Chapter 42

MILITARY AND PUBLIC HEALTH ASPECTS OF NATURAL DISASTERS

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INTRODUCTION

The involvement of the US military in providing disaster relief is an original intent of the Constitution and is defined in Titles 10 and 32 of the US Code.[1] Humanitarian disaster relief efforts date back to the pre–Civil War era, when Congress in 1847 approved the loan of naval vessels for transport of supplies to the victims of the Irish potato famine.[2] Army troops were subsequently used in the administration and maintenance of stockpiles of food, clothing, and tents during domestic relief operations. After the turn of the 20th century, the Army also assumed a role in the conduct of sanitation and vaccination programs in the United States and its territories.[2] Since 1972, the military has been actively involved in conducting medical, logistic, operational, and command and control functions during emergency humanitarian relief after major natural disasters. Examples include earthquakes (Peru, 1970; Nicaragua, 1972; Guatemala, 1976), floods (Sudan, 1988; Venezuela, 1999), windstorms (Bangladesh, 1970, 1991; Sri Lanka, 1978; Florida, 1992, 1995; Hawaii, 1992; Central America 1998-1999), and volcanic eruptions (Philippines, 1990).[3,4]

Since the Persian Gulf War in 1991, the US military has deployed smaller contingents more frequently in peacekeeping operations and civilian assistance missions. For example, on a typical day in April 1996, as many as 41,000 US Army soldiers were deployed on temporary duty to as many as 59 separate locations in the United States and overseas in support of foreign humanitarian assistance missions.[5] Clearly, there is an ever-increasing need for military preventive medicine and other medical personnel to know about the specific needs that arise in domestic or international natural disaster relief operations.

MILITARY ROLE AND RESPONSIBILITIES

In the event of a natural disaster, the military may be tasked to provide assistance (Figure 42-1). In either a domestic or international scenario, military support to civil authorities is the responsibility of the Department of Defense, not the individual services. In international scenarios, the Department of State will request assistance through its coordinating agency, the Office of Foreign Disaster Assistance, which coordinates all military and civilian operations.[1] Military forces will be under the com-

a b

Fig. 42-1. The military is unique in its ability to get rapidly deployable medical systems to the site of a disaster quickly. After Hurricane Andrew struck southern Florida in August 1992, destroying hospitals and clinics as well as homes and schools, military units responded by moving needed medical infrastructure to the area. (**a**) This is a front line ambulance (FLA) that was driven to southern Florida by members of the 82nd Airborne Division, Fort Bragg, North Carolina. It transported victims to medical treatment facilities such as (**b**) this Air Force Air Transportable Hospital, which was set up close to the previously existing military hospital of Homestead Air Force Base. This transportable hospital was set up within a few days of Hurricane Andrew's landfall. US Army photographs.

mand of the Commander in Chief (CINC) responsible for the US military units' activities within that theater of operations. The CINC may establish a Joint Task Force (JTF) to provide the necessary response in the disaster area. The JTF Commander will have the responsibility, in turn, to deploy US forces to the area. The JTF Commander will rely on the JTF Surgeon to direct and coordinate the medical response. Routinely, all military preventive medicine (PVNTMED) assets will be subordinate to the JTF PVNTMED structure and will report to the JTF Surgeon. On occasion, however, PVNTMED personnel or teams will provide direct assistance to a civilian lead agency, usually local public health officials.

The JTF Surgeon will first focus on immediate lifesaving efforts and distribution of emergency resources through host-nation and international relief organizations, as well as through the host-nation's military. A Humanitarian Assistance Survey Team is normally deployed within 12 hours of the CINC's notification. The team's mission is to assess mortality, injury and illness, dislocation or displacement of persons, and disruption of governmental and national infrastructure. Within 48 to 72 hours, direct relief operations will start in the affected area. At the same time, a Civil–Military Operations Center directed by the US military will be established to provide security and humanitarian assistance in the field in coordination with the United Nations (UN), non-governmental and private volunteer organizations, and the local military.[1] See Chapter 45, The International Humanitarian Response System, for a further explanation of the roles of these organizations in disaster relief.

In the absence of a large-scale military PVNTMED deployment or when military PVNTMED professionals are involved in a disaster response only as consultants, the chain of command is not as clear. It is essential, however, that one individual, preferably the senior military officer present, coordinate the military response with the local government agency responsible for the relief effort.[6]

TYPES OF NATURAL DISASTERS

Disasters are catastrophic events that overwhelm a community's emergency response capability and threaten the public health and the environment.[7] Natural disasters are a major cause of premature death, impaired health status, and diminished quality of life.[8] It is estimated that between 1977 and the mid-1990s, 3 million people have been killed by natural disasters, 820 million others have been adversely affected, and property worth $25 billion to $100 billion has been damaged.[9,10] It was estimated that the US government spent an average of $1 billion per week in 1994 as a result of natural disasters.[11]

The natural disasters to be considered in this chapter can be subdivided into (*a*) climatological (ie, weather-related) disasters, such as windstorms, tornadoes, and floods (including associated landslides and avalanches), and (*b*) geophysical disasters, such as earthquakes, tsunamis, and volcanic eruptions (Table 42-1). These two types of disasters are generally of sudden onset and pose unforeseen, serious, and immediate threats to public health. Other disasters requiring external assistance but that are predictable and slowly developing in nature will not be considered here.[9,12] These include droughts, which are often associated with famine and desertification, and wildfires, which can sometimes be caused by natural forces such as lightning, extreme heat, earthquakes, or volcanic eruptions.

Windstorms

Windstorm-related events cause an average of 30,000 deaths and $2.3 billion in damages worldwide each year.[9] Severe tropical storms (called hurricanes if they are located in the Atlantic Ocean, Caribbean Sea, and eastern Pacific Ocean; typhoons in the western Pacific; and cyclones in the Indian Ocean), tornadoes, blizzards, and other storms affect man-made structures and agricultural areas in every country of the world (Figure 42-2). About 15% of the world's population is at risk from tropical storms. Tornadoes are notorious in the midsection of the United States, with some reaching wind speeds of 500 kph (300 mph). As many as 700 to 1,000 strike that area every year, causing an average of 80 deaths per year.[9,13]

Floods

Flooding, generally the result of torrential rains and other factors such as poor farming practices, deforestation, and urbanization, was responsible for more than 63% of the federally declared disasters in the United States from 1965 to 1985. Floods are the most commonly occurring natural disaster worldwide. In the United States alone they cause an average of 140 deaths per year. Their impact is long-term because of (*a*) damage to human settlements,

TABLE 42-1

MAJOR NATURAL DISASTERS AND ASSOCIATED MORTALITY

Type		Country (Yr)	No. of Deaths
Climatological			
	Windstorms	East Pakistan (1970)	300,000
		Bangladesh (1991)	140,000
		East Pakistan (1963–1965)*	10,000–30,000 ea
		India (1971)	10,000–25,000
		India (1977)	20,000
		Bangladesh (1988)	15,000
		Hong Kong (1906)	10,000
		USA—Galveston, Texas (1900)	> 6,000†
		USA—Florida; Louisiana (1992)	50‡
	Tornadoes	USA—Illinois; Indiana; Missouri (1925)	689
	Floods/Landslides	China (1887)	900,000
		China (1969)	> 50,000
		USA—9 Midwest states (1993)	50§
Geophysical			
	Earthquakes	China (1556)	830,000
		India (1737)	300,000
		China (1976)	240,000
		China (1920)	200,000
		Japan (1923)	143,000
		USSR (1948)	100,000
		Italy (1908)	75,000
		China (1932)	70,000
		Peru (1970)	70,000
		Iran (1990)	40,000
		Armenia (1988)	25,000
		Iran (1978)	25,000
		Guatemala (1976)	23,000
		USA—Anchorage, Alaska (1964)	131
		USA—Loma Prieta, California (1989)	62
		USA—Northridge, California (1994)	60¶
	Tsunamis	Indonesia (1883)	36,000
		Japan (1933, 1946, 1983, 1995)*	1,000–5,000 ea
	Volcanic eruptions	Martinique (1902)	38,000
		Colombia (1985)	25,000
		Sicily (1669)	20,000
		Guatemala (1902)	6,000
		Indonesia (1919)	5,200

*Four separate events are shown
†Deadliest natural disaster in US history
‡Costliest hurricane disaster, Hurricane Andrew, in US history ($32 billion)
§Costliest flood disaster in US history ($10 billion)
¶Costliest natural disaster in US history ($40 billion)
Data sources: (1) Sharp TW, Yip R, Malone JD. US military forces and emergency international humanitarian assistance: observations and recommendations from three recent missions. *JAMA*. 1994;272:386–390 (2) Sidel VW, Onel E, Jack Geiger H, Leaning J, Foege WH. Public health responses to natural and human-made disasters. In: Last JM, Wallace RB, eds. *Maxcy-Rosenau-Last Public Health and Preventive Medicine*. 13th ed. Norwalk, Conn: Appleton & Lange; 1992: 1173–1186 (3) National Research Council Advisory Committee on the International Decade for Natural Hazard Reduction Report. *Confronting Natural Disasters: An International Decade for Natural Hazard Reduction*. Washington, DC: National Academy Press; 1987: 1–60 (4) Lechat MF. Disasters and public health. *Bull World Health Organ*. 1979;57:11–17 (5) National Geographic Society. *Raging Forces: Earth in Upheaval*. Washington, DC: National Geographic Society; 1995 (6) Disasters. *The World Book Encyclopedia.* Chicago: World Book Inc.; 1988: D225.

Fig. 42-2. Devastation of a mobile home park in southern Florida by Hurricane Andrew in August 1992. This level of destruction presented a range of problems to rescue workers, from navigating streets with no street signs or traffic lights to dealing with broken water and gas lines, downed electrical lines, and lots of debris. US Army photograph.

(*b*) forced evacuation or migration of large numbers of people, (*c*) damaged crops and food stocks, (*d*) erosion of large areas of land, and (*e*) loss of vital irrigation systems that have been washed away. The Mississippi River flood of 1993, the costliest flood disaster in US history, caused an estimated $10 billion in damages. Landslides, which often follow floods, cause an estimated $1 billion to $2 billion in economic losses and 25 to 50 deaths each year in the United States.[13]

Earthquakes and Tsunamis

Earthquakes have the potential for causing the greatest human losses of all natural disasters. Dangers associated with earthquakes include other phenomena, such as surface faulting, landslides, and tsunamis. Tsunamis are large ocean waves generated by the earth's motion occurring in the ocean's bottom, which cause damage by inundation, wave impact on structures, and coastal erosion. At least 35 countries, mostly located in the Pacific region's "Rim of Fire," face a high probability of earthquakes or tsunamis. Scientists estimate that there are some 500,000 detectable quakes worldwide each year. Of these, 1,000 are capable of causing significant damage. The extent of damage depends on three main factors: the quake's magnitude, its proximity to populated urban areas, and the population's degree of preparation.[13]

Volcanic Eruptions

Volcanic eruptions have killed more than 266,000 people in the past 400 years.[9] There are, on average, 50 volcanoes erupting above sea level each year.[13] Eruptions have immediate catastrophic effects through ash falls, surges of lethal gas, blasts, mudflows (also known as lahars), and lava flows. Fatalities occur in approximately 5% of all eruptions. Very large eruptions can also cause worldwide climatic changes and agricultural disruption, as was illustrated by the eruptions of Mount St. Helens in Washington State (1980) and Mount Pinatubo in the Philippines (1991).

IMPACT OF DISASTER PREPAREDNESS PLANS

Early warning systems allow the population to prepare, especially in cases of windstorms and tsunamis. It is important that early warning systems be in place to foster early evacuation and proper sheltering of communities threatened by these types of disasters. The timing of the warning is all-important; the earlier the notification, the more effectively the evacuation can be conducted, even if this means false alarms are given. The development of Doppler radar technology in the 1980s has helped tremendously in preventing problems associated with windstorms in the United States and the Caribbean region.[12] An adequate predisaster preparedness plan, such as the one in California, has limited the mortality of recent earthquakes in Loma Prieta (1989, 62 deaths) and Northridge (1994, 60 deaths).[14] Also reasons for decreased mortality and morbidity in the United States after natural disasters are the availability of pre-determined evacuation routes, a National Disaster Medical System (see Chapter 46, Domestic Disaster Response: FEMA and Other Governmental Organizations) for medical regulating of casualties, and government and private agencies with dedicated resources for disaster relief, facilitated by the Disaster Relief Act of 1974.[9] There is no question that vital preparedness programs and public awareness in the United States have been major factors in reducing mortality rates after natural disasters since 1982.[15] Similarly, the countries of Latin America and the Caribbean (with assistance from the Pan American Health Organization) have also developed health preparedness plans and training that have greatly improved the response to natural disasters in the region.

SURVEILLANCE

A basic knowledge of the types of illnesses and injuries caused by natural disasters is essential to determine appropriate relief resources on-site, such as supplies, equipment, and personnel.[16,17] A knowledge of the phases of a disaster is also useful. Disasters have three phases: the impact phase, which includes 2 to 3 days after the event; the relief phase, which is an indeterminate amount of time when active relief activities are ongoing; and the rehabilitation phase, during which life and disease rates start to return to normal. Epidemiologic surveillance is the tool used to evaluate the distribution and determinants of disaster-related deaths, illnesses, and injuries in the population affected. Surveillance efforts also tend to separate into three types: (1) immediate ("quick and dirty") assessment, (2) short-term assessment, and (3) ongoing medical surveillance (Table 42-2). An explanation of each follows.

Immediate Assessment

This "quick and dirty" type of surveillance involves the rapid collection of information immediately after (within 2 to 3 days) the impact phase of a disaster to help define the geographic extent of the disaster, the major problems occurring before and immediately after the disaster, and the number of people affected. In this initial survey, quantifiable but not highly technical information is collected by the military PVNTMED health officer in charge. An aerial survey by helicopter is an ideal means of obtaining part of this information. Census data can be obtained from local health and disaster assistance centers. This will provide a rough estimate of the population living in the disaster-stricken area—the denominator or population at risk. The measurement of total and age-specific mortality is useful to quickly evaluate the severity of the impact phase of a disaster.[12] Hospitals, clinics, and morgues may be able to provide estimates of numbers and types of known deaths and injuries that have occurred within 2 to 3 days after the event.[8,19] Background, or baseline, data can be collected from reporting medical treatment facilities (MTFs) and practitioners in the area to help define disease and injury patterns existent before the disaster.[19]

Monitoring patterns of visits to health care sites after a disaster is a vital part of surveillance. The number of deaths or injuries usually peaks in the first 3 to 4 days, which is the impact phase. Morbidity usually returns to baseline after 1 to 2 weeks during the relief phase (more quickly for earthquakes, more slowly for other natural disasters). The medical needs after the impact phase is over are related to normal, baseline medical conditions and emergencies, not to disaster-associated trauma. Except in the case of earthquakes, the number of disaster casualties requiring medical attention immediately after the impact is usually low in relation to the number of deaths.[12] Major earthquakes can produce a very high number of deaths compared to the number of injuries (ie, a high disease-to-injury ratio) during the impact phase. The evaluation of the need to deploy field emergency MTFs or mobile surgical hospitals by the military has to be done immediately after impact, based on initial estimates of morbidity, because these facilities are of less practical use later, during the relief phase.

Short-term Assessments

This type of surveillance involves a more systematic and detailed method of collecting data and should result in more reliable and refined estimates of damages, condition of shelters and health care facilities, water and food supply, and nutritional status of the affected population. The measurement of total, age-specific, and cause-specific morbidity rates, as well as the death-to-injury ratio, are more reliable parameters to evaluate the postimpact severity and are significant in the planning of the need for relief supplies, personnel, and equipment. Other health-related outcomes that are useful for planning include the bed occupancy rate, the area-specific injury rates, the proportional morbidity rate (ie, percentage of visits for each cause), and the average duration of stay in the hospital.[12,15,20,21] It is

TABLE 42-2

EPIDEMIOLOGIC METHODS USED IN THE ASSESSMENT OF NATURAL DISASTERS

Type of Method	Characteristics
1. Immediate Assessment	Is rapid, superficial, "quick and dirty" (look and listen) Is conducted preferably within 2 to 3 d of impact Defines geographical extent of disaster Defines major health problems encountered (deaths and injuries) Estimates number of people affected (denominator) Assesses roughly - availability of shelter facilities - access to potable water - current level of sanitation - status of health care infrastructure - level of communications network - status of transportation systems
2. Short-term Assessment	Uses more systematic and detailed methods (surveys, questionnaires) Is conducted within the first week after impact, then every 1 to 2 wks as necessary Uses cluster, modified cluster, or random sampling methods Determines number of deaths and injuries by age and sex Assesses in a more complete fashion - damage to buildings, public utilities, roads, transport, and communication systems - condition of shelters, schools, public buildings, and health facilities - condition of water and food supply - type and number of medical personnel, equipment, and supplies in area - nutritional status of affected population
3. Ongoing Medical Surveillance	Is longer-term monitoring of disaster-associated problems Starts as soon as possible after impact Is run by local workers at each site Monitors daily the visits to health care facilities categorized by age, sex, location, and diagnostic or symptom group Daily monitoring of number of beds available and deaths Is established early at MTFs, DMATs, shelters, tent cities, camps, food distribution centers, and daycare centers Serves as excellent source of reports or rumors of problems that may need to be investigated Allows analysis of data for critical evaluation of relief efforts and cost-effectiveness of emergency response measures

MTF: medical treatment facility
DMAT: disaster medical assistance team

important to remember, however, that for these health outcomes to be evaluated appropriately, comparisons have to be made with baseline (ie, predisaster) experiences.

This assessment preferably should be conducted by mobile teams of 2 to 3 people who sample the disaster-stricken area by dividing it into discrete clusters and survey a sample of homes within each cluster.[22,23] Teams from the Centers for Disease Control conducted rapid health assessments, in a good example of this approach, immediately after Hurricane Andrew in southern Florida and Louisiana.[23] The information requested in these surveys should be as brief and concise as possible. These assessments may take only a few hours to administer and collect or they may take a few days. The data should be compared with predisaster, baseline data and the results summarized in a report to be sent to either the JTF Surgeon or the local government agencies responsible for the relief effort or to both.

Ongoing Medical Surveillance

The basic principles of epidemiologic surveillance after disasters are no different from those applied in other settings.[16,24] Ongoing medical disaster surveillance is directed at monitoring disaster-associated problems and determining the effects that relief activities have on these problems. It should start as soon as possible after impact and concurrently with emergency care of casualties. It should continue throughout the relief and rehabilitation phases. The initial setup of this early warning system to detect outbreaks of infection or diseases or an increase in certain types of injuries is of fundamental importance. An active surveillance system, consisting of in-depth monitoring of selected conditions at existing MTFs by mobile, field-deployed, military medical teams, will be necessary. Ideally this would involve assessment teams that are familiar with the particular types of disaster areas affected, as well as local customs. Ideally, assessment teams should be available on stand-by in risk areas or disaster-prone countries where the US military has a presence. In practice, however, this effort will usually be limited to the use of selected, local workers at each MTF and other reporting sites (eg, shelters, tent cities, camps, food distribution centers, daycare centers) and disaster medical assistance teams who will monitor conditions of interest.

EPIDEMIOLOGIC ASSESSMENT TEAMS

The concept of a deployable epidemiologic assessment team was pioneered in the early 1980s at the Walter Reed Army Institute of Research in Washington, DC, and repeatedly tested during peacetime deployments throughout the world. Quickly fielding an epidemiologic assessment team with initial medical assets and under the direct control of the JTF Surgeon is an absolute necessity. Military health experts who should participate as part of this assessment team include: (*a*) public health physicians, (*b*) epidemiologists, (*c*) emergency or family practice physicians, (*d*) community or public health nurses, (*e*) environmental health, sanitary engineering, or entomology officers, (*f*) public health technicians, and (*g*) data entry clerks. Additional consultants from nongovernmental organizations, private volunteer organizations, the Pan American Health Organization, the World Health Organization, the UN Children's Fund, the Centers for Disease Control and Prevention, or the country affected should also be included as necessary.

Some basic information must be obtained immediately after arriving in the area. Maps of the affected area will be necessary, preferably showing streets, airports, and MTFs. The location of tent cities, camps, schools, clinics, hospitals, military medical units, disaster medical assistance teams, and civilian relief agencies need to be plotted and posted for easy access by team members at all times. Lists, including phone numbers, of all involved agencies should be obtained as early as possible and a compendium of points of contact in each location should be made for the use of team members and other JTF medical and logistics personnel. Checking this information with the JTF operations section ensures completeness and accuracy.

Certain methods should be followed to help ensure the reliability and timeliness of the data gathered. The disaster area should be divided into blocks or segments. Population centers (eg, tent cities, camps, shelters) should be emphasized first in the start-up of surveillance efforts. Data should be collected using simple, preformatted, standardized forms. A list of symptom and diagnostic categories should be created a priori, and data should include total numbers in each of these categories by age groups, sex, and reporting location. It is also important to be able to separate medical visits by civilians from those by military personnel. Samples of reporting forms can be found in the surveillance chapter of this textbook (Chapter 31, Disease and Nonbattle Injury Surveillance Outcome Measure for Force Health Protection). Initially, monitoring should be done daily; it should encompass facilities such as clinics, hospitals, tent cities, camps, shelters, disaster medical assistance teams, food distribution centers, daycare centers, and all military MTFs in the area. After 2 to 3 weeks, frequency of reporting can be decreased to two to three times per week, eventually decreasing to a standard of no less than once a week on return to baseline conditions, which usually occurs during the rehabilitation phase. The transition of medical surveillance responsibilities from the military to the local civilian health authorities should be done in a step-by-step fashion, preferably with an overlap of 1 to 2 weeks.

DISEASE CONTROL

Communicable Diseases

Risk

The risk of communicable disease outbreaks after natural disasters is very low. Epidemics are likely only if a new pathogenic agent is introduced, transmission of preexisting pathogens is increased, or susceptibility of the population is increased.[25] The introduction of new pathogens after a natural disaster is a rare occurrence.

Increased transmission or susceptibility can occur because of several factors. These include (*a*) malnutrition (as in the case of measles outbreaks in refugee populations),[26] (*b*) massive population movements, which cause increases in crowding and concomitant increased risk of infection with respiratory pathogens by person-to-person transmission (eg, meningitis, tuberculosis, viral respiratory pathogens), and (*c*) deterioration of environmental and personal hygiene, causing increased risk of waterborne and foodborne diseases (eg, cholera, shigellosis, hepatitis).[27–29] Additionally, the increased breeding of disease vectors can cause outbreaks of vector-borne diseases such as malaria (eg, Haiti, 1963[30]; Guayas River Basin, Colombia, 1982-1985[31]). The contamination and breakdown of the potable water supply can lead to outbreaks of typhoid fever (Puerto Rico, 1956[32]; Mauritius, 1980[32]), balantidiasis (Truk District, Trust Territories of the Pacific, 1971[32]), hepatitis (Dominican Republic, 1979[33]), and giardiasis (Utah; 1983[34]; Washington State, 1980[35]). Lastly, increased contact with water and contamination of water sources with human or animal waste and waterborne pathogens, such as leptospira and hepatitis E, often occurs following floods (Portugal, 1967[36]; Brazil, 1975[32,37]; Nicaragua, 1995[38,39]; Vietnam, 1994[40]; Nepal, 1995[41]; Puerto Rico, 1996[42]).

There is a higher probability of waterborne epidemics after floods and windstorms than other natural disasters because of contamination of surface water by run-off and contamination of piped water supplies by cross-connections (typhoid fever and diarrheal diseases early, hepatitis A and E later). Also, because of direct contact with accumulated surface water, leptospirosis and skin infections could represent a problem in endemic areas. The potential for increased vector breeding and vector contact because of destruction of housing in windstorms and floods can result in epidemics of dengue (within 2 to 4 weeks) and malaria (within a few months). There can be a higher risk for acute respiratory illnesses, measles, and gastrointestinal illnesses in shelters, tent cities, daycare centers, feeding centers, and refugee camps because of overcrowding, lower levels of sanitation, and possible importation of endemic diseases into these locations. Finally, recent global climatic changes are beginning to exert a role in the acceleration and resurfacing of infectious diseases following major natural disasters.[43]

Control

Attempts to control communicable diseases should focus principally on improving personal and environmental hygiene and providing clean food and water. Other preventive measures of secondary importance include chemoprophylaxis, vaccination, early treatment of infectious patients, and isolation of infectious patients. Massive immunization campaigns, although sometimes popular with political authorities and the public, are often of only short-term benefit and should be undertaken only on the basis of sound epidemiologic evidence.[33] Examples of vaccinations that may be indicated include: (*a*) measles vaccine in crowded camps and refugee populations at risk, (*b*) meningococcal meningitis and typhoid fever vaccines for early control of outbreaks in specific populations at high risk, (*c*) tetanus toxoid for minor trauma victims, and (*d*) rabies diploid cell (inactivated) vaccine for animal bite victims in areas with ongoing rabies transmission. The use of any of the oral cholera vaccines, although debatable, may be considered during acute emergencies, such as natural disasters and refugee crises, or before impending cholera outbreaks in populations at risk.[44,45] Giving chemoprophylaxis to close contacts may be advisable during epidemics of meningococcal meningitis, cholera, or shigellosis. Chemoprophylaxis may also be indicated for high-risk groups in areas with significant threats of leptospirosis (eg, during or immediately following floods) or malaria (eg, following an influx of refugees from endemic areas). The most important element for the control of communicable diseases after natural disasters, however, is the establishment of effective surveillance.

Malnutrition

Another major disaster-related problem, especially in developing countries, is malnutrition (see

Chapter 47, Nutritional Assessment and Nutritional Needs of Refugees or Displaced Populations). Malnutrition affects populations in many ways, principally by direct effects on the population's level of immunity and fertility potential.[12] It also causes higher rates of morbidity and mortality from diseases such as measles, acute respiratory infections, tuberculosis, and diarrheal diseases, especially in the very young (under 4 years old), nonimmune, susceptible age groups.[46] The military can play a major role in securing transport and availability of food supplies, especially to remote, rural areas, as was the case during Operation Restore Hope in Somalia (1992–1993).[3] The role of malnutrition is especially important when addressing refugee or displaced populations and superimposed disasters, such as acute diarrheal disease following Bangladesh cyclones or measles, cholera, and shigella following droughts in Ethiopia and Somalia. It is in these situations that provision of potable water, adequate nutritional supplementation, and vaccines is especially crucial. These measures are the most effective ones in reducing mortality among disaster victims, especially young children.[46,47]

Psychological Effects

The mental health effects of disasters can be significant, especially in urban areas and during civil unrest or war. Psychological symptoms common during the immediate postdisaster period include intrusive thoughts, emotional numbness, difficulty concentrating, anxiety episodes, depression, and, in some cases, shock syndrome.[48] In most cases, the majority of people quickly adapt. Sociological studies[49] in the postdisaster period document that within 30 minutes of a major disaster, up to 75% of healthy survivors will be engaged in rescue activities. Affected populations have also proved remarkably effective at rapidly reestablishing the basic microenvironment in which they can survive. For example, after the 1976 earthquake in Guatemala, as many as 50,000 families had relocated to improvised dwellings within the first 24 hours.[50] Delayed, long-term effects, such as posttraumatic stress disorder syndrome, are directly related to the intensity of the event (eg, loss of life, destruction of property) and are more common in females and in those without access to social support systems, such as relatives and close friends.[51,52]

Quick adaptive response and low-level violent behavior by the affected persons are the norm after most natural disasters. Previous "disaster experience" has been shown to be of greater value than any other human factor in decreasing the risk of adverse mental events, as well as death or injury, during a natural disaster.[53] This is nowhere more evident than in the populations of the US Virgin Islands and Puerto Rico, who are frequently exposed to the threat of hurricanes. In addition, social support systems have been found to be more important than the actual magnitude or severity of the event in helping the individual cope with the situation.[54]

The loss of life or property can cause a significant amount of stress in relief workers already overburdened by disaster-associated job responsibilities. Role conflicts and acute stress reactions are more likely to occur in these workers.[55] Losses after the main disaster (eg, loss of loved ones) can precipitate mental crises in already stressed disaster workers and victims.

Neuropsychiatric casualties will require specialized triage and both psychological stress intervention and long-term support.[56] Emergency mental health services should be delivered and supervised by practitioners in the field as soon and as far forward as possible. This is analogous to the military's forward treatment and return-to-duty concept of combat stress management. This task is best managed by mental health intervention (also known as combat stress control or CSC) teams, a number of which are a part of major deployable military medical units.[57]

Long-term Illnesses

Available, but limited, data collected among disaster-affected populations in developed countries seem to point to certain associations with long-term morbidity and mortality following major disasters. Significant increases in mortality from all causes and from malignant diseases, as well as an increase in reporting of surgical conditions and hospitalizations, was noted in a study of flood victims in Bristol, England, in 1968.[58] Similarly, Melick[59] and Logue[60] conducted two long-term follow-up studies in the Wyoming Valley in Pennsylvania from 1975 to 1977 after the floods caused by Hurricane Agnes (1972) and found more health problems were reported among flood victims and their close relatives than unaffected people. Flood victims also experienced more stress from major life events after the floods. A 35% increase in rates of leukemia, lymphoma, and spontaneous abortion, beginning about 2 years after the floods, was also noted in the river valley areas of southern New York State that were affected by the flooding caused by

Hurricane Agnes.[61] There also is some evidence in the literature to support a disaster–stress association with cancer.[21] Recently, the mortality of residents on Kauai, Hawaii, was examined after Hurricane Iniki struck in September 1992; the overall mortality rate during the 12-month period after Iniki was found to be elevated, especially the rate of deaths related to diabetes mellitus.[62] The extent and types of long-term or chronic illnesses seen after a natural disaster can vary, however, and accurate generalizations to developing countries cannot be made.

DEATH AND INJURY

Patterns and Mechanisms

The degree to which disasters, regardless of their location, cause death and injury varies within and between disaster types; the predominant causes of death and injury will also depend on the region or country where the disaster occurs.[63] The main distinction is between earthquakes, which frequently cause large numbers of deaths and severe injuries, and other types of disasters (Table 42-3). Earthquakes generally cause deaths through the collapse of dwellings and other structures, as well as by secondary fires. They tend to cause more serious problems when they happen at night because sleeping people become trapped inside their homes, especially those people occupying upper floors of apartment buildings.[64,65] Injuries tend to be orthopedic in nature; "crush syndrome" has been reported after many earthquakes.[66] Death-to-injury ratios have ranged from a low of 1:3 to 1:4 (Guatemala, 1976[67]; Italy, 1980[68]) to as high as 3:1 (Armenia, 1988[69]).

Tsunamis, floods, and landslides may cause large numbers of deaths, especially in urban, coastal areas and in areas where large segments of the population live around major rivers, such as the Yellow River in China (see Table 42-1). Usually there are deaths but few, if any, severe injuries after these events. For example, the great storm surge that struck East

TABLE 42-3

HEALTH AND ENVIRONMENTAL EFFECTS OF NATURAL DISASTERS

	Earthquakes	Volcanoes	Tsunamis	Floods	Hurricanes	Tornadoes
Deaths	Few-Many*	Few-Many	Many	Few	Few-Many†	Few
Injuries						
Severe	Many*	Few-Many	Few	Few	Few†	Few
Mild	Many	Few	Few	Few	Many	Few-Many‡
Outbreak risk	Minimal	Minimal	Minimal	Moderate§	Moderate§	Minimal
Damage	Great*	Great	Great	Variable	Great†	Great
Food scarcity	Rare	Variable	Common	Common	Rare	Rare
Migration	Rare¶	Common	Common	Common	Rare	Rare

*Depending on pre-earthquake existence of a seismic building code and intensity
†Depending on location (ie, greater in coastal urban areas) and storm intensity
‡Depending on tornado path, pre-impact warning, and type of housing
§Risk of direct contact waterborne diseases (leptospirosis, skin infections) and diarrheal illnesses in first 2 weeks, vector-borne illnesses and hepatitis A and E afterwards; increased risk of person-to-person transmission in overcrowded settings
¶Significant population movements to marginal zones may occur in heavily damaged urban areas (eg, Nicaragua, 1972)
Sources: (1) Sidel VW, Onel E, Jack Geiger H, Leaning J, Foege WH. Public health responses to natural and human-made disasters. In: Last JM, Wallace RB, eds. *Maxcy-Rosenau-Last Public Health and Preventive Medicine*. 13th ed. Norwalk, Conn: Appleton & Lange; 1992:1173–1186 (2) Blake PA. Communicable disease control. In: Gregg MB, ed. *The Public Health Consequences of Disasters*. Atlanta: Centers for Disease Control; 1989: 7–12. (3) Pan American Health Organization. *A Guide to Emergency Health Management after Natural Disaster*. Washington, DC: PAHO; 1981. Emergency Preparedness and Disaster Relief Coordination Program Scientific Publication No. 407 (4) Llewellyn CH. Public health and sanitation during disasters. In: Burkle FM, Sanner PH, Wolcott BW, eds. *Disaster Medicine: Application for the Immediate Management and Triage of Civilian and Military Disaster Victims*. New York: Medical Examination Publishing; 1984: 132–161 (5) Western K. *The Epidemiology of Natural and Man-made Disasters: the Present State of the Art*. London: London School of Hygiene and Tropical Medicine, University of London; 1972. Dissertation.

Pakistan (now Bangladesh) in 1970 killed an estimated 300,000 people, approximately 20% of the population in affected areas. Injuries, however, were largely limited to cuts and bruises.[70] An individual who is caught by the flooding waters drowns; one who is not, survives, usually uninjured.

Windstorms cause deaths and injuries in developed countries, but, unlike in developing countries, rarely on a large scale. The wind is not the biggest killer; more important is the flooding due to the storm surge that usually accompanies a windstorm, especially in coastal areas of developing countries where there is no adequate warning system in place. The East Pakistan cyclone of 1970 is an example.[71] This phenomenon is also illustrated by Hurricanes Hugo (1989), Andrew (1992), Marilyn (1995), and Opal (1995), which affected Puerto Rico, the Bahamas, and southeastern United States. Although only 128 deaths were reported in those four hurricanes (41, 50, 10, and 27, respectively), hundreds of injuries, especially minor cuts and bruises during the relief phase, were reported.[20,72–76] Most of the deaths were preventable, occurred during the impact phase, and were mainly due to drowning, electrocution, and asphyxiation and burns from home fires. In some cases, the incidence of heart attacks has also increased after major hurricanes and is mainly attributed to physical exertion of older people during the clean-up process.[74–76]

Like other windstorms, tornadoes cause deaths and injuries in modest numbers when compared with earthquakes. The leading causes of death during tornadoes are craniocerebral trauma and crushing wounds of the chest and trunk.[77,78] These are most often caused by high-speed, flying debris. Fractures are the most common type of nonfatal injury, involving mostly the lower extremities (35%), head (25%), upper extremities (16%), and thorax, vertebrae, and pelvis (8% each). Contusions, lacerations, and other soft-tissue injuries are also frequent, with a subsequent increased risk of secondary sepsis complications from wound contamination.[78,79]

Human and Socioeconomic Factors

The very young and the very old are at increased risk of death and injury during earthquakes and flash floods.[12] In East Pakistan in 1970, those younger than 4 years and older than 60 years who could not escape the flooding were at increased risk.[70] Likewise, during the Guatemalan earthquake in 1976, the death rates in the 5- to 9-year-old age group and the over-60 age group were found to be higher, suggesting that they got trapped inside collapsed brick and adobe homes. It appears also that parents took preferential care of the very young and more defenseless children.[80] For some disasters, such as tornadoes,[81] floods, and cyclones,[70] females have been found to be at increased risk. By comparison, males tend to be at increased risk of minor injuries during the clean-up period (Figure 42-3).

Socioeconomic level appears to be inversely related to risk; the poorest and least educated are the worst prepared for the disaster before impact and have less access to medical care after impact. This is especially true in rural areas. Other special high-risk groups include alcoholics, physically and mentally disabled persons, and older persons with chronic medical conditions. Studies of victim behavior during floods have suggested an association between alcohol con-

Fig. 42-3. In this photograph, Marines are putting up tents and stringing electrical wire as part of the military's response to Hurricane Andrew in southern Florida in August 1992. The need of the community was so great that military rapid-response personnel worked long hours at physically demanding jobs. This exhausted Marine fell asleep on top of a tent he had just helped to erect and next to a high voltage electrical wire. Risk of injury for rescue personnel, especially those doing heavy manual labor, is serious and often discounted in the push to alleviate the suffering of victims of a disaster. US Army photograph.

sumption and mortality.[82] Other studies of tornado victims have indicated that older people are less likely to heed evacuation warnings.[81,83]

Physical, Environmental, and Geographic Factors

Improper building techniques, the introduction of newer, cheaper building materials (such as concrete), and the inappropriate use of these materials in construction have resulted in high mortality rates after earthquakes in certain areas of the world (eg, Mexico City, 1985; Armenia, 1988). In certain areas, such as Iran, eastern Turkey, and Central America, the practice of building unframed rock and earth houses and the use of insufficiently reinforced adobe walls has resulted in high casualty rates.[15,49,80] By comparison, more strict seismic building codes in California have resulted in significantly lower mortality rates.[14] The construction of elevated shelters and physical barriers in flood- and cyclone-prone areas has been recently proven to be very effective in reducing morbidity and mortality in areas such as Bangladesh[53] and Japan.[9]

Perhaps the best example of government involvement in the prevention of disaster casualties can be found in Japan and its implementation of disaster-mitigation measures for typhoons, tsunamis, floods, and landslides in 1958. There was a consequent marked reduction in mortality and property damage (pre-1958 vs. post-1958).[9] Another example of the positive effect of disaster-mitigation measures, such as improved building codes, can be seen in southern Florida. Although Hurricane Andrew was one of the strongest recorded hurricanes to make landfall in the United States, only 50 deaths were attributed to that storm.[14]

There is an increased risk of serious or fatal injuries for people inside vehicles during flash floods and tornadoes.[81,84] Conversely, there is a documented decreased risk of injury during tornadoes for people inside buildings, especially in basements.[81,83] The intensity and duration of the disaster is directly related to the amount of damage; location of the disaster is also important as higher damage is sustained in populated, urban, and coastal areas.

ENVIRONMENTAL HEALTH

Preventive medicine plays a key role in the relief effort, as natural disasters can disrupt the ecological balance and so cause outbreaks of disease. Measures to ensure needed sanitation and pest management must be planned before and implemented as soon as possible after the occurrence of a disaster. Organizational and educational efforts and other public health measures to help victims avoid disease outbreaks are important aspects of preventive medicine support.

Natural disasters cause considerable deterioration of environmental conditions. Disruption of environmental health services commonly occurs, particularly in services such as potable water and waste disposal systems. When waste disposal systems are disrupted and general sanitation levels decrease, the contamination of food and water supplies and the proliferation of insect and rodent pests increase the risk of disease.

The sudden creation of areas of high population density, such as camps for displaced persons, causes additional public health concerns. The lack of proper shelter, water, soap, detergent, and basic cleaning and washing facilities makes it difficult to maintain usual standards of personal hygiene and often results in outbreaks of diarrheal disease and vector-borne diseases in areas where they were prevalent before the disaster.[17,30–32,34,35]

Initial Environmental Health Assessment

During the immediate impact phase, there are five major environmental health issues that need to be addressed promptly: safe drinking water, shelter, human waste disposal, personal hygiene, and vector-borne disease avoidance.[17,85] The specific objective of emergency measures is to restore environmental health conditions and services to whatever levels existed before the disaster occurred, regardless of judgments about predisaster quality.[17] It is counterproductive to solve chronic problems by giving sophisticated aid that the local government cannot sustain. If the local professionals and facilities are unable to continue a procedure after relief organizations withdraw, that procedure should probably not be started.

To assist in solving these problems, a PVNTMED team should be deployed to the disaster area as soon as possible after military assistance has been requested. Areas of expertise on this team should include epidemiology and public health, entomology, environmental health, sanitary engineering, veterinary medicine, civil affairs, and occupational health and toxicology.

The US Army, Navy, and Air Force all deploy specialized units or teams to provide preventive medicine support to contingency operations. Army PVNTMED detachments provide preventive medicine support and consultation in the areas of entomology, field sanitation, sanitary engineering, and epidemiology.[18] The Navy forms contingency preventive medicine or vector control teams from supporting Navy Disease Vector Ecology and Control Centers and Navy Environmental and Preventive Medicine Units. These teams become part of the Mobile Medical Augmentation Readiness Team and are tailored to the needs of each contingency operation. The mission and capabilities of these teams are similar to those of the Army units described above. The US Air Force support for contingency operations may be provided by Prime BEEF (Base Engineer Emergency Force). Capabilities of this team include field sanitation and hygiene, general pest management, and specialized aerial pesticide spraying.

Water

Sources and Storage

The first priority in a disaster-stricken area is to ensure an adequate supply of drinking water, followed by water for personal hygiene. During the initial on-site assessment, all potential local sources of potable water need to be investigated. The assistance of local authorities in this assessment is very important, as is the advice of a sanitary engineer or water system specialist familiar with the host country conditions. Daily water supply requirements for relief operations (eg, temporary shelters and camps), is 15 to 20 L per person for eating and drinking purposes.[17,19,86] Greater amounts are required in field hospitals and mass feeding centers.

Drinking water should be obtained from operational water distribution systems, if possible, and from undamaged private sources (eg, breweries, dairies, wells).[17] These same private sources can also be contacted for the use of their trucks to transport bulk volumes to refugee camps or centers. Tanks used for storing and transporting drinking water must be free of and protected against contamination. Gasoline, chemical, or sewage trucks or containers should not be adapted to hold drinking water. All water sources and water produced from existing facilities should be tested by PVNTMED personnel before use. Bulk water treatment and distribution is a quartermaster responsibility. PVNTMED personnel should assist in selecting sources of water and establishing water points. They should also advise both the quartermaster and the engineer groups and perform water quality assessment functions.

Multi-liter containers should be provided to store and distribute water. These containers should be easily transportable and have a means to prevent recontamination during storage. A study in Bolivia, for example, demonstrated that 20-L plastic containers with screw-top lids and a spigot were ideal for preventing recontamination of treated water.[87] Similar containers were also used successfully during Operation Uphold Democracy (1994–1995) relief efforts in Haiti.

Disinfection

Residual concentration of chlorine in the water distribution system should be increased after a disaster. For drinking water under normal field conditions, the US military requires a chlorine residual of 5 ppm (5 mg/L) after a 30-minute contact time.[88] Under emergency conditions, the JTF Surgeon or senior medical authority may authorize reduced chlorine residuals and decide which water quality standards apply: the Department of Defense's, the World Health Organization's, or some other agency's. In a disaster situation, a large quantity of reasonably safe water may be preferable to a smaller amount of very pure water. Water quality standards vary; the Pan American Health Organization recommends at least a 1 ppm residual after 30 minutes.[17] The United Nations High Commissioner for Refugees recommends a minimum of 0.2 ppm residual.[89] The rationale is that if the chlorine content of water is much above 0.5 ppm, people may prefer drinking untreated water. One way to avoid over-chlorinating drinking water is to check that the water is free of a chlorine residual before starting chlorination efforts. PVNTMED personnel should check public water supplies daily to ensure an adequate chlorine residual is maintained.

If water supplies in the disaster area are not being chlorinated because chlorination systems within the distribution networks are not functioning, water must be disinfected in small quantities. This can be accomplished by boiling the water or by adding agents in the form of pills, powder, or solution (Table 42-4). For boiling water, the US military recommends keeping the water at a rolling boil for 5 to 10 minutes. The United Nations High Commissioner for Refugees recommends boiling water for 1 minute for every 1,000 m of altitude above sea level.[89] In general, boiling water for 1 minute will

TABLE 42-4

EMERGENCY DISINFECTION OF SMALL VOLUMES OF WATER

Disinfectant	Techniques	Contact Time
Calcium Hypochlorite 70% $CaOCL_2$ (powder)	Add 1 heaping tsp (7 g) to 8 L water for stock solution of 500 ppm (500 mg/L). Add stock to water in proportion of 1 part to 100 parts water for a 5 ppm (5 mg/L) concentration.	30 min
Sodium Hypochlorite 5% NaOCL (liquid)	Household bleach usually contains 5% chlorine. Add 2 drops bleach per liter water (double the dose if water is very cold or cloudy).	30 min
Halazone tablets (4 mg or 160 mg)	Chlorine tablets. Add one 4 mg tablet per L water. One 160 mg tablet is added to 40 L water (double the dose if water is very cold or cloudy).	30 min
Iodine Tablets	Add one to 1 L water (double the dose if water is very cold or cloudy).	30 min
Tincture of Iodine (2% solution)	Common household tincture of iodine. Add 5 drops of tincture of iodine to 1 L clear water (double the dose if water is very cold or cloudy).	30 min
Potassium permanganate $KMnO_4$ (powder)	Dissolve 40 mg $KMnO_4$ in 1 L warm water for stock solution. This solution will disinfect approximately 1 m^3 (250 gal) of water. This method is seldom used because of the long contact time required.	24 hr
Heat	Boil water for 5 to 10 min. This requires extra effort to protect water, as boiling provides no residual protection from recontamination.	N/A

ppm: parts per million
Sources: (1) Pan American Health Organization. *A Guide to Emergency Health Management after Natural Disaster*. Washington, DC: PAHO; 1981. Emergency Preparedness and Disaster Relief Coordination Program Scientific Publication No. 407 (2) US Dept of the Army. *Occupational and Environmental Health: Sanitary Control and Surveillance of Field Water Supplies*. Washington, DC: DA, 1986. Technical Bulletin MED 577.

kill most disease-causing bacteria and viruses. In areas where protozoal and helminthic diseases are endemic, longer boiling times are necessary.[90] The availability of adequate fuel and containers for boiling needs to be kept in mind.

Individual water purification methods should only be considered during an emergency for disinfecting small quantities of drinking water in limited and controlled populations, on an individual basis, and for only 1 to 2 weeks.[17] PVNTMED personnel should determine the chlorine residual before any form of disinfectant is distributed to individual users. Providing tablet, powder, or liquid disinfectants to individual users should be considered only when distribution can be coupled with a strong health education campaign teaching people how to use the disinfectants properly. Additionally, PVNTMED personnel will need to provide follow-up instruction and supervision to ensure proper and continued use of the disinfectants. There is potential for misuse of these disinfectants, especially with children.

Human Waste

An acceptable and practical system for the disposal of human waste should be a primary consideration. Improper disposal not only leads to the contamination of food and water supplies, it also attracts flies and other disease-carrying pests. The waste disposal system must be developed in cooperation with the refugees or local population and be culturally appropriate. Expert advice should also be sought from a sanitary engineer who is familiar with the habits of the refugees or inhabitants of the disaster area.[17]

Two main factors will affect the choice of a toilet system: the traditional sanitation practices of the users and the physical characteristics of the area, including the geology, rainfall, and drainage.[89] Once these considerations have been taken into account, the cleanliness of the latrines and their accessibility will determine whether they are used. Users must be trained in latrine upkeep. Frequent on-site visits by PVNTMED personnel will help ensure latrines are maintained properly.

Latrines should be placed where needed in relocation camps, relief worker settlements, and areas of dense population where facilities have been destroyed. There are many simple options that, if properly constructed and maintained, will meet all public health requirements. Examples of different types of field latrines suitable for disaster relief operations are shown in Table 42-5. The ideal latrine confines excreta; excludes insects, rodents, and animals; prevents contamination of the water supply; provides convenience and privacy; and remains clean and odor-free.[90]

Waste Water

Waste water is created by personal hygiene and food preparation activities. Sources of waste water should be localized as much as possible, and drainage should be provided. Water allowed to stand will soon become malodorous, provide breeding sites for insect pests (especially mosquitoes and filth flies), and become an additional source of contamination of the environment. Soakage pits or trenches can be used for the collection of bath and wash water. This same system equipped with a grease trap can also be used for the collection of liquid kitchen waste.

Solid Waste and Dust

Uncontrolled accumulation of solid waste (garbage) and improper disposal increases the risk of diseases spread by insects and rodents. An effective garbage disposal system using burial or incineration must be provided.[88] Garbage burial sites should be located at least 30 m from any potable water source and at least 50 m downwind from camps. Open burning of garbage on-site should be avoided; incinerators should be used to burn garbage.

Solid waste disposal containers in tent camps should be waterproof, insect-proof, and rodent-proof. The waste should be covered tightly with a plastic or metal lid. A 50-L waste receptacle should be provided for every 10 families (25 to 50 persons). The containers should be placed throughout the site such that no dwelling is more than about 15 m away from one. The weight and shape of containers must also be kept within the limits that can be conveniently

TABLE 42-5

TYPES AND CHARACTERISTICS OF LATRINES SUITABLE FOR DISASTER RELIEF OPERATIONS

Type	Characteristics
Shallow trench latrine	A quick-action solution; cheap and easy to construct. Should only be used a few days. Approximately 30 cm wide, 1 m deep. Excreta covered with soil after each use.
Deep trench latrine	Easy to construct. Can be used for a few months. Appropriate for tent camps. Approximately 2 m deep, 80 cm wide. Recommended length for 100 persons is 3.5 m. Requires a structure providing a seat or squatting hole with lid. Trench should be fly-proofed.
Pit latrine	Most common worldwide. Appropriate for tent camps. Consists of a superstructure for privacy and a squatting hole or seat above a hole in the ground. Can be used by individual families or in clusters as communal facilities. Pit should be about 1 m across, and more than 2 m deep.
Chemical latrine	Self-contained, expensive to maintain. Includes a holding tank with chemical additives. Contents must be pumped out daily for disposal in a conventional sanitary waste water system.
Burn-out latrine	Used when soil is hard, rocky, or frozen and when sufficient fuel is available for burning (a mixture of 1 part gasoline with 4 parts diesel oil is effective). Also suitable in areas with high water tables. Oil drums, cut in half, can be used to collect the waste. A structure that has a seat with a fly-proof, self-closing lid is required.

Sources: Pan American Health Organization. *A Guide to Emergency Health Management after Natural Disaster*. Washington, DC: PAHO; 1981. Emergency Preparedness and Disaster Relief Coordination Program Scientific Publication No. 407. United Nations High Commissioner for Refugees. *Handbook for Emergencies*. Geneva: UNHCR; 1982.

handled by the collection crew. The collection of garbage from the containers should take place regularly, daily if possible.

Large amounts of dust carried in the air can be harmful to human health by irritating eyes, respiratory systems, and skin and by contaminating food and water.[89] The best preventive measure is to stop the destruction of vegetation around the site. Dust control can be achieved by spraying roads with water (especially helpful around health facilities and feeding centers), limiting traffic, and banning traffic from certain areas, if necessary.

Hazardous Substances and Medical Waste

Hazardous wastes include chemical, biological, flammable, explosive, and radioactive substances, which may be solid, liquid, or gaseous.[90] Handling of hazardous substances may be a significant public health problem during and after certain disasters. The advice of an industrial hygienist may be necessary to handle such waste safely. The treatment and disposal of medical waste requires special attention. Needles, scalpels, and materials contaminated with infectious waste are especially dangerous. Medical waste should be treated separately; as much of it as possible should be burned without delay. The designated burning area should be fenced to prevent unauthorized access.

Management of the Dead

Suitable arrangements for the management of the dead are required from the start of any natural disaster that causes a refugee emergency.[89] The mortality rate after a refugee influx will probably be higher than under normal conditions. The health hazards associated with unburied bodies are minimal, especially if death resulted from trauma. However, bodies must be protected from rodents, animals, and birds. Additionally, bodies decomposing in wells and streams can cause gastroenteritis in those that drink the water.

Dead bodies have the potential to create social problems, which must be delicately addressed by public health authorities. Every effort should be made to treat bodies with respect. Whenever possible, the customary method of disposal should be used, and the traditional practices and rituals should be allowed. Burial is the simplest and best method of disposal if it is acceptable to the community and physically possible. The necessary space for burial will need to be taken into account when planning the site, particularly in crowded conditions. Cremation may be used, but it can require large amounts of fuel and is not required as a public health measure. Before burial or cremation, bodies must be identified and the identification and cause of death recorded, if possible. This is important for disease control, registration, and tracing. Procedures must be in place to assure the care of orphaned minors who are left without appropriate care.[89]

Shelter

Natural disasters can result in the sudden creation of areas of high population density, such as camps for displaced persons. These persons need temporary public shelter that will not lead to further deterioration of public health or the environment. The site selection, planning, and provision of shelter require expertise and must be closely integrated with the planning of other services, especially water and sanitation.[89] It is important that PVNTMED specialists work closely with engineers, experts from the Pan American Health Organization and the World Health Organization, and local authorities early in the process to select refugee camp locations.

Existing public buildings, such as schools, churches, and hotels, are good choices as temporary shelters because they will likely have their own washing and toilet facilities that are usually sufficient for emergency purposes. If existing buildings are used as shelters, the recommended floor space is 3.5 m^2 per person.[17] Overcrowding can have serious health implications.

If tent cities or camps are necessary to accommodate the evacuees, the requirements are more complex. Sites should be chosen that have adequate drainage and are away from mosquito breeding areas, refuse dumps, and commercial and industrial zones. The layout of the site should meet the following specifications:[17,19,86]

- 3 m^2 of floor space per person,
- 10-m–wide roads between tents, minimum distance of tents to road of 2 m,
- Minimum distance between tents of 8 m, and
- 4 hectares (10 acres) of land per 1,000 persons.

Tent camps should be subdivided into a community service area and a residential area. The residential area should be further subdivided into clusters around personal service areas, which contain cooking and washing facilities and latrines. This subdivision is important because personal service areas used by relatively few persons are more likely to be self-maintained.

Safe water, food, and basic sanitation facilities must be available in all camps for displaced persons. Sanitation teams that provide such services and educate camp dwellers should be designated for each campsite.[17] Teams can be composed of volunteers, but they must be supervised by an environmental health technician. Teams should develop sanitation regulations for the sites and educate the residents about basic sanitation measures.

Water distribution points should be located in the camp so that families are not required to carry water for more than 100 m. These points should be located in the community service center and in the center of each residential area. Multi-liter containers for carrying water should be made available to camp residents.

Characteristics of tent camps, such as a high density of people, combustible shelter materials, and individual cooking fires, make them vulnerable to major fires.[89] The most effective preventive measure is the proper spacing and arrangement of tents to provide fire breaks. Other measures include allowing individual fires only in specific areas and having an alarm system, fire-fighting teams, and plans prepared. Residents must also take proper precautions in storing and using fuels and other highly flammable materials.

Food Sanitation

The availability and distribution of food may be disrupted after a natural disaster. Food can become contaminated, especially in mass feeding centers, by flood waters, insects, rodents, and unsanitary handling. Degradation of food products results from power outages that disrupt refrigeration; contact with water; and purposeful adulteration. The use of outdated stocks can also be a problem.

Bulk distribution of food is not always necessary in a disaster area. Food becomes a problem only if local stocks are destroyed or if the road system is so disrupted that normal distribution patterns break down. Available food supplies should be located and inspected by a qualified health specialist. It is important to try to provide familiar foodstuffs to refugees and displaced persons. Priority should be given to the consumption of uncontaminated perishable food, particularly if the food supply originates in areas where there have been power outages. The health specialist should also inspect all damaged places of food production and distribution before food is prepared and distributed. Food storage and preparation at mass feeding facilities should also be closely supervised.

To avoid health problems related to contaminated food, the public should be informed about proper food preparation and handling measures and which foods are the most likely to be safe. Local public health personnel should be used to the fullest extent possible to educate those affected, particularly refugees. Military food supplies may not be suitable for refugees, and their use may unintendedly cause detrimental results.[3] During disaster relief operations, US military forces will initially rely on the field ration Meal, Ready-to-Eat (MRE). These high-calorie, highly salted rations may be potentially dangerous to malnourished persons, especially children.[3] Recently, the Department of Defense has been involved in developing an MRE designed for humanitarian relief purposes. Its use in this scenario remains to be defined, however.

Personal Hygiene

Personal hygiene is obviously more difficult during emergencies, especially in densely populated areas such as refugee camps. As such, the potential for diseases associated with poor personal hygiene rises. Diarrheal diseases are very common in developing countries, and the added stress and relatively poor environmental services in refugee camps accentuate the problem. Public health workers should inform disaster-stricken populations about personal hygiene practices that will lessen the potential for disease. Trained and respected individuals from the refugee community should be more effective than outsiders in communicating health-related issues to their own people.[89]

Adequate cleaning and bathing facilities are critical for displaced persons to practice good hygiene, and local customs will dictate specific policies. Generally, however, there should be separate washing blocks for men and women.[17] One wash basin should be provided for each 10 people or a 3-m, double-edged wash bench for every 50 persons. Approximately 70 cm of wash bench should be fabricated for each wash basin. One shower head should be available for every 30 to 50 persons. For washing clothes, washtubs and clotheslines are necessary and scheduling of some sort will be required.

Insect and Rodent Control

By altering the environment, disasters may increase the transmission of diseases that already exist in a region. This may be due to the movement of large numbers of people, resulting in overcrowding in some areas and poor sanitation; the disruption of routine vector control programs; or the alteration of the distribution of vector species.[85,91] The increased risk of transmission of vector-borne diseases must be seriously considered after all natural disasters.

Pest control in a disaster situation is difficult, and physical barriers, such as screens, may be the best immediate measure.[89] The most effective method of controlling pests over the long term is to practice preventive measures, such as proper sanitation, garbage disposal, and food storage. Pest problems need to be explained to the affected populace, who need to be educated on the significance of pest control efforts, especially those with which they may not be familiar.

All pest or vector control activities should be supervised by an entomologist, preferably one with disaster experience and familiarity with local conditions before the disaster. Specialist advice about and supervision of all chemical pest control measures are essential. Detailed recommendations for the selection, application, and use of pesticides in field situations worldwide can be found in the US Department of Defense *Contingency Pest Management Pocket Guide*.[92] This guide is a concise reference to pesticides available through military supply channels (National Stock Numbers are listed) and designated for contingency use by one or more of the armed services. It contains information on pesticide uses, dosages, application methods, dilution formulas, and dispersal equipment; surveillance, trapping, and safety equipment; personal protective equipment against disease vectors; air transport of pesticides that do not meet transport requirements; and US military points of contact overseas who can provide information on vector-borne disease control in their areas of the world.

An additional source of information on vector control is the Pan American Health Organization publication, *Emergency Vector Control After Natural Disasters*.[91] This guide provides technical information necessary for evaluating the need for disease vector and rodent control following natural disasters, information for initiating immediate and postdisaster control measures, and guidelines for planning and carrying out surveillance and control programs against specific vectors under austere conditions.

An increased incidence of animal bites, especially dog bites, may occur as neglected strays come into close contact with persons living in temporary shelters. A program for the elimination of stray dogs should be considered, especially in areas where rabies is endemic.

SUMMARY

The role of the US military in providing assistance following major natural disasters is a role for which PVNTMED personnel need to be trained.[18] Familiarity with the procedures to follow in such support operations is critical to the successful accomplishment of the mission. The primary mission of PVNTMED personnel or units will continue to be to support US, allied, and coalition forces. However, involvement in a wide range of activities in support of the local or host-nation populace will also be required. Definition (a priori) of the military's roles and responsibilities and delineation of unit preparedness plans are necessary to respond to such contingencies in a timely and efficient manner. PVNTMED personnel serving in both operational and garrison units may also be called on to assist units in the preparation of disaster preparedness plans or to provide direct support during these types of missions. It is with this in mind that we have written this chapter. The Recommended Readings, which follow the references, may be helpful to PVNTMED personnel during disaster assistance deployments.

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