. 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.[89] The philosophy that increasing political clout is the key to reducing overall vulnerability, including vulnerability to disasters, underlies individual and community empowerment efforts.[88]

Social vulnerability includes the formal institutional structures that marginalize certain groups and individuals based on their socioeconomic[81,83] or other characteristics, such as race or ethnicity. Informal social relations with friends, family and others[78] are included here as well. A community is socially vulnerable when people feel victimized, fatalistic, or dependent,[79,80] often resulting in apathy and a low sense of personal responsibility.[87] 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.

There has been some effort to quantify social vulnerability to disasters, despite the lack of consensus in the research community on which dimensions should be incorporated. The Social Vulnerability Index[72] was developed using factor analysis and provides a score for each county in the United States. The index measures 11 independent factors reflecting *social* inequalities and *place* inequalities. Social inequalities are factors that influence the susceptibility of various groups to harm, and govern their ability to respond. Place inequalities are characteristics that contribute to the social vulnerability of places, such as the level of urbanization, growth rates, and economic vitality. Preliminary data show that the index is not correlated with presidential disaster declarations, thus providing limited evidence for construct validity. Nonetheless, the concept is a promising one; research studies on this and other indices that attempt to quantify social vulnerability are worth pursuing.

Psychological vulnerability is studied at the level of the individual in terms of the psychological characteristics that influence the individual's ability to cope with disaster stress and their likelihood of experiencing an emotional injury or distress from disasters.[90] In the extant literature, previous mental health problems are the most robust and consistent predictors of postdisaster distress.[91] Contrary to popular belief, psychological effects of nonterrorist disasters tend to be mild and transitory in the general population, rarely resulting in psychopathology.[92–94] Severe levels of psychological impairment are more likely to occur in disasters involving mass violence compared with other types of disasters.[95] Thus, psychological vulnerability is a more prominent factor in exposure to intentional disasters, and individuals with previous mental health problems would be anticipated to fare the worst.

The notion of dimensions of vulnerability 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 2005 hurricanes Katrina and Rita affected areas that were physically vulnerable because of the levee construction (physical vulnerability). Political factors (political vulnerability) determined the low priority given to levee repairs and upgrades before the disaster and the inadequate governmental response as the disaster unfolded. The low socioeconomic and marginalized status of many of the individuals affected by the hurricanes influenced their ability to cope with and recover from the disaster, both in the short term and the long term (economic and social vulnerability). The hurricane-associated deaths were predominantly among the elderly (physiological and social vulnerability).[96] As a function of the long-term disruption in social networks, the ongoing stressors associated with the disaster, and what might be perceived as an intentionally unresponsive rescue and recovery effort, psychological disorders have emerged (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.[97–100] 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.[99]

## 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 the physical characteristics of the hazard that triggers an abnormal event, the physical, social, and political environment in which the hazard event occurs, and 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 (among other factors): the intensity of the ground shaking, the duration of shaking, and the intensity and frequency of aftershocks and the soil type (i.e., hazard characteristics); the population density and proximity of human settlements to the areas where the greatest shaking occurs, common construction types, the emergency response and health-care infrastructure in place (i.e., physical environment); 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 (i.e., social and political environment); and the age, preexisting health conditions, and socioeconomic status of the population (i.e., 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 due to injuries caused by the Northridge earthquake[37]); 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.[101]

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 postdisaster 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.[91,102] The CDC, especially through the *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 including how frequently events involving that hazard occur, whether there is a clear beginning and end point to the hazard event, thus, making causal attributions less ambiguous, whether the hazard tends to cause multiple human casualties, and whether there have been especially devastating or dramatic events that surround the disaster.

There is an accumulation of literature and knowledge about the health impact of hurricanes (and floods associated with them) and tornadoes in the United States, both of which are seasonal hazards that occur annually. Earthquakes also have been well studied internationally and in California (even though they are infrequent events) because there is little ambiguity about when an earthquake begins and ends, and because large earthquakes may cause 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 previously, and including infrequent events, ambiguous event thresholds, and low human impact. Concomitant with recent interest in the effects of global warming,[117] there has been a recent rise in the number of studies of heat-related health consequences, with a greater willingness to conceptualize extreme temperatures as a disaster. The occurrence of a catastrophic event can reenergize or completely change the research activity in these areas. The Indian Ocean tsunami in December 2004 has spawned an unprecedented amount of research on the morbidity, both physical and psychological, and mortality associated with tsunamis.

Among the hazards that are not "natural," *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 been well documented also, especially the occurrences in 1995 in Oklahoma City and in 2001 in New York City. In contrast, there have been very few opportunities for conducting research on the intentional use of biological, radiological, or chemical agents. The medical or physical health consequences of direct exposure to these hazards are perhaps better known than those resulting from exposure to other hazards, however, partly because exposure can be defined more clearly.

The psychological morbidity resulting from disasters is known to be less differentiated by the type of hazard and more affected by whether a disaster was due to unintentional or intentional causes, with the latter causing greater psychological distress to victims who are aware it is intentional. Posttraumatic stress disorder is by far the most common disorder studied, followed by depression, anxiety, and panic disorders.[103,104] Most studies reveal a significant drop in symptoms over time.[103,105]

### *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 that has been caused by a disaster varies, not only within, but also across, disaster types. The U.S. 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 disaster and also based on whether the event is directly or indirectly related to the disaster: "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."[106] Although strong in theory, the schema is difficult to apply in practice, especially when estimating indirect effects.

Morbidity estimates are harder to ascertain than mortality estimates. In many cases, estimates 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 in an affected area for their estimates of the number of 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.[37] Thus, morbidity estimates often include a fairly substantial margin of error, including both under- and overreporting. Careful review of emergency department logs and admission records is essential and will improve estimates but cannot eliminate ambiguity in every case.[31,91]

## RECOMMENDATIONS FOR FURTHER RESEARCH

Despite the common belief that disaster and hazard research is an emergent discipline, the formal study of disasters has a long, multidisciplinary history. As outlined in the historical overview section, disasters are an established focus of research within the fields of medicine, public health, sociology, psychology, engineering, economics, geology, and geography, among other disciplines. The multidisciplinary approach to the study of disasters is not accidental. The interacting societal problems caused by disasters benefit greatly from and, in fact, demand the multiple methodological and theoretical lenses provided by the disciplines represented in disaster research.

Given the diversity of research perspectives, it is not surprising that communication between disaster researchers from different fields remains an ongoing challenge. Consequently, researchers sometimes conduct parallel and redundant lines of research, without knowledge of pertinent contributions to the disaster literature made by researchers outside their own discipline. With the broad history and nature of disaster research in mind, several recommendations for improving the quality of and access to disaster research are offered.

One strategy for improving the quality of disaster research is to design, fund, and conduct mixed method studies that involve collaboration across disciplines. Such efforts would improve communication across fields and contribute to the integration of methods and theoretical frameworks for understanding disasters. Stimulating cross-disciplinary work should maximize the likelihood that researchers will be knowledgeable about disaster research outside their discipline and minimize the chance of repeating or reinventing what has already been done. Conducting mixed method studies could, for example, capitalize on both the rich tradition of qualitative disaster research in the social sciences and the quantitative analytical techniques that are predominantly used in epidemiology.

In addition to active promotion of cross-disciplinary work, it will be beneficial to encourage collaborations between local experts and individuals with training and experience in the broader study of disasters. Local emergency management experts have community-specific knowledge, whereas "career" disaster researchers are more broadly trained, experienced, and familiar with the extant literature and emerging disaster knowledge base.

Ensuring adequate training of incoming professionals is another important strategy for improving the quality of disaster research. High-profile events, such as the 9/11 World Trade Center attacks and Hurricane Katrina, tend to cause a convergence of disaster researchers, both old and new. Newcomers who are attracted to disaster studies may not be well grounded in the accumulated knowledge in the field, the methods that are appropriate for disaster research, or the unique ethical considerations for conducting this type of research. Training centers and grants that provide infrastructure to support new researchers through fellowships, mentoring programs, and other training activities are appropriate and can help mitigate these challenges.

The quality of disaster research can be improved by supporting research strategies beyond those based in traditional health settings, such as hospitals and emergency departments. Population-based studies, for example, can provide information about the impact of disasters on the population as a whole rather than only the subset of individuals who sought treatment at a particular hospital. Although there is often competition among researchers to be the first to report results, it is both possible and desirable to expand the disaster time line, before *and* after disaster impact. Collecting data in communities at risk can help establish a predisaster baseline, provide information about individual and community preparedness and hazard mitigation, and potentially, provide the relevant information to study the relationship between preparedness and later disaster experiences. Longitudinal research can provide data on the rate and level of disaster recovery over time and study some of the changes that are secondary to the disaster event. Regardless of the research methods used, consistency of estimation methods can greatly improve the quality of disaster research. Establishing consensus on the definitions of what constitutes a disaster, exposure to disaster, and a disaster-related death, injury, or disease would improve the validity of findings. The same is true for the particular methods used to estimate morbidity and mortality associated with disasters.

One approach to enhancing 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.

A separate challenge within the field of disaster medicine is that published research frequently lacks the structure necessary to enhance scientific development of the specialty. In 2003, an international task force released recommendations to standardize the manner in which disaster medical research is reported.[116] The group modeled their approach after the Utstein style for reporting out-of-hospital cardiac arrest research. This work is constructed primarily around the medical and public health aspects of Disaster Medicine and consists of three major sections, each provided in a separate volume: 1) conceptual framework; 2) operational framework; and 3) research templates. The three volumes combine to form a structure that defines the development, implementation, and evaluation of the processes that produced the disaster. In addition, they provide standards for evaluation of the effectiveness, efficiency, costs, and benefits of any interventions. Using the structures provided, it is possible to compare similar and dissimilar disasters and any intervention provided. Use of this structure will facilitate the development of the science of Disaster Medicine that is essential for the identification and codification of best practices and standards upon which education, training, credentialing, and accreditation must be based.

Underlying efforts to advance the quality of disaster research is the need to improve access to research strategies and findings. These efforts should be directed to disaster researchers and to consumers of disaster-related information. Particular attention should be paid to countering disaster-related myths. It is well established that dead bodies pose minimal risk for epidemics and that mass panic and widespread social disorder typically do not occur in disasters. Emergency management policies and practices should be informed by such empirical research findings. One means of improving access to disaster-related research findings is to support the integration of search engines on which pertinent publications are indexed to help make the task of reviewing the disaster literature less daunting. Improving access to and dissemination of disaster research findings will likely yield better-informed disaster researchers, practitioners, and policymakers, thereby increasing the likelihood that disaster-relevant policies are evidence based.

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# 2

# Disaster Education and Training: Linking Individual and Organizational Learning and Performance

Peter W. Brewster

## OVERVIEW

The purpose of this chapter is to identify the principles and practices for training those who respond and provide care to victims of disasters. To understand adequately the scope of disaster education and training, it is first necessary to have an appreciation of its interdisciplinary nature, the health and medical operational system, and how education and training fits within the broader organizational learning context. This discussion is limited to conveying an overview of the process used to develop and deliver education and training to support organizational performance in emergencies and disasters. What follows is a discussion of important background concepts and the basic theory used in instructional design, with examples of disaster education and training for various medical and health target audiences. At the conclusion of this chapter, the reader will be able to

- Explain the overall context for disaster health education efforts
- Describe the Instructional System Development (ISD) approach to developing education and training programs
- Identify various examples of disaster health education and training programs for various audiences

## STATE OF THE ART

### Disaster Health

Disaster education and training is interdisciplinary by nature and addresses all hazards. In October 2004, a World Association for Disaster and Emergency Medicine seminar was convened to discuss disaster education and training. As reported by Murray and others, the group defined "disaster" as "a major event which actually or potentially threatens the health status of a community." They recognized these major events could be the result of any type of hazard. The term "disaster health" was chosen to replace "disaster and emergency medicine" because it was more inclusive of the variety of disciplines that would become involved in a response. Bradt's visual depiction of this "disaster health" framework included clinical and psychosocial care, public health, and emergency and risk management as three interrelated core domains (see Figure 2.1).

### Operational System

Students in disaster health education and training programs need to have an understanding of the operational system within which health and medical services are provided in disasters. Integration of out-of-hospital medicine, public health, acute care medicine, and mental health into a medical and health functional group called an Emergency Support Function (ESF) was first described in the U.S. Federal Response Plan in 1992.[2] Table 2.1 illustrates the variety of ESFs in the 2009 version of the National Response Framework and shows the specific activities conducted under ESF 8, Public Health and Medical Services. This framework (or a similar one) is also found in state and local government emergency operations plans (EOPs) across the United States.

Although EOPs reflect the desired integration between health and medical entities and between levels of government, reality may be somewhat different. Barbera and Macintyre note

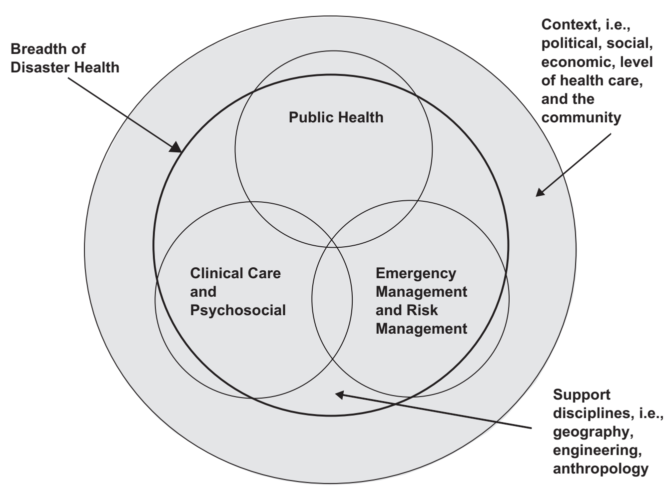


Figure 2.1. A framework for disaster health[1]

**Table 2.1: Emergency Support Functions of the National Response Framework and the Specific Activities Under ESF 8, Public Health and Medical Services**

Transportation
Telecommunications and Information Technology
Public Works and Engineering
Firefighting
Emergency Management
Mass Care, Housing, and Human Services
Resource Support
Public Health and Medical Services (ESF 8)
- Assessment of Public Health and Medical needs
- Health Surveillance
- Medical Care Personnel
- Health/Medical Equipment and Supplies
- Patient Evacuation
- Patient Care
- Safety and Security of Human Drugs and Biologics
- Blood and Blood Products
- Worker Health and Safety
- Food Safety and Security
- Agriculture Safety and Security
- Behavioral Healthcare
- Public Health and Medical Information
- Vector Control
- Protection of Animal Health
- Technical Assistance

Urban Search and Rescue
Oil and Hazardous Materials Response
Agriculture and Natural Resources
Energy
Public Safety and Security
Community Recovery, Mitigation, and Economic Stabilization
Emergency Public Information and External Communications

healthcare facilities have traditionally engaged in preparedness activities as independent entities, not as part of a larger system. Public health agencies have not been well integrated into the first response/public safety system on an operational level, and they have not been effectively linked to acute care medicine or mental health. Furthermore, they saw preparedness efforts being aimed at individual problems, such as patient tracking, by individual disciplines without first defining the overall response system.

To improve operational level integration, the U.S. government has mandated the use of the Incident Command System (ICS).[3] ICS provides a standardized management structure and process that allows disaster health education and training efforts to clarify the role an individual plays within an organization's EOP. Revised in 2006, the Hospital Incident Command System provides one approach to integrating the various departments and services within a healthcare facility for responding to disasters.[4] An example of such integration within the Operations Section is listed in Table 2.2. What is notably different from previous versions (Hospital Emergency Incident Command System or HEICS) is the broader focus of hospitals beyond simply providing medical care in emergencies.

**Table 2.2: Operations Section: Hospital Incident Command System**

- Medical Care
- Infrastructure
- Hazardous Materials
- Security
- Business Continuity

**Table 2.3: Operations Section: MaHIM System**

- Epidemiological Profiling
- Prehospital Care
- Medical Care
- Mental Health
- Hazard Containment
- Mass Fatality Care

At the local jurisdiction level, another model, the Medical and Health Incident Management (MaHIM) System, describes how the various medical, public health, emergency management, and support disciplines are integrated within an ICS structure (see Table 2.3).[5]

Finally, the publication, *Medical Surge Capacity and Capability* provides an overall system description that explains how the various levels or tiers operate and coordinate within a national system (see Table 2.4). This guidance currently serves as a foundation for health system preparedness efforts.[6]

### Emergency Management Program Development Cycle

The relationship among an organization's operational procedures, education, training, implementation, evaluation, and corrective actions is an import context. Education and training programs need to communicate the organization's EOP, standard operating procedures, job action sheets, and checklists to the variety of staff, as appropriate to their roles. Although this seems obvious enough, many times exercises, whose purpose is to "test" the organization's emergency operations procedures, are designed around a high-profile scenario and not tied to the procedures. Organizational performance can only be improved if the procedures exist and training is provided prior to validation occurring through a well-designed exercise program. Rather than starting with full-scale exercises, it is highly recommended to begin with orientation seminars, tabletop discussions, and functional exercises leading to the full-scale events. Evaluation tools should be designed from exercise objectives and produce impartial data identifying where improvement is needed (e.g., procedures, training, and equipment). Table 2.5 illustrates the role of education and training within the overall development cycle of an emergency management program.

**Table 2.4: Tiers within the Medical Surge Capacity and Capability Management System**

- Individual Healthcare Asset
- Healthcare Coalition
- Local Jurisdiction
- State Response and Coordination of Intrastate Jurisdictions
- Interstate Regional Management and Coordination
- Federal Support to State and Local Jurisdictions

**Table 2.5: Steps in the Emergency Management Program Development Cycle[7]**

- Establish an Advisory Committee
- Develop an "all-hazard" EOP that incorporates the ICS
- Conduct a hazards vulnerability analysis to identify priority hazards, threats, and events
- Write incident-specific operational procedures for priority hazards, threats, and events
- Maintain ongoing mitigation and preparedness efforts
- Coordinate with external entities
- Provide education and training to staff on their roles and responsibilities
- Implement the EOP/ICS and incident-specific guidance during actual disasters and exercises
- Review performance and identify recommendations for corrective action to the Advisory Committee

**Table 2.6: Key Terminology that Supports Emergency Management for Healthcare Systems[8]**

*Competency:* A specific knowledge element, skill, and/or ability that is objective and measurable (i.e., demonstrable) on the job. It is required for effective performance within the context of a job's responsibilities and leads to achieving the objectives of the organization.

*Education:* Education is instruction, structured to achieve specific competency-based objectives, that primarily imparts knowledge. This may be general knowledge or it may be job specific but extend to "higher order" knowledge (e.g., understanding the "big picture," or working under stress) not specifically included in the job description but of great value during emergency management activities. Educational material should be competency based and specify a level of proficiency that relates to the competencies ("awareness, operations, or expert").

*Training:* Training is instruction that imparts and maintains the skills (and abilities such as strength and endurance) necessary for individuals and teams to perform their assigned system responsibilities. Training objectives should also be competency based and specify a level of proficiency that relates to the relevant competencies ("awareness, operations, or expert"). As much as possible, training should address skills that will function under the conditions likely when the skill must be conducted.

*Exercise:* A scripted, scenario-based activity designed to evaluate the system's capabilities and capacity to achieve overall and individual functional objectives and to demonstrate the competencies for relevant response and recovery positions. The purpose of exercise evaluation is to determine a valid indication of future system performance under similar conditions and to identify potential system improvements.

*Organizational Learning:* A systems-based process for assessing proposed changes to the system and incorporating accepted proposals to effect lasting change in system performance. This is accomplished through alterations to system structure, process, competencies, facilities, equipment, supplies, and other parameters. This process is accessible to the whole organization and relevant to the organization's core mission and objectives.

## Developing a Disaster Education and Training Program

Terminology is the foundation for education and training efforts. Because disaster health is interdisciplinary by nature, the establishment of an integrated compendium of terms, acronyms, and definitions is an important first step. A glossary developed by The George Washington University's Institute for Crisis, Disaster and Risk Management to support a major health system's emergency management education and training program is available in the public domain. Selected terms from the Institute for Crisis, Disaster and Risk Management glossary that are important to this discussion are presented in Table 2.6.

The basic theory that supports the development of education and training programs is called ISD. The ISD process, originally developed by the U.S. military[9] involves five phases (see Figure 2.2)

- Analysis of training needs and identification of requirements for each target audience, including regulations, standards and accepted practices
- Design of the education and training program and schedule, individual activities, and delivery methods
- Development of content and instructional resources
- Implementation of the education and training program
- Evaluation and improvement activities

### ANALYSIS

Reviewing the organization's records will provide information on the topics, target audiences, frequency, recertification cycles, and attendance at past training. Evaluation forms or discussions with staff who helped deliver and who attended the events are good sources that will help to determine the focus, direction, and usefulness of past efforts. It is also important to look at the annual schedule of education and training offerings to see whether they were sequenced to support development of organizational procedures and exercises. For U.S. hospitals, the Joint Commission standards require healthcare organizations to conduct at least two exercises per year, separated by 4 months.[10] The requirements for these exercises include use of the organization's operational procedures for priority hazards, and a corrective action process.

Regulations and standards that need to be incorporated within any disaster education and training program include (in U.S. terminology) the ICS (as part of the National Incident Management System), hazardous materials, and worker health and safety (Occupational Safety and Health Administration).[11] The National Fire Protection Association Standard 1600, the standard for Disaster/Emergency Management and Business Continuity Programs, recommends that each entity assess the training needs and develop a curriculum to support implementation of the program. The frequency and scope of the training should be identified and training records maintained.[12]

For U.S. hospitals, additional Joint Commission requirements specify that staff, including volunteers and licensed independent practitioners and volunteers, will be oriented and

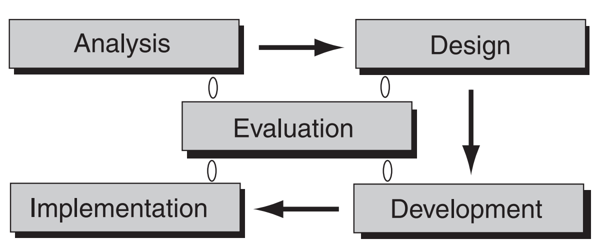

Figure 2.2. The phases of the ISD model.

trained on their assigned roles in the EOP.[13] National Fire Protection Association Standard 99, Chapter 12, Health Care Emergency Management, recommends that each organization implement an educational program that includes an overview of the emergency management program and ICS. Education concerning the staff member's specific duties and responsibilities needs to be provided at the time of joining the organization and annually thereafter.[14] The American Society for Testing and Materials, in its Hospital Preparedness and Response standard designation E 2413–04, also requires education and training for staff response to myocardial infarctions, psychosocial impacts, managing information, documentation, and principles of coordination.[15]

Also important for those involved with patient admission and tracking is the Health Insurance Portability and Accountability Act (HIPAA), enacted by the U.S. Congress in 1996 (see Chapter 10). Title I of the Act protects health insurance coverage for workers and their families when they change employers or lose their jobs. Title II addresses the security and privacy of health data, through the establishment of national standards for electronic data transactions. Protected health information is individually identifiable health information. Protected health information can be shared for the purposes of preventing or controlling disease, injury, and disability or for other public health and law enforcement purposes.[16]

The organization's role in the community's emergency response system should be incorporated into education and training. The local government's EOP should be reviewed to ensure the programs clarify the organization's role and responsibilities.

Education and training should be competency based; in other words, instructional activities are guided by learning objectives designed for the particular target audiences and linked to training drills and exercises of the EOP.[17]

Identifying target audiences must occur before any further design and development occurs. The Veterans Health Administration, in developing its Emergency Management Academy, identified its target audiences as staff belonging to one of several "job groups" (see Table 2.7).

Competencies for disaster education and training relate to the role played by a particular target audience in emergency response and recovery, recognizing the importance of the organization's emergency procedures and ICS[18] (see Table 2.8). After the target audiences and competencies are identified, learning objectives can be developed for the overall program and for each individual lesson. The use of "levels of proficiency" (awareness, operations, and expert) is common in education and training courses. Awareness-level proficiency would involve having the basic knowledge or understanding of the topics, usually to prevent injury. Operations-level proficiency entails the knowledge, skills, and abilities of a topic to safely perform any tasks involved. Expert-level proficiency is the operations-level, plus the knowledge, skills, and abilities to apply expert judgment necessary to solve complex problems.[18]

Proficiency levels were first identified in the regulations developed to guide training for those who respond to releases of hazardous materials (see Table 2.9).[19]

**Table 2.7: Job Groups Used to Define Target Audiences in a Healthcare System**

- All personnel (with responsibilities in the EOP)
- Facilities and Engineering
- Police and Security
- Clinical Support
- Patient Care Providers
- Emergency Program Managers
- Health System Leaders

**Table 2.8: Sample Emergency Response and Recovery Competencies**

All Personnel Job Group – Includes all personnel with assigned job positions within the EOP and supervisory staff who may be required to perform the duties of an initial Incident Commander. The competencies within this group are referred to as core competencies necessary as a base for every position within the organization. Emergency response and recovery competencies for this job group include

- Utilize general ICS/Incident Management System principles during incident response and recovery (operations level)
- Recognize situations that suggest indications for full or partial activation of the healthcare facility's EOP, and report them appropriately and promptly (operations level)
- Participate in healthcare facility mobilization to transition rapidly from day-to-day operations to incident response organization and processes (operations level)
- Apply the organization's core mission statement to actions taken during emergency response and recovery (operations level)
- Apply the organization's Code of Ethics during emergency operations (operations level)
- Execute personal/family preparedness plans to maximize availability to participate in the facility's emergency response and recovery (expert level)
- Respond with a prepared and maintained personal "go-kit" to maximize the ability to perform and maintain the assigned role during response and recovery (expert level)
- Follow the occupant emergency procedures and assist others (e.g., personnel, patients, and visitors) as necessary to accomplish the directives (operations level)
- Perform specific roles and responsibilities as assigned in the facility's EOP (operations level)
- Follow the communication plan and reporting requirements as outlined in the facility's EOP and the specific Incident Action Plan for an emergency event (operations level)
- Follow and enforce safety rules, regulations, and policies during emergency response and recovery (operations level)
- Follow and enforce security measures consistent with the nature of the incident that has prompted the EOP activation (operations level)
- Utilize or request (as appropriate) and integrate equipment, supplies, and personnel for the employee's specific role or functional area during emergency response and recovery (operations level)
- Follow demobilization procedures that facilitate rapid transition to recovery operations for the healthcare facility (operations level)
- Follow recovery procedures that ensure facility return to baseline activity (operations level)

### DESIGN

In this phase, the content and delivery methods are identified and matched to the target audiences, competencies and desired levels of proficiency. The development of learning objectives and an instructional outline begins this process. An instructional outline with learning objectives for a course on weapons of mass destruction (WMD) is found in Table 2.10.

**Table 2.9: Proficiency Levels for Hazardous Materials Training**

*Level 1: First Responder Awareness*
This is the person who witnesses or discovers the release of hazardous material and notifies the proper authorities. Training includes recognition and identification of hazardous materials, notification procedures, and the employee's role in the emergency response plan.

*Level 2: First Responder Operations*
These individuals are persons who respond to release of hazardous substances without trying to stop the release. They require Level 1 competency and 8 hours of additional training in basic hazard and risk assessment, personal protective equipment (PPE) selection, containment and control procedures, decontamination, and the emergency release plan (ERP).

*Level 3: Hazardous Materials Technician*
Persons trained to this level respond aggressively to stop a release. This level requires 24 hours of Level 2 training and competencies in detailed risk assessment, toxicology, PPE selection, advanced control, containment, and decontamination procedures, air-monitoring equipment, and the ICS.

*Level 4: Hazardous Materials Specialist*
The specialist has advanced knowledge of hazardous materials and responds with and provides support to hazardous materials technicians. Requirements are 24 hours of Level 3 training and proven competencies, along with advanced instruction, on all specific hazardous material topics.

*Level 5: On-site Incident Commander*
This individual assumes control of the incident. Level 5 requires 24 hours of training equivalent to Level 2 with competencies in the ICS and ERP, hazard and risk assessment, and decontamination procedures.

Unless specified by the standards or regulations, it can be difficult to determine which staff members require which education and training topics. The job groups and key aspects described earlier can be used to begin this "curriculum mapping" process. One approach for recommending which ICS courses are appropriate for various staff positions is found in Table 2.11.

Deciding how to deliver disaster education and training programs will depend on the desired target audience(s), topic(s), and level of proficiency. Members of a decontamination team, patient reception team, hospital emergency response team, or incident management team will require an operations- or expert-level proficiency. For these groups, traditional face-to-face methods are best for practicing hands-on skills, such as triage or the use of specialized equipment, with a limited number of students who require the ability to perform some type of procedure. For awareness level proficiency, the number of students increases and the focus of the activity is primarily imparting knowledge. Many technologies exist to provide content and the desired level of interaction. Information in electronic documents, videos, and DVDs, that support instructional activities or entire courses are increasingly available from government, university and private sector sources. Web-based courses, satellite broadcasts, and videotapes are practical methods for delivering this information to all except those who require an operations or expert level of proficiency.

Adult learning principles should be used, particularly when designing site-specific training. These characteristics include encouraging self-direction; reinforcing and building on prior experiences; providing training in small groups; and offering a supporting and challenging environment.[22]

**Table 2.10: Sample Instructional Outlines for a Hospital WMD Course**[20]

*1.0 Event Recognition*
Use surveillance systems
Recognize a possible terrorist attack
Report WMD-related information to the appropriate person(s)

*2.0 Unified Incident Command/Management Structure*
Use a unified system of command

*3.0 Response Support*
Provide the necessary logistical support for victim care, responders, and the response as a whole

*4.0 Safety and Protection*
Select and work effectively in PPE
Demonstrate behaviors that help ensure personal safety

*5.0 Decontamination*
Decontaminate victims at an incident site, medical facility, or other areas as needed

*6.0 Isolation and Containment*
Appropriately isolate and contain victims of each type of WMD event

*7.0 Evidence Preservation*
Use appropriate techniques for preserving possible at an incident site or medical facility

*8.0 Psychological Effects*
Prepare for, recognize, and treat the psychological impacts of a WMD event on victims and healthcare professionals

*9.0 Communication and Agency Interaction*
Maintain and help facilitate effective communication during a WMD incident response
Interact effectively with appropriate agencies and organizations involved in responding to an incident

*10.0 Triage*
Perform effective triage of victims of specific types of WMD incidents involving a variety of agents

*11.0 Treatment*
Perform effective assessment, stabilization, diagnosis, and treatment of victims of specific types of WMD incidents involving a variety of agents

*12.0 Transportation*
Transport victims as required, considering potential contamination risks, resource shortages, and communication needs

*13.0 Recovery Operations*
Complete recovery operations, including reports and debriefings

*14.0 Fatality Management*
Appropriately handle human remains, addressing safety, psychosocial, and forensic needs

#### DEVELOPMENT AND IMPLEMENTATION

In these phases, the course materials, instructional strategies, and methods are finalized. Many commercial and governmental sources of education and training products exist that address personal and family preparedness, occupant life safety, and the

**Table 2.11: Matrix of Courses Required Under the National Incident Management System to Staff Positions**[21]

| *Position/Employee Group* | *IS-100* | *IS-200* | *IS-700* | *IS-800* |
|---|---|---|---|---|
| Headquarters Staff with Disaster Responsibilities | | | X | X |
| Regional Director | | | X | X |
| Regional Safety Manager/ Industrial Hygienist | X | X | X | X |
| Medical Center Director | | | X | X |
| Medical Center Associate Director | | | X | X |
| Medical Center Chief of Staff | | | X | X |
| Key Operations Managers | X | | X | |
| Emergency Preparedness Coordinator | X | | X | X |

ICS. Others are designed to fulfill specific standards and regulations, such as those promulgated by the U.S. Occupational Safety and Health Administration and HIPAA. Programs on WMD and medical surge capacity and capability topics are widely available.

## EXAMPLES OF DISASTER EDUCATION AND TRAINING PROGRAMS

### Public

In the United States there are several programs that involve training the public to support formal response efforts in disasters. These include: the Citizens Corps, the Medical Reserve Corps (MRC), and the Community Emergency Response Team (CERT). Table 2.12 contains additional information on each of these programs.

**Table 2.12: Public Education and Training Programs**

A new cabinet level Department of Homeland Security was formed after the terrorist attacks in the fall of 2001. In collaboration with the U.S. Department of Health and Human Services, this department promulgates programs that are designed to organize the general public into effective volunteers. These programs include the Citizens Corps, MRC, and CERTs. They provide instruction on improving preparedness at home, in the workplace, and in the general community. As a result, participants can assist the formal emergency response system during disasters by performing such activities as house-to-house welfare inspections, providing basic first aid, and giving assistance to neighbors.

***Citizens Corps***

"Are You Ready?" is the slogan for the Citizens Corps program.[23] This program provides guidance to individuals, families, and businesses in developing emergency plans. Successful implementation of these plans will reduce injury, mitigate damage, and increase the ability of all citizens to assist others during disasters.

***Medical Reserve Corps***

This organization enables healthcare professionals (including retirees) to augment effectively local health officials' capacity to respond to an emergency. MRC units are community-based and function in a way to locally organize and use volunteers who want to donate their time and expertise to prepare for and respond to emergencies and to promote healthy living throughout the year. MRC volunteers supplement existing emergency and public health resources. MRC volunteers include medical and public health professionals such as physicians, nurses, pharmacists, dentists, veterinarians, and epidemiologists. Many community members – interpreters, chaplains, office workers, legal advisors, and others – can fill key support positions.

MRC training topics are organized under the following three general competencies.

*Health, Safety, and Personal Preparedness*
- Introduction to disasters
- Are you ready?
- Family and workplace preparedness
- Standard precautions and respiratory hygiene
- Psychological first aid

*Roles and Responsibilities of Individual Volunteers*
- Introduction to the ICS
- Hospital ICS

*Public Health Activities and Incident Management*
- Public health 101

***CERTs***

The CERT program supports local government responders by training volunteers to organize themselves and spontaneous (convergent) volunteers at the disaster site, to provide immediate assistance to victims, and to collect disaster intelligence to support responders' efforts when they arrive. CERT training consists of

- Disaster Preparedness
- Fire Safety
- Disaster Medical Operations
- Light Search and Rescue Operations
- CERT Organization
- Disaster Psychology
- Terrorism
- Disaster Simulation

## FIRST RESPONDERS

### The National Domestic Preparedness Consortium[24]

The National Domestic Preparedness Consortium is the principal vehicle through which the U.S. Department of Homeland Security, Office of Grants and Training identifies, develop, tests, and delivers training to state and local emergency responders. The following is a brief description of each member and their expertise:

- *Center for Domestic Preparedness*: The center provides hands-on specialized training to state and local emergency responders in the management and remediation of WMD incidents. Located at the former home of the U.S. Army Chemical School, Fort McClellan, the Center for Domestic Preparedness conducts live chemical agent training for the nation's civilian emergency response community. The training emergency responders receive at the center provides a valid method for ensuring high levels of confidence in equipment, procedures, and individual capabilities.
- *National Energetic Materials Research and Testing Center at the New Mexico Institute of Mining and Technology*: This center offers live explosive training including the use of field exercises and classroom instruction. The National Energetic Materials Research and Testing Center is the lead National

Domestic Preparedness Consortium partner for explosives and firearms, live explosives, and incendiary devices training.

- *Academy of Counter-Terrorist Education at Louisiana State University*: The academy provides training to law enforcement agencies and focuses its efforts on the delivery of the Emergency Response to Terrorism: Basic Concepts for Law Enforcement Course, and the development and delivery of the Emergency Response to Domestic Biological Incidents Course.
- *National Emergency Response and Rescue Training Center at Texas A&M University*: Texas A&M delivers a set of courses to prepare state and local officials for the threat posed by WMD. Courses are developed and designed to provide each specific segment of the emergency response community with the tools needed to accomplish its role in the event of a WMD incident. Additionally, Texas A&M has developed an Interactive Internet WMD Awareness Course for emergency responders. Texas A&M also provides technical assistance to state and local jurisdictions in the development of WMD assessment plans.
- *National Exercise, Test, and Training Center at the U.S. Department of Energy's Nevada Test Site*: This test site conducts large-scale field exercises by using a wide range of live agent simulants as well as explosives. The National Exercise, Test, and Training Center develops and delivers a Radiological/Nuclear Agents Course.

### *Collaborative Medical Readiness Initiative*

The Center for Disaster and Humanitarian Assistance Medicine's Chemical, Biological, Radiological, Nuclear, and Explosive/WMD Collaborative Medical Readiness Training Initiative[25] is designed to provide healthcare practitioners with current health and medical information on WMD. The program includes a scenario-based, interactive program that follows a hypothetical healthcare provider responding to a mass casualty incident. As the scenario evolves, the course presents a series of lessons, discussions, and information sessions that address public health, medical, and emergency management issues.

#### *Awareness*

- Define the steps to conduct a threat assessment
- Describe the physics of radiation energy and pathophysiology of radiation effects on the human body

#### *Management*

- Recognize types of radiation injuries and describe how to manage their treatment
- Identify principles of triage and resource utilization to care effectively for numbers of patients that exceed the immediately available resources
- Define the steps to assess the level of exposure for the casualties and staff and identify necessary laboratory and diagnostic procedures that support the clinical management of contaminated casualties
- Identify surface decontamination principles for ambulatory and litter patients exposed to radiation and demonstrate principals of reverse isolation
- Describe how to protect staff, other patients, and facilities from secondary contamination and recognize the special inpatient considerations for the internally contaminated patient

#### *Integration*

- Describe the roles and responsibilities of the public health agencies and how providers must interact with them during a response; discuss evacuation, food safety, and veterinarian care considerations; and, recognize the need for using epidemiological tools
- Describe the presentation of acute stress disorders in responders and the interventions to mitigate them; discuss how to safely handle human remains, autopsy considerations, and the need to comply with legal standards for chain of custody and evidence collection
- Describe the roles of the ICS, hospital ICS, and the National Incident Management System (NIMS) and the response system at the facility, local, state, and federal levels; and describe the overall structure of the National Response Framework
- Discuss the importance of effective interactions with the media and the need for a unified public message; identify the principles and science of crisis and emergency risk communication; and describe the role of risk communication in response

### *Urban Search and Rescue*[26]

Urban Search and Rescue (US&R) involves the location, rescue (extrication), and initial medical stabilization of victims trapped in confined spaces. Structural collapse is most often the cause of victims being trapped, but victims may also be trapped in transportation accidents, mines, and collapsed trenches.

US&R is considered a "multihazard" discipline because it may be needed for a variety of emergencies or disasters, including earthquakes, hurricanes, typhoons, storms and tornadoes, floods, dam failures, technological accidents, terrorist activities, and hazardous materials releases.

Medical Specialist training course units consist of the following.

- Introduction
- Medical Development
- Medical Team Responsibilities
- US&R Medical Problems
- Confined Space Medicine
- Task Force Canine
- Medical Skills Station
- Patient Care Scenarios
- Other US&R Operational Considerations
- Field Exercises

## HOSPITALS AND HEALTHCARE SYSTEMS

There are six important dimensions that need to be addressed in a healthcare system's disaster education and training program.

### PERSONAL AND FAMILY PREPAREDNESS

Preparedness for emergencies begins with the individual employee and his or her family. Staff whose roles are deemed essential must feel comfortable that their family members know what to do in the event of an emergency. This is even more important for staff who may deploy on response teams for 10–14 days. Family disaster planning information is available from the American Red Cross[27] and the Federal Emergency Management Agency (see Table 2.13).

**Table 2.13: Family Disaster Plan**

- Discuss the type of hazards that could affect your family. Know your home's vulnerability to storm surge, flooding, and wind
- Locate a safe room or the safest areas in your home for each hazard. In certain circumstances the safest areas may not be your home but within your community
- Determine escape routes from your home and places to meet. These should be measured in tens of miles rather than hundreds of miles
- Have an out-of-state friend as a family contact so all your family members have a single point of contact
- Make a plan now for what to do with your pets if you need to evacuate
- Post emergency telephone numbers by your phones and make sure your children know how and when to call 911 or the equivalent emergency services number
- Check your insurance coverage – flood damage is not usually covered by homeowners insurance
- Stock nonperishable emergency supplies and a Disaster Supply Kit
- Use a weather radio. Remember to replace its battery every 6 months, as you do with your smoke detectors
- Take First Aid, Cardiopulmonary Resuscitation (CPR), and disaster preparedness classes

### OCCUPANT LIFE SAFETY

Fire and severe weather drills are a tradition within hospitals and public institutions. In the United States, "duck, cover and hold on" is taught to school-aged children in areas prone to earthquakes. The focus of this type of life safety education and training is ensuring building occupants understand the facility's alerting signals, notification procedures, and the appropriate actions to take (see Table 2.14). This type of education and training is driven by local ordinances, building codes and standards, and regional or national priorities.

### INCIDENT COMMAND SYSTEM

The use of the ICS by federal, state, local and tribal governments and the private sector, including hospitals, became a priority with adoption of the NIMS following the terrorist attacks of September 11, 2001 in the United States (see Table 2.15).

A big part of the NIMS requirements is to incorporate ICS into the organization's existing EOP and procedures. Although the various NIMS-required courses described above are important building blocks necessary to understand the basic concepts and principles of ICS, major emphasis should be placed on providing education and training on the EOP, such as applying ICS to the organization.

**Table 2.14: Sample Occupant Emergency Procedures**

i. Emergency Evacuation Plan
ii. Reporting
iii. Emergency Response Procedures
  A. General
  B. Emergency Situations
    Fire
    Medical Emergency
    Bomb Threat
    Hazardous Materials
    Odor of Smoke/Burning
    Other Emergencies
iv. Emergency Teams
v. Building Information
  A. General Description
  B. Miscellaneous Information
  C. Special Circumstances
  D. Posting for Conference Rooms

**Table 2.15: National Incident Management System[28]**

- Organizational Adoption
- Command and Management
- Preparedness Planning
- Preparedness Training
- Preparedness Exercises
- Resource Management
- Communications and Information Management

### ORGANIZATIONAL RESILIENCY

Resiliency relates to the capability of an organization to recover from the effects of a hazard impact. Developing procedures and processes for resiliency is a focus of the 2008 Joint Commission emergency management standards.

Continuity planning has long been a focus of emergency preparedness activities with government agencies and major corporations. This type of planning was solidified within the healthcare industry because of the "Year 2000" or Y2K, when manufacturers of computer chips that were used in a variety of medical devices and equipment could not guarantee their performance when 1999 changed to 2000. In the United States Department of Veterans Affairs (the largest integrated healthcare system), Y2K preparedness focused on "mission critical systems" (see Table 2.16) and developing contingency plans for maintaining continuity of patient care through the use of manual techniques and alternate systems.

### INTERNAL MEDICAL SURGE CAPACITY AND CAPABILITY

The traditional focus of hospital planning, training, and exercise activities has been on creating "surge capacity" for mass casualties (see Chapter 3). Medical surge consists of two dimensions: surge capacity, which refers to the ability to evaluate and care for a markedly increased volume of patients; and surge capability, which refers to the ability to manage patients requiring unusual or specialized medical evaluation or care.[30] Education and training programs for medical surge are aimed at developing staff competencies in the treatment of injuries and illnesses generated

**Table 2.16: Mission Critical Systems[29]**

- Lighting
- Electrical Power
- Steam Distribution
- Heating, Ventilation, and Air Conditioning
- Room or Hood Exhaust
- Water Delivery
- Water Conditioning
- Waste Stream
- Critical Supplies
- Communications
- Computer and Information Management Systems
- Alarms
- Vertical Transport
- Central Medical Gases

**Table 2.17: Resources and Activities that Support Medical Surge**[31]

- Beds
- Isolation Capacity
- Healthcare Personnel
- Pharmaceutical Caches
- Personal Protective Equipment
- Decontamination
- Behavioral Health
- Trauma and Burn Care

by various hazardous agents and managing key resources and activities (see Table 2.17).

#### SUPPORT TO EXTERNAL SYSTEMS

Implicit in medical surge capacity and capability are the concepts of mutual aid and resource management. Healthcare facilities have long maintained sharing agreements for the purpose of relocating patients during events such as fires or loss of utilities. Historic events such as Hurricanes Katrina and Rita in the United States demonstrated that large-scale mutual aid efforts to support the care and evacuation of patients from damaged hospitals required more attention to pre-event resource identification, education, and training (see Table 2.18).

The U.S. federal response to south Florida after Hurricane Andrew in 1992 stimulated an effort to develop more effective mutual aid between states.[32] This effort has turned into the Emergency Management Assistance Compact, a nationwide mutual aid network consisting of all 50 States, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands as signatories.[33] The Department of Homeland Security is focusing efforts on strengthening the ability of counties and cities to provide mutual aid locally, through the Emergency Management Assistance Compact and under the National Response Framework.[34] The National Mutual Aid and Resource Management Initiative includes resource typing and credentialing of public health and medical resources. Healthcare staff who may deploy as part of these resources require additional education and training such as field living skills, use of communications equipment, intermediate ICS, and understanding of the National Response Framework.

In summary, all hospital employees should receive information on personal/family preparedness, and occupant safety procedures should be the basis for their training. All operating unit supervisors and managers should be provided additional information on organizational resiliency and the ICS. Operating units that provide or support patient care should also focus on medical surge capacity and capability topics. Finally, leadership should have additional information on support to external systems.

**Table 2.18: Hospital Resource Categories Requiring Augmentation**[35]

- Critical Care
- Medical/Surgical
- Behavioral Health
- Dialysis
- Laboratory
- Neonatal
- Infectious Disease
- Burn
- Obstetrics
- Operating Room
- Pharmacy (inpatient and outpatient)

**Table 2.19: Masters–level Curriculum in Disaster Medicine and Public Health**[38]

European Master in Disaster Medicine – The Master is intended to provide participants with a clear picture of current concepts and developments in the medical preparedness and management of disasters.

At the end of the course, participants are expected to

- Evaluate health risks in disaster situations
- Participate in medical disaster preparedness
- Direct the medical response team in case of disasters
- Organize and manage evaluation and debriefing sessions
- Provide introduction and awareness to disaster management for medical response personnel
- Conduct research on the medical aspects of disasters

## GENERAL MEDICAL AUDIENCES

### National Disaster Life Support Courses[36]

The National Disaster Life Support family of courses are designed for physicians and other health professionals to respond to mass casualty events caused by terrorist acts as well as from explosions, fires, disasters, and infectious diseases. The courses were developed by the American Medical Association in collaboration with the National Disaster Life Support Education Consortium partners: Medical College of Georgia, University of Georgia, University of Texas Southwestern Medical Center at Dallas, and the School of Public Health in Houston. One of these courses is the Advanced Disaster Life Support Course, which includes lectures and skills stations on mass triage; PPE and decontamination; community and hospital disaster planning; media and communications during disasters; and management of mass fatalities. This material is widely available and undergoes internal review by the National Disaster Life Support Education Consortium; however, it has not undergone independent review. In addition to the material produced by the American Medical Association, there are multiple other sources of education that include courses taught at medical schools and national and international conferences.

## UNIVERSITY PROGRAMS

In the United States alone, there are at least 20 colleges and universities with degree programs in emergency health and medical services.[37] Tables 2.19 and 2.20 provide examples of postgraduate degrees in public health or disaster medicine.

#### EVALUATION

Evaluation of education and training is both formative and summative. Formative evaluation relates to whether the educational activity itself reached its stated goals and objectives. An example of this is a course evaluation form that is completed by

**Table 2.20: Master of Science in Disaster Medicine and Management[39]**

Philadelphia University School of Science and Health – The program is a 36-credit, 12-course curricula to be completed in 1–3 years depending on the course load taken by the student.

***Master of Science in Disaster Medicine and Management Courses***

- Principles of Disaster Medicine and Management
- Hazardous Materials and Industrial Safety
- Natural Disasters
- Weapons of Mass Destruction
- Principles of Terrorism
- Organization Management and Communication in Disasters
- Psychological Aspects of Disasters
- Disaster Exercises and Drills
- Public Health Implications of Disasters
- Disaster Emergency Planning
- Applied Research Methods and Statistics
- Capstone Experience
- Master's Writing or Research Project
- Internship
- International Experience

attendees. Summative evaluation is an analysis of whether the outcomes of the activity produced the expected improvement to the organization's emergency management capability.

Disaster education and training events are designed to improve individual and organizational performance during emergencies. The degree to which this is accomplished involves the design of the operational system description (the organization's EOP and procedures); the education and training activities; and the evaluation process. It is standard practice to complete evaluation forms or After Action Reports whose purpose is to document performance in exercises and actual emergency responses. Issues identified in the After Action Reports will almost certainly have an education or training component. Before issuing recommendations based on the input from these forms, it is important to take into account the types, frequency, participation, and evaluations of previous education and training events and the degree to which these events reflect revisions to the organization's procedures over time.

The use of ISD concepts may involve one or more of the following levels of evaluation[40]

- *Reaction*: Student and instructor satisfaction with the course
- *Learning*: Student mastery of course objectives
- *Behavior*: Translation of the instructional experience to improved job performance
- *Results*: Alignment of instructional activity to the organizational goals and objectives

## Recommendations for Further Research

In December of 2001, the U.S. Agency for Healthcare Research and Quality published a report that reviewed the literature on the most effective ways to train clinicians for public health events relevant to bioterrorism.[41] Although the purpose of the report was to address the topic of bioterrorism, the findings can apply to many disaster-related subjects. Some of the summary information is presented in Table 2.21.

**Table 2.21: What Is Known About the Most Effective Ways to Train Clinicians for Public Health Events**

The most common educational methods found in the literature surveyed were lectures, discussion, audiovisual aids, and written materials. More than half of the studies combined more than one educational method. The ability to correlate results from these education and training methods is limited because of differences in learning objectives, setting, targeted clinicians, and methods.

The Agency for Healthcare Research and Quality report acknowledged there is a lack of well-designed published studies on the most effective methods to train clinicians for bioterrorism preparedness or in management of public health events relevant to bioterrorism preparedness. Particular attention should be paid to the design of evaluation methods, such as an increased use of pretesting and posttesting and in the linkage of outcomes to course objectives.

Aside from improving the quality of research into determining the most effective methods to deliver disaster education and training, other studies are needed to address

- Whether implementation of the ICS by the medical and health disciplines under the NIMS requirements improves their integration within the larger emergency management system and by incorporating ICS into operational procedures are education, training, and evaluation simplified through the use of this standardized management system
- The use of competencies as a basis for course design rather than topics. Currently, the majority of disaster education and training courses are developed around comprehension of specific subject matter, not around target audiences. Job group competency frameworks describe the knowledge, skills, and abilities necessary for response and recovery to all hazards across a broad group of target audiences. Functional group competencies more specifically focus on performance of a particular function within the response system
- How information technology can improve coordination between individuals and organizations. Part of the coordination problem during disasters is due to the lack of a universal management system, although implementation of the NIMS should help to alleviate this. Another part of this problem is the infrequent nature of exercises. Use of the Internet and software to create realistic simulated disasters in which personnel from a variety of departments, agencies, and/or levels of government could interact more routinely would improve understanding of the overall response system and cooperation
- What is the real value of exercises? Are disaster drills and tabletop exercises cost-effective educational methods for training clinicians in how to respond to a bioterrorist attack or other public health event?
- Duration and extent of certification and refresher cycles. How often does clinicians' knowledge about preparedness for bioterrorism or other public health events need to be reinforced?

## Summary

Disaster education and training programs must be designed to reflect the interdisciplinary and intergovernmental nature of the emergency management, public health, public safety, and medical systems. The use of the ISD model can improve the efficacy of these programs, emphasizing the emergency management program development cycle. Understanding the critical relationships among operational procedures, education and training programs, implementation activities (exercises and actual events), and the corrective action process is necessary to ensure individual and organizational learning.

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# 3

# Surge Capacity

Donna Barbisch, Josef Haik, Ariel Tessone, and Dan Hanfling

"On March 11th, 1918 – an Army private reported to the camp hospital before breakfast. He had a fever, sore, throat, headache . . . nothing serious. One minute later, another soldier showed up. By noon, the hospital had over a hundred cases; in a week, 500 . . . Over 11,000 people would die in Philadelphia alone that October . . . In 31 shocking days, the flu would kill over 195,000 Americans. It was the deadliest month in this nation's history".[1] It was not only happening in the United States, it was happening all over the world.

Developing the capacity and capability to handle a rapid increase in demand for patient care and public health services related to disasters or significant events impacting the healthcare community has become known as medical surge. The need for surge capacity is characterized by a mismatch between patient care needs and the capability and/or capacity to fill those needs during a catastrophic medical event. Figure 3.1 demonstrates a national response. Health and medical needs rise sharply after an event. Local response rises to meet the demand but becomes exhausted and begins to degrade after 24 hours. Preincident capacity for routine services is reduced in the immediate aftermath of a disaster. National and other external resources are activated and arrive after approximately 72 hours. The gap in requirements or needs compared with the capability is the surge requirement.

Significant effort has been placed on developing concepts to build medical surge capacity. The World Health Organization (WHO) identifies capacity building within the public health infrastructure as a global responsibility for all countries. In the 2005 Global Health Report, WHO outlined core capacity requirements that all countries must meet to detect, assess, notify, and report events covered by the International Health Regulations.[2] Capacities identified in the Global Health Report include

- Components such as building or strengthening national public health institutes
- Ensuring that national surveillance and response systems use internationally recognized quality standards
- Strengthening human resources capacity through training programs in intervention epidemiology, outbreak investigation, laboratory diagnostics, case management, infection control, social mobilization, and risk communication
- Using WHO indicators to conduct regular assessments of core capacities to monitor progress and assess future needs

The complexities and interdependencies of the healthcare environment present considerable challenges in developing a viable and cost-effective, sustainable medical surge solution. Limited evidenced-based data exist on the efficacy of proposed interventions. Standard healthcare practice based on individual care does not transition easily to population-based best outcomes decision making; the approach to surge requires a change in perspective on healthcare management. Understanding the essential elements in developing surge capacity and developing a system to balance the rapidly increasing demands given the limited resources available is critical. A comprehensive approach will build resiliency into the healthcare system and optimize outcomes when patient care needs exceed capacity. A focus on resiliency in healthcare management will not only facilitate best outcomes during the event, it will develop the ability to maintain nonevent-related essential services during the surge and promote rapid recovery in the aftermath of the disaster to restore pre-event healthcare services. A comprehensive surge system consists of well-balanced capacity and capability in personnel (staff), supplies and equipment (stuff), and physical structure and management infrastructure (structure).[3–4] This 3S Surge System will be described in detail in this chapter.

## OVERVIEW OF THE PROBLEM

When the numbers or types of patients overwhelm the medical system's capability, existing competence, or capacity, the time-sensitive ability to manage healthcare resources must surge to meet demand to optimize patient outcomes. In certain situations, some patient care capacity or capability may be underutilized whereas others are exhausted and overwhelmed. Balancing needs and resources to affect best outcomes is challenging.

Incidents requiring surge capacity fall into a spectrum of scenarios that may have low-complexity/high-numbers such as

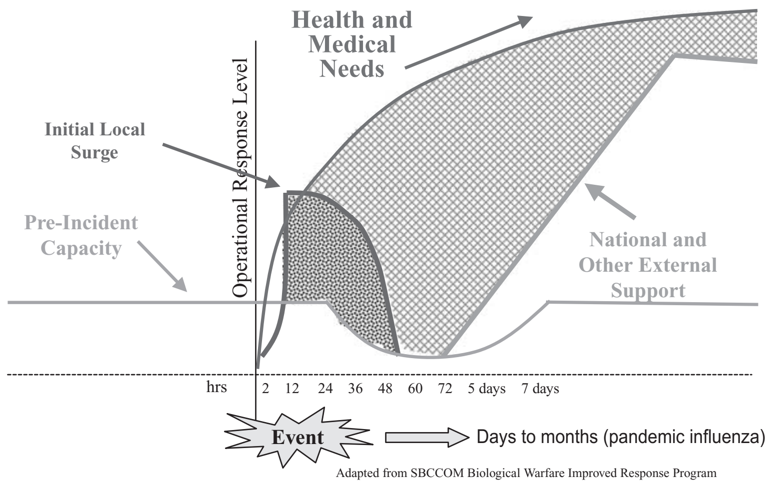


Figure 3.1. Medical surge.

some blast events, high-complexity/low-numbers such as motor vehicle collisions, or high-complexity/high-numbers as is projected in a pandemic influenza (Figure 3.2). "Complexity" in this context refers to the degree of difficulty in treating patient injuries. Many low-complexity/high-numbers events are characterized by a significant number of minor injuries that stress emergency triage capability. The event is localized and the majority of patients can be treated as outpatients. In high-complexity/low-numbers events there are fewer patients, but each patient requires intensive medical attention stressing critical care resources. In the preparation for mass burn events for example, although the numbers traditionally are relatively low (e.g., in Israel only ~9% of all terror and warfare injuries are burn related) the complexity of the injuries and the durations of stay are usually higher. Following detonation of an improvised explosive device, burn surge may move into the high-complexity/high-numbers category. In highly specialized treatment areas, required personnel, supplies, and accompanying expenses (e.g., imaging and laboratory studies) are increased compared with other mass trauma incidents or infectious outbreaks.[5] Hick et al., addressed the issue of specialized evaluation or interventions, a category under which most major burn patients will fall.[6]

In high-complexity/high-numbers events, such as pandemic influenza and other infectious diseases, the projected requirements stress multiple geographical areas simultaneously across a wide region of the healthcare community. Mutual aid agreements and the promise of support from governments and other entities capable of directing resources may be unavailable. Communities may be "on their own" to manage the surge in healthcare requirements. These complex events may be particularly challenging due to the shift in some systems toward managing fragile patient populations as outpatients with home health services that may include oxygen therapy, dialysis, and even in-home ventilatory support.

In prolonged or escalating events, an integrated approach is essential to coordinate and share resources. Even under "normal" conditions, some nations face extreme shortages of emergency resources. This includes developed countries like the United States where diverting patients to other hospital emergency departments due to crowding is common.[7] As disasters escalate it is imperative to recognize that medical and health needs will exceed healthcare resources.

In the management of surge, a transition is necessary from individual-based care to a population-based best outcomes approach. Healthcare professionals will be faced with ethical dilemmas in determining how to allocate scarce resources (see Chapter 5). Population-based triage protocols require shifting resources to achieve the "greatest good for the greatest number."

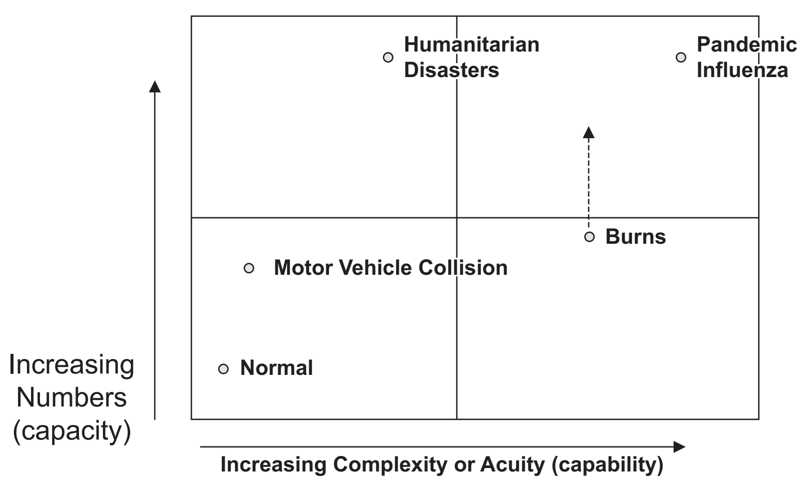


Figure 3.2. Spectrum of incidents requiring surge capacity.

This means that individual patients with little to no chance for survival may receive "comfort care" only and not be allocated resources for resuscitation.[8] Developing guidelines to support a shift in focus from optimizing individual to population outcomes is essential.[9]

Existing guidelines for building surge capacity (particularly over a prolonged time period) are limited. The State of California developed comprehensive surge capacity standards and guidelines in 2007–2008 with the input of a broad group of stakeholders from both government and the private sector. These experts addressed issues of worker liability, reimbursement, development and operation of alternate care sites, and surge plan templates for healthcare facilities and communities.[10]

The U.S. national planning effort has identified medical surge as one element of a Target Capabilities List.[11] The list, a companion to the U.S. National Preparedness Guidelines,[12] is contained within guidance from the Department of Health and Human Services, Office of the Assistant Secretary for Preparedness and Response (known as "ASPR"). ASPR provides resources to eligible jurisdictions for medical surge capacity and capability to support, but not supplant local jurisdictions. Department of Health and Human Services also houses the Centers for Disease Control and Prevention (CDC), Public Health Emergency Preparedness Cooperative Agreement Program.

The Target Capabilities List is intended to cross-reference capabilities in the health and medical arena. The list of health and medical capabilities is not all inclusive; this can lead to critical points of failure when it is used as a sole planning document. The CDC and ASPR programs provide funding linked to surge capacity planning. The original U.S. Hospital Preparedness Program (HPP) focused on increasing hospital surge capacity by 500 beds per million population. The 2007 HPP identifies priorities associated with bed tracking, medical evacuation and facility management, rapid distribution and administration of medical countermeasures, effective utilization of mobile medical assets, interoperable communications systems, advanced registration of volunteer healthcare professionals, fatality management, alternate care sites, and decontamination and personal protective equipment.

The programs provide funding linked to objectives; however, the measurement of the objectives is highly subjective. The 2007 HPP provided funding of $415,032,000 to eligible jurisdictions[13] and the CDC awarded more than $896,000,000 for public health preparedness to improve national preparedness and strengthen medical surge and mass prophylaxis capabilities.[14] The public health emergency preparedness focus was on chemical events, laboratory readiness, improved coordination of public health and medical services, increasing proficiency of volunteers, and increasing the numbers of skilled and experienced physicians.

In 2004, the U.S. Government Accountability Office reported that public health response capacity was improving but much remained to be done.[15] To date, limited evidence-based data exist to determine whether the large amount of money expended in an effort to improve U.S. capabilities related to public health emergencies represent an investment that will improve outcomes.

Barbisch and Koenig describe a comprehensive approach to providing appropriate capacity or capability that takes into consideration the required supplies and equipment (stuff), the personnel (staff), and the physical space and management system (structure) to form a Surge System.[16] The system must be developed with evidence-based practice guidelines to achieve a seamless and scalable capability that will optimize outcomes in any given scenario whether of short or prolonged duration.

## Defining Surge Capacity

The complexities surrounding surge capacity start with the myriad of definitions related to medical surge. In its broadest context, *Webster's* dictionary defines surge as "a sudden rise to excessive or abnormal value." Capacity is defined as the "facility or power to produce, perform, or deploy capability." In its generic form, it can be said that surge capacity is the ability to rise suddenly to an excessive or abnormal value to produce, perform, or deploy a capability. Surge definitions have evolved from a number of different perspectives. Surge can be defined relative to a practice setting, such as hospital, laboratory, emergency department, home health, and so forth; event type, such as blast, chemical, pandemic influenza, and so on; or magnitude of the requirements, such as daily surge or disaster surge. Daily surge is encountered regularly in chronically crowded emergency departments and some would argue that it is a predictable and manageable event and therefore the term could be considered a misnomer.[17] Disaster surge involves complex issues not encountered in daily situations. Disaster surge requires a shift from focus on best outcomes for the individual patient to a population-based best outcomes model.[18] Medical surge, in general, refers to an increase in patient flow above the norm and is characterized by an imbalance between resources and needs.

Kelen and McCarthy define surge as "a sizable increase in demand for resources compared with a baseline demand."[19] Related to healthcare, surge implies this increase in demand is for medical or public health resources. In addition to influx (volume rate), surge is further composed of the following components: event (type, scale, and duration) and resource demand (consumption and degradation). They define surge capacity as "the maximum potential delivery of required resources, either through augmentation or modification of resource management and allocation." Barbara et al., describe a tiered system of surge capacity focused on geographical integration. Barbara's model differentiates between capacity and capability, identifying capacity as the ability to evaluate and care for a markedly increased volume of patients that exceeds normal operating capacity, and capability as the ability to manage patients requiring unusual or specialized medical evaluation or care.[20]

The U.S. Targets Capability List defines medical surge as "rapid expansion of the capacity of the existing healthcare system in response to an event that results in increased need of personnel (clinical and non-clinical), support functions (laboratories and radiological), physical space (beds, alternate care facilities) and logistical support (clinical and non-clinical equipment and supplies)."[21]

The California Department of Public Health describes healthcare surge by stating that following a significant emergency or circumstances, "the healthcare delivery system has been impacted, resulting in an excess in demand over capacity in hospitals, long-term care facilities, community care clinics, public health departments, other primary and secondary care providers, resources, and/or emergency medical services."[22]

The multitude of efforts to define medical surge is indicative of the challenges in describing a comprehensive approach to managing the overwhelming medical needs in an escalating event. The common element in existing definitions refers to patient care needs exceeding medical and health resources at a

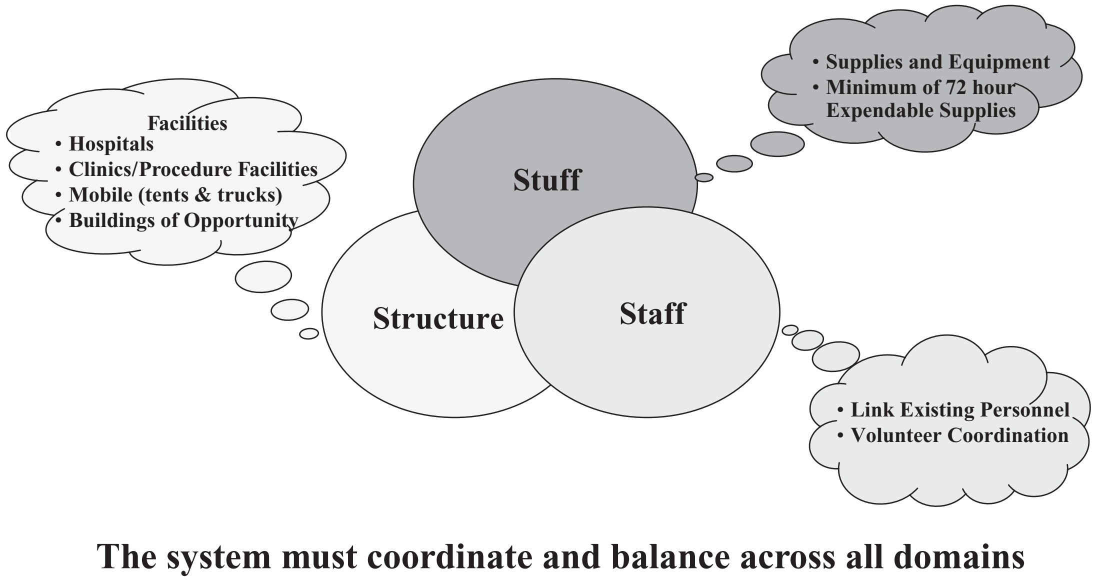


Figure 3.3. S-3 Surge System logistics management challenges.

given point in time. What is left to be determined is a consensus on how to meet those needs.

## CURRENT STATE OF THE ART

### Prepared for What?

In developing a resilient strategy to manage healthcare surge, the first objective is to gain an understanding of "prepared for what?" Because of the variety of events that could require a rapid increase in healthcare resources, it is critical to develop a comprehensive approach to "what" needs the preparations address. If the definition of "what" is limited to individual care associated with a specific event, or a specific capability, there is a risk of increasing capacity in one area and unintentionally disabling capacity in another as the event evolves. Consider a hospital plan that redirects home health staff into the hospital to increase the hospital's capacity to manage individual care. Although the shift in personnel may increase the in-hospital care capacity, if the needs continue to rise and the hospital must discharge patients to home healthcare, the overall system's patient care capacity will be reduced due to insufficient numbers of personnel working in the home health environment. Planning for one area without consideration of the impact in another area creates critical points of failure that reduce overall healthcare system surge capacity. The planning must be comprehensive, community based, and coordinated at the regional, national, or international level depending on the type and size of the event.[23] Hence the "what" can be defined as optimizing a population-based best outcome, scalable system.

### Outcomes-based Planning

A lack of consensus exists on what is or what should be measured and what "population" is being served. Evidence-based data on the efficacy of proposed solutions to prepare for peak events at all levels (local, regional, national, or international) are incomplete. How can it be determined that plans will achieve the goals? Is the purchase of ventilators or a list of volunteers an adequate measurement of medical surge? It is not how much equipment is available, but rather how well the population is served that must be measured. Is it best outcome for the patient, the provider, the institution, or the population as a whole? The objective in medical surge must be best outcomes for the entire population.

Outcomes-based planning is a multidimensional process that starts with an accurate assessment of overall surge requirements, a realistic measurement of overall capability and capacity, and the potential impact to the overall system as a result of the interventions. Identifying the type of patient care required is not enough. A determination of how much care will be needed and how quickly it must be provided to be effective must be contrasted with what can reasonably be accomplished considering the available resources. Once the needs are identified, the timeline of delivery is critical and must match the rapidly escalating requirements.

Because surge capacity can be applied to numerous diverse scenarios with overwhelming requirements in both impact and complexity, solutions must transition from individual-based best outcomes to population-based best outcomes as limitations in resources escalate. Triggers to shift from an individual patient to a population-based focus are ill defined. Furthermore, in a prolonged event such as a pandemic, there may be multiple shifts back and forth between baseline operations and periods of time when allocation of scarce resources demand a population-based approach.

Koenig and Backer coined the term "crisis standard of care" to describe the clinical practice in the setting of a catastrophic disaster.[24] The shift to improving population-based outcomes occurs when healthcare needs exceed currently available resources. The mismatch occurs when any of the 3Ss of a surge system (staff, stuff, and structure) are insufficient (Figure 3.3). The lack of, or limited numbers of, qualified personnel (staff) in public health and specialty service (e.g., trauma, burn, or surgical services) or generalists in large-scale events can impact surge capacity. Limitations in surge capacity may be due to supply or equipment (stuff) shortages such as specific antidotes, respiratory equipment, or monitors. The mismatch can also be due to limitations in the physical space available for patient care and related services (structure) such as the number of functional hospitals or alternate care sites in an area, the capacity of the laboratory infrastructure to process specimens, or the mismatch of facilities designed for specific needs such as critical care or burn care, or nonacute and long-term care facilities. The most critical element is the system itself, which is used to manage all of the resources. Ventilators without personnel to operate them or a mass care arena without pharmaceutical support lack the ability to improve outcomes. Effective surge capacity requires a systems approach and a process to transition between differing surge numbers and complexity levels.

Given the interdependency of the various elements of the healthcare environment, a significant challenge exists. A rapid increase in demand superimposed on existing healthcare shortages, just-in-time inventory, projected breakdowns in the supply chain, personnel shortages and capability mismatch, and the dire consequences of limitations in healthcare make the concept of healthcare surge capacity extraordinarily complex. If not considered, these interdependencies can lead to critical points of failure resulting in a total systems breakdown. Proposed solutions in one area often create cascading untoward effects in other practice settings or parts of the surge system. Surge concepts are generally defined relative to the needs of a specific practice setting such as a hospital or the public health community, or specific elements within those communities: emergency departments, intensive care settings, home health, hospice, and so forth. Other surge concepts have been developed relative to the type or cause of injury or illness, for example trauma, burn, and infectious diseases. If uncoordinated, multiple entities can be competing for the same resources rather than complementing each other.

Consider the assumptions used to decide where to manage a critical care patient when both the emergency department and the critical care unit of a hospital are filled to capacity. There is an understanding in both environments that the patient will not get optimal care if the appropriate stuff, staff, and structure are unavailable and if the system is not coordinated to provide all of the patient's necessary services. In some cases, patients are placed in hallways without essential requirements while awaiting appropriate care environments. The practice begs the questions: Which environment will create the best outcomes for the patient, for the other patients, for the staff, and overall for the hospital? Depending on the goal, the answer may change. In a true scarce resource environment, the goal will be to optimize outcomes for the entire population of patients rather than for each individual patient.

Challenges associated with complex issues that have incomplete, contradictory, and changing requirements can be characterized as "wicked problems."[25] Defining best outcomes in wicked problems requires understanding the environment and assumptions of all stakeholders, acceptance of differing perspectives, and a comparison of the impact of actions that may not be optimal for each individual stakeholder, but deliver best outcomes for the community at large. Using the wicked problems approach, enduring processes can be developed to link the seemingly disparate influences in the health and medical environment with the desired outcome.

### Assumptions in Surge Capacity Planning

Contributing to the challenges in developing evidence-based planning are commonly held assumptions in healthcare such as that the number of hospital beds is a reflection of capability or that stockpiling ventilators is a measure of readiness. Beds and ventilators are important elements of the "stuff" component of the 3S Surge System; however, equipment does not take care of patients by itself.

Some experts suggest that field and mobile hospitals are too little, too late and cost ineffective because they arrive from 2 to 5 days after impact, well after the last casualties are evacuated in sudden impact disasters.[26] Additional reports indicate that field hospitals may undermine efforts to restore services to baseline because they divert staff, supplies, and patients away from regular services in the aftermath of the disaster.[27] Any plan to use field hospitals should clearly identify the types of services provided as well as the time required before the capability is operational. In addition, these resources should be as self-sufficient as possible so as not to drain resources from existing local supplies. Operational plans must also specify at what point the field hospital mission will be completed because it is often uncertain when to withdraw these outside resources, particularly if their presence has provided a higher level of care than the affected population was receiving at baseline.

Measuring capacity and capability requires a review of the continuum of healthcare and the throughput of patients from the time they enter the healthcare system until they are no longer in need of care. It is incorrect to assume that if there are sufficient hospitals or hospital beds, the healthcare system is prepared. Projections for pandemic influenza suggest 30% of the U.S. population will be ill; 50% of those will need outpatient services; more than 10% will require hospitalization; 1.6% will require intensive care; 0.8% will require mechanical ventilation; and 2% will die.[28] Historical data from 1918 suggest the majority of illnesses will occur in a 1-month period. Figure 3.4 provides the numbers for a 1918 and a 1957-like pandemic. Several questions arise. What is "hospitalization" if hospitals are not available? How many victims will actually receive hospital care? If not managed in a hospital, where will care take place? Who will provide the care? Will appropriate triage occur to dedicate scarce resources to those who are expected to live? If not, will more suffer and die?

Using assumptions that not only project level of care but correlate the level of care with what will realistically be available is critical. Data on the influenza pandemic of 1918 within the U.S. show that the death rate escalated from 14/1,000 to 44/1,000 in October. It then immediately declined to 24.9/1,000 in the following month, returning to nearly baseline in less than 2 months (Figure 3.5). With a surge in requirements of the magnitude seen in the 1918 pandemic, traditional healthcare will be unavailable. Planning therefore should address how to optimize patient outcomes by using nontraditional care.

Finally, developing realistic planning focusing on the number of lives that can be saved or the impact on positive outcomes is critical. The assumption that everyone can be saved is false. People will die in catastrophic events. The focus should be on maximizing lives saved and minimizing morbidity given the available resources. Resources should be directed to the portion of the population who, with appropriate intervention, has the most likely chance for recovery. Plans must be not only theoretical, but based in reality.

## DYNAMIC CAPABILITIES IN SURGE CAPACITY

### Defining Surge Requirements

Defining evolving requirements is critical when managing an event. Several predictive models can assist planners in describing

## Medical Planning Assumptions

**Population: 1,000,000**

- **50% of ill persons will seek medical care***
- **Hospitalization and deaths will depend on the virulence of the virus**

| | Moderate (1957-like) | Severe (1918-like) |
|---|---|---|
| **Illness** | **300,000 (30%)** | **300,000 (30%)** |
| **Outpatient medical care** | **150,000 (50%)** | **150,000 (50%)** |
| **Hospitalization** | **3,000** | **30,000** |
| **ICU care** | **429** | **4,800** |
| **Mechanical ventilation** | **216** | **2,400** |
| **Deaths** | **996** | **6,000** |

* CDC

Figure 3.4. Medical Planning Assumptions.

the magnitude of the event. The Humanitarian Assistance in Disaster Situations: A Guide for Effective Aid recommends all countries should give high priority to the preparation of their own health and medical personnel to respond to the emergency needs of the affected population and that regional coordination planning should be a priority.[29] The first step in planning is to define projected needs or requirements. The following models provide communities with the ability to project needs.

### THE HOSPITAL SURGE MODEL

The Hospital Surge Model estimates the hospital resources needed to treat casualties arising from biological (anthrax, smallpox, pandemic influenza), chemical (chlorine, sulfur mustard, or sarin), nuclear (1 KT or 10 KT explosion), or radiological (dispersion device or point source) attacks.[30]

### PANDEMIC INFLUENZA ESTIMATE MODEL

FluSurge is a spreadsheet-based model which provides hospital administrators and public health officials estimates of the surge in demand for hospital-based services during an influenza pandemic. The FluSurge model estimates the number of hospitalizations and deaths from an influenza pandemic (whose length and virulence are determined by the user) and compares the number of persons hospitalized, the number of persons requiring intensive care, and the number of persons requiring ventilator support during a pandemic with existing hospital capacity.[31]

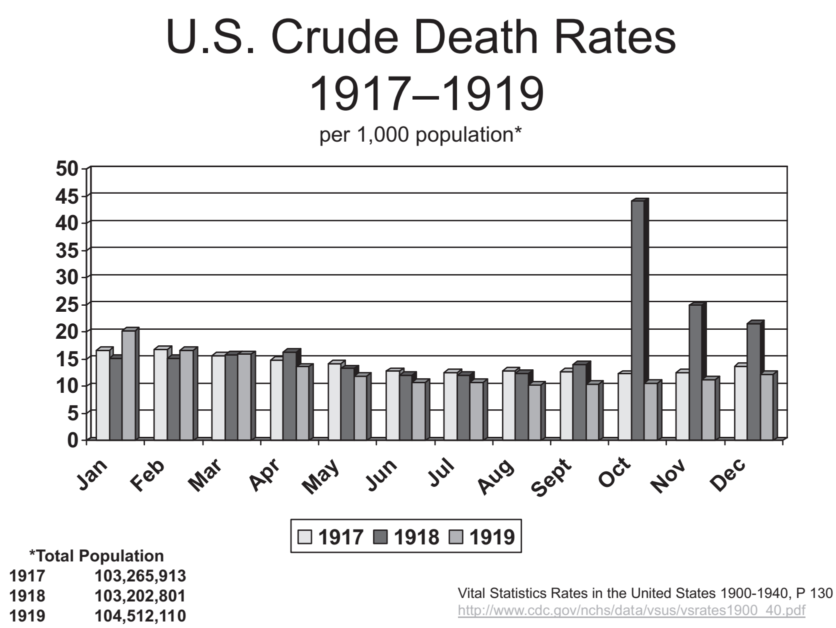


Figure 3.5. U.S. Crude Death Rates 1917–1919.

#### MASS EVACUATION TRANSPORTATION MODEL

The Mass Evacuation Transportation Model is designed for use before a mass casualty event or disaster to estimate the time required to evacuate patients and other evacuees from healthcare facilities and other locations and transport them to receiving facilities.[32]

At the international level, most programs focus on the coordination of resources at the local area of the disaster or those flowing into the impacted region. The United Nations' International Search and Rescue Advisory Group provides guidance relative to assets such as country specific Urban Search and Rescue teams.[33] Several evaluation tools exist. These include the Global Disaster Alert and Coordination System, a joint initiative of the United Nations and the European Commission. This system provides near real-time alerts about disasters around the world and tools to facilitate response coordination, including media monitoring, map catalogues and a Virtual On-Site Operations Coordination Center.[34] The Pan-American Health Organization supported the development of a Supply Management System database to facilitate the receipt, inventory, classification, and rapid distribution of key humanitarian supplies and equipment such as medicines, food, clothing, and blankets.[35]

While these templates exist, most have not been validated with respect to time sensitive delivery of resources. In many cases, the time to mobilize outside assistance exceeds that necessary to have a positive survival benefit and resources intended for response do not arrive until the recovery phase. Further research is required to develop evidence based approaches to identify which actions will deliver capability and capacity in an effective and timely manner.

According to the London Regional Resiliency Flu Pandemic Response Plan, the UK Department of Health will initiate a national 'FluLine' with access to algorithms that can assist in identifying protective actions for the general public. The UK plan advises symptomatic people to remain at home and "self care." The logistical support for managing self care in the home is not identified. Primary Care Trusts (PCTs) mobilize general practitioner and primary care resources supporting and monitoring the development of integrated health response arrangements, specifically antiviral collection points, the management of excess deaths, and social issues. The PCTs are also responsible for developing arrangements to maintain and support patients in a community setting and for ensuring that health plans account for the needs of vulnerable populations, closed communities such as care homes, military bases and prisons and other establishments that may require special planning.[36]

Within the US, many templates exist that primarily focus on the provision of necessary staffing, supplies, equipment and pharmaceuticals coupled with the structure and processes to integrate requirements to support a large scale disaster response. Due to their closer proximity, local and state resources will arrive to the disaster region before national assets. However local resources are limited and may be depleted by the event itself. This highlights the critical need for contingency planning. Local planners must recognize the need to meet surge requirements without the benefit of outside resources for a minimum of 72 hours. Examples of the type of planning and the resources available can be broken down into local, regional, national, and international efforts. The following are sample initiatives from the US system. Portions of these models may be applied to global preparedness efforts depending on country-specific resources and conditions.

## Local Surge Planning and Coordination

### *Metropolitan Medical Response System*

The Metropolitan Medical Response System (MMRS) is a locally managed emergency preparedness and response system that is integrated into state and federal programs. It is active in over 120 of the largest metropolitan regions in the United States. Originally formed in 1996 in the wake of the 1995 Oklahoma City bombing and the Tokyo Sarin gas attacks to focus explicitly on the traditional first responder approach to biological and chemical terrorist events, the program has evolved to be inclusive of all response disciplines, and has become a useful adjunct for support of surge capacity planning in local jurisdictions. The federal government provides funding linked to comprehensive plan development which is evaluated through a series of community wide exercises. These focus on medical surge response, mass prophylaxis distribution, chemical/biological/radiological/nuclear (CBRN) and other hazardous material responses and decontamination, medical supplies management and distribution, emergency public information and warning, interoperable communications, isolation and quarantine, fatality management and information sharing and collaboration. The MMRS integrates emergency response partners within communities and their surrounding regions to develop the collaboration that is critical in events of significant magnitude. Many MMRS communities have stores of personal protective equipment and caches of pharmaceuticals oriented towards CBRN response that complement other stocks of supplies and equipment. In summary, "the Metropolitan Medical Response System (MMRS) program assists designated localities to develop and maintain plans, conduct training and exercises, and acquire pharmaceuticals and personal protective equipment to achieve the enhanced capability necessary to respond to a mass casualty event during the first crucial hours of such an event, until significant external resources arrive and become operational."[37]

An expansion model related to the MMRS was initiated in Washington DC in 2007 designed to provide the tools to manage multiple capabilities within the region and identify timely integration of capabilities. The Seamless Emergency Medical Logistics Expansion System (SEMLES) established a program within the DC Department of Health to translate concepts into an integrated operational reality. The model provided a cost effective and integrated approach to synchronize parallel systems to create critical surge capacity for rapid and sustained response. The process requires extensive inter-organizational collaboration in assessing existing medical emergency capability, projecting needs in a variety of disasters and catastrophic events, and analyzing capability gaps. The program established a hub within the Department of Health to link resources into a modular expansion capability as needs grow. Regardless of the resource: prehospital, hospital; non-hospital healthcare; health related; or infrastructure support; SEMLES enables connectivity to optimize capability. It builds on MMRS to integrate all existing local, regional, and federal programs. Despite inevitable organizational, financial and political obstacles, SEMLES coordinates and synchronizes programs to provide a template to optimize surge capacity[38] (Figure 3.6).

### *Alternate Care System Development: The Stratification of Care Model*

Increasing attention has been given to the need to broaden surge capacity planning to include the full spectrum of patient

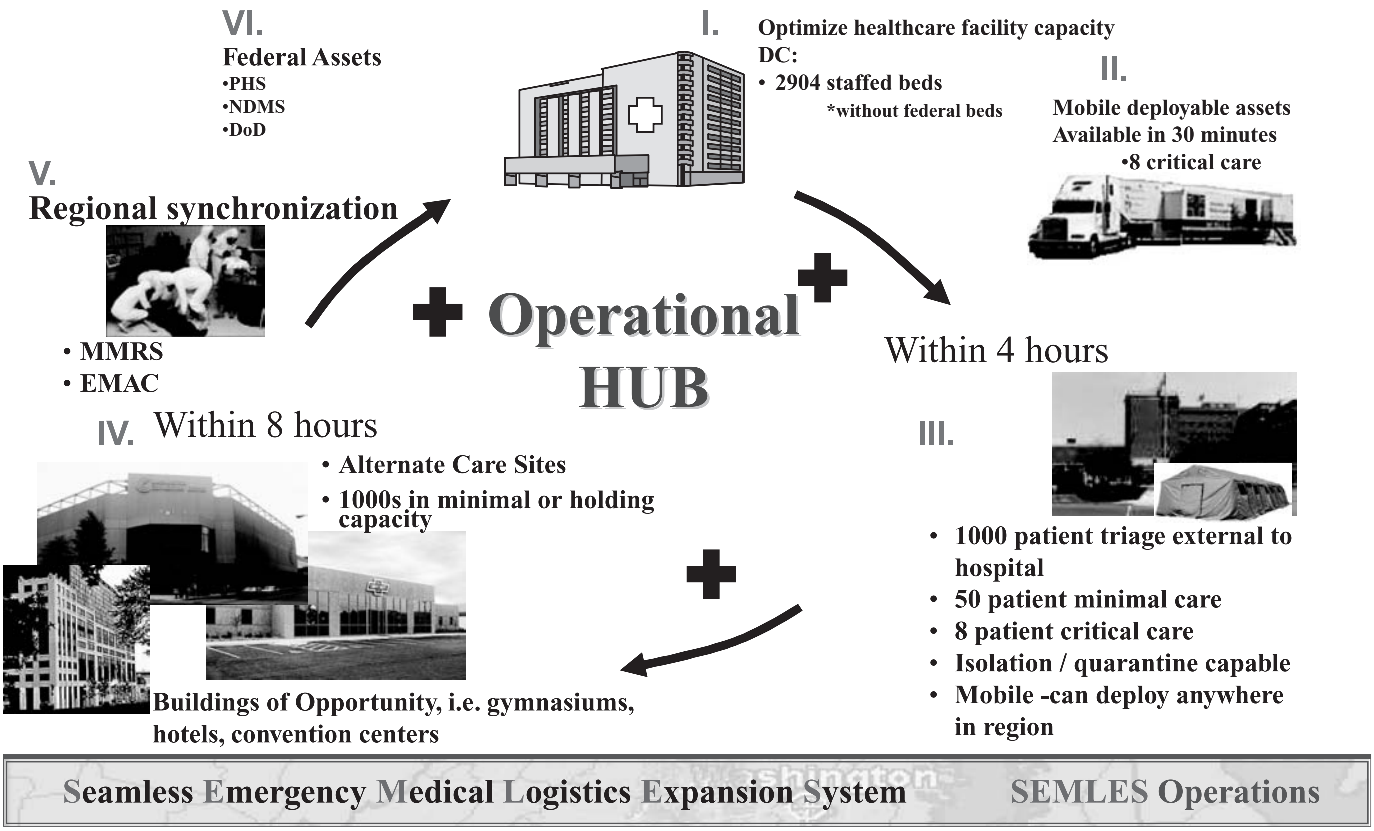


Figure 3.6. Modular/Phased Immediate and Sustained Capability.

care delivery capabilities in a disaster impacted community. Much of this work started with a focus on alternate care facility planning for extension of hospital-like services in an unregulated, non-healthcare setting. Examples include the establishment of Federal Medical Shelters (FMS) in the US during the responses to the multiple Florida hurricanes in the summer of 2004, Hurricanes Katrina and Rita (2005) and Hurricanes Gustav and Ike (2008). The initial concepts for such planning came from work conducted by the US Army Soldier Biological Chemical Command (SBCCOM), Biological Warfare Improved Response Program (BW-IRP) in the late 1990's. These efforts focused on a combination of out-of-hospital capabilities divided between Neighborhood Emergency Help Centers (NEHC) and Acute Care Centers (ACC).[39,40] The NEHC is intended to function as a community care station that provides functions including victim triage and distribution points for medical countermeasures. The ACC, similar to the FMS concept, serves as an out-of-hospital medical treatment facility for lower acuity patients not requiring a hospital critical care setting, but not well enough to be managed at home. Additional work in this arena continues to evolve, focusing on the spectrum of care delivery options and broadening the focus to a stratification of care model as elucidated in the *Mass Medical Care with Scarce Resources: A Community Planning Guide* publication in 2007.[41] Pandemic influenza planning has galvanized many communities to adopt such an approach to surge capacity planning, largely based on this theoretical framework.[42]

The US CDC adopted the framework for surge capacity planning, emphasizing the importance of coordinating public health and healthcare related planning for pandemic influenza under the umbrella of a Community Alternate Care Site (ACS), comprised of community partners who are essential to delivering care in the setting of a surge response to disaster (Table 3.1). The components of an ACS are built around the stratification of care model, with an important emphasis on developing consensus based community wide agreement on the use of triage algorithms, particularly those that relate to the ethical and legal implications of allocating scarce resources in a disaster event.

### *Healthcare Facility Surge Capacity*

The implementation of surge capacity strategies in healthcare facilities requires a graded approach using a variety of strategies. There are a number of steps that healthcare facilities can take to expand capacity over discrete time frames. There are several steps that can be taken to augment the delivery of care for an increased volume of high acuity patients. Space to deliver care, clinical staffing availability, and the critical use of supplies must all be considered. A continuum of surge capacity implementation may be subdivided into conventional, contingency and crisis surge implementation.[43] In turn, these respective levels of surge will be accompanied by an equivalent conventional, contingency or crisis care process to maintain the standard of care. Such an approach is based upon the recognition that not all disaster events will require the same degree of response, thus requiring a scaled approach to surge capacity implementation in the hospital. Examples of methods to support conventional care that are outside the normal operations of daily patient care delivery

**Table 3.1: Community Alternate Care Site Partners**

| |
|---|
| Ambulatory Surgical Centers |
| Call Centers |
| Emergency Departments |
| Emergency Management |
| Emergency Medical Services |
| Faith Based Organizations |
| Home Health Agencies |
| Hospice Agencies |
| Hospital Administration |
| Law Enforcement |
| Legal Counsel |
| Local Government |
| Long Term Care Facilities |
| Medical Examiners Office |
| Non Profit Organizations |
| Pharmacies |
| Private Community Physicians |
| Public Health Department |
| Schools and Universities |
| Special Needs Agencies |
| Urgent Care Centers |
| Veterans Affairs Health Centers and Community Based Outpatient Clinics |

include doubling of beds in single patient rooms and canceling elective surgical procedures. The other end of this spectrum, the delivery of crisis care, might involve the placement of patients in non-conventional treatment settings. In order to maximize the level of care delivered in a crisis care environment, there are a number of steps that can be taken to prepare to manage an influx in patients requiring critical care services.[44,45,46] Within the context of a surge response to a disaster event, the delivery of "emergency mass critical care" takes place in a crisis care environment. The pool of available critical care resources is limited by the disaster event, or because the total number of patients requiring such care exceeds that capacity that is normally available. A deliberate framework for planning to care for patients under these circumstances must be developed prior to the onset of an event. The framework must contain clearly delineated plans for the stepwise expansion of critical care services outside of the normal intensive care setting. These services must provide the highest level of care that can be sustained over an extended period of time. Essential components of emergency mass critical care include the use of mechanical ventilation; the administration of intravenous fluids, vasopressors, medications to treat specific disease conditions, and adequate sedation and analgesia; and other select practices that are known to reduce the adverse consequences of critical illness. Some experts recommend that hospitals with intensive care units should prepare to deliver such care for a daily critical care census that is three times their usual capacity, for up to 10 days of care delivery. Further research is necessary to validate this recommendation.

### Examples of Local Level Resources and Tools

#### *Hospital and Healthcare Facility Surge Options*

Hospitals and other healthcare facilities must have plans to expand their capacity to manage a surge in the number of patients needing care during a disaster. The California Department of Public Health developed a comprehensive program of standards and guidelines, operational tools, and training materials to facilitate planning for healthcare surge.[47] Figure 3.7 reflects basic requirements for staffing when establishing an Alternate Care Site.

The US-based Joint Commission identified the following examples as options for consideration.[48] Detailed planning is required to integrate the comprehensive stuff, staff and structure to meet standard of care requirements in crisis care.

##### SHUTTERED HOSPITALS

Hospitals that have been closed may offer an option for surge capacity. The process of opening a facility that has been closed requires considerable attention to environmental safety. Planning is critical as the cost of improving the facility may be more than the cost of replacement. Recently closed facilities offer the most viable expansion solutions.

##### FACILITIES OF OPPORTUNITY

"Facilities of opportunity" are nonmedical buildings that can offer healthcare facility surge opportunities. Examples include veterinary hospitals, convention centers, exhibition halls, empty warehouses, airport hangars, schools, sports arenas, or hotels. Considerations such as staffing, ease of patient care, sanitary facilities, and food service should be considered. Facilities such as day surgery centers and other existing healthcare facilities may provide options for expansion with minimal cost and effort.

##### MOBILE MEDICAL AND PORTABLE FACILITIES

Mobile and portable facilities build on the military model of independent hospital facilities. Many models exist commercially that may offer expansion capability. As with other options, a cost benefit analysis along with assessment of the ability to deliver care in a timely manner is critical in developing the capability.

In 2007, the state of California engaged in a program to develop three mobile field hospitals designed to provide surge capacity of 200 beds each within 72 hours after activation.[49] The program provides facilities and an equipment package designed to maintain operations for 72 hours. Personnel are organized from existing resources within California. Each Mobile Field Hospital includes emergency/triage facilities, an operating room with two suites, two Intensive Care Units with a total of 20 critical care beds, 180 ward beds, mobile radiology, laboratory and pharmacy supply units. Locations for the care of special patient populations include pediatric care units, obstetrics/gynecology units, orthopedic and neurology units and a negative pressure isolation ward for highly contagious patients. The units require contractor support to maintain operations such as food services, potable water service, waste water removal, trash removal, medical waste removal, showers, toilets, laundry facilities, oxygen

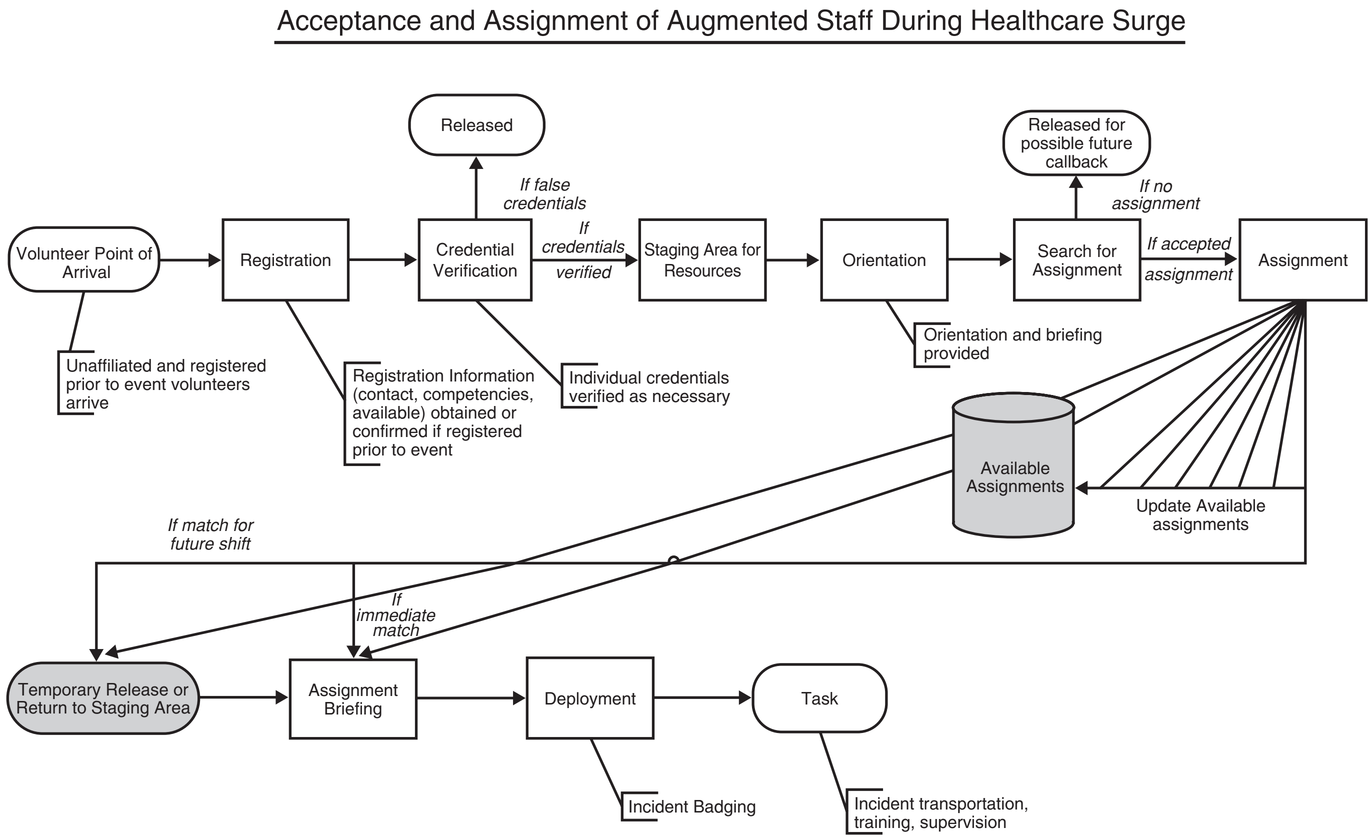


Figure 3.7. Considerations for Staff Support.

cylinder refill service and fuel delivery service for power generation systems. The program was designed to support services as needed to restore or replace available hospital capability during a disaster or public health emergency.

### *Local Staff Support Options*

Staffing for surge capacity presents many challenges. Uninvited but well-meaning volunteers may converge on the disaster region. Often there is no plan to integrate these spontaneous volunteers into the local command and control structure and their management consumes resources that were programmed for the response. In addition to anticipating this group of volunteers, a better approach is to establish systems to coordinate volunteer resources prior to rather than during an event. Even with pre-event initiatives, there are difficulties related to confirming current qualifications, identifying sufficient providers who are not already committed to other responsibilities, and compliance with existing country-specific regulations. For example, in the US, multiple entities may have requirements for credentialing personnel including states and local healthcare facilities. These initiatives are focused on identifying health personnel who may be mobilized to help support the surge in demand for patient care service delivery. State based registry systems are being established under the Emergency System for Advance Registration of Volunteer Health Professionals (ESAR-VHP) program. Additional federal resources are being developed within the Medical Reserve Corps (MRC) program to identify local volunteers in the medical and public health arenas who can contribute their skills during times of disaster response. Nevertheless, significant controversy surrounds credentialing and management of volunteers. For example, Schultz and Stratton argue that all of the currently available credentialing options have serious limitations that would make it difficult for hospitals to use the health care workers provided by such entities. Most of these systems require significant time to activate and implement. In addition, they don't all provide volunteers with skill levels that hospitals can utilize. Hospitals require highly trained professionals within hours of a disaster. These two authors suggest a hospital-based credentialing system that is shared among local facilities within one jurisdiction. All credentialed healthcare providers at each hospital are listed in a database and this information is distributed to all facilities. Immediately after a disaster, hospitals can consult the database to verify the credentials of volunteers in the area. This system would permit rapid credentialing of qualified volunteers in the first hours and help to maintain hospital function.[50]

Expanding scope of practice under disaster conditions is another option under development. The State of California is developing guidance with the support of professional member organizations to identify professional skills sets that could be used during crisis care to expand capability in resource constrained environments. For example, State of California paramedics are trained to give injections, but not normally permitted to administer vaccinations. If regulatory relief and training were provided, prehospital personnel could assist with mass vaccination programs during exposures and outbreaks.

State Medical Assistance Teams are also being developed across the US to provide support within states rather than deploying to other states as has been the traditional focus. Mutual aid agreements may allow these resources to deploy to other states with approval of State leadership.

STATE MEDICAL ASSISTANCE TEAM (SMAT)

The North Carolina State Medical Response System developed a deployable State Medical Assistance Team (SMAT). Their level one team is designed to provide medical care in disasters or during special events, deploy a 150-bed alternate care facility, support a Strategic National Stockpile receiving site, establish drug distribution and immunization sites and establish a field medical station capable of treating 250 patients within a twenty-four hour period. The team deploys with 12 to 54 members depending on the requirements of the emergency.[51]

CalMAT TEAMS

California Medical Assistance Teams (CAL-MAT) are a state of California volunteer resource designed to respond across California during a state of emergency. California has three teams designed to deploy within 12 hours of notification and operate without resupply for 72 hours.[52]

### Regional Support

#### *Emergency Management Assistance Compacts*

Another important source of surge response within the US is that provided by formal State to State requests and offers of support. After the delays in delivery of assistance experienced during Florida's Hurricane Andrew in 1992, the Southern Governors Association created a mechanism by which states could assist one another in times of disaster. This was the origin of the Emergency Management Assistance Compact (EMAC), a congressionally ratified organization that provides form and structure to interstate mutual aid. Through EMAC, a disaster impacted state can request and, when approved by the providing state, receive assistance quickly and efficiently. These process resolves two key issues: liability and reimbursement.[53] EMAC is a model that illustrates how to manage the response at the lowest level possible. It provides a process to request personnel and equipment more quickly that may be available through Federal programs.

#### *Medical Reserve Corps*

The MRC is a community-based program developed by the US federal government. It is designed to organize and engage volunteers to prepare for and respond to emergencies. The MRC supplements existing emergency and public health resources. The MRC identifies specific, trained, credentialed personnel and prepares them to respond to local disasters.[54]

### U.S. National Planning for Surge Capacity

#### *National Disaster Medical System*

The National Disaster Medical System (NDMS) is a nationally driven, top down program designed to provide resources to local jurisdictions upon their request, in the event of a disaster. It was established in 1984 as a partnership between the Departments of Defense, Veterans Affairs, Health and Human Services, Federal Emergency Management Agency, and private hospitals. The program evolved from the Contingency Hospital System designed to provide medical care for military personnel returning from overseas conflicts. Originally focused on transport of patients and bed capacity at definitive care sites, the program expanded in 1997 to include deployable teams designed specifically for domestic emergency medical response. Lead responsibility resides in Department of Health and Human Services. The Homeland Security Act of 2003 transferred oversight for the NDMS to the Department of Homeland Security, however this authority was transferred back to the Department of Health and Human Services by the Pandemic and All Hazards Preparedness Act of 2006.[55]

NDMS constitutes the primary federal response mechanism for management of mass casualty events in the United States, with focus placed on three discrete areas of response (Chapter 9). The first is the provision of deployable teams designed to provide basic emergency healthcare support in the disaster affected area. The teams mobilize under federal authority to provide support as requested.[56]

The second component of NDMS is that related to patient transport and the provision of medical evacuation out of a disaster affected area. Transport management and coordination is a responsibility of the Department of Defense with the assistance of the Department of Veterans Affairs. This includes communicating onsite organization, coordination and transportation of evacuated patients from a mobilization center near the incident site (e.g., a designated airport facility) to a reception site (e.g., an airport in a non-affected region of the country). DoD (USTRANSCOM) estimates that dedicated assets will be able to transport 81 critically ill or injured patients over a 54-hour timeframe. A Civil Reserve Air Fleet (approximately 1400 aircraft including 45 Boeing 767s) provides additional transportation support. The conversion of civilian aircraft to a configuration capable of supporting the transport of disaster casualties takes a minimum of 60 hours. Additional private sector assets are under contract to assist in patient evacuation including those provided by the HHS private ambulance contract and the availability of approximately 800 civilian rotor wing assets.[57]

The third major component of NDMS is the provision of definitive care. About 1800 hospitals have signed agreements guaranteeing a minimal number of staffed and available beds for patient placement in the event of a catastrophic event requiring evacuation of patients out of a disaster stricken region. Theoretically, this provides a nationwide capacity for placement of approximately[58] 100,000 patients in unaffected regions of the US. For a widespread disaster that extends beyond a region or State or one that involves contagious or contaminated patients who cannot readily be transported to remote areas, this system would be problematic.

#### *National Disaster Medical System Teams*[59]

Table 3.2 contains a list of NDMS teams. A snapshot of capability of the most common teams includes:

DISASTER MEDICAL ASSISTANCE TEAM (DMAT)

DMATs are the basic team of the NDMS. As of 2009, there are 55 DMATs located across the United States, although only 24 are deemed to be operational, with demonstrated ability to deploy between 6 and 12 hours after activation. They are expected to arrive on site within 48 hours and maintain operations for 72 hours without resupply. Teams consist of 35 people who are capable of providing primary and acute care, triage,

**Table 3.2: National Disaster Medical System Response Teams**

| |
|---|
| 55 Disaster Medical Assistance Teams (DMATs) |
| 4 National Medical Response Teams (NMRTs) |
| 5 Burn Teams |
| 2 Pediatric Teams |
| 1 Crush Medicine Team |
| 3 International Medical/Surgical Teams (IMSuRTs) |
| 3 Mental Health Teams |
| 3 Veterinary Medical Assistance Teams (VMATs) |
| 11 Disaster Mortuary Operational Response Teams (DMORTs) |
| 1 Joint Management Team (JMT) |
| 3 Nurse/Pharmacist National Response Team |

initial resuscitation and stabilization, advanced life support and preparation of sick or injured for evacuation. DMAT members are capable of providing ambulatory care for up to 250 patients per 24-hour mission cycle, with limited laboratory point of care testing and bedside radiology services. They have the means to stabilize and hold 6 patients for extended treatment for up to 12 hours, and can support an additional 2 critical care patients for up to 24 hours. They can provide sustained ward care for 30 non-critical inpatients at NDMS designated facilities, and can augment staffing at alternate care facilities and assist with mass medical countermeasure distribution.[60]

#### Disaster Mortuary Operational Response Team (DMORT)

DMORTs provide technical assistance and support for recovery, identification, and processing of deceased victims. Teams include medical examiners, coroners, funeral directors, pathologists, forensic anthropologists, medical records technicians and transcribers, fingerprint specialists, forensic odontologists, dental assistants, x-ray technicians, and other personnel. Stand-alone capability is available through Disaster Portable Morgue Units (DPMU).

#### Veterinary Medical Assistance Team (VMAT)

VMATs are designed to support veterinary services during disasters or emergencies. Their capabilities include support in assessing the medical needs of animals; medical treatment and stabilization of animals; animal disease surveillance; zoonotic disease surveillance and public health assessments; technical assistance to assure food and water quality; and animal decontamination. The teams are organized to support the specific event and include various members of the veterinary health management community.

#### National Medical Response Team (NMRT)

An NMRT is a 50-member specialized team designed to provide medical care following a nuclear, biological, or chemical incident. The team is capable of providing mass casualty decontamination, medical triage, and primary and secondary medical care to stabilize victims for transportation to tertiary care facilities in a hazardous material environment.

#### International Medical Surgical Response Team (IMSURT)

IMSuRTs are designed to support the US State Department. They were implemented in response to attacks directed against the US embassies in Nairobi, Kenya and Dar es Salaam, Tanzania in August 1998. IMSuRTs provide worldwide deployable medical and surgical treatment capability.[61] They are supposed to deploy within 3 hours of notification. IMSuRTs are the only NDMS team with surgical operating room capability designed to provide emergency surgery, treatment, and stabilization. They deploy with all necessary equipment but are not designed to function in austere environments.

### *Strategic National Stockpile*

The Strategic National Stockpile (SNS) is a program created in 1999 by the U.S. federal government designed to supplement and re-supply state and local governments with medical materiel supplies (Chapter 16). It contains antibiotics, medical supplies, antidotes, antitoxins, antiviral medications, vaccines and other pharmaceuticals. The SNS program coordinates governmental and non-governmental capabilities including the National Veterinary Stockpile, commercial business vendor managed inventory (VMI) process, and commercial carriers. The purpose is to integrate critical medical supplies for distribution in emergencies. The program also coordinates with the research and development community to acquire medical countermeasures for CBRN threats and to expedite access to drugs that are not commercially available for non-research purposes. The SNS maintains 12-hour push packs that are strategically located across the US near major transportation hubs as well as forward placed caches of chempacks that are integrated into local hazardous materiel response programs. A Technical Advisory Response Unit (TARU) is also available to support local authorities in receipt and coordination of distribution of the SNS. The SNS also maintains Federal Medical Stations designed to provide for 250 non-acute and special needs patients over three days. The medical stations increase in 50-bed increments and contain supplies for first aid, pharmaceuticals and housekeeping.[62,63]

#### Vendor and Stockpile Managed Inventory

In addition to the 12-hour push packages (Chapter 16), ventilators and vaccines, are stored and managed under a managed inventory program. This consists of either Vendor Managed Inventory (VMI) or Strategic Stockpile Managed Inventory (SMI). When specific supplies are known to be needed in order to support the medium to long term objectives of a disaster surge response, VMI or SMI will be used to supplement the initial shipments. VMI is maintained by the primary corporate vendor under contract with the federal government. VMI and SMI supplies are designed to arrive 24 to 36 hours following the initial receipt of the push packages. The process to request SNS assets requires a request from the affected state's public health authority through the governor's office to HHS. The request is evaluated and upon authorization will be released for shipment. HHS maintains authority for the SNS materiel until it arrives at the designated receiving and storage site where upon it is transferred to state and local authorities. State and local authorities will then begin the breakdown of the 12-hour Push Package for distribution. A Technical Assistance Response Unit (TARU), a team of medical logisticians, will deploy to assist state authorities in the breakdown and distribution of the stockpile.