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# Disasters: Introduction and State of the Art

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Fifteen years have passed since the last update on this topic was published in *Epidemiologic Reviews* (1) and 24 years since the first (2). In the intervening years, disaster prevention, mitigation, and preparedness have evolved in important ways (3). Clearly, it was time to update the last review. Fifteen years ago, disaster management was simply left to a few dedicated professionals. Roles were clear: Rescue workers rushed to help victims, and certain agencies stepped in to provide temporary shelter and food. Usually within weeks after the disaster's impact, most people forgot about the disaster—until the next one came to wreak new destruction. Unfortunately, disasters throughout the world, such as the series of four destructive hurricanes that struck the southeast coast of the United States from August to September of 2004 (4) and the tsunami disaster in December 2004, have provided ample opportunities to test the policies and recommendations set out in the late 1980s. At least 80 percent of the population growth in the 1990s has occurred in towns and cities. According to the United Nations, in the year 2005, one half of the world's population will live in urban areas, crowded onto just 3 percent of the earth's land. This is an alarming increase in population density. Problems inherent in such rapid growth are especially unwieldy in developing countries; 17 of the 20 largest cities are now in developing countries compared with seven of 20 in 1950. By 2025, 80 percent of the world's population will reside in developing countries. One of every two large cities in the developing world is vulnerable to natural disasters such as floods, severe storms, and earthquakes (3).

Fortunately, over the past decade, the public health approach to disasters has changed significantly. Today, the management of humanitarian assistance involves many more and different players, and disaster management is recognized as a significant priority of the public health system. Today, prevention, mitigation, and preparedness are part of the vocabulary of public health officials in national and international organizations and, more importantly, they are used to advance the cause of reducing mortality and morbidity from disasters (5).

Epidemiology, as the applied instrument of public health interventions, can provide much needed information on which a rational, effective, and flexible policy for the management of disasters can be based. In particular, epidemiology provides the tools for rapid and effective problem solving during public health emergencies, such as natural and technologic disasters and emergencies from terrorism.

After sudden-impact disasters, time constraints and disruption of an area's infrastructure have frequently made it necessary to conduct rapid assessment surveys using nonprobability sampling methods. These methods may produce biased results because they are often based on purposive, convenience, or haphazard selection of subjects for interview (6). In the last 15 years, investigators demonstrated the use of a modified cluster-sampling method to perform a rapid needs assessment after hurricanes (7, 8). In the first survey conducted 3 days after Hurricane Andrew struck south Florida in August 1992, clusters were systematically selected from a heavily damaged area by using a grid that had been overlaid on aerial photographs. Survey teams interviewed seven occupied households in consecutive order in each selected cluster. Results were available within 24 hours of beginning the survey. Surveys of the same heavily damaged area and of a less severely affected area were conducted 7 and 10 days later, respectively.

Initial survey workers found few households with injured residents, but a large proportion of households were without telephones or electricity. The workers' findings convinced disaster relief workers to focus on providing primary care and preventive services to residents rather than to divert resources in order to establish unnecessary mass-casualty trauma services. The cluster-survey method used in this rapid assessment was modified from methods developed by the World Health Organization's Expanded Programme on Immunization to assess vaccine coverage. Although cluster surveys have been used in refugee settings to assess nutritional and health status, this activity represented the first use of the Expanded Programme on Immunization survey

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method to obtain population-based data after a sudden-impact natural disaster.

Although cluster-survey techniques hold promise for providing information rapidly after a disaster, in certain settings these techniques may be less applicable. For example, epidemiologists who used a cluster-survey technique after the January 1994 earthquake in Northridge, California, found that the technique needed modification. Unlike the damage from hurricanes, which is generally uniform over a large geographic area and thus can support the use of cluster sampling, earthquake-related damage varies considerably, with some areas experiencing little destruction and others experiencing heavy destruction. The extent of damage after earthquakes depends on local soil conditions, the distance and rate of ground-shaking attenuation from the epicenter, and the quality of building construction. Therefore, using a cluster-sampling approach to assess damages after an earthquake may cause health authorities to miss seriously affected areas and, thus, to underestimate overall damages (9).

Results of epidemiologic studies of disasters have not only led to the scientific measurement and description of disaster-associated health effects but also been used to identify groups in the population at particular risk for adverse health events, to help emergency managers match resources to needs, to monitor the effectiveness of relief efforts, to improve contingency planning, and to formulate recommendations for decreasing the adverse public health consequences of future disasters (3). Unfortunately, it is assumed by many that all disaster research has been and will be based upon ''scientific evidence.'' Evidence consists of data upon which a judgment or conclusion may be based. Evidence must be ''valid.'' Evidence-based disaster medicine, therefore, supposedly is based upon facts. For example, disaster planning is only as good as the assumptions on which it is based. However, these assumptions are often based on conventional wisdom and stereotypes rather than on systematically collected evidence. While these assumptions may be logical, what is logical is not always what is true (10). For example, it is often assumed that disasters trigger widespread panic and leave stricken populations helpless and dependent on government authorities and rescue and relief organizations for strong leadership and assistance. Disaster planning often focuses on what these agencies can do for the public with the view that the public can do little for itself.

Planners may be unaware that there exists a large body of evidence on disaster responses that has been collected over several decades by rapid-response field teams from scientific institutions specializing in disaster research. This evidence shows that panic is extremely rare in disasters and that members of the public in the impact area will take the initiative to help themselves and others.

Most postearthquake or post-building collapse search and rescue, for example, is carried out not by police, firefighters, and formally trained rescue teams but rather by the survivors themselves (family members, neighbors, coworkers, friends, and those who just happen to be in the area) (11). To the lay public, the best emergency care is seen as transport as quickly as possible to the closest hospital. If ambulances are not immediately available in sufficient numbers, the survivors will use whatever means of transport that is expedient to accomplish that objective (e.g., private car, bus, taxi, or even on foot). During the September 11, 2001, World Trade Center attack, for example, only 6.7 percent of the casualties were transported by ambulance.

As a result, in most disasters the closest hospitals receive most of the casualties, while those slightly farther away wait for casualties that never arrive. Furthermore, field triage, first aid, and decontamination stations are often bypassed because those transporting victims are unaware of their existence or location, or because they believe that better care is available at hospitals. This all happens very quickly, with hospitals usually receiving no warning that a disaster has even occurred and, most importantly, that they will be inundated with casualties beginning to arrive within a few minutes.

Officials who are unaware of this evidence may inadvertently create dysfunctional plans. For example, they may designate one hospital to receive casualties contaminated by hazardous substances. They may assume that the fire department will decontaminate casualties at the scene, or that hospital staff will have advanced notice so they can don chemical protective suits and set up decontamination equipment before patients arrive.

Evidence collected by epidemiologists is also useful for planning. For example, the primary focus for disaster medical planning has traditionally been on hospital treatment of the critically injured. However, evidence from epidemiologic studies indicates that most disaster injuries are relatively minor and could easily be treated in urgent care centers, private physicians' offices, outpatient surgery centers, and clinics—sparing hospitals for the more serious cases. Additional evidence suggests that many postdisaster visits to hospital emergency departments are for medical conditions other than injuries (10). In some cases, these patients are elderly people who have lost access to their routine sources of medical care (e.g., pharmacies, private doctors, home health care). Yet, there seems to be little planning to ensure that these sources of medical care can survive, function, or expand capacity in disasters (4).

Evaluation of the medical and public health responses to disasters is one of the principal responsibilities of epidemiologists with an eye toward progressive improvement in the ability of the health system to respond more effectively and efficiently to disasters (2). Such responses must be evaluated from the perspective of their outcomes and to what extent these interventions benefited victims of the disaster, especially relative to the goals that were expected by such planned responses. Epidemiologists have used a great variety of data collection methods and strategies to study the postdisaster health effects of major disasters involving acute events, such as earthquakes and tropical cyclones. Primarily using descriptive epidemiology, they have collected large amounts of epidemiologic data through case studies of new and previous disasters.

However, interventions also may be evaluated with regard to prevention or mitigation of the effect of an event. Such evaluations often are difficult, as their success is assessed by the fact that nothing happened that could have happened.

Identification of risk factors for death or injury will require a more sophisticated, analytical approach. Such analytical studies have usually been of a case-control design. For example, why did some people die while their neighbors, family members, or others survived? Isolated case studies of the relation between death or injuries and the type of traditional housing structures have provided clear indications regarding simple measures to be implemented in order to reduce human losses. Such analyses following disasters have yielded new information that has altered traditional thinking about the prevention of disaster-related mortality. Results of epidemiologic research on disasters have formed the scientific basis for increasingly effective prevention and intervention strategies to decrease mortality in several disaster situations. For example, epidemiologic studies of tornadoes have resulted in changes in local housing and land-use regulations regarding the danger of mobile homes and have formed the basis of National Weather Service safety guidelines issued to citizens in tornado-prone parts of the country (12). Results of epidemiologic investigations of a wide spectrum of adverse medical and health consequences of disasters have allowed us to target specific interventions to prevent specific disaster-related health effects (e.g., improved warning and evacuation before flash floods and tropical cyclones (13), the identification of effective safety actions that building occupants should take during earthquakes (14), and the development of measures to avoid clean-up injuries following hurricanes (15)), to measure the effectiveness of disaster prevention and preparedness programs, and to help local communities develop better emergency preparedness and mitigation programs. More analytical studies such as these are needed to test conventional warnings and public safety advisories (5).

Despite the existence of useful, systematically collected evidence from hundreds of disasters, this body of knowledge can quickly become out-of-date (1, 2). This is because of changes in disaster threats (e.g., pandemic influenza, suicide terrorism, specific targeting of medical personnel in war zones) and in the health-care system (advances in emergency medical service systems, emergency department overcrowding, nursing shortages, closures of trauma centers). In addition, there still exist critical data gaps in how the health-care system deals with disasters. An example is the lack of systematically collected data on the medical and public health response to releases of hazardous chemicals. Furthermore, we lack an effective, nationally institutionalized process of knowledge transfer for gathering and disseminating lessons learned from health and medical responses to disasters from researchers to first responders.

Fifteen years ago, the term ''complex humanitarian disasters'' was not commonly used. The focus of attention was usually the plight of refugees fleeing conflicts related to the tensions between the two superpowers, the Soviet Union and the United States. Much has changed in the intervening years. First, the geopolitical context has altered dramatically, with an initial increase in the intensity and scope of Cold War-related conflicts in the 1980s followed by the collapse of the Soviet Union and the subsequent ''epidemic'' of ethnic and religious conflicts. Second, the public health impact of armed conflicts on civilian populations has significantly worsened, especially during the years since the end of the Cold War. Third, on a more positive note, there has been a steady increase in technical publications in the form of journal articles, books, and manuals documenting public health outcomes and proposing more effective responses to conflict-associated population emergencies. The term complex humanitarian disaster reflects the multicausal nature and complicated response mechanisms of recent emergencies. In terms of their public health impact, complex humanitarian disasters may be defined as ''relatively acute situations affecting large populations, caused by a combination of factors, generally including civil strife or war, often exacerbated by food shortages and population displacement, and resulting in significant excess mortality'' (16, p. 1012).

The public health impact of complex disasters in the 1990s has been extensively documented. *The Lancet* and *JAMA* have both published reports on emergencies in northern Iraq, Somalia, Bosnia and Herzegovina, Nepal, and Zaire. One useful article that appeared following the Somali emergency documented the different approaches to the collection of public health information among various agencies (17). Several years later, however, when 1 million Rwandan refugees fled into the eastern Zaire province of North Kivu, there was a remarkable degree of cooperation and standardization of information-gathering methods among the agencies present. This was reflected in a landmark article jointly authored by 24 epidemiologists from the Zaire Ministry of Health, World Health Organization, United Nations High Commissioner for Refugees, US Centers for Disease Control and Prevention, Médecins Sans Frontières (Doctors without Borders), the French Army, and the Red Cross (18).

Major advances have been made during the past decade in the way the international community responds to the health and nutrition consequences of complex emergencies. The public health and clinical response to diseases of acute epidemic potential has improved, especially in camps. Case-fatality rates for severely malnourished children have plummeted because of better protocols and products. Renewed focus is required on the major causes of death in conflict-affected societies—particularly, acute respiratory infections, diarrhea, malaria, measles, neonatal causes, and malnutrition—outside camps and often across regions and even political boundaries. In emergencies in sub-Saharan Africa, particularly, southern Africa, human immunodeficiency virus/acquired immunodeficiency syndrome is also an important cause of morbidity and mortality. Stronger coordination, increased accountability, and a more strategic positioning of nongovernmental organizations and United Nations agencies are crucial to achieving lower maternal and child morbidity and mortality rates in complex emergencies (19, 20).

While our understanding of the public health problems of refugees and displaced persons steadily improved, the causes of and response mechanisms to man-made emergencies became significantly more complicated. Whereas the focus of assistance programs in the 1970s and early 1980s was on refugees who had crossed borders to escape armed conflicts, in the 1990s it was often necessary to provide

assistance to civilians still in the proximity of the conflict or displaced within their own countries. Civil wars in the Darfur region of western Sudan, Somalia, Liberia, Sierra Leone, Angola, Afghanistan, Chechnya, Sri Lanka, East Timor, and the former Yugoslavia had profound and tragic effects on the health of local civilian populations (21). Today, complex emergencies are humanitarian crises that involve, if not war, then high levels of violence. Increasingly, civilians have become the intentional target of violence. Hundreds of thousands of civilians have been trapped in urban enclaves and siege-like situations where public utilities have been destroyed and basic medical services have collapsed. Children have been forcibly conscripted into opposing armed forces and have proved to be the most violent and pitiless of combatants. The provision of humanitarian assistance in these settings has proved extremely difficult and dangerous. The symbol of the Red Cross is no longer a guarantee of neutrality or even safety, with dozens of staff from the International Committee of the Red Cross murdered. Similar targeting and assassination of United Nations and humanitarian relief workers have now become an accepted hazard of doing such work. We all mourn the death of Sergio Viera de Mello, United Nations Special Representative to Iraq, on August 19, 2003.

Since Somalia in 1992, military involvement has often become essential for the provision of security, intelligence, and logistic support to international relief organizations. In fact, without such assistance in Bosnia, Kosovo, Liberia, Sierra Leone, and the recent tsunami disaster in South Asia, relief operations would have ground to a halt. As could be predicted, the decade of the 1990s brought much confusion and uncertainty to the traditional humanitarian relief community (both government and nongovernment) in the role of the military in complex emergencies. Usually, in these situations, organizations such as the United Nations (e.g., World Health Organization, United Nations Children's Fund, United Nations High Commissioner for Refugees), nongovernmental organizations, the International Committee of the Red Cross, and the International Federation of Red Cross have retained overall coordination, if not leadership and control. Until recently, this alone was felt to be essential for maintaining the neutrality (and thus safety) of relief workers. However, since the Balkan wars, Western militaries (particularly those of the United States) have substantially increased their activities in humanitarian projects, such as providing field clinical hospitals, water, sanitation, communicable disease control, food programs, and community health. Despite the humanitarian motives for such military operations, many relief organizations believe that this engagement contributes to the danger to their field staff by blurring the lines between civilian and military function and falsely associates them with the military forces. This became a major issue in the planning, execution, and recovery of the health infrastructure in Iraq following the end of major hostilities in Operation Iraqi Freedom. One author of *World in Crisis* concluded his chapter on the role of medical relief agencies as follows: ''many issues remain unresolved and hotly debated ... foremost is the challenge of working in the hostile and threatening environment of armed conflict in a global climate of political indecisiveness and moral inconsistency. While we await a concrete manifestation of the much-heralded new world order, relief agencies and the individuals who make up their field teams will continue to work on the front lines in an ethical limbo'' (22, p. 134).

On September 11, 2001, the United States experienced the worst terrorist attack in its history. As the nation sought to deal with this tragedy, it would face a second wave of terrorism—this time, in the form of a biologic attack. There should be no doubt by now that the challenge of terrorism has left an indelible mark on the world as we know it, spanning all inhabited continents, crossing all cultures, and penetrating the borders of all countries.

Unfortunately, a disaster caused by the intentional release of biologic weapons would be very different from other natural or technologic disasters, conventional military strikes, or even attacks with other weapons of mass destruction (e.g., nuclear, chemical, or explosive). The initial responders to a biologic disaster will most likely include county and city health officers, hospital staff, members of the outpatient medical community, and a wide range of personnel in the public health system and *not* traditional first responders such as police, fire, rescue, and ambulance services. Expanded public health laboratory capacity, increased surveillance (disease monitoring), early alert, warning and outbreak response capacity, and health communication and training are critical for an effective response to bioterrorism—with the focus of such public health preparedness resources and expertise at the state and local levels.

It is likely that recognition of the nature of and appropriate response to future bioterrorist attacks and natural epidemics, such as West Nile virus, pandemic influenza, and the international outbreak of severe acute respiratory syndrome (SARS), also will unfold over time. This is a difficult lesson in an age of 24-hour media coverage and expectations of instant answers. It is critical that public health authorities familiarize the communities they serve and the media with the likelihood that reliable answers to questions arising in future attacks will take time to assemble and validate (23). Furthermore, the public must understand that messages (including medical advice, recommendations about who is at risk, and treatment) conveyed at one given point in time, although based on the best available information, are subject to change when new facts become known.

The myth that things go back to normal within a few weeks is especially pernicious. The truth is that the effects of a disaster last a long time (24). Disaster-affected countries deplete many of their financial and material resources in the immediate postimpact phase. The bulk of the need for external assistance is in the restoration of normal primary health-care services, water systems, housing, and income-producing work. The longer-term recovery and rehabilitation needs in the affected areas are more poorly understood than the short-term needs, but they may be even more important. Many of the large relief agencies have substantial capacity for both relief and development, but effecting a transition from relief activities to sustainable

and meaningful reconstruction activities is neither a simple nor a straightforward task. Relief organizations still have much to learn about shifting from short-term medical-aid efforts to productive, sustainable interventions that promote the development of a local health-care system (25).

In particular, social and mental health problems will appear when the acute crisis has subsided and the victims feel (and often are) abandoned to their own means (10). Unfortunately, mental health and the psychological consequences of disasters have not yet received the attention they deserve in the epidemiologic literature (especially compared with the extensive research and body of knowledge in the social and behavioral sciences). Research of populations affected by disasters (whether due to civil conflict or volcanic eruptions) has revealed that these populations may have to cope with widespread depression, anxiety, and post-traumatic stress for years after the disaster (24). Successful relief programs incorporate long-term mental health-care services in their overall planning for disaster relief, recovery, and reconstruction.

The physical health of survivors may also be adversely affected for years, particularly in technologic disasters, such as those involving chemicals and radiation. For example, the most pressing health concerns associated with nuclear-reactor incidents are the delayed effects from long-term exposure to low levels of radiation (26). Cancer or genetic defects induced by radiation exposure may not appear until many years after exposure and may be induced by low levels of exposure (26).

Epidemiologic study of disasters has clearly increased during the past 15 years, especially in university and academic communities, and it has undergone an explosive acceleration since September 11, 2001. Dozens of new professional societies and scientific forums for the presentation of original work in the epidemiology of disasters appeared. Dozens of university research centers now concentrate on the health and medical effects of disasters, including collaborating centers under the sponsorship of the World Health Organization. Some of these institutions have also developed curricula that include basic disaster epidemiology, information systems for disasters and communicable diseases, immunization, emergency food programs, and reproductive health.

A refugee crisis in western Sudan (Darfur) (21), a catastrophic tsunami in the Indian Ocean (4), investigations of deliberate biologic and chemical weapons releases, and earthquakes in California (11) may not have much in common, but in the investigation of all four, the epidemiologic approach has proved powerful. As relief agencies have come to accept the role of epidemiology in disaster responses, their reliance on the ad hoc crisis management approach has lessened. An organized approach to data collection in disaster situations also helps disaster managers make crucial decisions and predict the variety of options that they will face during the different phases of a disaster (3).

In summary, with both disasters and the number of people affected by such events on the increase, the importance of disasters as a public health problem is now widely recognized. This is now reflected by the fact that every school of public health in the United States now offers some training opportunities in the public health consequences of disasters (up from just 10 percent 8 years ago).

This issue of *Epidemiologic Reviews* consists of several updates and reviews that will provide readers with substantial technical descriptions of recent disasters and humanitarian crises (3–5, 10, 11, 21, 23, 24, 26). The articles published in this issue of *Epidemiologic Reviews* were selected on the basis of their demonstration of advances in the conduct of disaster relief and humanitarian assistance and the methodology of disaster research since the last major review of this topic.

A common theme that runs through every single one of these articles is that, although all disasters are unique, some similarities exist among the health effects of different disasters, which, if recognized, can ensure that health and emergency medical relief and limited resources are well managed.

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