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Mini-Review

Impact of Climatic Variables on Zoonoses with Special Reference to Vector Borne Zoonoses

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Abstract

Among the major drivers of pandemic, climate change is the one which is terrorizing the globe by unleashing it's potential and shaking up the entire world by rewriting disease algorithms on the planet, which may pose serious health threat to animals & human beings. Changes in the mean climatic variables can affect health of people via changes in biological and ecological process that influence transmission of zoonotic diseases. Vector borne zoonotic diseases are markedly affected by climate variability when compared to non vector borne zoonotic diseases, because in the Vector borne zoonotic diseases, vector's biology is inextricably interlinked with the climatic factors such as precipitation, temperature and humidity. There is an evidence of anomalous weather Phenomena like El nino which are associated with heavy rainfall causing outbreaks of Rift valley fever, Cholera, Malaria etc. throughout the world and La nina is implicated in epidemics of Dengue, Yellow fever and Chikungunya etc. All these determinants along with anthropogenic and socio-economic factors are congregated to make the spread of zoonotic diseases like West Nile fever, Murray valley encephalitis and Lyme disease even worse than before, which is gaining concern throughout the world. However, the effects of climate change are anticipated to be worse for the underdeveloped and developing countries where challenging socio economic and political environments are escalated by lack of epidemiological studies on zoonoses.

Keywords: Climate Change; El Nino, La Nina; Vector Borne Zoonoses; Food Borne Zoonoses; Waterborne Zoonoses; Airborne Zoonoses

Introduction

Climate change refers to long-term statistical shifts of the weather, including changes in the average weather condition or in the distribution of weather conditions around the average (i.e., extreme weather events). The Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland. has predicted an average temperature rise of 1.5-5.8°C across the globe during the 21st century, accompanied by increased anomalous weather events including heat-waves, floods and droughts etc. For the purpose of this review, Zoonosis is defined as "Disease which is naturally transmitted between vertebrate animals and man" and vector is defined as an agent which transmits the disease from animals to humans (also from humans to humans) mostly of the class Arthropoda. All the infectious diseases which infect humans are not zoonotic. For a disease to get establish successfully, it requires the interaction among three components such as Host, Pathogen and Environment (Epidemiological triad) and some pathogens are carried by vectors or require intermediate hosts to complete their life cycle (Vector borne zoonotic diseases) Therefore, changes in climate or weather conditions may impact infectious diseases through affecting the pathogens, vectors, hosts and their living environment [10]. The present article summarizes the effects of climatic factors on differ-

ent categories of zoonoses such as Vector borne zoonoses (much emphasis is laid on this category because, this accounts for about 22% of emerging infectious diseases and arthropod vectors are highly susceptible to climatic variables since they are cold blooded), Water borne zoonoses, Air borne zoonoses and Food borne zoonoses.

Vector borne zoonoses

Vector borne zoonoses can be defined as those diseases which are transmitted from animals to humans via a biological carrier called vector. The most influential climatic factors for vector borne diseases include temperature and precipitation but wind, sea level elevation and daylight duration are additional considerations which are important [10]. Vector borne pathogens spend part of their life cycle in arthropods which are highly susceptible to changes in climatic factors like temperature, rainfall, precipitation, extreme flooding, wind, drought, and rise in sea level.

Effect of climatic factors on selected vectors

On mosquitoes

Mosquitoes are the most efficient vectors for diseases, causing millions of infections every year. Hence they are called as "Winged terrorists". There are roughly about 3500 species of mosquitoes in the world. Of those, only a small percentage are of public health concern. Temperature affects the spatio-temporal distribution of vectors, as temperature tends to rise, the insects in lower latitude regions may expand their horizons to mid or high latitude regions and recent studies have reported that some vector-borne zoonoses, including Malaria, African trypanosomiasis, Lyme disease, Tick-borne encephalitis, yellow fever, plague and dengue have distributed to a broader range [18]. However, change in temperature may as well curtail the spread of disease vectors. As the planet warming continues, mosquitoes may expand their horizons towards poles or upward thereby increasing the risk of exposure to diseases like malaria, dengue, yellow fever etc. Study published in *Malaria journal* reported that strong correlation do exist between El Nino and malaria in Eastern part of India [8]. La Nina (1974) in South Africa produced an epidemic of West Nile fever and Japanese encephalitis [21].

On ticks

As it has been happening in case of other vectors, temperature hasten up the development cycle, egg production, population density and distribution of Ticks [15]. Due to the effects of global warming in India, the prevalence of vector-borne zoonoses is likely to increase in the coming years. According to Chakraborty., *et al.* one of the main causes of Kyasanur forest disease transmission is deforestation [22]. Due to increased human activity and agricultural intensification, the Western Ghats mountain ranges, where the virus is geographically spread have experienced a significant loss of forest cover, increasing the likelihood of disease onset in new zones due to tick bite exposure. In case of Lyme disease, the distribution of the spirochete *Borrelia burgdorferi,* may extend to Himalayan region as climate change causes a shift to milder temperature. The disease is transmitted to humans during blood feeding by the hard ticks of the genus *Ixodes.* It is worth mentioning that, though rising temperatures may increase distribution pattern of ticks. Droughts and severe floods may negatively affect their distribution, at least temporarily [20]. These changes in temperature are known to have less effect on ticks than on mosquitoes because of the tick's ability to find shelter in their woodland habitats [17].

On flies

Among the diseases spread by flies, Leishmaniasis (protozoal infection) is one of the most important fly born zoonosis having Sand fly species as it's vector. Temperature influences the biting activity rate of the vector, the diapause, and the maturation of the protozoan parasite in the vector [19]. Once conditions are favourable, imported cases may act as a rich source of infection and thus lead to the development of new endemic foci. On the contrary, if climatic conditions become too hot and dry for vector survival, the disease may be curtailed. Temperature and humidity play an important role in growth, survival, development and activity of sand fly. The global distribution of sand flies is confined to areas that have at least one month with a mean temperature of 20°C [14]. Sand flies are sensitive to abrupt temperature changes and usually prefer those regions where differences between maximum and minimum temperatures slightly differ.

Water borne zoonoses

Water borne zoonoses which are transmitted to humans through infected vehicle (water) are classified under indirectly transmitted zoonoses. People get exposed to water borne infections as a result of contact with contaminated drinking water, coastal water or recreational water. Water contamination events are affected by the rates and timing of precipitation1 [3]. Rainfall patterns can influence the transport and dissemination of infectious agents while temperature can affect their growth and survival (NRC, 2001). Contamination of water with faeces in extreme weather events (droughts, floods) could result in increased prevalence of diseases such as echinococcosis, taeniasis, and toxoplasmosis [15]. A study from England and Wales reported that 20% of waterborne epidemics in the past century were associated with a prolonged episode of low rainfall, compared with 10% associated

with heavy rainfall [13]. Waterborne and foodborne diseases are considered as a major cause of mortalities worldwide. The close association among climate, environment and infectious diseases in the developing world is well recognised. For example, the importance of warm ocean waters in disseminating cholera in the Ganges river delta and elsewhere in Asia[4]. Increasing temperatures may extend the seasonality or change the geographical distribution of waterborne diseases. Increasing sea surface temperatures can indirectly influence the viability of enteric pathogens such as *Vibrio cholerae* by increasing their reservoir's food supply [6]. An increase of few degrees in environmental temperatures may lead to marked increase in cercarial emergence from snails[1]. Heavy rains can contaminate watersheds by disseminating human and animal faecal products and other wastes in the groundwater. Evidence of water contamination succeeding heavy rains has been documented for *Cryptosporidium, Giardia* and *E. coli* [3]. This type of outcome may be increased in conditions of high soil saturation due to more efficient transport of microbes. At other extreme, water shortage in developing countries have been linked with increase in diarrhoeal disease outbreaks that are likely ascribed to improper hygiene [9].

Food borne zoonoses

Zoonotic diseases which gets transmitted to humans through ingestion of contaminated food products like meat and dairy products etc or through ingestion of raw food which gets contaminated by water. Many foodborne pathogens are prevalent in India. Enterohaemorrhagic *Escherichia coli* (EHEC) O157 sorbitol phenotype has been isolated from the Ganges river in Varanasi [7]. Brucellosis, Listeriosis and infections due to drug resistant *Staphylococcus aureus*, *Campylobacter jejuni, Salmonella paratyphi*, *S. typhi* and *Shigella* species are other important emerging foodborne zoonoses that have been reported in India [2]. Climate change may cause increased risk of food contamination by contaminated water thus leading to increased survival of pathogens in the environment.

Air borne zoonoses

Air borne zoonoses which transmits to humans through infected vehicle such as air are classified under indirectly transmitted zoonoses. Zoonotic diseases like Plague, Anthrax, TB are spread via air. While warm and humid conditions may increase the risk of transmission of airborne zoonoses, hot and drier conditions may reduce their incidence in certain parts of the country [11]. Many respiratory pathogens, including Influenza viruses, exhibit winter seasonality that is often ascribed to seasonal changes in temperature or population behaviour. If cold temperatures are an important driver of respiratory disease, climate change might be expected to attenuate the impact of influenza epidemics in the country [12]. Climate change also has the potential to indirectly affect the transmission of communicable diseases [16]. Coerced migration of people because of flooding or drought could increase the risk of transmission of many communicable diseases because of enhanced intermingling of populations that have previously been isolated from one another.

Other important zoonoses

Besides the aforementioned zoonoses, climate change portends many other zoonoses like fungal and rodent borne zoonoses. Fungus thrives mostly in warm and humid climate which is attributed to precipitation events. The fungal infections like Histoplasmosis, Aspergillosis have all been reported across the India [5]. Apart from them, rodent borne zoonoses like leptospirosis and hanta virus are also linked to sensitivity of climatic variables. For example, climatic variables like rainfall and temperature accounts for the host reservoir dynamics in causing hanta viral infection. Elevated rainfall increases the availability of food resources (natural vegetation) for rodents which in turn expands rodent populations and may promote contact with humans. Outbreaks of hanta virus infections in the south-western United States have clearly been linked to El Nino impacts on rodent populations (Hjelle and Glass, 2000).

Conclusion

In brief, the aim of this review article is to provide evidence of how climatic change is responsible for the emergence of zoonotic diseases through its variables (temperature, humidity, rainfall etc). Though climate change itself is not a single determinant for the emergence of zoonoses but it is probably considered as one of the major drivers of pandemics. However, the degree of human intervention by adapting certain behavioural and socio-economic methods to prevent or alleviate effects of climate change on health will affect the final outcome.

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