Development of systems for early detection, early warning and control of malaria outbreaks in Iran

Assignment report

15-20 October 2007

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Contents

Executive summary

1. Although standard guidelines for MEWS implementation exist, appropriate design of specific surveillance and prediction systems will vary between countries and epidemic-prone areas. Development and implementation of MEWS should, where possible, build on current approaches to malaria surveillance and incorporate existing approaches to communication and data dissemination. New models, algorithms, thresholds need to be screened, selectively applied and adapted to specific country situations through an interactive research and practice approach. Work under the current STC represents an early step in this process.

2. In practice, an epidemic early detection system already exists in Iran. Malaria surveillance are fully integrated into the primary health care system and provide timely, specific and accurate data to decision-makers at district-level. Evidence from the field suggests that such warnings are being translated rapidly into response measures – and certainly it appears that general WHO targets for rates of epidemic detection and response are being met. There is, however, scope for greater efficiency in the way surveillance data are managed – and also for improvements in the organization of response activities. In addition there is a need to incorporate objective, threshold-based early detection tools into existing data management systems at the level of the District Health Centre. Recommendations concerning the development and implementation of new early detection tools are included in this report.

3. It is not yet clear whether any added benefit (in terms of providing earlier warnings) can be achieved through modelling malaria case data in combination with climate data. More research is needed to evaluate climate-based models using retrospective malaria time series. If viable, early warning models should inform the planning of preventive measures but are unlikely to change current modes of epidemic response.

4. In future there will be an increasing need to coordinate scientific and operational research on MEWS in Iran. Recommendations regarding an appropriate research agenda and mechanisms for coordination at national level are included in this report.

1 MEWS implementation: generic issues

Malaria epidemics can result from a wide variety of determinants over a range of transmission settings. Universal methods for defining, detecting and predicting epidemics are difficult to apply because characteristics of epidemic events can vary greatly. Consequently there is no 'one size fits all' solution either to malaria surveillance or to MEWS development. Needs differ between countries, not only because of varying biophysical conditions, but also as a result of social, economic and political factors. Different surveillance/MEWS solutions will be appropriate for different countries – and possibly for different areas within one country. Best practices therefore need to be screened, selectively applied and adapted to specific country situations through an interactive research and practice approach[1]. Work under the current STC represents an early step in this process.

Appropriate MEWS design is determined by a number of factors, including patterns of malaria transmission in time and space, likely principal determinants of epidemics, overall epidemic-related disease burden, existing modes of malaria surveillance and associated institutional relationships, wider health system organization and availability of human and other resources.

MEWS detect aberrations in malaria-surveillance data and/or predict increases in malaria transmission on the basis of prevailing environmental conditions. They have been advocated chiefly as a means of maximizing the amount of lead time during which decision makers can plan and implement malaria control activities[2]. The standard blueprint for MEWS includes elements of early detection of epidemics (case surveillance), early warning (typically based on monitoring meteorological conditions) and long-range forecasting using seasonal climate forecasts. These elements are separate but complementary. Based on different data inputs, their outputs differ in terms of temporal and spatial specificity, lead times and inherent degrees of uncertainty. These elements also represent different types of technical challenge.

From a programmatic point of view, it is important that individual MEWS components be implemented incrementally and in an appropriate order of priority. Specifically, it is generally recommended that an effective early detection system, based on case surveillance, is in place before more complex (and necessarily exploratory) work on the application of predictive models of transmission is carried out. In this respect it is important to recognise that, provided a well-conceived epidemic preparedness plan is in place to translate outputs from an early detection system into pre-defined disease control responses, it is possible to significantly reduce epidemic-related morbidity even in the absence of early warning information. The extent to which the reductions in epidemic burden brought about by early detection systems can be further improved through predictive modelling of malaria transmission (early warning and disease forecasting) is unclear, and relevant evidence in the scientific literature is scarce.

Early detection systems are essentially specialized forms of disease surveillance that ensure timely delivery of spatially- and temporally-specific data for epidemic-prone areas. In certain instances routine modes of surveillance may be appropriate for purposes of epidemic early warning, but this is rarely the case. More commonly

certain changes need to be made to standard modes of malaria surveillance in epidemic-prone areas, or, where existing surveillance systems are weak, new, specialized systems operating in parallel with routine information systems may be required. However, wherever possible new systems should build on existing structures and processes in the health system.

2 Assignment objectives and main activities

There is a strong demand for MEWS tools within Iran at various levels of the health system, and a limited amount of scientific and operational research has already been carried out. The purpose of the current assignment is to guide the continuing process of MEWS development by:

1. Assessing current national data/information systems (relevance of indicators, quality, frequency and completeness of data, *etc.*);
2. Evaluating the suitability of current modes of disease surveillance and response for epidemic early detection and control;
3. Providing recommendations on future national MEWS strategy and an incremental plan of future activities

Ideally this process would include an analysis of epidemiological patterns and risk indicators in representative settings. Given the limited duration of the current assignment, this was not feasible; however, extensive analysis of historical malaria datasets will be required before appropriate MEWS systems can be advocated (see Recommendations).

To achieve the assignment objectives meetings with key informants were held in Tehran and in Chabahar District, Sistan and Baluchistan Province, in order to obtain relevant information on:

1. General temporal and spatial patterns of malaria transmission and associated morbidity/mortality, plus insights on epidemic determinants;
2. Detailed information on existing modes of malaria surveillance, epidemic detection and response (particularly with respect to the range of current reporting systems and their objectives, organizational procedures, infrastructure, communication, data analysis and interpretation);
3. Information on current prevention and control measures, including evidence of speed of response and loci of decision-making.

Given the highly decentralized nature of malaria surveillance and response, the main focus of this report is on surveillance and prevention/control activities at the district level. An assignment itinerary and list of persons consulted are included in the appendices of this report.

3 Current organization of malaria surveillance activities

Malaria surveillance is fully integrated within the national primary health care (PHC) system. Nationally, PHC is delivered at the most peripheral level through a network of Heath Houses (n=16,278) in rural areas and Health Posts (n=1,176) in urban areas. These are supported by Rural Health Centres (RHC; n=2,361) and Urban Health

Centres (UHC; n=2,261) and by District Health Centres (DHC) and District Hospitals. At the provincial level, Provincial Health Centres and Universities of Medical Science provide medical education and direct supervision and support to district-level staff.

In Chalabar the DHC supports 11 RHC, 4 UHC and 68 Health Houses. It also has close operational links with the Chabahar General District Hospital (Iman Ali Hospital). In Chabahar District visits were made to two Health Houses, two RHC and one UHC, in addition to the DHC and District Hospital. In each case key informants were interviewed about surveillance activities and routine procedures. Summarized findings are presented here.

3.1 Health houses

Health houses represent the most peripheral level of the Iranian health system and the first point of contact with formal health services for the rural population. In principle they are staffed by male and female *behvarz* – with the male staff member taking responsibility for malaria-related activities (case finding, treatment and larval source control). Two health houses were visited during our field visit to Chabahar District and in each case the male *behvarz* was interviewed.

Dambedaf Health House serves its own village plus four satellite villages (total population ~1500 in 230 households). The male *behvarz* routinely carries out active case finding in each of the five catchment villages twice a month. These visits follow a predefined schedule and are recorded on printed forms. The frequency of village visits increases to once per week following the detection of malaria cases – and potentially up to every second day once an outbreak has been detected. During village visits the *behvarz* prepares blood films for all suspected malaria cases, as well as for possible treatment failures and, where appropriate, as a means of assessing potential foci of infection after a malaria case has been confirmed. The *behvarz* completes, *in situ*, a printed form including basic data on name, age, sex, and nationality – as well as the type of case finding carried out (suspected case, monitoring of drug efficacy, or follow up of potential foci). One copy of this form is then delivered, together with the blood slides to the closest RHC. Slides are read and results provided to the *behvarz*, who then traces parasite-positive cases for treatment. Travel is by motorbike (the farthest satellite village is 8 km from the health house; the RHC is 15 km away). In most circumstances this whole process is carried out within a single day.

In addition to case finding, the male *behvarz* is also responsible for larval control in the catchment villages. During active case detection larvicide (BTi) is administered to suspected breeding sites and larvivorous fish introduced to larger water sources. All activities are logged. RHC staff visit Health Houses weekly for supervision purposes and DHC staff visit on an *ad hoc* basis. Each month Health Houses also receive summary feedback including aggregated case numbers for all Health Houses in the RHC catchment and comments on their performance.

Baluchi Health House serves a smaller catchment (3 villages; roughly 750 people in 126 households). Few patients present directly to the Health House, but it seems common for persons to call by telephone and request the *behvarz* to visit them in order to diagnose for malaria. Active case finding is carried out in each village every 10 days rather than twice a month (which is seen as a minimum frequency for visits –

RHCs are free to set their own visiting schedules within this). In other ways all operational aspects are the same as at Dambedaf Health House.

3.2 Rural Health Centres

Health Houses are supported by RHCs staffed by technicians and administrative personnel working under at least one physician. There is a dedicated member of staff responsible for malaria follow-up and treatment ('malaria focal person'). We were able to visit two RHCs during our visit to Chabahar. Kambel Solaiman RHC has a total catchment population of around 6,000 (~1,200 households; 35 villages) and services four health houses. Patients presenting with symptoms of malaria are sent to the RHC malaria laboratory, where a blood smear is prepared and key data on patient name, father's name, age, sex, nationality, address and date of onset of illness are entered in the lab register. Daily reports are made to the DHC by telephone, providing basic information on any parasite-positive patients. If data have been received from health houses, these are reported during the same call, but separately. At Kambel Solaiman RHC a telephone report is provided even if no positives are recorded, but this is probably not typical. The RHC is also required to compile monthly data using three different forms, which are then sent to the DHC by post or courier (one copy is also kept at the RHC for 5 years). The RHC does not receive any routine feedback from the DHC apart from specific information relating to quality control of slide reading. It appears that during monthly supervision meetings DHC staff do present summarized data and graphs and provide an overview of transmission patterns elsewhere in the district – but it is not clear whether this is required under standard policy. In addition, the RHC can expect to be informed by telegram of any serious ongoing outbreaks occurring in neighbouring areas.

RHCs are responsible for carrying out vector control activities in their catchments following the detection of an outbreak. Staff at Kambel Solaiman RHC could not recall having to carry out vector control activities, but at the larger Nobandian RHC (catchment population ~12,000; 11 Health Houses), four such instances have occurred over the past two years. When asked how these outbreaks were detected and which indicator was used to gauge the need to respond, the answer here (and elsewhere) was that staff followed their own 'general sense', rather than any set threshold. In the most recent outbreak, for example, the occurrence of three autochthonous cases in a single household was enough to trigger direct intervention (in other instances intervention might follow the detection of *P. falciparum* gametocytes or the occurrence of more than one case of *P. falciparum* in a village). Once an outbreak is detected, both RHCs reported that their first actions are to inform staff at the DHC and to instigate more intensive case finding. Any subsequent intervention is on the advice of the DHC. In principle, stocks of insecticide and spray equipment should be held by RHCs but neither of the RHCs visited had its own supply of insecticide. During a recent malaria outbreak in the Nobandian RHC catchment it turned out that only two of the four sets of spray equipment were functional. Extra spraying equipment had to be requested from a nearby RHC at Polon, while equipment for thermal fogging was supplied by the DHC. According to RHC staff, thermal fogging was initiated within a day of the outbreak being declared. They could not remember at what point IRS operations began, but estimated that spraying of the immediate area was completed within two weeks. Significantly, all cases in this outbreak were detected by active case finding. Interestingly, at Nobandian RHC larval control was

mentioned as a routine response to outbreaks – but this was not mentioned in Kambel Solaiman RHC. It is not clear whether explicit national guidelines exist in this area.

3.3 Urban Health Centres

One UHC (UHC #3; catchment population ~22,000) in Chabahar City was visited during our field trip. Patients are referred to the UHC's malaria lab by the resident physician, or may present directly at the lab itself. Patients may also be referred by private practitioners (who do not have access to antimalarial drugs). The UHC lab register is the same as that of the RHC and contains information of patient name, father's name, age, sex, nationality, address and date of onset of illness. Cases are reported daily to the DHC by telephone and monthly using three official forms, as for RHCs.

The malaria focal person at the RHC reported that all malaria cases are followed-up by RHC personnel in order to check for potential foci of transmission. When an outbreak is discovered, the DHC is informed immediately and vector control (thermal fogging and IRS) and community sensitization activities were initiated. This is coordinated by UHC staff but with the support of DHC in terms of supervision and provision of insecticide and equipment. The last such outbreak appears to have occurred in 2005. Intervention occurred within about two days of detection and the total number of cases reported was ~10.

When asked about the threshold used for declaring an outbreak, the response was again that 'general sense' was used, based on a good knowledge of expected patterns of transmission in the local area. However, this UHC, in common with other UHCs and RDCs in the province is trialling a new system to provide an objective measure of epidemic status based on ongoing research at Zahedan University of Medical Sciences. The system is based on a modified c-sum algorithm, in which case numbers from the most recent week are compared to an historical average of the same week plus the two previous weeks, and also to case numbers in the preceding two weeks of the current year. The week is given a letter to describe epidemic status (A1-D2, depending on whether case loads based on previous weeks and/or the historical profile have been exceeded). This is a useful exercise but is seriously undermined by the fact that currently only one year of historical data is used as a baseline (the standard approach is to use data from the preceding five years, but it has been questioned whether even this is sufficient to provide an adequate baseline[3]). This tool is clearly at an evaluation stage, but it is unclear why it has been implemented in all RHCs and UHCs. It would have been more appropriate to pilot the scheme in a limited number of facilities in the first instance. Moreover, it would have been advisable to test the algorithm on a time series of collated historical data before the instrument was introduced in the field. At each health facility 'expected' case numbers have to be calculated by hand – and in terms of workload this is not a trivial undertaking. It is doubtful whether currently this is an effective use of time for staff at UHC and RHC level.

3.4 District Health Centres

DHCs are responsible for planning and implementation of malaria control activities and associated monitoring and evaluation at district level and specific staff members

have responsibility for malaria activities and entomological surveys. The DHC in Chabahar oversees activities in 11 RHCs, 5 UHCs and 68 Health Houses in a total catchment of around 200,000 people. The DHC receives daily reports of malaria cases by telephone from RHCs and UHCs and data are logged using a special form. If reports are not received by 10 am the following day, DHC staff follow up by telephone. Daily data are entered on computer using Microsoft Excel and summaries are sent to the PHC twice a week by fax. The summary form, includes columns showing cumulative case numbers at the same time point in the previous two years – and these are screened in a basic way to detect anomalies in case numbers. Unfortunately these columns are not generated automatically by the system, and have to be computed separately.

Staff at Chabahar DHC have recently been manipulating their data in Microsoft Access and have developed a system in which weekly data can be displayed against epidemic thresholds (currently mean plus two standard deviations, based on six years of historical data). Cases can also be mapped according to areal unit using EpiMap 2002. However, these analyses are only done once a month, and the extent to which they have so far informed malaria control activities is not clear. A basic problem with the system is that case data need to be entered manually into the system (rather than being uploaded automatically from the Excel spreadsheets), and this is time consuming. There is therefore a clear and urgent need to harmonize data entry and analysis systems at the DHC to allow for efficient data management and timely interpretation. As part of this system, potential areas of redundancy among the three monthly forms reported by RHCs and UHCs, and between the daily and monthly reporting systems, should be assessed.

The DHC is responsible for fortnightly entomological monitoring of vector adult and larvae populations at six villages (four fixed, two changing annually). It appears that the main purpose of this work is to evaluate sensitivity of vectors to insecticides, although entomological and meteorological results are compared with data from previous years in order to gauge relative changes in abundance. In principle results also inform the timings of IRS rounds in targeted villages. The number of villages sprayed each year depends on case loads experienced in the previous year and resource availability. In 2007, for example, relatively few villages (90) were targeted for IRS based on relatively low levels of malaria transmission in 2006.

3.5 District hospitals
A visit was made to Chabahar General District Hospital (Iman Ali Hospital). From March 2007 it appears that only 26 patients have presented with malaria – of which 11 cases were admitted, and four were considered severe. Patients may come directly to the hospital or, more commonly, are referred from other facilities. Data management is similar to that at UHCs.

4 Advantages and disadvantages of the current surveillance system for early warning
The following discussion is based on observed activities during the current visit to selected health facilities in Chabahar District. The degree to which these observations can be generalized to national level depends on the extent to which the situation in

Chabahar, and in the health facilities visited, can be seen as representative of the wider epidemic-prone region of Iran.

4.1 System strengths

Comprehensiveness: a major advantage of the current surveillance system is that it represents a comprehensive system incorporating data from all Health Houses, DHCs and UHCs in the district. In other countries sentinel systems have been proposed, based on the dual premise that (a) the health system is not able to support 'intensive' surveillance at all health facilities; and (b) a system based on a small number of representative sites is sufficient to monitor large scale epidemic events. In Iran, however, comprehensive coverage of early detection activities can be justified given the nature of current surveillance arrangements and the relative importance of small, isolated outbreaks within individual villages.

Organization: the current surveillance system is extremely well organized and managed. Roles and responsibilities of different stakeholders are clearly defined, as are backup procedures (for example in situations where the primary male *behvarz* is absent from the Health House). There appear to be very few problems in terms of data dissemination and communication.

Active case detection: the use of frequent case finding to identify malaria cases in the community and screen for potential foci of transmission is a major strength of the current system and is integral to outbreak detection and response. At the district level active case finding currently accounts for around 45% of cases reported.

Local epidemiological understanding: the effectiveness of the current surveillance system relies to a large extent on district and Health House staff having a detailed understanding of expected patterns of malaria transmission in their areas. This is an advantage over objective, threshold-based systems because it means that response to an outbreak can be prompted by very low numbers of new cases and can take into account additional information, such as the occurrence of multiple cases in one household.

Decentralized decision-making and resources for response: timely and effective response to outbreaks is facilitated by decentralised (district level) decision-making in terms of identifying and responding to outbreaks. Any new tools developed in this area should be targeted at district level.

Adequate resources: at present the surveillance system appears to be well-resourced in terms of human capacity. Communication does not seem to be a significant problem – particularly in view of availability of motorbikes at Health Houses and the apparently universal availability of reliable telephone links.

4.2 Weaknesses and potential issues

Data management and interpretation: it is likely that there is some duplication of effort and redundancy of data in the current system. For example, each month RHCs and UHCs have to fill out three separate summary forms for their malaria data, but it is unclear whether this effort is justified. At the DHC, data entry, analysis and interpretation are not well coordinated and better synergies between these activities

could be achieved through unified systems for data management. Such a system should incorporate, at DHC level, a means of summarizing data on a weekly basis and providing automatically an assessment of epidemic status based on validated thresholds (see below).

Outbreak detection and response: currently, declaration of outbreaks is subjective and relies on excellent knowledge of expected patterns of malaria transmission on the part of *behvarz* and staff at RHCs, UHCs and DHCs. This system is currently highly effective, but there is a clear need (and demand) for objective, threshold-based systems for outbreak detection to back-up current modes of surveillance. Additionally there presently appears to be some lack of clarity at district level regarding areas of responsibility for outbreak response. In particular the roles of UHCs/RHCs and the DHC seem to vary. Specific problems with availability of equipment were reported.

It is worth noting that commentators have generally been sceptical about the effectiveness of thermal fogging in epidemic situations[4] and, indeed, one WHO document includes a statement that 'there is no evidence to support the use of ULV space spraying (fogging) as a means of epidemic prevention and control'[5]. However, in southern Iran there is evidence that thermal fogging is effective as a means of reducing case numbers through its impact on adult vector abundance. Where possible, this evidence should be documented.

Planning of preventive IRS: although there appears to be a good system in place for the spatial targeting of IRS, decisions regarding the number of villages to be sprayed each year, and their locations, are based on a retrospective review of malaria transmission in the previous year. Clearly, in future, it would be preferable if decisions of this type could incorporate early warning information. There may also be scope for adjusting the design of current entomological surveys to include a greater number of monitoring sites at specific points in the transmission season.

Reliance on behvarz : a potential issue within the current system is its dependence on a small number of key individuals at the peripheral level to generate and interpret surveillance data. This system depends on diligent, conscientious and highly motivated staff – however, recently questions have been raised about motivation and levels of job satisfaction among *behvarz* in Iran [6]. Although it was difficult to get a measure of job satisfaction during the field visit to Chabahar, one RHC staff member did concede that the performance of *behvarz* varies 'according to personality' – and this potentially has important implications for malaria detection activities. In East Africa the motivation of peripheral staff has been improved by increased levels of supervision by (and hence interaction with) district level staff and by the provision of regular feedback regarding trends in malaria cases in their areas and beyond, occurrence of outbreaks in nearby areas, *etc.* In Iran, the level of supervisory support to *behvarz* provided by RHCs appears to be good, but there may be scope for increasing the amount of feedback provided to them. Currently they only receive a monthly tally of their own data, but this is not particularly helpful in terms of motivation and esteem, nor does it provide any evidence to Health House workers of the importance of the data they collect. As one respondent put it: '*behvarz* 'do the job, but don't know why they do it'.

5 Recommendations

Enhancing current surveillance and response activities

1. New data management tools need to be developed and implemented at DHC level. In the short term these should simplify and make more efficient the process of data entry, collation, analysis and interpretation. In the medium term such a system should incorporate early detection algorithms/thresholds as appropriate (see below).

2. Future guidelines need to make more explicit the roles and responsibilities of DHCs and RHC/UHCs in response to outbreaks. Ideally, DHCs should take central coordinating roles for epidemic detection and response and should manage a central supply of drugs, insecticides/larvicides and spray and fogging equipment.

3. Current mechanisms for providing feedback to Health House personnel should be reviewed, with a view to providing more detailed information to *behvarz*. Any existing informal arrangements should be encouraged.

Developing and implementation of early detection thresholds

4. More research is required in order to develop appropriate, fully validated algorithms for detecting outbreaks over a range of epidemic-prone localities in Iran. The aim should be to develop tools that allow DHCs to monitor temporal changes in malaria case numbers at RHCs and UHCs on a weekly basis. Research should use long time series (ideally > 10 years) to assess the relative performance of published early detection methods (Cullen, WHO, c-sum *etc*.) against recognised epidemic years. This exercise should assess a number of methodological considerations including: the relative benefits of untransformed and transformed case numbers; the need for de-trended time series; the impact of varying the length of data record used to define the historical baseline; the impact of removing or retaining known outbreaks in the historical baseline; the use of passive case detection data versus active and passive data combined; the use of alternative indicators, including slide positivity rate.

5. This research should be based on retrospective datasets. The status of ongoing prospective studies on thresholds should be reviewed.

6. Recommended thresholds should be piloted as part of new data management tools within selected DHCs before wide scale implementation can be recommended. The process of piloting should incorporate monitoring of basic process indicators (*e.g.* relating to timeliness of data analysis) and work loads at DHCs. The impact of new epidemic detection methods on decision-making and epidemic response also needs to be carefully observed and documented.

Developing early warning models

7. Parallel research efforts are required to assess the potential utility of predictive models for early warning and for guiding preventive activities. Modelling should be based on the same time series of malaria used for evaluating early detection thresholds. A variety of datasets should be screened as covariates, including ground-based meteorological data, remote sensing-derived rainfall data (*e.g.* CMORPH: http://www.cpc.ncep.noaa.gov/products/janowiak/cmorph_description.html)

and seasonal climate predictions. Model assessment should ideally be based on ability to predict the relative scale of cases (*e.g.* quartiles), rather than absolute numbers (see, for example, refs [7, 8]). Where appropriate, such work should build on previous work on predictive modelling in Iran (*e.g.* refs [9, 10]).

Management of scientific and operational MEWS research

8. There is a need to constitute a national steering group to agree a research agenda for MEWS in Iran, to coordinate all scientific and operational activities, to oversee implementation of early detection and early warning activities and to monitor uptake and performance across all epidemic-prone districts. A national focus person, preferably within the Disease Management Centre of the Ministry of health, should have responsibility for coordinating such a group.

6 Suggested plan of action

Activity	Period	Responsible partner
1. Identify national management team and clarify responsibilities; assign national coordinator; assess ongoing MEWS research activities	Nov. 2007 – Jan. 2008 (3 months)	Director General, Disease Management Centre
2. Review current data management procedures at district level; draft implementation plan for modified system; circulate to stakeholders; conduct workshop with stakeholders and local experts to finalize	Nov. 2007 – Apr. 2008 (6 months)	Malaria Control Programme (DMC)
3. Carry out research to validate candidate algorithms for epidemic early detection	Nov. 2007 – Apr. 2008 (6 months)	Malaria Control Programme (DMC); Kerman University of Medical Sciences
4. Phased piloting and introduction of suitable early detection algorithms and monitoring of impact on health system and management of epidemics	May 2008 – May 2009 (12 months)	Malaria Control Programme (DMC); participating PHCs and DHCs
5. Define terms of reference for future research on predictive modelling for epidemic early warning; identify suitable financial support and collaborating partners	Nov. 2007 – Apr. 2008 (6 months)	Malaria Control Programme (DMC); Kerman University of Medical Sciences (advisory role)
6 .Carry out modelling work using appropriate historical datasets for malaria and environmental covariates	May 2008 – May 2010 (24 months)	To be determined

7 Conclusion

Unlike in many epidemic-prone regions of the world, existing malaria surveillance activities in Iran provide timely, specific and accurate data to decision-makers at district-level. Evidence from the field suggests that such warnings can be translated very quickly into response measures because of efficient communication and the availability of insecticide, spray pumps and other equipment at the district level. Under existing modes of surveillance and outbreak management it therefore appears possible that epidemic control interventions can be delivered within days of the index case of an outbreak being identified. Current arrangements are certainly consistent with WHO policy, which incorporates targets for epidemic detection indicating that 60% of malaria epidemics should be detected within two weeks of onset and 60% responded to within two weeks of detection[11].

At present, quick and effective response to epidemic relies on rigorous and frequent active case detection combined with a detailed knowledge of expected transmission patterns in time and space on the part of local health staff. In some ways it is difficult to envisage how the current system could be made any more effective, either through major modifications to the early detection system or through the provision of extra 'layers' of early warning system from climate data or seasonal forecasts. The recommendations of this report therefore point towards relatively minor changes to existing practices, as well research into new tools (data management tools incorporating early detection thresholds, predictive models based on climatic data) that support, rather than replace current operations.

Appendix 1: STC terms of reference provided by WHO/EMRO

1. Assist the national control programme in development of early detection, early warning and control of malaria outbreaks;
2. Hold an orientation session with malaria control staff on ED and EWS plan
3. Submit to WR/Iran at the end of the assignment during debriefing, an assignment report in English in hard copy and in electronic in MS Word along with an Executive Action Document comprising an executive summary, recommendations and plan of action.

Appendix 2: persons met/consulted

CDC, MOH&ME, National Malaria Control Programme, Tehran
Dr Gouya; Director General, Centre for Disease Management
Dr Esteghamati; Deputy for Communicable Disease
Dr Raeisi; National Program Manager for Malaria Control
Dr Ranjbar; Senior Malaria Officer
Mrs Faraji; Malaria Officer

Dr Ali-Akbar Haghdoost, Kerman University of Medical Sciences

Tehran University of Medical Sciences
Prof Mesdaghinia; Dean, School of Public Health
Prof Malekafzali; Professor of Biostatistics, School of Public Health
Prof Edrissian; Professor of Parasitology of Public Health (retired)
Dr Vatandoost; Associate Professor of Entomology, School of Public Health
Dr Nateghpour; Associate Professor of Parasitology, School of Public Health
Dr Ardalan; Assistant Professor of Epidemiology, School of Public Health
Dr Basseri; Assistant Professor of Entomology, School of Public Health

In Chabahar
Mr. Seidak Hoot; *behvarz*, Dambedaf Health House
Mr. Abdolmaged Badpa; *behvarz*, Baloochinobandian Health House
Mr. Mohammad Reza Sarani; Kambel Soleiman Health Center
Mr. Vahedbakhsh Divakee; microscopist, Kambel Soleiman Health Center
Mr. Abdolshakoor Sarani; Nobandian Health Center
Dr. Bahman Jalili; physician, Nobandian Health Center
Mr. Mohammad Hassan Azadi; microscopist, Nobandian Health Center
Mr. Emambakhsh Saberi; Urban Health Centre #3
Mr. Shir Mohammad Jadgal; microscopist, Urban Health Centre #3
Dr. Sheikh Zadeh; Disease Control Department Manager, Sistan and Baluchistan Province
Mr. Hasanzahi; Malaria Vector Control and Entomology, Sistan and Baluchistan Province
Mr. Sakeni; Malaria Focal Point, Sistan and Baluchistan Province
Dr Zanganeh; DHC Manager, Chabahar District
Dr Ebrahim Zadeh; Deputy for Health Affairs, Chabahar District
Dr Mehdi Zadeh; Disease Control Department, Chabahar District
Mr Gorgiz; Malaria Focal Point, Chabahar District
Dr Izadi; Epidemiologist, Zahedan University of Medical Sciences
Dr Shafaroudi, Manager, Chabahar General District Hospital

Appendix 3: STC assignment timetable

Monday 15 October
Consultation with Malaria Control Programme staff, Tehran
Consultation with faculty members, Tehran University of Medical Sciences (School of Public Health/Institute of Public Health Research)

Tuesday 16 October
Travel to Chabahar
Visit to District Health Centre, Chabahar City: consultation with health staff at district and provincial level (Sistan and Baluchistan) and faculty from ??
Visit to Dambedaf Health House, Chabahar District
Visit to Urban Health Centre #3, Chabahar City
Visit to International University, Chabahar Free Zone

Wednesday 17 October
Visit to Kambel Sulaiman Rural Health Centre, Chabahar District
Visit to Nobandian Rural Health Centre, Chabahar District
Visit to Baluchi Health House, Chabahar District
Visit to District Health Centre, Chabahar City: further consultation with DHC and PHC staff

Thursday 18 October
Visit to Chabahar General District Hospital (Iman Ali Hospital)
Visit to District Health Centre, Chabahar City: further consultation with DHC and PHC staff
Travel to Tehran

Friday 19 October
Report writing
Consultation and briefing session with Malaria Control Programme staff and Dr Ali-Akbar Haghdoost (Kerman University of Medical Science)

References

1.	WHO/RBM, *Malaria early warning systems - concepts, indicators and partners. A framework for field research in Africa (WHO/CDS/RBM/2001.32).* 2001, World Health Organization/Roll Back Malaria: Geneva. p. 80.

2.	Cox, J. and T.A. Abeku, *Malaria early warning systems in Africa: from blueprint to practice.* Trends in Parasitology, 2007. **23**(6): p. 243-246.

3.	Hay, S.I., et al., *Defining and detecting malaria epidemics in the highlands of western Kenya.* Emerging Infectious Diseases, 2002. **8**(6): p. 555-562.

4.	Nájera, J.A., R.L. Kouznetsov, and C. Delacollette, *Malaria epidemics, detection and control, forecasting and prevention.* 1998, Division of Control of Tropical Diseases, WHO: Geneva.

5.	WHO, *Malaria epidemics: forecasting, prevention, early detection and control: from policy to practice*. 2004, World Health Organization: Geneva. p. 48.

6.	Carabin, H., et al., *Prediction of community prevalence of human onchocerciasis in the Amazonian onchocerciasis focus: Bayesian approach.* Bulletin of the World Health Organization, 2003. **81**(7): p. 482-490.

7.	Thomson, M.C., et al., *Malaria early warnings based on seasonal climate forecasts from multi-model ensembles.* Nature, 2006. **439**: p. 576-579.

8.	Thomson, M.C., et al., *Use of rainfall and sea surface temperature monitoring for malaria early warning in Botswana.* American Journal of Tropical Medicine and Hygiene, 2005. **73**(1): p. 214-21.

9.	Haghdoost, A.A., *Assessment of seasonal and climatic effects on the incidence and species composition of malaria by using GIS methods*, in *Infectious Disease Epidemiology Unit*. 2004, London School of Hygiene and Tropical Medicine: London. p. 317.

10.	Haghdoost, A.A., N. Alexander, and J. Cox, *Modelling of malaria temporal variations in Iran.* Tropical Medicine & International Health, 2007. **(Submitted)**.

11.	WHO, *Roll Back Malaria global strategic plan 2005-2015*. 2005, World Health Organization: Geneva. p. 43.