Climate change may alter malaria patterns

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Temperature is an important factor in the spread of malaria and other mosquito-borne diseases, but researchers who look at average monthly or annual temperatures are not seeing the whole picture. Global climate change will affect daily temperature variations, which can have a more pronounced effect on parasite development, according to a Penn State entomologist.

"We need higher resolution environmental and biological data to understand how climate change will affect the spread of the malaria parasite," says Matthew Thomas, professor of entomology. "We need to understand temperature from the point of view of the mosquito."

Female Anopheles mosquitoes spread malaria by biting infected humans and ingesting the malaria parasites along with the blood they need to reproduce other mosquitoes. In the mosquito's gut, the parasites are implanted in the gut wall where they develop into cyst-like structures and multiply. Once mature, the cysts burst releasing thousands of parasites, which migrate to the mosquito's salivary glands. The next time the mosquito bites a human, the parasites enter the human along with mosquito saliva. Except through blood transfusions, humans cannot directly spread malaria to other humans.

Temperature plays a key role in the development of malaria parasites in the mosquito. Adult female Anopheles mosquitoes can live up to eight weeks but most die within two or three weeks, so malaria parasites must complete their development before the last time a female feeds to infect humans. Scientists have known for a long time that temperature

influences the speed at which malaria parasites develop in mosquitoes, but temperature's effects are more complicated than previously thought.

"A day in the tropics may vary from something like 65 degrees Fahrenheit at night to 86 degrees Fahrenheit in the day, even though the daily average may be 77 degrees Fahrenheit, " Thomas told attendees at the annual meeting of the American Association for the Advancement of Science today in Chicago. "Our research suggests this fluctuation matters because it alters the parasite incubation period in the mosquito, which is the most important factor in the spread of malaria. Small changes in incubation can lead to big changes in transmission."

The cooler the ambient temperature, the slower the malaria parasite develops. The warmer the ambient temperature, the faster the malaria parasite develops. If the incubation period takes longer than the life of the mosquito, the parasite will never infect a human. In some places, especially at higher elevations, malaria does not exist or is seasonal because, with cooler temperatures the mosquitoes die before the parasites are mature. While other factors such as how often a mosquito bites and the fertility of the mosquitoes remain important, the development of the parasite is the key to infection.

A daily mean temperature of 77 degrees Fahrenheit can indicate that the temperature was 77 degrees for 24 hours, or that it dipped to 59 degrees Fahrenheit and rose to 86 degrees Fahrenheit and still had a mean of 77 degrees Fahrenheit. Depending on how long the temperature stays cool and how long it is warm, the malaria parasite's time to maturity changes and the effects can be complex because fluctuation around cooler average temperatures has the opposite effect to fluctuation around warmer average temperatures.

"Daily temperature fluctuation can increase or decrease malaria risk, depending on background conditions," said Thomas.

Day-long fluctuations are not the only thing that influences the development of the malaria parasite. According to Thomas, during the first 12 hours of parasite development, temperature fluctuations can be fatal. Most mosquitoes bite to feed on blood in the evening or at night. If they bite in the early evening, the temperature will remain cool for at least 12 hours. Some mosquitoes may feed much closer to morning. If the morning feeders then face rapidly rising daytime temperatures reaching 88 to 90 degrees before 12 hours elapse, then the malaria parasite development can be stopped.

"If climate change increases the frequency of days when the temperature quickly exceeds the threshold temperature, then entire cohorts of mosquitoes could fail to develop the parasite," says Thomas.

In the developed world, the key to eradicating malaria, which once existed in parts of the U.S. and Europe, was an infrastructure that included good healthcare, mosquito control and habitat management. Future changes in temperature and rainfall are not likely to bring endemic malaria back to the U.S. or Europe. However, in parts of the world where these malaria preventing approaches do not exist, climate change may well lead to changes in malaria dynamics; whether this will be an increase in malaria or a decrease in malaria will depend not only on changes in mean conditions, but also changes in the daily temperature fluctuations.

The control of malaria depends on the environment of a small bodied, cold blooded insect -- the mosquito. A complete understanding of the temperature regime where they live as both larvae and adults is important to understand disease risk.

"Unfortunately, the areas where we need to get more sensitive temperature readings are also sometimes the most difficult places to obtain data," said Thomas. "But, this is the basic biology we need."

Source: Penn State