

## Hurricanes, Floods and Ritual Infectious Disease Outbreak Warnings

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### Abstract

The relationship between natural disasters, as hurricanes and floods, and communicable diseases is often overstated. Nevertheless, mainstream media reproduce their yearly ritual warnings with no evidence cholera, yellow fever, leptospirosis, hepatitis A, typhoid fever, malaria and Zika outbreaks are occurring in non-endemic countries as the U.S., manifesting only little surges in dengue and West Nile Fever, following hurricanes and floods. In this mini-review water-and vector-borne disease outbreaks occurring after floods and hurricanes worldwide are discussed.

### Introduction

Even after a hurricane's immediate flooding threat goes away residents could face a host of potential health problems from what the water leaves behind. A combination of circumstances including compromised drinking water and sanitation, decreased access to safe food and water, increased amounts of standing water, and the interruption of mosquito control efforts have amplified the possibility of spreading infectious diseases, such as leptospirosis, hepatitis A and mosquito-borne illnesses as dengue and West-Nile Fever. Power failure may cause subsequent additional problems in life care support.

The WHO flooding and communicable fact sheets name water-borne diseases as typhoid fever, cholera and hepatitis A. Vector borne diseases at increased risk after floods are dengue, yellow fever, malaria and West-Nile Fever [1]. Risks differ between high-income countries and low-income countries, where some of these diseases are endemic, such as malaria and dengue. In this mini-review the effects of some hurricanes and floods during the last decades are analyzed by sort of infectious disease outbreaks, both in Western and low-income countries.

## Water-Borne Diseases

### Leptospirosis

The only epidemic-prone infection which can be transmitted directly from contaminated water is leptospirosis, a zoonotic bacterial infection [1]. According to the World Health Organization (WHO) the incidence of leptospirosis in tropical regions is 10 times higher than in temperate climates [2]. It is estimated that each year more than a million cases occur worldwide that result in some 60.000 deaths [3-5]. Of the 100-200 cases identified in the U.S., half occur in Hawaii [5]. The infection has been underreported and under recognized, but awareness is slowly increasing given the leptospirosis outbreaks

A recent leptospirosis outbreak was noted in Puerto Rico after Hurricane Maria, 2018 [6]. A Puerto Rico mortality database listed 26 deaths in the six months after Hurricane, Maria, that were labeled by clinicians as “caused” by leptospirosis That’s more than twice the number of deaths as were listed in Puerto Rico the previous year, according to the analyses of federal records. The mortality database does not indicate whether the cases were confirmed in laboratory tests, that can take months, if ordered anyway. However, also lab confirmed cases showed a two-fold increase and the leptospirosis cases after Maria should have been classified as an epidemic [6].

Hurricane Harvey has put health officials on alert for water-borne infections as e.g. leptospirosis [7]. One of the most destructive hurricanes that hit the U.S. since Katrina in 2005, Harvey damaged more than 100.000 homes in the Houston area. In addition, the storm flooded numerous wastewater treatment plants. Stadler *et al.* surveyed post-Harvey floodwaters on bacteria. Floodwaters showed the presence of E.coli to be 125 times higher than is considered safe for swimming. No leptospira cases were reported [8]. Leptospirosis has not been a problem post-Katrina [9] and for recent Florence no reports are yet available [10,11].

A quite different picture is seen in India where flood-hit Kerala now battles “rat fever” after weeks of torrential rains [12]. Suspected cases of leptospirosis has climbed to 800 since mid-august 2018. Confirmed deaths caused by leptospirosis so far total 12, with suspected deaths, pending full medical reports, number 41. There is a shortfall of preventive doxycycline tablets. About 3 million tablets are needed the coming 2 months, but only 800.000 tablets are in stock [12].

Philippine DOH (Department of Health) reports 1227 leptospirosis cases in Metro Manilla due to floods so far in 2018 [13]. This is about 50% of the Philippine leptospirosis burden. Out of 1030 leptospirosis cases 99 deaths were recorded [14].

Leptospirosis is not transmitted by rats alone but can be transmitted also through the urine of infected animals as cattle, horses, sheep, pigs and dogs. Recently, new variants of *Leptospira* that infected cattle were detected in Uruguay, a country where beef and dairy exports are leading sources of national income. Twenty percent of all cattle sampled were shedding pathogenic *Leptospirae* in their urine, representing a large public health risk [15].

The clinical picture of leptospirosis rises after an incubation period of 5-14 days. As mentioned above leptospirosis most commonly occurs in subtropical and tropical low-income regions, escalating after hurricanes, typhoons and floods. The course is highly variable. Most cases involve flu-like symptoms (fever, chills, muscle aches, headaches). Other symptoms include conjunctivitis, vomiting, diarrhea, stomach pain, jaundice, cough and rarely a skin rash. About 10 percent of people with leptospirosis develop severe disease, including kidney or liver failure, difficulty breathing, bleeding and meningitis. Case fatality rate is 5-15% with severe clinical illness [16]. Confirmation of the disease is mostly made by ELISA or PCR assays [17]. Mild leptospirosis is treated with doxycycline, ampicillin or amoxicillin. For severe leptospirosis penicillin G has long been the drug of choice, although the third generation cephalosporins, cefotaxime and ceftriazone have become widely used [18].

## **Cholera**

Cholera is an infamous scourge, particularly in impoverished, flooded and war-torn areas. It causes a severe form of diarrhea and can quickly lead to death, if untreated. As hurricanes barrel through some of the most poor countries in the Western Hemisphere and floods ravage Yemen, Sierra Leone, Bangladesh and India, cholera epidemics increase. In the aftermath of Hurricane Matthew in 2016 a surge of cholera in Haiti increased the death toll from the disease. Officials are already urging people purging their drinking water, adding bleach, to prevent the spread of cholera in the aftermath of Irma [19,20]. Cholera has been eliminated in Florida and Texas as a sequel of hurricane for years.

Cholera and malaria outbreaks are feared in Kerala, India, where 800.000 people have been displaced and a further 10.000 are stranded. In the 4000 relief camps cholera outbreaks have not been reported so far [21]. In Zimbabwe and Zambia landfalls of Hurricane Florence caused cholera outbreaks in an already compromised sanitation system. In Zambia 3800 cases of cholera and 83 deaths have been reported [22]. In Zimbabwe, 3621 suspected cases with 71 confirmed cases and 32 deaths have been reported now (case fatality rate 0,8%)-[23]. Primary drug resistance has been reported in Harare, Zimbabwe [24]. These outbreaks are dwarfed by the cholera outbreak in war-torn Yemen, the largest documented cholera outbreak until now, with more than 1 million of cases since the fall of 2016. Case fatality rate is 0,22% and the population infection rate is 3,7%, known as the attack rate, is devastatingly high [25].

Cholera is an acute diarrheal infection caused by ingestion of food or water contaminated with the bacterium *Vibrio cholera*. It is estimated that every year there are roughly 1,3-4 million cases and 21.000-143.000 deaths worldwide to cholera [26]. Cholera is an extremely virulent disease that can cause severe acute watery diarrhoea. It takes between 12 hours and 5 days for a person to show symptoms after ingesting contaminated food or water. Cholera affects both children and adults and can kill within hours if untreated.

Most people infected with *V.cholera* do not develop any symptoms, although the bacteria are present in their faeces for 1-10 days after infection and are shed back into the environment potentially infecting other people. Among people who develop symptoms, the majority have mild or moderate symptoms, while a minority develop acute watery diarrhoea with severe dehydration, leading to death if untreated.

Treatment is by oral rehydration solution (ORS). A standard ORS sachet is dissolved in 1 litre of clean water. Adult patients may need up to 6 L of ORS on the first day. Mass administration of antibiotics is not recommended, as it has no proven effect on the spread of cholera and contributes to antimicrobial resistance. Antibiotics is recommended for severely ill or hospitalized patients. Doxycycline is the first-line treatment for adults, while azithromycin is recommended as first-line treatment for children and pregnant women. In all other cases antibiotic susceptibility should be monitored through regular testing of sample isolates [27]. Second-line antibiotics may be erythromycin, trimethoprim-sulfamethoxazole (TMP-SMX) and ciprofloxacin.

Oral cholera vaccins (OCVs) are used in endemic areas and can be given to all individuals aged over 2 years. All three vaccins n use (Pukoral, Shanchol and Euvichol) require 2 doses for full protection with a minimum of 1 week between the 2 doses and no more than 6 weeks delay between each dose. More than 15 million doses of OCVs have been used in mass vaccination campaigns [26].

## **Typhoid Fever**

Typhoid outbreaks have not occurred following hurricanes or floods in the U.S, including the massive Midwestern floods during the late 1990's, belying multiple yearly warnings. Thus, even though the water and sewage systems are damaged or out of operation in many areas, the risk of a typhoid epidemic is extremely low [28].

Typhoid outbreaks is a problem in Harare, Zimbabwe, since October 2016 where broken sewer lines cause raw sewage flooding the streets. Since then, 860 cases of illness onset were noted, including 780 suspected cases, 80 confirmed cases and 4 deaths [29]. An ongoing typhoid fever outbreak is present after floodings with developing extensive drug resistant (XDR) *Salmonella typhi* [30].

In the U.S. each year about 350 patients are diagnosed with typhoid fever mostly among people who travel to countries as India, Bangladesh and Pakistan. An estimated 22 million cases of typhoid fever occur worldwide each year with 200.000 deaths. Typhoid fever is caused by the bacterium *Salmonella enterica* serotype "typhi". Symptoms are fever, headache, constipation or diarrhoea, malaise, chills and myalgias, with few clinical features that reliable distinguishes it from a variety of other infectious diseases. A transient maculopapular rash or rose-coloured spots may be present on the trunk. Confusion, delirium and intestinal perforation may occur in severe cases, typically after 2-3 weeks of illness The incubation period for typhoid is 6-30 days. Blood culture is the mainstay of diagnosis. Bone marrow cultures have sensitivity of 80% in some studies and can remain positive despite antibiotic therapy. Stool and urine cultures are positive less frequently. Multiple cultures are usually needed to identify the pathogen. Serologic tests as the Widal test are not recommended, because of the high rate of false positives.

Without treatment the illness can last for 3-4 weeks and death rates range between 12% and 30%. Relapse occurs in 30% of patients 1-3 weeks after recovering from the illness. A chronic carrier state in which stool and urine cultures remain positive for more than 1 year occurs in up to approximately 5% of infected persons [31]. Treatment is with antibiotics as amoxicillin, TMP-SMZ and cephalosporins or fluoroquinolones, as e.g. ciproxin. However, resistance has occurred and XDR for ceftriaxone is developing [30]. Treatment should be guided by susceptibility culture results preferably.

Currently three types of typhoid vaccines are licensed for use in endemic or epidemic areas. Typhoid conjugate vaccine (TCV, unconjugated Vi polysaccharide (VIPS) vaccine and live attenuated Ty21 a vaccine [32].

## **Hepatitis A**

The largest documented outbreak of hepatitis A in the U.S has started in October 2017 in California, San Diego county. There were 633 reported cases of hepatitis A and 21 deaths. The state had a 65% hospitalization rate. Most of the cases “occurred primarily among persons who are homeless, persons who use injection and non-injection drugs and their close contacts” the CDC said. This is one of the greatest outbreaks since the hepatitis A vaccine became available in 1996. No hepatitis A outbreaks related to flooding and hurricanes have occurred since 1996, belying the yearly ritual warnings again.

## **Vector-Borne Diseases**

### **Yellow Fever**

Like cholera and typhoid also yellow fever is not common in the U.S., so an outbreak is highly unlikely. Nevertheless, yellow fever is called a risk factor following hurricanes and floods again and again in the mainstream news articles, reproducing themselves every year.

Yellow fever is endemic in Brazil. An outbreak that began end 2016 is now spreading further. The WHO started recommending yellow fever vaccination for all travellers and residents of areas where yellow fever was noted. Since then, 10 travellers contracted the disease, all unvaccinated, and four died. Yellow fever is a virus carried by mosquitoes, usually *Aedes aegypti*, the same species that transmits dengue fever, chikungunya and Zika. It starts with typical viral symptoms, including fever, chills, headache, backache and muscle aches, about 3-6 days after infection. For the 15% of people with severe illness, the disease can cause internal bleeding, organ failure, shock and death. For every five people with severe disease, one to three of them dies [33,34]. Yellow fever has been circulating in Brazil for centuries and the country produces its own vaccine. Yellow fever outbreaks were not caused by floods or hurricanes [33,34].

### **Dengue Fever**

Adult mosquitoes do not generally survive high winds during a hurricane. Immediately following a hurricane flooding occurs. These results in very large populations of floodwater mosquitoes laid in the soil during previous flood hatch.

Most of these mosquitoes are considered nuisance mosquitoes, In general, nuisance mosquitoes do not spread viruses that make people sick. The type of mosquitoes that can spread viruses may increase 2 weeks to 2 months after a hurricane, especially in areas that did not flood but received more rainfall than usually. In areas with *Aedes aegypti* mosquitoes increased rainfall may result in increased hatching of *Ae aegypti* eggs from water holding containers. Large numbers of nuisance mosquitoes can affect recovering efforts. For this reason, local or state mosquito control experts will often take steps to control these mosquitoes [35].

Dengue fever is a disease of tropical climates and outbreaks after flooding or severe rainfalls are mostly seen in these countries. The Philippines are known for their yearly dengue outbreaks. Philippine's DOH also record in 2018 the number of dengue cases have increased again compared to the same period last year [36]. Just in the first 3 months of 2018 DOH recorded over 26.000 dengue cases [37]. In Singapore, 2062 cases of dengue were reported in the first 38 weeks of 2018 [38]. Three deaths were linked to the largest dengue cluster [39]. Post-flood cases of dengue in Kerala, India, are just coming in. On sept 11th 2018, 11 confirmed and 39 suspected cases were recorded [40]. Large outbreaks of dengue have occurred in Paraguay and Uruguay in 2018 [41].

Dengue is a mosquito-borne viral disease that has rapidly spread in all regions of WHO in recent years. Dengue is transmitted by female mosquitoes mainly of the species *Aedes aegypti* and to a lesser extent, *Aedes albopictus*. Dengue is widespread throughout the tropics, with local variations in risk influenced by rainfall, temperature and unplanned rapid urbanization. Severe dengue (also known as Dengue Hemorrhagic Fever) was first recognized in the 1950's during dengue epidemics in the Philippines and Thailand. Today severe dengue affects most Asian and Latin-American countries and has become a leading cause of hospitalization and death among children and adults in these regions.

There are 4 distinct, but closely related serotypes of the virus that cause dengue (DEN-1, DEN-2, DEN-3 and Den-4). Recovery from infection by one provides lifelong immunity against that particular serotype. However, cross immunity to the other serotypes after recovery is only partial and temporary. Subsequent infections by other serotypes increase the risk of developing severe dengue. Dengue is now endemic in more than 100 countries. Before 1970, only 9 countries had experienced severe dengue epidemics. A recent estimate indicates 390 million dengue infections of which 96 million are clinically manifest [41].

Most people infected have mild or no symptoms. About 1 in 4 people infected with dengue will get sick. Mild symptoms of dengue may be confused with other illnesses that cause fever and flu-like illness. Most people will recover after one week. The most common symptoms are fever, headache, eye pain (behind the eyes), muscle, joint or bone pain, rash, nausea and vomiting, unusual bleeding (nose or gum, bruising). Severe dengue is an emergency that develops 24-48 hours after fever goes away. There may be severe stomach pain and vomiting, bleeding from the nose and gums, vomiting blood or blood in the stool, drowsiness or irritability, pale, cold or clammy skin, and difficulty breathing There is no vaccine available in the U.S. There is no treatment other than symptomatic [42].

## West Nile Fever

The relationship between natural disasters and communicable diseases is often misconstrued and overstated. Previous research found that deaths from communicable diseases are not common. The risk of infectious disease outbreaks shortly after natural disasters is not as high as one might think, according to an overview published by researchers from the WHO in 2007 [43]. A study published in the CDC journal *Emerging Infectious Diseases* reported that Louisiana and Mississippi did not experience an increased number of West Nile Virus (WNV) cases immediately following Hurricane Katrina. Hurricane-force winds may have actually decreased the risk of WNV by killing birds and mosquitoes and destroying their habitat [44].

However, another study by the Tulane University School of Public Health and Tropical Medicine in 2008 examined WNV in the areas affected by Katrina. This study found there were no WNV cases in Louisiana in the 3 weeks before Katrina, but 11 WNV cases were reported 3 weeks later. The study authors noted a correlation with the 3-14 day incubation period for WNV and also observed that the increase in the number of cases occurred despite relocating of the population [45]. West Nile Fever is caused by a virus transmitted by mosquitoes and whose reservoir includes wild birds and mosquitoes. Humans are infected mainly through mosquito bites, but infection can occur through organ transplantation and blood. Humans and horses are incidental dead-end hosts.

West Nile Virus is an enveloped RNA virus of the genus *Flavi virus* and belongs to the Japanese encephalitis antigenic complex. The virus was first isolated in 1937 from the blood of a woman of the West Nile province in Uganda, who was suffering from a mild febrile illness. There are two distinct genetic lineages of human importance:

1. Viruses of lineage 1 are the most dispersed occurring in Africa, Middle East, Europe and North- America and are involved in large outbreaks.
2. Viruses from lineage 2, which are circulating in Africa, were reported recently in Italy, Hungary, Greece and Romania.

The WNV is now distributed worldwide and outbreaks may occur in humans, birds and horses in the Americas, Africa, Europe, Russia, Middle East, Asia, Australia and in Europe. WNV is present in Europe since the 1960's, but outbreaks are erratic and spatially, occurring quite unpredictable, even if all conditions are present in a definite place [46].

Most human WNV infections are asymptomatic (80%). Clinical cases present with flu-like symptoms, including fever, headache, and body aches. Weakness, malaise, anorexia, lymphadenopathy, nausea and vomiting may also be seen. An erythematous, maculo-papular or morbilliform skin rash occurs occasionally on the neck, trunk, arms or legs. Most uncomplicated infections resolve in 3-6 days. In more severe cases there may be signs of encephalitis, meningo-encephalitis or meningitis. In some outbreaks myocarditis, pancreatitis and fulminant hepatitis occur. An estimated 1 out to 140 to 320 infectious result in meningitis or encephalitis. The case fatality rate in patients with neuro-invasive disease ranges from 4% to 14% [46].

Recent outbreaks have been documented in Italy and Romania. In Romania there have been 215 cases of meningitis, meningo-encephalitis in the 2018 season with 25 attributable deaths [47]. WNV infections spiked threefold in Europe with Serbia(126 cases), Italy (120 cases), Greece (75) cases following Romania [48]. In the US as of September 18, overall 1077 WNV cases have reported to the CDC. Of these 608 (56%) were classified as neuro-invasive disease, such as meningitis or encephalitis, and 469 (44%) were classified as non-neuronvasive disease. Thirty -five deaths were recorded [49]. Hurricane Harvey did not cause large WVN outbreaks belying ritual warnings [50].

## **Malaria**

Malaria epidemics in the wake of flooding are a well-known phenomenon in malaria-endemic areas. For instance, an earthquake and subsequent flooding in Costa Rica's Atlantic region in 1991 and flooding in the Dominican Republic in 2004 led to malaria outbreaks [1]. Recent hurricanes and floods didn't lead to reports of malaria surges or outbreaks in endemic and non-endemic areas, belying he ritual warnings. After Hurricane Katrina increased cases of dengue and malaria were not reported as sites have been effective in prevention [51].

## **Zika**

Following Hurricane Harvey and Irma last year the CDC issued usual concerns about potential Zika infection outbreaks in the continental U.S., including Florida and Texas. In addition, the CDC advised pregnant women against travel to Puerto Rico, where the public health impact from Hurricane Maria will likely be measured to come [52]. Until now direct relationships between hurricanes, floods and reported Zika infections have not been demonstrated. Thai Zika microcephaly cases couldn't be related to recent floods [53]. For this year spikes in Zika infections related to floods, hurricanes also have not been reported by the CDC, until now. Most cases are still travel related or by local or sexual transmission [54].

## **Conclusion**

It is obvious low-resource countries are hardest hit by infectious disease outbreaks following natural disasters, as floods and hurricanes. A lot of these disease are endemic in these impoverished countries and compromised sanitation systems, water supply, lack of medicines, bad infrastructure and war or conflict zones complicate the picture further

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