Disaster epidemiology: prudent public health practice in the Pacific Islands

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REVIEW PAPERS

Introduction

No aggregation of human settlements is immune from disasters. Globally, it is estimated that natural disasters of a magnitude requiring international assistance to affected populations, occur on a weekly basis.[1] Death, injury, disability, illness and loss of housing are some of the ways in which people may be affected by disasters. The morbidity, mortality and economic loss following a given disaster originate from two primary sources: from the disaster itself (e.g. the devastation left behind by a cyclone) and from the mismanagement of the disaster (e.g. delayed and/or inappropriate response and relief efforts).[2]

The most frequent types of disasters reported from the Pacific Islands from 1900 to 1994 in descending order were cyclones, earthquakes, floods and volcanoes.[3] During the ten-year period from 1990-1999, there were a total of 173 disasters reported from this region of the world, killing approximately 3600 people, and causing injury, illness or economic loss to more than 18 million people. The estimated total cost of disaster-related damages during that same time period was almost 11 billion US dollars.[4] In light of the massive impact that disasters have on the health and economic status of the Pacific people on a recurring basis, public health officials in the Pacific Region, have a responsibility to better understand the nature and health impact of disasters, and to increase the emergency preparedness and response capabilities of their public health infrastructure.

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The field of disaster epidemiology evolved as a result of an increasing awareness of the utility of applying epidemiological methods to the study of the effects of disasters on human populations.[5] Descriptive and analytic epidemiological studies conducted before, during and after disasters can help to rationalize the process of disaster management. This entails prevention, mitigation, preparedness, response, relief and rehabilitation.[1,6]

Definitions

Epidemiology is the study of the distribution and determinants of disease frequency in human populations. It yields information on the demographic characteristics of populations affected by a given disease or group of diseases (i.e. distribution). It also provides crucial insights into the factors that contribute to disease frequency in certain populations (i.e. determinants).[7] *Disaster epidemiology* is the application of epidemiological methods to the study of the nature and magnitude of the impact of disasters on the health status of populations.[8]

A *disaster* is defined as "the result of a vast ecological breakdown in the relations between man and his environment, a serious and sudden event (or slow, as in drought) on such a scale that the stricken community needs extraordinary efforts to cope with it, often with outside help or international aid".[9] It can then be inferred that an event of a similar nature that does not exceed the ability of the affected society to cope is technically defined as an *emergency*.

Disasters can be broadly classified into two types: *natural* or *technological* (i.e. human-generated). Natural disasters are events such as earthquakes, volcanic eruptions, cyclones, floods, and droughts that occur as result of natural phenomena. Whereas disasters such as food shortages due to economic embargoes, large refugee populations fleeing conflict situations, toxic spillages from industrial plants, blast injury from explosives, or breaking of a dam are classified as technological disasters.[8,10] A *hazard* is the probability that an emergency of natural, technological, or social origins will occur[11] and *vulnerability* is "the degree of loss to a given element at risk, or set of such elements

resulting from the occurrence of a natural phenomenon of a given magnitude."[9]

It must be noted that natural phenomena occurring away from human settlements, and thus not having a significant impact on human populations, are not considered disasters. They are simply dramatic geological or meteorological events. Furthermore, many natural disasters can be viewed as partly technological because of actions, or lack thereof, of humans. For example, the failure of public officials to enforce strict antiseismic building codes, plays a major role in the degree of human and material destruction caused by an earthquake.[10,12] Another example, perhaps less obvious, is the impact of climate change, due to increased atmospheric greenhouse gases, on the natural climate variability of the El Nino Southern Oscillation (ENSO) events in the Pacific Basin.[13] Since the frequency of droughts and floods in susceptible geographical areas has been shown to increase during ENSO warm-event years,[14] decreasing the intervals between ENSO warm-event years which has been occurring since 1976, will tend to increase the frequency of droughts and floods in these areas.[13-15]

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Objectives

Epidemiological data, if timely, relevant, and objective, can be effectively used by decision-makers to prevent and/or minimize the severity and magnitude of adverse health effects of a disaster on a given population. Specific objectives of disaster epidemiology are outlined below:

1. assessing the needs of the affected populations,
2. matching available resources to needs,
3. preventing further adverse health effects,
4. evaluating program effectiveness, and
5. planning for contingencies.[2,16]

Principles

A useful theoretical framework upon which to apply epidemiological techniques in disasters has been proposed by Binder and Sanderson. In this paradigm, disaster management is addressed as a 3-phased exercise: *pre-impact*, *impact* and *post-impact*.[1] These phases are not discrete but rather lie along a continuum of events and conditions that determine the likelihood of the occurrence of a disaster and its subsequent impact. The epidemiologic activities that are best pursued during each phase are described below.

I. Pre-impact phase

Disaster epidemiological studies during the pre-impact phase can determine the populations at risk for a given disaster and assess the emergency preparedness and response capabilities of the community, where the term community is broadly defined. This information can be derived from two types of studies: a community hazards analysis and a vulnerability analysis. Data on the nature, causes, frequency, distribution, and impact of prior disasters are essential to analyzing a community's risk for a given hazard. Interpretation of these data provides the disaster epidemiologist a means of predicting the occurrence and impact of future disasters.[8]

A vulnerability analysis, on the other hand, requires the collection of data on the potential impact of future disasters on a community. Data on population density and distribution, location of physical infrastructure such as critical roads and bridges, and high-occupancy structures such as high-rise buildings are critical for this analysis.[8] Individuals and groups may be considered vulnerable to potential disasters for the following reasons:

a) physical location in relation to the site of a given hazard,
b) physical inability to cope (e.g. the elderly and disabled are less able to evacuate a disaster-affected area in an emergent fashion),
c) poor or delayed response from emergency services in their jurisdiction,
d) decreased ability to cope economically with the consequences of the disaster (e.g. lack of home insurance).[12]

In addition, baseline information on the capacity of the public health and medical care systems of the community is required during this phase. The surge capacity of acute care hospitals, number of hospital back-up generators, mortuary capacity, pharmaceutical stockpiles, food reserves, proportion of the population dependent on the community water supply versus private wells, and other such baseline data must be known prior to the occurrence of a disaster.[17] These data are necessary to facilitate appropriate contingency planning before the disaster occurs when some of these components of the health system may be damaged or destroyed. It would be an inefficient allocation of resources to attempt to gather this type of baseline information during the actual disaster when resources would be better utilized in the assessment of the current status of the health infrastructure as well as on response and relief efforts.

In February 2000, the United States Centers for Disease Control and Prevention (CDC) established the Pacific Emergency Health Initiative (PEHI), which had as one of its goals to assess the emergency public health and medical systems in the Pacific Islands. To date assessments have been conducted in Palau, Samoa, American Samoa, Cook Islands and the Marshall Islands. Based on the findings of the assessment teams, recommendations have been made to the appropriate governmental entities, on ways to improve

their emergency health systems and the skills of their public health and medical staff during emergencies and disasters.[18]

Given information such as that obtained in the CDC PEHI assessments, public health officials within the jurisdiction can institute policies and implement programs to prevent, mitigate or prepare for future disasters. These may include public awareness and education campaigns, training and drills for emergency staff, land use regulation, development of emergency operations plans, early warning systems, and mutual aid agreements with neighboring communities.[1,6] This multi-pronged approach to disaster prevention and control emphasizes health education strategies, engineering solutions and legislative enforcement. This approach is firmly rooted in William Haddon's paradigm of conceptualizing injuries and trauma-related deaths in an etiological rather than a descriptive framework, a paradigm that has been applied effectively to highway safety and other public health issues.[19,20]

Knowledge of the nature and extent of the impact of the disaster allows disaster managers to deploy personnel, medical, and other resources in the most effective and efficient manner.

II. Impact phase

A good and useful assessment during a disaster, or immediately post-impact, is characterized by its rapidity and simplicity particularly in the first few hours or days. This is because this assessment provides an essential input into the decision-making process of disaster managers. Knowledge of the nature and extent of the impact of the disaster allows disaster managers to deploy personnel, medical, and other resources in the most effective and efficient manner.[8]

Assessments performed during the impact phase are usually referred to colloquially as "quick and dirty" because they can be carried out quickly, without significant human or material resources, and in adverse physical conditions.[21] The most pressing or 'immediate relief' questions that need to be answered as early as possible are the extent and nature of the basic needs of food, shelter, medical care, sanitation, fuel, and communications. Explicitly, these questions are:

a) What is the geographical extent of the disaster-affected area?
b) What is the number of people affected?
c) What are the major public health problems occurring in the area? [2,22]
d) Is there a disruption to medical, public health and other public services? And if so, what is the extent of the damage?

Intermediate-level or 'secondary relief' questions address the status of nutrition, mental health and community self-help activities.[22] It is during this phase also that public health surveillance systems should be established to look for the distribution of disaster-related adverse health events in time, person and place.[1,2,22] In countries where a reasonable public health infrastructure exists, this will most likely be a supplemental temporary surveillance system to capture any changes in disease patterns that may be suggestive of an epidemic. However, in poorer countries where there may be no pre-existing public health surveillance system, a new one has to be designed. This needs to be simple, appropriate and relatively easy to implement in austere conditions. Furthermore, it should be designed in such a way that it can be maintained long after the acute stage of the disaster, and perhaps form the foundation for a more comprehensive national surveillance system.[23]

The eight steps in planning a surveillance system have been outlined by Teusch[24] and modified for use in disaster epidemiology by Wetterhall and Noji.[21] They are presented below:

1. establish objectives,
2. develop case definitions,
3. determine data source or data-collection mechanism,
4. develop data-collection instruments if necessary but ideally, use pre-existing ones,
5. field-test methods, if feasible,
6. develop and test analytic approach,
7. develop dissemination mechanism, and
8. ensure use of analysis and interpretation.

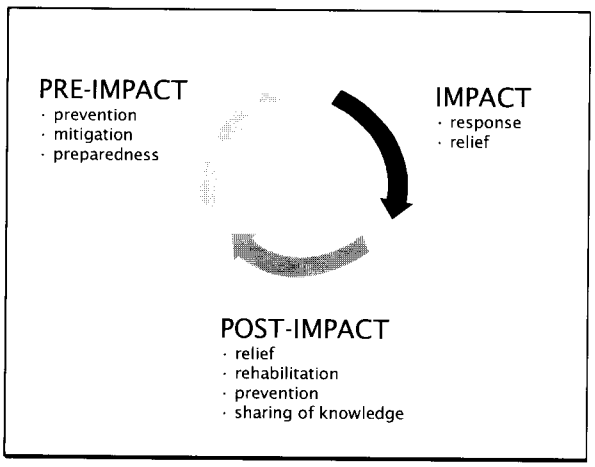
III. Post-impact phase

The surveillance system established during the disaster phase should be continued after the disaster, where appropriate, to monitor different illnesses, symptom complexes, and diseases in the affected population. Case-control studies and other retrospective study designs, using surveillance data or hospital medical records, allow the disaster epidemiologist in the post-impact phase to understand the risk factors for disaster-related illnesses, injuries and deaths. In addition, prospective studies can also be conducted on the survivors of the disaster as individuals go through long-term rehabilitation and communities rebuild their health infrastructure.[1,8]

Epidemiologic data collected during the post-impact phase can be viewed in some ways as a pre-impact exercise since the distribution and determinants of adverse health outcomes in specific locations or populations in the current disaster can help in planning for future disasters locally as well as regionally.[1,2] This concept is illustrated in the Figure. The three phases of disaster management are represented as interrelated stages in a life cycle.

Another important utility of post-impact epidemiologic studies is that they can be used to dispel myths and rumors about the impact of disasters. For example, many people in the general public believe that epidemics of infectious diseases typically follow a disaster and that the impact of disasters is random whereas the opposite has been shown to be true by objective scientific studies.[1,25] See Figure 1.

Figure 1. Phases of disaster management



Challenges

The disaster epidemiologist is faced with several challenges in the field that may be quite different from those faced by other epidemiologists. First and foremost is the need to collaborate and coordinate with other key partners in disaster management: (a) public officials (inside and outside the health department), (b) private industries such as hospitals, laboratories and other health care facilities, (c) nongovernmental relief organizations who often play a major role in disaster response and relief, and (d) nongovernmental community organizations which are usually crucial components of the initial response team. The epidemiologist is often dependent on these entities for historical and current data on the health status of the population. It is equally important for the epidemiologist to provide timely and objective feedback to these entities to assist them in their assessment and relief efforts in the short term, and disaster prevention and mitigation activities in the long term.[1,5,8,23]

Second, the epidemiologist may be in a situation where the time pressure, and general disorder among the public, may make designing the ideal epidemiologic study impossible. This awareness gave rise to the derivation and acceptance of the "quick and dirty" epidemiologic methods discussed above. Further challenges to study design are unreliable numerator and denominator data because of potential large shifts in population from and within the disaster-affected area. Compounded on this problem may be poor baseline information in settings where there is no reliable census data or public health surveillance system. In addition, the selection of control subjects for a case-control study may present a problem in the quantification of exposure, since to a certain extent, everybody in the disaster-affected area was 'exposed' to the disaster.[8]

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Third, the data collection process can be hampered by the chaos that often follows major disasters. Information or misclassification bias may be inadvertently introduced into the study due to the emotional and physical distress of the people being surveyed. Shifting populations within and out of the disaster area might also create a selection bias and problems in the calculation of prevalence and incidence rates.

Fourth, since basic demographic data may not be obtained initially because of the intense need to provide health and medical services as quickly as possible to as many people as possible, follow-up of cases in prospective study designs or for rehabilitation interventions may sometimes be difficult. In addition, people may relocate away from the disaster-affected area and there may not be a good tracking system in the public health structure.[8]

Finally, the enthusiasm and funding from the public health officials for post-disaster epidemiologic surveillance systems may diminish with the passage of time even if it is for only selected illnesses and injuries.[23] The disaster epidemiologist may be the lone voice advocating for this need. To minimize this phenomenon, injuries and illnesses related to environmental emergencies should be made an integral part of every comprehensive public health surveillance network during non-disaster times too, whenever logistically and financially possible. Currently, there are efforts underway to establish such a surveillance system in the Pacific Region as a component of the CDC PEHI project.[26] If successful, this regional surveillance system which will be called PEHI-NET, would ultimately necessitate the inclusion of this spectrum of illnesses and injuries in public health surveillance systems on national and local levels too.

Summary

Natural or technological disasters may strike a community at any time, causing death, disability, illness and material destruction. Loss of human life, healthcare costs associated with disaster-related injuries and illnesses, pain and suffering, economic loss from destruction of homes, commercial enterprises and public structures are some of the myriad ways in which the impact of the disaster may be felt by the community. Disaster managers seek to prevent,

Table 1. The role of epidemiologic studies in disaster management

Phase of Disaster Management	Primary Activities	Types of Epidemiologic Studies
Pre-impact	Prevention Mitigation Emergency Preparedness	1. Community hazards analysis 2. Vulnerability/risk assessment 3. Baseline information on routine and surge capacity of public health and medical systems 4. Surveillance for disaster-related injuries and illnesses
Impact	Response Relief	1. Population surveys to assess the nature and impact of the disaster 2. Surveillance for disaster-related injuries and illnesses
Post-impact	Rehabilitation Prevention	1. Case-control studies 2. Retrospective cohort studies 3. Prospective cohort studies 4. Surveillance for disaster-related injuries and illnesses.

mitigate and prepare for disasters during the pre-impact phase. If and when a disaster occurs, they seek to provide timely, appropriate and effective response, relief and rehabilitation services.

Disaster epidemiology arose out of a need to apply objective descriptive and analytic tools to the field of disaster management in order to improve its relevance, effectiveness, and efficiency. The table illustrates the types of studies that can be undertaken during each phase of disaster management. During the pre-impact phase vulnerability and community hazards analyses can provide useful information to public health officials responsible for prevention and mitigation of potential disasters. Epidemiologic surveys of the disaster-affected area to assess the nature and the impact of the disaster are crucial during the impact phase since the information is valuable to public health, paramedical, and medical staff in tailoring their response and relief efforts. Post-impact retrospective and prospective epidemiologic studies can assist with the establishment of appropriate rehabilitation services. They can also serve as pre-disaster exercises since results and conclusions from these studies can help disaster managers in planning the resources needed for future disasters. Finally, there is a need for surveillance of disaster-related or emergency-related illnesses, injuries and deaths during all three phases so that baseline data is readily available for comparison during or after the disaster occurs. See Table 1.

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