

Managing Disaster-Related Health Risk: A Process for Prevention

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Abstract

In 1994, the first World Conference on Natural Disaster Reduction held in Yokohama, Japan affirmed that “Disaster prevention, mitigation, and preparedness are better than disaster response in achieving the goals and objectives of the decade. Disaster response alone is not sufficient, as it yields only temporary results in a very high cost.” Since then, disaster risk reduction has become the mainstay for international development related to disasters. According to the National Research Council (Washington, DC USA), “Disaster research, which has focused historically on emergency response and recovery, is incomplete without the simultaneous study of the societal hazards and risks associated with disasters, which includes data on the vulnerability of people living in hazard prone areas.” Despite over 25 years of global policy development, the National Academies of Sciences, Engineering, and Medicine (Washington, DC USA) recently noted that, “while some disaster management and public health preparedness programming may be viewed as tangentially related, a multi-sectoral and inter-disciplinary national platform for coordination and policy guidance on involving disaster risk reduction in the United States does not exist.” Today, one of the world’s “seven targets in seven years” as agreed upon in the Sendai Framework for Disaster Risk Reduction is to substantially reduce global mortality by 2030. Significant reductions in health risk (including mortality) have historically required a comprehensive approach for disease management that includes both a preventive and a curative approach. Disaster risk management has arisen as a primary means for the world’s populations to address disaster losses, including those related to health. Prevention has been proven as an effective approach for managing health risk. This report describes the role of disease prevention in managing health risk due to disasters.

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Historical Background

Twenty-five years ago, world policy makers began to formalize relationships between health, sustainable development, and disaster management and began to implement this alignment within international strategies for risk management.¹ The outputs of these meetings (furthered by subsequent development of international standards for risk management) have since contributed to a global doctrine for disaster risk management for all sectors, including health.² Table 1,^{1,3-9} lists key events in the development of international policies for managing disaster-related health risk according to a comprehensive approach.

Disaster Risk Management

Risk

Risk can be viewed as a representation of the degree of uncertainty involving the interaction between an event and its outcome. Uncertainty adversely effects ability to predict the risk of outcome.

Management

Processes that decrease the degree of uncertainty among activities are known to improve the likelihood of accomplishing the outcome (or objective). Management is a process used to reduce the uncertainty of outcomes through organization and coordination of the activities intended to achieve defined objectives.

Year	Context	Event	Output	Significance
1992	Rio	UN Conference on Environment and Development	Agenda 21	Identified the goal of “Reducing health risks from environmental pollution and hazards” as one of five key priority actions for sustainable development.
1994	Yokohama	World Conference on Natural Disaster Reduction	Yokohama Strategy and Plan of Action for a Safer World	Recognized “that sustainable economic growth and sustainable development cannot be achieved in many countries without adequate measures to reduce disaster losses...”
1994	BPoA	Global Conference on Sustainable Development of Small Island Developing States	Barbados Program of Action	First conference that translated Agenda 21 into a program of action for a group of countries. Recognized that “Small island developing states are particularly vulnerable to natural as well as environmental disasters and have a limited capacity to respond to and recover from such disasters.”
2002	UNISDR	The Geneva Mandate on Disaster Reduction	United Nations International Strategy for Disaster Reduction	Established the United Nations International Strategy for Disaster Reduction, the secretariat to “ensure coordination and synergies” among United Nations member risk reduction activities.
2002	Rio + 10	World Summit on Sustainable Development	The Johannesburg Plan of Implementation	First recognized that “An integrated, multi-hazard, inclusive approach to address vulnerability, risk assessment, and disaster management, including prevention, mitigation, preparedness, response, and recovery, is an essential element of a safer world in the twenty-first century.”
2004	Pacific Health Summit	Pacific Health Summit for Sustainable Disaster Risk Management	Declaration of the Pacific Health Summit	First conference that translated BPoA and Rio + 10 into a regional plan for the health sector of multiple nations. Called for “an integrated, multi-hazard, and inclusive approach to address vulnerability, risk assessment and disaster management, including prevention, mitigation, preparedness, response and recovery.”
2005	Yokohama + 10	Second World Conference on Disaster Reduction	Hyogo Declaration	Recognized “that a culture disaster prevention, resilience, and associated pre-disaster strategies, which are sound investments, must be fostered at all levels, ranging from the individual to the international levels.” Stated that, “disaster risks hazards and their impacts pose a threat but appropriate response to these can and should lead to actions to reduce risks and vulnerabilities in the future.”
2005	BPoA + 10	Mauritius International Meeting for review of the BPoA	Mauritius Strategy for Implementation	Recognized “the need to enhance and establish, if necessary, means and tools at the international level aimed at implementing a preventive approach for natural disasters...and properly integrating risk management into development policies and programs...”
2012	Rio + 20	United Nations Conference on Sustainable Development	Rio + 20 Outcome Document	Emphasized the need for “action on the social and environmental determinants of health” and called for “disaster risk reduction and the building of resilience to disasters to be addressed with a renewed sense of urgency in the context of sustainable development...”
2015	Yokohama + 20	Third World Conference on Disaster Reduction	Sendai Framework for Disaster Risk Reduction 2015-2030	15-year, voluntary, non-binding agreement articulates “the need for improved understanding of disaster risk in all its dimensions of exposure and vulnerability in hazard characteristics” inclusive of health.

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Table 1. Key Events in the Development of International Policies for Managing Disaster-Related Health Risk^{1,3-9}

Systems-Based Approach	Inputs	Outputs
Process Management	Processes, “the means”	Outcomes, “the ends”
Risk Management	Functions (capacity-focused)	Goals (capability-focused)
Performance Management	Efficiency	Effectiveness

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Table 2. A Comparison of Systems for Managing Process, Risk, and Performance

Process Management

A process is a set of activities that interact to achieve a result (or outcome). Process management is an approach based upon systems to measure and control processes to achieve an intended goal or outcome. Here, process is considered as an input which accomplishes an outcome. These outcomes are represented in terms of goals or objectives and are thus considered as outputs of the system. Similarly, risk management systems apply inputs (referred to as capacity) which accomplish an output (known as capability).

Table 2 illustrates the relationship between inputs used for risk management, process management, and performance management. The significance of these concepts is based upon the recognition that risk management activities (ie, risk assessment) are part of an integrated management system with measurable inputs and outputs that may be controlled for efficiency and effectiveness.

Risk Management

Risk management is activity directed toward assessing, controlling, and monitoring risks. In risk management, evidence on risk factors is collected and analyzed, contexts are assessed, and risk treatment measures are implemented using standard strategies.²

Strategies for risk management include risk assessment and risk treatment measures. Risk assessment typically involves application of an analytical risk assessment used to guide the most cost-effective options for treatment of the risk.

These control measures include: avoiding the risk; reducing the negative effect of the risk; transferring the risk to another party; and accepting some or all of the consequences of a particular risk. ISO 31000 is a set of international standards relating to risk management as codified by the International Organization for Standardization (Geneva, Switzerland).²

Disaster Risk Management

Disaster risk management applies the general principles of risk management to disasters. It is a comprehensive approach that entails developing and implementing strategies for the entire disaster life cycle, before and after hazard impact.¹⁰ Disaster risk management includes pre-impact risk avoidance, reduction and transfer measures, as well as post-impact measures including risk transfer and risk retention.

Once risks have been identified and assessed, techniques to manage or “treat” the risk fall into one or more of these four major

Risk Treatment Measure	Description	Examples
Avoidance	Elimination of the hazard itself	Flood prevention Smallpox eradication
Reduction	Reducing exposures to the hazard	Population evacuation Public education
Transfer	Transferring or sharing risk with others	Insurance Mutual aid
Retention	Accepting and budgeting for risk when it occurs	Preparedness Response Recovery

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Table 3. Four Strategies for Treating Disaster Risk¹¹

categories described in Table 3,¹¹ (note that that efficiency and cost effectiveness tend to decrease for strategies listed lower in the table).

Figure 1 and Table 4,^{12,13} describe the components of disaster risk management, in terms of risk assessment and risk treatment.

Natural History of Disaster-Related Disease

Natural History of Disease

The fundamental principle upon which disease management is based recognizes that development of any disease (which also includes injury) progresses through a natural history that can be broken into a series of stages. If left untreated, a disease will evolve through a series of stages that characterize its natural history. But if an intervention is applied, the natural history is modified to improve the outcome. Preventive measures can be applied at any stage along the natural history of a disease, with the goal of preventing further progression of the condition.¹⁴

Figure 2 represents the “natural history of disease,” the concept of health and disaster-related disease as processes that unfold over time in a series of steps. Effective disease management requires management of the immediate problem, then of the patient’s risk factors, and finally, of the underlying determinants.

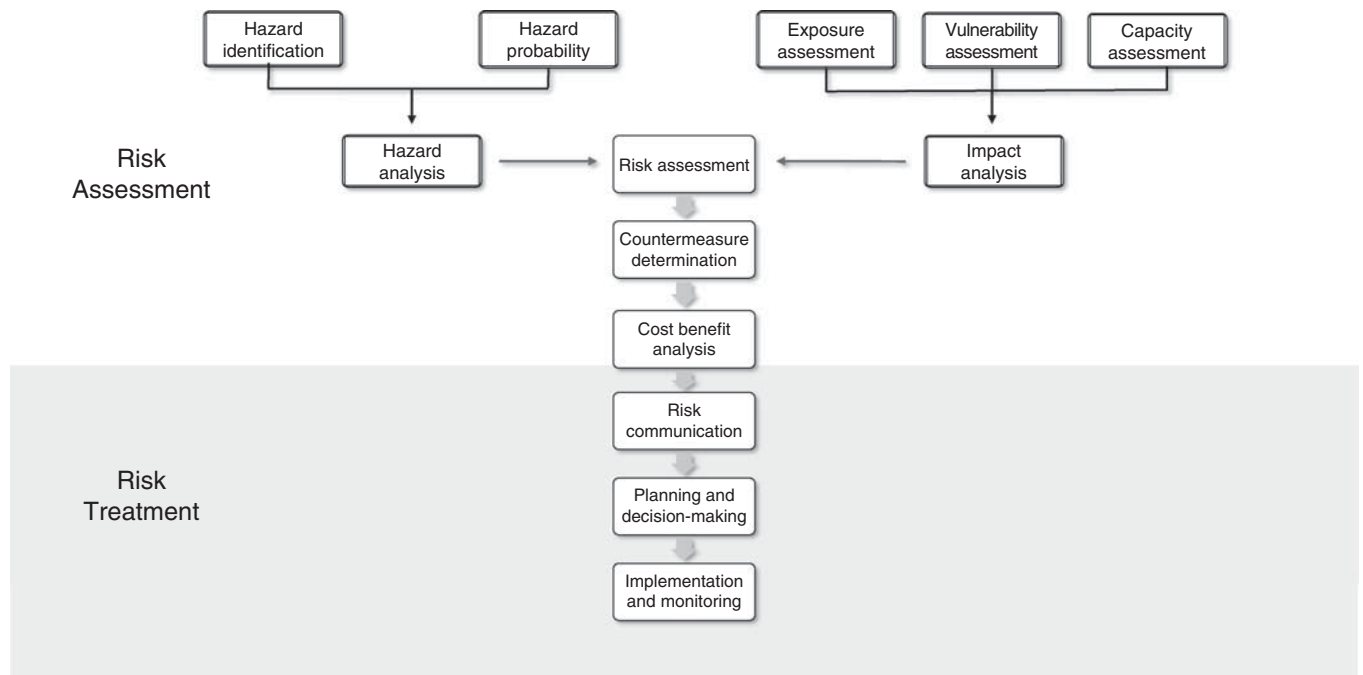
Casual Factors for Disease

Disease does not occur randomly. It is caused when vulnerable hosts are exposed to an environment containing agents that are hazardous to health. It is therefore possible to study the causal factors involving the agent, host, and environment, including both risk and protective factors. Figure 3,¹⁵ illustrates how disease is caused by a complex interaction between the person (host), the disease agent (hazard), and the environment (exposure).

The Natural History of Disaster-Related Injuries

The time between exposure to the hazard and onset of disease (the “incubation period”) is of critical importance when prioritizing public health activities intended to reduce disaster-related mortality.

The period for developing a life-threatening injury is commonly measured in minutes to hours, whereas this period for



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Figure 1. Schematic Overview of Disaster Risk Management Process.^{10,12,13}

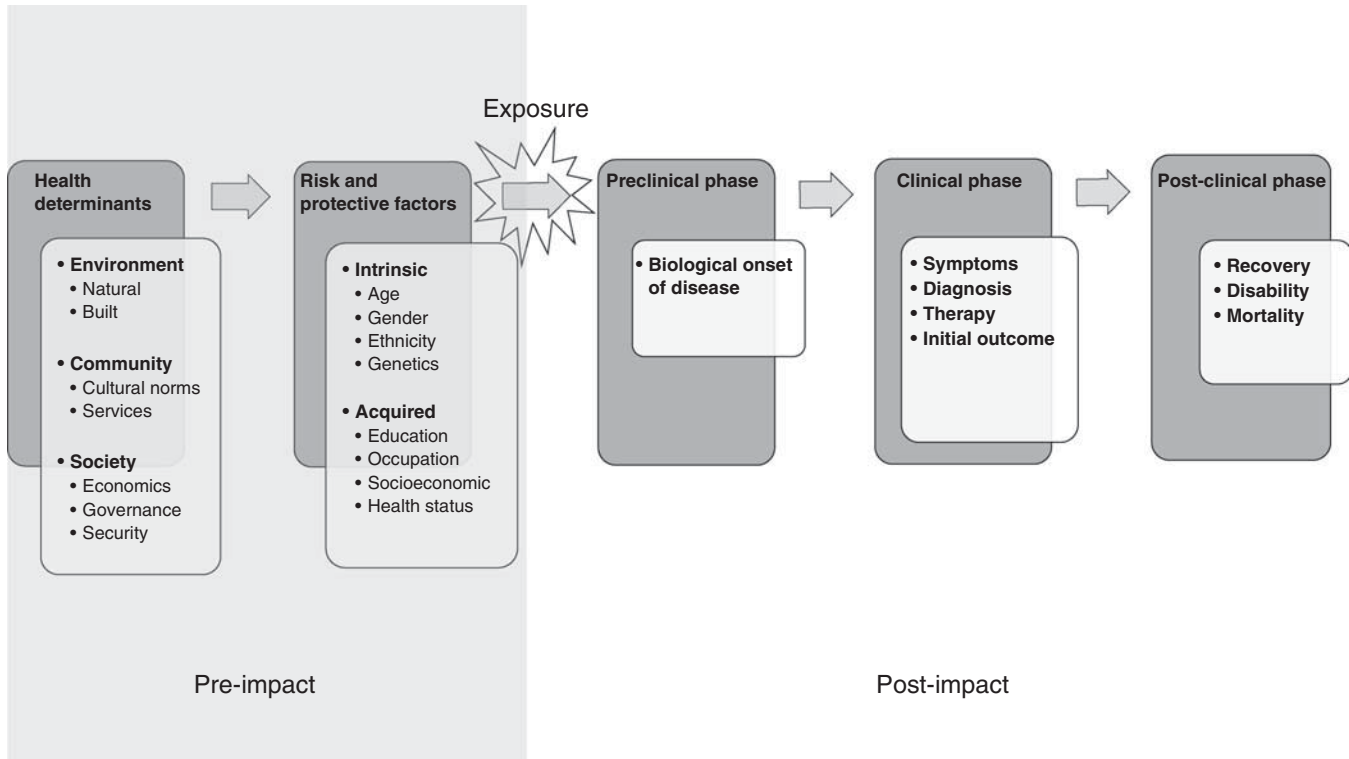
Component	Activities
Hazard Analysis • Hazard Identification • Hazard Probability	Identifying hazards with the potential to cause loss or damage of an asset. Determining frequency of past hazard events.
Impact Analysis • Asset Assessment • Loss Assessment	Determining critical assets (ie, population or medical facilities). Identifying expected loss or damage of each asset for each hazard. Prioritizing assets based on consequence of loss.
Capacity Assessment	Identifying strengths, attributes, and resources available to counter the adverse effects of a disaster.
Exposure Assessment	Determining degree of asset contact with or exposure to the hazard.
Vulnerability Assessment • Susceptibility • Severity	Estimating degree of vulnerability of each asset for each hazard. Identifying pre-existing countermeasures and their level of effectiveness.
Countermeasure Determination • Avoidance/Reduction • Transfer/Retention	Identifying new countermeasures which may be taken to eliminate or lessen hazards, and/or exposures, and vulnerabilities.
Cost - Benefit Analysis	Identifying countermeasure costs and benefits. Prioritizing options.
Risk Communication	Preparing a range of recommendations for decision makers and/or the public.
Risk Management Plan	A plan for disaster risk treatment is developed for each phase of the emergency cycle.
Implementation and Monitoring	The risk management program is implemented and monitored per plan.

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Table 4. Key Components of Disaster Risk Management^{10,12,13}

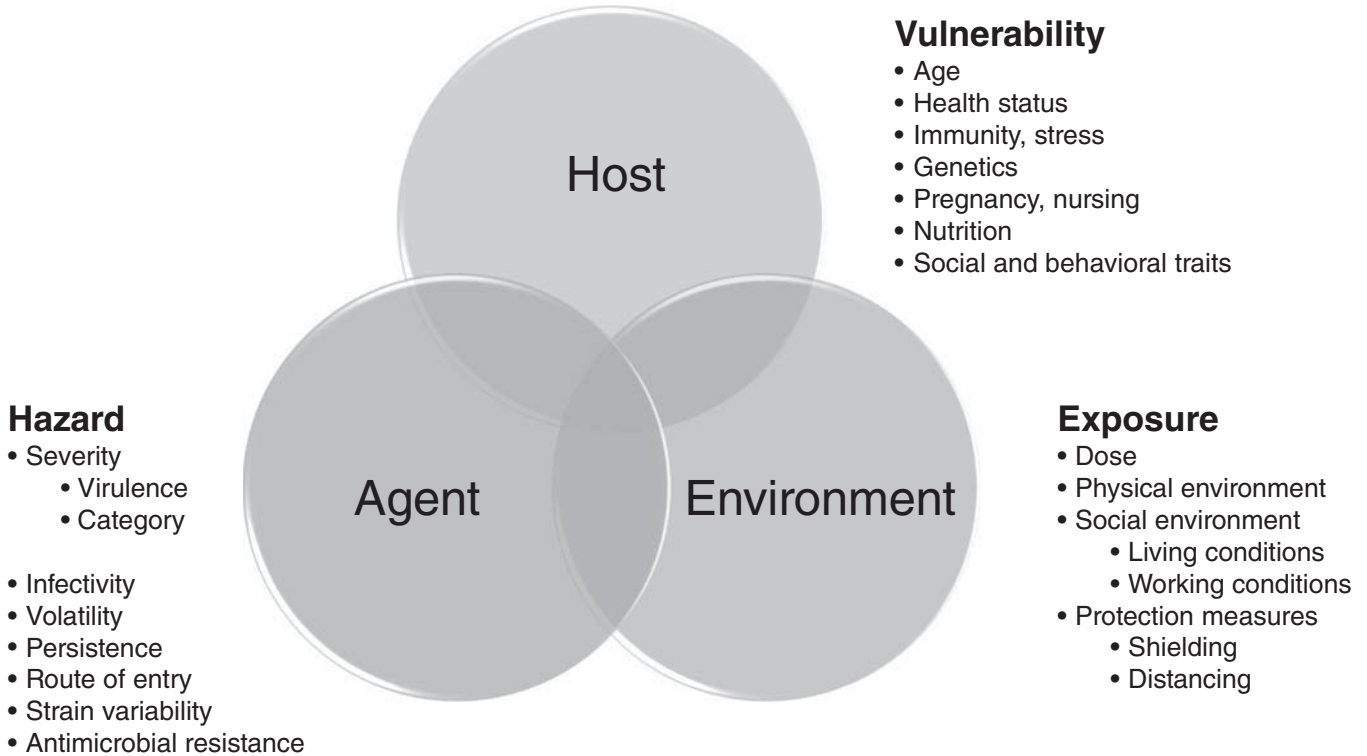
outbreaks of disease is most commonly measured in days to weeks. This rapid onset of disaster-related injuries markedly limits the effectiveness of secondary and tertiary prevention (eg, response and recovery interventions). For example, the outcome of

traumatic injuries is highly dependent upon the rapid availability of definitive surgical care within one hour from exposure (commonly known as the “golden hour” due to its valuable critical impact on survival outcome; Figure 4).



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Figure 2. Natural History of Disease.¹⁴



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Figure 3. Causal Factors for Disease.¹⁵

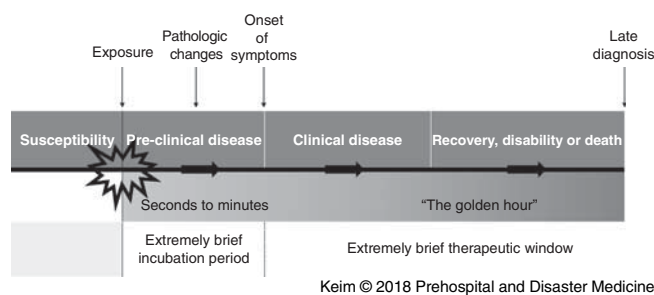


Figure 4. Natural History of Disaster-Related Injuries.

However, the character of most large-scale, environmental (eg, technological, hydro-meteorological, and geophysical) disasters commonly precludes accessibility of life-saving surgical care for the overwhelming majority of patients. This is of critical significance considering that 60% of the world's disaster deaths during the past 50 years were due to injury caused by these same environmental hazards.¹⁶

Thus, the natural history of disaster-related injuries often limits the effectiveness of secondary and tertiary prevention following disasters from technological, geophysical, and hydro-meteorological hazards, emphasizing the importance of primary prevention before the event occurs. On the other hand, the comparably slower onset and chronic nature of events caused by biological and societal hazards does allow more time for effective mortality reduction through secondary and tertiary prevention measures during response and recovery. In order to be effective in reducing mortality, health-related actions must be applied during the appropriate window of opportunity. It is important to recognize the value of a comprehensive approach to the prevention for disaster-related mortality.

Primary prevention of the exposure (before injury can occur) is therefore of critical importance to reducing mortality risk from these environmental hazards. In outbreaks and societal disasters, there is frequently more time available to allow for effective clinical and public health intervention before significant disease, disability, or death occurs.

Disease Prevention

Disease prevention includes a wide range of activities aimed at reducing health risks and improving health outcomes. Prevention occurs in four main stages: primordial, primary, secondary, and tertiary.¹⁴ Primordial prevention involves preventing health hazards from occurring. Primary prevention involves preventing exposure, given that hazards exist. Secondary prevention involves preventing disease, given exposure has occurred. Tertiary prevention involves preventing further progression (eg, prolonged impairment; permanent disability; or death) given that disease (including injury) has occurred.

Primordial prevention seeks to modify the fundamental health determinants ("the cause of the cause" of disease). Primary, secondary, and tertiary prevention seek to modify risk and protective factors. Primary prevention focuses on reducing risk factors for exposure to the disaster hazard. Secondary and tertiary prevention focus on reducing the risk factors for vulnerability to disease. Secondary prevention seeks to prevent disease by reducing disease susceptibility. Tertiary prevention seeks to prevent disability and death by reducing disease severity. Table 5 represents a model

for integration of approaches for managing disease, disaster risk, and emergencies.

Primordial Prevention

Primordial prevention involves preventing the hazard occurrence and thus avoiding the environmental, economic, health, social, behavioral, and cultural factors of vulnerability known to amplify the risk of disease. It addresses broad health determinants rather than preventing personal exposure to risk factors, which is the goal of primary prevention.¹⁴ Primordial prevention seeks first to prevent the disaster hazard from ever occurring. For example, floodplain management in an area of frequent flooding may actually prevent future flood hazards altogether, and therefore aligns with the disaster risk management activity of hazard avoidance. In examples where the hazard cannot be prevented, primordial prevention may be used to guide developmental decisions that avoid placing critical infrastructure and human settlements within hazardous areas.

Primary Prevention

The adverse health effect of a hazard is often characterized by a dose-response relationship. Typically, as the degree of exposure to a health hazard increases, the adverse health effect appears in more of the population. In the case of natural and infectious disease disasters, the degree of exposure of a given population to the hazard (eg, extremes of wind, temperature, precipitation, seismicity, volcanism, or biological agent) has a direct relationship to the incidence and severity of adverse health outcomes. Persons receiving a higher dose (magnitude of exposure to the disaster hazard over time) of the hazardous agent have a higher risk for adverse health outcomes as compared with those less exposed.

Primary prevention involves preventing exposures that would lead to disease. The goal of primary prevention is to prevent population exposure to risk factors.¹⁷ It involves an interdisciplinary approach for identifying, characterizing, monitoring, and avoiding exposure to human health hazards. This includes those investigational aspects (like monitoring, forecasting, modeling, and dose reconstruction), as well as structural (eg, engineering controls, construction methods, and architectural design) and nonstructural (eg, public policy, education, and population protection measures) means for reducing exposures.¹²

Secondary Prevention

The goal of secondary prevention is to prevent disease, given that exposure has already occurred.¹⁷ These activities typically involve emergency response activities, such as search and rescue, mass-casualty response, disease control, and hazardous material response, that enable early diagnosis and appropriate management of disease. Disaster response is predominantly focused on immediate and short-term needs and is sometimes called "disaster relief." Response usually includes those actions immediately necessary to remove the affected population from ongoing exposure or risk of harm. Effective response reduces adverse health impacts.

This element of risk retention accepts the risk of disease and seeks to prepare and respond to disease incidence with ameliorative and curative approaches. Risk retention involves accepting disaster loss when it occurs and then attempting to respond and recover (if possible). By default, all residual risks that are not avoided or transferred are retained and will require allocation of resources at some time in the future. Risk acceptance is not

Stage of Prevention	Prevention Goal	Risk Management Goal	Disaster Risk Management Goal	Emergency Management Goal
Primordial	Prevent hazards	Risk avoidance	Hazard avoidance	Mitigation
Primary	Prevent exposures	Risk reduction	Exposure reduction	
Secondary	Prevent disease	Risk transfer and risk retention	Vulnerability reduction (disease susceptibility)	Preparedness/ Response
Tertiary	Prevent disability and death		Vulnerability reduction (disease severity)	Recovery/ Rehabilitation

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Table 5. Public Health Prevention as an Integrated Approach for Managing the Risk of Disease

considered sustainable since the likelihood of future losses created by current developmental decisions is, in effect, being transferred to future generations for subsequently more expensive ad hoc emergency resource allocations.

Tertiary Prevention

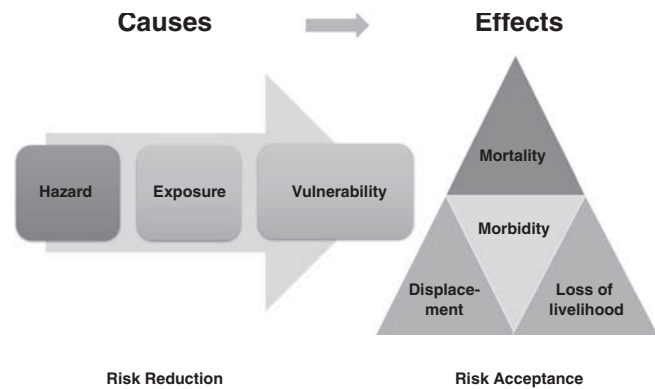
The goal of tertiary prevention is to prevent the progression of impairment, disability, and death given that disease has occurred.¹⁷ Tertiary prevention includes capabilities that reduce vulnerability as applied to disease severity, thus minimizing the risk of additional risk in the form of protracted illness, medical complications, disability, and death.

The capabilities involved in the tertiary prevention of disaster-related morbidity and mortality largely involve a network of curative health, rehabilitative health, communication, and social services intended to prevent additional or ongoing disability and death after the disease or injury occurs. This rehabilitation and recovery phase is characteristically long in duration and often an opportune time to initiate new aspects of primary prevention as the society attempts to “build back better” and reduce future risk.

Tertiary prevention of disaster risk involves measures taken during the recovery and rehabilitation phase as a component of risk retention. Recovery and rehabilitation begin soon after the emergency phase has ended, and should be based on pre-existing strategies and policies that facilitate clear institutional responsibilities for recovery action and enable public participation. The division between the response stage and the subsequent recovery stage is not clear-cut. Some response actions, such as the supply of temporary housing and health care, may extend well into the recovery stage.

Public health has systematically developed significant state, national, and international capabilities to address the effects of disasters (eg, mortality, morbidity, displacement, or loss of livelihood), but less so for addressing the root causes (hazards, exposures, and vulnerability). Figure 5 compares these root causes with the associated outcomes of disaster-related health effects.

Table 6 reveals the means by which disease prevention may be integrated to achieve the mutual goal of reducing disaster-related health risk. All stages of prevention begin with an assessment of the health risk. These data are collected from routine health surveillance as well as other disaster-specific outreach activities involving enhanced surveillance, needs, hazard characterization, risk analysis, and communication.



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Figure 5. Relationship between Causal Factors and Outcomes for Disaster-Related Health Risk.

Conclusion

Effective disaster risk management requires not only management of the immediate problem (disaster-related injuries and disease), but also of the patient’s risk factors and of the underlying health determinants. This requires the involvement of many sectors and disciplines which contribute to the management of health risks associated with emergencies and disasters. Disaster-related deaths are effectively reduced by health interventions and other measures that occur within a framework of: primary prevention (preventing hazards and exposures); secondary prevention (preventing injury or disease following exposure); and tertiary prevention (preventing disability and death following injury/disease).

The natural history of disaster-related injuries often limits the effectiveness of secondary and tertiary prevention following disasters from technological, geophysical, and hydro-meteorological hazards, emphasizing the importance of primary prevention before the event occurs. On the other hand, the relatively slower onset and often chronic nature of events caused by biological and societal hazards does allow more time for effective mortality reduction through secondary and tertiary prevention measures during response and recovery. In order to be effective in reducing mortality, health-related actions must be applied during the appropriate window of opportunity. It is important to recognize the value of a comprehensive approach to the prevention for disaster-related mortality.

Stage of Prevention	Disaster Risk Management Capability	Capabilities for Environmental Hazards	Capabilities for Societal Hazards	Capabilities for Biological Hazards
Primordial Prevention <i>Preventing Hazards</i>	Risk Assessment	Health surveillance Geological and hydro-meteorological hazard analysis Hazard mapping	Health surveillance Disease risk assessment Security threat assessment	Health surveillance Disease risk assessment
	Hazard Avoidance	Land use regulation Hazard substitution Preventive maintenance Engineering controls	Conflict resolution Peacekeeping	Veterinary health Agricultural sciences Environmental health Public utilities and services
Primary Prevention <i>Preventing Exposures after Hazards Occur</i>	Risk Assessment	Health surveillance Health impact assessment Hazard, vulnerability, and capacity analysis	Health surveillance Disease risk assessment Security threat assessment	Health surveillance Disease risk assessment
	Hazard Monitoring	Health surveillance Environmental monitoring Industrial hygiene	Health surveillance Medical intelligence	Health surveillance Veterinary surveillance Vector surveillance
	Exposure Reduction	Public warning systems Weather forecasting Industrial hygiene Structural mitigation Building codes Evacuation Sheltering/ settlement	Public warning systems Evacuation Sheltering/settlement Security Water, sanitation, and hygiene (WASH)	Public warning systems Isolation/Quarantine Social distancing Personal protective equipment (PPE) WASH
Secondary Prevention <i>Preventing Disease after Exposure Occurs</i>	Risk Assessment	Health surveillance Rapid needs assessment Exposure assessment Damage/loss assessment	Health surveillance Rapid needs assessment Security threat assessment	Health surveillance Disease risk assessment Disease early warning systems
	Vulnerability Reduction (susceptibility)	Emergency health services Curative health services Risk communication Psychosocial services	Vaccination Emergency health services Curative health services Risk communication Psychosocial services	Emergency health services Curative health services Risk communication Psychosocial services
Tertiary Prevention <i>Preventing Disability/Death after Disease Occurs</i>	Risk Assessment	Health surveillance	Health surveillance	Health surveillance
	Vulnerability Reduction (severity)	Emergency health services Curative health services Rehabilitative health services Risk communication		

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Table 6. Examples of Capabilities for Preventing Disaster-Related Health Effects¹⁷

Abbreviations: PPE, personal protective equipment; WASH, water, sanitation, and hygiene.

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