# Building Human Resilience

## The Role of Public Health Preparedness and Response As an Adaptation to Climate Change

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**Abstract:** Global climate change will increase the probability of extreme weather events, including heatwaves, drought, wildfire, cyclones, and heavy precipitation that could cause floods and landslides. Such events create significant public health needs that can exceed local capacity to respond, resulting in excess morbidity or mortality and in the declaration of disasters. Human vulnerability to any disaster is a complex phenomenon with social, economic, health, and cultural dimensions. Vulnerability to natural disasters has two sides: the degree of exposure to dangerous hazards (susceptibility) and the capacity to cope with or recover from disaster consequences (resilience). Vulnerability reduction programs reduce susceptibility and increase resilience. Susceptibility to disasters is reduced largely by prevention and mitigation of emergencies. Emergency preparedness and response and recovery activities—including those that address climate change—increase disaster resilience. Because adaptation must occur at the community level, local public health agencies are uniquely placed to build human resilience to climate-related disasters. This article discusses the role of public health in reducing human vulnerability to climate change within the context of select examples for emergency preparedness and response.

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### Climate Change and Extreme Weather Events

Global climate change will increase the probability of extreme weather events[1] (Table 1), which may be associated either with high precipitation (i.e., storms, floods, and landslides) or with low precipitation (i.e., heat, drought, wildfire).[1] These events often overwhelm the capacity of communities and local governments to respond, requiring outside assistance. Such mismatches between needs and resources often result in declarations of disaster.

High-precipitation events, which are likely to increase in frequency, will compound the risk of flood and landslide disasters. According to the UN Intergovernmental Panel on Climate Change (IPCC): "Many millions more people are projected to be flooded every year due to sea-level rise by the 2080s. In some areas heatwaves are expected to increase in severity and frequency, expanding drought affected areas."[1] In low-latitude regions, crop productivity is expected to decrease, thus increasing the risk for hunger, particularly in Africa and small island developing States. "By 2020, between 75 and 250 million people are projected to be exposed to an increase in water stress."[1]

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### The Public Health Impact of Extreme Weather Events

By 2008, the cost of natural disasters, in mortality and in public resources, had exceeded that of previous periods for which data were available.[2] In particular, climate-related (hydrologic and meteorologic) hazards affected an increasing number of people and caused increasingly large economic losses.[3] Between 1970 and 1999, climate-related events accounted for 90% of the world's disaster-related fatalities,[2] with the world's poor disproportionately affected.[4]

The literature thoroughly describes how climate change affects natural disaster–related health risk.[1,3,5–12] Determinants of population health, such as education, health care, public health prevention efforts, and infrastructure, play a major role in vulnerability and resiliency.[1]

Table 2 compares the public health emergencies associated with the six climate-related hazards mentioned above: storms, floods, landslides, heat, drought, and wildfire. Such disasters result in public health needs that often exceed local response capacity. This article focuses on the five natural disasters other than heatwave, which is discussed in detail elsewhere in this journal issue.[13]

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#### Human Vulnerability and Disaster Risk

The UN[2] and the WHO[3] define a disaster as "a serious disruption of the functioning of a community or a



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**Table 1.** Trends of extreme weather events predicted to occur as a result of climate change (%)

| Phenomenon and direction of trend | Likelihood that the trend occurred in the late 20th century | Likelihood of human contribution to trend | Likelihood of future trends based on projections for 21st century |
|---|---|---|---|
| **Increased incidence of heatwaves** | 66–90 (likely) | 51–66 (more likely than not) | 90–99 (very likely) |
| **Increased incidence of heavy precipitation events** | 66–90 | 51–66 | 90–99 |
| **More areas affected by drought** | 66–90 | 51–66 | 66–90 |
| **Increased incidence and severity of cyclones** | 66–90 | 51–66 | 66–90 |
| **Increased incidence of extremely high sea levels** | 66–90 | 66–90 | 66–90 |

Adapted from IPCC Working Group II Report. Impacts, Adaptation, and Vulnerability, 2007.[1] www.ipcc.ch/ipccreports/ar4-wg2.htm

society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources."[14] Thus, the disaster consists of the interaction between the hazard and the vulnerability of those affected, not the mere fact of the hazard's occurrence.[15] For any given hazard, disaster risk varies according to a population's vulnerability (e.g., age, gender, health status, SES).

## Disaster Risk Management

Recently, the international approach to emergencies and disasters has shifted from largely post-impact activities (i.e., ad hoc relief and reconstruction) to a more systematic and comprehensive risk management process.[16,17] As described by disaster experts Lisa Schipper and Mark Pelling, "Disaster risk management includes both pre-impact disaster risk reduction—prevention, preparedness, and mitigation—as well as 'response and recovery' post-impact crisis management activities."[18] Preparedness is defined as "activities and measures taken in advance to ensure effective response to the impact of hazards." Mitigation is the "structural and nonstructural measures undertaken to limit the adverse impact of natural hazards, environmental degradation and technologic hazards."[18] (This definition of mitigation is not to be confused with "mitigation" used in the climate change context, which refers to reduction of greenhouse gas emissions.) Figure 1 provides an overview of the four phases of the disaster risk management cycle. These concepts are very applicable to climate change.[19]

## Reducing Human Vulnerability As an Adaptation to Climate Change

Mitigation policies focus on reducing the hazard, either by controlling the emissions of greenhouse gases or by capturing and sequestering those emissions. Adaptation policies focus on reducing the vulnerability, by taking steps to make social and environmental systems more resilient to the effects of climate-related hazards. Effective climate policy necessarily requires a combination of mitigation and adaptation policies, although public support and funding for adaptation have been limited.[20]

Reducing human vulnerability is a key aspect of reducing climate change risk.[18] The 2002 Yokohama Strategy and Plan of Action for a Safer World led to a change in the UN's approach to mitigating disasters to treating human actions and vulnerabilities as the main causes of disasters.[17]

## Human Resilience As a Means for Vulnerability Reduction

Many economists believe that measures directed toward the underlying macro-level causes of climate change vulnerability should be broadly integrated into development policy, not confined to climate change adaptation strategies.[21] Human vulnerability to disasters is a complex phenomenon that includes social, economic, health, and cultural factors. Vulnerability to natural disasters has two sides: the degree of exposure to dangerous hazards (susceptibility) and the capacity to cope with or recover from the consequences of disasters (resilience). Vulnerability reduction programs reduce susceptibility and increase resilience. Susceptibility to disasters decreases through activities such as prevention, and through mitigation measures that prevent or limit a population's exposure to the hazard.[22] Preparedness, response, and recovery activities all increase resilience. Resilience has two components: that provided by nature, and that provided through human action. An example of resilience provided by nature is the manner in which porous soil allows more rapid drainage of flood water than more occlusive soil. An example of human action that affects resilience is social organization that facilitates (or hinders) response and recovery. Disaster resilience is composed of (1) the absorbing capacity, (2) the buffering cap-

**Table 2.** The relative public health impact of the six natural disasters expected to worsen with climate change

| | High-precipitation events | | | Low-precipitation events | | |
|---|---|---|---|---|---|---|
| **Public health impact** | **Storms** | **Floods** | **Landslides** | **Heat** | **Drought** | **Wildfire** |
| **Number of deaths** | Few, but can be many in low-income countries | Few, but can be many in flash floods | Few to moderate | Moderate to many in high-income countries | Few, but can be many in low-income countries | Few to moderate |
| **Risk of an associated epidemic** | Unlikely | Unlikely, except for low-income countries | Unlikely | Unlikely | Unlikely, except for low-income countries | Unlikely |
| **Severe injuries** | Few | Few | Few to moderate | Moderate to many cases of heat stroke | Unlikely | Few to moderate |
| **Loss of clean water** | Widespread | Focal to widespread | Focal | Unlikely | Widespread | Focal |
| **Loss of shelter** | Widespread | Focal to widespread | Focal | Focal to widespread | Focal to widespread | Focal |
| **Loss of personal and household goods** | Widespread | Focal to widespread | Focal | None | Unlikely among displaced populations | Likely among displaced populations |
| **Permanent migration** | Unlikely | Unlikely | Unlikely | Unlikely | Likely | Unlikely |
| **Loss of sanitation** | Widespread | Focal to widespread | Focal | Unlikely | Likely among displaced populations | Likely among displaced populations |
| **Loss of routine hygiene** | Widespread | Focal to widespread | Focal | Unlikely | Likely among displaced populations | Likely among displaced populations |
| **Disruption of solid waste management** | Widespread | Focal to widespread | Focal | Unlikely | Likely among displaced populations | Likely among displaced populations |
| **Public risk perception** | High | High | High | Moderate to high | Moderate to high | High |
| **Increased pests and vectors** | Widespread | Widespread | Unlikely | Unlikely | Possible | Unlikely |
| **Loss and/or damage of healthcare system** | Widespread | Focal to widespread | Focal | Unlikely | Unlikely | Focal |
| **Worsening of existing chronic illnesses** | Widespread | Focal to widespread | Focal | Widespread | Widespread | Focal to widespread |
| **Toxic exposures** | Possibly air, water, food | Possibly air, water, food | Possibly air, water | Possibly air | Possibly water | Likely air |
| **Food scarcity** | Uncommon except in low-lying remote islands | Uncommon | Unlikely | Unlikely | Common | Possible |

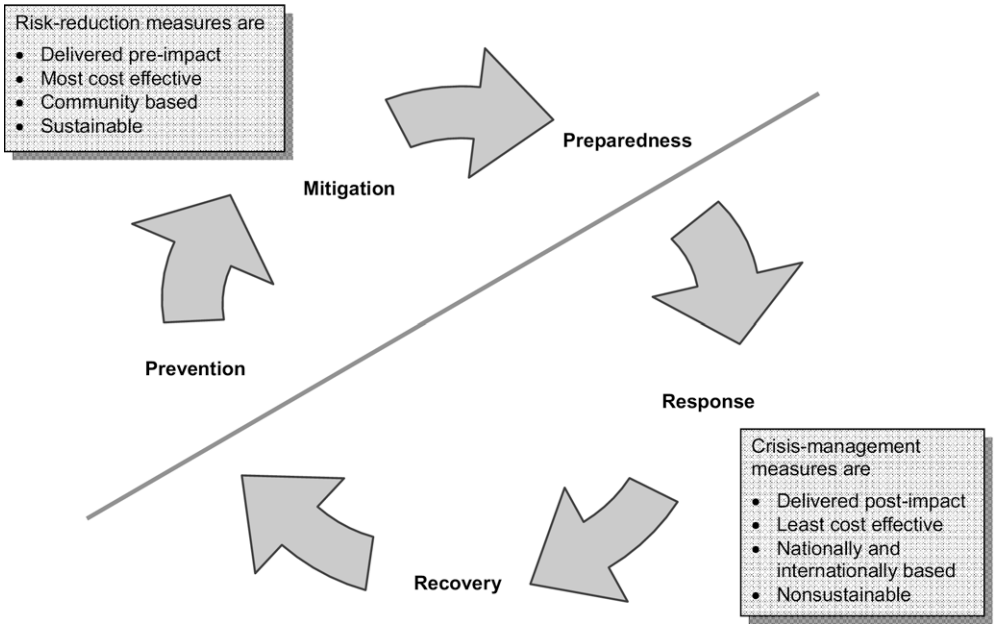


**Figure 1.** A diagram of the disaster risk management cycle comparing risk-reduction measures (above) to crisis-management measures (below)

acity, and (3) response to the event and recovery from the damage sustained.[22]

## Building Resilience to Extreme Weather Events Through Public Health Preparedness and Response

Adaptation to disaster occurs at the community level. Public health is uniquely placed at the community level to build human resilience to climate-related disasters. "By focusing on vulnerability and the ability of individuals and communities to recover (resilience), vulnerability reduction places the individuals at risk at center stage and tasks the responsible authorities with enhancing social equity and promoting community cohesiveness, alongside a heightened sense of individual responsibility."[23] By promoting safety and health, public health works to reduce the pre-existing burden of disease, build social capital, and strengthen community resilience to a wide range of health hazards, including extreme weather events.

Community public health and medical institutions can play an active part in reducing human vulnerability to climate-related disasters through promotion of "healthy people, healthy homes and healthy communities."[24] Healthy people are less likely to suffer disaster-related morbidity or mortality and are therefore more disaster-resilient. Healthy homes are disaster-resilient; they are designed and built to stay safe during extreme weather events. Healthy "communities minimize exposure of people and property to natural disasters. Sustainable communities are disaster-resilient communities."[25] Public health preparedness and response activities build community resilience and reduce human vulnerability, including vulnerability to climate change.

Preparedness is defined as "activities and measures taken in advance to ensure effective response to the impact of hazards."[26] Emergency response begins with the impact of an event. During a cyclone, flood, wildfire, or landslide event, the onset of the disaster impact is quite clear; during times of drought, however, it may be more insidious. The response phase usually begins with ad hoc local emergency response followed some time later by a formal declaration of disaster and external assistance and emergency relief.

## Resilience-Building Strategies for Extreme Weather Events Related to Climate Change

### Drought

**The public health impact of drought disasters.** Drought is usually defined as a "period of abnormally dry weather that is sufficiently prolonged so that the lack of water causes a serious hydrologic imbalance in the affected area."[27] Ironically, very few people die of thirst or dehydration during a drought, even in low-income countries. Drought-related deaths are generally secondary to the agricultural, economic, and health effects of drought, such as famine, malnutrition, poverty, poor public health practices, contamination of existing water supplies, infectious diseases, social strife, and heat-related illness.[2] In addition to increasing the likelihood of food insecurity and famine, a drought can have catastrophic effects on the regional or national economy.[28] The predominant psychosocial impacts of drought include decreased quality of life, major changes in lifestyle, and increasing conflict over water resources.

**Preparing for drought-related public health emergencies.** Public health preparedness for drought emergencies should begin with a risk assessment. This assessment should focus on critical health needs such as food security, water, sanitation, and shelter, as well as on the psychosocial, political, and economic impact of the drought. Accurate short- and long-term forecasting and early warning may improve preparedness and may guide development over the long term. Drought emergency plans

should specifically include contingencies for long-term, sustained emergency operations, for an insidious onset (and therefore a difficult-to-identify threshold for declaration and implementation of emergency measures), and for population displacement. Public education about locally relevant water use, health risks, and behaviors that protect health also represents a key component of public health preparedness. A well-established capability for epidemiologic investigation and disease surveillance can guide the need for evidence-based interventions.

**Responding to drought-related public health emergencies.** Public health responses to drought emergencies are ideally based on locally developed plans, which in turn are based on national and international guidance. The most significant risks for drought-related hunger, disease, and population displacement occur in low-income countries. During a drought emergency response, the principal expected interventions relate to the public need for:

- food security
- safe water and adequate sanitation
- hygiene
- infection control in healthcare settings
- surveillance
- temporary shelter for displaced populations

In high-income countries, the economic impact from the higher cost of food and safe water will likely outweigh the direct risk of famine or epidemic, yet that impact will significantly hinder economic growth and development. During other types of disasters, water shortages have been reported to affect a wide range of hospital services, including food preparation, environmental control, toilet availability, housekeeping, laundry, infection control, renal dialysis, and fire safety.[29]

## Wildfire

**The public health impact of wildfire disasters.** Wildfire is defined as "a sweeping and destructive conflagration, especially in a wilderness or a rural area."[30] At the turn of the twentieth century, three major wildfire disasters occurred in the U.S., each resulting in about 1000 fatalities.[31] Since that time, advances in information dissemination, warning systems, and firefighting equipment and control capabilities have reduced wildfire-related mortality in the U.S. In 2007, California wildfires caused over $1 billion in damage, destroyed over 1500 homes, and affected over 1 million people, yet very few deaths and injuries were reported.[32] As has also been the case for floods and cyclones, developed nations such as the U.S. have been able to achieve a considerable impact in reducing wildfire-related mortality through enhancement of local preparedness and response activities.

The public health impact of wildfires may include:

- burn injuries
- exacerbations of chronic obstructive pulmonary disease and asthma
- population displacement resulting in a need for humanitarian assistance that includes safe shelter, water and food, security, sanitation, and health care

In 1991, grass wildfires in Alameda County CA resulted in 26 deaths and >225 injuries.[33] Emergency department records showed that more than twice as many people sought treatment for smoke-related problems as for other traumatic injuries.[34]

**Preparing for wildfire-related public health emergencies.** The first step in a community-based risk assessment for wildfire should be a fire hazard evaluation. Moreover, emergency plans that detail the local, state, and federal responses to wildfire should incorporate this risk assessment. Once developed, the plans should be validated through regularly scheduled exercises and drills. These plans and exercises should include contingencies for population evacuation and for mass care and shelter. The public should be educated as to the potential risk of wildfire and, in the case of a wildfire disaster, what protective steps to take (i.e., evacuation or shelter-in-place). Further studies are needed to identify risk factors for short- and long-term wildfire-related morbidity and mortality and to establish best practices for public health risk management of wildfire disasters.

**Responding to wildfire-related public health emergencies.** Immediately after the disaster-impact phase, rapid needs assessments of an affected community are conducted to identify gaps among health, medical needs, and available resources. Mass casualties are very rare in the case of wildfires, especially in high-income countries. To ensure safe and healthy living conditions, public health is often involved in shelter and resettlement decisions. Public health also plays a role in healthcare delivery, in inspections of food, in air safety and water quality, and in assessment of sanitation and hygiene in mass-care shelters. If wildfire threatens manufactured hazardous materials, public health may also be called upon to perform hazard risk analysis or to promote the occupational health and safety of responders. Also, health-related public information campaigns can encourage family-based preparedness, inform vulnerable populations, and promote evacuation preparedness.

## Floods

**The public health impact of floods.** Floods are defined as "the overflow of areas that are not normally submerged with water or a stream that has broken its normal confines or has accumulated due to lack of drainage."[35] Floods may be caused by natural processes that are either fluvial (an abundance of rainfall, melting snow) or coastal (a hurricane-related storm surge,

coastal inundation, or seismically induced tsunami) in origin. Since tsunamis are not associated with climate change, this article will not consider flooding from this cause. Worldwide, floods are the most common natural disaster—during the decade from 1996 to 2005 floods accounted for 42% of all natural disasters.[18] During that same decade, 1.3 billion people were affected by floods, and over 90,000 of them died. That decade also saw floods cause more damage than any other natural disaster, accounting for one third of all disaster-related costs.[36]

Public health impacts of flooding include:

- damage to homes and consequent displacement of occupants
- compromised personal hygiene
- contamination of water sources
- disruption of sewage service and solid-waste collection
- injuries sustained during cleanup
- stress-related mental health and substance abuse problems
- deaths, mostly caused by drowning[37]

**Preparing for public health emergencies caused by flood.** Meteorologic forecasting and early warnings have decreased mortality from flash floods by >50%.[38] Similarly, public health emergency response planning should address key precautionary flood-related health issues, such as those associated with potential loss of shelter, sanitation, hygiene, and health care among affected populations, as well as exacerbations of chronic disease, toxic exposures, mental illness, family violence, and loss of healthcare services.[37] Drills and exercises should include contingencies for population protection as well as alert/notification systems for public health and medical staff and for special populations. Public health communications can encourage preparedness in the home, in schools, in the work place, and at healthcare facilities; health communications can also raise public awareness of evacuation routes, flood zones, and community response plans. Development of robust public health surveillance systems helps to prepare for rapid needs assessments and for surveillance of flood-related morbidity and mortality. Power generators and water pumps are examples of equipment commonly useful during flood emergencies. These devices help to maintain critical health and medical infrastructure, including public health departments, hospitals, nursing homes, schools, and outpatient clinics.

**Responding to flood-related public health emergencies.** Some evidence indicates that the way a flood disaster response is handled by community and professional agencies can have a significant effect on mental health outcomes, which in turn are strongly associated with physical health.[39] Strategies that minimize population displacement and favor an early return of victims to routine activities of daily living are known to lessen the health impact of flood disasters.

As a natural disaster evolves, the demands for environmental health services and consultation often rise.[40] Although communicable disease outbreaks after flood disasters are rare in the U.S., some potential disease transmission does exist, and affected communities should therefore remain under close surveillance.[41] Moreover, studies of flood disasters have shown that outbreaks of vaccine-preventable diseases rarely result[42]; thus mass immunization in absence of a documented outbreak diverts limited human resources and materials from other more effective and urgent measures.[42–44] In preventing potential spread of infectious disease by floodwaters, basic rules of hygiene and sanitation are far more important than are immunizations.[45]

In many parts of the world, floods are often followed by a proliferation of mosquitoes. The relationship between flooding and vectorborne disease is complex. Severe weather can either increase or decrease the transmission of vectorborne illness.[46] In the U.S. as compared to other regions of the world, floods rarely result in outbreaks of arboviral disease, which is attributable mostly to the relatively low prior prevalence of vectorborne diseases in the region.[45,46] Furthermore, given that most flood-related injuries are minor soft tissue injuries, trauma care teams are usually not required.[40] Community-based primary care outreach activities are often necessary to overcome the barriers to healthcare access encountered by flood victims. During flood disasters, evacuation of special populations, such as those in hospitals, schools, prisons, and nursing homes, as well as migrants, tourists, and people with disabilities, can create the need for a major public health intervention.

## Tropical Cyclones

**The public health impact of tropical cyclones.** Tropical cyclones are low-pressure weather systems that develop over the warm waters of the oceans, typically between the latitudes of 30°N and 30°S.[47] In the past 2 centuries, tropical cyclones have caused an estimated 1.9 million deaths worldwide, and 16 of the 18 deadliest occurred in the Asia–Pacific region.[36]

Storm surge is the unusually high ocean level caused by pressure differentials and surface winds along coastlines in advance of a cyclone landfall. Absent early warning and evacuation measures, drowning from storm surge can cause an estimated 90% of cyclone-attributable mortality.[47,48] In low-income countries without critical preparedness measures, storm surge remains the primary cause of mortality following tropical cyclones.[49,50]

Injury is the major cause of tropical cyclone morbidity.[51] Some researchers have also noted an increased incidence of animal and insect bites in the aftermath of tropical

cyclones.[52,53] However, the increased incidence of insect bites has not been associated with increases in vector-borne disease. Chronic diseases such as asthma and emphysema are exacerbated after tropical cyclones, as is a potential for exposure to hazardous substances—such as mold—during cleanup and recovery efforts. Outbreaks of infectious diseases following tropical cyclones are rare, but both waterborne and arthropodborne diseases have been reported in low-income countries.[54–57] As of yet, there is no clearly defined common etiology for this incidence. Behavioral health effects are among the most significant long-term adverse health outcomes of tropical cyclones.[58–64]

**Preparing for public health emergencies caused by tropical cyclones.** Weather monitoring and forecasting are clearly essential components of an early warning system for cyclones. Accurate weather monitoring and early warning allow for timely implementation of a safe evacuation, thus preventing drowning—the leading cause of cyclone death. Emergency operations plans should take into consideration the priority public health needs experienced after cyclones, which most often include at-risk population evacuation and provision of adequate shelter, as well as food, water, sanitation, and health care. Public education can encourage preparedness in the home, in schools, at the workplace, and at healthcare facilities. Such education can raise public awareness of evacuation routes, storm surge, and riverine flood zones, and community response plans. It can also assist in development of public health surveillance assistance when preparing rapid needs assessments and when conducting post-impact surveillance of cyclone-related morbidity and mortality. With regard to equipment, power generators are critical for maintaining health and medical infrastructure, such as public health departments, hospitals, nursing homes, schools, and outpatient clinics.[29]

**Responding to public health emergencies caused by cyclones.** The public health effects of cyclones are mostly secondary to the loss of access to shelter and services (e.g., food safety, electricity, water sanitation, and health care). In the event of population displacement and resettlement, public health is often called upon to evaluate the need for these health and medical services, and possibly to deliver them. Health information systems and public health surveillance data monitor the health and safety of the flood-affected populations, as well as that of relief and recovery workers.[41]

In a cyclone's wake, clinical care typically involves treatment of soft tissue injuries incurred during evacuation and cleanup, rashes, chronic disease and mental illness exacerbations, and self-limited respiratory and gastrointestinal infections.[37,65–67] After cyclones, multisystem trauma is rare; thus, external assistance such as surgical ships or mobile hospitals is usually unnecessary. In absence of a documented outbreak or a mass casualty event, public health interventions involving vector control, immunization, and trauma care are rarely necessary and can divert limited human resources and materials from other, more effective and more urgently needed measures.[43,44,46] Research has indicated, however, that providing increased social support after cyclone disasters can significantly lower illness burdens.[39] Moreover, the appropriate use of personal protection equipment among disaster recovery workers can help to prevent toxic exposures from chemicals or mold.[68]

## Landslides (Debris Flows)

**The public health impact of landslides.** Landslides include all types of gravity-induced ground movements, ranging from rock falls through slides/slumps, avalanches, and flows, triggered mainly by precipitation (including snowmelt), seismic activity, and volcanic eruptions.[68,69] A debris flow is a rapidly moving mass of water and material that is mainly composed of sand, gravel, and cobbles, but typically includes such items as trees, cars, and even small buildings. Most debris flows have the consistency of wet concrete and move at speeds in excess of 35 miles per hour.[70]

Landslides occur in every U.S. state and territory. In the U.S. alone, landslides cost an estimated $1–$3 billion per year.[71] Landslides are associated with high rates of traumatic injury and mortality, with mortality largely due to trauma and asphyxiation. Landslide morbidity is generally associated with traumatic injuries, wound infections, and disruptions of water, sanitation, and shelter, as well as disruption of the affected population's locally grown food supply.[72,73] Arthrospores can be dispersed in dust clouds, as occurred during landslides triggered by the 1994 Northridge earthquake in California, when an outbreak of 203 cases of coccidioidomycosis resulted.[74] Debris flows associated with 1999 floods in Venezuela killed 30,000 people, then came dangerously close to causing a hazardous chemical release with the potential to affect 80,000 nearby residents, as well as that country's largest airport and second largest seaport.[75,76]

**Preparing for public health emergencies caused by landslides.** Rainfall monitoring, together with warning and population evacuation, can reduce potential loss of life due to landslides. Early warning systems based on weather forecasts and rainfall information can substantially improve emergency warning for and evacuation of threatened communities.[70] In advance of heavy rains, public health information campaigns can communicate risk and protective behaviors. The public health community should become educated about hazard awareness, as well as emergency preparedness and mitigation and response measures.[77] Public health can also play a part in promoting development of safe and healthy communi-

ties, where the terrain remains well-drained and stabilized through land use regulation and building codes.

Without early warning systems or evacuation and shelter programs, landslides can cause high rates of traumatic injury and mortality.[72] After the landslide occurs, it is often too late for response activities to have a significant effect on morbidity and mortality. Response operations with the most potential to save lives and prevent injuries begin before the landslide—whenever heavy rainfall or slope instability is detected—with population evacuation and temporary resettlement out of high-hazard zones.

In the immediate aftermath of a landslide disaster, the first responses are life-saving search and rescue efforts and first aid for immediate, life-threatening traumatic injuries. Occupational health and safety are also important concerns for landslide responders who work in and around unstable debris flows.[77] In addition to injury, the public health effects of landslides are secondary to the population's loss of access to shelter and loss of public services, such as food safety, electricity, water, sewer, and health care. After a landslide occurs, and especially in the event of population displacement, public health is often called upon to evaluate the need for, or to assist in, the delivery of health and medical services.

## Summary

Climate change is predicted to result in an increased number of extreme weather events, including heatwaves, drought, wildfire, tropical cyclones, and heavy precipitation events resulting in floods and landslides. The consequences of these events are expected to include significant public health needs, which in turn will necessitate disaster declarations.

Community-based risk-reduction activities lessen human vulnerability to the vagaries of natural disasters, especially those activities that integrate public health, disaster management, and climate change. Sustainable adaptations to climate change, along with community-based public health preparedness and response activities, build human resilience and lessen human vulnerability. Such local adaptation activities are also enhanced by a supportive policy environment at the national and international levels.[70]

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