

## The Impact of Natural Hazards on Population Vulnerability and Public Health Systems in Tropical Areas

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Natural hazards and disasters are a common occurrence in many developed and developing countries, and the national and international communities typically provide at least some relief to those who suffered losses due to the disasters [1]. The definition of what constitutes a disaster is a contentious issue; but in its most basic sense it is used to describe an event that brings widespread losses and disruption to a community [2]. The Intergovernmental Panel on Climate Change (2012) defines disaster as severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery [3].

Floods are the most common type of disaster globally, responsible for thousands of deaths and public health problems [1-4]. Most deaths caused by floods occur in poor countries. In October 1998, Hurricane Mitch hit Central America and 5,657 people were killed in Honduras [3]. Over the past decades, Isla Hispaniola, the island shared by Haiti and the Dominican Republic, has been affected by several hydrological disasters [5]. A recent example occurred on May 24, 2004, when extreme rainfall, originated by a tropical depression, impacted the island producing a devastating flash-flooding and tens of thousands of people were affected on both sides of the border [4]. During October 2005 Hurricane Stan hit Guatemala, El Salvador, east and south of Mexico, Nicaragua, Honduras and Costa Rica causing at least 1,620 deaths, most of which were due to floods and landslides [6]. In September 2007, Hurricane Felix caused losses in human lives and huge damages in infrastructure and the environment. More than 198,000 people were affected and more than 100 people were killed [7].

Something very striking about floods is that they vary significantly across time and space since flooding incidents are strongly influenced by a wide range of factors including land use and land cover, urbanization, malfunction or bad conditions of drainage pipelines, and climate variability, among others. Nevertheless, floods do not have to be huge in scale to affect homes and livelihoods, and they do not have to be physically destructive to pose risks to human health [2]. During the past decade (2000-2009), in the United States of America, flooding, severe storms and hurricanes have been responsible for economic losses estimated in more than \$1.14 billion (US Department Homeland Security). Although the amount of money allocated for public assistance projects after a disaster is considerable, even so, it may not be enough, because the communities can be severely affected due to the sudden demand which exceeds the irresponse capability and infrastructure. Therefore, the response process becomes very difficult [8-10]. Recently in 2013, a total of 19 natural disasters affected about 552,000 people in Latin America and the Caribbean. In addition, at the end of 2013, the Philippines were impacted by the most devastating super typhoon (Haiyan), which affected 16 million people; 4.1 million were displaced, 6,069 reported dead, and 1.1 million houses received damages or were destroyed [11].

Puerto Rico, like many other Caribbean countries, has suffered the direct impact of severe storms, floods and hurricanes [12]. Between

1986 and 2011, Puerto Rico was declared a disaster zone by the US Federal Emergency Management Agency (FEMA) on 18 occasions. Only six of these declarations (33%) were due to hurricane damages. Nine of the incidents (50%) were severe storms, which led to floods, landslides and mudslides. Data from the National Oceanographic and Atmospheric Administration (NOAA) the Advanced Hydrological Prediction Service (AHPS) show that in the last 25 years there have been 78 floods in Puerto Rico, of which 71% were classified as major floods (extensive deluge of structures and roads, significant evacuations of people and/or transfer of property to higher elevations) and 19% as moderate floods (some inundation of structures and roads near streams, some evacuations of people, and/or transfer of property to higher elevations are necessary).

The Pan American Health Organization discusses a number of reasons why threats posed by disasters will likely be worse in the near future. Among the reasons given are: increased population density in flood plains and in vulnerable coastal areas near fault lines, weather events, development and transportation of thousands of toxic and hazardous materials, and the rapid industrialization of the developing countries [13]. Disasters, whether natural or caused by humans, generally have a negative impact on human, psychological, social, economic, political and ecological aspects. Clearly, disasters are not just the result of natural forces, but also of human behavior. They also impact individual health and public health, and pose great challenges to health care services systems due primarily to damages to hospital facilities, at a time when these are faced with the responsibility of increasing the provision of medical services to assist those affected [9,10,14]. Disaster events can cause an immediate demand for public health resources and health care services, basically committing a vast amount of the affected country's resources and bringing out their deficiencies at various levels of the disaster mitigation process. In addition, disasters can lead vulnerable populations to suffer permanent injury which may reduce their capabilities, and even decrease the ability to work, to live independently and care for themselves [3].

In this context, and in a hydro-climatic perspective, there is a substantial concern that climate change will make certain environments more vulnerable than others. In 2010, almost 45% of the total population in Puerto Rico lives in a designated flood zone, exposed to flood

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hazards. Exposure might be understood as presented in the [15] “the presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected”. Nearly 44% out of the 1.5 million lives in designated Special Flood Hazard Areas – High Risk and 4% lives in Coastal High Hazard Areas – High Risk. Considering vulnerable populations, children under 5 years old and elderly (> 65 years), account for 3% (99,680) and 15% (232,084) respectively of this population. Vulnerable populations are individuals whose characteristics such as age, health status, physical limitations or lack of resources put them at greater risk for a disaster event. They also require special attention and needs that must be supplied during and after a disaster event [15].

Therefore, it has to be a government priority to identify communities exposed to different natural and physical hazards, to characterize their vulnerability, evaluate shelters capacity (temporary and emergency) and evaluate the State Emergency Response and Recovery Plan. In case of an emergency, temporary and emergency shelters must be able to provide daily necessities such as food, water, sleeping arrangement, and other needed services [16]. However government dependencies tend to have limited capability to respond to disasters, specifically when homes and settlements are fully destroyed or severely damaged [17]. Another important complex element of community recovery is associated with the infrastructure that is fundamental for the operations of other systems dependent upon transportation, electricity, water, and waste disposal to carry out their normal activities [16]. In that manner, not only the government agencies must be organized, but also hospital and health care services must be prepared to deal efficiently and effectively with different emergencies and disasters [18].

Extreme events can have very different effects due to differences in the coping ability of affected populations. Climate adaptation strategies should also be considered in relation to more general characteristics, such as population growth, poverty, health, nutrition and environmental degradation, which influence the vulnerability of the population and their ability to adapt. The adaptations that enhance the ability of a population to face a disaster event promoting sustainability may also help protect them against current climate variability and future climate change. Finally, sustainability is essential for maintaining the balance among all the natural and human systems. If these systems deteriorate, the population's welfare and health may be jeopardized.

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