









REVIEW PAPER

Water-related diseases following flooding in South Asian countries – a healthcare crisis

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ABSTRACT

Introduction and aim. Industrialization and elevated greenhouse gas emissions pose significant threats to the environment, raising atmospheric carbon dioxide levels and leading to climate change. Climate change may impact human health either directly via increasing extreme weather frequency and altering disease patterns or indirectly via social institutions and disrupted global supply chain resulting in consequences like undernutrition

Material and methods. This review conducted a comprehensive literature search on PubMed, Google Scholar, and Cochrane Library, from inception to September 2022, using relevant keywords.

Analysis of the literature. Massive flooding in South Asia is leading to a surge in water-related diseases. *Cholera* outbreaks have occurred in countries like Pakistan, India, and Bangladesh following floods, and waterborne diseases like typhoid, rotavirus, hepatitis A, and leptospirosis are prevalent in flood-affected regions. Additionally, *Cryptosporidium*, *Campylobacter*, *Shigella*, and *Polio* outbreaks are reported. Water-scarce diseases, including scabies, impetigo, and cellulitis, are also on the rise in flood-affected areas. Water-based diseases, such as dracunculiasis, schistosomiasis, and Leishmaniasis, pose significant risks. Vector-borne diseases, including malaria, dengue, and Leishmaniasis, are becoming more prevalent due to flooded areas providing breeding grounds for disease vectors like mosquitoes and sandflies. These diseases are now more common in flood-affected regions, affecting millions of people.

Conclusion. Urgent measures are needed, including early warning systems, resilient infrastructure, drainage maintenance, and stricter land-use regulations, to reduce the impact of these natural disasters. International cooperation and immediate action at national and global levels are essential to mitigate the health crises caused by flooding and other natural disasters.

Keywords. floods, South Asia, vector-borne disease, water-based disease, water-borne disease, water-washed disease

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Introduction

Increasing industrialization and the resultant elevated greenhouse gases (GHG) emission unequivocally pose great threats to our environment. The economy-centered human initiatives have pushed the environmental carbon dioxide levels to a striking 412 parts per million (ppm), an almost fifty percent escalation since the industrial revolution. Figure 1 illustrates the increasing CO₂ levels since 2015. These atmospheric changes and the consequent temperature rise results in changes in precipitation patterns, rapid snow melting, and several environmental deteriorations.¹ Climate change may impact human health in two ways: (a) Directly via increasing extreme weather frequency and altering disease patterns; (b) Indirectly via social institutions and disrupted global supply chain resulting in consequences like undernutrition.^{1,2}

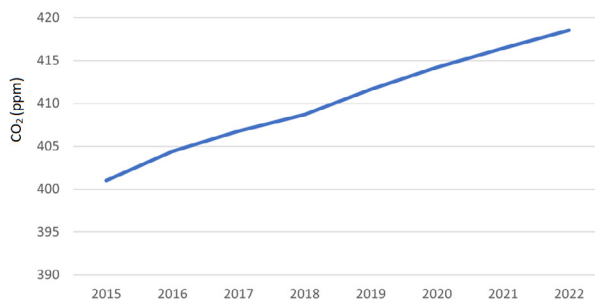


Fig. 1. CO₂ levels from 2015-2023¹

Floods, the most recurrent natural disaster, occur when a water overflow submerges dry land. Several factors including heavy rainfalls, glacier melting, and storms like the tsunami in coastal areas may contribute, all of which may be attributed to climate change. Floods depending upon their cause and severity can be classified into three categories: (a) flash floods are usually caused by excessive rains which significantly increase water levels and results in rapidly flowing flood water; (b) river floods usually result from persistent and slow rain or snow-melting which gradually raises river levels; (c) coastal floods which are generally associated with storms like cyclone and tsunami.³

According to the World Health Organization (WHO), floods impacted over 2 billion individuals worldwide between 1998 and 2017.³ South Asia is amongst one of the most vulnerable and prone regions to floods and natural disasters. One such example is of Pakistan, which has experienced several floods during the previous few decades. Recently it was affected by the worst of all, due to the unprecedented torrential rainfall with the country receiving almost 60% of the record-breaking monsoon rains in just three weeks. The recent flooding has impacted the entire country with prominent damage in Baluchistan, Khyber Pakh-

tunkhwa, and Sindh. Following massive flooding, a state of emergency has been declared with the government urging local and foreign organizations for optimum humanitarian support.⁴

Alongside financial and economic crises, the overburdened healthcare infrastructure and disrupted water supply further exacerbates communicable and non-communicable water-related diseases burden. These can be classified into four broad types, as depicted in figure 2. In this review, we have highlighted the potential water-related disease outbreaks that have followed massive flooding in South Asia and discuss the potential way forward.

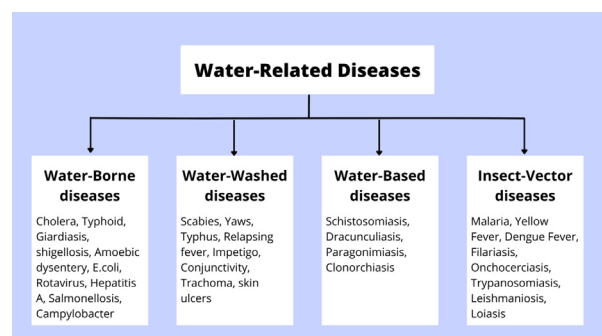


Fig. 2. Classification of water-related diseases

With contaminated flood water covering more than one-third of the country and disrupting clean water access, water-related diseases are expected to rise steeply, and may potentially cause more grievous consequences than the floods themselves. In an interview, the secretary general of the Pakistan Medical Association (PMA) highlighted that water-related diseases are capable of causing more deaths than the flood itself.⁵

Aim

This paper aims to determine the impact of flooding in South Asia on water related diseases.

Material and methods

Two independent authors (SHA, SW) conducted a thorough literature search over PubMed, Google Scholar and Cochrane Library from inception till September 2022 using the following key words: “Floods”, “flooding”, “flash flood”, “natural disaster”, “waterborne disease”, “water washed diseases”, “water-based disease”, “insect vector disease”, “Asia”, “South Asia” and “South East Asia”. The results of the literature search were screened for their adherence to the eligibility criteria, which encompassed all original studies (cross-sectional, cohort, longitudinal) reporting the healthcare consequences of floods in South-east Asia. Following a thorough literature search, relevant data was extracted by two authors (TGS, MZ) independently.

Analysis of the literature

Water-borne diseases

According to WHO, infectious WBD are one of the leading causes of morbidity and mortality in humans worldwide accounting for 1.5 million deaths annually.⁶ Water-borne outbreaks are among the most well-known, immediate effects of flood catastrophes promoted by the failure of sewage disposal and purification systems. However, additional impacts of flooding, such as displacement of large numbers of people into over-crowded shelters and subsequent fecal-oral dissemination of gastrointestinal pathogens, may contribute to the acute aftermath of the flood.⁷ Since 1980, there has been an increase in water-borne infections worldwide, which has been correlated with an increase in flood events.⁸

Low-resource nations like Pakistan are further taxed in times of floods secondary to accelerated, urban sprawl, which is driving people into regions with deteriorating drainage systems and poor hygiene standards.⁹ The outbreak of water-borne diseases following the devastating floods of 2010 and 2013 are particularly relevant in this regard. Reports from the 2010 flooding in Pakistan revealed that from the start of the floods until the August 12th, 86,671 cases of diarrhea were reported. Similarly, the 2013 flooding in Pakistan showed that from 6th to 21st Baluchistan alone reported a total of 10,431 patient consultations from flood-affected districts of Baluchistan of which 2,031 (20%) cases were of acute diarrhea.¹⁰ There are several bacterial, viral, and parasitic species that can cause acute watery diarrheal disease, listed below.

Vibrio cholerae, a gram-negative bacteria causing cholera, has wreaked havoc in impoverished nations and thrives in environmental upheavals like floods.¹¹ Countries like India and Bangladesh are at high risk for cholera due to their dense population, lack of development, and poverty.¹² In August 2010, Pakistan experienced major floods and a subsequent *cholera* epidemic ensued. WHO reported 164 laboratory-confirmed sporadic *cholera* cases from a wide geographic area in the flood-affected provinces of Sindh, Punjab, and KPK.¹³ Similarly, in Dhaka, Bangladesh, *cholera* was the most frequently identified pathogen in flood-associated diarrheal epidemics.¹⁴ The impact of flooding can be judged by the fact that the *V. cholera* O139 re-emerged during April and May 2017 following a massive flooding in Odisha, India.¹⁵

Typhoid fever is caused by a bacterium *Salmonella enterica serotype Typhi* and to a lesser extent, serotypes *Paratyphi* A, B, and C. With 493.5 cases per 100,000 people reported in 2018, Pakistan has the highest rate of typhoid among the South Asian nations. Cases in Pakistan sharply surged in 2016, following the introduction of a highly drug-resistant (XDR) typhi outbreak in Hyderabad.¹⁶ Typhoid appears to have a seasonal pattern,

peaking from July to October after rain, notably in the majority of South Asian and South East Asian countries, perhaps due to floods brought on by heavy rains that contaminate drinking water sources with sewage.¹⁷ Per this, a study conducted in Karachi showed a prevalence of serologically positive patients at 20.13% in the summer and 17% in the winter.¹⁸

Rotaviruses are members of the double-stranded RNA family *Reoviridae*. With a mortality incidence of 67.6 deaths per 100,000 children in Pakistan, it is one of the most common causes of fatal dehydrating diarrhea in children under five.¹⁹ High precipitation and flooding events can induce water logging, which eventually paves pathways for pathogen transmission.²⁰ In 2014, flooding in the Solomon Islands led to a *rotavirus* outbreak that spread across the country. During the 2007 floods, Dhaka witnessed one of the most severe rotavirus outbreaks.¹⁴ The history of rotavirus in Bangladesh is not new. In 1988, the nationwide floods the prevalence of *Rotavirus* mixed infections from 8.1% to 22.7%. In 1994, an estimated one death per 111-203 children under five years of age was attributed to this deadly virus.²¹

Hepatitis A is an enterically transmitted viral disease caused by the virus, *hepatitis A virus* (HAV).²² It has been acknowledged that hepatitis A outbreaks could occur when flood-related sewage contaminates sources of drinkable water.⁸ Children in a flood relief camp in Uttarakhand State, India, had an outbreak of acute viral hepatitis in 2013 that was brought on by the HAV.²²

Leptospirosis is one of the most pervasive zoonotic illnesses in the world.²³ The disease is typically reported post-flooding in impoverished nations that struggle with disaster management.²⁴ Excessive precipitation has also been linked to Leptospirosis outbreaks in flood zones in Australia, the United States, Germany, India, Malaysia, and Thailand.²⁵ Investigations conducted in populations affected by flood disasters in 2000 in India and Thailand reported Leptospirosis epidemics to be associated with bathing and drinking contaminated water.²⁴ A cross-survey study of Pakistan showed significant differences in leptospiral seroprevalence in different geographic locations, with the highest in the humid sub-tropical climatic region. Further analysis revealed a positive correlation with exposure to flooding water.²⁶

Cryptosporidium, a water-borne zoonotic parasite is the second leading cause of diarrhea and deaths in children after rotavirus.^{27,28} In a study of 300 water samples from the flood-affected district, Nowshera, the overall prevalence of *Cryptosporidium* was found to be 30.33%. The highest prevalence was recorded in the summer (June-September).²⁷ According to studies from India, a rise in temperature and humidity increases the frequency of infections. This may be attributed to the dissemination of infectious oocysts into the surface water post heavy rainfall between March and July.²⁸

Campylobacter infections in children commonly occur under the age of two years. South Asian countries have a significant burden of *Campylobacter* infection and a study revealed it to be one of the most frequently occurring organisms that cause gastroenteritis in Bangladesh, India, and Pakistan.²⁹ According to Cann et al., the most common water-borne pathogens associated with heavy rainfall were *Campylobacter*, followed by *vibrio spp.*⁸ According to the available data, campylobacter and cryptosporidium were amongst the most common pathogens in outbreaks associated with extreme water related weather events.³⁰

Shigellosis is a highly contagious disease in poor and crowded communities.³¹ *Shigella* breed and thrive better in humid environments during floods due to its increased fecal-oral transmission. According to a prospective multi-center study, the *Shigella* is prevalent in impoverished Asian population and over a period of time antibiotic resistant strains have developed and the conditions become worse during floods.³²

Poliomyelitis is a viral disease that primarily affects children under the age of five causing acute paralysis, muscle weakness, and autonomic dysfunction. The fecal-oral mode of transmission is most prevalent in areas with poor sanitation and health issues. In 2022, Pakistan had 15 cases of wild poliovirus recorded. In the previous year, only one case was reported.³³ Due to the significant population dislocation caused by the floods in 2010, a nationwide polio vaccination program was impeded. The trend is predicted to continue given the ongoing, enormous flooding and it would be very challenging to keep up the pace needed for a successful polio vaccine program.³⁴

Water-washed diseases

Water-washed diseases, or water-scarce diseases, intuitively result from inadequately available clean washing water. Their incidence is primarily determined by the quantity, hence adequate availability and hygienic conditions are intrinsic to controlling their spread. Diseases classified in this category include dermatologic and ophthalmologic conditions like scabies, impetigo, skin ulcers, trachoma, typhus, relapsing fever, yaws, and conjunctivitis.³⁵

Several factors contribute to its increased incidence in flood-affected areas. The water along with its flow brings contaminants, allergens, and sewage discharge into the environment. Ambient temperature further enhances microbial growth.³⁶ Moreover, massive flood-associated destruction disrupts clean water supply, washing areas, and sanitation facilities, hence causing a water outage, and further predisposing individuals to greater risk.³⁷ Often flooding results in trauma compromising skin's continuity, leaving individuals susceptible to developing infections.

Scabies, a parasitic infestation caused by *Sarcoptes scabiei*, infects almost 200 million individuals globally with a higher prevalence in resource-limited regions. In Pakistan, scabies accounts for 38.15% of dermatological conditions.³⁸ It is characterized by itchy lesions comprising of papules, nodules, and vesicles predominantly affecting the skin between fingers, axillae, wrists, genital area, palm, soles, and head but may involve any other region. The diagnosis is usually clinical via examination using a dermatoscope, which allows visualization of the characteristic scaly curved burrows.³⁹ Several studies report an association between scabies and natural disasters like flooding.^{2,36} Following the 2010 flooding in Pakistan, scabies was among the most common causes of morbidity in Baluchistan accounting for 2,070 cases between 29th July and 11th August.⁴⁰ Similarly, reports from the 2013 flooding in Pakistan revealed scabies accounting for the highest proportion of consultations in the affected regions of Punjab with 2,708 consultations between 6th to 16th August⁴¹ and 9,943 between 12th and 21st August 2013.¹⁰

Impetigo, a superficial bacterial skin infection, commonly affects children between the age of two and five years. It has a global prevalence of 140 million and is usually caused by either *Staphylococcus aureus* or *Streptococcus pyogenes*. Clinically, it is characterized by honey-crusted lesions that may involve the face, trunk, extremities, and intertriginous regions. It may manifest either as a bullous or non-bullous form of the disease. The diagnosis is based on clinical examination while culture and sensitivity assist in detecting the causative agent and treatment regimen.⁴²

Inflammation of the deep skin and the subcutaneous tissue is referred to as cellulitis. Cellulitis classically manifests as erythema, edema, tenderness, and warmth, but the diagnosis may be challenging due to its resemblance with certain other conditions such as stasis dermatitis, ulcers and deep vein thrombosis.⁴³ Literature also reports increased consultations for lower limb cellulitis in flood-affected areas, which may be due to lower limb trauma disrupting the physical skin barrier.³⁶

Multiple studies report skin infections following natural disasters like flooding.^{36,44} During the 2010 flooding in Pakistan, 40,100 skin infections were reported from Khyber Pakhtunkhwa (KPK) between 31st July and 12th August, making it a more significant cause of morbidity than watery diarrhea, which accounted for 34,373 cases.⁴⁰ Skin infections also remained a significant contributor to consultations in other flood-affected areas of Punjab and Sindh.⁴⁰ Similarly, in 2015 the devastating floods in Chennai and South Indian coast following extreme rain. A study conducted in the medical camp of Thiruvallur, one of the worst affected districts of the region observed that 14.41% of the people in those camps had skin diseases.⁴⁵

Along with causing dermatologic conditions such as impetigo, cellulitis and scabies, contaminated flood water and the associated clean water inadequacy may escalate eye infections. Trachoma, a leading cause of infectious blindness worldwide, refers to chronic conjunctivitis caused by *Chlamydia trachomatis*. It may lead to scarring of the tarsal conjunctiva, trichiasis, and corneal opacity. Poor hygiene, inadequate water supply, and overcrowded settings increase its risk. Although it is typical in children, scarring occurs more frequently in adults.⁴⁶ Increased exposure to the underlying risk factors during flood events can increase its incidence and potentially lead to life-long visual disabilities.^{36,47} Similarly, studies suggest an increased incidence of bacterial conjunctivitis during flooding events.⁴⁸ *Toxoplasma gondii* infection-associated cases of focal retinal whitening and necrotizing retinochoroiditis were also observed during flooding episodes in Brazil.⁴⁹ During the 2010 flooding in Pakistan, 337 eye infections were reported between 29th July to 12th August in Baluchistan.⁵⁰ Similarly, it remained among the top contributors to consultations in Sindh, alongside skin and respiratory problems.⁵¹ Again, ocular infections remained a major health problem during the 2013 flooding in Pakistan.⁵²

Several factors may account for these associations including water outages, poor hygienic conditions, shared resources like towels, clothes, and beds in refugee camps, overcrowded camps, and malnutrition. Therefore, the government and authorities working in flood-affected regions must promote good hygiene practices among the affected and ensure adequate medicines availability alongside isolation facilities to prevent outbreaks as in previous floodings.

Water-based diseases

The term refers to the diseases caused by parasites in the intermediate organisms living in contaminated fresh water. It most commonly includes dracunculiasis, paragonimiasis, schistosomiasis, and Clonorchis's.

The fight against dracunculiasis, also known as guinea worm disease, was initiated in Pakistan in the year 1986 as a collaborative effort between Pakistan's National Institute of Health, the Global 2000 Project of the Carter Center, and the CDC. Rapid detection, thorough investigation, intensive surveillance, and case-containment measures resulted in the complete eradication of dracunculiasis by 1994.⁵³ A further follow-up on the eradication of dracunculiasis in the district Dera Ismail Khan, KPK, reported no active cases in the area.⁵⁴

Another water-based disease, schistosomiasis, is caused by blood flukes (trematode worms) of the genus *Schistosoma*. The infectious form of parasite, cercariae, is acquired by skin contact with freshwater snails, which serve as an intermediate host, and is transmitted when the excretory material of the infected per-

son contaminates the freshwater resource.⁵⁵ According to the WHO, schistosomiasis is prevalent in tropical and subtropical regions, especially in poor communities without access to safe water and inadequate sanitation. There are two major forms of schistosomiasis, intestinal and urogenital, caused by five species of blood fluke worm. The Intestinal form usually causes abdominal pain, diarrhea, and hematochezia. In severe cases, the liver might be enlarged. The urogenital form mostly manifests as hematuria.⁵⁶ There are reports of isolated cases of schistosomiasis mostly due to traveling history in endemic areas, but according to Rollinson D et al., the prevalence of schistosomiasis in Pakistan was less than 10% based on the data from WHO's weekly epidemiological record.^{57,58} Therefore, human schistosomiasis is less likely to become endemic in Pakistan owing to the continuous efforts of the government in providing safe drinking water and proper sanitation. According to the official data of 2015, 91.4% of the population had access to improved drinking water and 63.5% of the population had access to improved sanitation.⁵⁹ But the recent catastrophic flooding in Pakistan has severely affected the under-developed areas with already prevailing resource inequities. Lack of safe drinking water and improper sanitation conditions possess a great risk of waterborne and vector-borne diseases including schistosomiasis.⁶⁰ Although most of the cases of Schistosomiasis in Pakistan are secondary to travel in endemic areas, the presence of *Biomphalaria* species of snails, carriers of *Schistosomiasis mansoni*, which is already present in Pakistan, may trigger the disease in the flood-affected areas.⁵⁵

Vector-borne diseases

These diseases are caused by insect vectors that require water for breeding. Several species of mosquitoes and flies may serve as vectors and are responsible for multitudinous life-endangering diseases like malaria, dengue fever, kala-azar, yellow fever, and multiple others.⁶¹ Their incidence is majorly determined by the environmental aptness involving climate, altitude, vegetation, and application of control measures; as a result, poverty, natural disasters, and wars are intrinsically tied to their increased prevalence.⁶² Natural calamities like flooding provide additional breeding grounds to these vectors and increase their densities, hence placing the populations at a higher risk. The risk is further exacerbated by the increased exposure and absence of control facilities in relief camps.

Malaria, caused by the *Plasmodium* species, is transmitted to humans by the female anopheles mosquito. Although over 120 species of *plasmodium* have been recognized, only six are responsible for morbidity in humans: *Plasmodium falciparum*, *Plasmodium vivax*, *Plasmodium malariae*, *Plasmodium knowlesi*, *Plasmodium*

ovale curtisi and *Plasmodium ovale wallikeri*.⁶² According to the recent world malaria report by WHO, approximately 241 million cases and 627,000 deaths were reported in 85 malaria-endemic countries in 2020, with the African region being affected the most.⁶³ About 98 percent of Pakistan's population resides in malaria-endemic regions, with almost 1 million new cases and 50,000 deaths reported annually.⁶⁴ With the recent nationwide flooding, the numbers are expected to rise, and if prompt action is not taken, the repercussions may be irreparable. According to a Ugandan study, individuals were about 30% more likely to test positive for malaria in flood-affected river-bordered settlements, with a striking 47 percent rise in positive malaria tests observed in the post-flood era compared to the pre-flood span.⁶⁵ Similarly, malaria-related hospital admissions were significantly higher during the post-flood period, with almost 50 percent more admissions reported.⁶⁵ According to data from the 2010 flooding in Pakistan, almost 182,762 consultations between 29th July and 17th September in 36 flood-affected malaria-endemic regions, were conducted for suspected malaria. Similarly, a malarial surge was witnessed during the 2013 flooding in Pakistan, with 17 percent of consultations conducted for suspected malaria in Baluchistan between the 6th and 21st of August.¹⁰ The current literature suggests an almost two to three months delay between flooding and post-flood peak malaria epidemic.⁶⁵⁻⁶⁷ This delay may be accountable to rapid flood-water flushing away the existing breeding grounds and vectors setting up new breeding sites in the affected regions.⁶⁵ The situation in Nepal and Bangladesh was not so different. According to several media reports there had been thousands of cases of malaria following flooding in 2017 which is considered the worst flood in South Asia in the last decade. In Nepal alone thousands of cases related to malaria had been reported.⁶⁸

Dengue and yellow fever belong to a family of single-stranded RNA, positive sense, *flavivirus* transmitted through *Aedes aegypti* mosquito in endemic and epidemic regions. According to the WHO, there could be 390 million dengue cases globally of which 70% could be in Asia alone.^{69,70} Pakistan's first dengue outbreak was reported in 1994.⁷¹ The annual epidemic trend was first reported in Karachi, Pakistan in the year 2005 potentially due to irregular monsoon patterns and rising temperatures, making the climate favorable for mosquito breeding.^{69,71} The year 2022 is no different at least in terms of dengue cases. It's been more than two months since the calamitous floods and heavy rain spells began and yet across Pakistan, many villages are submerged in water, leaving hundreds and thousands of families displaced. According to a local news report published on 14th September 2022, the Sindh province reported at least 1,098 dengue cases during the current month and

nine people lost their lives.⁷² Similarly, the cases of dengue are on a continuous rise in the federal capital, Islamabad, where the total number of dengue patients has reached 871.⁷³ In 2010, Pakistan was severely affected by massive flooding and extreme rainfalls which impacted 14-20 million people. The floods were followed by an enormous spike in dengue cases and according to data, the country recorded the highest dengue cases during that year.⁷⁴ The numbers can be significantly higher this year since the unofficial data suggests that the flooding this year has directly impacted 33 million people so far and the numbers are expected to rise further.

The situation across the border is not very different too. The recent heavy rain and flooding in Delhi and other states such as Punjab, Assam, and Haryana, the cases of dengue and other vector-borne infections are at high year high. Karnataka alone has reported over 4500 cases of dengue from January 2023 to July 2023.⁷⁵

With over one million cases reported annually, Leishmaniasis is a parasitic protozoan infection caused by over 20 species of *Leishmania*.⁷⁶ Preponderantly transmitted via sandfly phlebotomine, *Leishmania* may manifest in three distinct ways: (i) Visceral Leishmaniasis (VL), also known as Kala Azar or Black fever, (ii) Cutaneous Leishmaniasis (CL), and (iii) Mucocutaneous Leishmaniasis (ML). While CL is the most prevalent one, the deadliest is the visceral form of *Leishmania*. Depending on the type, the disease may emerge with a myriad of signs and symptoms, with VL typically inducing fever and hepatic enlargement while the cutaneous variant causes sores on the skin.⁷⁷

While Leishmaniasis occurs worldwide, its highest frequency is associated with illiteracy, malnutrition, lack of resources, and poor housing facilities. Moreover, it is a fact that climate changes affect the vector reservoir, thereby directly affecting areas pounded by a natural calamity.⁷⁸ Flood-affected regions have traditionally provided an enormous breeding ground for the parasite. In addition, flood-affected regions in Bangladesh and India recorded higher instances than others in history.^{79,80} Bihar, a region in India is endemic to floods have seen a remarkable surge in leishmaniasis since 1977.⁷ Pakistan has been no different. Record-breaking cases were identified during the mass displacement at the Afghan-Pakistan border. Similarly, during the flood of 2010, a *Leishmania* surge was observed throughout the afflicted areas in Pakistan.⁷

The way forward

Much of the associated destruction secondary to natural disasters is human induced, aggravated by our dwelling patterns, uncontrolled deforestation, poor infrastructural quality, and the geographical, economical, and social marginalization of our impoverished population. Floods and other natural disasters have been socially construct-

ed due to years of weak governance, inaction, and negligence. One such example is of Pakistan. Despite having large bodies at both the federal and provincial levels, meager progress has been achieved. The lack of district-level disaster management systems has further exacerbated the situation. According to the Federal Flood Commission, Pakistan has witnessed 28 riverine floods since its independence in 1947, which have affected 616,558 square kilometers of land, caused a loss of over 39 billion rupees to the economy, and snatched at least 13,262 lives. The situation at provincial level is equally worse. The provincial governments of Sindh province in Pakistan since partition have been unable to act, despite it having a long history of floods. The lack of proactiveness can be judged from the fact that on July 22, 2010, the flood started in Baluchistan, and though the governments of Sindh and Punjab had ample amount of preparation time to arrange resources, several areas of Sindh were still inundated with flood water.⁸¹

There is a long history of international agencies such as the WHO and the United States Agency of International Aid (USAID) helping in relief operations. Additionally, civilian volunteers, independent teams of doctors, non-governmental organizations, and various other people always come forward for help with their limited resources. There is a widespread mistrust to donate for the governmental funds in South Asian countries and even in 2022, this perception has not changed, which is hindering people from cooperating with governmental initiatives.

Since the beginning of these devastating floods, several countries have come forward and have provided aid, including the UN, to the flood effected countries.⁸² But the solution to natural disasters like floods cannot be resolved with financial assistance alone. Pakistan contributes less than 1% to the global greenhouse gas emissions but according to the German Watch index, it is constantly on the list of top 10 climate vulnerable countries and is bearing the brunt of global industrialization.⁸³

There are several scientific based actions which developing South Asian countries can take to reduce the effect and improve its ability to deal with the floods. One such example is the use of nationwide early warning systems that can alert the authorities of an expected flood and give them sufficient time for evacuation operations. In addition to this, immediate attention should be given to have modified construction plan in flood susceptible areas to reduce structural damage. Along with this, flood prone areas should be regularly monitored and any construction on such land should be banned, and any violation should be dealt with accordingly. There is also a need for regular drainage system maintenance, especially in urban cities and drains should be cleaned be-

fore every monsoon season to prevent incidents of flash flooding.

There is an urgent need for global acknowledgment that despite contributing less, several countries are on the worst to receive the repercussions of climate change, including flash floods, water scarcity, unbearable heatwaves, rising sea levels, food shortages, and the displacement of its people. International cooperation, immediate measures at the national level, and individual contributions can halt this climate change.

The concerned international and national stakeholders need to act now and implement the necessary measures, including:

- a. Issuing well-defined guidelines, demarcating roles and responsibilities of the provincial and the federal entities.
- b. At the district level, there should be proper guidance tools to speed up the rescue process with full transparency and competitiveness.
- c. A proper financing mechanism should be established for disaster management and a small portion of the budget should be allotted to combat future natural disasters.

Conclusion

This manuscript underscores the urgent need for comprehensive policies to address the escalating impact of climate change-induced flooding on public health in South Asia. The increasing frequency and severity of floods expose vulnerable populations to a surge in water-borne, water-washed, water-based, and vector-borne diseases. As exemplified by recent flooding in Pakistan, the aftermath extends beyond immediate damage to infrastructure, exacerbating health crises and overburdening healthcare systems. Key findings reveal heightened risks of cholera, typhoid, rotavirus, hepatitis A, leptospirosis, cryptosporidium, campylobacter, shigellosis, and polio. In addition, inadequate clean water access during floods leads to a surge in dermatologic and ophthalmologic conditions, including scabies, impetigo, cellulitis, and eye infections. Contaminated freshwater fosters diseases like schistosomiasis, with potential resurgence in flood-affected regions. Furthermore, floods create breeding grounds for disease vectors, increasing the risk of malaria, dengue, leishmaniasis, and other life-threatening illnesses. Policy recommendations include the implementation of early warning systems, modification of construction plans, international cooperation, comprehensive data collection, transparency, and the establishment of financial mechanisms for disaster management. Immediate and coordinated action is imperative to mitigate the adverse health consequences of climate change-induced flooding. Policymakers must prioritize the development and implementation

of robust policies addressing both the immediate aftermath and long-term resilience against the compounding challenges posed by these natural disasters.

Declarations

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Author contributions

Conceptualization, M.A.H.; Methodology, M.A.H.; Formal Analysis, S.H.A. and S.W.; Data Curation, T.G.S. and M.Z.; Writing – Original Draft Preparation, S.H.A, S.W. and M.Z.; Writing – Review & Editing, I.U. and K.A.H.M.A.; Visualization, T.G.S.; Supervision, M.A.H.; Project Administration, S.H.A. and M.A.H.

Conflicts of interest

The authors declare no conflict of interest.

Data availability

This paper uses publicly available data.

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