

RATIONALE FOR FORECASTING MALARIA EPIDEMICS

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The malaria burden

After more than 100 years since the discovery of the malaria parasite, malaria is still one of the major public health concerns in the world. According to the 1998 WHO statistics, malaria is responsible for almost 300 million clinical cases and over one million deaths. More than 90% of the malaria burden occurs in sub-Saharan African countries especially in children and pregnant women who are most at risk for developing severe diseases. In Asian countries, significant achievements in malaria control have been noted during the ten past years in majority of malaria endemic countries. In countries where successful malaria control interventions have been set up, the environment is still favourable for malaria transmission. This makes them persistently under threat of malaria epidemics since the level of immunity against the disease cannot be maintained unless exposure and man-vector contact are frequent and regular.

Since malaria transmission does not occur in the highlands, and in arid and desert fringe zones, this ecological situation puts all inhabitants at risk of developing severe malaria diseases in cases of epidemic outbreaks or when they are travelling in malaria endemic zones. In Africa, about 20% of the population (all age groups) is not immune against the malaria parasite. Unacceptably acute high mortality rates are being noted during epidemics when they are not immediately detected and controlled. It has recently been the case in Southern and Eastern African countries making malaria as a top political concern.

Precipitating factors of malaria epidemics

Factors which may cause an "unexpected" increase in transmission are numerous. They operate mainly by modifying the environment thereby increasing the capacity of the vectors to transmit the malaria parasite from one person to another. They can be classified into two large groups: man-made and natural. Many factors, operating alone or together, are linked to human activities resulting in changes or modifications of the environment which are generally expected. In contrast, climatic variations, natural disasters, and other disturbances can lead to unexpected environmental modifications.

These may be accompanied by (large scale) population movements. In this context, there has been a resurgence of malaria epidemics, for example during a civil war

when degradation of curative health services, deficient surveillance within the control services and absence of control measures develop.

Malaria epidemic prevention and control: current situation in areas prone for malaria epidemics.

In countries that have not developed and/or have yet to maintain a good surveillance system, as well as appropriate control measures, malaria epidemics are not detected quickly and control measures when taken, are implemented too late with minimal co-ordination and expertise, usually under political pressure. As a theoretical model, figure 1 shows a graph with a sudden increase of morbidity/mortality malaria cases on a monthly basis. Expensive control measures can be taken when malaria cases and deaths are around the epidemic peak as indicated by the arrow in figure 2. Control measures when decided too late, lead to a marginal benefit in terms of morbidity and mortality reduction (yellow surface). In terms of deaths and morbidity cases averted, as well as for budget considerations, such late decisions are definitely not cost-effective approach for controlling malaria epidemics.

How improving the prevention and control of malaria epidemics ?

Early detection of epidemics based on epidemiological data routinely collected

A timely detection of the occurrence of cases of an illness in a community or region, which is above the normal expectancy level is one vital step to make health authorities and policy-makers aware of the serious and immediate threat before them and to decide urgent and effective control measures. Usually, an early detection system is based on malaria data recorded on a monthly or weekly basis within the health care facilities which are supposed to diagnose malaria and deliver effective treatment. If the surveillance system, laboratory procedures, data analysis, reporting and notification, are well established, control measures can be taken immediately but inevitably with some delay after the onset of the epidemic. As an example, figure 3 shows the expected benefit (in yellow) in terms of morbidity/mortality reduction if such unique approach is efficiently used in the field within the health care system.

• Early warning system based on meteorological data

Meteorological data such as rainfall and temperature, which have a direct impact on breeding sites suitable for malaria mosquitoes, as well as on the development of the malaria parasites in mosquitoes, are currently collected in all endemic countries but not used by health authorities for various reasons. Through numerous experiences from past malaria epidemics, it is obvious that meteorological data, when routinely collected and analysed in specific locations, can provide a warning signal in predicting malaria epidemics. Unusual climatic events such as heavy rainfall after an unusually dry period in arid zones, or unexpected higher temperature and/or humidity

according to certain altitudes appear to be the prominent cause in many epidemics. Such warning system which needs a good collaboration between the meteorological services and control programmes located within the Ministry of Health, can predict an epidemic from 1 to 2 months in advance allowing health district staff to be better prepared to detect and control the epidemic at its earliest stage.

Long range forecasting

Long-range forecasting data are expected to provide health authorities with warning at national or regional scale with longer time lag (from 2 to 6 months) than meteorological data mentioned above. Depending on regions and variables used, probabilistic seasonal predictions are not yet reliable and cannot predict with reasonable accuracy on future conditions suitable for malaria epidemics except highly accurate rainfall predictions based on the El Nino/Southern Oscillation. Long-term predictions could provide a very early warning (3-6 months in advance) to regional and national authorities. It makes them aware of the potential threat to give them sufficient time to strengthen their early warning and detection systems, as well as to establish emergency stocks for control measures. If a high probability level of long-range forecasting is reached, together with early warning data, preventive control measures could be decided and implemented before the expected onset of the epidemic. If inaccurate or unreliable long-range forecasting data are used, it is obvious that such expensive preventive measures cannot be recommended to national authorities.

Building up an integrated monitoring system including the above-mentioned three elements.

All warning options described above (early detection, early warning and forecasting) can be put together in order to set up a comprehensive epidemic warning system including the use of accurate indicators at various levels (sub-regional, national, province, district and commune levels) (see figure 5). Each component, particularly forecasting and early warning indicators, is expected to reinforce the capacity of district health officers to quickly prepare drugs, supplies and other equipment needed for control, as well as to recognise at an early stage the occurrence of a malaria epidemic. It will eventually allow local authorities and communities to better cope with cost-effective, preventive and control options in a timely manner.

The Technical Resource Network (TRN) on malaria epidemic prevention and control within the WHO Roll Back Malaria project

The Roll Back Malaria (RBM) project, which was initiated by Dr G.H. Brundtland, upon assuming her post as WHO Director-General focuses on the reduction of poverty by decreasing the malaria burden in Africa where more than 90% of malaria mortality and morbidity cases occur. In order to better and quickly respond to various challenges in malaria control, the RBM project initiated 9 Technical Resource Networks with the goal of providing to countries cost-effective and comprehensive

control options / tools to fight malaria within the ongoing health sector reform, in collaboration with other government sectors and national / external partners.

One of the networks focuses on the prevention and control of malaria epidemics with the following terms of reference (in summary):

- (1) Development of methodologies (methods / options) and support to epidemic-prone countries: (i) for forecasting and prevention, and (ii) for early detection and control of malaria epidemics;
- (2) Development of regional, sub-regional or country strategies for epidemic preparedness and emergency action.

The first TRN meeting on malaria prevention and control took place in Geneva in November 1998 with participants from all the continents. Three major recommendations came out of the meeting : (1) need to better document previous epidemics where basic information is available in order to obtain background information to produce practical guidelines ; (2) through research activities, need to explore and validate forecasting and warning indicators / tools to prevent and better control malaria epidemics timely ; (3) need to establish and maintain at inter-regional levels emergency stocks of effective drugs, materials, insecticides and equipment as part of regional preparedness plans of action. Details are in the first report of the meeting.

On-going activities within the TRN are listed below:

Retrospective analysis of previous malaria epidemics in 7 countries: Ethiopia, Kenya, Mali, Rwanda, Senegal, Uganda and Zimbabwe. A guideline on malaria epidemic prevention and control is expected to be developed and disseminated according to the various country experiences,

Support for research activities focusing on the validation of forecasting, early warning and early detection indicators in Kenya, Tanzania, Uganda, and Southern African countries,

A regional technical network has been recently set up in New Delhi for Asian countries focusing on analysis of previous experiences in malaria epidemic prevention and control and on establishment of accurate forecasting indicators.

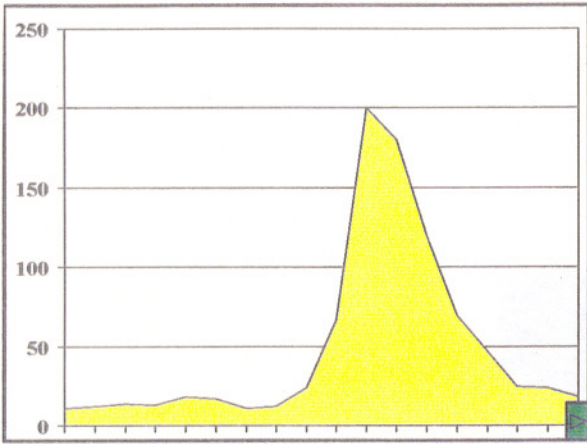


Fig 1. Example of a malaria epidemic suddenly occurring. Number of cases or deaths (x axis) are increasing 10 fold in 3 months time compared to "normal" baseline data by months (y axis).

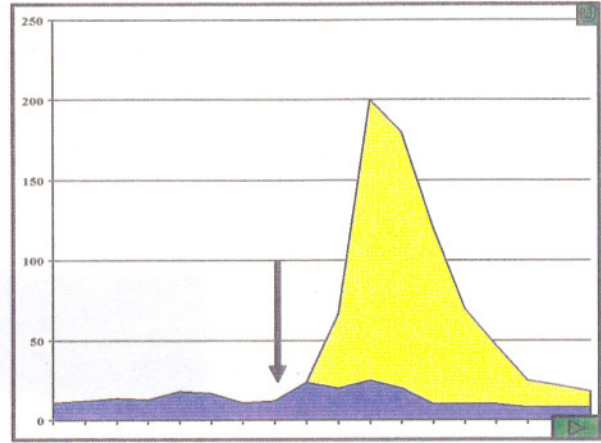


Fig 4. Thanks to better awareness of local health authorities and communities. Control measures are taken at early stage minimizing occurrence of deaths and severe malaria cases.

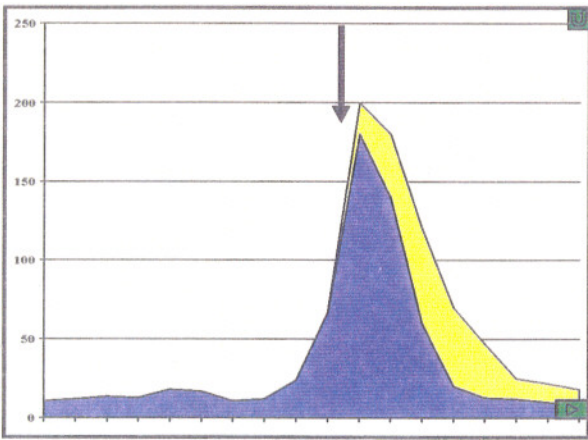


Fig 2. Expensive control measures are decided and implemented too late around the epidemic peak making benefit marginal (yellow surface) in terms of lives saved and deaths averted.

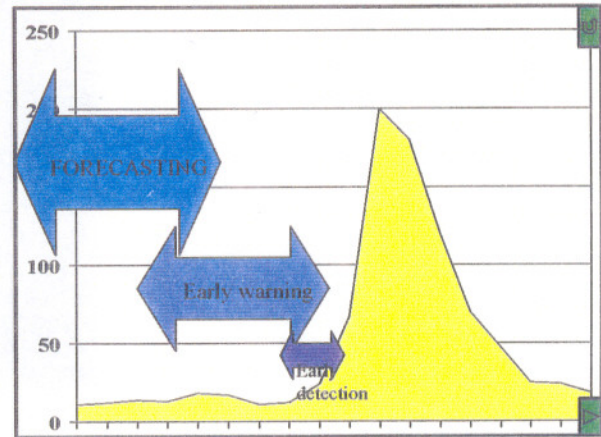


Fig 5. Building a cost-effective monitoring system including forecasting, early warning and early detection systems leads to (i) either very early recognition of the emergency and immediate control measures or (ii) leads to the implementation of preventive control measures before epidemic starts. The last option is strongly correlated to the accuracy (probability above 90% ?) of the integrated forecasting system in place to predict epidemics.

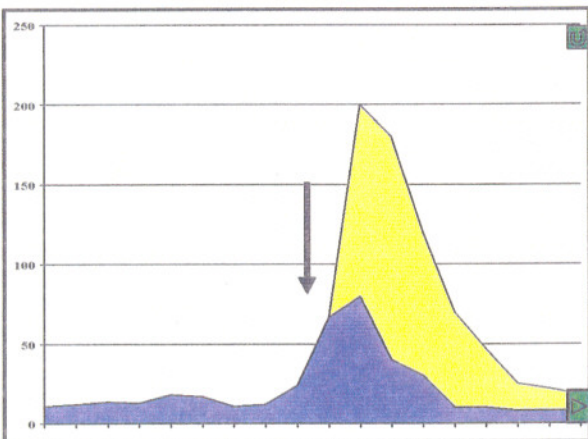


Fig 3. Malaria epidemic is detected and notified with control measures taken with some delay in implementation. There is recognised benefit in terms of lives saves and deaths averted.