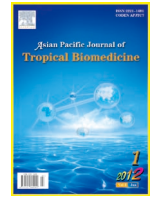




Contents lists available at [ScienceDirect](http://www.sciencedirect.com)

Asian Pacific Journal of Tropical Biomedicine

journal homepage: www.elsevier.com/locate/apjtb



Document heading doi:10.1016/S2221-1691(11)60194-9 © 2012 by the Asian Pacific Journal of Tropical Biomedicine. All rights reserved.

Infectious diseases in the aftermath of monsoon flooding in Pakistan

Maryam Baqir¹, Zain A Sobani¹, Amyn Bhamani², Nida Shahab Bham¹, Sidra Abid³, Javeria Farook³, M Asim Beg^{4*}

¹Aga Khan University, Karachi, Pakistan

²Barts and The London School of Medicine and Dentistry, London, England

³Dow University of Health Sciences, Karachi, Pakistan

⁴Department of Pathology and Microbiology, Aga Khan University, Karachi, Pakistan

ARTICLE INFO

Article history:

Received 18 May 2011

Received in revised form 7 June 2011

Accepted 28 June 2011

Available online 28 January 2012

Keywords:

Infectious diseases

Moosoon flooding

Pakistan

Epidemiology

Natural disaster

Acute setting

Sub-acute setting

Malaria

ABSTRACT

Pakistan is ranked 9th in terms of flood-affected countries worldwide. In the summer of 2010, the northern province of Khyber-Pakhtunkhwa received more than 312 mm of rain in a 56 hour period. This resulted in over 1 600 deaths across the region. In addition, over 14 million people were directly affected by this record-breaking deluge. Flood affected regions serve as ideal breeding grounds for pathogens, leading to the spread of diseases. The poor standards of hygiene in camps set up for individuals displaced by the floods also contribute to this. It is essential that those involved in relief efforts are aware of the epidemiology of diseases that have historically seen a sudden upsurge after natural disasters. Keeping this in mind, we conducted a simple review of literature. An extensive literature search was conducted using the PubMed data base and online search engines. Articles published in the last 20 years were considered along with some historical articles where a background was required. Seven major diseases were identified to increase substantially in the aftermath of natural disasters. They were then classified into acute and sub-acute settings. Diarrhea, skin & eye infections and leptospirosis were identified in the acute setting while malaria, leishmaniasis, respiratory infections and hepatitis were identified in the sub-acute setting.

1. Introduction

Rainfall in Pakistan varies radically from year to year. The 3-month period from July to September is usually marked by heavy rainfall across the country. Along with depressions arising from the Bay of Bengal, this affects the upper catchments of the major rivers, leading to extremely high flood peaks and generalized flooding. An average of 579 732 people are adversely affected by this phenomenon each year, putting Pakistan 9th in terms of flood-affected countries worldwide^[1].

This year, the northern province of Khyber Pakhtunkhwa received the highest recorded rainfall in the last 80 years. According to estimates, over 1 600 people lost their lives in the resulting floods, with 14 million people across the region adversely affected^[2,3]. Despite extensive relief and rescue operations, the death toll is expected to rise as thousands of people are still cut off from the rest of the country. The army has predicted that rebuilding the infrastructure and

providing the people with basic necessities will take up to 6 months^[4]. During this time, it is anticipated that a significant percentage of those affected will remain in relief camps across the country.

Stagnant pools of flood water serve as ideal breeding grounds for pathogens that result in diarrhea and other waterborne infections. Cases of diarrhea, cholera and scabies have already been reported and an outbreak of cholera has been confirmed in Swat^[2].

In this paper, we would like to review major infectious diseases that see an upsurge in the weeks and months after natural disasters, especially floods. For the convenience of the reader, these have been divided into two categories: acute and sub-acute phases. It must be emphasized, however, that these time lines are not absolute and some overlap exists among the phases.

2. Acute phase

2.1. Diarrhea

Flooding has been shown to cause epidemics of water and

*Corresponding author: M Asim Beg, Associate Professor, Department of Pathology and Microbiology, Aga Khan University, Karachi 74800, Pakistan.

Fax: # (92 21) 34934294

E-mail: masim.beg@aku.edu

vector borne diseases^[5]. Water–borne outbreaks of diarrheal illness after floods are thought to result primarily from the contamination of water. This occurs due to the disruption of purification and sewage disposal systems. However, secondary effects of flooding, including crowding and subsequent fecal–oral spread of gastrointestinal pathogens, may also contribute to the spread of diarrheal diseases^[6,7].

During the July, 2004 floods in Bangladesh, outbreaks of diarrheal diseases occurred throughout Dhaka, with more than 17 000 patients seen at a single centre^[8]. Additionally, compared with non–flood periods, patients who presented during the 1988, 1998 and 2004 floods due to diarrhoea were found to be more severely dehydrated and of lower socioeconomic status^[9]. When considering embankment structures, it was found that the crude child mortality was significantly decreased and death rates outside the embankment were higher^[10]. However, another study showed that the construction of flood control structures such as dams was associated with an increase in cholera cases among the residents protected in the long run^[11]. Such a finding requires attention from the health community, governments and non–governmental organizations involved in ongoing water management schemes.

The floods in Pakistan have resulted in a similar situation. 115 922 cases of acute diarrhoea had been reported in fixed and outreach medical centres before the 12th of August. In Khyber Pakhtunkhwa, the province worst affected, acute diarrhoea was reported as a leading cause of illness, accounting for 17% of medical consultations^[12].

Medical teams in the region fear that cholera could spread rapidly in the aftermath of these floods. It is thought that the full picture will only be revealed once access to affected areas is improved.

2.2. Skin and eye infections

Skin and eye infections often occur as a result of direct contact with polluted water. These include wound infections, dermatitis and conjunctivitis. However, in general, these diseases are not known to be major causes of epidemics^[13].

Extensive water damage after major hurricanes and floods increases the likelihood of mould contamination in buildings, exposure to which can cause adverse health effects. Skin conditions related to this are particularly common, regardless of the type of mould or the extent of contamination^[14]. In one study conducted in Thailand, it was found that eczema is the most common dermatosis during floods^[15]. Topical medications that combine antiinflammatory, antibacterial and antifungal properties are the most suitable medications to combat this.

During the current floods, approximately 143 870 skin infections have been reported in fixed and outreach medical centres across the southern province of Sindh. As a group, these are the third most common cause of illness, after respiratory infections and acute diarrhea^[12].

The risk of eye infections also mounts as torrential rains occur. In the aftermath of floods in 1993, the University of Iowa saw a record number of eye infections related to water–borne pathogens^[16]. The contamination of the water supply

by sewage and the prevailing high temperatures were cited as potential reasons for this.

2.3. Leptospirosis

Leptospirosis is a common zoonotic infection in the world^[17]. Primary sources of this condition are infected rodents and other wild animals who excrete leptospire in their urine^[18]. Once excreted, bacteria can live for a long time in fresh water, damp soil, vegetation, and mud.

Environmental changes, including increased vector population, facilitate the transmission during floods^[13]. Human infection results from contact with carrier animals or their environment. Additionally, contact with contaminated water bodies is a potential cause of acquiring this condition^[19]. Drainage material contaminated with rodent urine may also collect on roads after floods. This creates a potential source of infection for those walking bare foot. Children, who are attracted by puddles of rain water, are therefore at risk.

The majority of leptospiral infections are either sub clinical or result in very mild illness. Most patients recover without any complications. However, a small proportion develop complications due to the involvement of multiple organ systems. In this case, the clinical presentation depends upon the organs involved and the case fatality ratio could be as high as 40%^[18].

3. Sub–acute phase

3.1. Malaria

Both *Plasmodium falciparum* and *Plasmodium vivax* are widely distributed across Pakistan due to extensive agricultural practices, vast irrigation networks and monsoon rains. In most parts of the country, the transmission season is post–monsoon, occurring from July to November, with an estimated 1.5 million cases of malaria infection occurring annually^[20].

Malaria epidemics in the wake of flooding are a well–known phenomenon in endemic areas worldwide. These have been seen after flooding in Costa Rica (1991), The Dominican Republic (2004), Mandla, Benin (Annual) and northern Peru (periodic)^[13,21,22]. There is also substantial evidence of increased malaria transmission in urban areas of Asia as a consequence of the clogging of storm water drains^[23,24].

Locally, when torrential rain and floodwater inundated large swathes of land in Karachi in 2006, the incidence of malaria saw a sharp spike. It was also reported that the prevalence of cerebral malaria had increased. Particularly worrying was the fact that it subsequently began appearing in resistant forms that did not respond to the conventional therapy, enabling it to pose an even greater threat^[25]. Similarly, in January, 2009, suspected malaria was reported as the primary diagnosis in 18% of total medical consultations in flood affected districts of Balochistan. This made it the second leading cause of consultations^[26].

Interestingly, the onset of floods initially reduces mosquito breeding. However, as the floods recede, stagnant pools of water left behind serve as a perfect breeding ground for malaria-causing mosquitoes. In most cases, the lag time is usually around 6–8 weeks before the onset of a malaria epidemic[7].

3.2. Leishmaniasis

Leishmaniasis is caused by *Leishmania* spp transmitted by the sand fly. It can lead to deep, disfiguring sores at the site of the bite, which are more likely on the exposed parts of the body. Systemic or visceral leishmaniasis which is rarer in Pakistan affects the internal body organs, particularly the spleen and liver. The situation is further complicated by the fact that very few local physicians can differentiate between leishmaniasis and other skin diseases.

The disease is endemic in Pakistan and Afghanistan, and its incidence has been rising[27–30]. Outbreaks have been seen in refugee settlements along the north–western border of Pakistan during the Afghani crisis[31]. Poor sanitation and malnutrition also help spread the disease by providing a habitat for the sand fly and lowering the general health of the population, making them more susceptible. Leishmaniasis is hence common in overcrowded, poverty stricken and underprivileged areas with restricted access to healthcare.

Floods can potentially increase the transmission of leishmaniasis. Bihar, a region in India endemic to floods, has seen a surge in the disease since 1977[32]. As the relief efforts in flood-hit Pakistan intensify, officials should brace themselves for an outbreak of leishmaniasis among the millions affected by the country's worst deluge in 80 years.

To control the spread of leishmaniasis, preventive measures similar to those used against malaria should be implemented. Residual insecticide spray and impregnated bed nets are effective. Even more important, however, is improving environmental and sanitation living conditions.

3.3. Respiratory infections

In the aftermath of floods, infections of the respiratory tract are usually amongst the most common causes of morbidity and mortality in survivors. When devastating floods affected millions of people in Bangladesh in 1988, it was found that respiratory tract infections accounted for about 17.4% of all illnesses and 13% of all reported deaths[33]. Similarly, it has been reported that 30 new cases of tuberculosis developed amongst 30 000 survivors of floods caused by the overflowing Kosi River in Bihar, India in 2008. Moreover, since symptoms of this condition may take several weeks to develop, it is possible that these cases were just the tip of the iceberg[34].

The increased risk of respiratory tract infections is due to the loss of shelter and exposure to flood waters and rain. In the flood-affected communities of Pakistan, 113 981 cases of respiratory tract infections have been reported[12]. Patients are suffering from allergic bronchitis, asthma, chronic obstructive pulmonary airway disease (COPD), pneumonia and viral flu. Additionally, without proper precautions, most of them are at risk of catching secondary infections.

Furthermore, even though there is no evidence to suggest that corpses play a role in the development of disease epidemics after natural disasters, workers who routinely handle corpses may be at risk of contracting tuberculosis. Studies suggest mycobacteria can be aerosolized when the residual air in the lungs is exhaled during handling of the corpse[13]. This indicates that relief workers handling corpses may require prophylaxis.

3.4. Hepatitis

Pakistan's already failing water and sanitation supply is further taxed in times of natural disaster. In such situations, water often gets contaminated by human and animal waste carrying microorganisms with feco-oral transmission cycles. These are capable of producing diarrhea, dysentery, and viral hepatitis. Previous experience has shown how badly affected the water supply in the country can be at such times. The outbreak of acute watery diarrhea involving more than 750 cases in the aftermath of the devastating earthquake of 2005 is particularly relevant in this regard[35].

The potential for hepatitis A outbreaks after flood-related sewage contamination of potable water sources has been recognized. Increases in the incidence of hepatitis A have been noted in association with natural disasters and attributed to disruptions in water and sanitation facilities. Overcrowding may also contribute[6]. Shears *et al* noted a marked increase in the number of hepatitis A cases after the Khartoum floods in 1988[36]. Similarly, after the 2005 earthquake in Pakistan, clusters of hepatitis E were common in areas with poor access to safe water. In all, over 1 200 cases of acute jaundice, many confirmed as hepatitis E, occurred among the displaced.

It is essential that adequate sanitary and hygienic provisions are made in flood affected regions. This would significantly reduce the morbidity and mortality associated with viral hepatitis. It is also worth mentioning that Watson, in his review, states that although hepatitis A may be an issue during floods, most of the adult population in developing countries will possess a degree of immunity to it. This is due to the endemic nature of the disease[40].

4. Conclusion

Despite great advances in medicine over the past few decades, medical complications arising from natural disasters are still extremely common. These are particularly problematic for developing countries like Pakistan where resources are limited and the infrastructure weak. The recent floods that have inundated vast portions of the country have only served to highlight the inadequacies within the health system. With public health spending currently standing at 2% of the country's GDP, it is obvious that more can be done in order to protect those affected by these disasters from the adverse effects of the conditions described above. Unfortunately, awareness of these conditions is something that is lacking in the general population. It is, therefore, imperative that this is promptly addressed in order to

prevent a repeat of the humanitarian crisis currently being witnessed in much of the country.

Conflict of interest statement

We declare that we have no conflict of interest.

References

- [1] Nakashima K, Yanagisawa M, Arakawa H, Kimura N, Hisatsune T, Kawabata M, et al. Synergistic signaling in fetal brain by STAT3–Smad1 complex bridged by p300. *Science* 1999; **284**: 479–482.
- [2] *Pakistan floods 'hit 14m people'*. BBC News; 2010. [Online] Available from: <http://www.bbc.co.uk/news/world-south-asia-10896849>. [Accessed on 20 April, 2011]
- [3] Reporter S. *Pakistan faces worst monsoon crisis in 80 years*. 2010. [Online] Available from: <http://www.ekkleisia.co.uk/node/12776>. [Accessed on 15 August, 2010]
- [4] *'2.5m people affected' by Pakistan floods officials say*. BBC News; 2010. [Online] Available from: <http://www.bbc.co.uk/news/world-south-asia-10834414>. [Accessed on 25 February, 2011]
- [5] Kondo H, Seo N, Yasuda T, Hasizume M, Koido Y, Ninomiya N, et al. Post-flood infectious diseases in Mozambique. *Prehosp Disaster Med* 2002; **17**(3): 126–133.
- [6] Aghababian RV, Teuscher J. Infectious diseases following major disasters. *Ann Emerg Med* 1992; **21**(4): 362–367.
- [7] Kunii O, Nakamura S, Abdur R, Wakai S. The impact on health and risk factors of the diarrhoea epidemics in the 1998 Bangladesh floods. *Public Health* 2002; **116**(2): 68–74.
- [8] Qadri F, Khan AI, Faruque AS, Begum YA, Chowdhury F, Nair GB, et al. Enterotoxigenic *Escherichia coli* and *Vibrio cholerae* diarrhea, Bangladesh, 2004. *Emerg Infect Dis* 2005; **11**(7): 1104–1107.
- [9] Schwartz BS, Harris JB, Khan AI, Larocque RC, Sack DA, Malek MA, et al. Diarrheal epidemics in Dhaka, Bangladesh, during three consecutive floods: 1988, 1998, and 2004. *Am J Trop Med Hyg* 2006; **74**(6): 1067–1073.
- [10] Myaux JA, Ali M, Chakraborty J, de Francisco A. Flood control embankments contribute to the improvement of the health status of children in rural Bangladesh. *Bull World Health Organ* 1997; **75**(6): 533–539.
- [11] Carrel M, Voss P, Streatfield PK, Yunus M, Emch M. Protection from annual flooding is correlated with increased cholera prevalence in Bangladesh: a zero-inflated regression analysis. *Environ Health* 2010; **9**: 13.
- [12] WHO. *Floods in Pakistan—health cluster bulletin No 12–16 August 2010*. Geneva: WHO; 2010. [Online] Available from: <http://www.who.int/hac/crises/pak/sitreps/16august2010/en/index.html>. [Accessed on 14 October, 2010]
- [13] WHO. *Flooding and communicable diseases fact sheet: risk assessment and preventive measures*. Geneva: WHO. [Online] Available from: <http://www.who.int/hac/techguidance/ems/en/FloodingandCommunicableDiseasesfactsheet.pdf>. [Accessed on 20 December, 2010]
- [14] Brandt M, Brown C, Burkhardt J, Burton N, Cox–Ganser J, Damon S, et al. Mold prevention strategies and possible health effects in the aftermath of hurricanes and major floods. *MMWR Recomm Rep* 2006; **55**(RR–8): 1–27.
- [15] Vachiramon V, Busaracome P, Chongtrakool P, Puavilai S. Skin diseases during floods in Thailand. *J Med Assoc Thai* 2008; **91**(4): 479–484.
- [16] Iowa Uo. *Eye safety in flood waters*. Iowa: University of Iowa Health Care Today; 2008. [Online] Available from: <http://www.uihealthcare.com/kxic/2008/06/eyesafety.html>. [Accessed on 10 January, 2011]
- [17] WHO. Leptospirosis worldwide, 1999. *Weekly Epidemiol Rec* 1999; **74**: 237–242.
- [18] Vijayachari P, Sugunan AP, Shriram AN. Leptospirosis: an emerging global public health problem. *J Biosci* 2008; **33**(4): 557–569.
- [19] Boland M, Sayers G, Coleman T, Bergin C, Sheehan N, Creamer E, et al. A cluster of leptospirosis cases in canoeists following a competition on the River Liffey. *Epidemiol Infect* 2004; **132**(2): 195–200.
- [20] WHO. *Roll back malaria: situation analysis of Pakistan*. [Online] Available from: <http://www.emro.who.int/rbm/CountryProfiles-pak.htm>. [Accessed on 23 March, 2011]
- [21] Singh NSM, Chand SK, Sharma VP, Singh N. Outbreak of falciparum malaria in submerged villages of Narayanjanj PHC, district Mandla due to Narmada irrigation project, central India (Madhya Pradesh). *Curr Sci* 1997; **73**(8): 686–691.
- [22] Wang SJ, Lengeler C, Smith TA, Vounatsou P, Akogbeto M, Tanner M. Rapid urban malaria appraisal (RUMA) IV: epidemiology of urban malaria in Cotonou (Benin). *Malar J* 2006; **5**: 45.
- [23] Mathur KK, Harpalani G, Kalra NL, Murthy GC, Narasimham MV. Epidemic of malaria in Barmer district (Thar desert) of Rajasthan during 1990. *Indian J Malariol* 1992; **29**(1): 1–10.
- [24] Sharma RS, Lal S, Sharma SN, Joshi RD, Dhillon GP. Malaria outbreak in Mewat region Gurgaon district of Haryana State. *J Commun Dis* 1997; **29**(3): 307–308.
- [25] Ebrahim Z. *As floods recede, epidemics wait in the wings*. Pakistan: IPS News; 2006.
- [26] WHO. *Monthly morbidity and mortality report: flood affected districts, Balochistan–Pakistan*. Geneva: WHO; 2009.
- [27] Brooker S, Mohammed N, Adil K, Agha S, Reithinger R, Rowland M, et al. Leishmaniasis in refugee and local Pakistani populations. *Emerg Infect Dis* 2004; **10**(9): 1681–1684.
- [28] Kolaczinski J, Brooker S, Reyburn H, Rowland M. Epidemiology of anthroponotic cutaneous leishmaniasis in Afghan refugee camps in northwest Pakistan. *Trans R Soc Trop Med Hyg* 2004; **98**(6): 373–378.
- [29] Bhutto AM, Soomro RA, Nonaka S, Hashiguchi Y. Detection of new endemic areas of cutaneous leishmaniasis in Pakistan: a 6-year study. *Int J Dermatol* 2003; **42**(7): 543–548.
- [30] WHO. *Essential leishmaniasis maps*. [Online] Available from: http://www.who.int/leishmaniasis/leishmaniasis_maps/en/index.html. [Accessed on 28 July, 2010]
- [31] Rowland M, Munir A, Durrani N, Noyes H, Reyburn H. An outbreak of cutaneous leishmaniasis in an Afghan refugee settlement in north–west Pakistan. *Trans R Soc Trop Med Hyg* 1999; **93**(2): 133–136.
- [32] Zora PWD. *Black fever in India: an epidemic rooted in poverty*. 2004. [Online] Available from: <http://www.wsws.org/articles/2004/dec2004/ind-d30.shtml>. [Accessed on 20 June, 2010]
- [33] Siddique AK, Baqui AH, Eusof A, Zaman K. 1988 floods in Bangladesh: pattern of illness and causes of death. *J Diarrhoeal Dis Res* 1991; **9**(4): 310–314.
- [34] Bhalla JS. *After the flood, victims fall prey to tuberculosis in Bihar camps*. Hindustan Times; 2008.
- [35] WHO. *Acute water diarrhea outbreak*. Weekly Morbidity and Mortality Report; 2005, p. 6.
- [36] Shears P. The Khartoum floods and diarrhoeal diseases. *Lancet* 1988; **2**(8609): 517.