Enabling environment

Product and service development

Evaluation

CASE STUDY 5I

RISK FORECASTS

FORECASTING MALARIA TRANSMISSION: FINDING THE BASIS FOR MAKING DISTRICT-SCALE PREDICTIONS IN UGANDA

Authors: A.M. Tompkins (Abdus Salam International Centre for Theoretical Physics, Italy); F. Di Giuseppe (European Centre for Medium Range Weather Forecasts, UK); F.J.Colón-González (Abdus Salam International Centre for Theoretical Physics, Italy); D.B. Namanya (Uganda Ministry of Health, Uganda).

CONTEXT

Despite a global contraction in range over the past century *(51)*, malaria still imposes a significant health and socioeconomic burden in over 100 countries *(52)*. Every year about 10 million cases and 43 000 deaths occur in Uganda *(53)*, which ranks third for malaria-related mortality in Africa *(53)*. Nearly 50% of all outpatient visits and 35% of hospital admission are malaria-related *(54)*. Malaria is a climate-sensitive disease as some of its key cycles are influenced by temperature and rainfall. Temperature steers several mosquito and parasite traits (development rates, survival and mosquito biting rate) that ultimately determine transmission intensity *(55)*. Rainfall regulates the production of mosquito breeding sites *(56)*. Since monthly and seasonal dynamic climate prediction systems have significantly improved their capability in the tropics over recent years, there is potential to use such forecasts to drive malaria models to provide early warnings of climate-related malaria transmission anomalies several months in advance. These malaria early warning systems (MEWS) would enable decisions concerning human and material resources mobilization to be made in advance, in particular regarding areas of high interannual variability in transmission (epidemic zones).

NEW APPROACHES

A pilot dynamic malaria prediction system was developed driving the International Centre for Theoretical Physics (ICTP) dynamic malaria model *(57)* with the operational weather forecast system of the European Centre for Medium-Range Weather Forecasts (ECMWF) up to four months in advance. Temperature and precipitation forecasts were computed using ECMWF prediction systems. The fine spatial scale used allowed predictions to be made at the health district level. The entomological inoculation rate (EIR) was predicted, the logarithm of which is approximately correlated to malaria incidence *(58)*. Malaria forecasts were evaluated over a period of approximately one decade against normalized laboratory confirmed cases obtained from six sentinel sites, and against malaria incidence obtained from the national epidemiological surveillance system.

Figure 5.22 Geographical areas where the MEWS shows skilful predictions four months ahead. Green shaded areas indicate significant correlation between observed malaria incidence and the malaria forecasts four months ahead.

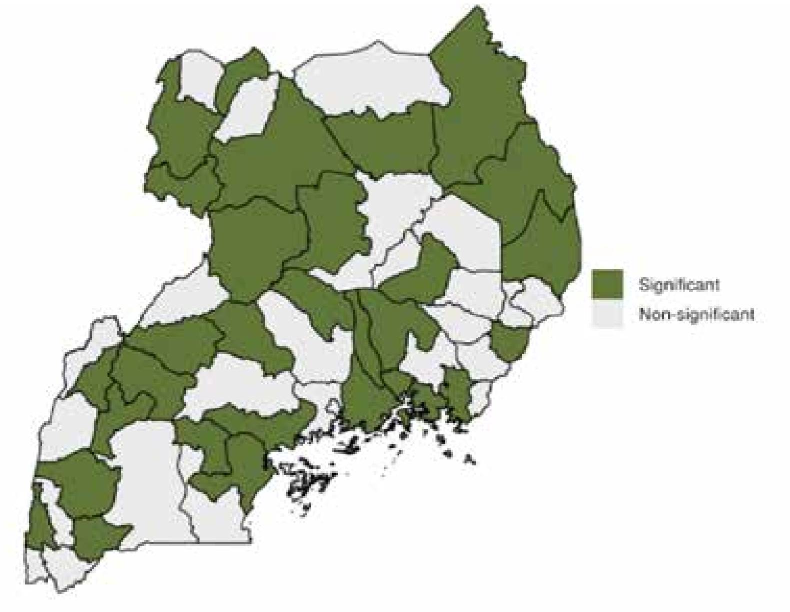

Figure 5.22 presents the areas where the malaria forecasts were skilful (in green) four months ahead, as evaluated against monitored malaria incidence. Statistically significant correlations (Spearman rho range: 0.3 - 0.8) were observed in areas considered of 'very low' and 'low' transmission such as Kanungu, Kabarole, Ntungamo and Mbale, as well as in 'medium–high' and 'very high' transmission areas (e.g. Arua, Moroto, Kotido, and Nakasongola). Areas showing significant correlations contain about 51% of the country's population.

BENEFITS AND LESSONS

The results demonstrate potential for skilful malaria predictions up to four months ahead over wide areas of Uganda, a country characterized by highly variable malaria transmission. We show, for the first time, that climate forecasts may usefully extend the early warning available from environmental monitoring across large geographical areas and at the health district scale. They reaffirm the potential importance of accurate climate information for enhancing public health actions. The next stage, currently underway, involves the close collaboration of ICTP, ECMWF with the Ministry of Health to determine the best way to feed information into decision-making processes and policy. Clear and simple metrics will need to be developed, and training given, so that the uncertainty of the system is appreciated by users in the malaria control division. To aid this process, a simple cost–loss analysis of the system is presently being undertaken, using simulated and real cost–loss data for Africa based on the cost–loss ratio methodology developed by Richardson (2000) *(59)* for estimating the economic value of meteorological forecasts.

Despite considerable evidence that climate information could increase advance warnings, MEWS based on climate monitoring or forecasting have not been widely adopted in operational environments to assist planning anywhere in Africa. Decisions concerning drug distribution and interventions are still mostly based on long-term mean malaria prevalence maps. One obstacle seems to be the unfamiliarity with the operational paradigm of using climate information to predict outbreaks in advance and the complexity of accounting for forecast uncertainty compared to the relative certainty of health surveillance. Integrating climate forecast information into the decision-making process will require extensive and long-term interaction between health ministries and research institutes to ensure the forecast information is provided in a format that is understandable and that end-users are conversant with the uncertainties involved. In preparation for this, the use of MEWS for malaria preparedness and control has been recently incorporated in the *Uganda Malaria Reduction Strategy 2014–2020*. The goal is to pilot the system in an operational setting in Uganda by the end of 2017.

ACKNOWLEDGEMENTS

This work was partly funded by the EU-FP7 HEALTHY FUTURES (grant agreement 266327) and QWECI (grant agreement 243964) projects.

ECMWF

The Abdus Salam International Centre for Theoretical Physics

Republic of Uganda, Ministry of Health