

Climate Change and vector-borne disease in Punjab, India

Climate is one of the many variables that can affect the incidence pattern of vector-borne diseases (VBD) thus changes in the climate need to be addressed in order to be able to adequately monitor, make predictions control and prevent infection from these diseases. However this is a complex interplay between climate change and ecology of insect vectors, animal hosts and life cycle of pathogens carried holds the potential of altering the spreading and incidence of vector-borne diseases.¹ Our current understanding of the complex transmission cycles of these diseases, along with incomplete understanding of the ecology of insect vectors and animal hosts, and the lack of long-term historical datasets linking weather with VBD outcomes, makes projections very difficult. ¹ The present work will be focusing on one vector-borne disease, malaria, and effects of climate change.

Malaria, the world's most important and deadly tropical mosquito-borne disease is caused by *Plasmodium* parasites. The parasites are spread to people through the bites of infected *Anopheles* mosquitoes, called "malaria vectors", which bite mainly between dusk and dawn ²(who fact sheet no 94). Episodes recorded in 2010 were approximately 216 million and the estimated deaths reached 655000.³ Approximately 86% of malaria deaths globally were of children under 5 years of age. Malaria is a major public health concern in India resulting in 2 million cases annually and about 1,000 deaths.⁵ Environmental conditions play an important role in the transmission dynamics of malaria, as the parasite has to pass its developmental cycle in the mosquito. The three main climatic factors that affect malaria transmission and distribution are temperature, precipitation and relative humidity.⁴ Studies on possible impacts of climate change in malaria transmission have shown that northern states of India such as Punjab are more vulnerable to climate change.⁴ Therefore, the present work will be mainly exploring the effects of changes in these climatic factors on the distribution and intensity of malaria with reference to Punjab, India.

Malaria in humans can be caused by four Plasmodium parasites, *P.falciparum*, *P.vivax*, *P.malariae* and *P.ovale*. Malaria transmissions from *P.falciparum* are the most deadly and present the highest mortality rates.² The most common parasites in India are *P.vivax* and *P.falciparum* whereas out of the six major malaria vector species the *Anopheles fluviatilis*, *Anopheles culicifacies* and *Anopheles stephensi* are those met in Punjab state in India.⁴ *Anopheles* mosquitoes that have been infected through a previous blood meal taken from an infected person can transmit malaria. When the mosquito bites the infected person it receives malaria gametes which are developed into sporozoites and injected with saliva into the next person bitten.⁶ The sporozoites enter the hepatic cells and the red blood cells of the person bitten where they develop into male and female gametes within about 2 weeks; the parasite cannot develop further in humans.⁴

The development of gametes into sporozoites in the mosquito is called extrinsic incubation period or sporogony and its duration depends on environmental temperatures.⁴ The minimum temperature required for the development of *P.vivax* and *P.falciparum* in the mosquitoes is between 14.5-19 °C and the optimum is 20-30 °C with relative humidity 60%.⁴ Experiments under laboratory conditions have demonstrated that under lower temperatures sporogony needs more time to be completed compared to higher temperatures; at 16 °C the sporogony of *P.vivax* takes 55 days whereas under 28 °C it can be completed within 7 days only.⁴ Reduction of the extrinsic incubation period is related with increases rates of transmission.⁴ Furthermore, it was suggested that under increased temperatures the blood-feeding rate of *Anopheles* mosquitoes, increases as well as the rate of digestion of the blood meal resulting in accelerated ovarian development, egg laying and frequency of feeding on hosts.⁴ In turn, under such circumstances the probability of malaria transmission also increases.⁴ On the other hand transmission will be reduced under very high temperatures due the inability of the mosquito to survive long enough. Previous studies demonstrated that at 40 °C the *A.culicifacies* does not survive for more than 24 hours under laboratory conditions whereas its life cycle is shortened to 4-10 days from the average of 8.5-14 days estimated, under 35 °C⁴. In addition humidity

affects the life span of the mosquitos where below 55% and above 80% of relative humidity the life of the mosquito becomes that short that the scope of malaria transmission diminishes.⁷

Changes in the precipitation patterns can also affect malaria transmission. In areas where precipitation may present increases in the future an increase in malaria transmission may be notable. The reasoning behind this is that more breeding areas are created for Anopheles mosquitoes which breed in fresh water collections.⁵ In addition rainfall increases relative humidity which helps in the survival of adult mosquitoes.^{5,7}

It is widely known that ENSO has worldwide weather implications and has been suspected to affect vector-borne diseases and especially in areas where periodic malaria epidemics occur.^{5 8} The area of Punjab India is one such area, considered as vulnerable to malaria epidemics due to excessive rainfall during the summer monsoon and higher relative humidity, both being climatic factors important in the occurrence of malaria epidemics.⁸ Future climate changes can result in more extreme ENSO events that could further accelerate malaria transmission and epidemics occurrence. In addition areas like Punjab, that experience periodic epidemics are expected to have be more vulnerable to malaria due to the relatively low levels of immunity that the population in these areas is likely to have⁷

Keeping in view the minimum required temperature and relative humidity (18 °C and 55% RH) for ensuing transmission of malaria, it was found that northern states like Punjab are more vulnerable to climate change.⁴ In these areas projections revealed that transmission windows may extend by 1-3 months. This is based on the fact that low temperatures are not optimum for transmission partially because the density of malaria vectors in urban areas is very low.⁴

Malaria dynamics of transmission have been strongly correlated to climatic factors such as temperature precipitation and relative humidity (fig.1). Nonetheless despite the links identified there is still uncertainty in the potential impact of climate change on malaria due to incomplete understanding of the ecology of vectors and parasites and also due to the lack of long-term historical datasets linking weather with VBD outcomes.^{1 5} Further, projections in the

increase or decrease of malaria incidence and distribution pattern are not considered complete without including other parameters that also have an effect on malaria transmission.^{4 5} These parameters include agricultural practices performed, type of intervention measures undertaken, socioeconomic status and the pre-existing health status of the population.^{4 5}

Apart from the continued efforts undertaken for the mitigation of climate changes involving the reductions in greenhouse gases emissions further adaptation measures in regards to climate change and malaria transmission need to target the non-climatic factors aforementioned to play a role. Thus strengthening of health infrastructure, improved surveillance and monitoring programmes, development of programmes where community may be involved and empowered to participate in disease control and public education are all steps that need to be taken for the mitigation of climate change effects on malaria transmission. The above and in combination with further research in the ecology of the vectors and parasites long-term research on weather and climate effects and continues attempts for development of more robust predicting models linking climate and malaria incidence can help reduce vulnerability to malaria under climate change conditions.^{7 8}

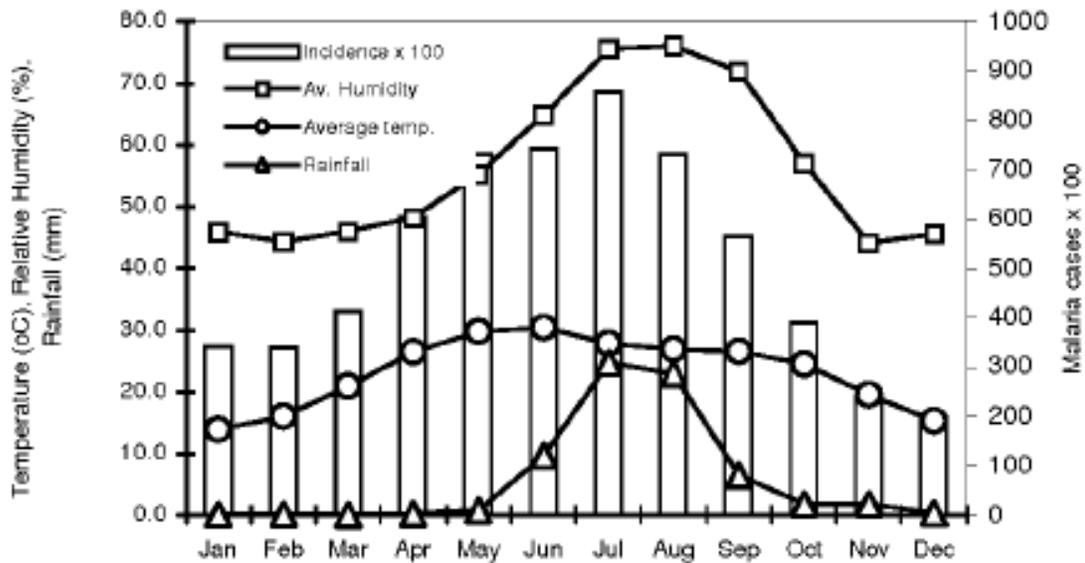


FIGURE 1 TRENDS OF AVERAGE MONTHLY TEMPERATURE, PRECIPITATION, RELATIVE HUMIDITY AD MALARIA CASES IN INDIA BETWEEN THE PERIOD 1970 AND 2000 ⁷

- 1) Centers for Disease Control and Prevention
<http://www.cdc.gov/climatechange/effects/vectorborne.htm>
- 2) World Health Organization
<http://www.who.int/mediacentre/factsheets/fs094/en/>
- 3) WHO, 2011. World Malaria Report: Executive Summary
- 4) Dhiman, R.C, Pahwa, S., Dash, A.P. 2008. Climate change and Malaria in India: Interplay between temperatures and mosquitoes, *Regional Health Forum*, **12**(1)
- 5) Garg, A., Dhiman, R.C., Bhattacharya, S. 2009. Development, malaria and adaptation to climate change: A case study from India, *Environmental Management*, **43**:779-789
- 6) Centers for Disease Control and Prevention
<http://www.cdc.gov/malaria/about/faqs.html>
- 7) Bhattacharya, S., Sharma, C., Dhiman, R.C, Mitra, A.P. 2006. Climate Change and Malaria in India, *Current Science*, **90** (3): 369-376
- 8) Bouma, M.J., Kaay, H.J. 1996. The El Niño Southern Oscillation and historic malaria epidemics in the Indian subcontinent and Sri Lanka: an early warning system for future epidemics? *Tropical Medicine and International Health* **1**(1):86-96

