



Bangladesh: Innovation for Universal Health Coverage 5

Reducing the health effect of natural hazards in Bangladesh

Richard A Cash, Shantana R Halder, Mushtuq Husain, Md Sirajul Islam, Fuad H Mallick, Maria A May, Mahmudur Rahman, M Aminur Rahman

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Authors listed alphabetically

Public Health Foundation of India, New Delhi, India

(R A Cash MD); Harvard School of Public Health, Boston, MA, USA (R A Cash);

Comprehensive Disaster Management Programme, Government of Bangladesh, Disaster Management and Relief Bhaban, Dhaka, Bangladesh (S R Halder PhD);

Institute of Epidemiology and Disease Control Research, Dhaka, Bangladesh (M Husain PhD, M Rahman PhD);

Environmental Microbiology Laboratory, International Centre for Diarrhoeal Disease Research, Bangladesh, Dhaka, Bangladesh (M S Islam PhD);

Postgraduate Programs in Disaster Management, Department of Architecture, BRAC University, Dhaka,

Bangladesh, with a population of 151 million people, is a country that is particularly prone to natural disasters: 26% of the population are affected by cyclones and 70% live in flood-prone regions. Mortality and morbidity from these events have fallen substantially in the past 50 years, partly because of improvements in disaster management. Thousands of cyclone shelters have been built and government and civil society have mobilised strategies to provide early warning and respond quickly. Increasingly, flood and cyclone interventions have leveraged community resilience, and general activities for poverty reduction have integrated disaster management. Furthermore, overall population health has improved greatly on the basis of successful public health activities, which has helped to mitigate the effect of natural disasters. Challenges to the maintenance and reduction of the effect of cyclones and floods include rapid urbanisation and the growing effect of global warming. Although the effects of earthquakes are unknown, some efforts to prepare for this type of event are underway.

Introduction

Bangladesh is a country with great geographical vulnerability, with 70% of the population living in regions at risk of floods and 26% in regions at risk of cyclones (figure).² Not only is Bangladesh plagued with natural disasters, its population density makes it especially vulnerable to high rates of mortality and morbidity. With regard to the effect of natural disasters in south Asia in the 1960s–80s, Bangladesh had fewer events than either India or Indonesia, but had the highest overall mortality.³ However, the death rate from floods and cyclones has substantially fallen (table 1).⁹ Through both planned and unplanned interventions, Bangladesh has evolved effective strategies to mitigate the damage of natural disasters on human health and development. This success can be linked to several key insights that guide disaster management efforts: (1) identification of and focus on the greatest drivers of mortality; (2) use of each experience in disaster management to inform and improve strategies for future events; (3) designing of

interventions that draw on existing social capital and self-sufficiency of the community; and (4) viewing of poverty as a key source of vulnerability in disasters, and support of ongoing poverty reduction and development efforts. Application of these principles has enabled the country to establish and continually improve efforts to prepare for, mitigate, and respond to these natural hazards.

Through a large network of public, civil society, and community stakeholders, Bangladesh has distributed capacities and responsibilities broadly, with mechanisms in place to rapidly move information, goods, and financial resources. Disasters can be drivers of poverty, creating greater vulnerability to future risks. Bangladesh has focused on breaking this cycle by integration of disaster recovery and resilience in its overall strategy of poverty reduction.⁹ Present efforts to acknowledge changing social and economic demographics, including specific consideration to urban contexts and increasing availability of technology (such as mobile phones), show the ongoing learning and experimentation at the core of Bangladesh's approach. These insights inform a framework that can be applied globally for improved disaster management.

Floods and cyclones in Bangladesh

In general, disasters create several phases of public health needs: immediate rescue, infrastructural rebuilding, long-term livelihood, and health interventions.⁹ In Bangladesh, floods and cyclones each pose distinct threats to health that need separate consideration. Cyclones, also known as hurricanes or typhoons in different regions of the world, are characterised by sustained, strong winds of more than 63 km/h and the storm surges they create. The high floods of water caused by wind and low pressure, so-called storm surges, have reached up to 10 m in height and cause inland flooding. During high tides, these floods are particularly severe. Most damage and deaths from cyclones are caused by the storm surge;¹⁰ however, by simply moving to a level higher than the

Key messages

- In Bangladesh, the health consequences of floods and cyclones have reduced substantially in the past 40 years
- With improvements in the health of the population through such interventions as high levels of immunisation, knowledge, and use of oral rehydration therapy, and with increased distribution of health care and low-cost drugs, the health effect of natural disasters can be mitigated
- Political commitment, activities of non-governmental organisations, and community mobilisation contribute to Bangladesh's ability to respond to natural hazards
- Data for risks associated with morbidity and mortality from natural disasters should be obtained as soon after the event as possible to inform planners what needs to be done to mitigate the effect of the next natural disaster
- Improvements in preparedness, both before and after disasters, are a continuing process, especially as knowledge and technology improves
- Urbanisation and climate change create new challenges, and earthquakes remain an unaddressed threat

surge—eg, an elevated cyclone shelter—one can remain safe. In situations after cyclones when people remain in crowded shelters without adequate sanitation and sources of clean water, the risk of outbreaks of diarrhoeal disease is increased.¹¹ Because floods move into an area more slowly than do cyclones, they rarely take communities by surprise, but by breaching embankments, they damage or destroy crops, household assets, and infrastructure. Loss of livestock, crops, and fisheries increases poverty and lessens the ability to cope with additional shocks.² The resulting river erosion and loss of biodiversity might render some livelihoods unsustainable.

In the past 42 years, Bangladesh has had five major cyclones and six floods. Great variability is shown in available epidemiological data from each of these events, leading to some difficulty in comparison of effect. Even when some inaccuracies are accounted for, there is a clear decrease in death rate between the Bhola cyclone (1970), which resulted in at least 225 000 deaths, and the recent cyclones Sidr (2007) and Aila (2009), with 3400 and 190 deaths, respectively.^{2,4} This reduction could be attributable to a confluence of several factors: increasing overall health and development gain, and improved disaster management.

Identification of opportunities for effective intervention

For all natural hazards, the immediate goal is to reduce mortality and morbidity and the longer-term goal is to reduce the time needed to recover and regain self-sufficiency. Natural disasters create an extreme environment in which health is threatened by a few key factors. The strategies for mitigation of the effect of disasters usually fall into three categories: preparedness or risk reduction, readiness, and response. The relative importance of interventions in each category is dependent on the characteristics of the type of hazard (table 2).

The distribution of consequences is defined by several factors, ranging from individual and community-level characteristics to the macro-level infrastructure. One way to explain the importance of risk in the effect of a hazard is the equation: vulnerability + hazard = effect. Vulnerability can be defined as “the differential capacity of groups and individuals to deal with hazards, based on their positions within physical and social worlds.”¹² Women, elderly people, and children are most likely to die in natural disasters.⁴ Low-income households are also at risk because their homes offer the least protection. Many of these vulnerabilities can be mitigated through pre-disaster interventions, such as the creation of proximate shelters, dissemination of information, and mobilisation of at-risk households before the storm or flood (panel 1). Improvements in communication infrastructure, including increased ownership of mobile phones, have created new routes to inform individuals and communities about incoming

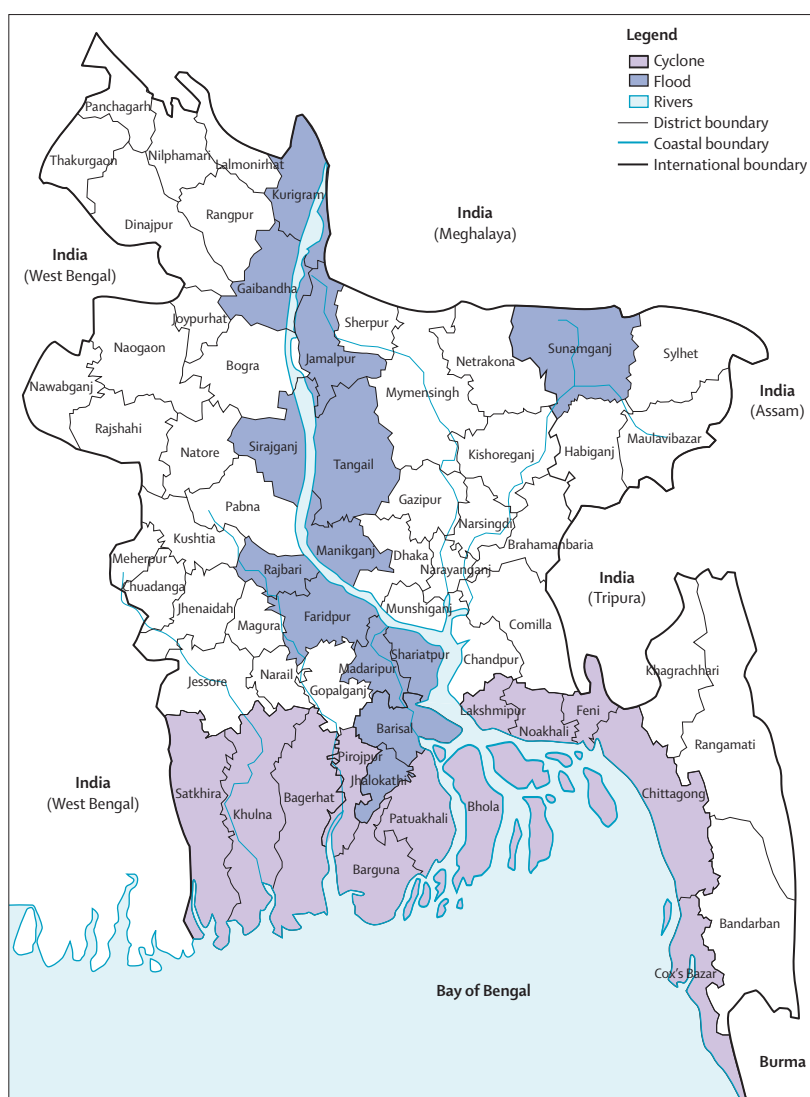


Figure: Disaster-prone regions of Bangladesh, by district¹

	Type of hazard	Proportion (%) of total region or population affected (n)	Height of storm surge (m)	Deaths (n)
1970	Bhola cyclone ⁴	..	6–10	225 000–500 000
1974	Flood ⁵	35.4%	NA	..
1985	Cyclone ²	167 500	3–4.6	11 000
1987	Flood ⁵	38.6%	NA	1657
1988	Flood ⁵	52.4%	NA	2379
1991	Cyclone Gorky ²	4.56 million	6–7.6	138 000
1998	Flood ⁵	67.4%	NA	918
2004	Flood ⁷	25%	NA	<800
2007	Cyclone Sidr ²	18.3 million	4.5–6.1	3300
2009	Cyclone Aila ^{2,8}	3.9 million	2–3	190

NA=not applicable.

Table 1: Notable events in the history of Bangladesh

Bangladesh (F H Mallick PhD, M A Rahman MA); **Social Innovation Lab, BRAC, BRAC Center, Dhaka, Bangladesh** (M A May BA)

Correspondence to: Maria May, Social Innovation Lab, BRAC, BRAC Center, Dhaka 1212, Bangladesh maria.a@brac.net

	Flood	Cyclone
Frequency	Seasonal	Seasonal
Average advance notice	Predictable	Restricted
Duration of event	Days or weeks	Hours
Moments of high risk	Slowly rising waters	Storm surge
Potential long-term effects	Damage to constructed facilities, river erosion, salinity, damage to water supply, livelihood damage	Damage to constructed facilities, infrastructure, waterlogging
Preparation	Embankments, shelters, and elevated homesteads	Two-storey shelters and raising of awareness to seek shelter
Readiness	Evacuation to nearby high ground, flood shelters when appropriate, supplying of water and food, and movement of assets to higher ground	Evacuation to nearby shelters
Response	Rehabilitation of water sources, provision of food support and agricultural resources (several months of assistance, particularly for food, might be needed)	Provision of water and food in the immediate aftermath, and of cash, work, or materials to rebuild houses

Table 2: Characteristics and responses to floods versus cyclones

Panel 1: Creation of systems for rapid response: Bangladesh's strategy for disaster management

Timely action is crucial to prevent mortality and morbidity in disaster situations.¹³ Bangladesh's rapid mobilisation is the result of robust policy and coordination at the highest levels. These strategies explicitly include community engagement and localised decision making. These policies are vital in the context of a country with a restricted communications infrastructure.¹³

The beginning of the present architecture began with the formation of the Cyclone Preparedness Programme (CPP) in 1972. Early efforts included the training of more than 38 000 local volunteers who communicated with a transceiver telecommunication network of coastal stations. The CPP has grown to cover 19 districts in the coastal area (population of 50 million). The headquarters are in Dhaka and receive warnings of approaching cyclones from the Bangladesh Meteorological Department. This information is disseminated to all offices and units (see below). Unit-level staff issue the warnings via the radio network and hoist cyclone warning flags. Team leaders and local volunteers move through villages to distribute the messages with megaphones and hand sirens, and local media broadcast information on their channels.¹³

Network of responders

One head office → seven regional stations → 37 subdistrict offices → 322 union-level offices → 2845 units → 49 632 volunteers

In 2004, Bangladesh established the Comprehensive Disaster Management Plan (CDMP) to supplement the coordination of the CPP and create additional institutional capacity and resources. The structure was decentralised, from its inception; much of the focus was on creation of a local capacity of 600 000 inhabitants in high-risk communities and public-sector staff operating in these regions. In 2010, CDMP expanded to cover 5 million people. More than half the present 5-year budget of CDMP is allocated to rural risk reduction and strengthening of community resilience. Particular emphasis is placed on support of groups that historically have fared the worst during hazards, such as fishermen, weavers, char dwellers, and those in waterlogged regions.

Management of natural disasters is also incorporated into other national strategies. The direct effect of such disasters on health and poverty is acknowledged in the poverty reduction strategy, as is the importance of enhancement of community capacity as a key strategy to combat both poverty and the consequences of natural disasters.¹⁴

storms and what they should do. General health is also an important factor. Improvements in immunisation coverage, health-care systems, nutrition, water and sanitation, availability of low-cost effective drugs, and the home-based treatment of diarrhoea are some factors that have improved the ability of individuals and the community to cope with natural disasters.¹¹

After the disaster, much can be done to reduce the short-term and long-term consequences. Provision of potable water is the most crucial intervention, followed by provision of food, health care, and other necessary relief services, with distribution strategies to ensure that these approaches reach the people in greatest need.¹⁰ High levels of individual and community resilience enable more rapid use of immediate assistance to effectively regain self-dependence. A pertinent definition of resilience is, "the ability of an actor to cope with or adapt to hazard stress. It is a product of the degree of planned preparation undertaken in light of a potential hazard, and of spontaneous or premeditated adjustments made in response to felt hazard, including relief and rescue."¹⁵

Focus on communities

Community capital can be an important factor to reduce vulnerability and mitigate existing inequalities. Much of Bangladesh's response strategies focus on the community and support existing coping strategies.¹⁴ Findings from qualitative research frequently suggest that the community is an important safety net; people are often reluctant to seek shelter if it means separation from a group.¹⁶ Informal loans, and sharing of transportation and scarce resources are examples of communities creating economies of scale and distributing the benefits.¹⁷ Many disaster victims received assistance from their relatives (79%) and community members (33%).¹⁶ Communities in regions of high vulnerability might develop distinct practices of agriculture, animal husbandry, and water storage that increase their ability to survive and thrive in a risky environment.¹⁸

Learning from experience: evolving strategies for disaster management

Cyclones

For disaster management, several interrelated systems need to work together in times of crisis, with very little advance notice. Opportunities to pilot or test strategies are restricted. The various responders to cyclones, including local non-governmental organisations (NGOs) and the Government of Bangladesh, have developed a discipline that involved reflection on natural disasters and responses to identify patterns of death to improve its systems for the future. Because storm surges account for most mortality from cyclones, preparedness and readiness activities should attempt to prevent drowning and trauma. An early readiness strategy in Bangladesh has been to encourage people to move to safer places in a timely way to immediately reduce mortality and morbidity. After the disaster, priorities shift to returning people to their homes, to provision of potable water and immediate food relief, and to rebuilding of communities.

The Bhola cyclone that hit Bangladesh (then East Pakistan) in 1970 shows the destructive demographic and political consequences of a cyclone. Wind speeds reached 362 km/h with a storm surge height of 10 m in some regions.² With restricted communication infrastructure or ability to forecast the cyclone's path, no evacuation or warning notifications were issued. Rapid epidemiological surveillance showed a mortality rate of about 16·5%, with disproportionate numbers of deaths in women, children, and elderly people.⁴ Most people died during the storm surge. No major disease outbreaks were reported, and because the physically weaker members of the population had perished, the overall health of survivors was better than those in nearby unaffected areas.⁴ With more than 180 000 homes destroyed, fishing boats lost, and draught animals killed, the real challenges were in helping communities to regain their agricultural self-sufficiency and other means of livelihood and shelter.⁴

In the 1980s, cyclone shelters were built in highly vulnerable regions (panel 2). In 1991, Cyclone Gorky ripped through Bangladesh, claiming 138 000 lives.² Storm warnings were issued through many channels and reached almost all people at risk; however, the messages were the standard type designed for port damage and were difficult for many to interpret. Some speculated that because communities often received urgent messages, they no longer heeded the guidance provided through these services.²⁰ Furthermore, mobilisation efforts were cash starved because the government's budget allocated about 0·24 Bangladeshi taka (US\$0·50) per person in cyclone-prone regions.²¹ Nationally, there were only 300 storm shelters in the most vulnerable subdistricts²⁰ and 60% were non-functional because of inadequate maintenance and flooding.¹³ Death rates were lowest for people who took refuge in two-storey concrete buildings (particularly formal shelters).²⁰ Some findings showed

that cyclone shelters tended to be built near the homes of wealthier residents and were difficult for poor households to access.²¹ Most local houses offered little protection, because they were made of bamboo and thatch. Many people chose not to leave their home through fear of losing their livestock (panel 2) or because they misunderstood when the cyclone would arrive.^{22,23} Nearly 40% of children who did not reach shelters died.²² Overall, only 33% of people sought shelter before the storm.²³

Immediately after the cyclone, NGOs responded with emergency relief, providing dry food, clothing, medical treatment, and water.²⁴ In the worst affected districts, commissioners were stationed at sub-district and even union level to assess the damage, manage local relief activities, and provide consistent feedback on progress. The government divided the unions between NGOs to avoid duplication. Poor access to potable water, compounded by insufficient sanitation facilities, was a critical health issue, particularly on islands. However, mortality after the cyclone was small compared with that caused by the cyclone itself.²⁵ In addition to provision of water, relief agencies also distributed oral rehydration packets. Immediate efforts were taken to clean contaminated ponds and restore tube wells.

The cost per death averted by cyclone shelters was \$80.²⁵ Many people advocated for expansion of facilities, but in view of the large number of shelters that had become unusable, improvements in design were needed. Construction guidelines recommended provision of 0·6 m² per person, which would allow a person to remain at the shelter for the storm surge (lasting a few hours),

Panel 2: Innovations in the design of cyclone shelters

The greatest issue with the first generation of shelters was the poor maintenance, which often rendered facilities unusable. Despite evidence showing that evacuation to a cyclone shelter greatly reduces mortality, many people chose to remain in their homes. A new design was needed that retained functionality and was attractive to local households.

The new strategy for cyclone shelters insures that they have various uses, such as for schools, government buildings, or community centres. The space is maintained because it is important for daily use, and families are aware of where to seek shelter during a storm. Some families still remain at home because they refuse to abandon their livestock, often their most important asset. In the past few years, designs for multipurpose cyclone shelters with provisions for cattle and livestock have been piloted. The decision to scale up will require difficult choices. One cow needs 2·4–3 m² of space—the same amount needed for two to four people, and some of the designs are fairly costly to construct.¹⁹

Additionally, architects have begun to think about how to construct houses and infrastructure that are more likely to withstand cyclones, terming the concept Disaster Resilient Habitat (DRH).¹⁹ The largest DRH project to date is in Shyamnagar, a region destroyed by Cyclone Aila in 2009. Efforts were taken to combine the building skills of the community with technical knowledge from architects and engineers. The house owners voluntarily participated in the design, construction, and management processes. 43 houses and a school were built with a reinforced concrete frame at the base. Although high winds might blow away weak parts of the house, the basic structure will remain, allowing for faster reconstruction. From a cost perspective, this strategy seems to be similar or favourable to cyclone shelters.

and to locate shelters so they were no more than 1.5 km from any community.¹⁹ To ensure maintenance, a building would have to have various purposes (panel 2). By framing shelters as schools, community centres, training facilities,

or health centres, these buildings were used more and were better known. In some regions, shelters were built to include room for livestock, because people would be more likely to relocate if they did not have to abandon their animals. So far, 3500 designated cyclone shelters have been built in Bangladesh's coastal regions.¹³

Cyclone Sidr struck in 2007 (panel 3). Although the infrastructure and asset losses were great, the total death toll of 3400 was almost a hundred times less than that from the 1970 cyclone.¹⁴ Two factors contributing to the reduced mortality were the trajectory of Cyclone Sidr and the level of the tides. The cyclone first struck the Sundarbans, where population density is fairly low, and the dense tree line buffered some of the winds; tides were only 2 m instead of a possible 8–12 m at the time of storm surge. Improved satellite imaging enabled officials to track the storm and issue warnings, a capability which was later considered a pivotal activity in reducing mortality from the event.²⁸ The Cyclone Preparedness Programme had 44000 volunteers within the communities who helped to ensure awareness and shelter seeking.¹² Although some communities still had restricted access to a shelter, roughly 1.5 million people used a cyclone shelter.^{13,14}

After Cyclone Sidr, the press and the media widely disseminated information. Volunteers from the Cyclone Preparedness Programme undertook search and rescue efforts, provided first aid, and assisted in emergency relief operations of the earliest responding institutions. The government provided food to more than 5.6 million people in affected districts, with NGOs reaching another 5.3 million.¹⁴ The army helped with delivery of temporary

Panel 3: Cyclone Sidr

Cyclone Sidr, which struck Bangladesh on Nov 15, 2007, affected 12 districts in southwestern Bangladesh. Home to 18.3 million people (12% of Bangladesh's total population), the region had storm surges of up to 6 m in height and winds reaching 240 km/h.¹⁴ The accompanying floods and high winds felled many trees and destroyed homes. About 3400 people were killed and an additional 55 000 injured.¹⁴

In the days before the cyclone, widespread efforts were made to notify communities of the approaching danger. The Bangladesh Meteorological Department issued increasingly intense cyclone warnings and 44 000 volunteers disseminated information at the local level via megaphones and other means, urging people to move to local shelters or to multistorey concrete buildings.¹⁴ Compared with previous cyclones, the Bangladesh Government quickly mobilised multilateral and civil-society partners to undertake quick but thorough needs assessments, enabling more effective relief efforts. The UN World Food Programme ran a food security assessment in parallel, in which respondents listed food (95%), cash (68%), and clothes and blankets (60%) as immediate needs.¹⁴ BRAC had 240 local community health workers who responded just hours after the storm passed.²⁶ Major health challenges in the immediate aftermath were related to water and sanitation. Most individuals relied on tube wells for their water, many of which were contaminated by debris or salt water from the tidal surges. Pit latrines—the main type of sanitation facility—overflowed, thus increasing the risk of waterborne diseases. Although no notable disease outbreaks were reported after the storm, increases were noted in the incidence of diarrhoea, respiratory tract infections, eye infections, skin diseases, and fever.¹⁴

The Government of Bangladesh, working with several multilateral partners and civil-society groups, coordinated the immediate response, which focused on food aid, water and sanitation, shelter and disease surveillance. In view of the long-term nutritional consequences of past natural hazards, vitamins and food supplements with micronutrients were provided, especially to children and pregnant or lactating women. Relief efforts were challenged by damaged roads, difficulty of charging mobile phones in affected regions, and the shortages of labour that led to very high wages.²⁶

Public-sector health providers from nearby districts were dispatched to help. Additionally, many civil-society groups sent medical teams and set up medical camps. The armed forces responded immediately, providing search and rescue, helping bury the dead, and removing dead livestock. The storm's toll on livestock and poultry was intense; in four districts, 80% of livestock and domestic birds were killed.¹⁴ National microfinance lenders waived loan payments for affected households. Half a million houses were completely destroyed, with about 900 000 substantially damaged.²⁷ Although funds were quickly mobilised to help the most vulnerable people rebuild their home, an assessment noted that the new homes were similar to those that had stood before (rather than reinforced or strengthened), and would therefore be likely to suffer the same level of damage in future storms.¹⁴ In agriculture, more than 2 million farming families were affected and many fisheries destroyed.

Because thousands of schools were ruined, the Government of Bangladesh supported rapid development of temporary programmes in makeshift structures, providing new books and study materials, waiving examination fees, and rescheduling public examinations. Local government and schools had great autonomy in terms of how to allocate resources. Within 6 months, more than 80% of schools had regained functionality. Most businesses were small to medium enterprises scattered geographically. Sawmills, rice mills, ice factories, and brick and tile and pottery factories were the most affected industries and, on average, businesses remained closed for almost 6 weeks. However, within 3 months, 80% of businesses were back in operation.¹⁴

Panel 4: A low-cost intervention to decontaminate water after a disaster

Implementation of a point-of-use strategy for water treatment during natural disasters can reduce levels of contamination of drinking water and prevent outbreaks of waterborne illnesses that cause diarrhoea. When alum potash is added to contaminated water, it coagulates the organic matter and settles to the bottom of the container or tank, making water transparent but acidic and unpalatable. When lime is added, the acidity of the mixture is reduced and the water can be consumed safely and enjoyably.

During the 2004 floods, scientists at the International Centre for Diarrhoeal Disease Research, Bangladesh discovered the effectiveness of this mixture of alum potash, bleaching powder, and lime. Field tests have shown that so-called Siraj mixture, named after its developer, was culturally accepted, affordable, and effective in preventing diarrhoea in the community.²⁹ The mixture is packaged in an amount that will purify the contents of a standard water-storage container in rural Bangladesh (ie, 15 L), weighs 3–4 g, and costs US\$0.05. BRAC used this novel mixture to combat waterborne diseases in its relief response after Cyclone Sidr in 2007.

medical services and human resources. Some NGOs quickly transitioned from the provision of water to methods to purify water (panel 4), and provided ready-to-eat foods and other necessities, such as fuel and matches. A rapid epidemiological assessment after the hazard predicted that 1.5 million people had a heightened risk of communicable disease, yet no cholera outbreaks were reported.¹⁴ Unexpectedly, high-income households in affected areas had the highest rate of post-cyclone illness, particularly in women and children;²⁷ however, this finding might be a reporting bias. The UN World Food Programme noted that the most urgently needed forms of support were food (95%), money (68%), and clothing and blankets (60%).¹⁴ 500 000 homes were destroyed and another 900 000 were heavily damaged;²⁷ as such, many people had to live in tents or improvised temporary shelters.

Residents of affected communities began to create local commercial opportunities. BRAC (the world's largest NGO) moved to cash transfers (instead of in-kind relief), noting that local markets quickly initiated the movement of food and other commodities to affected areas. The cash transfers allowed households to focus on their own needs, and transfers were much less costly than was direct distribution of food and other goods. The government provided small rebuilding grants and shelters to help families re-establish their livelihoods.^{14,27} Large microfinance organisations, including Grameen, Association for Social Advancement (ASA), and BRAC, forgave loans for many victims.

With more than 7000 schools partly or completely destroyed, the government mandated that temporary structures be erected and new textbooks distributed to rehabilitate schools as quickly as possible. Within 4 months of the cyclone, 90% of schools were rebuilt. Losses within the agriculture and fishery industries—mainstays of the local economy—were substantial. The scarcity of communication, electricity, and other crucial services brought other industries to a temporary halt. Whereas overall recovery was fairly quick, some

individuals needed longer-term assistance to regain self-sufficiency. More than 4 million vulnerable households received 6 months of continued food relief assistance.¹⁴ Although no major cyclones have affected Bangladesh in the past 3 years, efforts are underway to create preparedness strategies that allow communities to better protect their assets, particularly their homes and schools, from the destruction of storm surges (panel 2). The overall approach to cyclone management suggests learning over several decades of experience (table 3).

Floods

Floods pose many different challenges to health (table 2). Risk of immediate mortality is lower with floods than for cyclones, but floods insidiously disrupt community activities, ruin crops, and need long-term assistance for affected populations to regain self-sufficiency. In 1988, half of Bangladesh was submerged, affecting 30 million people.⁶ More than 172 000 livestock were lost and 7 million households suffered partial or complete damage.¹⁶ Diarrhoeal disease was the major cause of illness, accounting for 35% of the 45 000 hospital admissions and 27% of 154 reported deaths,³⁰ although the reliability of the data is questionable. Most people remained in their homes, either because they had no viable options for designated shelters or because they wanted to stay to protect their assets. Creation of raised homesteads, from earthen materials or a plinth, was a fairly effective household strategy to remain safe during flooding. Some people raised their gardens so that in the case of floods, their produce would be preserved.

A decade later, a flood covered almost two-thirds of the country for an average of 8–9 weeks (panel 5). 33 million people were affected and 18 million needed emergency provision of food and drinking water.⁵ 500 diarrhoea-related deaths were reported.⁵ In one study done to assess the extent of losses, BRAC found that members of its rural microfinance programme lost on average

	Issues and experiences	New innovations applied	Action after event
Cyclone Bhola (1970)	Urgent need for more cyclone shelters	..	300 cyclone shelters built in highly vulnerable areas
Cyclone Gorky (1991)	People did not heed warning messages, cyclone shelters were often ill maintained and positioned to be convenient to wealthy households, and many people were reluctant to leave home or livestock	The government divided NGO relief efforts geographically	Multipurpose cyclone shelters were better maintained—the total number of shelters available increased substantially; the Cyclone Preparedness Programme recruited 44 000 volunteers to communicate information about cyclones and mobilise communities to shelters
Cyclone Sidr (2007)	..	Satellite imaging was used to track the storm; the media were involved in relief strategies, such as helping to find missing people; NGOs began to provide cash to affected households, instead of just relief items	..

NGO=non-governmental organisation.

Table 3: Major learning and innovations in cyclone management

45% of total household assets. An absence of information sharing between responding NGOs resulted in incorrect estimates of the extent of the damage and the distribution of needs.⁶

The 1998 floods had an unprecedented effect on Dhaka and its infrastructure. Roads, sewage systems, and blocked drainage increased health risks for the entire city, particularly for people in low-lying regions and slums. Commercial activity almost completely stopped for several weeks. People took shelter on their roofs and in small boats, and schools, community

centres, and construction sites were converted into temporary shelters.⁶ Families often sought shelter with their neighbours. Access to safe drinking water was a major challenge, particularly for families who could not afford to buy it from people who owned uncontaminated tube wells. In some cases, landlords opened the main tap for water collection. NGOs distributed alum and water-purification tablets, but some people strongly disliked the taste of treated water.⁶ Many individuals collected water from schools, mosques, or other places where water was stored, boiled, or distributed with water-purifying tablets.⁶ Sanitation was another major issue, particularly for women and girls.

In 2004, another massive flood affected 38 of Bangladesh's 64 districts. About 36 million people (25% of the population) were affected, including residents of Dhaka.⁷ Basic emergency health supplies were distributed widely in rural regions and among slum dwellers in Dhaka. The damage sustained by staple crops, such as rice, and in the poultry and fishery sectors, prolonged the food insecurity and poverty.⁷ Some support for seeds and fertilisers were provided by the Government Agricultural Rehabilitation Programme. Overall, almost 1 million houses were destroyed and 1.4 million badly damaged. Families mostly rebuilt their homes independently with cash gained through loans or income.⁷ Affected communities advocated (unsuccessfully) for the provision of food-for-work or cash-for-work programmes.⁷

Rapid assessment of the health effects of disasters is essential for the quick and effective allocation of restricted resources (panel 6). Although diarrhoeal disease is reported to be the leading cause of mortality during floods in Bangladesh, in more recent floods, fewer outbreaks or deaths from diarrhoea have been reported in rural areas.³⁰ However, urban areas are much more vulnerable to post-flood outbreaks of diarrhoeal disease because of the population density and contamination of vulnerable water supplies due to a overburdened infrastructure.

Compared with cyclone shelters (where people stay for only a few hours), flood shelters need more space per person and greater attention to facilities for sanitation and livestock.³¹ Building on the success of multipurpose cyclone shelters, in 2005, the government constructed 181 three-storied school buildings-cum-flood shelters and converted an additional 179 existing buildings to provide similar functions in particularly flood-prone regions (unpublished). These shelters are functional, but also costly, at about \$365 per household. In other regions, efforts have been made to strengthen individual households (table 4). In the chars (unstable islands formed of silt deposits) more than 75 000 households have been flood proofed by raising the plinth to at least 0.06 m higher than the highest known flood level.³² Although families voice a preference for flood proofing of homes versus moving to shelters, the cost of home fortification is about \$122—beyond the reach of most rural households.³¹

Panel 5: The 1998 flood

The worst flood in Bangladesh's recent history took place from July to September, 1998. With two-thirds of the country submerged, families struggled to find shelter for themselves and their livestock.³ Some communities were marooned for up to 2 months. With many roads submerged and much of the country affected, emergency response activities were scarce. Fewer than 1000 people died, but many individuals had acute morbidity and longer-term health issues.⁵ Immediate health issues included respiratory infections, skin diseases, and diarrhoea.⁵

Acquisition of drinking water, food, and fuel were daily challenges for many people. Rural households often had some existing food stocks at home from the previous harvest; however, the urban poor kept little food at home and prices rose substantially. Staple foods in Bangladesh, such as rice and lentils, need cooking and for most individuals, fuel typically consisted of brush and sticks, but even these resources were scarce.⁵ When possible, households opted for dry foods that needed no preparation. Many sources of water were submerged and methods of purification were restricted—boiling required use of precious fuel; furthermore, alum tablets were not universally available. Most people used the floodwater for urination and defecation (women sometimes used a bag or paper indoors then disposed of it in the water), bathing, and collection of water (at least for washing dishes if not for drinking).⁵ Staple crops of aman rice were largely destroyed for the season. In regions that were accustomed to annual flooding (at a moderate level), a deep water variety of aman was often grown that could withstand some degree of flooding.

Day labourers faced almost 2 months of unemployment.⁵ Many street vendors and rickshaw drivers saw their carts or vans destroyed in the flood. Women, whose informal work options included tailoring and domestic work, had few alternative options for earning during the flood. Some factories reopened and expected individuals to come to work.⁶ Cost of living in urban regions was a concern for many, particularly because tenants were expected to pay their rent throughout and had to purchase goods and foods from the market at inflated prices. In rural regions, fishing continued for some, but in general, many households had to rely on money lenders and relatives to get through the crisis.⁵ Families coveted their livestock and often would share their food with the animals because their food options were also few. In some cases, wealthier families shared food and other goods with their poorer neighbours, and communities worked together to access relief materials and available supplies. Although many non-governmental organisations (NGOs) and the government tried to provide relief, the scale of activity was often insufficient for the needs of the community.⁵

Most schools were closed for 1 month or more, and even NGO offices were badly damaged, impeding their ability to work in the most affected regions. Microfinance institutions did not have policies on repayment after disasters. Some institutions pressured clients to maintain the payment schedule whereas others went so far as to forgive the loans. The flooding led some people to move to shelters, which caused other issues such as an increase in intimate partner violence and sexual violence, particularly when crowding meant that men and women had to stay in close proximity.

Future issues

Geographically, Bangladesh is highly vulnerable to climate change. In the next few years, the country will probably experience more extreme river flooding, more intense cyclones, rising sea levels, and very high temperatures.³³ Because crops are affected, food security might emerge as a renewed threat. Urban dwellers will face increased health risks and vulnerability during natural hazards. In early 2013, Bangladesh's risk for an earthquake was emphasised.³⁴ Worldwide, earthquakes account for 60% of deaths caused by natural disasters, and cities in developing countries are particularly vulnerable because of the combination of population density, weak infrastructure, and substandard buildings.³⁴ Bangladesh's two largest cities, Dhaka and Chittagong, are no exception, and many of their 849 hospitals would be rendered non-functional in the event of a serious earthquake.³⁴

Two major fault lines run through Bangladesh, one 144 km and the other 370 km from Dhaka. Bangladesh has had several fairly mild earthquakes, such as one in 2001 that measured 4.0 on the Richter scale. To date, deaths and damage from earthquakes have been few. Rapid urbanisation without proper planning and regulation has created a highly vulnerable building stock. With rapid migration to cities, enforcing of regulations has been a challenge. A national building code with earthquake-related guidelines was published in 1993 and approved by parliament in 2006, but it has been largely ignored or inconsistently enforced.³⁵ Dhaka's Metropolitan Development Plan states that many flood-flow zones would be off limits to new buildings, but unauthorised buildings continue to appear in these areas. Sites of former bodies of water—small ponds, lakes, and canals—are often illegally reclaimed. Although experts in urban geology emphasise the importance of pre-construction testing of soil, few people seem to heed these recommendations, leading to construction taking

place on loose soil or in areas filled with sand and waste.³⁶ In the event of an earthquake, this land will be unable to sustain a building's weight, leading to extensive damage and probable loss of life. The Government of Bangladesh is recruiting 62 000 urban community volunteers to be disaster responders.³⁴ However, if a severe earthquake were to strike Dhaka, casualties could be hundreds of thousands and the ability of a response strategy to mitigate the catastrophe would be low.

Lessons learned

The successes in Bangladesh's approach can be linked to several key insights that guide disaster management efforts: (1) identification and aversion or mitigation of phases with the greatest rates of morbidity and mortality; (2) assessment of previous experiences in disaster management to ascertain opportunity for improvement; (3) recognition of the importance of social capital and self-sufficiency of the community, and designing of interventions to leverage or rebuild it in the context of disasters; (4) recognition that poverty reduction and development are crucial in the ongoing processes with clear benefits for disaster management.

The experiences in Bangladesh show that even with restricted resources, the effect of natural hazards on health can still be greatly reduced. The effect of public health programmes that emphasised immunisations, low-cost drugs, nutritional interventions, and home care have most likely contributed to reducing the health impact of cyclones and floods.^{37–40} Substantial improvements have been made in overall infrastructure, education, and communications, which have reduced vulnerability overall. Instead of focusing solely on individuals, Bangladesh has put more attention on households and communities in its prevention, response, and recovery strategies, which reduces the need for temporary shelters and camps (which can themselves create disease risks) and encourages rapid rejuvenation of markets and livelihoods.

Iterative learning, both formally and informally, is crucial. Attention to epidemiological patterns, through the collection of data during and immediately after disasters, has enabled policy makers to identify causes and vulnerabilities of morbidity and mortality and implement evidence-based practices in disaster management. The creation of more than 3500 cyclone shelters, embedded in efforts to train local volunteers and educate communities about warning systems, is a good example of a successful system that improves with experience.¹³ Distribution of water or water-purification methods has been an essential priority, ensuring that food, and when necessary, shelter, can follow. Demonstration of effective mechanisms, often through NGOs designated by the government, to provide for the immediate needs of water and food, and for the provision of money, is another important lesson to help families return quickly to their homes. Additionally,

Panel 6: Systems for surveillance after disasters

The Institute of Epidemiology, Disease Control and Research (IEDCR) is a government institute mandated to undertake disease surveillance and outbreak response. Health data are obtained and compiled at IEDCR throughout the year through routine and several specialised surveillance systems. From the start of any outbreak or natural disaster, IEDCR institutes specific surveillance of the health event. In the floods of 2004, IEDCR set up a surveillance system to document outbreaks of diarrhoea throughout the country (unpublished). Shortly after Cyclone Sidr in 2007, the institute did a joint rapid needs assessment (unpublished). In addition to informing the immediate response of the government and its partners, IEDCR undertakes research to assess how the health system functions after a disaster. With chronic disorders on the rise, investment in protection and resilience of the health system can insure that patients receive continuous treatment during natural disasters.

For more on the IEDCR see <http://www.iedcr.org/>

	Issues and experiences	New innovations applied	Action after event
1988 flood	Many livestock were killed and post-flood diarrhoea led to many deaths and hospital admissions	..	Some families independently flood proofed their homes
1998	Insufficient sharing of information between NGOs created inefficiencies in relief efforts; urban dwellers faced substantial health and sanitation issues	Drinking water and food were distributed to millions of households	Informal urban coping strategies took place in some places
2004	Staple crops and fisheries were affected in many regions	Emergency health supplies were widely distributed and support for seed and fertiliser was provided to many rural households	Several hundred flood shelters were constructed and some houses in vulnerable regions were flood proofed

NGO=non-governmental organisation.

Table 4: Major learning and examples of innovations in flood management

avoiding of overcrowding in affected populations reduces the likelihood of disease outbreaks.

The success of disaster management with floods is more nuanced than for cyclones; floods usually affect a much larger proportion of the population, have a different time frame, and need fairly long-term assistance. Less explicit use of community capital has been shown in flood management, compared with cyclone strategies that systematically engage thousands of local volunteers. Community ability to absorb cash and re-establish local markets and livelihoods seems to be high.⁵ One of the greatest drivers of Bangladesh's success is the residents themselves. Informal sharing of resources and collective activities of rebuilding are the rule rather than the exception.

Limitations

Comparing outcomes between different disasters can be problematic because the effect is most often dependent on other factors over which human beings have little control. Where a cyclone makes landfall; the time of day it strikes, especially related to tides; and its path will all have a major bearing on the extent of destruction. In Bangladesh, studies examining levels and causes of morbidity are also problematic because data collection is often episodic and has only become more routine in the past few years. Mental-health status after disasters has not been assessed to any noteworthy level. Findings from some studies of natural hazards show that quickly returning home can reduce mental trauma after disasters.⁴¹

To date, disaster policies in Bangladesh have focused on rural villages, but the rapid growth of cities has created a need for development of urban strategies for disaster management. Despite these limitations, examination of the association between health and natural disasters in Bangladesh from a historical perspective has a great deal to offer to present efforts in disaster management.

Conclusions

Within its resource constraints, Bangladesh has achieved good results in mitigation of adverse effects on health from natural disasters. We believe these results are mainly due to applied insights, including the coordination of

poverty reduction with disaster management, learning from each experience, focusing on regions where the effect of interventions is likely to be highest, and focusing on community resilience. We have identified several ways to build on successes to further protect the health of the population. First, after disaster, urban regions are more vulnerable to outbreaks of infectious disease than are rural regions, especially diarrhoea. Furthermore, urban regions need distinct plans to ensure potable water and sanitation, and to prevent crowding to the greatest extent possible. Second, geographically, Bangladesh remains vulnerable to earthquakes. Its high population density in both urban and rural regions; the scarcity of enforcement of building codes; the high number of vulnerable buildings; and a greatly overstretched infrastructure of roads, electricity, and water makes the country especially vulnerable to the effect of earthquakes. Enforcement of land usage and building codes should be bolstered to prevent catastrophic consequences of an earthquake. Third, many people are unidentified in Bangladesh's national birth and death registries. Development of the database to enable identification of every citizen and place of residence will greatly improve the ability of government to further define at-risk populations and appropriate interventions. Fourth, people receiving long-term treatment often have their immediate needs compromised by natural disasters and subsequent damage to the health system. Creation of mechanisms to deliver care or empower patients to maintain adherence should be strengthened. Fifth, use of robust surveillance systems before and after disaster creates a baseline and the ability to understand the precise effects of disasters so that relief efforts can be maximised both in terms of timing and effectiveness. Sixth, Bangladesh should continue to expand use of mobile phones to provide early warning to communities, assess health status and needs, and provide advice about how to minimise the post-disaster risk to health, especially about ways to improve water quality and quantity.

Contributors

All authors contributed to initial discussions, development of an outline, and literature review. MAM and RAC wrote the body of the paper, panel 3, and panel 5. SRH wrote panel 1, FHM and MAR wrote panel 2, SI wrote panel 4, and MH and MR wrote panel 6. MAM prepared the tables with assistance from RAC and MAR. All authors reviewed and edited the paper.

Conflicts of interest

We declare that we have no conflicts of interest.

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