A Collaborative Epidemic Early Warning & Response Initiative in Ethiopia.

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Abstract

M*alaria is the most well known of the climate sensitive diseases. Epidemics of malaria are often triggered by climate anomalies and climate informed early warning systems have been advocated in recognition of this. Africa bears the greatest burden of malaria worldwide and it is estimated that almost 125 million people live in areas prone to malaria epidemics. Ethiopia is the second most populous country in Africa and due to widespread poverty combined with highland and desert-fringe terrain it is the country with the highest proportion of the population (more than two thirds) living at risk of malaria epidemics. Prevention and control of malaria epidemics is a priority for the Ethiopian Ministry of Health and during recent years the Ministry of Health has commissioned the National Meteorological Agency to provide routine meteorological information to inform on changing conditions in epidemic prone districts. This innovative action in epidemic malaria prevention and control is outlined here with consideration of its effective operational uptake and sustainability.*

Problem focus

Many of the world's major public health issues are sensitive to climate. Those that generate most attention are the vector-borne diseases – with malaria, the globally important mosquito borne disease, being the most studied [1]. While economic development has had a major bearing on the distribution of malaria over the past century it is clear that, where malaria is not adequately controlled, true of much of the less developed world, the spatial and temporal distribution of endemic malaria is greatly influenced by seasonality and trends in climate, with periodic epidemics triggered by anomalies in rainfall, temperature, and humidity [2].

It is currently estimated that 3.2 billion people in 140 countries remain at risk of malaria and at least 500 million cases and 2 to 3 million deaths occur each year. Malaria is caused by protozoan parasites of the *Plasmodium* species that are transmitted to people by infected mosquitoes. The malaria parasites enter the human bloodstream through the bite of an infected female *Anopheles* mosquito. Of the four malaria parasites that affect humans, *Plasmodium falciparum* is the most deadly, and unfortunately in Africa the most common. Indeed Sub-Saharan Africa bears the brunt of the global burden of malaria with more than 60% of the world's malaria cases and more than 80% of the world's malaria deaths [3, 4]. The greatest burden of malaria in Africa is in endemic (or stable transmission) areas where the parasite is continuously present in the community. The environment encourages interactions between the *Anopheles* mosquito, malaria parasites and human hosts, providing: surface water in which mosquitoes can lay their eggs; humidity for adult mosquito survival; and temperatures that allow both the mosquito and the malaria parasite to develop and survive. Where malaria control measures are inadequate, the disease distribution is closely linked with seasonal patterns of the climate and local environment. Those most vulnerable to endemic malaria are young children who have yet to acquire immunity to the disease, pregnant women whose immunity is reduced during pregnancy, and non-immune migrants or travelers.

Epidemic (or unstable) malaria tends to occur along the geographical margins of endemic areas, when the conditions supporting the balance between the human, parasite and mosquito vector populations are disturbed. This leads to a sharp, but temporary, increase in disease incidence. More than 124 million Africans live in such areas, and experience epidemics causing around 12 million malaria episodes and up to 310,000 deaths annually [5]. All age groups are vulnerable to epidemic malaria, because their exposure to disease is infrequent and they have little immunity. In the case of 'classic' or 'true' epidemics, the change in equilibrium is brought about by natural causes such as climate anomalies in regions where the environment does not normally allow mosquito and parasite development. Typically these involve desert-fringes (usually too dry to support transmission) or highland-fringes (usually too cool). The climate anomalies are often periodic and temporary, and there is a return to equilibrium. Examples include the epidemics occurring in the semi-arid areas of Southern Africa in 1996-1997, East Africa in 1997-1998, and the West African Sahel in 1999-2000, all of which were associated with wide-scale and unusually heavy rainfall[6]. Being poorly prepared, health services often become rapidly overwhelmed, leading to perhaps ten times more malaria-related deaths than in non-epidemic years, across all age ranges[7].

Measures to control both endemic and epidemic malaria need to be applied in the right place at the right time, and climate and weather information can help focus appropriate control interventions to protect vulnerable communities [8]. Prevention and control of epidemics has been one of the four key technical elements of the Global Malaria Control Strategy which was adopted by the 1992 World Health Assembly [9, 10]. The prioritization of epidemic prevention and control was voiced at a high level in Africa [11-13] and strongly reflected in the inception, in 1998, of the Roll Back Malaria Partnership[14] which immediately established a Technical Support Network on Epidemic Prevention and Control [15]. It was recognised that in the majority of instances epidemics were first reported from outside the formal health sector. While it was seen as essential that epidemiological surveillance systems be strengthened it was also recognised that information on changes in epidemic potential are most likely to be available from outside the health sector. In view of this considerable interest emerged in developing operational Malaria Epidemic Early Warning and Response Systems (MEWS) which could integrate timely information on changes in community vulnerability, as well as meteorological and environmental conditions, to improve advanced planning and prevention of malaria epidemics[6, 16, 17].

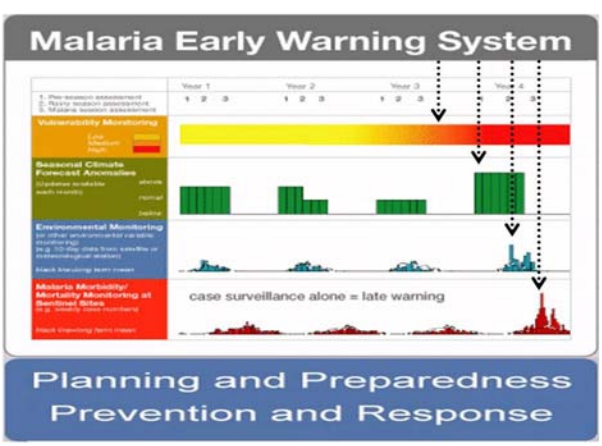

Figure 1. A conceptual model of an Integrated Malaria Epidemic Early Warning and Response System providing incremental evidence of changes in epidemic risk (modified after WHO 2004)

There has been good progress and promising results with MEWS development in Botswana, and Southern Africa[18-21]. However, epidemic risk in Ethiopia and other densely populated countries in the East African highlands remains a major challenge for malaria prevention and control in Sub-Saharan Africa. It is this region which is home to more than three quarters of Africans, of all age groups, living at risk of epidemic malaria. Recently an innovative collaboration between the Ethiopian Ministry of Health and the National Meteorological Agency which was funded by the Global Fund for AIDS, TB and Malaria has begun to address this issue. Success with this venture would provide an excellent example of how meteorological services can aid effective control of a major issue constraining Ethiopia's social and economic development.

An Ethiopian collaborative initiative in climate informed Epidemic Early Warning and Response

Ethiopia has a diverse climate and topography, consequently malaria transmission throughout much of the country shows marked inter-annual, seasonal and geographical variations. However, the majority of Ethiopians live in highland and mid-altitude regions that are prone to highly seasonal and unstable malaria transmission, and it is estimated that more than two-thirds of the country's population (58 million) are at risk of epidemic malaria [1]. Recent malaria epidemics in Ethiopia have been particularly severe. The 1998 epidemic was especially intense and widespread, somewhat reminiscent of the classic epidemic thirty years earlier in which an estimated 3 million cases and 150,000 deaths occurred[22]. During the 1998 outbreak, more than 403 localities in Tigray, 1,544 localities with 3.4 million people in Amhara, 812 localities with more than 1.2 million people in Oromia, 300 localities with more than 216,317 clinical cases in SNNPR were seriously affected, with a high mortality rate among the affected communities. In SNNPR 60% of all hospital admissions in 1998 were due to malaria. Based on the data collected outside of the health system, a local NGO called the Anti-Malarial Association (AMA) reported a total of 7,783 deaths in Western and Eastern Gojam zones of Amhara region between September and December 1998. These figures most likely represent a fraction of the true impact on morbidity and mortality

[1] The desert fringe or semi arid lowlands of Afar and Somali regions are also known to be epidemic prone however these regions are less densely populated.

due to the tremendous strains that were placed on health systems during this period and the large proportion of cases that went undocumented. Due to low levels of acquired immunity all age groups were highly vulnerable to the disease. In certain parts of the Amhara region during the 1998 epidemic, the median age at death due to malaria was about 25 years old. Periodic upsurges in malaria cases far exceeding normal seasonal fluctuations occur periodically in epidemic regions, straining local health institutions beyond their capacity and overwhelming their ability to respond effectively. It is for this reason that interest in the development of epidemic early warning systems, which could provide lead times sufficient for advance preparation and preventative response, is great.

Following a retrospective analysis of the role of meteorological determinants in 'triggering' malaria epidemics in Ethiopia, which suggested the potential to predicts epidemics some months in advance, the Ministry of Health was successful in obtaining a grant from the Global Fund for AIDS, TB and Malaria (GFATM) to build and implement an epidemic early warning system. The early warning system comprises four levels – each producing alerts or 'flags' designed to trigger a surveillance and control response:

Flag	Indicator	Accuracy	Response
1	Long-term forecast	Low	Heighten surveillance
2	Short-term forecast	Low-moderate	Assess and enhance readiness
3	Real time weather data	Moderate	Initiate selective interventions
4	Early detection	High	Mobilise widespread interventions

Table 1. Proposed Early Warning and Detection Graded Response Mechanism for Ethiopia

The National Malaria Control Programme has, to date, identified 14 sentinel surveillance districts in Ethiopia for monitoring impacts and outcomes of anti-malarial interventions. This heightened surveillance capacity is considered necessary for early detection of anomalous trends in cases and other indicators of epidemics. Their widely dispersed distribution throughout the country ensures that even localized epidemics may be detected. Districts to be considered for the initial installation and assessment of a sentinel early warning system include: Dubti, Jabi Tahnan, Bahir Dar, Guba Lafto, Assosa, Gambella, Hagre Mariam, Fentale, Kersa, Errer, Awassa, Arbaminch, Tahtay Koraro, Alamata. However, the number of stations in the list is considered to be insufficient for the proposed early warning system. Hence, Ministry of Health and the National Meteorological Agency need to work together in revising the list and selecting additional sentinel stations.

In collaboration with the National Meteorological Agency, the general capacity of all epidemic-prone districts to monitor climatological anomalies will be improved through the upgrading of all Class IV weather stations which monitor rainfall only, to Class III status which includes the measurement of minimum and maximum temperature. A total of 319 weather stations will be upgraded in this manner. This enhanced coverage will benefit those districts that are not served by Class III weather stations and thus, cannot receive relevant information about an epidemic indicator as important as minimum temperature. While funds from the GFATM grant will bear the initial cost of upgrading these weather stations with thermometers, NMA will maintain the responsibility of staffing the weather stations, collecting data and reporting. The data will be made available to the general health care system of Ethiopia for utilisation in a malaria early warning system.

Development and deployment of early warning systems based on meteorological and clinical indicators at the district and facility level will be extended to RBM sentinel surveillance sites. Partnerships will also be developed with other government sectors and NGOs to monitor other determinants associated with malaria transmission including ecological changes due to development activities or natural disasters, and social factors such as migratory labour or political unrest. These factors are not currently considered by the health sector in assessing epidemic risk but may play a major role in determining the occurrence and severity of epidemics.

The National Meteorological Agency received approximately US$500,000 through the MoH's GFATM award to be used for activities related to malaria early warning activities. Specifically: upgrading of 319 class IV meteorological stations (currently measuring rainfall only) to class III stations (to be able to additionally monitor minimum and maximum temperatures); work with the MOH on developing sentinel stations in the 14 target districts; provision of meteorological data and information products for malaria early warning and detection.

Progress to date

Approximately three quarters of the funds available have been used for the purchase of meteorological equipment, purchase of Personal Computers, freight costs and installation of a Local Area Network. The National

Meteorological Agency has given due attention to the need for establishing as many as possible 3rd class and 1st class stations in its recent meteorological stations network master plan studies. Additionally, the Agency has already established over a hundred of such stations in the last two years and are planning to establish over 80 more next year. Thus, the newly established stations will bring about wider choices for selection of additional sentential stations.

Following meetings between NMA and MoH staff requests were made for monthly bulletins beginning in January 2007. These bulletins provide updates on the distribution of rainfall, temperatures and relative humidity in a map format. The bulletins are distributed to the Ministry of Health's National Malaria Control Team who then send a hard copy of the bulletin to the regional malaria control departments with a covering letter, the bulletin is also placed on the RANET (community RAdio-interNET) website. To date the maps used in the monthly Health Bulletins have been based on the 'climate suitability for malaria transmission' criteria published by Grover-Kopec, et al. in 2006. These are monthly rainfall greater than 80mm, temperatures between 18-32°C, and Relative Humidity greater than 60% [23]. http://meteo-ethiopia.net/

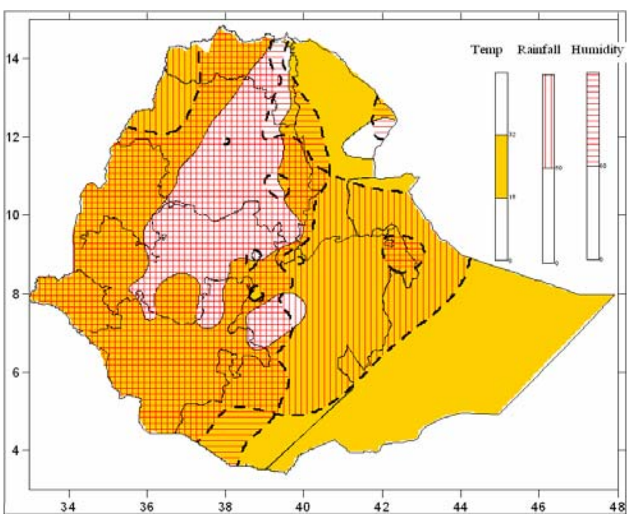

Figure 2. Combined temperature, rainfall and humidity conditions during September 2007. Areas under square patterns with yellowish background are assumed to satisfy favourable climatological conditions for malaria.

The MoH expects that the information to be provided by the NMA will be useful to help: plan on the purchase of drugs; identify where and when to implement more focal epidemiological surveillance; focus vector control more appropriately in space and time; raise community awareness of risk of epidemics; warn relevant players of any potential emergency as necessary.

Initial constraints and concerns

Lack of manpower has been flagged as a constraint to meeting the installation requirements in the time allotted in the project. The MoH has called for more detailed information on the effect of topography on climate and hydrology as this is considered crucial to localised changes in malaria risk. Both the MoH and the NMA believes that more concerted interaction is required to make the system most effective. It has been suggested that both the MoH and the NMA each need a dedicated employee with some training in biometeorology to act as the main interfacing focal point within the initiative. The problem of rapid turnover of well trained staff within the government agencies is seen as a major pitfall.

This collaborative initiative between the NMA and the MoH in Ethiopia is a very exciting development which has grown up around a real demand, and investment, for climate and weather service information to improve the control of climate sensitive epidemic diseases – diseases which are recognised as a major constraint to Ethiopia's prospects towards the Millennium Development Goals and other indicators of socio-economic benefit. However, the initiative is in its early stages and will need significant support to enable it to become an effective and sustainable mechanism for epidemic prevention and control. The role of climate and health is currently enjoying a high profile among the international community in terms of demonstrating climate risk management and practical adaptation to a changing climate. Public health is also enjoying significant international investment at present though funding mechanisms such as the Global Fund for AIDS, TB and Malaria. Success here in Ethiopia will very likely encourage similar multi-agency investments elsewhere in other epidemic prone countries.

The successful relationship between the Meteorological community and the aviation industry is held up as exemplary. However, this relationship did not become successful overnight and much concerted interaction had to take place between the two sectors over a significant period of time. We would suggest that the potentially highly beneficial relationship between PWS and the Public Health Services will also require this process – with strong technical support from the two community's natural partners, e.g. the UN WMO and WHO, to explore in detail the institutional and logistical constraints, help identify mechanisms to overcome them and support their implementation in the immediate and medium-term period.

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