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REVIEW ARTICLE

Health Risks of Flood Disasters

David L. Paterson, Hugh Wright, and Patrick N. A. Harris

Centre for Clinical Research, Faculty of Medicine, University of Queensland, Brisbane, Australia

Floods are the most common natural disaster occurring worldwide, with their impact expected to grow in the future due to the effects of climate change and population shift. Floodwaters pose immediate dangers to human health, but also long-term effects resulting from displacement and worsened living conditions. This review examines the health impact of flood disasters, including skin and soft-tissue infections, gastroenteritis, and zoonotic infections such as leptospirosis, and the impact on noncommunicable diseases and health infrastructure. Further work in the development of cost-efficient preparedness strategies may mitigate the morbidity and mortality associated with such natural disasters.

The recent floods in Texas and in other parts of the southern United States after Hurricane Harvey have garnered international attention. At the same time, floods in India, Nepal, and Bangladesh have killed >1000 persons and significantly affected tens of millions. Floods are the most common natural disaster occurring worldwide [1]. In 2016, floods (excluding landslides) affected >74 million persons globally, resulted in 4720 deaths< and had an economic cost of >$57 billion. Of 161 significant flood disasters worldwide in 2016, 43% occurred in Asia, 23% in the Americas, and 12% in Europe [2].

Floodwaters pose immediate dangers to human health, but also long-term effects resulting from displacement and worsened living conditions (see Table 1). The impact of flood disasters is expected to grow in the future owing to the effects of climate change and population shifts [3]. For example, in China, the number of elderly persons living in "rainstorm hazard areas" increased by 38 million between 1990 and 2010, greatly increasing the complexity of planning for future flood disasters [4]. The purpose of this review is to examine the health impacts of flood disasters, their management, and their prevention.

DROWNING AND OTHER ACUTE EVENTS

Drowning is the most frequent immediate cause of death soon after the onset of flooding [1]. The risk of death is dependent on the speed of onset of flooding, with flash flooding more hazardous than floods with more gradual onset. In developed countries, men are overrepresented among flood fatalities, potentially representing risk-taking behavior. In 1 2017 analysis, drivers and passengers in vehicles were commonly implicated in fatalities [5]. In the United States in 2016, drivers or passengers of vehicles accounted for 46% of flood-related fatalities [6].

Other acute events include orthopedic injuries and lacerations, hypothermia, electrocution, and even burns from flammable, low-density liquids spreading across the surface of floodwaters [1]. Carbon monoxide poisoning from unventilated electrical generators or cooking implements is surprisingly common after floods [7].

NONCOMMUNICABLE DISEASES

Flood disasters have a significant impact on chronic health conditions, with medication noncompliance due to nonavailability, difficulties with access to health services, and the physical workload associated with clean-up and reconstruction being significant issues [8]. The reported impact of any interruption to treatment varies according to the underlying condition, with increased mortality rates after disasters in patients with cardiovascular disease and diabetes [9]. Increased exacerbations of cardiovascular disease, including worsening control of hypertension and myocardial infarctions, with an associated increase risk of death, were observed after hurricane events with associated flooding [10]. Patients with chronic respiratory diseases were noted to have an increase in acute exacerbations after natural disasters, owing to disruption in maintenance therapy, loss of power, particularly among oxygen- and nebulizer-dependent patients, and overcrowding [11]. Glycemic control, particularly in users of insulin, was found to have deteriorated in the year after flooding in a large examination of British diabetics [12]. Disruption of treatment, poor nutrition, and change in activity can lead to increased risk of ketoacidosis and death [10].

Posttraumatic stress disorder (PTSD), anxiety and depression are potential mental health consequences for flood victims [13, 14]. In an assessment of patients with postflood PTSD, symptoms were still present more than a decade later in 19%, with long-standing PTSD predicted by losing relatives in the flood disaster, suffering bodily injury, having a low level

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Correspondence: H. Wright, Centre for Clinical Research, University of Queensland, Royal Brisbane & Women's Hospital, Herston, Brisbane, Queensland, Australia (hughw@live.com.au).

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Table 1. Health Risks of Flooding, Stratified by Time After Event

Immediate
Drowning
Trauma
Hypothermia
Electrocution
Carbon monoxide poisoning
Early (<10 d after event)
Cutaneous infection
Aspiration pneumonitis/pneumonia
Viral respiratory infections
Gastroenteritis
Late (>10 d after event)
Leptospirosis
Mosquito-borne illnesses
Cutaneous infection from atypical organisms (fungi, mycobacteria)
Hepatitis A or E virus infection
Mental health disorders, including posttraumatic stress disorder and depression
Management of chronic disease

of social support, and having a negative coping style [15]. In a controlled, interrupted time series analysis in the United Kingdom, an increase in prescription of antidepressants was observed in the year after flood onset, compared with the year before [16]. Stress in pregnant women affected by flood disasters has been linked to lower birth weights [17] and impaired social functioning in their children [18], although long-term analyses are lacking.

HEALTHCARE INFRASTRUCTURE

Considerable loss of healthcare infrastructure can be associated with flood disasters, including evacuation of entire tertiary care hospitals [19]. Loss of paper-based medical records and inaccessibility of electronic medical records and laboratory information systems is common. A vast array of other hospital functions may be affected by water supply issues, including recovery of sterile processing for surgical equipment [20]. Emergency department presentations may increase markedly. As noted after the Hurricane Sandy flooding, significant increases in emergency department visits may be recorded for homelessness or inadequate shelter, especially among the elderly [21].

INFECTION

The risk of infection after exposure to floodwaters captures considerable public attention and is a common cause of presentation for healthcare after floods.

Cutaneous Infection

Trauma is common in patients injured by fast-moving water, trying to escape floodwaters, or cleaning up after floods. Cellulitis and deeper skin infections are subsequently common. Cases of cellulitis have been shown to peak 3–4 days after a flooding event and remain above baseline levels for up to 3 weeks [22]. Any trauma can introduce pathogenic skin flora into wounds. Therefore, the typical bacterial causes of cellulitis and soft-tissue infections (*Staphylococcus aureus* and *Streptococcus pyogenes*) should be the first considerations when antibiotic therapy is indicated. However, a number of less commonly encountered water-dwelling organisms (notably *Aeromonas* species) may cause skin infections in patients exposed to floodwater [23]. Among 777 patients transferred to tertiary referral hospitals from regional centers after a disaster in December 2004, the most frequent medical problem was skin and soft-tissue infection, with *Aeromonas* spp. the most commonly identified organism (22.6% of cultured isolates) [23]. *Aeromonas* is a gram-negative bacillus and therefore is not covered by antibiotics usually used to treat the gram-positive staphylococci or streptococci.

Vibrio spp. may be associated with saltwater exposure in the context of storm surges. After Hurricane Katrina in 2005, 22 cases of *Vibrio* illness were identified, the majority of which were wound infections caused by *Vibrio vulnificus* or *Vibrio parahaemolyticus*, with 5 deaths reported [24]. The highly virulent species *V. vulnificus* poses a particular risk to individuals with comorbid conditions, such as chronic liver disease, immunosuppression, or iron-overload states, and those affected may present with severe sepsis, necrotizing infection, and characteristic hemorrhagic bullae. Other gram-negative bacteria that may be associated with soft-tissue infections after water exposure include *Shewanella* spp. (eg, *Shewanella putrefaciens* or *Shewanella algae*), *Leclercia adecarboxylata,* and *Chromobacterium violaceum* [25, 26].

Infection of contaminated wounds by *Clostridium tetani* may occur in areas of low immunization coverage. After the 2004 tsunami, 106 cases of tetanus were reported in Aceh province in Indonesia, with a case fatality ratio of 18.9% [27]. Mass tetanus immunization programs after flood events are likely not to be a cost-effective public health intervention in developed countries.

In endemic tropical regions, such as Southeast Asia and northern Australia, exposure to soil or water containing *Burkholderia pseudomallei* can result in melioidosis. The incidence of *B. pseudomallei* increases after severe weather events and reflects the frequency and amount of rainfall and the extent of groundwater, as well as elevated ambient temperatures and humidity [28]. Melioidosis may present as fulminant sepsis with pneumonia, bacteremia, or visceral abscesses, particularly in persons with specific risk factors, such as diabetes mellitus, excessive alcohol consumption, or corticosteroid use [29]. However, melioidosis can present with more indolent cutaneous disease, after direct inoculation into wounds or skin abrasions [30].

Mold infections are increasingly recognized after flood exposure [31], and may be a challenge to diagnose. Fungi are often cultured from wounds after natural disasters,

although their presence may reflect colonization rather than true infection. Adequate wound care, removal of foreign bodies and debridement of devitalized tissue may be sufficient, without the need for antifungal therapy. However, the Infectious Diseases Society of America guidelines for the management of cutaneous aspergillosis after traumatic injury recommend surgical debridement in addition to antifungal therapy and emphasize the importance of tissue biopsy to confirm a mycological diagnosis and visualize the presence of vascular invasion by hyphae within the dermis and subcutaneous tissue [32].

Although most soft-tissue infections after floodwater exposure will be bacterial, infections caused by fungal pathogens are well described, and infection may be polymicrobial [33]. Perhaps the most critical entity to recognize is mucormycosis, caused by zygomycete fungi such as *Rhizopus*, *Mucor,* and *Rhizomucor* [34]. Such infections may present as a rapidly progressive necrotizing fasciitis with high mortality rates if urgent surgical intervention and antifungal therapy is unavailable or delayed. Other fungal species that have been described to cause cutaneous infections after floods include *Fusarium* or *Cladophialophora bantiana*, although many additional species have been reported in this context [31, 26]. Noninfectious skin disorders, such as contact dermatitis, immersion foot syndromes, and exacerbation of existing skin conditions, are also common after floods [26].

Nontuberculous mycobacteria may also cause infections after exposure to floodwater, particularly rapid growing *Mycobacterium* species such as *M. fortuitum*, *M. chelonae,* and *M. abscessus* [35]. These may present late and be hard to recognize if adequate specimens are not collected (eg, tissue specimens rather than routine bacterial swab specimens) or specific mycobacterial cultures are not requested.

Respiratory Infections

In reports from the United States and the United Kingdom, acute respiratory infection was the most common infectious disease requiring consultation after flooding [36]. Flulike and upper respiratory tract symptoms were also the most commonly reported symptoms in sheltered evacuees after hurricane Katrina, probably owing to a combination of viral pathogens and increased exposure to allergens in atopic individuals [37]. Disruption of housing and overcrowding can increase the risk of transmission of respiratory viral pathogens. Direct contact with floodwater, with immersion, near drowning, or aspiration, can lead to inoculation of the lower respiratory tract. Flood associated aspiration pneumonia is frequently polymicrobial and may be complicated by pulmonary necrosis, abscess formation, and empyema [38]. A chronic cough syndrome has been recognized after a number of natural disasters with associated major flooding, though the cause remains unclear [39].

Gastrointestinal Disease

The risk of gastroenteritis after flooding is highest in areas with poor hygiene or an inadequate supply of clean drinking water, though outbreaks of diarrheal diseases are common even in resource-rich areas, particularly if the integrity of sewerage systems is compromised. Massive outbreaks of bacterial gastroenteritis after widespread flooding in Bangladesh, with *Vibrio cholerae* and enterotoxigenic *Escherichia coli* the most common pathogens isolated [40, 41]. Postflood cholera epidemics in Bangladesh had a median time of onset of 8 days after flood events [42].

Increased cases of other enteric infections, including shigellosis and salmonellosis, have been reported in the setting of flooding. Flooding of residential domiciles was associated with increased risk of enteric fever [43]. Viral gastroenteritis outbreaks may occur in the setting of overcrowding and compromised hygiene practices. After Hurricane Katrina, outbreaks of gastroenteritis were reported in facilities habituated by evacuees and aid workers, with norovirus the predominant pathogen [44]. In an epidemic of diarrheal illness in the Solomon Islands precipitated by flash flooding, rotavirus was the most common pathogen identified. Improving vaccination programs coverage in susceptible areas to natural disasters may well be effective in decreasing the associated burden of disease [45]. Other viruses transmitted via the fecal-oral route by ingestion of contaminated food or water, such as hepatitis A and E, may have increased transmission after flooding, with outbreaks reported in the Sudan and India [46, 47]. An outbreak of diarrhea in Germany caused by *Cryptosporidium* occurred 6 weeks after flooding, in the setting of damage to the local sewerage system [48].

Zoonoses and Vector-Borne Diseases

Leptospirosis, a spirochetal zoonosis causing an acute febrile illness, has increasingly been recognized as a pathogen associated with flooding and extreme weather events. Outbreaks of leptospirosis have been reported from diverse geographic locations in urban and rural settings, encompassing both the developed and developing world [49]. In some areas, flooding has been reported as the main risk factor for transmission [50]. In Mumbai, India, in 2005, massive rainfall of almost 1000 mm in 24 hours resulted in a significant outbreak, with >400 presumptive cases of leptospirosis diagnosed on the basis of screening serology within the next 3 months [51].

Humans can acquire infection through direct contact with animal hosts (including rodents, domestic pets, and livestock), or through an environment contaminated by animal urine. In flooding, the increase in transmission is probably multifaceted, with closer contact between animal hosts and humans, direct contamination of floodwaters, and damage to water and sanitation networks. The burden of leptospirosis after severe flooding may be underrecognized, given that it can cause a nonspecific febrile illness that resembles many other infectious diseases and

the potential lack of available testing facilities [52]. Because of the predictable increase in risk of developing disease, a role for antibiotic prophylaxis to prevent infection has been suggested. The benefit of using doxycycline in military personnel undergoing training in a leptospirosis-endemic area was reported in 1984, although no such benefit has been found in residents of endemic areas [53, 54]. A Cochrane review published in 2009 examined the broader question of the use of prophylaxis and found inadequate evidence to support its use [55]. No clinical trial data exist on the use of chemoprophylaxis after floods, although the use of modeling has suggested there may be benefit in a high-risk setting [56].

In endemic areas, mosquito-borne diseases (eg, Japanese encephalitis or dengue fever) may occur at an increased rate after flood events [57]. Major flooding in northern Peru in early 2017 was associated with large outbreaks of dengue fever and chikungunya, with >19 000 suspected cases of dengue reported [58]. Vector control programs at high-risk transmission sites have been effective in preventing increased cases of dengue and malaria after flooding [59].

PUBLIC HEALTH RESPONSE AND PREVENTION OF FLOOD DISASTERS

It is intuitive that the immediate public health response to flood disasters is provision of shelter, water, nutrition, sanitation, and hygiene. Public health preparedness is an essential element in preventing morbidity and mortality associated with flood disasters. Key elements are listed in Table 2. Data analysis of the Hurricane Sandy flooding in New York City suggests that preparedness was associated with lower-than-expected rates of food- and waterborne disease [60]. Recently released comprehensive guidelines on outbreak response, which would include those suspected after a natural disaster, have been released by the Society for Healthcare Epidemiology of America and provide an excellent framework to implement an appropriate and coordinated response [61].

Sophisticated "data aggregation" analyses can identify communities at greatest risk from flood disasters and can be used to plan cost-efficient preparedness strategies [62]. Social media data have been analyzed to provide early warning of flood disasters even before their advent [63].

Prevention of flood disasters rest on flood mitigation schemes and planned removal of populations from flood-prone areas. In developed countries, the process of "managed retreat," whereby properties at risk of flooding are purchased by government authorities has long been practiced. Since 1993, when the United States Congress authorized the Federal Emergency Management Agency to purchase vulnerable properties, 38 500 properties in 44 states have been resumed [64]. The health and social impact of moving persons and infrastructure out of "harm's way" has not yet been measured.

Table 2. Key Public Health Interventions to Prevent Deterioration in Noncommunicable Disease Associated With Flood Disasters [50]

Long-term intervention before event
Effective town planning
Mapping populations at risk by noncommunicable disease
Preplanning with pharmaceutical and medical equipment suppliers
Ensuring evacuation centers would have power for medical equipment
Establishment of mechanisms for information sharing between agencies
Immediately before event
Strong civic leadership
Evacuation of high-risk persons before flood disaster
Establish hubs for treatment and care after flood disaster
During event
Increased use of telemedicine
Health professionals prospectively visiting evacuation centers

CONCLUSION

Floods are the most frequent natural disaster and can have widespread social and health impacts. These effects can be acute but may present only weeks to months after the flood. Each flood disaster represents an opportunity for preparedness and preventive measures to improve. More rigorous methods of studying these measures are needed to more effectively reduce mortality and morbidity from flood disasters.

Note

Potential conflicts of interest. All authors: No reported conflicts of interest. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

References

1. Du W, FitzGerald GJ, Clark M, Hou XY. Health impacts of floods. Prehosp Disaster Med **2010**; 25:265–72.
2. EM-DAT: The emergency events database. Université Catholique de Louvain. Available at: www.emdat.be. Accessed 3 September 2017.
3. Allan RP, Soden BJ. Atmospheric warming and the amplification of precipitation extremes. Science **2008**; 321:1481–4.
4. Liang P, Xu W, Ma Y, Zhao X, Qin L. Increase of elderly population in the rainstorm hazard areas of China. Int J Environ Res Public Health **2017**; 14:E963.
5. Salvati P, Petrucci O, Rossi M, Bianchi C, Pasqua AA, Guzzetti F. Gender, age and circumstances analysis of flood and landslide fatalities in Italy. Sci Total Environ **2017**; 610–611:867–79.
6. National Weather Service, National Oceanic and Atmospheric Administration. 2016 Flash flood/river flood fatalities. Available at: http://www.nws.noaa.gov/om/hazstats/flood16.pdf. Accessed 4 September 2017.
7. Daley WR, Shireley L, Gilmore R. A flood-related outbreak of carbon monoxide poisoning—Grand Forks, North Dakota. J Emerg Med **2001**; 21:249–53.
8. Ryan BJ, Franklin RC, Burkle FM Jr, et al. Reducing disaster exacerbated non-communicable diseases through public health infrastructure resilience: perspectives of Australian disaster service providers. PloS Curr **2016**; 21:8.
9. Ryan B, Franklin RC, Burke FM, et al. Identifying and describing the impact of cyclone, storm and flood related disasters on treatment management, care and exacerbations of non-communicable diseases and the implications for public health. PLoS Curr **2015** Sep 28. doi: 10.1371/currents.dis.62e9286d152de04799644dcca47d9288.
10. McKinney N, Houser C, Meyer-Arendt K. Direct and indirect mortality in Florida during the 2004 hurricane season. Int J Biometeorol **2011**; 55:533–46.
11. Robinson B, Alatas MF, Robertson A, Steer H. Natural disasters and the lung. Respirology **2011**; 16:386–95.
12. Ng J, Atkin SL, Rigby AS, Walton C, Kilpatrick ES. The effect of extensive flooding in Hull on the glycaemic control of patients with diabetes. Diabet Med **2011**; 28:519–24.
13. Dai W, Kaminga AC, Tan H, et al. Long-term psychological outcomes of flood survivors of hard-hit areas of the 1998 Dongting Lake flood in China: prevalence and risk factors. PLoS One **2017**; 12:e0171557.

14. Chung MC, Jalal S, Khan NU. Posttraumatic stress symptoms, co-morbid psychiatric symptoms and distorted cognitions among flood victims of different ages. J Ment Health **2017**; 26:204–11.
15. Dai W, Wang J, Kaminga AC, et al. Predictors of recovery from post-traumatic stress disorder after the Dongting Lake flood in China: a 13-14 year follow-up study. BMC Psychiatry **2016**; 16:382.
16. Milojevic A, Armstrong B, Wilkinson P. Mental health impacts of flooding: a controlled interrupted time series analysis of prescribing data in England. J Epidemiol Community Health **2017**; 71(10):970–3. doi:10.1136/jech-2017–208899.
17. Hilmert CJ, Kvasnicka-Gates L, Teoh AN, Bresin K, Fiebiger S. Major flood related strains and pregnancy outcomes. Health Psychol **2016**; 35:1189–96.
18. Simcock G, Elgbeili G, Laplante DP, et al. The effects of prenatal maternal stress on early temperament: the 2011 Queensland flood study. J Dev Behav Pediatr **2017**; 38:310–21.
19. Kaliamoorthy I, Reddy MS, Rajakumar A, et al. Safe emergency evacuation of a tertiary care hospital during the "once in a century" floods in Chennai, India. Indian J Crit Care Med **2016**; 20:104–8.
20. Shelton S, Hamm J, Olatosi B, Johnson RO. Recovery of surgical equipment sterile processing during a floodwater boil advisory. Disaster Med Public Health Prep **2017** August 14; 1–4. doi:10.1017/dmp.2017.70.
21. Doran KM, McCormack RP, Johns EL, et al. Emergency department visits for homelessness or inadequate housing in New York City before and after Hurricane Sandy. J Urban Health **2016**; 93:331–44.
22. Lin PC, Lin HJ, Guo HR, Chen KT. Epidemiological characteristics of lower extremity cellulitis after a typhoon flood. PLoS One **2013**; 8:e65655.
23. Hiransuthikul N, Tantisiriwat W, Lertutsahakul K, Vibhagool A, Boonma P. Skin and soft-tissue infections among tsunami survivors in southern Thailand. Clin Infect Dis **2005**; 41:e93–6.
24. Centers for Disease Control and Prevention. Vibrio illnesses after Hurricane Katrina—multiple states, August--September 2005. MMWR **2005**; 54:928–31.
25. Tam V, Nayak S. Isolation of *Leclercia adecarboxylata* from a wound infection after exposure to hurricane-related floodwater. BMJ Case Rep **2012**; 2012. doi: 10.1136/bcr-2012-007298.
26. Bandino JP, Hang A, Norton SA. The infectious and noninfectious dermatological consequences of flooding: a field manual for the responding provider. Am J Clin Dermatol **2015**; 16:399–424.
27. Aceh Epidemiology Group. Outbreak of tetanus cases following the tsunami in Aceh Province, Indonesia. Glob Public Health **2006**; 1: 173–7.
28. Cheng AC, Jacups SP, Gal D, Mayo M, Currie BJ. Extreme weather events and environmental contamination are associated with case-clusters of melioidosis in the Northern Territory of Australia. Int J Epidemiol **2006**; 35:323–9.
29. Wiersinga WJ, Currie BJ, Peacock SJ. Melioidosis. N Engl J Med **2012**; 367:1035–44.
30. Gibney KB, Cheng AC, Currie BJ. Cutaneous melioidosis in the tropical top end of Australia: a prospective study and review of the literature. Clin Infect Dis **2008**; 47:603–9.
31. Benedict K, Park BJ. Invasive fungal infections after natural disasters. Emerg Infect Dis **2014**; 20:349–55.
32. Patterson TF, Thompson GR 3rd, Denning DW, et al. Practice guidelines for the diagnosis and management of aspergillosis: 2016 update by the Infectious Diseases Society of America. Clin Infect Dis **2016**; 63:e1–60.
33. Andresen D, Donaldson A, Choo L, et al. Multifocal cutaneous mucormycosis complicating polymicrobial wound infections in a tsunami survivor from Sri Lanka. Lancet **2005**; 365:876–8.
34. Spellberg B, Edwards J Jr, Ibrahim A. Novel perspectives on mucormycosis: pathophysiology, presentation, and management. Clin Microbiol Rev **2005**; 18:556–69.
35. Appelgren P, Farnebo F, Dotevall L, Studahl M, Jönsson B, Petrini B. Late-onset posttraumatic skin and soft-tissue infections caused by rapid-growing mycobacteria in tsunami survivors. Clin Infect Dis **2008**; 47:e11–6.
36. Carroll B, Balogh R, Morbey H, Araoz G. Health and social impacts of a flood disaster: responding to needs and implications for practice. Disasters **2010**; 34:1045–63.
37. Murray KO, Kilborn C, DesVignes-Kendrick M, et al. Emerging disease syndromic surveillance for Hurricane Katrina evacuees seeking shelter in Houston's Astrodome and Reliant Park Complex. Public Health Rep **2009**; 124:364–71.
38. Maegele M, Gregor S, Yuecel N, et al. One year ago not business as usual: wound management, infection and psychoemotional control during tertiary medical care following the 2004 tsunami disaster in Southeast Asia. Crit Care **2006**; 10:R50.
39. Barbeau DN, Grimsley LF, White LE, El-Dahr JM, Lichtveld M. Mold exposure and health effects following hurricanes Katrina and Rita. Annu Rev Public Health **2010**; 31:165–78 1 p following 178.
40. Qadri F, Khan AI, Faruque AS, et al. Enterotoxigenic *Escherichia coli* and *Vibrio cholerae* diarrhea, Bangladesh, 2004. Emerg Infect Dis **2005**; 11:1104–7.
41. Shimi A, Parvin G, Biswas C, et al. Impact and adaptation to flood: a focus on water supply, sanitation and health problems of rural community in Bangladesh. Disaster Prev Manage **2010**; 19:298–313.
42. Schwartz BS, Harris JB, Khan Ai, et al. Diarrheal epidemics in Dhaka, Bangladesh, during three consecutive floods: 1988, 1998, 2004. Am J Trop Med Hyg **2006**; 74:1067–73.
43. Vollaard AM, Ali S, van Asten HA, et al. Risk factors for typhoid and paratyphoid fever in Jakarta, Indonesia. JAMA **2004**; 291:2607–15.
44. Centers for Disease Control and Prevention. Infectious disease and dermatologic conditions in evacuees and rescue workers after Hurricane Katrina MMWR **2005**; 54:961–4.
45. Jones FK, Ko AI, Becha C, et al. Increased rotavirus prevalence in diarrheal outbreak precipitated by localized flooding, Solomon Islands, 2014. Emerg Infect Dis **2016**; 22:875–9.
46. McCarthy MC, He J, Hyams KC, el-Tigani A, Khalid IO, Carl M. Acute hepatitis E infection during the 1988 floods in Khartoum, Sudan. Trans R Soc Trop Med Hyg **1994**; 88:177.
47. Pal S, Juyal D, Sharma M, Kotian S, Negi V, Sharma N. An outbreak of hepatitis A virus among children in a flood rescue camp: a post-disaster catastrophe. Indian J Med Microbiol **2016**; 34:233–6.
48. Gertler M, Dürr M, Renner P, et al. Outbreak of *Cryptosporidium hominis* following river flooding in the city of Halle (Saale), Germany, August 2013. BMC Infect Dis **2015**; 15:88.
49. Pellizzer P, Todescato A, Benedetti P, Colussi P, Conz P, Cinco M. Leptospirosis following a flood in the Veneto area, North-east Italy. Ann Ig **2006**; 18:453–6.
50. Vanasco NB, Schmeling MF, Lottersberger J, Costa F, Ko AI, Tarabla HD. Clinical characteristics and risk factors of human leptospirosis in Argentina (1999-2005). Acta Trop **2008**; 107:255–8.
51. Maskey M, Shastri JS, Saraswathi K, Surpam R, Vaidya N. Leptospirosis in Mumbai: post-deluge outbreak 2005. Indian J Med Microbiol **2006**; 24:337–8.
52. Gaynor K, Katz AR, Park SY, Nakata M, Clark TA, Effler PV. Leptospirosis on Oahu: an outbreak associated with flooding of a university campus. Am J Trop Med Hyg **2007**; 76:882–5.
53. Takafuji ET, Kirkpatrick JW, Miller RN, et al. An efficacy trial of doxycycline chemoprophylaxis against leptospirosis. N Engl J Med **1984**; 310:497–500.
54. Sehgal SC, Sugunan AP, Murhekar MV, Sharma S, Vijayachari P. Randomized controlled trial of doxycycline prophylaxis against leptospirosis in an endemic area. Int J Antimicrob Agents **2000**; 13:249–55.
55. Brett-Major DM, Lipnick RJ. Antibiotic prophylaxis for leptospirosis. Cochrane Database Syst Rev **2009** Jul 8; (3):CD007342.
56. Schneider MC, Velasco-Hernandez J, Min KD, et al. The use of chemoprophylaxis after floods to reduce the occurrence and impact of leptospirosis outbreaks. Int J Environ Res Public Health **2017**; 14:594.
57. Zhang F, Liu Z, Zhang C, Jiang B. Short-term effects of floods on Japanese encephalitis in Nanchong, China, 2007–2012: a time-stratified case-crossover study. Sci Total Environ **2016**; 563–564:1105–10.
58. Peru: rainy season—Situation Report No. 10 (as of 10 May 2017). UN Office for the Coordination of Humanitarian Affairs, UN Country Team in Peru. Available at https://www.humanitarianresponse.info/en/operations/peru/document/sitrep-n%C2%B0-10-temporada-de-lluvias. Accessed January 2018.
59. Shortus M, Musto J, Bugoro H, Butafa C, Sio A, Joshua C. Vector-control response in a post-flood disaster setting, Honiara, Solomon Islands, 2014. Western Pac Surveill Response J **2016**; 7:38–43.
60. Bloom MS, Palumbo J, Saiyed N, Lauper U, Lin S. Food and waterborne disease in the greater New York City area following Hurricane Sandy in 2012. Disaster Med Public Health Prep **2016**; 10:503–11.
61. Banach DB, Johnston BL, Al-Zubeidi D, et al; Outbreak Response Training Program (ORTP) Advisory Panel. Outbreak response and incident management: SHEA guidance and resources for healthcare epidemiologists in United States acute-care hospitals. Infect Control Hosp Epidemiol **2017**; 38:1393–419.
62. Röthlisberger V, Zischg AP, Keiler M. Identifying spatial clusters of flood exposure to support decision making in risk management. Sci Total Environ **2017**; 598:593–603.
63. Tkachenko N, Jarvis S, Procter R. Predicting floods with Flickr tags. PLoS One **2017**; 12:e0172870.
64. Siders AR. Climate adaptation: past US floods give lessons in retreat. Nature **2017**; 548:281.