Protecting New Health Facilities from Natural Disasters:

Guidelines for the Promotion of Disaster Mitigation

Pan American Health Organization
Regional Office of the World Health Organization

The World Bank Group

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Guidelines for the Promotion of Disaster Mitigation

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Guidelines For Vulnerability Reduction in the Design of New Health Facilities
by R. Boroschek and R. Retamales of the
PAHO/WHO Collaborating Center at the University of Chile
and on the recommendations adopted
at the international meeting "Hospitals in Disasters: Handle with Care," El Salvador, July 2003.

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1. VULNERABILITY ANALYSIS

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Introduction

Hurricanes, floods, earthquakes, landslides and volcanic eruptions—and the devastation they inflict—are all too familiar to the countries of Latin America and the Caribbean. In the last decade, natural disasters have caused more than 45,000 deaths in the region, left 40 million injured or in need of assistance, and carried a price tag—in direct damage alone—of more than US$20 billion.[1]

The health sector has proven particularly vulnerable to such havoc. In the course of the past 20 years, as a result of natural disasters, more than 100 hospitals and 650 health centers have collapsed or been so severely damaged that they had to be evacuated. According to the United Nations Economic Commission for Latin America and the Caribbean (ECLAC), accumulated losses due to disasters in the health sector reached US$3.12 billion—the equivalent of 20 countries in the region each suffering the demolition of six hospitals and at least 70 health centers.[2]

Approximately 50% of the 15,000 hospitals in Latin America and the Caribbean are sited in high-risk areas. Many of them lack disaster mitigation programs, emergency plans, or the infrastructure required to withstand earthquakes, hurricanes, and other natural phenomena.

1 Inter-American Development Bank (IDB), *Facing the Challenge of Natural Disasters in Latin America and the Caribbean: An IDB Action Plan*, Washington, D.C., 2002.

2 Pan American Health Organization (PAHO/WHO), *Principles of Disaster Mitigation in Health Facilities, Mitigation Series*, Washington, D.C., 2000.

In this context, existing codes and regulations on the design and construction of health facilities must be revised and reoriented towards disaster mitigation, with the ultimate goal not only of protecting the lives of patients, staff and other occupants, but also of ensuring that such facilities can continue to operate after a disaster has struck—at the moment when they are most needed. The knowledge of how to build safe hospitals not only exists, but is readily available.

One of several efforts to disseminate this knowledge is being actively pursued by the Pan American Health Organization through the PAHO/WHO Collaborating Center on Disaster Mitigation in Health Facilities of the University of Chile. With support from the World Bank and the ProVention Consortium, the Collaborating Center published the *Guidelines for Vulnerability Reduction in the Design of New Health Facilities*. These Guidelines were assessed and validated at the international meeting *Hospitals in Disasters: Handle with Care*, which was held by PAHO/WHO in El Salvador on 8-10 July 2003.

It is the aim of this publication to present a summary of the Guidelines—emphasizing how they can be used, by whom, and for what purpose. In addition, some considerations are provided on how to promote the use of the Guidelines by national authorities, planners and funding institutions when developing projects for the construction of new health facilities. Potential users of the Guidelines include the following:

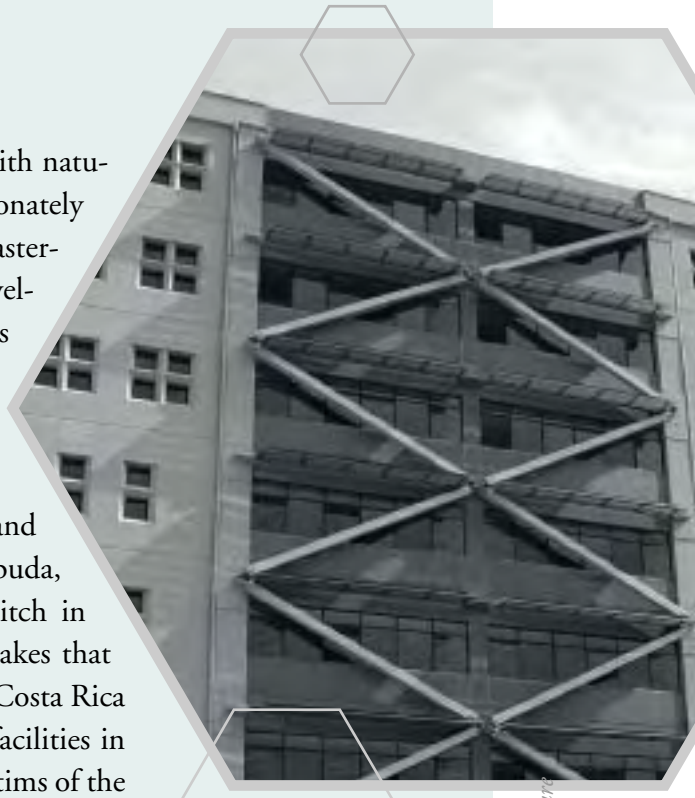
- ***Initiators of health facility construction projects*** (who recognize the need for new health facilities):
  - The public sector (Ministry of Health, Social Security, etc.)
  - The private sector
  - Unions
  - The military
  - Organized civil society
  - Municipal governments

*The *Guidelines* can be accessed at www.paho.org/disasters

- ***Executors and supervisors of health facility construction projects:***
  - The Ministry of Health
  - The Ministry of Public Works
  - Social Security
  - Government offices or independent agencies in charge of enforcing building standards
  - Subcontractors entrusted with hospital management
  - Subcontractors entrusted with the management, quality control, design and/or execution of the project
  - The private sector

- ***Financing bodies in charge of funding health facility construction projects:***
  - The government
  - The public sector bodies that have identified the need for new facilities
  - The Ministry of Finance
  - The Ministry of Health in tandem with the Ministry of Finance
  - International sources: development banks and bilateral and multi-lateral donors
  - Nongovernmental organizations
  - The private sector (including private banking)

Natural Phenomena and Health Infrastructure



While no country can afford the high costs associated with natural disasters, the impact of these events is disproportionately higher for developing countries. It is estimated that disaster-related losses as a ratio of GNP are 20 times greater in developing than in industrialized nations.[3] Among the effects of such phenomena, the damage caused to health infrastructure in Latin America and the Caribbean has been particularly severe (see Annex I).

Hurricanes such as Gilbert (Jamaica, 1988), Luis and Marilyn (in September 1995, afeccting Antigua and Barbuda, St. Kitts and Nevis, St. Martin and other islands), Mitch in Central America (October 1998) as well as the earthquakes that hit Mexico in 1985, El Salvador in 1986 and 2001, and Costa Rica and Panama in 1991, caused serious damage to health facilities in those countries, affecting their capacity to care for the victims of the disaster (see Table 1).

3 Pan American Health Organization (PAHO/WHO) and U.N. International Decade for Natural Disaster Reduction, *Lessons Learned in Latin America on Disaster Mitigation in Health Facilities: Aspects of Cost-Effectiveness*, Washington, D.C., 1997.

Table 1. Health facilities affected by natural disasters in selected countries of the Americas, 1985–2001.

Disaster	Hospitals and health centers affected	Hospital beds out of service
Earthquake, Chile, March 1985	79	3,271
Earthquake, Mexico, September 1985	13	4,387
Earthquake, El Salvador, October 1986	7	1,860
Earthquakes, El Salvador, January and February 2001a	113	2,021
Hurricane Gilbert, Jamaica, September 1988	24	5,085
Hurricane Joan, Costa Rica and Nicaragua, October 1988	4	---
Hurricane Georges, Dominican Republic, September 1998	87	---
Hurricane Georges, Saint Kitts and Nevis, September 1998b	1	170
El Niño, Peru, 1997-1998	437	---
Hurricane Mitch, Honduras, November 1998	78	---
Hurricane Mitch, Nicaragua, November 1998	108	---

Source: Proceedings, International Conference on Disaster Mitigation of Health Facilities, Mexico, 1996.
(a) Only health facilities of the Ministry of Health have been listed, not those of Social Security or the private sector.
(b) During its 35 years of operation, Joseph N. France Hospital in Saint Kitts was seriously damaged by hurricanes on 10 separate occasions.
--- Data unavailable.

What are the implications of such natural disasters for the health sector? Some are direct:

- Health facilities are damaged.
- Local infrastructure is damaged, interrupting the basic services that are indispensable to the provision of health care, and blocking or destroying access routes to the facilities.

- An unexpected number of deaths, injuries and illnesses impact the local community, overwhelming the health network's therapeutic response capacity.

Others are indirect:

- Population displacements occur, whether organized or spontaneous, away from the affected areas towards those that have not been directly hit, but whose health systems may not have the capacity to cope with the increased demand for its services.
- The risk of communicable diseases and mental illness as a result of the disaster is likely to increase among the affected population.
- Food supplies may become scarce, threatening the population with malnutrition and all its attendant hazards.
- Both remedial and preventive health care services may become harder or impossible to obtain, or too expensive.
- The supply of safe drinking water may become sporadic or be totally interrupted, or contamination may occur.
- Health priorities may end up in disarray as public health campaigns are suspended to meet emergency needs.

Figure 1 presents a summary of the socioeconomic impact of a disaster on the health sector. The cost of such damage, often hard to quantify, tends to build up throughout the rehabilitation and reconstruction period until operational capacity is fully restored. Damage to assets and services may contribute significantly to the impoverishment of the population, since they lead to loss of jobs and livelihoods.[4]

Specifically, the vulnerability of hospital facilities to potential hazards involves six major areas:[5]

- **Buildings:** The location and building specifications, particularly regarding design, the resiliency of the materials, and

4 Keipi, K. and J. Tyson, *Planning and Financial Protection to Survive Disasters*, Technical Report Series of the Department of Sustainable Development, Inter-American Development Bank (IDB), Washington, D.C., 2002.

5 Pan American Health Organization (PAHO/WHO), *Proceedings, International Conference on Disaster Mitigation in Health Facilities,* Mexico, 1996.

physical vulnerability, determine the ability of hospitals to withstand adverse natural events. The slightest structural or architectural element that collapses or fails entails both financial and human costs.

- **Patients:** It is customary for health facilities to work 24 hours a day at about 50 percent of their service capacity. Any disaster will inevitably increase the number of potential patients and amplify their level of risk. Waiting lists get longer, since it becomes impossible to meet both routine demand and that generated by the emergency. Patients also suffer from the decline in the provision of services as a result of damaged, partially evacuated or non-operational facilities.

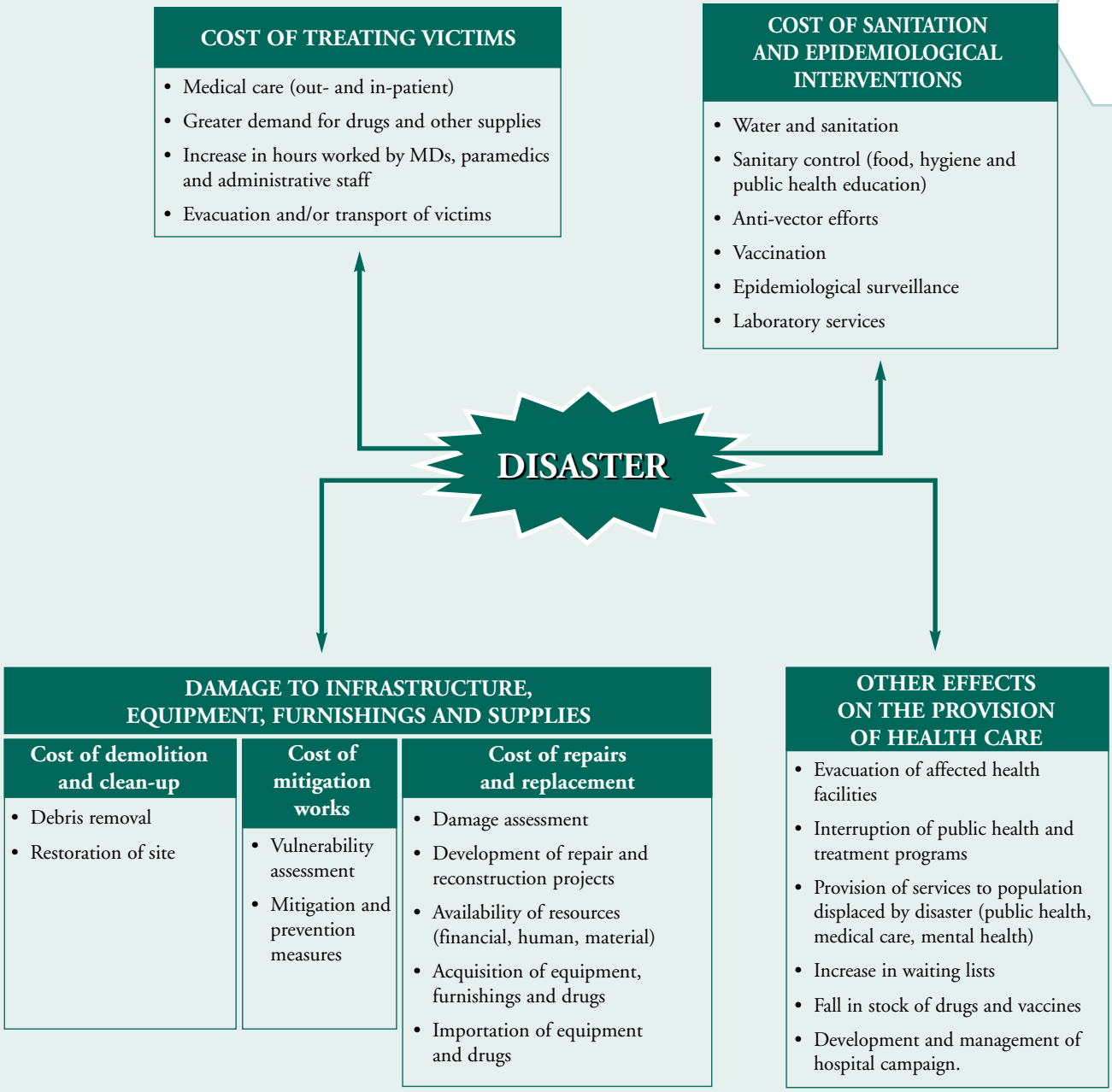
- **Hospital beds:** In the aftermath of a disaster, the availability of hospital beds frequently decreases even as demand goes up for emergency care of the injured.

- **Medical and support staff:** It is hardly necessary to describe the significant disruption to the care of the injured caused by the loss of medical or support personnel. In order not to suffer a concomitant loss in response capacity, outside personnel must be hired temporarily, adding to the overall economic burden. Sometimes the death of a specialist can entail major technical costs for the country affected by the disaster.

- **Equipment and facilities:** Damage to nonstructural elements (such as equipment, furniture, architectural features, and medical supplies) can sometimes be so severe as to surpass the cost of the structural elements themselves. Even when the damage is less costly, it can still be critical enough to force the hospital to stop operating.

- **Basic lifelines and services:** The ability of hospitals to function relies on lifelines and other basic services such as electrical power, water and sanitation, communications, and waste management and disposal. It is not a given that self-contained backup emergency services are available at all health facilities. When a natural disasters affects some of the services, the performance of the entire hospital is affected.

Figure 1. Socioeconomic impact of a disaster in the health sector.



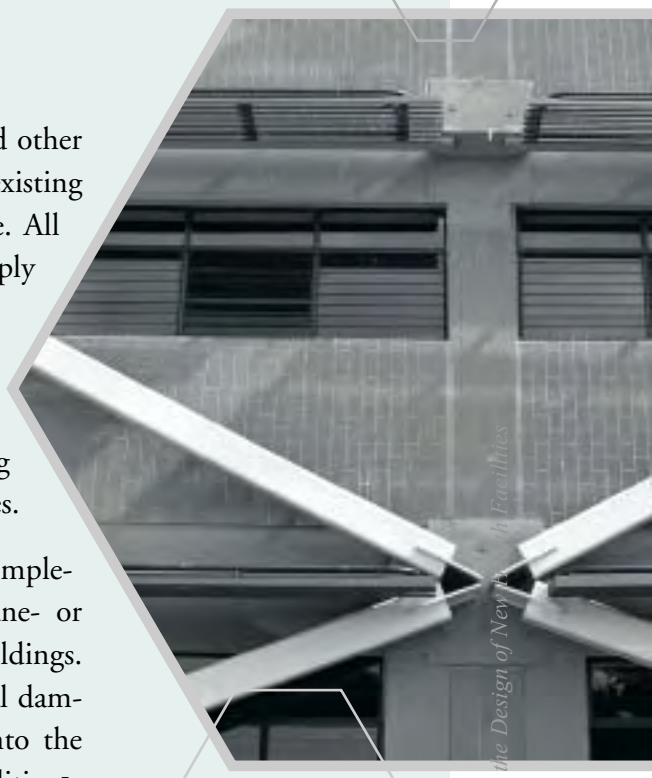
When it comes to disaster resiliency standards, the bar is inevitably raised in the case of health facilities, particularly hospitals. It is not enough for them to remain structurally sound long enough for non-ambulatory inpatients to survive; instead, these patients must continue to receive appropriate care even as new patients are coming in as a result of the injuries sustained during the event. It is also important that health promotion and prevention programs, such as prenatal care and hemodialysis, not be interrupted. For all these services to be maintained without interruption, the buildings and their contents must remain operational and formal disaster response plans must be in effect.

Hospital authorities, cognizant of the facts outlined above, frequently produce emergency response plans—but such plans often fail to incorporate prevention and mitigation measures, or to strengthen the role of hospital disaster committees in risk management. Hence the need to incorporate measures for improving general safety and, above all, preserving the functionality of key areas of the hospital when designing and building new health facilities. These areas include: emergency services, intensive care units, diagnostics facilities, the surgical theater, the pharmacy, food and drug storage areas, and registration and reservation services.

It is important to note that in the countries of Latin America and the Caribbean many hospitals damaged by natural disasters were designed in accordance with seismic-, wind-, and flood-resistant building standards. This suggests that the design of hospitals should apply even higher standards than those relevant to buildings meant for housing or offices. Most seismic and flood- or wind-resistant building codes in the region strive to protect the lives of those inside the building, not to ensure the continuity of the building's operations.[6] Both the architectural and the structural design of health facilities should consider not only the physical aspects of any given adverse event, but also the social, economic and human implications of the functions played by hospitals in a community.

6 Pan American Health Organization (PAHO/WHO), *Principles of Disaster Mitigation in Health Facilities, Mitigation Series*, Washington, D.C,. 2000

The *Guidelines for Vulnerability Reduction in the Design of New Health Facilities* and Their Incorporation into the Development of Projects Cycles



The loss of lives and property as a result of earthquakes and other extreme natural phenomena can be mitigated by applying existing technologies without incurring enormous financial expense. All that is required is to have the political and social will to apply the right techniques.

Since in most communities it takes about two generations for the current stock of buildings to be replaced, attention must be paid both to the structural intervention of existing edifices and to the design and construction of new structures.

At present, not all countries in the region have adopted or implemented the necessary technical standards for the hurricane- or earthquake-resistant design and construction of new buildings. This means that significant reductions in risks and potential damage are feasible if preventive measures are incorporated into the design, construction and maintenance of all new health facilities.[7]

In this respect, applying the *Guidelines for Vulnerability Reduction in the Design of New Health Facilities* can play a key role in reducing existing risks. The section that follows presents a summary of the *Guidelines* and shows how they can be incorporated into the development cycle of projects for the construction of new health facilities.

7 Pan American Health Organization (PAHO/WHO), *Principles of Disaster Mitigation in Health Facilities – Volume I: General Issues*, Washington, D.C., 1993.

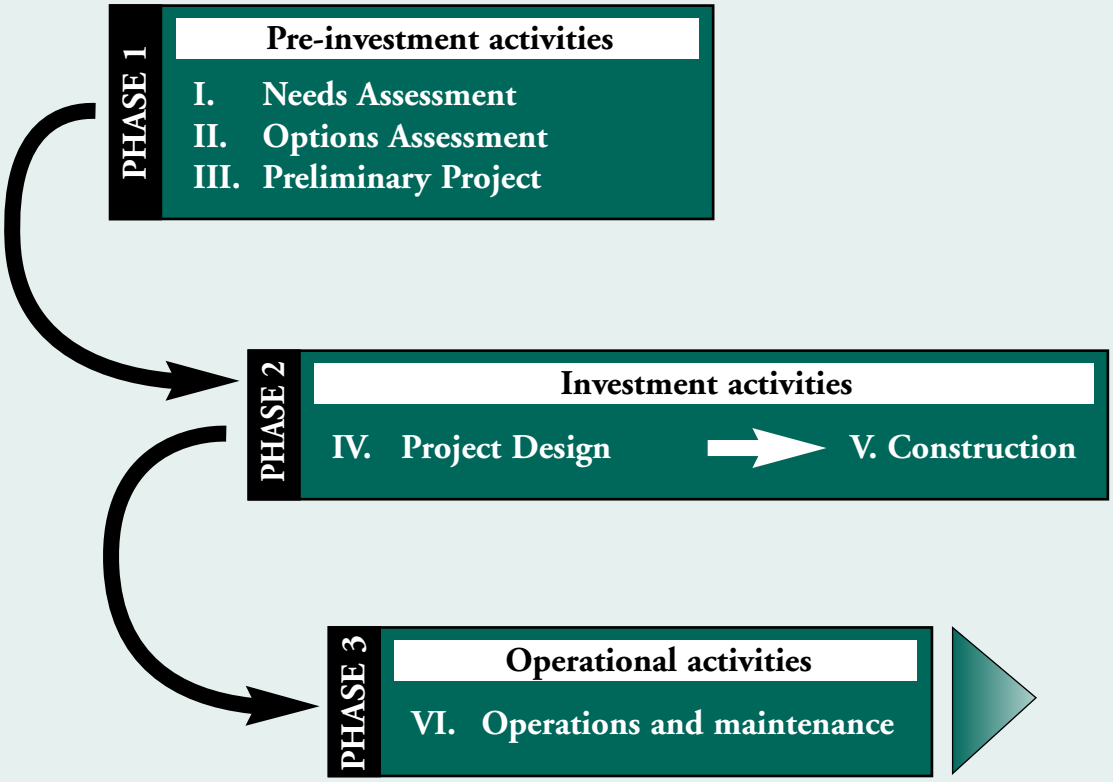
The purpose of the *Guidelines* is to assist health-sector managers, professionals and technical consultants involved in the administration, design, construction or inspection of health facilities so that mitigation measures are included to reduce vulnerability and ensure the highest level possible of protection to the facilities and their operation.[8]

Based on the three phases of the traditional project cycle—pre-investment, investment and operations—the *Guidelines* propose a series of critical guiding principles to facilitate the incorporation of vulnerability reduction mechanisms into the project. The *Guidelines* specify clearly which activities must be carried out at each stage in order to incorporate mitigation measures, and provide tools for their incorporation.

Figure 2 shows the project cycle for the construction of new health facilities, with its three phases and corresponding stages, which serve as the framework for the recommendations contained in the *Guidelines*. The following sections have been structured according to these phases and stages, specifying recommendations in each case.

8 The *Guidelines* cover natural hazards such as earthquakes, hurricanes, strong winds, landslides, debris and mudflows, floods and volcanic activity, excluding other phenomena such as fires or other man-made hazards.

Figure 2. The project cycle in the design of health facilities.



3.1 Phase 1: Pre-investment

PHASE 1	Pre-investment activities
	I. Needs Assessment
	II. Options Assessment
	III. Preliminary Project

Stage I: Needs assessment

At this stage, an assessment is made regarding the need for a new health facility. Relevant variables include: the characteristics of the existing health-care network, its development policies, the rate of use of the existing services, expected future demand, epidemiologic and demographic profiles, health policies, and geographic characteristics. The funding for the development of the new health facility must be secured at this stage.

Mitigation measure:
Defining the protection objectives of the new facility.

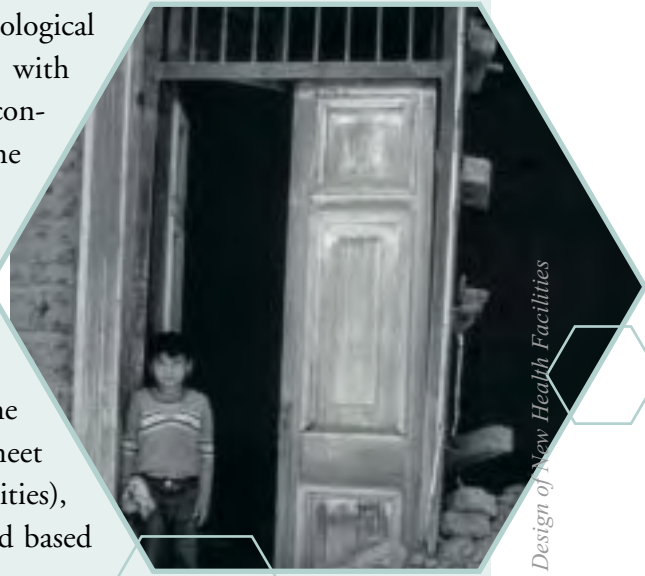
The effects of an adverse natural phenomenon on a health facility may include (a) panic, injuries and/or deaths among the patients and personnel, (b) partial or total damage to the structure, and (c) loss of the facility's operational capacity, and hence its capacity to meet the health care needs of the community when they are most pressing.

The prevention of each of these consequences depends on the **performance objective** that is set a priori for the facility. The first, most basic performance objective is known as **life safety,** and is the minimum prerequisite for any kind of infrastructure. The second is

known as **investment protection**, and essentially involves the protection of the infrastructure and equipment. The third performance objective is the most desirable, that is, **operational protection**. It is meant to ensure that the health facility can continue to operate after a disaster has struck.

At this preliminary stage of the project it will be necessary to define the overall performance objective that would be desirable, as well as feasible, for the intended facility, based on the various hazards prevalent in the region and the likely degree of severity of these hazards. The *Guidelines* include a tool for assisting decision-makers to determine what kind of response the planned health facility will be capable of, depending on the severity of an event and the protection objective chosen.

It should be borne in mind that, while current technological advances and changes in design philosophy, along with improvements in quality assurance procedures for the construction and maintenance of infrastructure can limit the damage and ensure almost certain operational continuity, it will not always be feasible to do so. In many instances there will be restrictions of various kinds: technical or natural (for example, the need for a health facility on an island with significant volcanic activity), economic (for example, achieving a balance between the need to expand the health care system in order to meet health goals, and the need to ensure the safety of the facilities), or political (when infrastructure is developed and located based on the expectations of a given constituency).



In situations in which the available resources do not make it possible to set the optimum protection objective for the facility as a whole, the *Guidelines* suggest alternatively that priority be given to critical services when choosing their location and resistance to the impact of disasters. As such, a facility may consist of two different areas: one where critical services are located, built in such a way that it meets operational protection objectives (i.e., which can continue

to function after a disaster), and another one housing less critical services, with lower protection standards.

The exercise of setting the performance objectives for the intended facility (or parts of the facility) should identify specific needs in terms of organization, safety, and damage control of infrastructural components, and should also state clear requirements regarding the characteristics of the site where the health facility will be built, as well as the infrastructure that will be involved.

Stage II: Assessment of site options

This stage involves the identification, evaluation and comparison of the various options for locating the intended health facility in order to meet the health care needs of the population, based on criteria such as public health policies, demographic data, and the geographical, sociopolitical and economic considerations considered pertinent by the client institution. The definitive site of the facility will be the outcome of this multiple assessment process.

Mitigation measure: Choosing a safe site for the new facility based on general criteria and an assessment of the existing risks from natural hazards

When assessing the available options for the site of the intended health facility, attention must be paid to performance objectives set for the facility at normal times and during emergencies, the comparative analysis of the natural and technological hazards present at the potential sites, the estimated cost and technical feasibility of implementing the necessary protection systems, the economic resources available, and a cost/benefit analysis of the options.

This assessment must cover not only the specific sites but also their surroundings. The way in which natural phenomena affect the sur-

rounding population, the population of reference and the relevant infrastructure must all be evaluated, particularly their impact on lifelines and access roads that allow a facility to meet its objective.

In short, when looking at potential sites for a new health facility, the following variables all come into play:

- Health care needs and public health requirements;
- Sociopolitical and cultural considerations;
- Technological hazards;
- Natural hazards;
- Mitigation or risk management requirements (including existing technology for hazard reduction and its cost);
- Performance objectives in normal times;
- Performance objectives during emergencies;
- Characteristics of the health care network;
- Socioeconomic restrictions;
- Technical restrictions; and
- Political and social restrictions.

Once the potential site options have been identified, it will be necessary to evaluate each on the basis of historical and other data as well as preliminary studies of the variables mentioned above. Special attention should be paid to the natural hazards prevalent at each site. In the case of each specific hazard, attention must be paid to (i) the technical and financial feasibility of implementing protection systems for the facility as a whole (prevention and mitigation); (ii) the potential impact on the client population, on lifelines, related services, and access to health care services; and (iii) the potential impact on the region's or country's health care network.

In the end, the selection of the site for the new health facility should be based on which of the options offers the best mix of safety vis-à-vis prevailing hazards and levels of risk and accessibility, in terms of the supply and demand of health care services and the cost-effectiveness of the site chosen.

There may be times when the desired performance objective cannot be met due to the extreme conditions of vulnerability confronting the target population or because the cost of achieving the desired level of protection would be prohibitive. Since the health care needs of such settlements cannot simply be ignored, decisions about location should contemplate the following measures:

- Distributing the intended functions of the facility so that they are carried out in locations that are remote from one another;
- Procuring mobile or temporary facilities, such as field hospitals, and deploying them in the relevant areas;
- Producing effective referral systems so that the population can easily be transferred to health facilities in other areas.

A key aspect of quality assurance, especially in the case of health facilities with high protection requirements, is the selection of experienced professional teams who are active and up-to-date in the field. During the preliminary stage of the project, including the hazard and risk assessments, a wide spectrum of professionals will be required, including urban developers, architects, topographers, geologists, specialists in soil mechanics, meteorologists, hydrologists, seismologists, and volcanologists, not to mention hydraulic, wind, seismic, and structural engineers. The specialists in charge of vulnerability and risk assessments must have plenty of experience, preferably in the design of health infrastructure.

Stage III: The preliminary project

It is at this stage that the services and physical spaces desired for the intended health facility are to be defined. This is known as the "medical and architectural program," which stipulates the functional relationship among the various structural and nonstructural components and their dimensions in square meters or feet. The preliminary plans will be drafted on the basis of this program. They will define how the services and spaces are to be handled. This process must include the definition of the physical characteristics and operations of the facility.

The selection of the preliminary plan, in addition to any functional and aesthetic considerations that may influence the final choice, should be guided by how thoroughly the existing regional and local risks have been taken into account, along with the necessary solutions to secure the protection objectives set for the project.

Mitigation measures: Criteria for evaluating the preliminary project and vulnerability reduction options

Depending on the hazards the facility may face, it will be necessary to choose protection methods and systems that can meet the challenges posed by these hazards. For instance, in areas of high seismicity, buildings must be regular in their floor and elevation plans, and systems that do not lead to sharp deviations in the structural system must be selected. In addition, it is convenient at this stage to determine whether the structure's protection systems will impose restrictions on the form and distribution of the facility. In areas prone to strong winds, for instance, the geometry of the roof and the façade elements are very important. In flood-prone areas, it may be necessary to use fill levels that are higher than normal.

The medical and architectural program's requirements must be interpreted correctly during the preliminary project stage in order to choose the right shapes and solutions to existing hazards. It is essential that the group in charge of this stage of the process have the required experience.

3.2 Phase 2: The Investment

PHASE 2	Investment activities		
	IV. Project Design	→	V. Construction

Stage IV: Project Design

This is the stage at which the technical specifications, plans, budget and tender documents are produced.

The design stage involves four key actors:

- The **client institution**, which sets the goals and requirements for the project;
- The **execution team**, which carries out the various tasks required at each stage;
- The **reviewing team**, whose job is quality assurance in fulfillment of the project goals and the needs of the client institution;
- The **financial agency**, which procures the funding for the project and often supervises its execution.

During this and the following stages, the oversight function of the working teams will be crucial. The contribution by mitigation

experts is also essential, and they must coordinate their efforts with all the other professionals involved in the project. Ideally, all basic stakeholders (the client institution, the execution team, the reviewing team and the financial agency) should remain watchful regarding the fulfillment of the safety and mitigation requirements.

It is also worth noting that in some countries, independent agencies entrusted with ensuring compliance with existing standards of safety and quality, sometimes called "quality-control bureaus", play a critical watchdog role in the project from this stage on. Since they specialize in the application of risk reduction principles, such independent agencies can ensure that the project meets all relevant quality standards in the face of the various hazards prevalent on site. The *Guidelines* recommend that the design of the project be overseen by independent specialists—either quality-control bureaus, where they exist, or else by consultants hired for that purpose—in order to guarantee the highest possible standards of quality in the design of the planned health facility.

In the course of any construction project, its components are typically divided into two categories:

- The **structural elements**—all those essential elements that determine the overall safety of the system, such as beams, columns, slabs, load-bearing walls, braces, or foundations. Structural elements comprise a building's resistance system.
- The **nonstructural elements**—all those other elements that, without forming part of the resistance systems, ultimately enable the facility to operate. They include architectural elements (non-load-bearing walls, floor coverings, ceilings, and other coverings or finishes); equipment and contents (electromechanical systems, medical and laboratory equipment, furnishings), and services or lifelines. In the case of hospitals, nearly 80 percent of the total cost of the facility is due to nonstructural components.

When designing the mitigation systems to ensure the safety of the infrastructure, the same classification is applied. Generally, the design team in charge of the structure is proficient in two disciplines: structural engineering and architecture. In the design of the nonstructural elements, all disciplines must be equally involved.

The impact of damage to the facility's nonstructural components may vary. For instance, damage to medical equipment or to the lifelines that supply medical and support services can actually cause loss of lives or the loss of the functional capacity of the facility. While less dramatic, partial or total damage to certain components, equipment, or systems may entail prohibitive repair and replacement costs. Major damage to systems, components, or equipment containing or involving harmful or hazardous materials may force the evacuation of some parts of the facility, resulting in a loss of operational capacity.

Secondary effects of the damage to nonstructural components are also important, for instance the fall of debris in hallways or escape routes, fires or explosions, or the rupture of water or sewerage pipes. Even relatively minor damage can compromise aseptic conditions in the affected areas, putting critical patients at risk. Special attention must therefore be paid to the safety of the nonstructural components.

The design stage culminates with the final version of the project, which includes all the technical specifications, plans, mockups, and tender documents, and budgets required to turn the concept into reality. Due to the complexity of a health facility, a large number of professionals representing different specialties must participate. Each team of specialists will be in charge of developing a specific subproject: the structure, heating, ventilation, air conditioning, the various essential services, and so on. Close coordination is the key to the success of this stage.

Mitigation measures: Criteria for the design stage in relation to the planned protection objective

Having chosen the best site, it is time to design a project that provides a level of safety commensurate with the protection objective chosen. The protection systems to be used for this purpose must meet two requirements: they must be feasible to build, and it should not be too difficult to give them effective maintenance. A poor design will lead to constraints during the other stages of the project that could make it difficult, even impossible, to meet the protection objective.

The structural system must meet the performance objectives defined for the facility as a whole and the services it will provide. In general terms, the design must incorporate structural detailing that can effectively meet the protection objective for each level of risk. It is also important to incorporate in the design any systems that, in case of damage and functional losses, will enable the facility's services to recover within a predefined timeframe.

From the point of view of vulnerability reduction and the fulfillment of the performance objective, the design coordination team must advise each of the specialized work groups on the functional and protection requirements specified for the facility and its services, and they in turn must specify clearly how they will achieve those objectives. Here, mitigation specialists must play a key role in the evaluation and enforcement of the performance objectives chosen. The proper design of a project calls for the integration of all the participating specialties; hence, coordination is indispensable.

At this stage, both the design execution team and the project review team must deliver a document certifying that the protection objective has been met. In this fashion, the protection systems to be incorporated will be clearly described in the technical specifications, construction plans, and "as-built" reports.

The *Guidelines* contain sets of standards, variables, indicators, reference materials and specific recommendations to guide the inclusion at this stage of mitigation criteria. A model "terms of reference" document is also included for vulnerability reduction in the design of new hospitals, so that it can assist in the revision of traditional terms of reference for the construction of health facilities.

While the *Guidelines* recommend the incorporation of mitigation specialists with special experience with hospitals from the start to the end of the project, in some cases such professionals are unavailable at the national level. Several mechanisms may be considered for solving this lack of national experience. One of them is the establishment of joint ventures or strategic alliances between national construction project design companies and international firms specializing in hospital design. This approach ensures the transfer of knowledge and technology, which would otherwise be hard to achieve. As long as the quality of the final product is assured, this could lead to a mutually advantageous association.

Stage V: Construction

This is the stage where the new infrastructure takes material form. The construction company is hired, the construction process is overseen and inspected, and the new facility is completed and delivered.

Mitigation measure:
Implementation of mitigation measures, evaluation of the work teams, and quality assurance

At this stage, the mitigation measures defined as part of the project design are to be implemented. The *Guidelines* stress two critical areas that require a great deal of attention: (i) the composition and coordination of the various work teams, and (ii) the quality assurance process.

The selection of the consultancy firms and teams of professionals for the project must be based on predefined criteria and requirements. These criteria should ensure that the selection process is transparent and quality-driven, and that all local and national standards are met, if not surpassed. The *Guidelines* include tools for setting such criteria and evaluating candidates.

During the construction and inspection stage as well as during the preliminary project and design, professionals will be needed in a variety of fields. These include: architecture, budgeting and finance, construction methods, electrical installations, fire safety, general safety, heating, ventilation and air conditioning, industrial equipment, medical and laboratory equipment, personnel management, sanitation facilities, structural design, telecommunications,

vulnerability analysis, waste management, and water treatment. Experts from other fields may also be required on a case-by-case basis. Mitigation specialists should participate in drafting the tender documents for the selection of the participating firms, and should be actively involved as part of the construction team and the oversight and evaluation team.

Applying quality-assurance procedures (also included in the *Guidelines*) will be crucial in guaranteeing the fulfillment of the protection objectives set for the facility. Internal quality-assurance teams, oversight firms and external quality-assurance consultants engaged in peer review processes must ensure that the plans and technical specifications are followed faithfully. These professionals should be able to certify that the functional and safety goals of the project have been met.

The client institution, the designers and the supervisory team must approve any changes to the original project proposed during the construction stage. Changes that modify the facility's performance objective should be the result of careful deliberations. The "as-built report" must include detailed descriptions of the proposed modifications. This is the only way that the real operational capacity of the facility can be established in the context of the overall health care network.

3.3 Phase 3: Operational activities

PHASE 3

Operations

VI. Operations and Maintenance

Stage VI: Operations and maintenance

While not part of the development of the new infrastructure, it is essential to take operations and maintenance into account during the design and construction stages. This informs the operation and functionality of the facility in the event of a disaster. Attention must be paid, in particular, to: the special distribution and relationships between the architectural spaces and the medical and support services provided by the hospital, the administrative processes (hiring and contracts, procurement, maintenance routines, etc.), and the physical and functional links between the various parts of the hospital.

The appropriate spatial distribution, linkages, and maintenance of the various components that make up the facility can ensure its smooth functioning not only in normal conditions but also during emergency and disaster situations.

Rigorous maintenance management—including regular inspection, replacement, technological upgrading, and training in prevention and the use and conservation of components—will ensure the highest possible resilience (the lowest degree of vulnerability) of the facility to a natural disaster.

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Investment in Risk Reduction Measures

As a consequence of recent disasters, which have underscored the extreme vulnerability of the region, several governments have placed disaster prevention near the top of their political agendas. In the health sector, national authorities and subregional and international organizations are more aware of the importance of implementing firm mitigation policies, given the strategic role that health facilities play in the event of a disaster. However, this increased awareness has yet to materialize in a sufficient number of concrete measures, due to budgetary, bureaucratic, and political constraints.

The main challenge consists in awakening the interest of countries in incorporating prevention and mitigation measures when allocating resources for investments in infrastructure. A key problem with mitigation projects is the belief that they will significantly increase the initial investment, affecting eventual profits or health care budgets. This reticence by governments and the private sector alike is aggravated when financial resources are scarce or expensive, forcing mitigation projects down the list of priorities when it should be just the opposite: protecting significant investments requires high safety and performance standards.

A mitigation investment that increases the structural integrity of a hospital will increase total construction costs by no more than 1 or 2 percent.[9] If to this we add the cost of the nonstructural elements (which account for about 80 percent of the total cost of the facility), it is estimated that incorporating mitigation elements to the construction of a new hospital accounts for less than 4 percent of the total initial investment. Clearly, a vulnerability assessment will indicate the advisability of such a small marginal investment, if only as an alternative to expensive insurance premiums or replacement costs—all this without taking into account the human and social losses that are likely to occur if mitigation measures are not taken into account.[10]

On the other hand, a good architectural-structural design can actually reduce the costs entailed in protecting nonstructural elements. The quality of such a design will depend on the collective experience of the work group, how well coordinated it is, what the conditions of the site are like, and how amenable the client institution is to such a way of working and thinking.

Another important consideration regarding costs has to do with the infrastructure's nonstructural components. It should be noted that if protection measures are taken into account as early as the design stage, their cost will be much lower than if such measures are implemented during the construction stage or after the building has been completed. For instance, a power-cut in a hospital as a result of severe damage to a generator costing, say, US$50,000, could be prevented if seismic isolation devices for protecting the generator and fastenings to prevent it from tipping over are installed, at a cost of approximately US$250.[11]

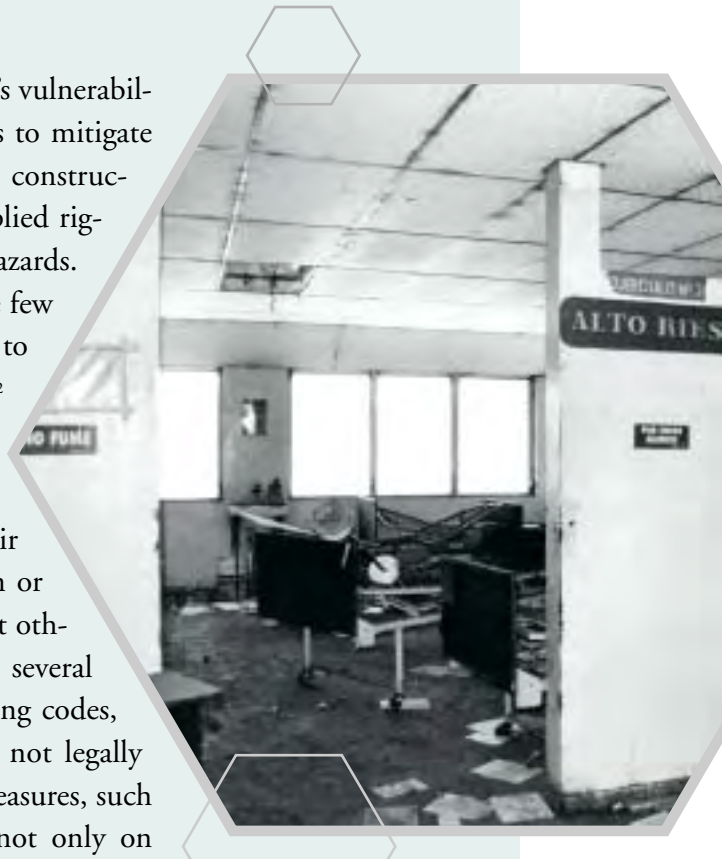
9 Pan American Health Organization (PAHO/WHO), *Principles of Disaster Mitigation in Health Facilities, .Mitigation Series*, Washington D.C., 2000.

10 Pan American Health Organization (PAHO/WHO), *Proceedings, International Conference on Disaster Mitigation in Health Facilities*, Mexico, 1996.

11 Pan American Health Organization (PAHO/WHO), *Guías para la mitigación de riesgos naturales en las instalaciones de la salud en los países de América Latina*. Washington, D.C., 1992.

Policies and Regulations

With rare exceptions, policies do not reflect the region's vulnerability to natural disasters, nor do they embody measures to mitigate this vulnerability. Land-use management policies and construction codes remain generally inadequate or are not applied rigorously enough in most places exposed to natural hazards. Policies concerning infrastructure, meanwhile, allocate few resources to basic maintenance—affecting resiliency to natural hazards and increasing the overall level of risk.[12]



The main obstacle to building codes' effectiveness as a tool for disaster mitigation is their actual application. Some countries in the region have not developed their own regulations, but have, instead, adopted European or U.S. standards that do not match local conditions. But others, such as Colombia, Costa Rica, Mexico, and several Caribbean countries, which have developed outstanding codes, do not always enforce them, either because they are not legally required or because oversight is lax. Similarly, other measures, such as land-use restrictions in hazardous areas, depend not only on whether the laws have "teeth" but on the institutional capacity to monitor their application.

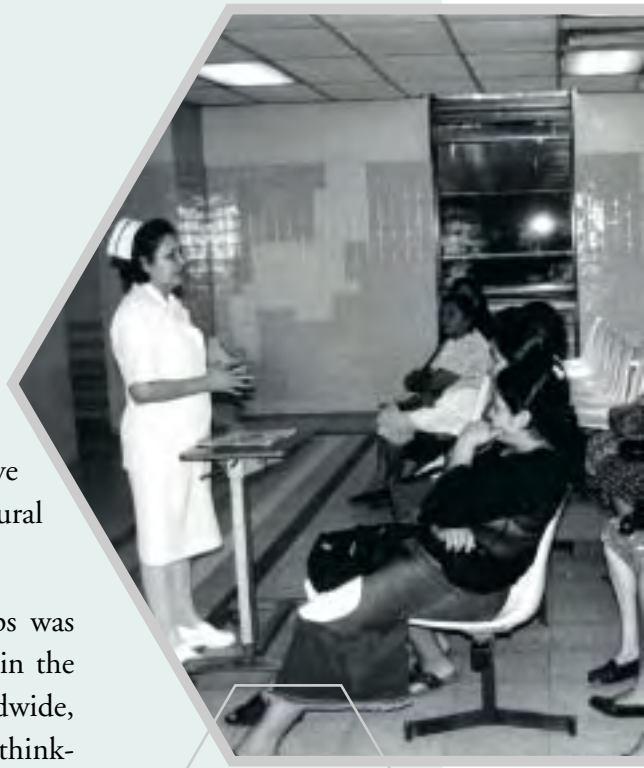
When it comes to hospitals and other essential facilities, experience shows that the most likely impact of a disaster is not structural, but functional collapse. Effective preventive maintenance programs can

12 Inter-American Development Bank (IDB), Facing the Challenge of Natural disasters in Latin America and the Caribbean: An IDB Action Plan, Washington, D.C., 2002.

alleviate this problem. Maintenance, as a planned activity, not only reduces the degradation of the facilities but can also ensure that public services such as water, gas, and electricity, and nonstructural components such as detailing, roofs, doorways, etc., continue to function properly during an emergency. The cost for preventive maintenance is not high if seen as part of the normal operating budget of a facility.[13] The importance of preventive maintenance as a vulnerability reduction measure cannot be over-stated; the incorporation of such preventive measures can ensure the fulfillment of the performance objective chosen during the preliminary design stage.

13 Pan American Health Organization. *A World Safe from Natural Disasters: The Journey of Latin America and the Caribbean.* Washington, D.C. PAHO/WHO, 1994. www.paho.org/English/Ped/ws-chapter6.pdf.

Training and Education



The design of a hospital is a joint responsibility of the architects and engineers involved. More specifically, it is imperative to underscore the physical relationships between architectural forms and seismic-resistant structural systems.

It would be ideal if an understanding of these relationships was among the intellectual features of all professionals involved in the design of health facilities in high-risk areas. Regrettably, worldwide, educational methods and practices do not foster this way of thinking, since future architects and engineers are educated separately and often practice their skills in relative isolation from one another.

It is likewise vital to promote the inclusion of disaster mitigation in all training programs related to the construction, maintenance, administration, financial management, and planning of health facilities, as well as of water and sanitation systems, power utilities, and communication systems, among others.

When it comes to strategies for dealing with the potential shortage of specialists with experience in hospital design at the local level, several options may be considered: for instance, establishing strategic alliances between national and international business groups or between the public and private sectors, or including concrete requirements to this effect in "turn-key" tender specifications. Such approaches would have the added advantage of contributing to building national technical capacity.

The Role of International Organizations in the Promotion and Funding of Mitigation Strategies

In the field of risk reduction in hospitals and other health facilities, the Pan American Health Organization (PAHO) has worked actively with the countries of the region to assess and reduce the vulnerability of such facilities to disasters and to summon the political will of their health authorities. It has also promoted the dissemination of key information and the technical training of relevant professionals. In the early 1990s, PAHO/WHO (www.paho.org) launched a project aimed at engineers, architects and maintenance supervisors in hospitals, as well as policymakers and decision-makers at various administrative levels. Its chief objective was to raise their awareness concerning the need of investing in the protection, maintenance and retrofitting of existing health facilities, as well as of designing and building new infrastructure based on specific criteria for reducing and mitigating the impact of natural hazards. As part of this initiative, PAHO has produced a series of training materials and launched several pilot projects; it has also supported vulnerability assessments of hospitals in many countries in the region.

In 1999, within the framework of the International Decade for Natural Disaster Reduction (IDNDR, www.unisdr.org), the countries in the Region set up the Inter-American Committee on Natural Disaster Reduction, under the oversight of the Organization of American States (OAS, www.oas.org). The Committee is entrusted

with developing strategic initiatives, and pays special attention to reducing the vulnerability of Member States.

At the regional level, institutions such as the Caribbean Disaster Emergency Response Agency (CDERA, www.cdera.org) or the Central American Coordination Center for Natural Disaster Prevention (CEPREDENAC, www.cepredenac.org) strive to promote international cooperation, technical assistance and the exchange of information for disaster prevention. The United Nations Economic Commission for Latin America and the Caribbean (ECLAC, www.eclac.cl) also plays a significant role in the field, particularly thanks to its experience in assessing the economic impact of natural disasters.

The World Bank and the Inter-American Development Bank (IDB, www.iadb.org) both exemplify how prevention and mitigation are becoming increasingly important in the funding of disaster-related reconstruction projects. The World Bank is the largest global provider of financial aid for disaster reconstruction, and it is taking steps to incorporate vulnerability reduction as one of the key components of its poverty reduction efforts.[14] From 1980 until 2000, it disbursed a total of US$2.5 billion for mitigation projects in Latin America alone.

At the institutional level, the World Bank's Disaster Management Facility (DMF, www.worldbank.org/dmf), established in 1998, strives to play a proactive leadership role in disaster prevention and mitigation through training, consultancies, and forging links with the international and scientific community in order to promote disaster reduction efforts.[15] To achieve these goals, the World Bank has decided to focus its efforts on the following tasks:

- Promote the establishment of sustainable development policies aimed at reducing the losses caused by natural disasters;
- Encourage among member countries the assessment of risks and potential losses, a cost-benefit analysis of risk management, and their use as inputs for planning and budget allocation;

14 Inter-American Development Bank, "Preparatory Group Meeting on Natural Disasters: Disaster Prevention and Risk Reduction" (Working Paper), Inter-American Committee on Natural Disaster Reduction (IANDR), Washington, D.C., 2001.
15 http://www.worldbank.org/dmf/.

- Encourage research on how natural disasters and disaster mitigation impact on long-term socioeconomic development, as well as research on how cost sharing and cost recovery affect mitigation;
- Incorporate risk management into member countries' economic strategy programs as an integral component of national development planning;
- Raise awareness of the importance of disaster mitigation, emphasizing its economic and social benefits, and search for solutions for existing constraints;
- Incorporate mitigation in the design of development projects, with the ultimate goal of making it an intrinsic part of every project. In short, the goal is for mitigation to be a standard part of the quality-auditing process within the project cycle. As part of this effort, the Prevention Unit has produced an information toolkit for World Bank personnel. The kit includes guidelines and examples of disaster mitigation and prevention projects, with a view to disseminating their adoption at the institutional level. It also provides training and technical assistance to various departments of the World Bank itself.

One of the coalitions that emerged from such mitigation promotion efforts by the World Bank was the ProVention Consortium (www.proventionconsortium.org). Made up of governments, international organizations, academic institutions and representatives of the private sector and civil society, its mission is to support developing countries in reducing the risk and the social, economic and environmental impact of natural and technical disasters, particularly among the poorest sectors of the population.

The IDB has also been proactive in this area. In 1999, it adopted a new policy aimed at placing disaster prevention near the top of the development agenda and applying a more integral and preventive approach to risk reduction and recovery. The IDB's policy, currently under review to expand and strengthen its objectives and fields

of action, contemplates assigning top priority to vulnerability reduction measures and providing financial resources to the region for disaster prevention and mitigation and capacity-building for improved risk management.

The IDB has committed itself to supporting Member States in the adoption of integral risk management plans by means of the following actions:[16]

- Establish new **financial mechanisms** (loans, or refundable and non-refundable technical cooperation services) to help countries undertake and strengthen disaster prevention and risk management actions;
- Engage in a **dialogue with member countries** on issues such as risk assessment, risk management strategies, and the use of available IDB in-struments for financing investments related to natural disasters;
- Incorporate **risk reduction in the project cycle**, including risk analysis and reduction in programming and in project identification, design, implementation and evaluation. As part of this process, a series of sectoral checklists for disaster risk management are being developed to support the drafting of projects in the various sectors;
- Identify **focal points for disaster management** at the institutional level in order to support countries in preparing risk reduction programs and coordinating prevention and response activities;
- Build **partnerships** for the establishment of an integrated information and response network that can assist in coordinating the preparation of pre-investment studies, as well as investing in prevention and reconstruction and establishing interagency response protocols.

16 Inter-American Development Bank (IDB), *Facing the Challenge of Natural Disasters in Latin America and the Caribbean: An IDB Action Plan*. Washington, D.C., 2002.

Annex I

Effects of natural disasters

Type of disaster	General effects	Effects on infrastructure
Earthquakes	Tremors and cracks Landslides Liquefaction Underground settling and rock falls Avalanches and landslides Changes in underground water courses Fires	Damage to constructions Diverse damage in roads, bridges, dikes and channels Broken ducts: pipes, posts and wires damage to dams, overflow of rivers causing local floods Sinking of structures and buildings Deterioration of underground constructions Destruction and damage to urban infrastructure (networks, streets, equipment and furniture) Fires
Hurricanes, typhoons and cyclones	Strong winds, both steady and gusts Floods (due to rain and swollen and overflowing rivers)	Damage to buildings Impact-damaged, broken and fallen power distribution lines, especially overhead Damage to bridges and roads due to landslides, avalanches and mudslides
Drought	Drying and cracking of the earth and loss of vegetation Exposure to wind erosion Desertification	Does not cause major losses to infrastructure
Floods	Erosion Water saturation and destabilization of soils, landslides Sedimentation	Loosening of building foundations and piles Burial and slippage of constructions and infrastructure works Blockage and silting of channels and drains

Continue

Effects of natural disasters

Type of disaster	General Effects	Effects on infrastructure
Tsunamis	Floods Salinization and sedimentation in coastal areas Contaminated water and water table	Destroyed or damaged buildings, bridges, roads, irrigation and drainage systems
Volcanic eruptions	Fires, loss of plant cover Deposit of incandescent material and lava Deposit of ash Deterioration of soils due to settling of air-borne chemicals Landslides, avalanches and mudslides Liquefaction Melting ice and snow, avalanches	Destroyed buildings and all types of infrastructure Collapsed roofs due to ash deposits Burial of buildings Fires Affect on channels, bridges and overhead and underground conduction and transmission lines

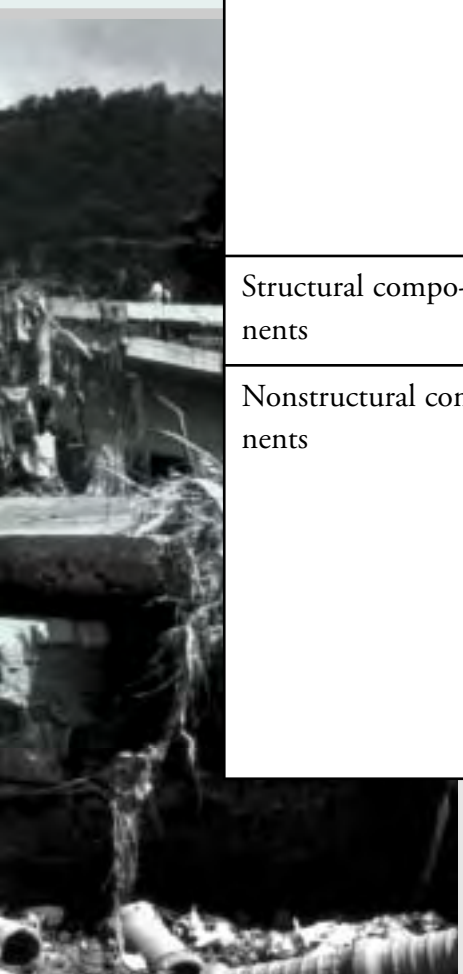
Source: Adapted from Frederick C. Cuny (1983), *Disasters and prevention*, Oxford University Press, New York.

Annex II

Glossary of key terms

Concepts of a general nature are defined below. Definitions of more specific concepts are included in the relevant chapters of the Guidelines for Vulnerability Reduction in the Design of New Health Facilities.

Natural hazard	An event of natural origin and sufficient intensity to cause damage in a particular place at a particular time.
As-built report	Set of documents prepared for project managers and the professionals involved in regional and local risk assessment. The documents include contractual documents, the design of the project, construction and inspection procedures, applicable codes and standards, certificates of component safety, final plans for the structure, its components and protection systems, and certificates of compliance with project specifications.
Structural components	Elements that are part of the resistant system of the structure, such as columns, beams, walls, foundations, and slabs.
Nonstructural components	Elements that are not part of the resistant system of the structure. They include architectural elements and the equipment and systems needed for operating the facility. Some of the most important nonstructural components are: architectural elements such as façades, interior partitions, roofing structures, and appendages. Nonstructural sys-tems and components include lifelines; industrial, medical and laboratory equipment; furnishings; electrical distribution systems; heating, ventilation and air conditioning systems; and elevators.



Structural detailing	A set of measures, based on the theoretical and empirical experience of the various participating disciplines, for protecting and improving the performance of structural components.
Nonstructural detailing	A set of measures, based on the theoretical and empirical experience of the various disciplines, aimed at protecting and improving the performance of nonstructural components.
Tender documents	Legal documents that stipulate the characteristics of the design or building contract or contracts (parties involved, financial amounts, deadlines, forms of payment, etc.) and the technical characteristics of the construction (general and detailed plans, structural and nonstructural components, standards and codes that must be followed, specialized inspection requirements, recommended and unacceptable construction methods, etc.).
Specialized inspection	Activities aimed at ensuring that the requirements of the project are met in matters such as: quality of the labor force, the use of construction processes and materials of a quality commensurate with the goals of the project, the fulfillment of the provisions established in the standards and codes referenced in the contracts, and the procurement of component safety certificates and others.
Life protection	Minimal level of protection required in a structure to ensure that it does not collapse or otherwise endanger the lives of those who occupy a building during a natural disaster. It is the protection level most commonly used in the construction of health facilities.
Investment protection	The level that protects all or part of the infrastructure and equipment, although the facility itself ceases to function. This level of protection would ensure that the facility would resume operations in a timeframe and at a cost that is in keeping with the institution's capacity.

Operations protection	This protection objective for a facility aims not only to prevent injury to occupants and damage to infrastructure, but to maintain operations and function of the facility after a disaster. It is the highest protection objective: it includes life protection and investment protection.
Risk	Extent of the likely losses in the event of a natural disaster. The level of risk is intimately associated with the level of protection incorporated into the structure.
Critical services	Services that are life saving, involve hazardous or potentially dangerous equipment or materials, or whose failure may generate chaos and confusion among patients or the staff.
Resistant system	A structural system especially designed to withstand the impact of external forces. The structural system must be designed in such a way that its detailing is proportional to the protection objective chosen for the structure.
Protection systems	Devices and procedures aimed at providing safety to the structural and nonstructural components of the building and meeting the protection objectives.
Vulnerability	The likelihood of a facility suffering material damage or being affected in its operations when exposed to a natural hazard.

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Other PAHO/WHO publications on disaster mitigation in health facilities

Guidelines for Vulnerability Reduction in the Design of New Health Facilities. 2004
New guide published in collaboration with the World Bank. Presents guidelines to protect the investment and operations in the design and construction of new health facilities.

Principles of Dissater Mitigation in Health Facilities. 2000
Provides the basis to prepare vulnerability studies and to apply practical mitigation measures in hospitals.
www.paho.org/english/dd/ped/fundaeng.htm

CD-ROM *Planeamiento Hospitalario para Desastres*
(in Spanish only). 2003
Self-teaching material for the organization and development of the course "Hospital Planning for Disasters."
www.disaster-info.net/planeamiento

CD-ROM *Disaster Mitigation in Health Facilities*. 2001
This disc contains the main training materials—books and PowerPoint presentations—that PAHO/WHO has on this subject.

These publications can also be consulted:

Lecciones aprendidas en América Latina de mitigación de desastres en instalaciones de salud ("Lessons Learned in Latin America in Disaster Mitigation in Health Facilities"—in Spanish only) www.paho.org/spanish/dd/ped/leccispa.htm.

International Conference on Disaster Mitigation in Health Facilities: Recommendations www.paho.org/english/dd/ped/mitrecs.htm.

Video: *Mitigation of Disasters in Health Facilities*. 1991

For more information, go to www.paho.org/disasters/

Technical knowledge and experience have taught us that it is possible to reduce to a minimum the risks and damage caused by disasters if preventive measures are incorporated in the design, construction and maintenance of new health facilities. However, this complex issue requires greater visibility in political and development agendas in Latin America and the Caribbean.

The Pan American Health Organization, in collaboration with the WHO Collaborating Center on Disaster Mitigation at the University of Chile, and with the support of the World Bank and the ProVention Consortium, has published comprehensive *Guidelines for Vulnerability Reduction in the Design of New Health Facilities* to help administrators, professionals and technical advisors of the health sector whose responsibilities include the management, design, construction and inspection of new health facilities projects.

This publication summarizes the more comprehensive guidelines, emphasizing who should use them, when and why. It includes recommendations on how to promote their use among national authorities, planners and financing agencies involved in the development of these projects. As an overview of the topic, it emphasizes the substantial social and economic benefits of applying disaster mitigation measures to the design, planning and construction of health facilities. Equally important, it describes how to apply these measures to achieve protection levels that not only ensure human safety but also the security of infrastructure and the operation of services.

This document can be viewed on the Internet at:

www.paho.org/disasters

Pan American Health Organization
Regional Office of the World Health Organization

The World Bank Group

Protecting New Health Facilities from Natural Disasters:

Guidelines for the Promotion of Disaster Mitigation

Produced by Tarina García Concheso, based on
Guidelines For Vulnerability Reduction in the Design of New Health Facilities
by R. Boroschek and R. Retamales of the
PAHO/WHO Collaborating Center at the University of Chile
and on the recommendations adopted
at the international meeting "Hospitals in Disasters: Handle with Care," El Salvador, July 2003.

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I Title

1. VULNERABILITY ANALYSIS

2. PREVENTION AND MITIGATION

3. HEALTH INFRASTRUCTURE

4. NATURAL DISASTERS

5. DISASTER PLANNING

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Introduction

Hurricanes, floods, earthquakes, landslides and volcanic eruptions—and the devastation they inflict—are all too familiar to the countries of Latin America and the Caribbean. In the last decade, natural disasters have caused more than 45,000 deaths in the region, left 40 million injured or in need of assistance, and carried a price tag—in direct damage alone—of more than US$20 billion.[1]

The health sector has proven particularly vulnerable to such havoc. In the course of the past 20 years, as a result of natural disasters, more than 100 hospitals and 650 health centers have collapsed or been so severely damaged that they had to be evacuated. According to the United Nations Economic Commission for Latin America and the Caribbean (ECLAC), accumulated losses due to disasters in the health sector reached US$3.12 billion—the equivalent of 20 countries in the region each suffering the demolition of six hospitals and at least 70 health centers.[2]

Approximately 50% of the 15,000 hospitals in Latin America and the Caribbean are sited in high-risk areas. Many of them lack disaster mitigation programs, emergency plans, or the infrastructure required to withstand earthquakes, hurricanes, and other natural phenomena.

1 Inter-American Development Bank (IDB), *Facing the Challenge of Natural Disasters in Latin America and the Caribbean: An IDB Action Plan*, Washington, D.C., 2002.

2 Pan American Health Organization (PAHO/WHO), *Principles of Disaster Mitigation in Health Facilities, Mitigation Series*, Washington, D.C., 2000.

In this context, existing codes and regulations on the design and construction of health facilities must be revised and reoriented towards disaster mitigation, with the ultimate goal not only of protecting the lives of patients, staff and other occupants, but also of ensuring that such facilities can continue to operate after a disaster has struck—at the moment when they are most needed. The knowledge of how to build safe hospitals not only exists, but is readily available.

One of several efforts to disseminate this knowledge is being actively pursued by the Pan American Health Organization through the PAHO/WHO Collaborating Center on Disaster Mitigation in Health Facilities of the University of Chile. With support from the World Bank and the ProVention Consortium, the Collaborating Center published the *Guidelines for Vulnerability Reduction in the Design of New Health Facilities*. These Guidelines were assessed and validated at the international meeting *Hospitals in Disasters: Handle with Care*, which was held by PAHO/WHO in El Salvador on 8-10 July 2003.

It is the aim of this publication to present a summary of the Guidelines—emphasizing how they can be used, by whom, and for what purpose. In addition, some considerations are provided on how to promote the use of the Guidelines by national authorities, planners and funding institutions when developing projects for the construction of new health facilities. Potential users of the Guidelines include the following:

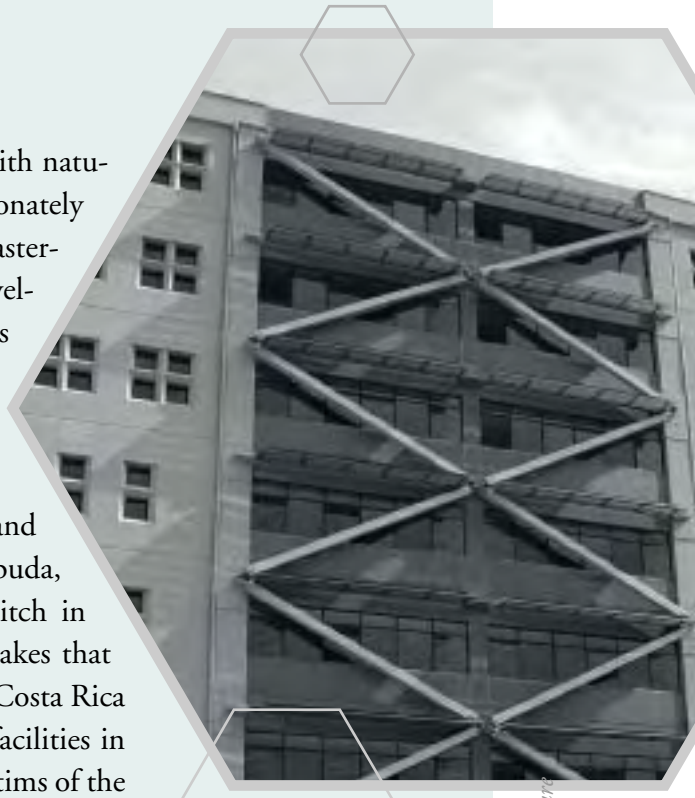
- ***Initiators of health facility construction projects*** (who recognize the need for new health facilities):
  - The public sector (Ministry of Health, Social Security, etc.)
  - The private sector
  - Unions
  - The military
  - Organized civil society
  - Municipal governments

*The *Guidelines* can be accessed at www.paho.org/disasters

- ***Executors and supervisors of health facility construction projects:***
  - The Ministry of Health
  - The Ministry of Public Works
  - Social Security
  - Government offices or independent agencies in charge of enforcing building standards
  - Subcontractors entrusted with hospital management
  - Subcontractors entrusted with the management, quality control, design and/or execution of the project
  - The private sector

- ***Financing bodies in charge of funding health facility construction projects:***
  - The government
  - The public sector bodies that have identified the need for new facilities
  - The Ministry of Finance
  - The Ministry of Health in tandem with the Ministry of Finance
  - International sources: development banks and bilateral and multi-lateral donors
  - Nongovernmental organizations
  - The private sector (including private banking)

Natural Phenomena and Health Infrastructure



While no country can afford the high costs associated with natural disasters, the impact of these events is disproportionately higher for developing countries. It is estimated that disaster-related losses as a ratio of GNP are 20 times greater in developing than in industrialized nations.[3] Among the effects of such phenomena, the damage caused to health infrastructure in Latin America and the Caribbean has been particularly severe (see Annex I).

Hurricanes such as Gilbert (Jamaica, 1988), Luis and Marilyn (in September 1995, afeccting Antigua and Barbuda, St. Kitts and Nevis, St. Martin and other islands), Mitch in Central America (October 1998) as well as the earthquakes that hit Mexico in 1985, El Salvador in 1986 and 2001, and Costa Rica and Panama in 1991, caused serious damage to health facilities in those countries, affecting their capacity to care for the victims of the disaster (see Table 1).

3 Pan American Health Organization (PAHO/WHO) and U.N. International Decade for Natural Disaster Reduction, *Lessons Learned in Latin America on Disaster Mitigation in Health Facilities: Aspects of Cost-Effectiveness*, Washington, D.C., 1997.

Table 1. Health facilities affected by natural disasters in selected countries of the Americas, 1985–2001.

Disaster	Hospitals and health centers affected	Hospital beds out of service
Earthquake, Chile, March 1985	79	3,271
Earthquake, Mexico, September 1985	13	4,387
Earthquake, El Salvador, October 1986	7	1,860
Earthquakes, El Salvador, January and February 2001a	113	2,021
Hurricane Gilbert, Jamaica, September 1988	24	5,085
Hurricane Joan, Costa Rica and Nicaragua, October 1988	4	---
Hurricane Georges, Dominican Republic, September 1998	87	---
Hurricane Georges, Saint Kitts and Nevis, September 1998b	1	170
El Niño, Peru, 1997-1998	437	---
Hurricane Mitch, Honduras, November 1998	78	---
Hurricane Mitch, Nicaragua, November 1998	108	---

Source: Proceedings, International Conference on Disaster Mitigation of Health Facilities, Mexico, 1996.
(a) Only health facilities of the Ministry of Health have been listed, not those of Social Security or the private sector.
(b) During its 35 years of operation, Joseph N. France Hospital in Saint Kitts was seriously damaged by hurricanes on 10 separate occasions.
--- Data unavailable.

What are the implications of such natural disasters for the health sector? Some are direct:

- Health facilities are damaged.
- Local infrastructure is damaged, interrupting the basic services that are indispensable to the provision of health care, and blocking or destroying access routes to the facilities.

- An unexpected number of deaths, injuries and illnesses impact the local community, overwhelming the health network's therapeutic response capacity.

Others are indirect:

- Population displacements occur, whether organized or spontaneous, away from the affected areas towards those that have not been directly hit, but whose health systems may not have the capacity to cope with the increased demand for its services.
- The risk of communicable diseases and mental illness as a result of the disaster is likely to increase among the affected population.
- Food supplies may become scarce, threatening the population with malnutrition and all its attendant hazards.
- Both remedial and preventive health care services may become harder or impossible to obtain, or too expensive.
- The supply of safe drinking water may become sporadic or be totally interrupted, or contamination may occur.
- Health priorities may end up in disarray as public health campaigns are suspended to meet emergency needs.

Figure 1 presents a summary of the socioeconomic impact of a disaster on the health sector. The cost of such damage, often hard to quantify, tends to build up throughout the rehabilitation and reconstruction period until operational capacity is fully restored. Damage to assets and services may contribute significantly to the impoverishment of the population, since they lead to loss of jobs and livelihoods.[4]

Specifically, the vulnerability of hospital facilities to potential hazards involves six major areas:[5]

- **Buildings:** The location and building specifications, particularly regarding design, the resiliency of the materials, and

4 Keipi, K. and J. Tyson, *Planning and Financial Protection to Survive Disasters*, Technical Report Series of the Department of Sustainable Development, Inter-American Development Bank (IDB), Washington, D.C., 2002.

5 Pan American Health Organization (PAHO/WHO), *Proceedings, International Conference on Disaster Mitigation in Health Facilities,* Mexico, 1996.

physical vulnerability, determine the ability of hospitals to withstand adverse natural events. The slightest structural or architectural element that collapses or fails entails both financial and human costs.

- **Patients:** It is customary for health facilities to work 24 hours a day at about 50 percent of their service capacity. Any disaster will inevitably increase the number of potential patients and amplify their level of risk. Waiting lists get longer, since it becomes impossible to meet both routine demand and that generated by the emergency. Patients also suffer from the decline in the provision of services as a result of damaged, partially evacuated or non-operational facilities.

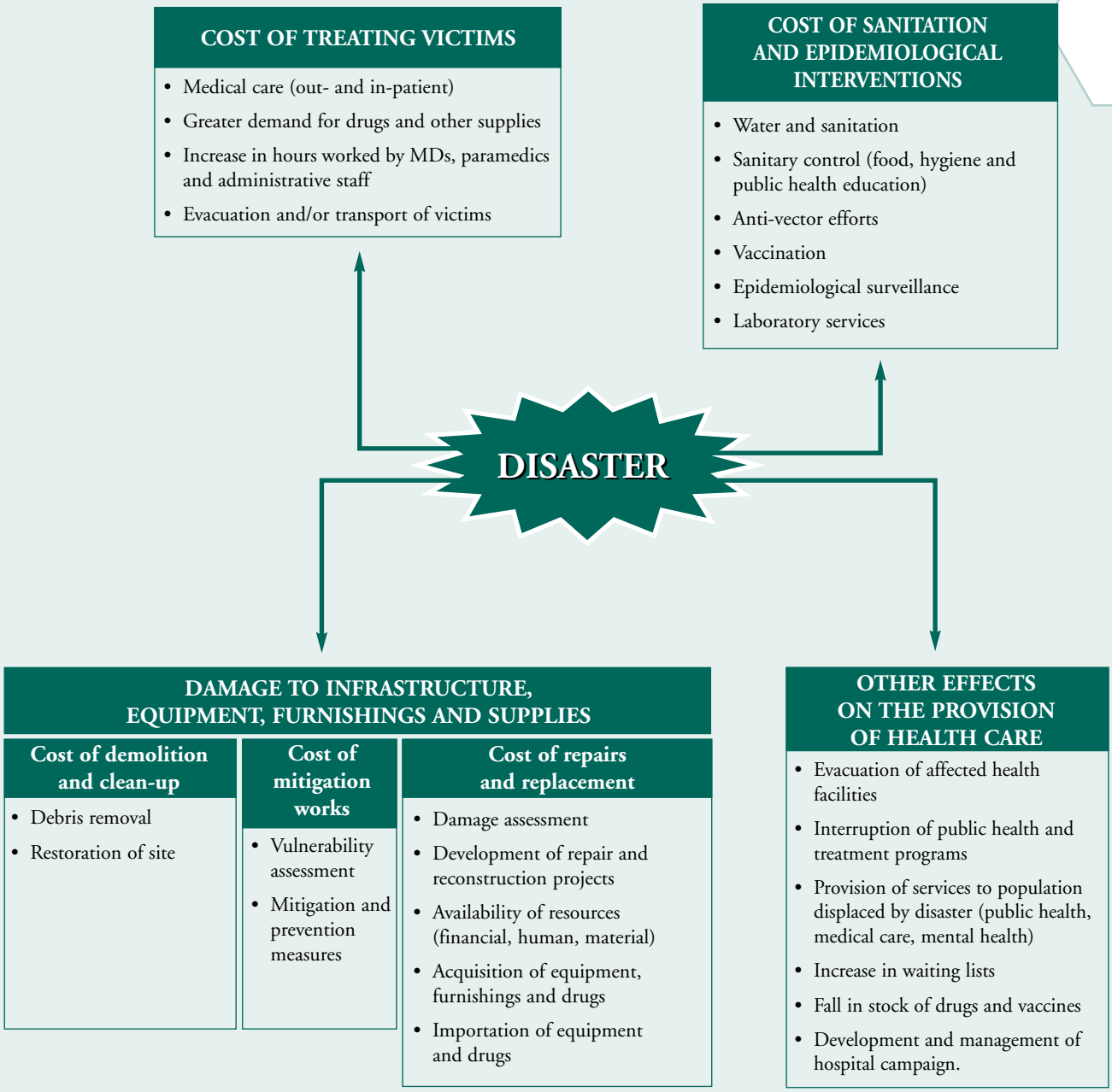
- **Hospital beds:** In the aftermath of a disaster, the availability of hospital beds frequently decreases even as demand goes up for emergency care of the injured.

- **Medical and support staff:** It is hardly necessary to describe the significant disruption to the care of the injured caused by the loss of medical or support personnel. In order not to suffer a concomitant loss in response capacity, outside personnel must be hired temporarily, adding to the overall economic burden. Sometimes the death of a specialist can entail major technical costs for the country affected by the disaster.

- **Equipment and facilities:** Damage to nonstructural elements (such as equipment, furniture, architectural features, and medical supplies) can sometimes be so severe as to surpass the cost of the structural elements themselves. Even when the damage is less costly, it can still be critical enough to force the hospital to stop operating.

- **Basic lifelines and services:** The ability of hospitals to function relies on lifelines and other basic services such as electrical power, water and sanitation, communications, and waste management and disposal. It is not a given that self-contained backup emergency services are available at all health facilities. When a natural disasters affects some of the services, the performance of the entire hospital is affected.

Figure 1. Socioeconomic impact of a disaster in the health sector.



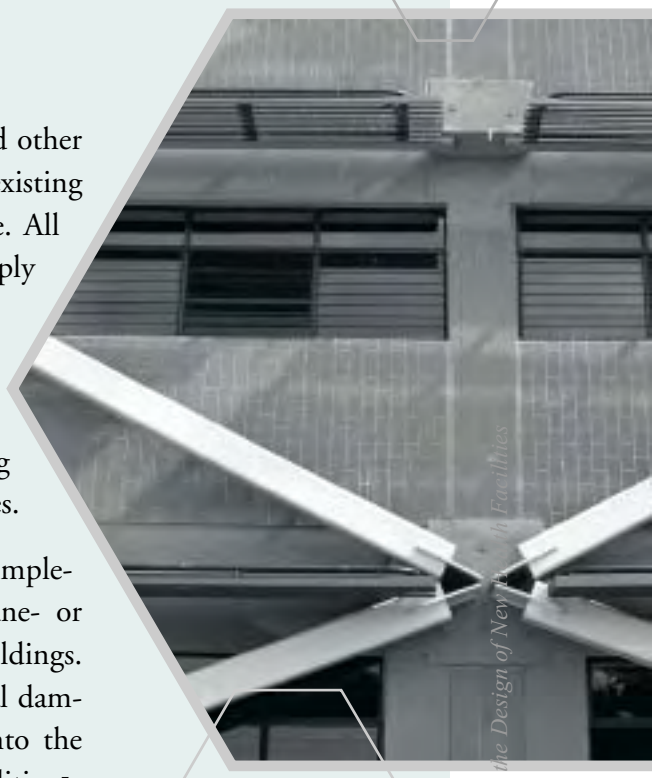
When it comes to disaster resiliency standards, the bar is inevitably raised in the case of health facilities, particularly hospitals. It is not enough for them to remain structurally sound long enough for non-ambulatory inpatients to survive; instead, these patients must continue to receive appropriate care even as new patients are coming in as a result of the injuries sustained during the event. It is also important that health promotion and prevention programs, such as prenatal care and hemodialysis, not be interrupted. For all these services to be maintained without interruption, the buildings and their contents must remain operational and formal disaster response plans must be in effect.

Hospital authorities, cognizant of the facts outlined above, frequently produce emergency response plans—but such plans often fail to incorporate prevention and mitigation measures, or to strengthen the role of hospital disaster committees in risk management. Hence the need to incorporate measures for improving general safety and, above all, preserving the functionality of key areas of the hospital when designing and building new health facilities. These areas include: emergency services, intensive care units, diagnostics facilities, the surgical theater, the pharmacy, food and drug storage areas, and registration and reservation services.

It is important to note that in the countries of Latin America and the Caribbean many hospitals damaged by natural disasters were designed in accordance with seismic-, wind-, and flood-resistant building standards. This suggests that the design of hospitals should apply even higher standards than those relevant to buildings meant for housing or offices. Most seismic and flood- or wind-resistant building codes in the region strive to protect the lives of those inside the building, not to ensure the continuity of the building's operations.[6] Both the architectural and the structural design of health facilities should consider not only the physical aspects of any given adverse event, but also the social, economic and human implications of the functions played by hospitals in a community.

6 Pan American Health Organization (PAHO/WHO), *Principles of Disaster Mitigation in Health Facilities, Mitigation Series*, Washington, D.C,. 2000

The *Guidelines for Vulnerability Reduction in the Design of New Health Facilities* and Their Incorporation into the Development of Projects Cycles



The loss of lives and property as a result of earthquakes and other extreme natural phenomena can be mitigated by applying existing technologies without incurring enormous financial expense. All that is required is to have the political and social will to apply the right techniques.

Since in most communities it takes about two generations for the current stock of buildings to be replaced, attention must be paid both to the structural intervention of existing edifices and to the design and construction of new structures.

At present, not all countries in the region have adopted or implemented the necessary technical standards for the hurricane- or earthquake-resistant design and construction of new buildings. This means that significant reductions in risks and potential damage are feasible if preventive measures are incorporated into the design, construction and maintenance of all new health facilities.[7]

In this respect, applying the *Guidelines for Vulnerability Reduction in the Design of New Health Facilities* can play a key role in reducing existing risks. The section that follows presents a summary of the *Guidelines* and shows how they can be incorporated into the development cycle of projects for the construction of new health facilities.

7 Pan American Health Organization (PAHO/WHO), *Principles of Disaster Mitigation in Health Facilities – Volume I: General Issues*, Washington, D.C., 1993.

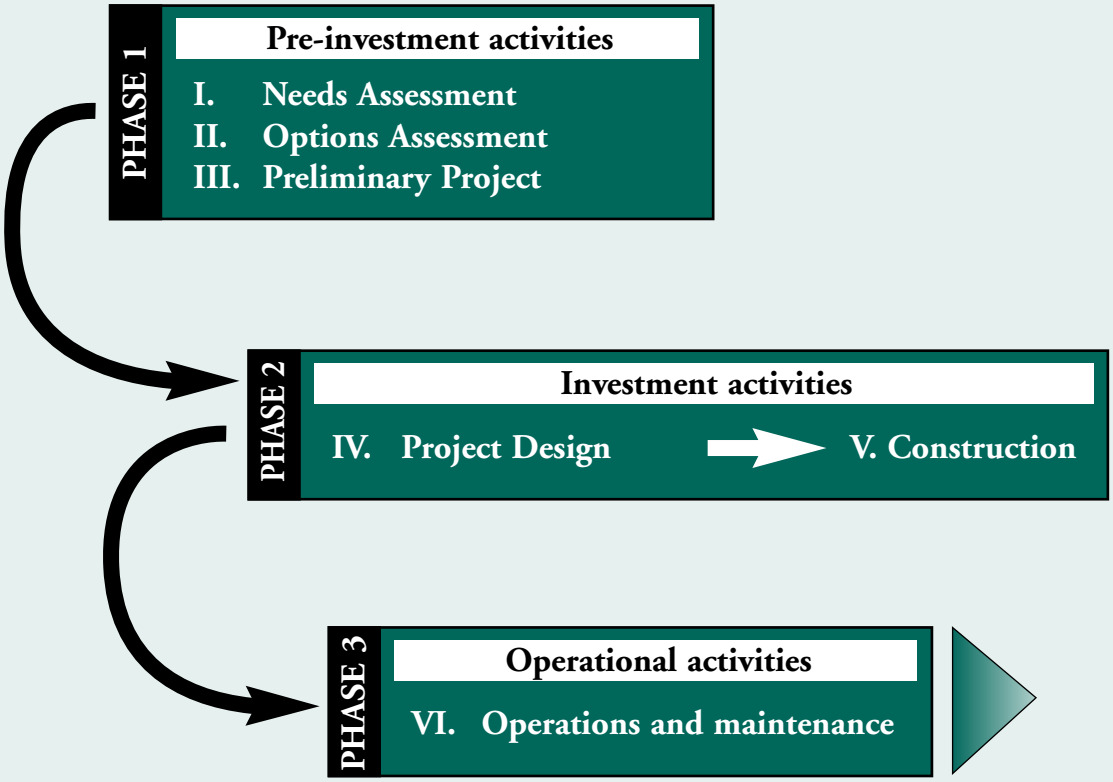
The purpose of the *Guidelines* is to assist health-sector managers, professionals and technical consultants involved in the administration, design, construction or inspection of health facilities so that mitigation measures are included to reduce vulnerability and ensure the highest level possible of protection to the facilities and their operation.[8]

Based on the three phases of the traditional project cycle—pre-investment, investment and operations—the *Guidelines* propose a series of critical guiding principles to facilitate the incorporation of vulnerability reduction mechanisms into the project. The *Guidelines* specify clearly which activities must be carried out at each stage in order to incorporate mitigation measures, and provide tools for their incorporation.

Figure 2 shows the project cycle for the construction of new health facilities, with its three phases and corresponding stages, which serve as the framework for the recommendations contained in the *Guidelines*. The following sections have been structured according to these phases and stages, specifying recommendations in each case.

8 The *Guidelines* cover natural hazards such as earthquakes, hurricanes, strong winds, landslides, debris and mudflows, floods and volcanic activity, excluding other phenomena such as fires or other man-made hazards.

Figure 2. The project cycle in the design of health facilities.



3.1 Phase 1: Pre-investment

PHASE 1	Pre-investment activities
	I. Needs Assessment
	II. Options Assessment
	III. Preliminary Project

Stage I: Needs assessment

At this stage, an assessment is made regarding the need for a new health facility. Relevant variables include: the characteristics of the existing health-care network, its development policies, the rate of use of the existing services, expected future demand, epidemiologic and demographic profiles, health policies, and geographic characteristics. The funding for the development of the new health facility must be secured at this stage.

Mitigation measure:
Defining the protection objectives of the new facility.

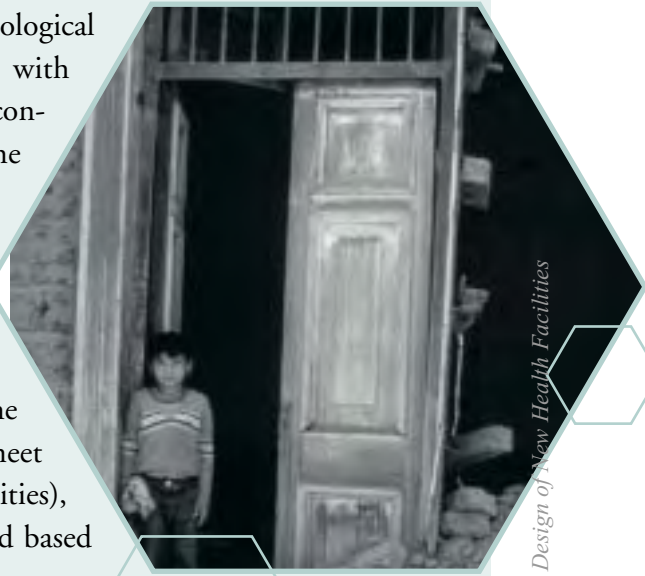
The effects of an adverse natural phenomenon on a health facility may include (a) panic, injuries and/or deaths among the patients and personnel, (b) partial or total damage to the structure, and (c) loss of the facility's operational capacity, and hence its capacity to meet the health care needs of the community when they are most pressing.

The prevention of each of these consequences depends on the **performance objective** that is set a priori for the facility. The first, most basic performance objective is known as **life safety,** and is the minimum prerequisite for any kind of infrastructure. The second is

known as **investment protection**, and essentially involves the protection of the infrastructure and equipment. The third performance objective is the most desirable, that is, **operational protection**. It is meant to ensure that the health facility can continue to operate after a disaster has struck.

At this preliminary stage of the project it will be necessary to define the overall performance objective that would be desirable, as well as feasible, for the intended facility, based on the various hazards prevalent in the region and the likely degree of severity of these hazards. The *Guidelines* include a tool for assisting decision-makers to determine what kind of response the planned health facility will be capable of, depending on the severity of an event and the protection objective chosen.

It should be borne in mind that, while current technological advances and changes in design philosophy, along with improvements in quality assurance procedures for the construction and maintenance of infrastructure can limit the damage and ensure almost certain operational continuity, it will not always be feasible to do so. In many instances there will be restrictions of various kinds: technical or natural (for example, the need for a health facility on an island with significant volcanic activity), economic (for example, achieving a balance between the need to expand the health care system in order to meet health goals, and the need to ensure the safety of the facilities), or political (when infrastructure is developed and located based on the expectations of a given constituency).



In situations in which the available resources do not make it possible to set the optimum protection objective for the facility as a whole, the *Guidelines* suggest alternatively that priority be given to critical services when choosing their location and resistance to the impact of disasters. As such, a facility may consist of two different areas: one where critical services are located, built in such a way that it meets operational protection objectives (i.e., which can continue

to function after a disaster), and another one housing less critical services, with lower protection standards.

The exercise of setting the performance objectives for the intended facility (or parts of the facility) should identify specific needs in terms of organization, safety, and damage control of infrastructural components, and should also state clear requirements regarding the characteristics of the site where the health facility will be built, as well as the infrastructure that will be involved.

Stage II: Assessment of site options

This stage involves the identification, evaluation and comparison of the various options for locating the intended health facility in order to meet the health care needs of the population, based on criteria such as public health policies, demographic data, and the geographical, sociopolitical and economic considerations considered pertinent by the client institution. The definitive site of the facility will be the outcome of this multiple assessment process.

Mitigation measure: Choosing a safe site for the new facility based on general criteria and an assessment of the existing risks from natural hazards

When assessing the available options for the site of the intended health facility, attention must be paid to performance objectives set for the facility at normal times and during emergencies, the comparative analysis of the natural and technological hazards present at the potential sites, the estimated cost and technical feasibility of implementing the necessary protection systems, the economic resources available, and a cost/benefit analysis of the options.

This assessment must cover not only the specific sites but also their surroundings. The way in which natural phenomena affect the sur-

rounding population, the population of reference and the relevant infrastructure must all be evaluated, particularly their impact on lifelines and access roads that allow a facility to meet its objective.

In short, when looking at potential sites for a new health facility, the following variables all come into play:

- Health care needs and public health requirements;
- Sociopolitical and cultural considerations;
- Technological hazards;
- Natural hazards;
- Mitigation or risk management requirements (including existing technology for hazard reduction and its cost);
- Performance objectives in normal times;
- Performance objectives during emergencies;
- Characteristics of the health care network;
- Socioeconomic restrictions;
- Technical restrictions; and
- Political and social restrictions.

Once the potential site options have been identified, it will be necessary to evaluate each on the basis of historical and other data as well as preliminary studies of the variables mentioned above. Special attention should be paid to the natural hazards prevalent at each site. In the case of each specific hazard, attention must be paid to (i) the technical and financial feasibility of implementing protection systems for the facility as a whole (prevention and mitigation); (ii) the potential impact on the client population, on lifelines, related services, and access to health care services; and (iii) the potential impact on the region's or country's health care network.

In the end, the selection of the site for the new health facility should be based on which of the options offers the best mix of safety vis-à-vis prevailing hazards and levels of risk and accessibility, in terms of the supply and demand of health care services and the cost-effectiveness of the site chosen.

There may be times when the desired performance objective cannot be met due to the extreme conditions of vulnerability confronting the target population or because the cost of achieving the desired level of protection would be prohibitive. Since the health care needs of such settlements cannot simply be ignored, decisions about location should contemplate the following measures:

- Distributing the intended functions of the facility so that they are carried out in locations that are remote from one another;
- Procuring mobile or temporary facilities, such as field hospitals, and deploying them in the relevant areas;
- Producing effective referral systems so that the population can easily be transferred to health facilities in other areas.

A key aspect of quality assurance, especially in the case of health facilities with high protection requirements, is the selection of experienced professional teams who are active and up-to-date in the field. During the preliminary stage of the project, including the hazard and risk assessments, a wide spectrum of professionals will be required, including urban developers, architects, topographers, geologists, specialists in soil mechanics, meteorologists, hydrologists, seismologists, and volcanologists, not to mention hydraulic, wind, seismic, and structural engineers. The specialists in charge of vulnerability and risk assessments must have plenty of experience, preferably in the design of health infrastructure.

Stage III: The preliminary project

It is at this stage that the services and physical spaces desired for the intended health facility are to be defined. This is known as the "medical and architectural program," which stipulates the functional relationship among the various structural and nonstructural components and their dimensions in square meters or feet. The preliminary plans will be drafted on the basis of this program. They will define how the services and spaces are to be handled. This process must include the definition of the physical characteristics and operations of the facility.

The selection of the preliminary plan, in addition to any functional and aesthetic considerations that may influence the final choice, should be guided by how thoroughly the existing regional and local risks have been taken into account, along with the necessary solutions to secure the protection objectives set for the project.

Mitigation measures: Criteria for evaluating the preliminary project and vulnerability reduction options

Depending on the hazards the facility may face, it will be necessary to choose protection methods and systems that can meet the challenges posed by these hazards. For instance, in areas of high seismicity, buildings must be regular in their floor and elevation plans, and systems that do not lead to sharp deviations in the structural system must be selected. In addition, it is convenient at this stage to determine whether the structure's protection systems will impose restrictions on the form and distribution of the facility. In areas prone to strong winds, for instance, the geometry of the roof and the façade elements are very important. In flood-prone areas, it may be necessary to use fill levels that are higher than normal.

The medical and architectural program's requirements must be interpreted correctly during the preliminary project stage in order to choose the right shapes and solutions to existing hazards. It is essential that the group in charge of this stage of the process have the required experience.

3.2 Phase 2: The Investment

PHASE 2	Investment activities		
	IV. Project Design	→	V. Construction

Stage IV: Project Design

This is the stage at which the technical specifications, plans, budget and tender documents are produced.

The design stage involves four key actors:

- The **client institution**, which sets the goals and requirements for the project;
- The **execution team**, which carries out the various tasks required at each stage;
- The **reviewing team**, whose job is quality assurance in fulfillment of the project goals and the needs of the client institution;
- The **financial agency**, which procures the funding for the project and often supervises its execution.

During this and the following stages, the oversight function of the working teams will be crucial. The contribution by mitigation

experts is also essential, and they must coordinate their efforts with all the other professionals involved in the project. Ideally, all basic stakeholders (the client institution, the execution team, the reviewing team and the financial agency) should remain watchful regarding the fulfillment of the safety and mitigation requirements.

It is also worth noting that in some countries, independent agencies entrusted with ensuring compliance with existing standards of safety and quality, sometimes called "quality-control bureaus", play a critical watchdog role in the project from this stage on. Since they specialize in the application of risk reduction principles, such independent agencies can ensure that the project meets all relevant quality standards in the face of the various hazards prevalent on site. The *Guidelines* recommend that the design of the project be overseen by independent specialists—either quality-control bureaus, where they exist, or else by consultants hired for that purpose—in order to guarantee the highest possible standards of quality in the design of the planned health facility.

In the course of any construction project, its components are typically divided into two categories:

- The **structural elements**—all those essential elements that determine the overall safety of the system, such as beams, columns, slabs, load-bearing walls, braces, or foundations. Structural elements comprise a building's resistance system.
- The **nonstructural elements**—all those other elements that, without forming part of the resistance systems, ultimately enable the facility to operate. They include architectural elements (non-load-bearing walls, floor coverings, ceilings, and other coverings or finishes); equipment and contents (electromechanical systems, medical and laboratory equipment, furnishings), and services or lifelines. In the case of hospitals, nearly 80 percent of the total cost of the facility is due to nonstructural components.

When designing the mitigation systems to ensure the safety of the infrastructure, the same classification is applied. Generally, the design team in charge of the structure is proficient in two disciplines: structural engineering and architecture. In the design of the nonstructural elements, all disciplines must be equally involved.

The impact of damage to the facility's nonstructural components may vary. For instance, damage to medical equipment or to the lifelines that supply medical and support services can actually cause loss of lives or the loss of the functional capacity of the facility. While less dramatic, partial or total damage to certain components, equipment, or systems may entail prohibitive repair and replacement costs. Major damage to systems, components, or equipment containing or involving harmful or hazardous materials may force the evacuation of some parts of the facility, resulting in a loss of operational capacity.

Secondary effects of the damage to nonstructural components are also important, for instance the fall of debris in hallways or escape routes, fires or explosions, or the rupture of water or sewerage pipes. Even relatively minor damage can compromise aseptic conditions in the affected areas, putting critical patients at risk. Special attention must therefore be paid to the safety of the nonstructural components.

The design stage culminates with the final version of the project, which includes all the technical specifications, plans, mockups, and tender documents, and budgets required to turn the concept into reality. Due to the complexity of a health facility, a large number of professionals representing different specialties must participate. Each team of specialists will be in charge of developing a specific subproject: the structure, heating, ventilation, air conditioning, the various essential services, and so on. Close coordination is the key to the success of this stage.

Mitigation measures: Criteria for the design stage in relation to the planned protection objective

Having chosen the best site, it is time to design a project that provides a level of safety commensurate with the protection objective chosen. The protection systems to be used for this purpose must meet two requirements: they must be feasible to build, and it should not be too difficult to give them effective maintenance. A poor design will lead to constraints during the other stages of the project that could make it difficult, even impossible, to meet the protection objective.

The structural system must meet the performance objectives defined for the facility as a whole and the services it will provide. In general terms, the design must incorporate structural detailing that can effectively meet the protection objective for each level of risk. It is also important to incorporate in the design any systems that, in case of damage and functional losses, will enable the facility's services to recover within a predefined timeframe.

From the point of view of vulnerability reduction and the fulfillment of the performance objective, the design coordination team must advise each of the specialized work groups on the functional and protection requirements specified for the facility and its services, and they in turn must specify clearly how they will achieve those objectives. Here, mitigation specialists must play a key role in the evaluation and enforcement of the performance objectives chosen. The proper design of a project calls for the integration of all the participating specialties; hence, coordination is indispensable.

At this stage, both the design execution team and the project review team must deliver a document certifying that the protection objective has been met. In this fashion, the protection systems to be incorporated will be clearly described in the technical specifications, construction plans, and "as-built" reports.

The *Guidelines* contain sets of standards, variables, indicators, reference materials and specific recommendations to guide the inclusion at this stage of mitigation criteria. A model "terms of reference" document is also included for vulnerability reduction in the design of new hospitals, so that it can assist in the revision of traditional terms of reference for the construction of health facilities.

While the *Guidelines* recommend the incorporation of mitigation specialists with special experience with hospitals from the start to the end of the project, in some cases such professionals are unavailable at the national level. Several mechanisms may be considered for solving this lack of national experience. One of them is the establishment of joint ventures or strategic alliances between national construction project design companies and international firms specializing in hospital design. This approach ensures the transfer of knowledge and technology, which would otherwise be hard to achieve. As long as the quality of the final product is assured, this could lead to a mutually advantageous association.

Stage V: Construction

This is the stage where the new infrastructure takes material form. The construction company is hired, the construction process is overseen and inspected, and the new facility is completed and delivered.

Mitigation measure:
Implementation of mitigation measures, evaluation of the work teams, and quality assurance

At this stage, the mitigation measures defined as part of the project design are to be implemented. The *Guidelines* stress two critical areas that require a great deal of attention: (i) the composition and coordination of the various work teams, and (ii) the quality assurance process.

The selection of the consultancy firms and teams of professionals for the project must be based on predefined criteria and requirements. These criteria should ensure that the selection process is transparent and quality-driven, and that all local and national standards are met, if not surpassed. The *Guidelines* include tools for setting such criteria and evaluating candidates.

During the construction and inspection stage as well as during the preliminary project and design, professionals will be needed in a variety of fields. These include: architecture, budgeting and finance, construction methods, electrical installations, fire safety, general safety, heating, ventilation and air conditioning, industrial equipment, medical and laboratory equipment, personnel management, sanitation facilities, structural design, telecommunications,

vulnerability analysis, waste management, and water treatment. Experts from other fields may also be required on a case-by-case basis. Mitigation specialists should participate in drafting the tender documents for the selection of the participating firms, and should be actively involved as part of the construction team and the oversight and evaluation team.

Applying quality-assurance procedures (also included in the *Guidelines*) will be crucial in guaranteeing the fulfillment of the protection objectives set for the facility. Internal quality-assurance teams, oversight firms and external quality-assurance consultants engaged in peer review processes must ensure that the plans and technical specifications are followed faithfully. These professionals should be able to certify that the functional and safety goals of the project have been met.

The client institution, the designers and the supervisory team must approve any changes to the original project proposed during the construction stage. Changes that modify the facility's performance objective should be the result of careful deliberations. The "as-built report" must include detailed descriptions of the proposed modifications. This is the only way that the real operational capacity of the facility can be established in the context of the overall health care network.

3.3 Phase 3: Operational activities

PHASE 3

Operations

VI. Operations and Maintenance

Stage VI: Operations and maintenance

While not part of the development of the new infrastructure, it is essential to take operations and maintenance into account during the design and construction stages. This informs the operation and functionality of the facility in the event of a disaster. Attention must be paid, in particular, to: the special distribution and relationships between the architectural spaces and the medical and support services provided by the hospital, the administrative processes (hiring and contracts, procurement, maintenance routines, etc.), and the physical and functional links between the various parts of the hospital.

The appropriate spatial distribution, linkages, and maintenance of the various components that make up the facility can ensure its smooth functioning not only in normal conditions but also during emergency and disaster situations.

Rigorous maintenance management—including regular inspection, replacement, technological upgrading, and training in prevention and the use and conservation of components—will ensure the highest possible resilience (the lowest degree of vulnerability) of the facility to a natural disaster.

HOSPITAL DE NIÑOS
BENJAMIN BLOOM

Investment in Risk Reduction Measures

As a consequence of recent disasters, which have underscored the extreme vulnerability of the region, several governments have placed disaster prevention near the top of their political agendas. In the health sector, national authorities and subregional and international organizations are more aware of the importance of implementing firm mitigation policies, given the strategic role that health facilities play in the event of a disaster. However, this increased awareness has yet to materialize in a sufficient number of concrete measures, due to budgetary, bureaucratic, and political constraints.

The main challenge consists in awakening the interest of countries in incorporating prevention and mitigation measures when allocating resources for investments in infrastructure. A key problem with mitigation projects is the belief that they will significantly increase the initial investment, affecting eventual profits or health care budgets. This reticence by governments and the private sector alike is aggravated when financial resources are scarce or expensive, forcing mitigation projects down the list of priorities when it should be just the opposite: protecting significant investments requires high safety and performance standards.

A mitigation investment that increases the structural integrity of a hospital will increase total construction costs by no more than 1 or 2 percent.[9] If to this we add the cost of the nonstructural elements (which account for about 80 percent of the total cost of the facility), it is estimated that incorporating mitigation elements to the construction of a new hospital accounts for less than 4 percent of the total initial investment. Clearly, a vulnerability assessment will indicate the advisability of such a small marginal investment, if only as an alternative to expensive insurance premiums or replacement costs—all this without taking into account the human and social losses that are likely to occur if mitigation measures are not taken into account.[10]

On the other hand, a good architectural-structural design can actually reduce the costs entailed in protecting nonstructural elements. The quality of such a design will depend on the collective experience of the work group, how well coordinated it is, what the conditions of the site are like, and how amenable the client institution is to such a way of working and thinking.

Another important consideration regarding costs has to do with the infrastructure's nonstructural components. It should be noted that if protection measures are taken into account as early as the design stage, their cost will be much lower than if such measures are implemented during the construction stage or after the building has been completed. For instance, a power-cut in a hospital as a result of severe damage to a generator costing, say, US$50,000, could be prevented if seismic isolation devices for protecting the generator and fastenings to prevent it from tipping over are installed, at a cost of approximately US$250.[11]

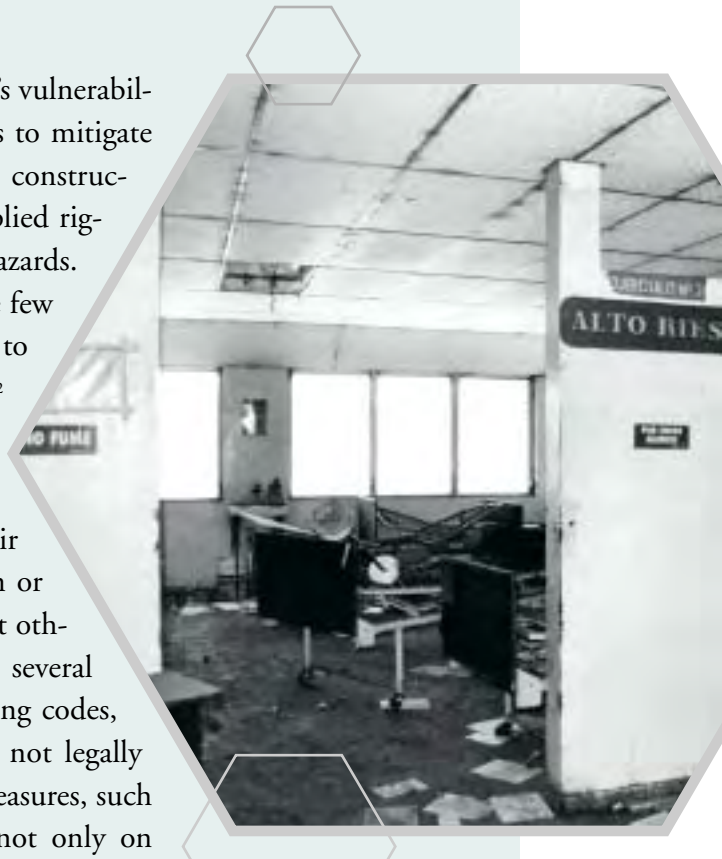
9 Pan American Health Organization (PAHO/WHO), *Principles of Disaster Mitigation in Health Facilities, .Mitigation Series*, Washington D.C., 2000.

10 Pan American Health Organization (PAHO/WHO), *Proceedings, International Conference on Disaster Mitigation in Health Facilities*, Mexico, 1996.

11 Pan American Health Organization (PAHO/WHO), *Guías para la mitigación de riesgos naturales en las instalaciones de la salud en los países de América Latina*. Washington, D.C., 1992.

Policies and Regulations

With rare exceptions, policies do not reflect the region's vulnerability to natural disasters, nor do they embody measures to mitigate this vulnerability. Land-use management policies and construction codes remain generally inadequate or are not applied rigorously enough in most places exposed to natural hazards. Policies concerning infrastructure, meanwhile, allocate few resources to basic maintenance—affecting resiliency to natural hazards and increasing the overall level of risk.[12]



The main obstacle to building codes' effectiveness as a tool for disaster mitigation is their actual application. Some countries in the region have not developed their own regulations, but have, instead, adopted European or U.S. standards that do not match local conditions. But others, such as Colombia, Costa Rica, Mexico, and several Caribbean countries, which have developed outstanding codes, do not always enforce them, either because they are not legally required or because oversight is lax. Similarly, other measures, such as land-use restrictions in hazardous areas, depend not only on whether the laws have "teeth" but on the institutional capacity to monitor their application.

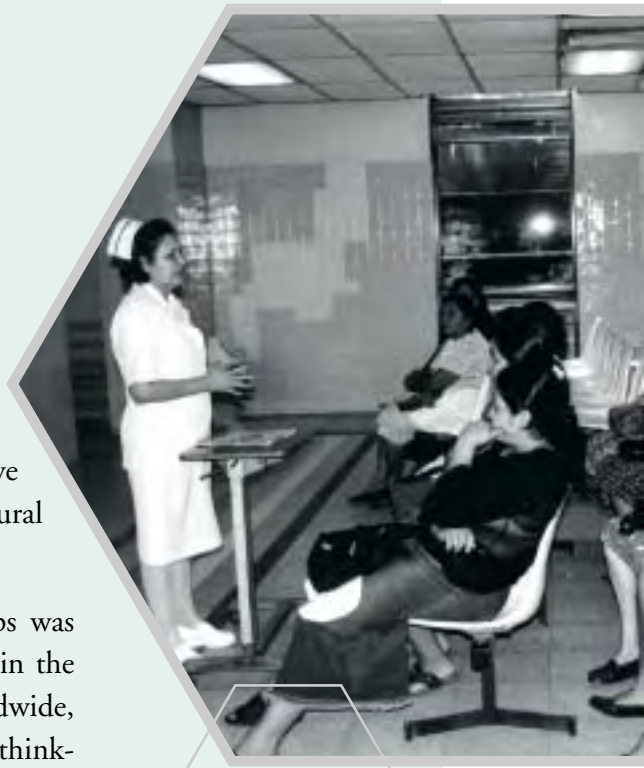
When it comes to hospitals and other essential facilities, experience shows that the most likely impact of a disaster is not structural, but functional collapse. Effective preventive maintenance programs can

12 Inter-American Development Bank (IDB), Facing the Challenge of Natural disasters in Latin America and the Caribbean: An IDB Action Plan, Washington, D.C., 2002.

alleviate this problem. Maintenance, as a planned activity, not only reduces the degradation of the facilities but can also ensure that public services such as water, gas, and electricity, and nonstructural components such as detailing, roofs, doorways, etc., continue to function properly during an emergency. The cost for preventive maintenance is not high if seen as part of the normal operating budget of a facility.[13] The importance of preventive maintenance as a vulnerability reduction measure cannot be over-stated; the incorporation of such preventive measures can ensure the fulfillment of the performance objective chosen during the preliminary design stage.

13 Pan American Health Organization. *A World Safe from Natural Disasters: The Journey of Latin America and the Caribbean.* Washington, D.C. PAHO/WHO, 1994. www.paho.org/English/Ped/ws-chapter6.pdf.

Training and Education



The design of a hospital is a joint responsibility of the architects and engineers involved. More specifically, it is imperative to underscore the physical relationships between architectural forms and seismic-resistant structural systems.

It would be ideal if an understanding of these relationships was among the intellectual features of all professionals involved in the design of health facilities in high-risk areas. Regrettably, worldwide, educational methods and practices do not foster this way of thinking, since future architects and engineers are educated separately and often practice their skills in relative isolation from one another.

It is likewise vital to promote the inclusion of disaster mitigation in all training programs related to the construction, maintenance, administration, financial management, and planning of health facilities, as well as of water and sanitation systems, power utilities, and communication systems, among others.

When it comes to strategies for dealing with the potential shortage of specialists with experience in hospital design at the local level, several options may be considered: for instance, establishing strategic alliances between national and international business groups or between the public and private sectors, or including concrete requirements to this effect in "turn-key" tender specifications. Such approaches would have the added advantage of contributing to building national technical capacity.

The Role of International Organizations in the Promotion and Funding of Mitigation Strategies

In the field of risk reduction in hospitals and other health facilities, the Pan American Health Organization (PAHO) has worked actively with the countries of the region to assess and reduce the vulnerability of such facilities to disasters and to summon the political will of their health authorities. It has also promoted the dissemination of key information and the technical training of relevant professionals. In the early 1990s, PAHO/WHO (www.paho.org) launched a project aimed at engineers, architects and maintenance supervisors in hospitals, as well as policymakers and decision-makers at various administrative levels. Its chief objective was to raise their awareness concerning the need of investing in the protection, maintenance and retrofitting of existing health facilities, as well as of designing and building new infrastructure based on specific criteria for reducing and mitigating the impact of natural hazards. As part of this initiative, PAHO has produced a series of training materials and launched several pilot projects; it has also supported vulnerability assessments of hospitals in many countries in the region.

In 1999, within the framework of the International Decade for Natural Disaster Reduction (IDNDR, www.unisdr.org), the countries in the Region set up the Inter-American Committee on Natural Disaster Reduction, under the oversight of the Organization of American States (OAS, www.oas.org). The Committee is entrusted

with developing strategic initiatives, and pays special attention to reducing the vulnerability of Member States.

At the regional level, institutions such as the Caribbean Disaster Emergency Response Agency (CDERA, www.cdera.org) or the Central American Coordination Center for Natural Disaster Prevention (CEPREDENAC, www.cepredenac.org) strive to promote international cooperation, technical assistance and the exchange of information for disaster prevention. The United Nations Economic Commission for Latin America and the Caribbean (ECLAC, www.eclac.cl) also plays a significant role in the field, particularly thanks to its experience in assessing the economic impact of natural disasters.

The World Bank and the Inter-American Development Bank (IDB, www.iadb.org) both exemplify how prevention and mitigation are becoming increasingly important in the funding of disaster-related reconstruction projects. The World Bank is the largest global provider of financial aid for disaster reconstruction, and it is taking steps to incorporate vulnerability reduction as one of the key components of its poverty reduction efforts.[14] From 1980 until 2000, it disbursed a total of US$2.5 billion for mitigation projects in Latin America alone.

At the institutional level, the World Bank's Disaster Management Facility (DMF, www.worldbank.org/dmf), established in 1998, strives to play a proactive leadership role in disaster prevention and mitigation through training, consultancies, and forging links with the international and scientific community in order to promote disaster reduction efforts.[15] To achieve these goals, the World Bank has decided to focus its efforts on the following tasks:

- Promote the establishment of sustainable development policies aimed at reducing the losses caused by natural disasters;
- Encourage among member countries the assessment of risks and potential losses, a cost-benefit analysis of risk management, and their use as inputs for planning and budget allocation;

14 Inter-American Development Bank, "Preparatory Group Meeting on Natural Disasters: Disaster Prevention and Risk Reduction" (Working Paper), Inter-American Committee on Natural Disaster Reduction (IANDR), Washington, D.C., 2001.
15 http://www.worldbank.org/dmf/.

- Encourage research on how natural disasters and disaster mitigation impact on long-term socioeconomic development, as well as research on how cost sharing and cost recovery affect mitigation;
- Incorporate risk management into member countries' economic strategy programs as an integral component of national development planning;
- Raise awareness of the importance of disaster mitigation, emphasizing its economic and social benefits, and search for solutions for existing constraints;
- Incorporate mitigation in the design of development projects, with the ultimate goal of making it an intrinsic part of every project. In short, the goal is for mitigation to be a standard part of the quality-auditing process within the project cycle. As part of this effort, the Prevention Unit has produced an information toolkit for World Bank personnel. The kit includes guidelines and examples of disaster mitigation and prevention projects, with a view to disseminating their adoption at the institutional level. It also provides training and technical assistance to various departments of the World Bank itself.

One of the coalitions that emerged from such mitigation promotion efforts by the World Bank was the ProVention Consortium (www.proventionconsortium.org). Made up of governments, international organizations, academic institutions and representatives of the private sector and civil society, its mission is to support developing countries in reducing the risk and the social, economic and environmental impact of natural and technical disasters, particularly among the poorest sectors of the population.

The IDB has also been proactive in this area. In 1999, it adopted a new policy aimed at placing disaster prevention near the top of the development agenda and applying a more integral and preventive approach to risk reduction and recovery. The IDB's policy, currently under review to expand and strengthen its objectives and fields

of action, contemplates assigning top priority to vulnerability reduction measures and providing financial resources to the region for disaster prevention and mitigation and capacity-building for improved risk management.

The IDB has committed itself to supporting Member States in the adoption of integral risk management plans by means of the following actions:[16]

- Establish new **financial mechanisms** (loans, or refundable and non-refundable technical cooperation services) to help countries undertake and strengthen disaster prevention and risk management actions;
- Engage in a **dialogue with member countries** on issues such as risk assessment, risk management strategies, and the use of available IDB in-struments for financing investments related to natural disasters;
- Incorporate **risk reduction in the project cycle**, including risk analysis and reduction in programming and in project identification, design, implementation and evaluation. As part of this process, a series of sectoral checklists for disaster risk management are being developed to support the drafting of projects in the various sectors;
- Identify **focal points for disaster management** at the institutional level in order to support countries in preparing risk reduction programs and coordinating prevention and response activities;
- Build **partnerships** for the establishment of an integrated information and response network that can assist in coordinating the preparation of pre-investment studies, as well as investing in prevention and reconstruction and establishing interagency response protocols.

16 Inter-American Development Bank (IDB), *Facing the Challenge of Natural Disasters in Latin America and the Caribbean: An IDB Action Plan*. Washington, D.C., 2002.

Annex I

Effects of natural disasters

Type of disaster	General effects	Effects on infrastructure
Earthquakes	Tremors and cracks Landslides Liquefaction Underground settling and rock falls Avalanches and landslides Changes in underground water courses Fires	Damage to constructions Diverse damage in roads, bridges, dikes and channels Broken ducts: pipes, posts and wires damage to dams, overflow of rivers causing local floods Sinking of structures and buildings Deterioration of underground constructions Destruction and damage to urban infrastructure (networks, streets, equipment and furniture) Fires
Hurricanes, typhoons and cyclones	Strong winds, both steady and gusts Floods (due to rain and swollen and overflowing rivers)	Damage to buildings Impact-damaged, broken and fallen power distribution lines, especially overhead Damage to bridges and roads due to landslides, avalanches and mudslides
Drought	Drying and cracking of the earth and loss of vegetation Exposure to wind erosion Desertification	Does not cause major losses to infrastructure
Floods	Erosion Water saturation and destabilization of soils, landslides Sedimentation	Loosening of building foundations and piles Burial and slippage of constructions and infrastructure works Blockage and silting of channels and drains

Continue

Effects of natural disasters

Type of disaster	General Effects	Effects on infrastructure
Tsunamis	Floods Salinization and sedimentation in coastal areas Contaminated water and water table	Destroyed or damaged buildings, bridges, roads, irrigation and drainage systems
Volcanic eruptions	Fires, loss of plant cover Deposit of incandescent material and lava Deposit of ash Deterioration of soils due to settling of air-borne chemicals Landslides, avalanches and mudslides Liquefaction Melting ice and snow, avalanches	Destroyed buildings and all types of infrastructure Collapsed roofs due to ash deposits Burial of buildings Fires Affect on channels, bridges and overhead and underground conduction and transmission lines

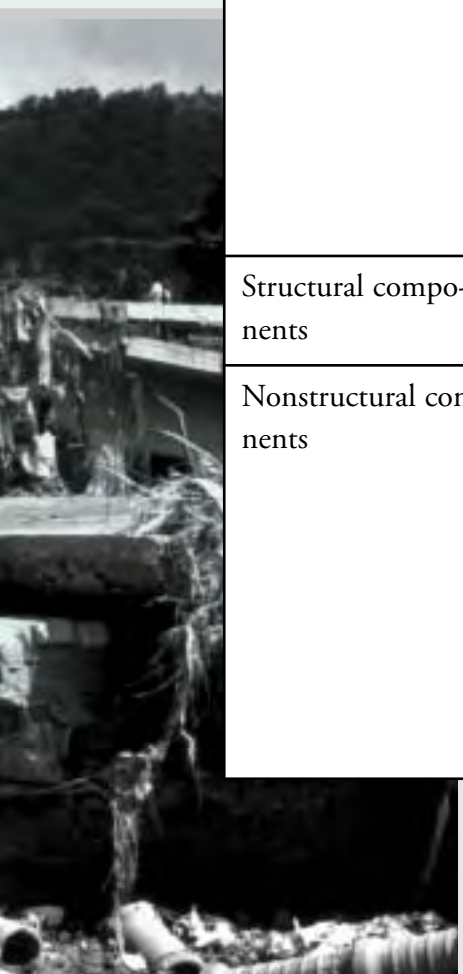
Source: Adapted from Frederick C. Cuny (1983), *Disasters and prevention*, Oxford University Press, New York.

Annex II

Glossary of key terms

Concepts of a general nature are defined below. Definitions of more specific concepts are included in the relevant chapters of the Guidelines for Vulnerability Reduction in the Design of New Health Facilities.

Natural hazard	An event of natural origin and sufficient intensity to cause damage in a particular place at a particular time.
As-built report	Set of documents prepared for project managers and the professionals involved in regional and local risk assessment. The documents include contractual documents, the design of the project, construction and inspection procedures, applicable codes and standards, certificates of component safety, final plans for the structure, its components and protection systems, and certificates of compliance with project specifications.
Structural components	Elements that are part of the resistant system of the structure, such as columns, beams, walls, foundations, and slabs.
Nonstructural components	Elements that are not part of the resistant system of the structure. They include architectural elements and the equipment and systems needed for operating the facility. Some of the most important nonstructural components are: architectural elements such as façades, interior partitions, roofing structures, and appendages. Nonstructural sys-tems and components include lifelines; industrial, medical and laboratory equipment; furnishings; electrical distribution systems; heating, ventilation and air conditioning systems; and elevators.



Structural detailing	A set of measures, based on the theoretical and empirical experience of the various participating disciplines, for protecting and improving the performance of structural components.
Nonstructural detailing	A set of measures, based on the theoretical and empirical experience of the various disciplines, aimed at protecting and improving the performance of nonstructural components.
Tender documents	Legal documents that stipulate the characteristics of the design or building contract or contracts (parties involved, financial amounts, deadlines, forms of payment, etc.) and the technical characteristics of the construction (general and detailed plans, structural and nonstructural components, standards and codes that must be followed, specialized inspection requirements, recommended and unacceptable construction methods, etc.).
Specialized inspection	Activities aimed at ensuring that the requirements of the project are met in matters such as: quality of the labor force, the use of construction processes and materials of a quality commensurate with the goals of the project, the fulfillment of the provisions established in the standards and codes referenced in the contracts, and the procurement of component safety certificates and others.
Life protection	Minimal level of protection required in a structure to ensure that it does not collapse or otherwise endanger the lives of those who occupy a building during a natural disaster. It is the protection level most commonly used in the construction of health facilities.
Investment protection	The level that protects all or part of the infrastructure and equipment, although the facility itself ceases to function. This level of protection would ensure that the facility would resume operations in a timeframe and at a cost that is in keeping with the institution's capacity.

Operations protection	This protection objective for a facility aims not only to prevent injury to occupants and damage to infrastructure, but to maintain operations and function of the facility after a disaster. It is the highest protection objective: it includes life protection and investment protection.
Risk	Extent of the likely losses in the event of a natural disaster. The level of risk is intimately associated with the level of protection incorporated into the structure.
Critical services	Services that are life saving, involve hazardous or potentially dangerous equipment or materials, or whose failure may generate chaos and confusion among patients or the staff.
Resistant system	A structural system especially designed to withstand the impact of external forces. The structural system must be designed in such a way that its detailing is proportional to the protection objective chosen for the structure.
Protection systems	Devices and procedures aimed at providing safety to the structural and nonstructural components of the building and meeting the protection objectives.
Vulnerability	The likelihood of a facility suffering material damage or being affected in its operations when exposed to a natural hazard.

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Other PAHO/WHO publications on disaster mitigation in health facilities

Guidelines for Vulnerability Reduction in the Design of New Health Facilities. 2004
New guide published in collaboration with the World Bank. Presents guidelines to protect the investment and operations in the design and construction of new health facilities.

Principles of Dissater Mitigation in Health Facilities. 2000
Provides the basis to prepare vulnerability studies and to apply practical mitigation measures in hospitals.
www.paho.org/english/dd/ped/fundaeng.htm

CD-ROM *Planeamiento Hospitalario para Desastres*
(in Spanish only). 2003
Self-teaching material for the organization and development of the course "Hospital Planning for Disasters."
www.disaster-info.net/planeamiento

CD-ROM *Disaster Mitigation in Health Facilities*. 2001
This disc contains the main training materials—books and PowerPoint presentations—that PAHO/WHO has on this subject.

These publications can also be consulted:

Lecciones aprendidas en América Latina de mitigación de desastres en instalaciones de salud ("Lessons Learned in Latin America in Disaster Mitigation in Health Facilities"—in Spanish only) www.paho.org/spanish/dd/ped/leccispa.htm.

International Conference on Disaster Mitigation in Health Facilities: Recommendations www.paho.org/english/dd/ped/mitrecs.htm.

Video: *Mitigation of Disasters in Health Facilities*. 1991

For more information, go to www.paho.org/disasters/