

Impact of Climate Change on Vector Borne Diseases with Emphasis on Malaria

The role of environment is an important component of epidemiology of vector borne diseases. In recent years, more precisely since 1990 there is greater awareness about the threat of climate change on human health in addition to various other sectors. Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). It may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere. The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.

As per Intergovernmental Panel on Climate Change's (IPCC) Third Assessment Report, about 3.8°C rise in temperature and 7% change in precipitation (increase as well as decrease) are projected by the year 2080 (IPCC 2001). The fourth Assessment Report of IPCC (2007) also projects rise in temperature up to 4°C and sea level rise up to 0.59 m by the year 2100. IPCC concludes that climate change is likely to expand the geographical distribution of several vector-borne diseases, including malaria, dengue and leishmaniasis to higher altitudes (high confidence) and higher latitudes with limited public health defences and to extend the transmission seasons in some locations. In some locations, reduced rainfall or incremental temperature may cause decrease in transmission of some vector borne diseases.

International bodies like IPCC, UNFCCC, and World Health Organization (WHO) have accelerated efforts to generate, collate and compile the data on assessments of impacts of climate change on different sectors like geology, forestry, agriculture, water resources, biodiversity, health and so on. UNFCCC through Global Environmental Facility (GEF) has also funded projects for national assessments in different parts of the world.

Ministry of Environment and Forests, Govt. of India has taken initiatives to assess the vulnerability due to climate change in different sectors, like agriculture, geology, hydrology, forestry, energy, health, etc and possible adaptation measures.

National Institute of Malaria Research in 2001 has also participated in the first National Communication Project to assess the impact of climate change on malaria in India.

Load of Vector Borne Diseases

India is afflicted with six major vector borne diseases (VBDs), namely malaria, dengue, chikungunya, filariasis, Japanese encephalitis and leishmaniasis of which malaria ranks at number one with about 1.48 million cases and 1173 deaths. As per NVBDCP, in 2007, cases and deaths due to Japanese encephalitis, dengue and visceral leishmaniasis were 4022/963, 5534/69 and 44001/189 respectively. Around 60,000 suspected cases of chikungunya were also reported in 2007. In addition to mortality, vector borne diseases cause morbidity of millions of persons resulting in loss of man-days causing economic loss.

The Logic of Impact of Climate Change on VBDs

The role of climatic factors has been studied extensively in the epidemiology of malaria due to its global public health importance. The minimum temperature required for development of *P. vivax* parasite in anopheline mosquitoes is 14.5–16.5°C while for *P. falciparum* it is 16.5–18°C. At 16°C it will take 55 days for completion of sporogony of *P. vivax* while at 28°C, the process can be completed in seven days and at 18°C it will take 29 days. The duration of sporogony in *Anopheles* mosquitoes decreases with increase in temperature from 20 to 25°C.

From 32 to 39°C temperature, there is high mortality in mosquitoes and at 40°C, their daily survival becomes zero. At increased temperatures, the rate of digestion of blood meal increases which in turn accelerates the ovarian development, egg-laying, reduction in duration of the gonotrophic cycle and more frequency of feeding on hosts, thus, increasing the probability of transmission.

Thus, climatic conditions play important role in the distribution, degree of endemicity and epidemicity of diseases in an area. Some areas, which have most favourable conditions of temperature and rainfall, experience transmission of disease throughout the year, while in areas experiencing colder months, transmission is seasonal and does not take place throughout the year.

Studies Undertaken by NIMR

The Ministry of Environment and Forests launched a mega project—India's initial National Communication to UNFCCC in 2002. Impacts of climate change on malaria was one of the projects under which vulnerability assessment and adaptation measures in view of climate change on malaria were studied by the NIMR.

Vulnerability Assessment and Future Scenario

Based on monthly incidence of malaria in different states of India, it was found that northern states, such as Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana, Uttarakhand and northeastern states, etc are more vulnerable to climate change whereas southern states, such as Karnataka, Kerala, Orissa, Tamil Nadu and Andhra Pradesh are less vulnerable, as the climatic conditions are already suitable for malaria transmission almost throughout the year .

Preliminary studies undertaken by NIMR (taking one district from each state of India), a baseline map showing transmission windows (TW) of malaria open for different months in different states of India was generated based on minimum required temperature (19°C) and RH (55%). It was found that in Rajasthan, Punjab, Haryana, Himachal Pradesh, and Meghalaya, the TWs are open for 4–6 months, while in Gujarat, Orissa, West Bengal and southern states for 10–12 months. In view of the projected rise in temperature, the future scenario by 2080 is likely to extend the TWs in Punjab, Haryana, Jammu & Kashmir, Uttarakhand, Himachal Pradesh and northeastern states, while in Orissa, Andhra Pradesh and Tamil Nadu, it is expected that there may be reduction in number of months of TWs due to projected high temperatures. However, in such situations mosquitoes may adapt to micro niche as evidenced in Rajasthan (where adult mosquitoes prefer to rest in “tankas” to avoid high temperatures). As malaria transmission dynamics depend on a number of factors like agricultural practices, ecological changes, developmental activities, social development, types of intervention measures undertaken and existing health infrastructure, etc further studies are being undertaken

to assess the negative impact of climate change on different vector borne diseases.

Evidence of Climate Change

Studies have been undertaken in Nanital district of Uttarakhand to find out the earlier evidence of climate change. Results have revealed very high densities of *An. fluviatilis* and presence of *P. falciparum* malaria cases in the month of March–April from the hilly parts which did not report malaria earlier. In-depth studies are being undertaken.

Early Warning of Malaria

As an adaptation measure to reduce the negative impacts of climate change, development of tools for early warning of malaria/diseases is warranted. Studies between climate variability and malaria with emphasis on different sites in India show that rainfall is an important indicator for early warning of malaria in Rajasthan and Gujarat. Work on relationship between El Nino Southern Oscillation (ENSO), vegetation index and malaria is being undertaken to find out the indicators for early warning of malaria. The case studies undertaken in selected districts of Gujarat, Rajasthan and Karnataka reveal that rainfall, ENSO and satellite derived Normalized Difference in Vegetation Index (NDVI) may be used for early warning of malaria in some epidemic prone states. Efforts are being made to develop such a system in India by using meteorological and satellite derived parameters.

Ongoing Studies at NIMR

Following studies are being undertaken to see the impact of climate change on malaria and dengue and developing early warning for malaria:

1. Assessment of the impacts of climate change on malaria and dengue at national scale and adaptation strategies for short, medium to long-term scales.
2. Impact of climate change on dengue in Delhi and environs.
3. Developing a framework for predicting malaria outbreaks in rural and urban Gujarat and Rajasthan, India (2007 to 2009) in collaboration with Michigan University, U.S.A.

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