Daily temperature shifts may alter malaria patterns

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Daytime temperature fluctuations greatly alter the incubation period of malaria parasites in mosquitoes and alter transmission rates of the disease. Consideration of these fluctuations reveals a more accurate picture of climate change's impact on malaria.

"Most studies use average monthly temperatures to study the impact of climate change on the global malaria burden," said Matthew Thomas, professor of entomology, Penn State. "But mosquitoes and the malaria parasites developing within them do not experience average temperatures; they are exposed to temperatures that fluctuate throughout the day."

According to Thomas, the key to understanding the transmission of malaria lies in the time parasites take to incubate within a mosquito. In areas of high malaria transmission, the parasites take between 10 to 14 days to mature and become infectious. But almost 90 percent of female mosquitoes -- which transmit the disease -- die within 12 days. So even a tiny increase or decrease in the parasites' incubation period can greatly alter the number of mosquitoes available to transmit malaria.

Thomas and his Penn State colleagues Krijn Paaijmans, post-doctoral fellow, and Andrew Read, professor of biology and entomology, used a thermodynamic model to estimate the growth of malaria parasites during 30-minute intervals while temperatures fluctuated.

They found that under warmer conditions the daily temperature fluctuation effectively slows down the parasites' growth, while under cooler conditions the parasites grow more quickly because at least for part of the day they experience a warm temperature.

"We measure how parasite growth rates accumulate over 24 hours and subsequently over days," explained Thomas, whose team's findings appear today (Aug 3) in the Proceedings of the National Academy of Sciences. "And if you add up the effects from parts of the day being very cool and parts of the day being very warm, you get a different outcome than if you simply use the mean monthly temperature."

The Penn State researchers' model suggests that in cooler areas with average monthly temperatures below 68 degrees Fahrenheit, a fluctuation of plus or minus 45 degrees Fahrenheit reduces the parasites' incubation period, making them infectious nearly two weeks earlier. For areas with mean temperatures above 77 degrees Fahrenheit, a similar fluctuation greatly increases their incubation period and thereby reduces their infectious potential.

"This is important because if we base our estimates of malaria transmission intensity on mean monthly temperatures alone then we are going to be wrong," said Thomas. "Most studies are probably overestimating transmission intensity under warmer conditions and underestimating the transmission intensity under cooler conditions."

To test their model Thomas and his colleagues looked up average monthly temperatures and change in daytime temperatures for 1987 through 2005 during the main malaria transmission season at Kericho, a site in the Kenyan Highlands.

Current malaria transmission models predict that for average monthly temperatures between 59 degrees Fahrenheit and 69 degrees Fahrenheit during Kericho's malaria season, the incubation time for malaria parasites is never less than three weeks and frequently exceed a number of months. However, because about 10 to 20 percent of mosquitoes die off each day and the oldest live for about 56 days, such lengthy incubation periods for the parasites make malaria transmission at Kericho possible only during six of the 17 years.

However, malaria epidemics have been reported from the Kenyan Highlands in all 17 years.

When researchers accounted for daytime temperature fluctuation, their model correctly predicted it would shorten the parasites' incubation period to below 56 days, making malaria transmission possible during all 17 years.

"In order to explain the frequency of malaria epidemics at Kericho, you need to invoke the effects of daytime temperature fluctuation," said Thomas. "You cannot simply explain it with coarser measures of monthly mean temperature."

The Penn State researcher added that the inclusion of daytime temperature fluctuations could be the key to accurately interpreting the potential impacts of climate change on the dynamics of diseases such as malaria.

"There is potential for climate change to increase or decrease the intrinsic risk of malaria, but predicting what will happen where and when requires we consider changes in temperature variation, and not just mean conditions, coupled with a more detailed understanding of mosquito ecology."

Source: Pennsylvania State University (news : web)