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Review Article

Epidemiology for better health

Climate Change and Emerging Vector-Borne Diseases in India

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Abstract: Climate change is considered as one of the greatest threats to human health by the World Health Organization. Climate change occurs as a result of both natural and human causes which directly impacts human health through extreme climatic conditions, air quality, sea level rise etc. There is an increasing evidence about the impact of climate change on Vector-borne Diseases (VBDs). Vector-borne diseases account for over 17% of all infectious diseases. Environmental change disturbs the ecological balance thus changing the context within which disease hosts or vectors and parasites breed, develop and transmit disease resulting in the emergence and re-emergence of different VBDs. India is endemic for six major vector-borne diseases namely Malaria, Dengue, Chikungunya, Visceral Leishmaniasis, Japanese Encephalitis and Lymphatic Filariasis. If we fail to reduce the adverse effects and adapt to climatic change then future changes are likely the same. Therefore, a better understanding of climate change and its effects on public health is necessary. Emphasis should be laid on new strategies for the prevention and control of vector-borne diseases. We collected secondary data from published articles, journals and reports on this issue to discuss the impacts of climate change on VBDs. This review aims to discuss the distribution, reasons of emergence and re-emergence of important VBDs and its association with climate change highlighting the changing epidemiology of the most important VBDs in India.The objective of this review is to summarize the studies conducted to examine the association between climate change and VBDs and to give suggestions for future research directions.

Keywords: Climate change, distribution, epidemiology, infectious diseases, disease hosts, vector-borne diseases.

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1. INTRODUCTION

Climate change is considered as one of the greatest threats to human health by the World Health Organisation (WHO) [1]. Climate change refers to any significant changes in climate over time which may result due to both natural as well as anthropogenic activities. It is evident from studies that changes in climatic conditions influence the appearance and spread of many infectious diseases of humans and animals. Vector-borne diseases (VBDs) account for over 17% of all infectious diseases. Vector-borne diseases (VBDs) are one of the major public health challenges attributed to climate change. Vectors are living organisms that transmit infectious diseases between humans and from animals to humans [2]. The current epidemiology of VBDs is highly influenced by climate change and variability whose effects may result in short-term epidemics to long-term gradual changes in disease trends. It is also estimated that by 2100 the average global temperatures will rise to 1.0-3.5 °C, increasing the likelihood of many vector-borne diseases in new areas [3].India is endemic for six major vector-borne diseases (VBDs) namely Malaria, Dengue, Chikungunya, Lymphatic Filariasis, Japanese Encephalitis and Visceral Leishmaniasis. There is increasing awareness regarding the potential impacts of climate change on VBDs in India [4]. The earth's surface has become successively warmer in the last three decades than any preceding decade since 1850. According to the Intergovernmental Panel on Climate Change (IPCC)[5], the global average surface temperature has increased approximately 0.6◦C since the 1850s when temperature records were first kept [5]. Significant anthropogenic contributions such as construction of buildings, clearing of forests, burning of fossil fuels has led to a sharp increase in the greenhouse gases in the atmosphere thus amplifying the 'Greenhouse Effect' and resulting in global warming [6]. The epidemiology of VBDs is quite complex as it involves several factors. The epidemiological triangle of VBDs includes a host, a pathogen and a transmitting agent called a vector such as insect vector/rodent vector in interaction with the environment. Generally, all the VBDs are climate sensitive as the pathogens need to complete a part of their development in an insect vector that transmits them and as insects are poikilothermic creatures, the developmental period of their life cycle as well as parasite development within their body are greatly affected by climatic conditions [4].Emerging vector-borne diseases is a major issue in global health [7]. Therefore, there is an increasing urgency to understand the link between climate change and disease outbreaks [8].This review aims to briefly summarize relevant literature on research works conducted to assess the trend of emerging and re-emerging VBDs and their association with climate change in India and also to give suggestions for future research directions in the mentioned topic for formulating steps to address its negative impact in the Indian context.

1.1 SCIENTIFIC EVIDENCES OF CLIMATE CHANGE AND ITS PROJECTIONS IN INDIA

Evidence suggests that climate change has occurred at a global level [5].Climate change refers to any significant change in the climatic variables such as temperature, precipitation and wind etc. for an extended period. In the Indian context, there is evidence of increasing heat waves, droughts and floods in the last three decades.18 heat waves have been reported from India between 1980-1998. Consecutively three heat waves in Odisha in 1998, 1999 and 2000 caused an estimated 2000, 91 and 29 deaths respectively. Over 3000 deaths were caused by heat waves on Andhra Pradesh in 2003.There are reports of increasing droughts in Maharashtra since 2013.In 2012, the worst summer has been experienced by Delhi in the past 33 years. Also, there is an increase in coastal flooding .As reported by the Indian Network of Climate Change Assessment (INCCA),[2] there is a projected climate change scenario in India by 2030 in four sectors: Himalayan region, North-eastern states, Western ghats and Coastal regions [2]. According to projections by the third assessment of IPCC, there will be a rise in temperature by 3.8°C and 7% change in precipitation (increase as well as decrease) by 2080. Similarly, the fourth assessment also projects a rise in temperature from 1.8°C to 4°C by 2099 and a rise in sea-level upto 0.59m by 2100. According to the range of models, there is a possibility that in near future hurricanes and tropical cyclones will become more intense with high wind speed and more heavy precipitation. As estimated by IPCC, VBDs are likely to increase and expand its geographical distribution. By 2050, there is a probability of decrease in rainy days over central and western parts of the country while the rainy days may increase in the Himalayan foothills, Northeastern India and Uttarakhand. There is an expected increase in the rainfall intensity all over India except some parts of Northwest India [2,4]. As estimated by the IPCC, the annual mean temperature is likely to increase by the end of the century from 2.5 °C -5°C with more warming in the northern parts of the country. The country except Punjab, Rajasthan and Tamil Nadu are expected to experience a 20% increase in monsoon rainfall. There is possibility of alterations in the hydrological cycle and the severity and intensity of droughts and floods are likely to increase [9].As the climate changes, the tropical insects may spread their habitats into more northern or southern latitudes as well as to higher elevations thus increasing pathogen transmission to newer areas where they were unknown earlier [10].

1.2 IMPACT OF CLIMATE CHANGE ON VECTOR-BORNE DISEASES

Climate is a key determinant of health. It has been seen that the epidemiological triangle of vector-borne diseases consists mainly of host, pathogen and a vector that transmits the disease. Many factors are responsible for the occurence of vector-borne diseases. Infectious VBDs are mostly transmitted by arthropod-vectors which are particularly climate-sensitive for a number of reasons such as the pathogens need to complete a part of their development in particular species of an insect vector which transmit them and as the insects are poikilothermic creatures, the development of the pathogen are directly influenced by the external climatic conditions [4]. Also, vector biting rates will be increased as temperature increases upto a threshold after which they decrease. Furthermore, the development and replication of pathogens within the vector known as extrinsic incubation period or EIP also occurs faster at higher temperatures. Vector development and survival as well as vectorial capacity consistently peak at relatively higher temperatures [1].

1.3 VECTOR-BORNE DISEASES (VBDS) IN INDIA

As the climate changes gradually, some new diseases are emerging and re-emerging and are spreading to areas where they are currently absent. Some common VBDs in India are discussed below:

1.4 MALARIA

Malaria is still a major health issue in India. Environmental conditions directly impact the role of transmission dynamics of malaria. Six major species of malaria vectors *Anopheles culicifacies, Anopheles stephensi, Anopheles fluviatilis, Anopheles sundaicus, Anopheles minimus* and *Anopheles dirus* are primarily found in India. There is an interplay between temperature and mosquitoes. At increased temperatures, the rate of digestion of blood-meal increases thus accelerating ovarian development, egg laying, reduction in gonotropic cycle and a greater frequency of feeding on hosts thereby increases the probability of transmission. Rainfall also plays an important role in creating breeding grounds for mosquitoes. It also helps in the increase of relative humidity and alters temperature, which affects the longevity of mosquitoes thus transmission of disease [11]. Malaria is considered as a re-emerging disease because after its successful control in many countries, its incidence has been increasing since the 1970s worldwide [10].The resurgence of malaria in India occurred with sporadic outbreaks in the early 1970s.Urban malaria is of major concern nowadays [12]. However, over the last 15 years, the Malaria burden has reduced in India.

1.5 DENGUE

Variability in the climatic conditions also plays a significant role in the transmission of dengue as well. Dengue is also a major vector borne disease to the public globally. For the past 10 years, the number of dengue cases has gradually increased in India. It is caused by DENV, 1-4 serotypes and *Aedesaegypti* and *Aedesalbopictus* are the major vectors for dengue in India. In India, the epidemiology of dengue was first reported in Madras (now Chennai) in 1780 and its first outbreak occurred in Calcutta (now Kolkata) in 1963. Since the 1990s, the epidemics of dengue have become more frequent and also spread to new regions such as Orissa, Arunachal Pradesh and Mizoram where it was unknown earlier. The incidence of dengue cases have been on the rise in India since 2001.Besidesthe increase in the number of cases, there is a major shift in its geographical range. Earlier dengue was restricted to urban areas but now it has gradually started spreading to rural regions as well. Unplanned urbanization, changes in climatic variables are responsible for the spreading of dengue in India. Also, favourable conditions for dengue transmission and its vectors is provided by inadequate vector control measures. Temperature, rainfall and humidity are important climatic variables factors affecting the mosquito population and transmission dynamics. Warm temperatures and high humidity increases the longevity of adult mosquitoes and shortens the viral incubation period within the vector and blood-intake intervals thus causing faster viral replication and increased transmission[13].

1.6 CHIKUNGUNYA

Chikungunya is a mosquito-borne viral disease mostly transmitted by the vectors *Aedesaegypti*and *Aedesalbopictus.* Numerous factors are responsible for the global spread of Chikungunya[14,16]. Chikungunya was first reported in India from Calcutta (now Kolkata) in 1963 and its transmission continued till 1973[4,15]. The virus re-emerged in 2005 and has spread to most of the southern states of India and since 2006 there have been large scale outbreaks of Chikungunya in different parts of the country. An epidemic occurred in Delhi in 2016. With the increased temperature, the disease is likely to spread to newer areas as well [4].

1.7 LYMPHATIC FILARIASIS

Lymphatic filariasis also commonly known as elephantiasis is a neglected tropical disease. It is less likely to be influenced by the changing climatic conditions as compared to malaria and dengue as the mosquito vector *Culex quinquefasciatus*for filariasis is widely distributed. Moreover, it has been revealed that almost the whole India is endemic for this disease [4].

1.8 VISCERAL LEISHMANIASIS

Visceral leishmaniasis is a parasitic disease caused by the parasite Leishmania. It is spread by the bite of certain types of phlebotomines and flies. There is available evidence of climate change and re-emergence of leishmaniasis and this link needs to be elucidated. The disease has re-emerged after 1982 in Assam, Gujarat and has also been detected in Himachal Pradesh, Uttar Pradesh and Uttarakhand. There was no record of leishmaniasis in Himachal Pradesh till 1984 when a number of cases have been reported[17]. The disease re-emerged in 2004 and cases have been increasing from 2007[4]. The last case in Assam was reported in 1951 after which re-emergence has been witnessed and in 98 cases were reported in 2008 [4]. Visceral Leishmaniasis also re-emerged in 2004.

1.9 JAPANESE ENCEPHALITIS

Japanese Encephalitis (JE) is a viral disease mostly spread by the mosquito vector *Culex tritaeniorhynchus*. The JE virus is maintained between vector mosquitoes and domestic pigs in endemic regions. The transmission cycle of JE is confined to rice field prone areas involving pigs as amplifier hosts [4]. In India, the virus was first isolated in 1955 from human in Tamil Nadu. Bankura and Burdwan in West Bengal experienced a large outbreak of the disease in 1973. Several cases have been reported in different parts of the country. It was known to be endemic in Gorakhpur and Uttar Pradesh. According to the National Program on Prevention and Control of JE, Assam, Uttar Pradesh, Bihar, Tamil Nadu and West Bengal are highly infected with the disease [2]. There is inadequate information on the impact of climate change on JE occurrence and its transmission [4]. However, in the context of Japanese Encephalitis (JE), there is inadequate information on the impact of climate change on its occurrence and transmission.

2. CONCLUSION

There is a wealth of evidence that climate change has now become a major threat to humanity which occurs as a result of both natural and human activities. The incidence of many vector-borne infectious diseases shows seasonality and severe weather conditions are frequently associated with major outbreaks of the diseases. Also, emergence and re-emergence of several vector-borne infectious diseases are major challenges which are highly influenced by changing climatic conditions. Climate change has its effects both on the vector and the pathogen as well. Available evidence indicates that significant anthropogenic contributions have led to a sharp increase in the greenhouse gases in the atmosphere thus amplifying the 'Green-House Effect' and resulting in global warming. Climate change has led to the emergence

and re-emergence of several vector-borne diseases in India. As the temperature rises due to climate change as a result of global warning which in turn shortens the incubation period of the vectors thus increasing the biting rates which ultimately increases transmission of vector-borne diseases. Therefore, there is a need to understand the eco-epidemiology of the diseases. More awareness should be created for human activities resulting in the increase of greenhouse gases. To conclude, it is imperative to conduct further research to confirm the association between climate change, occurrence and transmission of several infectious diseases.

2.1 FUTURE PERSPECTIVES

Climate change and its associated vector-borne diseases are of major public health concern that India faces today. With a view to minimizing the potential impact of climate change on the VBDs, it is imperative to conduct collaborative research among researchers, governments and communities to develop a common benefit strategy to assess the actual burden and development of proper tools for early warning.

3. AUTHORS CONTRIBUTION STATEMENT

Both the first and the second author contributed for the final manuscript. First author developed the idea and communicated with the publishing authority of the journal while the second author worked on review of different papers relevant to the mentioned topic and helped the first author in developing the concept and the objective for the paper.

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5. CONFLICT OF INTEREST

Conflict of interest declared none.

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