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Research Article

Risk Assessment and Impact of Floods on the Transmission of Vector Borne Diseases

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A B S T R A C T

Floods are the result of natural disasters in an area due to prolonged continued and heavy rains and are frequently followed by a proliferation of mosquitoes due to the creation of a large number of breeding habitats. In the endemic zones for VBDs, vector mosquito species require special attention for planning immediate control measures as these areas may pose a threat to public health. Natural disasters continue to strike unabated, flash floods due to heavy rains, riverine floods,coastal floods and cloud burst floods. In general, floods are witnessed due to the concentrated spells of heavy rains during the monsoon months and seasonal disturbances. The low lying areas are submerged under water and remain water logged for a long duration. Slowly, the low lying water bodies thus created after receding of flood water, act as a breeding potential source for the vector mosquitoes. Some of the areas receive water from flushing of water from high altitude areas due to heavy rains or melting of ice. There is definite need for public health preparedness and response for the flood affected areas to reduce the transmission of VBDs with proper risk assessment. There are chances for the onset of transmission of VBDs to the population shifted to temporary shelter homes away from homes. Given the situation with the presence of congenial conditions owing to presence of favourable climatic variables for propagation of vectors, pathogens and susceptible population, there are chances of disease outbreaks. Therefore, the risk assessment of the flood affected area with the vulnerable population is essential to make preparedness and response to any onset of VBDs transmission. Disease and vector surveillance are the key elements to be in place for such flood affected areas during and after the floods.

Keywords: Climate Sensitive VBDs, Vulnerable, Risk Assessment, Preparedness, Response

Introduction

Floods are commonly reported as natural calamities and disasters across the world. In 2016, globally more than 74 million people were affected by flooding, leading to 4720 deaths with high economic cost, out of which 43% happened in Asia.[1-3] Floods occurrence has tended to increase in recent decades, and this trend is likely to enhance with climate change. These floods had adverse impact on living conditions of people in the affected areas. Floods negatively affect supply systems and water sources,

in addition to waste-disposal systems and sewerage, than the transmission of pathogens is prone to be increased.[4,5] The risk of viral infections after floods is a really important health issue and different classes of infectious diseases can cause outbreaks during the weeks after flooding. Floods can increase the transmission of viral diseases specially water born infections, such as diarrheal diseases, hepatitis A and E, air-borne infections and vector borne diseases such as yellow fever, West Nile fever (WNF) and dengue fever.[5,6]

After flooding, mosquito borne diseases, for example dengue and malaria fever, especially in endemic areas, can increase. Standing water after overflow of the rivers with numerous pools of water bodies can act as the breeding sites for mosquitoes. Floods may indirectly lead to an increase in vector-borne diseases through the expansion in the number and range of vector habitats. Standing water caused by heavy rainfall or overflow of rivers can act as breeding sites for mosquitoes, and therefore, enhance the potential for exposure of the disaster-affected population, and Chances for infections such as dengue, malaria and other vector borne diseases. Flooding may initially flush out mosquito breeding, but it comes back when the waters recedes. The lag time is usually around 6-8 weeks before the onset of a malaria epidemic.

Malaria epidemics in the wake of flooding are a well-known phenomenon in malaria-endemic areas world-wide[7,8]. The risk of outbreaks is greatly increased by complicating factors, such as changes in human behavior (increased exposure to mosquitoes while sleeping outside, a temporary pause in disease control activities, overcrowding), or changes in the habitat which promote mosquito breeding (landslide, deforestation, river damming, and rerouting).

Types of Floods

Flash Floods – The situation of flash floods happens when there is continued moderate to heavy rain for 3-4 hours and continues for a longer period. Flash floods are also a result of heavy rainfall and may be associated with thunder storms and water release from dams or hills top. Sometimes, cloud bursts are reported in hilly areas with unknown water flash floods resulting in huge water bodies in and around affected areas. This type of flood requires rapid localized warning system in coordination with meteriological department and disaster management groups and immediate response in favour of affected communities with the support of local administration. Other reasons of flash floods may be due to damages in dams or rivers or sudden release of water resulting in accumulation of water bodies in the catchment areas near water bodies.

Riverine Floods

There are natural passages of the rivers situated in different parts of the country with its origin, and meeting with the main bed flow. However, water flows down from hills down to the main riverine belt in the plain areas. The flow and flooding of water depends on the seasonal variability due to melting of snow, rains etc. Due to the large flow of water, floods are caused by the rain water spilling to new areas low lying pits and pools of water. This take place in river systems with tributaries that may cover or drain large geographical areas and encompass many independent river basins. These floods are normally built up slowly or on seasonal basis and may continue for long durations as compared to flash floods. Factors such as ground conditions like moisture, vegetation cover, silt, encroachments etc. and size of the catchments govern the amount of flood covering the main rivers of India like Ganga, Satluj, Brahmaputra, Narmada, Cavery and Yamuna, etc. The riverine bed pools are the favourable breeding grounds for the vector mosquitoes.

Tsunami/ Sea-water Floods

Some floods are associated with cyclonic activities in the ocean and they affect the lives of the common man living in the coastal areas sea-water floods have become common these days at the coastal belt of West Bengal, Odisha, Andhra Pradesh, Telangana, Tamil Nadu, Gujarat, Maharashtra and Kerala and pose a threat for vector borne diseased in the affected areas. And they generate catastrophic floods from heavy rains in the coastal areas submerging areas for a long time. In river floods, intense rains falling over a large geographic area produce extreme flood situations in coastal river basins. When there are opposite water currents, the rain water is not able to go to sea, and may to stagnate over a considerable time and when it recedes; a large number of breeding habitats are left for the vector mosquitoes.

Desert Floods

Though strange, but desert floods are caused in the states of Rajasthan and Gujarat in the monsoon season due to prolonged moderate and heavy rains in these areas. These are not able to absorb water due to the rocky belt of Aravali ranges with huge desert land. Stone-quarry areas, may turn into large number of water bodies, which remain for many days and help in the propagation of mosquito populations and thereby result in the transmission of vector borne diseases.

Major arboviruses (viruses transmitted by mosquitoes or other arthropods) are of public health importance namely malaria, Dengue, Chikungunya, Japanese Encephalitis, Kala Azar. Receding flood waters and pooling water from heavy rainfall can provide perfect conditions for mosquito breeding. The increase in potential freshwater breeding sites can result in larger numbers of mosquitoes, which in turn increases the potential for outbreaks of mosquito-borne diseases.

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The best way to control mosquitoes is to prevent them from breeding by reducing/ minimizing the breeding habitats with options available under environmental modifications. It is important to address potential mosquito problems before there is a significant increase in the adult population. Mosquito control programs should integrate a variety of control strategies i.e. surveillance, source reduction, biological control methods, traps, larvicides, and adulticides, into a comprehensive program that exploits known mosquito vulnerabilities. During emergency situations when resources may be limited, available resources should be targeted at the most effective methods of mosquito reduction.

Dynamics of VBDs Transmission during Floods

Floods may indirectly lead to an increase in vector-borne diseases through the expansion in the number and range of vector habitats. One need to understand that the influence of other climatic variables such as temperature and humidity also provide suitability and congenial conditions playing a critical role in the transmission dynamics of vector borne diseases in different geo-ecological environmental conditions. Standing water caused by heavy rainfall or overflow of rivers can act as breeding sites for mosquitoes, and therefore enhance the potential for exposure of the disaster-affected population and emergency workers to infections such as Dengue, Malaria, Chikungunya, Zika and Japanese Encephalitis. Flooding may initially flush out mosquito breeding, but it comes back when the waters recede. The lag time is usually around 6-8 weeks before the onset of a malaria epidemic. Major arboviruses (viruses transmitted by mosquitoes or other arthropods) are of public health importance in India at present namely Dengue, Chikungunya, and Japanese Encephalitis and Kala azar. Post flood situations may help in the transmission of zoonotic diseases including ticks and mite borne diseases. A close watch is necessary to avoid contact with wild animals, rats and rodents that possibly carry viruses and diseases.

Disease Outbreaks

The risk of outbreaks is greatly increased by complicating factors, such as changes in human behaviour (increased exposure to mosquitoes while sleeping outside, a temporary pause in disease control activities, overcrowding), or changes in the habitat which promote mosquito breeding (landslide, deforestation, river damming, and rerouting). Rapid and appropriate precautionary vector-control measures applied in a post-natural disaster setting can prevent vector borne diseases. Prolonged rainfall and floods provide new breeding grounds – wet areas and stagnant pools – for mosquitoes and can lead to an increase in the number of mosquito-borne diseases. Floods may create new mosquito breeding sites in disaster rubble and stagnant pools. A general breakdown of sanitation may favour the multiplication of houseflies and rodents. Serious infection hazards may arise when massive migrations bring people of different origins together in temporary camps infested with disease vectors. Examples of disease outbreaks observed in such situations include malaria (transmitted by Anopheles mosquitoes), epidemic typhus (transmitted by lice) and dengue fever (transmitted by Aedes mosquitoes).

In addition to the disease hazards presented by vector species, many insects and other arthropods can constitute a major nuisance in disasters. The impact of nuisance further adds to the stress and psychosocial instability from which disaster victims usually suffer. Standing water rich in organic matter can produce massive numbers of biting midges (Culicoides spp.) which do not transmit any disease, but cause extreme nuisance and often trigger allergic reactions in sensitive people. Several mosquito species can also be a great nuisance without presenting a direct risk to health.

When wild or domestic host animals have been killed or driven away by disaster, ectoparasites, such as ticks, bugs, lice and fleas, may invade a community and produce a serious additional risk of zoonotic vector-borne disease. Another, related, vector-borne disease risk may arise when refugees enter territory formerly occupied only by wildlife and accompanying parasites. Examples of diseases that may then emerge include plague (from rats) and Lyme disease (from ticks). Rodent borne diseases also increase during massive rainfall and flooding.

Vector Borne Diseases

The primary diseases of concern from vector mosquitoes which can cause large outbreak of VBDs during and after flood disaster are as below:

Malaria

This disease is caused by the malaria parasite carried by Anopheles mosquitoes. The general symptoms of malaria are fever, shivering, nausea, flu-like illness, and in severe cases, it may result in the death of the patient. In general, malaria is a curable disease if diagnosed and treated promptly and correctly. Symptoms begin to present as soon as 7 days and can be delayed as long as 30 days following a bite from an infected mosquito.

Dengue

This is a mosquito-transmitted disease caused by any one of four related viruses by Aedes mosquitoes. There are not yet any vaccines to prevent infection with dengue virus nor are there medications to treat dengue virus infections. Symptoms begin to present as soon as 4 to 7 days and can last from 3-10 days following a bite from an infected mosquito.

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Chikungunya

This is a mosquito-transmitted disease caused by Aedes mosquitoes. There are no vaccines to prevent infection and treatment is based on symptoms. Infected humans can transmit the virus to mosquitoes and initiate local transmission. Symptoms begin to present as soon as 3 to 7 days following a bite from an infected mosquito. The transmission season and risk will be similar to dengue since they have the same vector mosquitoes.

Zika

This is a mosquito-transmitted disease caused by Aedes mosquitoes. There are no vaccines to prevent infection and treatment is based on symptoms. Infected humans can transmit the virus to mosquitoes and initiate local transmission. Symptoms begin to present as soon as 3 to 7 days following a bite from an infected mosquito. The transmission season and risk will be similar to dengue since they have the same vector mosquitoes.

Japanese Encephalitis

Japanese Encephalitis (JE) is a mosquito borne Zoonotic viral disease. The virus is maintained in animals, birds, pigs, particularly the birds belonging to family Ardeidae eg. Cattle egrets and pond herons etc. act as natural hosts. Pigs & wild birds are reservoirs of infection and are called amplifier hosts in the transmission cycle, while man and horse are 'dead end hosts. The virus does not cause any disease among its natural hosts and transmission continues through mosquitoes primarily belonging to vishnoi group Culex. Vector mosquito is able to transmit JE virus to a healthy person after biting an infected host with an incubation period ranging from 5 to 14 days. A mosquito-borne viral infection resulting in inflammation of the brain, JE can cause fever, headache and seizures. They could have a debilitating effect on children and might lead to even disability. Mortality rate is high too. However, vaccine had been made available for the disease.

The other VBDs of concern other than vector mosquitoes which can cause large outbreak after flood disaster are given below:

Kala Azar

A disease caused by parasites of the leishmania type, is spread by the bite of Sandflies. Visceral leishmaniasis (VL), also known as Kala-azar, black fever, and Dumdum fever, are the most severe forms of leishmaniasis and without proper diagnosis and treatment, are associated with high fatality. The parasite migrates to the internal organs such as the liver, the spleen (hence "visceral"), and bone marrow and if left untreated, will almost always result in the death of the host. Signs and symptoms include fever, weight-loss, fatigue, anemia, and substantial swelling of the liver and spleen. There are no vaccines or preventive drugs for visceral leishmaniasis. The most effective method to prevent infection is to protect from sand fly bites.

Scrub Typhus

Scrub typhus is a disease caused by bacteria called Orientia tsutsugamushi. Scrub typhus is spread to people through bites of infected chiggers (larval mites). The most common symptoms of scrub typhus include fever, headache, body aches, and sometimes rash. Symptoms of scrub typhus usually begin within 10 days of being bitten. People with severe illness may develop organ failure and bleeding, which can be fatal if left untreated. Scrub typhus should be treated with the antibiotic Doxycycline. Weil Felix test is a cheap and widely available test used for confirming the clinical suspicion of scrub typhus.

Kyanusar Forest Disease

Kyasanur Forest Disease (KFD) is caused by a virus, and usually presents with sudden onset of high grade fever with chills, intense frontal headache, severe myalgia and body aches, muscle tenderness, photophobia, nausea, vomiting and diarrhea with a fatality rate of 2-10%, and Incubation period of 3-8 days. Hard ticks (Hemaphysalis spinigera) are the reservoir of KFD virus and once infected, remain so for life. Rodents, shrews, and monkeys are common hosts for KFDV after being bitten by an infected tick. KFDV can cause epizootics with high fatality in primates. Repellents like DEET 33% (N,N-diethyl-m-toluamide or N, N-diethyl-3-methylbenzamide), Permethrin should be used to prevent tick bites.

Crimean Congo Haemorrhagic Fever

Crimean-Congo Hemorrhagic Fever (CCHF) is caused by a tick-borne virus, usually presents headache, high fever, back pain, joint pain, stomach pain and vomiting, red eyes, a flushed face, a red throat and petechiae (red spots) on the palate are common, fatality rates in hospitalized patients have ranged from 9% to as high as 50%, and Incubation period of 5-6 days. Ixodid (hard) ticks, especially those of the genus, Hyalomma, are both a reservoir and a vector for the CCHF virus. Numerous wild and domestic animals, such as cattle, goats, sheep and hares, serve as amplifying hosts for the virus. Transmission to humans occurs through contact with infected ticks or animal blood. CCHF can be transmitted from one infected human to another by contact with infectious blood or body fluids. Repellents like DEET 33% (N, N-diethyl-m-toluamide or N, N-diethyl-3-methylbenzamide), Permethrin should be used to prevent tick bites.

Lyme Disease

Lyme disease is caused by corkscrew-shaped bacteria called Borrelia burgdorferi and is transmitted to humans

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through the bite of infected blacklegged ticks (Ixodes). The tick must attach for at least 24 hrs to transmit the bacteria. Immature ticks called nymphs are the primary transmission source of Lyme disease in humans. Wild mammals, especially small rodents and deer, can carry the bacteria in nature. Typical symptoms include fever, headache, fatigue and a characteristic skin rash, if left untreated; infection can spread to joints, the heart, swollen lymph nodes. Repellents like DEET 33%, Permethrin should be used to prevent tick bites.

Plague

Plague is an infectious disease caused by the bacteria Yersinia pestis, Zoonotic bacteria, usually found in small mammals and their fleas. It is transmitted between animals through fleas. Humans can be infected through the bite of infected vector fleas Xenopsylla cheopis, unprotected contact with infectious body fluids or contaminated materials, and the inhalation of respiratory droplets/ small particles from a patient with pneumonic plague. Plague is a very severe disease in people, particularly in its septicaemic (systemic infection caused by circulating bacteria in bloodstream) and pneumonic forms, with a case-fatality ratio of 30% to 100% if left untreated and Incubation period of 1-6 days. Malathion may be used for anti-flea measures and rodenticides used for rodents.

Need for Vector Surveillance and Control Plans

The following components are essential for the Vector Surveillance and Control Plan during and post floods for the affected areas.

Surveillance

Vector Surveillance with Rapid assessment of flood-affected areas for potential mosquito breeding sites.

It is important to have in place habitat surveillance for mapping potential breeding sites; this may include reviewing any historical data. Continuous monitoring through larval dipping method will help determine where mosquitoes are breeding and determine type and density of larvae. There is need to collate and map high risk areas for mosquito breeding and where high numbers of adults and larvae are present. Surveillance must be completed to identify locations within the impacted areas that have standing water that could be possible breeding grounds for mosquitoes. Mapping should be done to highlight the highly populated areas identified to have standing water with a potential for mosquito breeding. Mapping areas of standing water will help for intervention planning.

Surveillance activities should be done for both larval and adult mosquitoes in flood affected areas where the spread of vector-borne diseases and/or nuisance mosquitoes pose a threat to emergency workers and local residents. Random selection of the site should be done immediately for both larval and adult surveillance of mosquitoes and other potential vectors.

Vector Surveillance with Rapid assessment of flood-affected areas for potential sites of other than mosquito breeding sites.

There are several effective methods that can be utilized for tick sampling, including flagging, dragging, walking sampling, CO2 traps and even collecting samples directly through hand collection from a range of hosts. Another efficient method of sampling chiggers is to trap their rodent hosts and examine them for the presence of these mites. Similarly fleas can be collected from rodents directly. Rodent collection can be done with the help of live traps, snap traps or glue boards. Tick, mites and flea density index are important parameters for both vector surveillance data as well as for estimation of human and epizootic risks.

Vector Control

Larval Control

There is need to survey and minimize the number of breeding potential habitats that may be standing or stagnant water with vegetation within 3-4 km of the human settlements. The initial activities may have to be focused within an area of 1-2 km radius of human populations and then expanded keeping in view the local resources. The larger water bodies should be treated with appropriate approved larvicides.

Adult Control

A close monitoring of adult population is required in such situations through regular vector surveillance, and in case of high densities of adult mosquitoes - the vector species; appropriate insecticides need to be used for vector control beside larval control. There would be reduction in vector population with these concerted efforts. Use of Indoor Residual Spray (IRS) with insecticides is recommended under the vector-borne disease control programme.Use of chemical larvicides like Abate to be used in potable water. Aerosol space with pyrethrum extract (2%) spray during day time may be used for knock down effect. Repellents like DEET 33% (N, N-diethyl-m-toluamide or N, N-diethyl-3-methylbenzamide), Permethrin should be used to prevent tick bites. Use of an Acaricide,formulation (e.g. dust, granule, emulsifiable concentrate) to control ticks and spraying of Malathion for mite control and chiggers bites repellents and dusting of Malathion may be used for anti-flea measures. Rodenticides including acute and chronic poisons can be used for rodent control.

Personnel protection to reduce mosquito or other vector contact

A number of personal protection methods are available

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and can be advocated to reduce the risk of mosquito-borne diseases. Personal Prophylactic Measures that individuals/ communities can take up by using mosquito repellent creams, liquids, coils, mats etc. Short term space spray may also be used for knock down effects for adult mosquitoes. LLINs or plain bed nets would be of great help to the community at those situations of rehabilitation of the populations during floods.

Disease Surveillance, Diagnosis and Management

Monitoring of the incidence of mosquito-borne diseases through disease surveillance should be in place in the post-flood period to keep the public and health providers advised of high risk areas. The provision of diagnostic facilities and treatment need to be established in the flood affected areas.

Discussion

Arthropod vector organisms for vector-borne diseases (VBDs) are sensitive to climatic and hydrometeorological conditions (especially temperature and humidity, stagnant water pools, and ponds), as are life-cycle stages of the infecting parasite within the vector[9-12]. Hence, the geographic range of potential transmission of VBDs may change under conditions of climate change[13-15]. Several studies have concluded that temperature affects the major components of vectorial capacity[16-17]. Mosquitoes, in particular, are highly sensitive to climatic factors. Anopheline spp. and Aedes aegypti mosquitoes have established temperature thresholds for survival, and there are temperature-dependent incubation periods for the parasites and viruses within them (the extrinsic incubation period).[18] There is an urgent need to map the flood sensitive and affected areas across the country sensitive to floods and thereby, developing a workable action plans to overcome the challenges during and post floods period to deal with the VBDs with proper assessment of climate change at macro and micro level with proper understanding of the vector biology and disease transmission dynamics for VBDs.

Conclusion

Floods are to be considered one of the natural disasters, which may have a massive range of health impacts including public health hazards. Besides other numerous human related issues, there may be risks that floods can increase the transmission of some vector borne diseases in view of the congenial conditions favourable for vector and pathogen propagation to be able to transmit a particular vector borne disease. Necessary preparedness, timely precautions and pro-active steps are required by the concerned health authorities for these to be in place with a close monitoring of the situation through effective disease and vector surveillance with timely case management in the affected areas with floods. There is definite need for public health preparedness and response for the flood affected areas to reduce the transmission of VBDs with proper risk assessment.

Conflict of Interest: None

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