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Predicting malaria's changing course in East Africa

"These efforts will help health service providers identify early warnings of a looming epidemic, to better protect people in affected communities."

– James Sang, Malaria Control Unit, Kenya Ministry of Health

East Africa is experiencing outbreaks of malaria in highland areas where there is little experience with the disease. Researchers led by the Kenya Medical Research Institute are combining climate observation with medical research to predict highland malaria outbreaks in Kenya, Tanzania, and Uganda so local officials can better prepare for them.

The problem: *malaria moves upland*

Rising 1500–2500 metres above sea level, East Africa's relatively cool and breezy highlands were the preferred site for European colonial settlement and the birthplace of many of Kenya's world famous athletes. They are the heartland of tea and coffee production. Until recently, the area was considered an oasis of good health: malarial mosquitoes couldn't tolerate the highlands' long-term average temperatures of 18 degrees Celsius or lower.

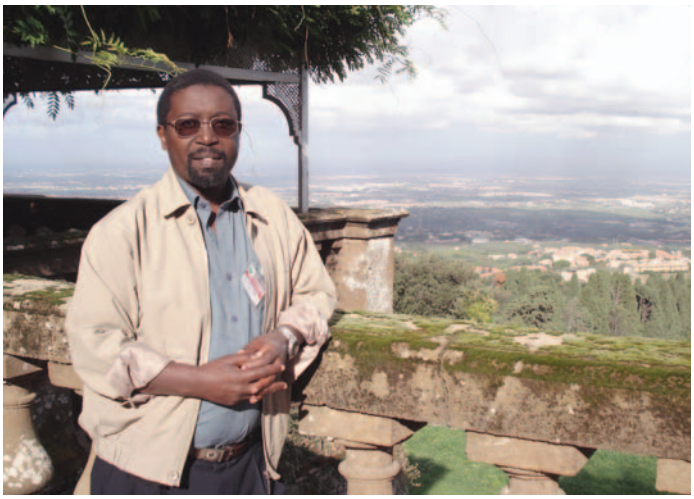
Malaria's toll in East Africa

7.1 million malaria cases in Uganda, 2003

19% malaria's share of Tanzanian health spending

40,000 infant deaths in Kenya annually

Canada



But highland temperatures have been rising in recent decades. In 1997–98, average temperatures in Kenya's highlands were as much as four degrees higher than usual and the incidence of malaria increased 300 per cent over the baseline average for 1995-2002. Meanwhile in Tanzania and Uganda, malaria incidence in highland areas increased by 146 and 256 per cent respectively over the baseline.

Highland health systems were unprepared for such outbreaks, with untold suffering and many deaths among patients who had to share hospital beds or spend days on hospital floors without proper medical care.

James Sang of the Kenyan government's Malaria Control Unit says the disease hits highlanders – mothers and children in particular – harder than lowland populations where it has long been endemic. During the 1998 epidemic, almost four times more school-aged children caught malaria in the Kisii Highlands than did children in the low-lying Bondo district on Lake Victoria's shores. In low-resistance areas malaria is associated with 20-30 per cent of all maternal deaths and spontaneous abortions, premature deliveries, and neonatal deaths.

With climate change and other factors such as deforestation, conditions considered unusual in the late 1990s may become the norm. Temperatures in the East African highlands have risen by half a degree Celsius in the last 50 years, mostly since the late 1970s. And even this small change may have doubled the number of malaria-carrying mosquitoes. Malaria is now considered endemic in some highland areas.

The idea: *meteorology meets medical research*

Climate science is a stretch for a medical research institute. But Dr Andrew Githeko and his colleagues at the Kenya Medical Research Institute (KEMRI) were struck by the surprising coincidence of outbreaks of malaria in Kenya's highland districts in 1997-98 and during other episodes of El Niño – a periodic disturbance that affects weather systems throughout the southern hemisphere. While recognizing that many factors may contribute to the spread of this vector-borne disease, the KEMRI team approached meteorologists to help explore the climate-malaria connection.

"It became apparent weather data could be used to reliably predict malaria epidemics," said Kenyan meteorologist William Ndegwa who is part of the malaria prediction effort.

Cover: ***A woman is treated for malaria in a Kenyan highlands hospital.*** *Photo: Panos/S. Torfinn*

page 2: ***Dr Andrew Githeko links climate observation to malaria preparedness.*** *Photo: KEMRI*

page 3: ***Kakamega highlands, Kenya: health officials test for malaria.*** *Photo: KEMRI*

page 4: ***Bed nets may help keep a family malaria-free.*** *Photo: IDRC/C. Lengeler*

Medical records in Ethiopia have also shown a high degree of correlation between rainfall and temperature increases and malarial incidence.

Warm conditions allow both the *anopheles* mosquito and the malarial parasite it carries to develop more quickly, while wet conditions increase mosquito life expectancy and provide breeding habitats. The malaria prediction model therefore detects risk conditions in highland temperature using a simple formula. When the identified risk level reaches 50 per cent there is a high degree of certainty an outbreak will occur within three months.

By 2001 the KEMRI team had developed a malaria epidemic prediction model that can detect an epidemic two to four months before it occurs. The challenge now, says project leader Andrew Githeko, "is to develop and deploy an instrument that health system managers can use to reliably predict the onset of a malaria epidemic in areas not traditionally prone to the disease, and to manage it better."

Collaborators in this KEMRI-led research include Uganda's Ministry of Health; Tanzania's National Institute for Medical Research; IGAD's Climate Prediction and Application Centre; the International Centre for Insect Physiology and Ecology; Community Health Support (a Kenyan NGO); and the Walter Reed Army Institute for Research.

On the ground: *fine-tuning the model*

In Western Kenya's Kakamega highlands, Dr Githeko and his team are taking blood samples from villagers, to test the prevalence of malaria in the local population. The findings will be matched with data from nearby weather stations to check for links between prevailing climatic conditions and malaria prevalence. Deforestation, a major concern in the area, may partly explain why temperatures in Kakamega have risen 1.2 to 1.8 degrees in recent years.

Work on the team's prediction model, which began more than five years ago, involved collecting malaria data from more than 12 mission hospitals in Kenya, Uganda, and Tanzania and matching it with local climate records.

These results convinced Dr Githeko and his team it was possible to develop site-specific skills in the use of the malaria prediction model and transfer it to end-users in each participating country. This gave birth to the current phase of the project.

"We aim to improve the model's predictive capacity by taking into consideration the local terrain and the immune profile of the affected population," says Mike Okia of Uganda's Ministry of Health. "This will mean better management of any epidemic." The work will involve mapping traditionally endemic areas where people have some level of resistance, and newly malarial zones where there is less resistance to malaria.

The project also will train district health care providers across the three countries to use the prediction model to anticipate and prepare for malaria outbreaks.

The goal: *preparing the highlands for a warmer future*

The race is on. While highland communities and their health providers struggle to adjust to the new prevalence of malaria, climate change is likely to bring more of it, and more often. While average temperatures increased regionally 0.5°C in the last half of the 20th century, the latest assessment reports by the Intergovernmental Panel on Climate Change foresee annual mean surface air temperatures increasing globally between 3°C and 4°C by the end of this century, using a medium-high carbon emission scenario.

Health experts say controlling malaria is crucial if the three East African nations are to achieve the UN Millennium Development Goal of halving the incidence of infectious diseases such as malaria, tuberculosis, and HIV/AIDS by 2015.

Looking ahead: *Prevention and treatment*

Improved malaria prediction will be an essential part of Africa's adaptation to climate change. If successful, the current three-year project Dr Githeko and his colleagues have embarked upon will give local health systems a greater base of certainty on which to plan prevention and treatment. With more lead time, health officials can respond by taking preventive measures such as distributing mosquito nets, and draining or spraying

mosquito breeding grounds. They also can have adequate staff and medical supplies on standby to deal with increased caseloads.

Dr Margaret Chan, Director-General of the World Health Organization, said in 2007 that climate change "may turn out to be the most ominous struggle" facing human health in coming years.

Each year malaria currently strikes more than 500 million people worldwide – most of them in Africa where it causes one in five childhood deaths. Given the prevalence of this scourge, its devastating toll, and the likelihood that climate change is altering its patterns, a tool that better predicts its occurrence may have impacts far beyond East Africa's highlands.

Ochieng Rapuro

"Transferring the malaria epidemic prediction model to users in East Africa" is a research project led by the Kenya Medical Research Institute, with support from the **Climate Change Adaptation in Africa (CCAA) research and capacity development program**. The CCAA program is jointly funded by Canada's International Development Research Centre and the United Kingdom's Department for International Development.

For further information, visit **www.idrc.ca/ccaa**