Indian J Med Res 146, November 2017, pp 560-562
DOI: 10.4103/ijmr.IJMR_933_17

Quick Response Code:

Commentary

Early warning systems for the detection of malaria outbreaks

Malaria is caused by the parasitic protozoan belonging to the genus *Plasmodium*. It is transmitted from person to person by the *Anopheles* mosquito and affects over half of the world's population. Though malaria is a disease of major public health importance, the burden of disease has declined on a global level[1]. Many countries in Africa and Asia have succeeded in reducing the burden of disease to low levels and are now targeting elimination. To achieve elimination, countries need to show no local transmission of malaria. Advance warnings of impending epidemics or situations conducive to malaria epidemics will afford national malaria control programmes the leeway needed to stockpile commodities necessary to deal with impending epidemics.

There have been many attempts to devise early warning mechanisms to forecast when malaria epidemics are to occur. The need for early warning is to allow measures to be implemented to mitigate against experiencing the envisaged epidemic thus reducing morbidity due to malaria and saving lives. It is to enhance our ability to plan for a coming event that drives the search for the perfect early warning system that could predict epidemics up to six months or a year in advance.

There is no universal definition of a malaria epidemic. It is generally accepted that a sharp increase in malarial incidence among populations in which the disease is rare or a seasonal increase in clinical malaria in areas of low-to-moderate transmission constitute a malaria epidemic. However, the definition of 'normal' occurrence can be defined only for a particular population in a specific area and time. Therefore, malaria epidemics can generally be considered as a disturbance of a previously existing epidemiological equilibrium. An alternative definition of an epidemic is the malaria caseload exceeding the capacity of the existing health-care facilities to handle it.

The practical importance of defining and declaring an epidemic is the level of support that may be triggered. Declaring an epidemic too late will lead to avoidable and unnecessary morbidity and mortality and to wastage of resources if control options are implemented late in relation to natural development of the epidemic curve. Declaring an epidemic prematurely may lead to overreaction at the expense of scarce resources and may distort the reality of the situation.

Many methods of predicting malaria epidemics have been developed over the years each with its associated lead time and sensitivities. These methods could be categorized as early warning systems or early detection systems. Malaria Early Warning Systems predict epidemics based on weather forecast and provide a longer lead time; this system lacks sensitivity and specificity. Early detection Systems, on the other hand, raise an alert immediately subsequent to the onset of an epidemic[2]. This system, however, provides almost no lead time but is a more accurate warning of an epidemic. An alert is raised when a weekly case count exceeds the corresponding weekly threshold triggering the necessary response from the Malaria Control Programmes which involves investigating or immediately implementing epidemic control measures.

Attempts have been made to identify thresholds that clearly define an epidemic in terms of the previous experience of the disease. The often used method of taking the mean plus two standard deviations (mean+2 SDs) has worked well in the past in situations where the previous data existed for some years, and the population remained more or less stable but is of limited benefit where historical data are either unavailable or irrelevant due to significant changes in the population and environment[3].

The method described by Ikeda *et al*[4] provides better detection of outbreaks than the conventional method of mean+2 SD. A curve-based method of analysis was developed for determining outbreak and using the properties of sine curve. In this issue, utilizing the methodology developed by Verma *et al*[5], malaria outbreaks could be predicted up to two months in advance. The analysis by these authors proposed a 'Case/mean-ratio scale' to detect and measure malaria outbreaks for early preparedness for control. It was concluded that this methodology was better than conventional method in that it was able to predict the onset of both minor epidemics as well as major epidemics. The limitation of this study was that it was limited to the geographical entity for which it was developed and for particular climates. In a country with varied geography, this methodology would become tedious. Although the authors claim that the tool can be adopted by national malaria control programmes, the data manipulation required to arrive at the value to determine if there is an epidemic or not is quite involved and will require advanced knowledge of mathematics. The conventional method is much simpler and is quite straightforward.

Several factors are associated with the seasonal and inter-annual variations of malaria incidences. Climate variation is a major factor. Both the development of the parasite and its vector are influenced by temperature, and other climatic variables such as rainfall and humidity also influences the distribution of the *Anopheles* vector. Previous studies have shown that some climate factors are more important than others. Weiss *et al*[6] used an air temperature suitability index to show that temperature across the entire African continent was a strong predictor for transmission of the malaria parasite. Other studies have reported that rainfall is a main driver of malaria incidence[7,8]. Komen *et al*[9] showed that incidence rates were related to both temperature and rainfall. However, they also showed that temperature played a more important role in influencing malaria transmission compared to rainfall[9]. Precipitation and temperature are the most commonly tested climate variables. Therefore, early warning systems utilizing temperature, humidity and rainfall as variables in epidemic forecasting will also give a more informed prediction rather those just based on malaria case numbers[10]. Ikeda *et al*[4] have reported that the lowest malaria burden is usually observed during the dry and cold season while the highest burden is observed during the warm and wet season. The study also suggests strong association between temperature and high incidence of malaria but only when precipitation is also higher than normal.

Utilization of climatic variables in the forecasting of malaria epidemics needs to be a dynamic process since climate change continues to influence malaria transmission. Through a shift in temperature and rainfall patterns, areas previously not suitable for malaria transmission are now reporting high levels of transmission. Therefore, the distribution of vectors is changing with the associated change in parasite bionomics. The impact on early warning systems, especially those involving climate variables, is that there is no historical data from these areas to train the forecasting model. The conventional method also fails under this circumstance since there are no or minimal data on which to base the mean estimates. Therefore, both early warning systems and early detection systems are data driven, relying on climatic data as well as malaria case data.

For any system to work, it needs to be simple to use, without having to transform data using complex mathematical formula. Malaria control managers need to be able to do the calculations and implement the system at their level, be it nationally, provincially, regionally or at a district level. It needs to be based on the local, current situation with regards to burden of disease and geographically relevant climate data. The system should be relevant and be able to provide a good forecast period for the necessary interventions to be put in place to address the epidemic. The early warning system should be accurate and as specific as possible as many false declarations of an impending epidemic will render the warning or threshold alert meaningless and the entire system will not be used.

Rajendra Maharaj
Office of Malaria Research, South African Medical Research Council,
Durban, South Africa
rmaharaj@mrc.ac.za

Received June 6, 2017

References

1. World Health Organization. *World Malaria Report 2017*. Geneva: WHO; 2017.
2. McKelvie WR, Haghdoost AA, Raeisi A. Defining and detecting malaria epidemics in South-East Iran. *Malar J* 2012; *11* : 81.
3. World Health Organization. *Field Guide for Malaria Epidemic Assessment and Reporting*. WHO/HTM/MAL/2004.1097. Geneva: WHO; 2004.

4. Ikeda T, Behera SK, Morioka Y, Minakawa N, Hashizume M, Tsuzuki A, *et al*. Seasonally lagged effects of climatic factors on malaria incidence in South Africa. *Nature* 2017; *7* : 2458.

5. Verma P, Sarkar S, Singh P, Dhiman RS. Devising a method towards development of early warning tool for detection of malaria outbreak. *Indian J Med Res* 2017; *146* : 612-21.

6. Weiss DJ, Bhatt S, Mappin B, Van Boeckel TP, Smith DL, Hay SI, *et al.* Air temperature suitability for *Plasmodium falciparum* malaria transmission in Africa 2000-2012: A high-resolution spatiotemporal prediction. *Malar J* 2014; *13* : 171.

7. Sena L, Deressa W, Ali A. Correlation of climate variability and malaria: A retrospective comparative study, Southwest Ethiopia. *Ethiop J Health Sci* 2015; *25* : 129-38.

8. Bomblies A. Modeling the role of rainfall patterns in seasonal malaria transmission. *Clim Change* 2012; *112* : 673-85.

9. Komen K, Olwoch J, Rautenbach H, Botai J, Adebayo A. Long-run relative importance of temperature as the main driver to malaria transmission in Limpopo Province, South Africa: A simple econometric approach. *Ecohealth* 2015; *12* : 131-43.

10. Jones AE, Wort UU, Morse AP, Hastings IM, Gagnon AS. Climate prediction of El Niño malaria epidemics in North-West Tanzania. *Malar J* 2007; *6* : 162.