Reduced death rates from cyclones in Bangladesh: What more needs to be done?

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Abstract

Tropical storms, such as cyclones, hurricanes, and typhoons, present major threats to coastal communities. Around two million people worldwide have died and millions have been left injured over the last two centuries as a result of tropical storms. Bangladesh is especially vulnerable to tropical cyclones, with around 718,000 people dying from tropical cyclones in the last 50 years. However, cyclone-related mortality in Bangladesh has declined more than 100 fold over the past 40 years, from 500,000 deaths in 1970 to 4,234 in 2007. Improved defensive measures, including early warning systems, cyclone shelters, evacuation plans, coastal embankments, reforestation schemes and increased awareness and communication are the main factors responsible for the reduced fatalities and injury risk. Although warning systems have been improved, evacuation before a cyclone remains a challenge, and illiteracy, lack of awareness, and poor communication present major problems. Despite the potential risks of climate change and tropical storms, little empirical knowledge exists on how to develop effective strategies to reduce or mitigate the effects of cyclones. We summarize the most recent data and outline the strategy adopted in Bangladesh, and offer guidance on how similar strategies can be adopted by other countries vulnerable to tropical storms. Further research is needed to enable countries to harness the benefits and limit the risks to public health presented by cyclones.

Background

Cyclones and storm surges threaten coastal communities worldwide. “A tropical cyclone is a generic term for a non-frontal synoptic scale cyclone originating over tropical or subtropical waters with organized convection and definite cyclonic surface wind circulation (WMO 2010)”. [1] More specifically, a storm in the Southeast Indian Ocean is cyclonic when the sustained wind speed is over 33 knots (>62 km/h). The storm surge represents a major cause of death and injury during a cyclone. A storm surge is the difference between the water level under the influence of a disturbance (storm tide) and the level that would have been reached in the absence of the meteorological disturbance.[2] Over the last two centuries, around two million people worldwide have died and millions have been left injured as a result of tropical storms, including cyclones, hurricanes and

typhoons.[3] Globally, the number of cyclones increased more than 3-fold (Fig. 1) from 1970 to 2006.[4] The strength and number of major cyclones may be increasing because of higher sea surface temperatures associated with global warming.[5] Tropical cyclones and storm surges are known to be particularly severe in the Bay of Bengal region.

We review the impacts of cyclones on health and livelihoods in Bangladesh, in light of the progress made and the challenges that remain. We explore cyclone-related severity and death in Bangladesh over the last 50 years, and discuss the experiences of other cyclone-afflicted countries. We also consider how international experience may be leveraged to reduce the adverse health impacts of natural disasters. Finally, we recommend mitigation and adaptation strategies, and future research needs.

Impacts of cyclones on public health and livelihoods in Bangladesh

Bangladesh is especially vulnerable to cyclones because of its location at the triangular shaped head of the Bay of Bengal,[6] the sea level geography of the coastal area, its high population density, and the lack of coastal protection systems. During the pre-monsoon (April–May) or post monsoon (October–November) seasons, cyclones frequently hit the coastal regions of Bangladesh. About 40% of the total global storm surges are recorded in Bangladesh,[7] and the deadliest cyclones in the past 50 years, in terms of deaths and casualties, are those that have struck Bangladesh.[8]

The number and severity of cyclones in Bangladesh and the associated mortalities have varied greatly during the past 50 years (Fig. 2). The two deadliest cyclones occurred in 1970 and 1991, with >500,000 and almost 140,000 deaths, respectively. However, Bangladesh has been somewhat spared from the effects of severe cyclones during the last 20 years, despite being struck by cyclones with high wind speeds. The last severe cyclone hit Bangladesh in 2007 leaving 4,234 people dead, a 100-fold reduction compared with the devastating 1970 cyclone.

In addition to the immediate death and suffering caused by such disasters, cyclones also have direct and indirect impacts on general public health, livelihoods, infrastructure, the economy, and socio-cultural foundations. Cyclones affect access to food and drinking water, and increase the transmission risks of infectious diseases, such as diarrhea, hepatitis, malaria, dengue, pneumonia, eye infections, and skin diseases,[9] thus contributing to the interruption of livelihoods. Surface water, the main source of drinking water in Bangladesh, becomes highly contaminated in coastal areas following a cyclone, because of saline intrusion and poor sanitation systems.[10,11] Open latrines and poor sanitation are common in rural Bangladesh and coastal areas, and already fragile sanitation systems break down after a cyclone.[10] The lack of safe drinking water in coastal areas of Bangladesh may be the most important reason for the spread of waterborne diseases after a cyclone. Illnesses are also caused by indirect impacts such as damaged infrastructure, population displacement, reduced food production, and the release of contaminants into the water (e.g., from storage and waste disposal sites). Childhood malnutrition is already a serious issue in Bangladesh, and the loss of crops and decreased access to fish compounds the problem. Indirect health-related impacts, such as increased suicide and crime rates, and adverse pregnancy outcomes, are clearly

associated with cyclones.[12] These tend to increase in the post-disaster period, as a result of post-traumatic stress and depression. Literacy rates are low and poor knowledge of environmental health issues creates additional problems following a cyclone.

Progress and challenges in Bangladesh

In the last 50 years, Bangladesh has learned how to adapt to recurrent cyclones and has succeeded in significantly reducing cyclone-related deaths. This has been achieved by modernizing early warning systems, developing shelters and evacuation plans, constructing coastal embankments, maintaining and improving coastal forest cover, and by raising awareness at the community level.

Cyclone preparedness has improved following the launch of the Cyclone Preparedness Program (CPP) by the Bangladesh Red Crescent Society in 1970. The program's goal is to minimize loss of lives and property in cyclonic disasters by strengthening and developing disaster preparedness and response capacity of the CPP and of coastal communities, and by increasing the effectiveness of volunteers. CPP's activities include disseminating cyclone warning signals issued by the Bangladesh Meteorological Department (BMD) through an extensive telecommunication network; providing and assisting in first aid, rescue, relief and rehabilitation operations; and coordinating participatory community capacity build-up, disaster management and development activities. The Bangladesh Disaster Management Bureau also issues cyclone alerts in the national media as soon as a cyclone is detected by environmental satellites. The BMD has three radar stations in Dhaka, Khepupara and Cox's Bazar, which transmit minute-by-minute weather updates.[13] The BMD also receives information from the United States' National Oceanic and Atmospheric Administration and from a Japanese satellite via the Bangladesh Space Research and Remote Sensing Organization.[13] The effective early warning system provided by the government in advance of Cyclone Sidr in 2007 enabled the successful evacuation of coastal communities resulting in fewer than expected deaths. Initiatives at central and local governmental, NGO and community levels seem to be keys for success in minimizing cyclone related mortality.

Apart from early warning systems, other measures such as cyclone shelters and coastal embankments have contributed to reducing death rates in Bangladesh. Prior to 2007, the country had developed 1,500 shelters, each capable of offering refuge to up to 5,000 people in coastal districts. After Cyclone Sidr, the Bangladesh government initiated the construction of 2,000 new cyclone shelters in 15 low-lying coastal districts (Paul, 2008), but the number and location of shelters remain inadequate for the population density. Bangladesh has more than 700 km of coastline. Since 1960 a series of embankments have been constructed to protect coastal regions, including around 4000 km of coastal embankments surrounding the Bay of Bengal and offshore islands.[14] Coastal vegetation was found to be protective during Cyclone Sidr when mangrove forests saved the south-western part of Bangladesh and during a different storm, reduced the death toll from a cyclone in India in 1999.[15] Reforestation of approximately 120,000 hectares of mangrove forests in Bangladesh has been carried out to mitigate cyclone risk.[16] Bangladesh, as part of the CPP, has implemented awareness campaigns to disseminate information about cyclone warning signals and preparedness measures, including through meetings,

discussions, posters, leaflets, film shows, and demonstration dramas.[17] Although there is currently no scientific evidence regarding the precise impact of shelters, coastal embankments, or awareness programs on cyclone-related mortality, they appear to have saved millions of lives. Continued technological advances will increase preparedness and help mitigate the effect of cyclones in Bangladesh.

Despite improvements in warning systems, pre-cyclone evacuation remains a challenge. Illiteracy, lack of awareness, and communication problems mean that some people do not understand or follow the warnings. Instead of moving to cyclone shelters, people in coastal areas often still believe in a wait-and-see approach.[18,19] Fear of property loss and previous false warnings also limit evacuation to shelters.[18] Others refuse to evacuate because of the poor condition of the public cyclone shelters, attributes of the warning message itself, or their individual perceptions and beliefs, while others believe that their houses can withstand a cyclone.[19] Building structures of concrete or brick prevent human loss, and people who shelter in such structures generally survive, while the death rate can be doubled in populations without access to sturdy shelters.[19] Maintenance of and access to cyclone shelters are important factors in enabling people to quickly find adequate protection. For example, only two out of every five shelters were usable during the 1991 cyclone, because of flooding.[20] People also suffered as a result of lack of access to shelters during Cyclone Sidr in 2007. Dissemination of warning messages presents another challenge; most residents in coastal areas of Bangladesh have no access to radio or television. Some Bangladeshis rely on natural warning signs, such as unusual animal behavior and weather and ocean patterns, to prepare for the impacts of a cyclone; [20] however, these signs may be unreliable and inconsistent. In remote localities, the effectiveness of the use of megaphones by volunteers (more than 20,000 during cyclone alerts),[19] can be affected by wind direction, as people to the side or upwind have little chance of hearing the warnings, while batteries for megaphones and microphones may not be locally available. Significantly, households with radios had lower death rates during cyclones than those without radios.[19]

Experiences and lessons from other countries and global implications

By examining the impacts of and responses to cyclones in other countries, we can improve our understanding of effective strategies for preventing the loss of life. Cuba has significantly improved its pre and post-cyclone early warning and evacuation systems and health services and has introduced a cyclone preparedness program for primary school children. Universal education and the eradication of illiteracy are further keys to success, improving awareness of the risks associated with hurricanes and the understanding of government warnings. Cuba also has a population with a very high level of civil participation, and one of the best primary healthcare systems in the world.[21]

In early May 2008, Cyclone Nargis struck Myanmar with sea surges and wind speeds > 200 km/h; more than 140,000 people died or were missing and almost 2.4 million people were seriously affected.[22,23] There was an international warning of the approaching Cyclone Nargis several days prior to its landing, but poor dissemination of information and lack of governmental responsibility were thought to have contributed to the outcome;

local authorities and populations were not proactive in their planning and response, no information on cyclone shelters in Myanmar was published before Cyclone Nargis, and a lack of awareness and political will and poor health infrastructure were also blamed for the large post-cyclone effects. Private organizations had to quickly decide how to become involved in relief distribution, with some organizations taking on relief work as a completely new task. There were delays in evacuating people and the international community was not allowed to access the most affected areas. A lack of boats also contributed to the problem. Interestingly, however, emergency projects after Cyclone Nargis opened up the way for peace building efforts in areas that had previously been difficult for the international community to access.[24]

In early 2011, Cyclone Yasi hit Queensland, Australia. The cyclone was 500 km wide with an eye 100 km in diameter, and 285 km/hr wind speeds. Local and district disaster management committees initiated their disaster management plans in advance. The media played a vital role in informing the public about weather events, where to get help and where to evacuate to, if necessary. Aircrafts were also prepared for use for evacuations after the cyclone. Hospitals were evacuated of patients, and the overall evacuation was completed more than four hours before the cyclone struck. Considering the magnitude of its destruction capability, not a single person lost their life during the cyclone or its aftermath. This was achieved through thorough preparedness and the early warning systems (EWS) that were implemented. [25]

Even with public warnings prior to Hurricane Katrina in the United States, drowning-related deaths were still reported, and two thirds of all related fatalities were reportedly caused by drowning as a result of cyclone-related storm surges and floods after the hurricane.[26] The early evacuation of 1,589 people from New Orleans to Oklahoma occurred based on the results of a rapid needs assessment.[27] Due to the successful evacuation of hospitals in the city of New Orleans, no patient deaths or injuries were reported. It was possible because of coordinated decisions made by administration, nurses and medical staff.[28]

Outbreaks of cholera, diarrhea, malaria and dengue have been common experiences after cyclones in India and in several African and Central American countries.[29,30,31,32,33] Careful preparations for epidemics prior to the arrival of a cyclone is important to ensure a rapid response and control of the outbreaks. Along with high death rates, the Philippines have experienced outbreaks of leptospirosis caused by coastal flooding after typhoons.[34] Basic hygiene kits were distributed to affected communities following the typhoon to reduce waterborne disease. EWS and evacuation programs have recently been improved, and the better coordination of relief efforts was also reported to have minimized typhoon-related health injuries and increase relief distribution. The early evacuation of 3,066 people from the path of Typhoon Megi saved lives.[35]

Cyclones are also responsible for many indirect traumas and mental disorders in different parts of the world. A high incidence (30.6%) of post-traumatic stress disorder (PTSD) was reported after a cyclone that struck India in 1999,[36] and a high prevalence of PTSD and major depressive symptoms have also been reported following cyclones in India, Sri

Lanka, Nicaragua and the United States.[37,38,39,40,41] PTSD and other mental health concerns might have long term impacts on health. However, these issues have so far been neglected in Bangladesh because of limited resources and poor health infrastructure. Post-disaster psychological care services should be developed including screening of affected populations, stratifying interventions on the basis of risk assessment, providing trauma/grief-focused interventions, and monitoring the course of recovery.

Cyclone-prone countries should consider investing in the construction of coastal embankments and the implementation of reforestation programs, as implemented in Bangladesh and other countries. Awareness-building programs provide another example, and many lessons learned from previous cyclones have been put into practice and have saved lives in Bangladesh.

Although observational evidence suggests the absence of any clear trend in the numbers of tropical cyclones in previous years, climate change is likely to cause an increase in the intensity of tropical storms (cyclones/hurricanes/typhoons).[42] It is crucial that other countries that experience regular cyclones consider the Bangladeshi experience in order to minimize the loss of human lives.

Recommendations for mitigation and future research needs

Based on the preceding discussion, we have compiled the following recommendations.

- Instead of developing large cyclone shelters, a dense network of small, sturdy and safe multipurpose buildings should be developed. Considering the population density, cyclone shelters should be established within a 2-km walking distance of a particular household/village. Geographic Information Systems and remote sensing technology should be used to determine the best locations in terms of factors such as access, road networks, and population density. Schools, mosques, local government buildings, or other locations where people congregate represent potential locations for these shelters. This should be given the highest priority in cyclone preparedness programs.

- Bangladesh is now fully covered by mobile telecommunication networks; distributing cyclone warning messages via mobile phones is thus a good option. Colorful hot air balloons can be used to convey cyclone-warning messages in remote and coastal areas of Bangladesh.

- The potential for the breakdown of water and sanitation systems during a cyclone should be considered carefully in the planning, design and implementation of future housing developments. This will help prevent vector- and water-borne disease outbreaks.

- Initiatives to collect and store drinking water should also be considered. Harvesting rain water during a cyclone can be an option.

- Coastal embankment projects should be extended to all coastal areas. Existing embankments should be repaired and maintained. Careful planning with sufficient sluice gates, especially in the southeastern area of Bangladesh, will protect against both flash floods and storm surges during a cyclone,[43] and will also help protect cropland, fisheries and livestock.

- Operational research should be conducted on the precise impacts of cyclone shelters, coastal embankments, and awareness programs on cyclone-related mortality. Additionally, research should be conducted on how to reduce drowning-related deaths during floods caused by cyclones.

- The development of a 500-m coastal mangrove forest zone will further reduce the vulnerability to cyclones, which is especially important given the likelihood of sea level rise and an increase in tropical storm frequency and strength with climate change.[44,45]

- Based on the elevation of houses/residential areas and in relation to nearby streams, maps of areas at high forecasted risk of flooding can be prepared to use during evacuations ahead of cyclone-related coastal surges.

- Planners, policymakers and development practitioners should endeavor to incorporate local knowledge into environmental and adaptation strategies. The building code in coastal zones can be changed to ensure that concrete houses (cinderblock construction) are raised 3 m off the ground. More broadly, a more compact development style may be recommended.

- To increase people's awareness of the severity of cyclone hazards, the Bangladesh government and NGOs should further strengthen the existing awareness program and initiate educational campaigns in coastal districts to ensure prompt utilization of public shelters during cyclones. Awareness should focus on public health and hygiene issues. The awareness program could target primary school children, following the Cuban model, which represents an excellent example for Bangladesh. Some operational research should be conducted in this regard.

- People's misconceptions about the strength of their houses, a lack of interest in moving to a cyclone shelter, and other potential causes of death should be identified through qualitative research. The design and delivery of community cyclone-preparedness education can then be based on these research findings. Community-based volunteer intervention programs should be introduced without further delay.

- Cyclone-related loss in terms of economic and human capital is exacerbated by poverty and poor infrastructure in coastal areas of Bangladesh. Donor agencies, politicians and planners in Bangladesh should take account of this in their future planning of coastal zones.

- Industrialized countries and newly emerging industrialized countries (G20) should provide financial support to vulnerable countries to help them adapt to and mitigate cyclone-related risks. At the same time, all countries should reduce their emissions of carbon dioxide and other greenhouse gases.

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Table 1. **Cyclone severity and deaths in Bangladesh 1960–2010**[9-11]

Year	Number of death	Wind speed	Severity index
1960	8119	210	5
1961	11466	146	5
1963	11520	203	5
1964	196	NA	NA
1965	20152	210	5
1966	850	146	5
1969	75	NA	NA
1970	500300	223	6
1973	183	122	5
1974	50	162	5
1985	11069	154	5
1986	12	100	4
1988	9590	162	5
1989	573	NA	NA
1990	132	102	4
1991	138958	225	6
1994	170	200	5
1995	172	100	4
1996	545	70	3
1997	410	225	6
1998	233	112	4
2007	4234	250	6
2008	15	80	3
2009	197	95	4

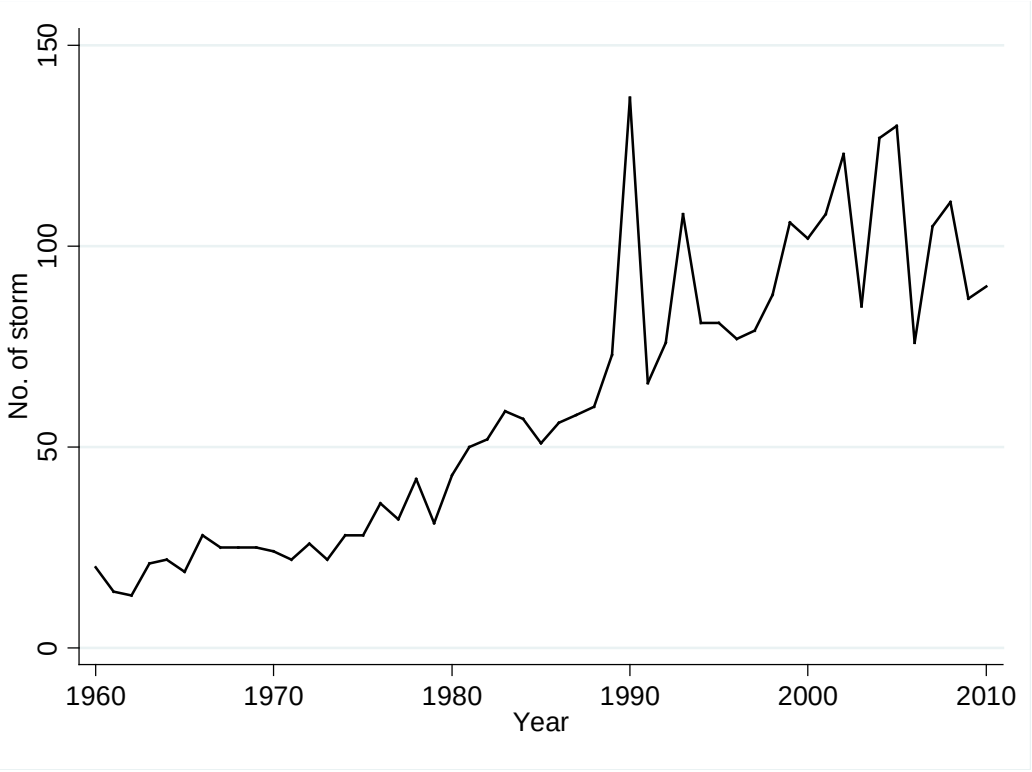

Figure 1: Frequency of cyclones in the world. Created on: Jun-22-2011. Data version: v12.07. Source: EM-DAT, the OFDA/CRED International Disaster Database, Université Catholique de Louvain, Brussels, Belgium (www.emdat.be).