Chapter **61**

Natural Disaster Mitigation and Relief

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Sudden-onset natural and technological disasters impose a substantial health burden, either directly on the population or indirectly on the capacity of the health services to address primary health care needs. The relationship between communicable diseases and disasters merits special attention. This chapter does not address epidemics of emerging or reemerging diseases, chronic degradation of the environment, progressive climatic change, or health problems associated with famine and temporary settlements.

In line with the definition of *health* adopted in the constitution of the World Health Organization (WHO), the chapter treats disasters as a health condition or risk, which, as any other "disease," should be the subject of epidemiological analysis, systematic control, and prevention, rather than merely as an emergency medicine or humanitarian matter. The chapter stresses the interdependency between long-term sustainable development and catastrophic events, leading to the conclusion that neither can be addressed in isolation.

DISASTERS AS A PUBLIC HEALTH CONDITION

According to the International Federation of Red Cross and Red Crescent Societies, internationally reported disasters in 2002 affected 608 million people worldwide and killed 24,532—well below the preceding decade's annual average mortality of 62,000 (IFRC 2003). Many more were affected by myriad local disasters that escaped international notice.

Disaster has multiple and changing definitions. The essential common element of those definitions is that disasters are unusual public health events that overwhelm the coping capacity of the affected community. This concept precludes the universal adoption of a threshold number of casualties or victims. What would be a minor incident in a large country may constitute a major disaster in a small isolated island state. Not only are "quantitative definitions of disasters unworkably simplistic" as noted by Alexander (1997, 289), but when based on the economic toll or the number of deaths, they are also misleading with regard to the immediate health needs of the survivors or their long-term impact on the affected country.

Classification of Disasters

In the early 1970s, a series of well-publicized disasters (the civil war and resulting famine in Biafra, the cyclone in Bangladesh, and the earthquake in Peru) triggered the scientific interest of the international public health community.

Disasters can be classified as *natural disasters, technological disasters,* or *complex emergencies.* The latter include civil wars and conflicts. These classifications are arbitrary and refer to the immediate trigger—a natural phenomenon or hazard (biological, geological, or climatic); a technologically originated problem; or a conflict. In reality, all disasters are complex events stemming from the interaction of external phenomena and the vulnerability of man and society.

The human responsibility in so-called natural disasters is well acknowledged. The term *natural disaster* remains commonly used and should not be understood as denying a major human responsibility for the consequences.

Disaster Terminology

The following definitions are adapted from those proposed by the Secretariat of the International Strategy for Disaster Reduction (ISDR), a United Nations (UN) body established to sustain the efforts of the International Decade for Natural

Disaster Reduction (UN/ISDR 2004) and the WHO *World Health Report 2002* (WHO 2002):

- *Hazards* are potentially damaging physical events, which may cause loss of life, injury, or property damage. Each hazard is characterized by its location, intensity, frequency, and probability.
- *Vulnerability* is a set of conditions resulting from physical, social, economic, and environmental factors that increase the susceptibility of a community to the effects of hazards. A strong coping capacity—that is, the combination of all the strengths and resources available within a community—will reduce its vulnerability.
- *Risk* is the probability of harmful consequences (health burden) or economic losses resulting from the interactions between natural or human-induced hazards and vulnerable or capable conditions. In a simplified manner, risk is expressed by the following function:

$$\text{Risk} = f\,(\text{Hazards} \times \text{Vulnerability})$$

A public health approach to disaster risk management will aim to decrease the vulnerability by adopting prevention and mitigation measures to reduce the physical impact and to increase the coping capacity and preparedness of the health sector and community, in addition to providing traditional emergency care (response) once the disaster has occurred.

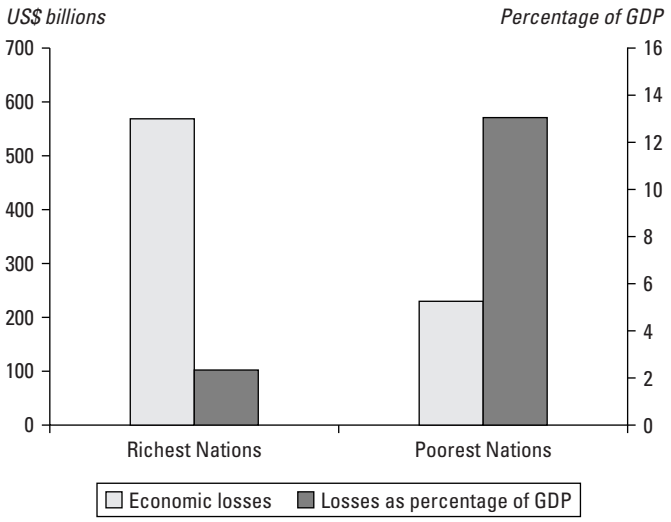
Distribution and Risk Factors

Health and relative economic losses of natural disasters disproportionately affect developing countries (Alexander 1997; UN/ISDR 2004). More than 90 percent of natural disaster–related deaths occur in developing countries. Even though the economic losses are far greater in industrial countries, the percentage of losses in relation to gross national product (GNP) in developing countries far exceeds that percentage in industrial countries (figure 61.1). At an individual level, a sudden reduction of US$5,000 from an annual income of US$50,000 is worrisome; however, the ongoing loss of US$50 from a monthly income of US$100 may be catastrophic.

For this reason, statistics of economic damage and mortality alone are not true indicators of the effect of disasters on the health and development of people and communities.

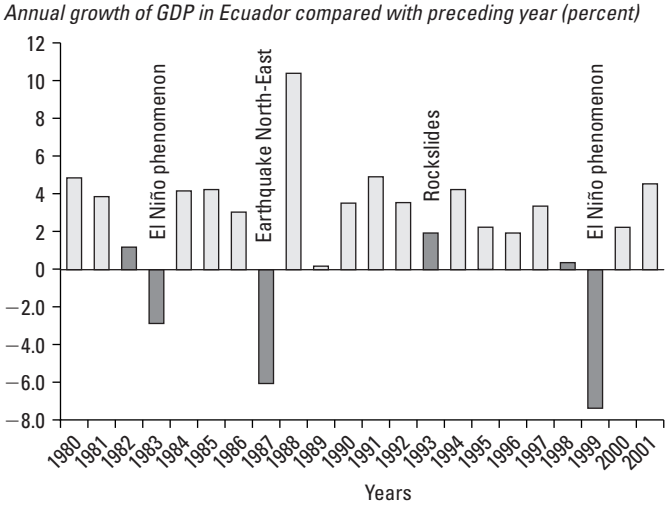
Disaster impact statistics show a global trend: more disasters occur, but fewer people die; larger populations are affected, and economic losses are increasing (IFRC 2000).

Geographic Distribution of Risk. Natural disasters do not occur at random. Geological hazards (earthquakes and volcanic eruptions) occur only along the fault lines between two tectonic plates on land or on the ocean floor. However, the local population often does not recognize the implications (the risks), as shown in the December 2004 tsunami in the Indian Ocean.



Source: UN/ISDR, 2004.

Figure 61.1 Disaster Losses, Total and as Share of Gross Domestic Product, in the Richest and Poorest Nations, 1985–99



Source: UN/ISDR, 2004.

Figure 61.2 Annual Growth of Gross Domestic Product and Occurrence of Major Natural Disasters in Ecuador, 1980–2001

Hydrometeorological hazards do not follow a well-established distribution. Although the areas subject to seasonal flood, drought, or tropical storms (cyclones, hurricanes, or typhoons) are well known locally, global warming may possibly redraw the map of climatic disasters. As the National Research Council (1999, 34–35) notes, "This change is far from uniform. A pattern of response 'modes' appears to be involved, in which warming is concentrated in northern Asia . . . while large regions of the northern Pacific and North Atlantic Oceans and their neighboring shores have actually cooled." El Niño–related fluctuations in relation to the gross domestic product (GDP) of Ecuador are shown in figure 61.2.

The risk of massive technological disasters, such as the catastrophic release of chemicals in Bhopal, India (methyl isocyanate), in December 1984, is serious in countries with significant industry (WHO 1992, 1996). Very few countries are immune to public health risks from hazardous chemical substances (from insecticides to industrial by-products) or discarded radioactive material from therapeutic or diagnostic use. Technological hazards increase rapidly with the unregulated industrialization of developing countries and the globalization of the chemical industry, suggesting that chemical emergencies may become a major source of disasters in the 21st century.

Factors Affecting Vulnerability. Vulnerability to all types of disasters—and to poverty—is linked to demographic growth, rapid urbanization, settlement in unsafe areas, environmental degradation, climate change, and unplanned development.

Age The importance of age as a factor of vulnerability can be significant in situations where physical fitness is necessary for survival. The higher fatality among children, elderly, or sick adults following the 1970 tidal wave in Bangladesh (250,000 fatalities) and the 2004 tsunami in Asia (more than 180,000 dead or missing) illustrates this point.

Gender Reports on immediate morbidity and mortality according to gender are not as conclusive. An Inter-American Development Bank paper indicated that 54 percent of the 3,045 people who died as a result of Hurricane Mitch in Nicaragua were male (IDB 1999). Stereotypes of gender vulnerability at the time of impact often do not apply. Depending on the type of disaster, far more significant vulnerability factors than gender or age are the time of day of the impact (and, therefore, the occupational activity of each group) and the structural vulnerability of housing, factories, and public buildings, including the location of the victims within the buildings. Following disasters, increased vulnerability of women is commonly noted in temporary settlements, where violence and sexual abuse are common. Specialized health care also may not be available (Armenian and others 1997).

Poverty Economic vulnerability might play a much greater role than age and gender. What has been noted regarding the greater vulnerability of poor countries also holds true at the community and family levels. Disasters predominantly affect the poor. Poverty increases vulnerability because of the unequal opportunity for healthy and safe environments, poor education and risk awareness, and limited coping capacity. A notable exception was the 2004 tsunami in Banda Aceh, Indonesia, where the middle- and upper-class neighborhood close to the shore was particularly affected.

A major example is the settlement of a large number of economically disadvantaged populations in highly vulnerable locations, particularly urban areas. Following Hurricane Mitch in Tegucigalpa, Honduras, families that were relocated from flooded areas to safer (but inconveniently remote) ground were rapidly replaced by new illegal settlers. In 2003, families killed by a landslide in Guatemala had been warned about their vulnerability but were unable to afford resettlement in safer (and more costly) areas. Subsidies alone may not have prevented this effect, given the overarching issue of land ownership by a few in Central America.

Short-Term Health Burden

Losses fall under three categories, which may have both direct and indirect components:

- lives and disabilities (both direct damage and an indirect consequence)
- direct losses in infrastructure and supplies (direct impact)
- loss or disruption in the delivery of health care, both curative and preventive (indirect impact).

The immediate health burden is directly dependent on the nature of the hazard. National health budgets of developing countries are, in normal times, insufficient to meet the basic health needs of the population. In the aftermath of a major disaster, authorities need to meet extraordinary rehabilitation demands with resources that often have been drained by the emergency response (as distinct from the resources destroyed by the event). Beyond the immediate response, decision making in the allocation of resources among sectors is mostly influenced by the magnitude of the economic losses rather than by the health statistics (principally the disability-adjusted life year, or DALY, losses) or social costs.

Earthquakes. As noted by Buist and Bernstein (1986), in the past five centuries, earthquakes caused more than 5 million deaths—20 times the number caused by volcanic eruptions. In a matter of seconds or minutes, a large number of injuries (most of which are not life-threatening) require immediate medical care from health facilities, which are often unprepared, damaged, or totally destroyed, as was the case in the earthquake in Bam, Iran, in 2003. In the aftermath of that earthquake, which resulted in 26,271 deaths, the entire health infrastructure of the city was destroyed. All traumas were evacuated by air to the 13 Iranian provinces long before the arrival of the first foreign mobile hospitals. Table 61.1 illustrates the accelerated pace with which priorities evolve and overlap in the first week following an earthquake.

After a few weeks, national political solidarity and external assistance wane, and the local budgetary resources are drained. At the same time, health authorities face the overwhelming task of providing services to a displaced population, rehabilitating

Table 61.1 Health Priorities Following Earthquakes

Priority	Time period	Comments
Search and rescue	0 to 48+ hours	Returns are rapidly diminishing. Most effective work is done by local teams.
Trauma care	0 to 48 hours: initial lifesaving care[a] 48 hours to 6 months: secondary care	External assistance generally arrives too late for initial care. Traumas may include burns and crush syndrome, especially in urban areas. Paraplegics and amputees require long-term care.
Routine medical emergencies and primary health care	Resumes as soon as the need for acute lifesaving care subsides (within 24 hours)	Emergencies include earthquake-related cardiovascular emergencies and premature births.
Attention to the dead	Varies. Not a public health issue but a social and political one	Priorities are identification and ritual burial.
Disease surveillance	Urgent—within 48 hours, unsubstantiated rumors of impending epidemics will be circulating	Surveillance is a sensitive public information and education issue. A simple, syndrome-based system is needed that will involve humanitarian organizations.
Provision of safe water	A predominant issue within 48 hours	The challenge is to provide a sufficient quantity of reasonably safe water.
Temporary shelter	48 hours to several months	Sanitation and provision of health services is a main issue. Accommodating families near their residence is preferable to setting up camps.
Provision of food	3 days to 6 weeks	Food provision is a social or economic issue. Food stocks and agricultural output are not affected by earthquakes.
Psychosocial care	7 days to 6 months	Mental health assistance is best provided by local personnel, if available.

Source: de Ville de Goyet 2001.
a. Following the earthquake in Mexico City in 1985 (10,000 deaths), bed occupancy rates did not exceed 95 percent despite the loss of 5,829 hospital beds.

health facilities, restoring normal services, strengthening communicable disease surveillance and control, and attending to the long-term consequences, such as permanent disabilities, mental health problems, and possibly long-term increases in rates of heart disease and chronic disease morbidity (Armenian, Melkonian, and Hovanesian 1998).

Tsunamis. Earthquakes on the ocean floor may cause catastrophic tidal waves (*tsunamis*) on faraway shores. Waves caused by the seismic event crest at less than a meter in open seas, but they are travel several hundred kilometers per hour, so when they reach shallow waters, they can be 10 meters high. Damage on the coast can be extensive. Usually, the number of survivors presenting severe injuries is small in proportion to the number of deaths.

Volcanic Eruptions. Volcanoes persist as a serious public health concern, though they are often overlooked by authorities and communities lulled by long periods of inactivity. Eruptions are preceded by a period of volcanic activity, which provides an opportunity for scientific monitoring, warning, and timely evacuation.

Some issues, such as ash fall, lethal gases, lava flow, and projectiles, although of concern to the public, are of minimal health significance: Ash fall causes a significant burden on medical services but is unlikely to result in excess mortality or significant permanent problems. However, ash fall affects transportation, communications, water sources, treatment plants, and reservoirs. Studies by Bernstein, Baxter, and Buist (1986) following the 1980 eruption of Mount St. Helens (United States) reviewed the transient, acute irritant effects of volcanic ash and gases on the mucous membranes of the eyes and upper respiratory tract as well as the exacerbation of chronic lung diseases with heavy ash fall. Concentrations of volcanic gases are rapidly diluted to nonlethal levels, which lead to inconvenience but negligible morbidity for the general public. Lava flows present little health risk because of their very slow speed of progression. Mortality caused by ballistic projectiles from a volcanic eruption is minimal.

Attention to these public concerns may distract the authorities from preparing for the greatest factors of mortality: the pyroclastic flows (Mount Pelé in Martinique, in 1902, with 29,000 deaths) and lahars. *Lahars* are mud flows or mud and ash flows caused by the rapid melting of a volcano's snowcap, as in Colombia in 1985 (23,000 deaths), or caused by heavy rains on unstable accumulations of ash, as in the Philippines in 1991. Historically, pyroclastic explosions or lahars have caused about 90 percent of the casualties from volcanic eruptions.

Potential contamination of water supplies by minerals from ash; displacement of large populations for an undetermined period of time (over five years in Montserrat, a small island in the Caribbean); accompanying sanitation problems; and mental health needs are of great public health significance (PAHO 2002a). Among the long-term problems, the risk of developing silicate pneumoconiosis requires further investigation.[1]

Climatic Disasters. Many communities and health services have learned to live with seasonal floods of moderate intensity. Periodically, the magnitude of the phenomenon exceeds the local coping capacity and overwhelms the resources of the health systems. The health burden associated with seasonal floods is well known locally: increased incidence of diarrheal diseases, respiratory infections, dermatitis, and snake bites. The actual risk of compromised water supplies depends on the level of contamination of the community's water supply before the disaster, compared with contamination after the flooding. Saline contamination is a long-term issue following sea surges and tsunamis. Prolonged flooding endangers local agriculture and occasionally requires food assistance on a large scale. The primary factors of morbidity remain overcrowded living conditions and poor water and sanitation in temporary settlements and other areas where water and sanitation services have deteriorated or are suspended.

Mortality and morbidity caused by tropical storms (hurricanes in the Atlantic Ocean and typhoons in the Pacific Ocean) result from, in increasing order of importance, high winds, heavy rainfall, and storm surge. When Hurricanes Mitch and George hit the Caribbean in 1998, traumatic injuries (lacerations or electrocution) caused by high winds of up to 150 miles per hour were relatively few; deaths from extensive rainfall (leading to flash floods and landslides) constituted the bulk of the more than 13,000 fatalities (PAHO 1999). In the Bangladesh delta, storm surges up to 6 meters traveled unimpeded over hundreds of kilometers and claimed between 250,000 and 500,000 lives in 1970 and up to 140,000 lives during five cyclones in the 1990s—primarily during one storm in 1991. Another cost is the need for specialized psychosocial assistance to large numbers of the population who survive the sustained violence of nature.

Cumulative mortality caused by small, undocumented mudslides and rockslides from water-saturated, unstable slopes probably approach the toll from well-known landslides (earthquakes in Peru in 1970 and in El Salvador in 2001, and the rains in Caracas, Venezuela, in 1999). Morbidity problems are often minimal, as survivors in the path of the landslide are few.

Impact on Communicable Diseases

Disasters related to natural events may affect the transmission of preexisting infectious diseases. However, the imminent risk of large outbreaks in the aftermath of natural disasters is overstated. Among the factors erroneously mentioned is the presence of corpses of victims, many buried beneath rubble. Dead bodies from a predominantly healthy population do not pose a risk of increased incidence of diseases (Morgan 2004). Catastrophic incidence of infectious diseases seems to be confined to famine and conflicts that have resulted in the total failure of the health system.

In the short term, an increased number of hospital visits and admissions from common diarrheal diseases, acute respiratory infections, dermatitis, and other causes should be expected following most disasters (Howard, Brillman, and Burkle 1996; Malilay and others 1996). This increase may reflect duplicate reporting (diarrhea cases were reported through both the emergency and the routine surveillance systems in Maldives after the 2004 tsunami), a temporary surge in surveillance, and medical attention available to an otherwise underserved population rather than representing a genuine change in the epidemiological situation.

In the medium term, heavy rainfalls may affect the transmission of vectorborne diseases. Following an initial reduction as mosquito-breeding sites wash away, residual waters may contribute to an explosive rise in the vector reservoir. When associated with a breakdown of normal control programs, this rise in the vector reservoir may lead to epidemic recrudescence of malaria or dengue. Retrospective studies (Bouma and Dye 1997; PAHO 1998; UN/ISDR 2004, 156) all confirm a direct but delayed relationship between the intensity of rainfall (regardless of the existence of flooding) caused by the El Niño phenomenon and the incidence of malaria. Flooding has contributed to local outbreaks of leptospirosis (in Brazil and Jamaica, for example; PAHO 1982) and hepatitis A in Latin America and Africa (WHO 1994).

In summary, what can be expected and prevented is a local surge in problems that the health services are normally used to handling.

Long-Term Impact and Economic Valuation

In addition to the delayed impact on transmission and control of endemic diseases and the burden of disabilities (paraplegia, amputation, burns, or chronic or delayed effects of chemical or radiological exposure), the health sector bears a significant share of the economic burden. Disasters must be seen in a systemic (that is, intersectoral) manner: what affects the economy will affect the health sector—and vice versa. After the emotional response of the first few days, decision makers in a crisis react primarily to political and economic realities, not to health indicators. Economic valuation of the social burden—that is, placing a monetary value on the cost—becomes a critical tool as the various sectors compete for scarce resources. The health sector, in particular, must learn how to use this tool in spite of being absorbed by its immediate relief responsibilities.

Valuation of Disasters. The Economic Commission for Latin America and the Caribbean (ECLAC) has developed over the decades a methodology for the valuation of disasters (ECLAC 2003). This tool, intended for reconstruction, has also proved its usefulness by developing historical records of major events, particularly of the health burden expressed in economic terms.

Valuation is made using all possible sources of information, from georeferenced satellite mapping and remote sensing to more conventional statistical data, direct observation, and surveys, with a reliance on information gathered immediately after the event. Economic valuation rests on the basic concepts of direct damage and indirect losses.

Direct damage is defined as the material losses that occur as an immediate consequence of a disaster.[2] Direct damage is measured first in physical terms. The physical loss includes assets, capital, and material things that can be counted: hospital beds lost, equipment and medicines destroyed, damaged or affected health service installations (number and type of installations, stocks of medicines, laboratory facilities, operating rooms, and so on), and pipes and water plants destroyed.

The physical plant then is valued both in terms of discounted present value and estimated replacement cost. Reconstructing facilities with the same vulnerability and level of service as before would be unacceptable; the affected health infrastructure must be replaced by more resilient and efficient installations to ensure better and sustainable service. This need is most evident in developing countries where impacts tend to be concentrated in those most at risk (the poor, marginalized, and less resilient sectors of the population).

Indirect effects refer to production of goods and services that will not occur as an outcome of the disaster, reduced income associated with those activities not occurring, and increased costs to provide those goods and services.

In the case of health services, indirect effects encompass both the income losses associated with the diminished supply of health care services and the increased costs of providing the services following the disaster. Indirect effects are valued at the current market value of goods or services not produced and the costs associated with the necessary provision of services under emergency, disaster-related conditions. Both components of the cost of illness—the cost of treatment and the cost of lost opportunities (lost income and employment, loss of time and productivity)—are sharply increased. The social burden is heavier on the poorest, who are unable to adjust their willingness to pay to absorb the additional expenses of alternative (private) providers of care.

The same approach applies to the economic valuation of lives lost. Kirigia and others (2004) found a statistically significant impact of disaster-related mortality on the GDP of African countries. One single disaster death reduced the GDP per capita by US$0.01828. Lost lives are given a higher economic value in places where productivity is high.

Because economic valuation uses standard sectored procedures that allow comparability of results, it can be used in the decision-making process and for policy formulation since it identifies sectors, geographical areas, and vulnerable groups that are more severely affected economically. Over the years, a number of conceptual improvements have been made to allow for the measurement of aspects not included in national accounting systems—to bring attention to environmental losses as a cross-cutting issue; to highlight the contribution of specific groups, namely women, as agents for change; and to focus on the better management of both the emergency and the reconstruction processes. It is also a valuable tool for preparedness and mitigation of future damage.

Table 61.2 summarizes the valuations made by ECLAC over the years for Latin America and the Caribbean in terms of deaths, affected populations, and economic losses (2003 values). Of interest are the decrease in the number of deaths and the increase in total damage (in particular, indirect damage) over time.

The distribution of direct and indirect damage in the health sector also varies. According to ECLAC (2003), direct damage between 1998 and 2003 in Latin America ranged from 44.6 percent to 77.2 percent of total damage.

Table 61.2 Impact of Disasters in Latin America and the Caribbean

	Population		Damage (2003 US$ millions)		
Date	**Deaths**	**Affected**	**Total**	**Direct**	**Indirect**
1972–80	38,042	4,229,260	9,376	5,420	3,956
1981–90	33,638	5,442,500	19,603	13,916	5,687
1991–2000	11,086	2,318,508	20,902	10,401	10,501
2001–2002	120	4,828,470	4,498	2,270	2,228
Total of major events 1972–2002	82,886	16,818,738	54,379	32,007	22,372
Overall estimate including small disasters[a]	103,608	21,023,422	67,974	40,009	27,965
Average per year	3,454	700,781	2,266	1,334	932

Source: ECLAC 2003.

a. The full image should include the recurrent small disasters that do not make the headlines but have a cumulative negative effect. Such disasters can be more pervasive and damaging to the development process because their economic, social, psychological, and political effects are hardly perceived. An estimate of the average losses of small disasters would be at least 25 percent greater than those of large disasters.

Specific Damage to the Health Infrastructure. Damage to housing, schools, channels of communication, industry, and so on contributes to the health burden. However, the following analysis focuses on the health infrastructure (understood as health care facilities, including hospitals, health centers, laboratories, and blood banks) and the drinking water and sanitation infrastructure.

Damage to Hospitals and Health Installations Most data and examples presented here come from Latin America and the Caribbean because of the disaster reduction programs in the health sectors of those regions. In the past two decades, damage to approximately 260 hospitals and 2,600 health centers resulted in interruption of services at a direct cost of US$1.2 billion. In the 1985 earthquake in central Mexico, 5,829 beds were destroyed or evacuated (PAHO 1985), at a direct cost of US$550 million (ECLAC 1998). Hurricane Gilbert (1988) damaged 24 of the 26 hospitals on Jamaica, and the El Salvador earthquake (2001) resulted in the loss of 2,000 beds—40 percent of the country's hospital capacity (PAHO 2002b). The health burden is not limited to the loss of medical care. The control of communicable diseases and other public health programs suffer from loss of laboratory support and diagnostic capabilities of hospitals. Further research on the actual impact of these losses, in terms of DALYs, is essential.

A common misperception is that damage to critical health facilities is promptly repaired. Experience shows that damaged health infrastructure recovers at a slower pace than infrastructure in other service sectors, such as trade, roads, bridges, telecommunications, and even housing. For example, as a result of the earthquake that affected El Salvador in 1986, renovation of the general hospital, the most sophisticated referral hospital in the capital, was completed 15 years after the earthquake. The only national pediatric facility was fully rehabilitated and strengthened six years after the earthquake. Two years after the earthquake of 2001 in El Salvador, several key hospitals still remained vacated or services were transferred to unsuitable temporary facilities. The factors are many: low priority assigned to a nonproductive sector, the sector's inexperience in developing comprehensive proposals for funding, conflicting attempts to use the reconstruction process to influence the ongoing reform and decentralization processes, the novelty of the engineering and design issues for safe hospital construction, the complicated negotiation process for loans, and the administrative inexperience of the health sector in executing large investment projects. Indeed, few large health installations have been built directly by developing countries in the past decades.

Damage to Water and Sewage Systems The primary goal of water and sewage systems is to safeguard the public health of the population. For that reason, these systems are considered part of the health infrastructure.

The developmental burden is significant. In the past 30 years in Latin America and the Caribbean alone, an estimated 400 urban water supply systems and 1,300 rural systems (in addition to 25,000 wells and 120,000 latrines) were severely damaged, at an estimated cost of almost US$1 billion—a major setback to efforts to expand coverage and improve those services. In severe flooding, the sudden interruption of these basic services coincides with the direct effect on the transmission of waterborne or vectorborne diseases. In the case of earthquakes, the number of people who are adversely affected by water shortage may far exceed those injured or suffering direct material loss.

As in the case of health care facilities, the rehabilitation of public water systems is slow, particularly for community-owned or community-operated rural systems, which may not be repaired for decades. The foregoing demonstrates the need for water authorities to harmonize their short-term objectives, which are oriented almost exclusively to increasing the coverage of these services, with the long-term objective of reducing vulnerability to extreme natural hazards.

INTERVENTIONS: FROM RESPONSE TO PREVENTION

The immediate lifesaving response time is much shorter than humanitarian organizations recognize. In a matter of weeks, if not days, the concerns of both the population and authorities shift from search and rescue and trauma care to the rehabilitation of infrastructure (temporary restoration of basic services and reconstruction). In Banda Aceh, Indonesia, after the December 2004 tsunami, victims were eager to return to normalcy while external medical relief workers were still arriving in large numbers.

Response and Rehabilitation

Immediate emergency response is provided under a highly political and emotional climate. The public demands visible, albeit perhaps unnecessary, measures at the expense of proven low-key approaches. The international community, eager to demonstrate its solidarity or to exercise its "right of humanitarian intervention," undertakes its own relief effort on the basis of the belief that local health services are unwilling or unable to respond. Donations of useless medical supplies and medicines and the belated arrival of medical or fact-finding teams add to the stress of local staff members who may be personally affected by the disaster. The cultural disregard of the humanitarian community to cost-effective approaches in times of disaster and the tendency to base decisions on perceptions and myths rather than on facts and lessons learned in past disasters contribute to making disaster relief one of the least cost-effective health activities.

The responsibilities of the national or local health authorities are significant.

Assessment of the Health Situation. A country's ministry of health is expected to assess the health situation. To influence the course of humanitarian response, this assessment must be rapid and, therefore, simple; transparent in collaboration with the main actors—nongovernmental organizations (NGOs) and donors; and technically credible. The input of WHO, as the lead agency in health matters, is most valuable. Confusion should be avoided between assessing emergency needs and inventorying or valuating the damage. In the first hours or days, relief actors base their decision making on the ministry of health's assessment of what is required and, more importantly, what is not required for emergency response. Later, the international community will request detailed data, such as the number of persons affected, buildings damaged, and monetary valuation.

Mass Casualties Treatment. Following natural disasters, hospital capacity may be considerably reduced by actual damage to the facility or, in the case of a seismic event, an often unnecessary—but hard to reverse—evacuation. Triage of patients is required in order to first treat those likely to benefit most, rather than the terminally injured or those whose care can be delayed. Lifesaving primary care takes place in the first six hours (the golden rule of emergency medicine), making most of the foreign field hospitals irrelevant for intensive acute care of traumas (WHO and PAHO 2003). Effectiveness of immediate care will depend on local preparedness before the disaster, not on faraway resources.

Strengthened Surveillance, Prevention, and Control of Communicable Diseases. Because the surveillance, prevention, and control of communicable diseases are strengthened, the anticipated massive outbreaks generally do not actually occur.

Traditional surveillance systems that are based on periodic notification of diseases by the health services are inadequate in a crisis situation. Early warning requires flexible and simple syndrome-based monitoring in temporary settlements and health centers, with information collected not only by the official health services but also by the medical humanitarian organizations. Systems that do not include consultation with NGOs are unlikely to succeed.

Disease control programs in place before the disaster are the fruit of local experience and external technical advice. In a disaster situation, there is generally no need to resort to new and expensive control measures. The key is to quickly resume, strengthen, and better monitor the routine control programs. No public health concerns justify the hurried disposal of corpses through mass burial or unceremonious incineration. This practice is socially and culturally damaging. In addition, improvised mass immunization campaigns, especially by external relief groups, should be discouraged in favor of opportunistically strengthening national routine immunization coverage, especially in temporary settlements.

Environmental Health. Typical interventions in the aftermath of disasters include strengthening the monitoring and surveillance of water quality, vector control, excreta disposal, solid waste management, health education, and food safety.

A first priority is water supply. It is often preferable to have a large quantity of reasonably potable water than a smaller amount of high-quality water (UNHCR 1998). Massive distribution of water purification disinfectants can be effective if the public is already familiar with their use and not confused by the availability of many different brands and concentrations of donated chemicals.

Health education and hygiene promotion efforts target populations in shelters, temporary camps, collective kitchens, or prepared food distribution centers.

The cost-effectiveness of the external relief effort could often be increased by shifting resources from the overattended medical response to the improvement of environmental health in temporary settlements.

Transparent Management of Donations and Supplies. If donations and supplies are managed transparently during the emergency, the flow of assistance to the intended beneficiaries will be improved. Unsolicited and often inappropriate medical donations compete with valuable relief supplies for scarce logistical resources. Good governance is critical, and effective logistics cannot be improvised following a disaster. A humanitarian supply management system developed by PAHO and WHO successfully helped developing countries improve transparency and accountability in managing humanitarian supplies and donations (de Ville de Goyet, Acosta, and others 1996).

Coordination of the Humanitarian Health Effort. Coordination of the humanitarian health effort is essential to maximize the benefit of the response effort and ensure its compatibility with the public health development priorities of the affected country. Effective coordination in the health sector must do the following:

- Be comprehensive and include all external health actors.
- Be based on mutual respect rather than regulatory authority alone. Dialogue and consultation are more effective than enforcement.
- Benefit all parties, starting with the victims. It should aim to support and facilitate the activities of other partners.
- Be evidence-based and transparent. Information is made to be shared and used, not jealously guarded.

Coordination cannot be improvised in the aftermath of a disaster. Preparedness before the occurrence of the hazard is essential.

Emergency Preparedness of the Health Sector

Effective response by national health authorities cannot be impromptu. Ministries of health that neglected to invest in capacity building before emergencies have generally experienced serious difficulties in exercising their technical and political leadership in the immediate aftermath of a disaster. Disaster preparedness is primarily a matter of building institutional capacity and human resources, not one of investing heavily in advanced technology and equipment.

Building local coping capacity is one of the most cost-effective ways to improve the quality of the national response and the external interventions.

Disaster preparedness is not merely having a disaster plan written by experts. It must involve the following:

- Identifying vulnerability to natural or other hazards. The health sector should seek information and collaborate with other sectors and institutions (civil protection, meteorology, environment, geology) that have the primary responsibility for collecting and analyzing this information.
- Building simple and realistic health scenarios of a possible and probable occurrence. It is challenging enough to prepare for a moderate-size disaster; building and sustaining a culture of fear based on unrealistic worst-case scenarios may serve the corporate interests of the disaster community but not the interests of the public at large.
- Initiating a participative process among the main actors to develop a basic plan that outlines the responsibilities of each actor in the health sector (key departments of the ministry of health, medical corps of the armed forces, private sector, NGOs, UN agencies, and donors). What matters is the process of identifying possible overlaps or gaps and building a consensus—not the paper plan itself. Disasters often present problems that are unforeseen in the most detailed plans.
- Maintaining a close collaboration with these main actors. A good coordinator is one who appreciates and adapts to the strengths and weaknesses of other institutions. Stability is essential. Changes of key emergency staff members during a disaster situation or when a new administration or minister take over have occasionally complicated the tasks.
- Sensitizing and training the first health responders and managers to face the special challenges of responding to disasters. Participation of external actors (UN agencies, donors, or NGOs) in designing and implementing the training is critical. The incorporation of disaster management in the academic curriculum of medical, nursing, and public health schools should complement the on-the-job training programs of the ministry of health, UN agencies, and NGOs. Well-designed disaster management training programs will improve the management of daily medical emergencies and accidents as well.

Prevention and Mitigation

The slogan "prevention is better than cure" was invented by the health sector. However, this sector has been slow to adopt the concept of preventing deaths and injuries from disasters through the mitigation (that is, reduction) of damage to its own facilities. As is unfortunately often the case, political action is often triggered only by a major disaster, such as the collapse of Hospital Juarez in Mexico in the earthquake of 1985; in that disaster 561 patients and employees died, (Poncelet 1997). Evaluating the damage (the past vulnerability) helps establish mitigation criteria for the future.

The level of protection required for each health installation must be negotiated—from life protection, which prevents an immediate structural collapse to permit the evacuation of people; to investment protection, which minimized the economic losses; to operational protection, which guarantees the sustainability of services under any extreme circumstances. Though a commercial or office building may be structurally designed only to prevent loss of lives, key hospitals must remain operational during the times they are most needed.

Local engineering and architectural experts play a key role in developing the knowledge, technical abilities, and cost-effectiveness analysis to establish mitigation priorities. Technical mitigation guidelines prepared at a global level (PAHO, WHO, World Bank, and ProVention Consortium 2004) need to be adapted to local culture, conditions, and resources.

Reducing the physical vulnerability of infrastructure can take place on three different occasions (UN/ISDR 2004, 324):

- *When reconstructing the infrastructure destroyed by a disaster.* At that time, risk awareness is high, political will is present, and resources are available.
- *When planning new infrastructure.* Reducing vulnerability is most cost-effective and politically acceptable when it is included at the earliest planning and negotiation stage, whether it involves a 1 to 2 percent additional cost for wind resistance or a 4 to 6 percent additional cost for earthquake resilience. Full resistance to any damage is prohibitively expensive.
- *Strengthening of existing facilities (retrofitting).* This most expensive measure has been adopted by several developing countries (Chile, Colombia, Costa Rica, Mexico, Peru, and others) to protect their most critical health facilities. In the earthquake in Colombia in 1999, partial retrofitting of the main hospital is credited for saving the installation. Costs vary greatly (see table 61.3).

Mitigation of Damage to Hospitals. Mitigation does not pretend to eliminate all possible damage from hazards but aims to ensure the continuing operation of the health facility at a level previously defined by the health authority. Hospitals

Table 61.3 Retrofitting of Hospitals in Costa Rica

Hospital	Number of beds	Duration of retrofitting (months)	Cost of retrofitting (US$)	Percentage of total value of the hospital
Hospital Mexico	600	31	2,350,000	7.8
Children's Hospital	375	25	1,100,000	4.2
Hospital Monseñor Sanabria	289	34	1,270,000	7.5

Source: PAHO and WHO 2000.

should be subject to stricter norms than other less critical facilities that are designed to prevent only total collapse and loss of life.

Hospital mitigation interventions fall into three categories:

- *Functional mitigation* to ensure that the necessary supporting infrastructure services permit continuing operation: water, electricity, road access, communications, and so forth. Improving routine maintenance will facilitate operations under normal circumstances and in the event of extreme hazards.
- *Nonstructural mitigation* to reduce losses and health injuries from falling or moving objects. Measures include, for instance, proper anchoring of equipment for earthquakes or strong winds or the location of only noncritical services on flood-prone floors.
- *Structural mitigation* to ensure the safety of the structure itself (columns, beams, load-bearing walls).

Given the high economic, health, and political costs represented by the avoidable loss of critical health facilities, health authorities and funding agencies should require that, in all new health infrastructure projects, natural hazards be a decisive factor for selecting the facility's location and for formulating the specifications at the earliest stage of the process.

Mitigation of Damage to Water Systems. Unlike hospitals, water supply systems are geographically extensive and thus are exposed to different types of hazards. The search for technical solutions is more complex, given the diversity of the water system's components. Finally, in many countries, the health authorities have no jurisdiction over the construction or operation of those services owned or administered by many local or municipal agencies.

Even a short disruption of water services may have serious and direct implications for the health of individuals, the operation of health services, and the community at large through its impact on business. A probabilistic model studied the disruptive potential of a water outage in the event of an earthquake in Los Angeles county in the United States. As noted by the authors, "water outage is more likely to be disruptive for businesses in some industries, such as health services, than for others" (Chang and Chamberlin 2004, 89).

The health sector should, therefore, coordinate with the institutions in charge of constructing, operating, and maintaining water and sanitation services, both urban and rural, to promote reduction of the vulnerability of existing systems. The health sector should also ensure that health aspects and mitigation of damage be included in the regulatory framework and operating procedures of water and sanitation services.

Protecting the water supply is feasible in developing countries. The Costa Rican Institute of Aqueducts and Sewage Systems reduced the vulnerability of one of the main aqueducts of the country, the Orosi Aqueduct. Over 10 years, Costa Rica invested almost US$1.5 million in studies and reinforcements, an amount equivalent to 2.3 percent of the total cost of the aqueduct. This investment would prevent a loss of nearly US$7.3 million in direct damages alone (FEMICA 2003).

INTERVENTION COST, COST-EFFECTIVENESS, AND ECONOMIC BENEFITS

The highly emotional and sensationalized climate of disaster response has long prevented the adoption of a cost-effectiveness approach in decision making. When survival of both people and political institutions is threatened, perceptions and visibility tend to prevail over facts and analysis, resulting in a lack of evidence-based studies on costs and benefits.

The willingness to spend hundreds of thousand of dollars per victim rescued from a collapsed building in a foreign country is a credit to the solidarity of the international community, but it also presents an ethical issue when, once the attention has shifted away, modest funding is unavailable for the mid-term survival of tens of thousands of victims.

Cost-Effectiveness of Selected Humanitarian Interventions

Emergency health interventions are more costly and less effective than time-tested health activities. Improvisation and rush inevitably come with a high price. The preferential use of expatriate health professionals; the emergency procurement and airlifting of food, water, and supplies that often are available locally or that remain in storage for long periods of time; and the tendency to adopt dramatic measures contribute to

making disaster relief one of the least cost-effective health activities.

Search and Rescue. Few developing countries have established the technical capacity to search for and attend to victims trapped in confined spaces in the event of the collapse of multistory buildings. Industrial nations routinely dispatch search and rescue (SAR) teams. Costs are high and effectiveness is reduced by delayed arrival and quickly diminishing returns. Following the 1988 earthquake in Armenia, in the former Soviet Union, the U.S. SAR team extracted alive only two victims at a cost of over US$500,000. In Turkey in 1999, 98 percent of the 50,000 people pulled alive from the rubble were salvaged by relatives and neighbors. In Bam in 2003, the absence of high-rise and reinforced concrete buildings ruled out the need for specialized teams. Nevertheless, according to UN statistics, at least US$2.8 million was spent on SAR teams. An alternative solution consists of investing these resources in building the capacity of local or regional SAR teams—the only ones able to be effective within hours—and training local hospitals to dispatch their emergency medical services to the disaster site.

Field Hospitals. The limited lifesaving usefulness of foreign field hospitals has been discussed. Again, the lessons learned from the Bam earthquake are clear. The international community spent an estimated US$10.5 million to dispatch approximately 10 mobile hospitals,[3] which arrived from two to five days after the impact, long after the last casualty had been evacuated to other Iranian provinces. This delay alone, hard to reduce further, rules out any significant contribution to immediate trauma care and led the hospitals to compete for routine outpatient care with the teams of Iranian volunteers from across the country. A few of the mobile hospitals, better prepared to meet nontrauma needs and to stay much longer than the usual two to three weeks, have been invaluable. No data are available on the number of lives actually saved by mobile hospitals (that is, lives that would not have been saved by local means). Less understood are the negative effects of such hospitals on local health services, which are often marginalized and discredited for their lack of technology and sophistication but which must cope once the external facility leaves.

The cost of mobilizing a mobile hospital for a few weeks often exceeds US$1 million, funds that would be more productive in the construction and equipping of a simple but sturdy temporary facility. Such an approach was adopted by the U.S. Army Southern Command in Wiwili, Nicaragua, in the aftermath of Hurricane Mitch. In the case of Bam, Iran, the cost of rebuilding the entire primary and secondary health care facilities and teaching institutions was estimated by the government of Iran to be US$10.75 million, an amount very similar to that expended for the dispatch of field hospitals from the international community. Guidelines for the use of foreign field hospitals are available from WHO and PAHO (2003).

In-Kind Donations. Unsolicited donations of inappropriate medical supplies not only are of limited use, but often cause serious logistic, economic, and political problems in the recipient country. Warehousing those supplies and, in many instances, building facilities (incinerators, for example) for the safe disposal of pharmaceutical donations diverts humanitarian funds from more effective uses. Recipient countries collectively share part of the responsibility by not clearly indicating what they do not want to receive and by not speaking out once inappropriate items arrived.

Disease Prevention and Control. Postdisaster interventions in surveillance and control of communicable diseases should focus on strengthening existing programs. Benefits will outlive the crisis. Improvised mass immunizations (instead of improved sanitation and public awareness) and vector control by aerial spraying or fogging (instead of breeding-site reduction or waste disposal) are just two examples of wasteful managerial decisions.

Shelters. Tent cities should be a last resort. Family-size tents may be expensive and do not last long. Establishing large settlements is easy, but such settlements are difficult to sustain and nearly impossible to terminate. They come with their own sanitation problems and social shortcomings (lack of privacy, loss of family identity, and loss of empowerment). Distributing construction material (or, preferably, cash subsidies) is more cost-effective and tailored to the needs and priorities of end users.

Cash Assistance. Developed societies long ago abandoned the distribution of in-kind relief goods and services to their nationals in favor of direct financial assistance in the form of subsidies, grants, or tax relief. The individual is free to determine actual priorities and to seek the most cost-effective source of services (shelter, medical, food, or other). It is therefore surprising that external assistance from these same countries remains focused on the costly delivery of predetermined services or commodities.

The most immediate lifesaving needs can be addressed only locally with existing resources and capacity. No cash contribution will meet those immediate needs. Beyond the acute phase, in many countries with market economies, most other services and goods are easily procured by those with financial means, suggesting that income availability is often the single limiting factor in rehabilitation.

Undoubtedly, this approach would affect considerably the type (and number) of humanitarian actors by transferring

power and decision making to the local beneficiaries and relying on local economic forces for delivery to the end user. It may also bring its own set of problems (and abuses), though perhaps that is a small cost, considering the economic and social benefits of the most interested party—the victim—being in charge.

Cost-Effectiveness of Prevention and Mitigation

The social benefits of making hospitals and water systems more resilient to the effects of natural hazards are recognized but too rarely applied. On the economic side, mitigation also increases the investment capacity in the health sector by preventing losses and the need for reconstruction (PAHO and UN/ISDR 1996; Bitrán 1996).

The most compelling case for the cost-effectiveness of mitigation can be made during the planning phase for new installations, when costs of additional structural safety are minimal. Although the social benefits of prevention and risk management are more evident in the health sector than in others, further studies are needed to provide decision makers with quantified parameters of the economic benefits brought about by investment in risk management and disaster reduction.

PAHO and UN/ISDR (1996) studies indicate that such increased investment fluctuates between 4 and 8 percent of a hospital's local construction cost. When the value of services lost is added to the infrastructure loss, the additional investment is reduced to between 2 and 4 percent of direct and indirect losses observed. Even though this is a gross estimate that requires further research in other regions and types of health facilities, the figure is ratified by the estimated cost of reinforcement, which fluctuates but averages between US$2,000 and US$5,000 per bed, compared with the average cost of a new hospital bed of between US$100,000 and US$150,000 (at 1996 prices).

Prevention of chemical and radiation accidents can be a highly cost-effective expense that is normally absorbed by the respective industries. Respect for existing norms in the use of radiotherapy and diagnostic equipment and, once such equipment is decommissioned, its proper disposal reduces DALYs from accidents at a modest cost.

Mobilization of Resources

Funding for preparedness and response programs follows rules and procedures that are distinct from those applicable to development projects. Most donors maintain a specific office or department for humanitarian affairs with a separate budget line. Procedures are also streamlined for quick response to unexpected situations. Processing a request takes a matter of days in emergencies and takes months for preparedness or mitigation projects, but it can take years in typical development projects negotiated with donors or financial institutions.

From a ministry of health point of view, competition for disaster resources is with other sectors or humanitarian organizations, not within the sector (as it would be, for instance, with malaria or tuberculosis control projects).

Funding for Preparedness. "By strengthening our public health planning for natural disasters and disease outbreaks, we will be in a better position to care for our populations, regardless of the type of hazard that confronts our health departments" (Rottman 2003, 1). This message, addressed to the public health community in the United States, is even more pertinent for developing countries. Most humanitarian offices in more developed countries allocate a modest but increasing proportion of their funds for predisaster capacity building. The capacity of the ministries of health to secure directly nonreimbursable funding depends on the following:

- The existence of an established disaster program within the ministry, demonstrating a long-term commitment to health disaster preparedness.
- An ongoing dialogue with local representatives of donors and their prior involvement in disaster-related activities or meetings of the health sector.
- A realistic projection of concrete activities, taking into consideration the efforts of others, especially NGOs. One- or two-year training or capacity-building projects are more likely to be supported than those of longer duration that have recurrent costs or involve the purchase of equipment (radios, vehicles).
- The technical endorsement and support of WHO and other UN agencies.

A multisectoral preparedness component is also increasingly included in loans negotiated in the aftermath of disasters. Intended to strengthen the capacity of the civil protection agency, the funding is no substitute for local political commitment to assume recurrent expenses, the only guarantee of sustainability.

Resources for Emergency Response. The amount of external resources available for response, financial or material, is influenced by the type of hazard, geopolitical considerations, and the number of deaths (rather than that of survivors in need of assistance). Funding is channeled mostly through humanitarian NGOs, the Red Cross system, or multilateral organizations, rather than through national governments. Consequently, the priority of the health authorities, rather than to seek direct contributions to the ministry, should be to ensure that health needs are properly identified and adequately covered by those agencies benefiting from the donations. Ministries of health often can obtain indirect financial support for their own activities through UN projects.

Concentrating on several key factors will improve the flow of external resources toward health priorities:

- Issuing a rapid and reliable assessment of what is needed and what is not needed for the emergency response, rather than waiting for a detailed assessment of the physical damage.
- Focusing on tomorrow's emergency health problems. External response is unable to address today's short-lived problems.
- Keeping a long-term view. Funding for emergency response is limited to a few months, whereas the health problems caused by the disaster will stay much longer. Projects should offer sustained benefits beyond their conclusion.
- Recognizing shortcomings in governance when in contact with the many bilateral fact-finding or assessment missions coming to the disaster site.

Funding for Reconstruction. Funding for reconstruction is multisectoral and is often coordinated by an international financing institution (global or regional), together with a consortium of large donor countries. The health sector will compete with other social priorities and the "productive" sectors in an arena where the health burden (measured in DALYs) does not carry the same weight as economic factors. Success will depend on an exhaustive monetary valuation of the health damage, rapid formulation of projects, political support from the country's highest authorities, and technical support and endorsement of specialized UN agencies and larger NGOs.

Funding for Mitigation of Damage. Protecting the national capital investment of the health sector is primarily the responsibility of the country at risk. Development agencies or financial institutions may contribute only marginally to the actual cost of retrofitting installations or improving the design of new facilities.

Modest funding for pilot or demonstration prevention programs may be available from both the humanitarian and the development sources of donor countries. Humanitarian offices may support promotion of the concept, development of guidelines or studies on vulnerabilities, and training.

The health sector will benefit from close contacts with financial institutions, the ministry of foreign affairs, and other national ministries. Negotiations to ensure that new installations are able to withstand disasters must be initiated at the earliest opportunity, and the corresponding additional costs should be considered in the earliest stages of the project.

IMPLEMENTATION OF CONTROL STRATEGIES: LESSONS OF EXPERIENCE AND CHALLENGES FACED

All countries in Latin America and the Caribbean have established programs and structures for disaster risk management within their ministries of health. Some lessons can be learned from this process:

- The occurrence of a major disaster in the country or its neighbor is the initial catalyst for health authorities to recognize that disasters represent public health risks that must be addressed in an institutionalized manner.
- Access to and support from the political level has determined the success or failure in coordinating the external and domestic health response.
- A multihazard program covering the entire health sector is most effective. Assigning responsibility for coordination and management among different technical departments according to the type of hazard (chemical or natural, for instance) does not work.
- A risk management program should cut across departments (medical care, epidemiology, water supply, sanitation, nutrition, and so forth) of the ministry of health and become sector wide.
- The synergy between normal development, preparedness, and disaster response activities should be recognized. Poor development practices increase vulnerability, whereas preparedness improves the attention to daily health challenges. Programs narrowly focused on operational response have generally failed.

In Asia, the Asian Disaster Preparedness Center also has documented some interesting experiences (http://www.adpc.ait.ac.th/).

THE RESEARCH AND DEVELOPMENT AGENDA

Disasters in any one country are relatively infrequent. In addition to being a dangerous temptation for the authorities to postpone preventive actions, this infrequency is an impediment for research and institutional memory. On one hand, the humanitarian culture tends to raise ethical questions on the role of observers at a time when action at all costs is expected. On the other hand, few health academicians wish to embark on projects when control groups and time for advance planning are unavailable.

Particularly encouraging are the increased numbers of publications and guidelines by UN organizations and NGOs and the trend toward organizing workshops on lessons learned a few months after a major disaster. These meetings of national experts and officials together with representatives from external actors are invaluable for identifying and sharing operational or institutional successes and failures for the collective benefit of other countries at risk.

Epidemiological Research

Most of the DALYs attributable to disasters occur immediately at the time of the disaster. Epidemiological research should,

therefore, complement engineering studies to design better facilities and preparedness measures. After the initial disaster, basic questions need to be answered: How many secondary deaths and disabilities can actually be prevented by improving search and rescue and trauma care? How critical is the time factor in reducing DALY losses and assessing the effectiveness of foreign SAR and field hospitals teams? How can researchers objectively assess the risk of outbreak following disasters? In particular, how can they better differentiate between cases attributable to increased transmission and those resulting from improved surveillance and medical attention provided to the victims? What is needed are data to put to rest unquestioned assumptions and clichés. The alternative is to continue to divert scarce resources away from routine disease control programs and toward costly measures of doubtful effectiveness.

Strategic Research

Research is required that will compare the effectiveness of preparedness and response strategies and approaches:

- With respect to preparedness, how should researchers assess the effectiveness of training and coordination versus that of investing in hardware and stockpiles? For instance, will the accreditation of hospitals based on their safety and readiness improve their disaster performance?
- With respect to mitigation, how should limited funding for retrofitting health facilities be allocated? Is nonstructural mitigation a workable alternative in the absence of structural measures?
- With respect to response, what is the effect of international assistance in terms of reductions in DALY losses that could not be achieved locally? Is it contributing to strengthening the capacity of the developing countries? What type of humanitarian assistance has proven to be development friendly?
- Finally, how should researchers measure the effectiveness of preparedness or mitigation given the unpredictability of disasters?

Economic Research

Humanitarian response is resistant to concepts of cost-effectiveness. Economists should contribute to the comparative study of the immediate and long-term effects of external interventions versus less costly alternatives such as relying on local resources and building local capacity. A cost-benefit analysis of international medical interventions prior to and during a disaster situation is also overdue.

Economic assessment of the damage to the health sector remains focused on physical losses and fails to sufficiently consider the broader burden on a society caused by the loss of health services over a sustained period. Refining the existing methodology and developing quantitative indicators to estimate those indirect costs should be a research priority.

CONCLUSIONS

Natural hazards are not likely to decrease in the foreseeable future. Though geological events may occur independently of any human control, available data suggest that mankind plays a role in global climate. Technological hazards may also increase rapidly as a result of the unregulated development of industries in most countries and possibly the use of weapons-grade hazardous substances against civilian populations. An increase in the number of hazards should not mean that the resulting health burden will also increase. A sustained effort is needed to minimize risk, both by reducing vulnerability through prevention and mitigation and by increasing capacity through preparedness measures.

A Strategic Approach

The prime objective of a developing country is to develop. Emergencies and disasters have proven to be major obstacles and setbacks in the path toward sustainable development. Conversely, the shortcomings in development programs and institutions reduce the effectiveness of the health response in times of crisis. Development and disaster risk management cannot be addressed separately. Reducing risk is not a luxury reserved for more developed societies; it is a necessity in countries with fragile economies and health systems. It is clearly a public health priority.

Disasters, as any other public health problem, need to be addressed on a long-term and institutionalized basis through the establishment in the ministry of health of a program or department for prevention, mitigation, preparedness, and response for all types of disasters. Trends in Latin America suggest that such an approach in the context of sustainable development contributes to narrowing the gap in disaster-related deaths and disabilities (as measured by DALYs) between industrial and developing countries.

Disaster risk reduction is not merely a health issue. The economic and political dimensions should not, however, be allowed to overshadow the fundamental fact that disasters are, above all, human tragedies incompatible with the definition of *health* adopted by the WHO constitution. On one hand, the health sector should adapt and use the methodology of economic valuation of disaster impact as developed by ECLAC; on the other hand, the financial world should also learn to give equal consideration to the health burden (DALYs) in its decision making for development or reconstruction. For this to take place, health and humanitarian actors need to dramatically improve the availability of data.

Disaster risk reduction is not the exclusive domain of a few experts or officials. It is the collective responsibility of all disciplines and programs in the health sector, as well as a remarkable tool or gateway for collaboration with other sectors. Alone, the ministry of health cannot reduce the health burden or play its coordinating role in the response.

Disaster risk reduction is unlikely to produce immediate results. It requires sustained commitment over the years.

Learning from Errors

Learning from past disasters is difficult. At a national level, the relatively long periods between major disasters result in few decision makers having prior disaster management experience. At an international level, the frequent turnover of relief workers ensures that many of the actors are relatively inexperienced and susceptible to adopting myths and clichés, which are rarely challenged by the media and the academic world. It is time for an international initiative to identify the best practices, and it is time for affected countries and scientists to point out the inadequacies of responses.

Humanitarian health interventions, as any other health intervention, should be subject to cost-benefit reviews that compare their benefits in terms of DALY loss reduction to other alternatives, including a possible shift of international emphasis from immediate medical response to preparedness or rehabilitation projects.

Local health services are best situated to address the health consequences of disasters. They should be better prepared to do so. A formalized mechanism to transmit and share those lessons learned from past errors and to build the response capacity is required in the health sector.

Finally, the greatest potential for saving lives is in reducing the risks and the vulnerability through better infrastructure, land-use management, public awareness, and training.

The challenge in risk reduction is to sustain public support and political will in periods of calm. International organizations—WHO in particular—have a unique and critical role to play as advocates for a long-term approach to disaster risk management in the context of sustainable development.

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NOTES

1. In a nonnatural phenomenon, such as the attacks in New York on September 11, 2001, a similar risk has been detected and is perceived as a remnant potential long-term health risk similar to the effect of air contamination from ash from volcanoes.
2. Evidently these direct losses are not easy to determine in long-developing events (such as the ones associated with slow processes or climatic variability), because over time there will be overlapping damage, in contrast to the damage that occurs in sudden events such as hurricanes or earthquakes.
3. Data came from reports of the UN Office of Coordinator for Humanitarian Affairs (http://www.reliefweb.org), supplemented by authors' estimated costs for donors that did not report actual costs.

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