

EMRO Technical Publications Series 34

**Guidelines on
prevention of the
reintroduction of
malaria**



**World Health
Organization**

Regional Office for the Eastern Mediterranean

WHO Library Cataloguing in Publication Data

WHO Regional Office for the Eastern Mediterranean

Guidelines on prevention of the reintroduction of malaria / WHO Regional Office for the Eastern Mediterranean

p. - (EMRO Technical Publications Series ; 34)

ISBN: 978-92-9021-577-6

ISSN: 1020-0428

1. Malaria – prevention and control 2. Malaria – epidemiology 3. Malaria - diagnosis 4. Communicable Diseases 5. Guidelines I. Title II. Regional Office for the Eastern Mediterranean III. Series

(NLM Classification: WC 765)

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Cover design by Ahmed Salah Mostafa

Printed by WHO Regional Office for the Eastern Mediterranean, Cairo

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Preface

Many countries have succeeded in eliminating malaria from their territories. However, they are still at risk of reintroduction from endemic countries and areas. The malaria programmes in these countries face many challenges for prevention of malaria reintroduction, including weak malaria surveillance and vigilance systems, lack of malaria awareness among health professionals and travellers, uncontrolled population movement and lack of cooperation among countries.

In the WHO Eastern Mediterranean Region 13 countries have either eliminated malaria many years ago (Bahrain, Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Palestine, Qatar, Tunisia, United Arab Emirates) or are very close to malaria elimination (Egypt, Morocco, Oman and Syrian Arab Republic). The main priority for these countries is to prevent re-establishment of local malaria transmission in receptive and vulnerable areas in their territories.

To address the needs of the managers of disease/malaria programmes in those countries, the Regional Office developed this publication on the prevention of the reintroduction of malaria. These guidelines provide scientific information on malaria surveillance and vigilance, malaria early warning system, prevention and control of re-introduced malaria, emergency preparedness for malaria outbreaks and monitoring, and evaluation of activities. It is targeted at policy and decision makers, health authorities responsible for malaria at national and subnational levels and field staff. This document can also be used in training courses on planning and management of malaria elimination.

Acknowledgments

WHO Regional Office for the Eastern Mediterranean wishes to thank Dr Anatoli Kondrachine for his work on development of this guideline and also wishes to acknowledge the valuable contribution of Dr Peter Beales and Dr Walther Wernsdorfer, who reviewed and edited the guidelines. Thanks are also due to participants in the informal consultation on elimination of residual malaria foci and prevention of reintroduction of malaria (Rabat, 2002) and the sixth intercountry meeting of national malaria programme managers (Cairo, 2006) who reviewed, respectively, the first and final draft of the document.

1. Introduction

The achievement of malaria eradication in some countries, or parts of countries, should not be jeopardized by its re-introduction from areas where the disease continues to be a serious public health problem. By re-introduction is meant the occurrence of an outbreak/epidemic or the re-establishment of endemic malaria in a country or area from which it was previously eliminated.

Reintroduction of malaria has occurred more than once in areas of the Eastern Mediterranean Region that had been freed of malaria.

- An outbreak of 30 cases of vivax malaria took place in Jordan following one case imported from Pakistan in 1990.
- In Lebanon, two small outbreaks of vivax malaria occurred due to an infection of local mosquitoes, *Anopheles claviger*, probably from Syrian construction workers: in Jounieh in 1995 with 2 introduced cases; and in Ain Saadi in Greater Beirut in 1997–1998, with 4 cases.
- In Oman, Somali refugees reintroduced falciparum malaria in an area which had been malaria-free for decades, resulting in 21 cases among the local population, in 1998.
- Besides reintroduction from abroad, there have been occurrences of internal reintroduction within the same country from the few remaining residual foci. Thus, in Morocco in 2002 transmission of vivax malaria reappeared in one focus in Chefchaouen province resulting in 19 cases, where there had been no transmission of malaria throughout the 1990s, due to an importation from one of the residual foci elsewhere in the country.

To prevent re-introduction, in the past particular attention has been given to a greater collaboration between the national services dealing with immigration and international travel, notification of malaria cases, dissemination of information on the status of malaria, analysis of the receptivity of formerly malarious areas, prompt, competent malaria diagnosis and early effective treatment [1]. Furthermore the role of malaria epidemiological vigilance in

countries where malaria has been completely or in part eliminated is crucial [2]. Vigilance should be directed towards furnishing information to medical and paramedical staff on malaria status, improvement of laboratory diagnosis of malaria, malaria awareness among the population, registration, reporting and investigation of imported cases and outcome of treatment of patients.

During the last three decades of the 20th century, the malaria situation in the world changed considerably. Many countries converted their eradication programmes into national malaria control programmes with different goals and objectives. However, some of them retained many features of the eradication structure and strategy, and eventually attained their original aim—to eradicate malaria. Hence the renewed interest in the prevention of re-introduction of infection to malaria-free areas. Revision of existing WHO recommendations on this subject revealed that although some of them are still valid, others do not meet the requirements of the present situation. Moreover, certain concepts have undergone evolution, like that of malaria surveillance.

Among the main problems that must be solved to ensure adequate protection against the re-establishment of malaria transmission are:

- the inadequate availability of international information on the status of malaria in different areas;
- inadequate cooperative action by malarious countries, which often do not provide relevant information to persons leaving their territory;
- the risk of importation of multi-resistant strains of *Plasmodium falciparum* into receptive areas;
- difficulties in the establishment of checked passage of people across borders;
- inadequacies in malaria vigilance in the countries where malaria eradication has been achieved;
- lack of awareness of malaria re-introduction into areas free of malaria among the general health services staff; and
- inadequacies in malaria training.

2. Historical evolution of the concept of malaria surveillance

The concept of malaria surveillance underwent evolutionary development as the WHO malaria eradication campaign progressed. At its onset, little attention was given to the status of malaria epidemiological surveillance within the campaign, the reason being a prevailing philosophy of a rapid eradication of malaria on a massive scale. It was only with the occurrence of operational setbacks in various countries at the end of the 1950s and early 1960s, that the role of malaria surveillance assumed more importance in the malaria eradication programmes. WHO initiated a series of case studies on the organizational forms and methods of epidemiological surveillance deployed in various countries of the world.

The seventh report of the WHO Expert Committee on Malaria [3] defined malaria surveillance as *"that part of a malaria eradication project designed to discover evidence of any continuation of transmission, to establish its nature and causes, to eliminate residual foci, to prevent or cure such residual or imported malaria infections in man as would delay the ending of transmission or threaten its resumption in a given area, and, finally, to substantiate the fact that eradication has been achieved"*. This definition bore all the features of a time-limited operation, aimed at strengthening the measures for eradication of malaria. As such, it consisted of three parts:

- surveillance proper, which was associated with malaria case detection, and all consequent epidemiological and entomological surveys and investigations;
- measures oriented towards effective treatment of all malaria cases and suppression of malaria foci; and
- substantiation of the achievement of malaria eradication.

The eighth report of the WHO Expert Committee on Malaria [4] enlarged the scope of malaria surveillance. It recommended that surveillance operations be conducted not only in the attack and consolidation phases of malaria eradication, but also during the maintenance phase, thus establishing the concept of a *"vigilance*

system". The latter was subsequently introduced into the terminology of malaria eradication as "a function of the public health service during the maintenance period, consisting of alert watchfulness for any occurrence of malaria in an area in which it had not existed or from which it had been eradicated, and the application of the necessary measures against it". [5]

The twelfth and thirteenth reports of the WHO Expert Committee on Malaria [6,7] made various recommendations towards the maintenance of eradication once achieved. It was stated that the risk of re-establishment of malaria in areas freed from the disease would continue unless there was a system of vigilance with a properly developed epidemiological service and an effective organization for initiating prompt remedial measures. Particular attention was given to various vigilance mechanisms, which could provide total coverage and be capable of discovering any case of malaria occurring at any time anywhere in areas free of malaria transmission. Special attention had to be paid to those areas where, and at times when, the conditions for transmission were most favourable. These conditions were identified as *vulnerability* to infection and *receptivity* through the abundant presence of vector anophelines and the existence of other ecological and climatic factors favouring malaria transmission. A very important recommendation was made that areas of different receptivity should be delimited, based on the epidemiological experience in the country both before and during the eradication programme, so that the degree and type of vigilance might be appropriately planned and organized.

The fourteenth report of the WHO Expert Committee on Malaria [8] highlighted that surveillance was not only an epidemiological tool, but a mechanism without which the extinction of malaria transmission would be very difficult to achieve.

In the context of the re-examination of the malaria eradication strategy, the Twenty-Second World Health Assembly (1969) emphasized that the problem of *vigilance* activities continued in many areas of the world freed of malaria transmission [9]. Therefore, the Health Assembly underlined the need for parallel development of the general health services and much closer links with the malaria

eradication programme in each country. Experience demonstrated that the malaria eradication programmes needed full support from the general health services at all stages, and particularly in the advanced stages of eradication. In the maintenance phase, the vigilance activities were required to be taken over by the general health services. It was therefore essential that when plans for malaria eradication programmes were drawn up, due consideration was given to the parallel development of the general health services, so that by the time malaria eradication was achieved, these services could take on the responsibility of maintenance of the malaria-free status.

Although the maintenance of malaria-free status is the responsibility of the general health services, the role of specialized services is also important, as mentioned in the fifteenth report of the WHO Expert Committee on Malaria [10]. It stated that during the maintenance phase, the malaria service, as a part of the country's epidemiological service, should remain active and share the responsibilities with the general health services for case detection, epidemiological investigation and remedial measures. It further stressed that a vigilance organization had to be adequately provided with funds, supplies and equipment and trained personnel who could rapidly be mobilized to deal with emergencies. Further, the Committee made a very important proposal regarding *vigilance patterns, which should be neither rigid nor too schematic*. On the contrary, they should be adapted continuously to variable local factors, namely, the *malariogenic potential* and associated factors, and the level of development and effectiveness of the general health services. A vigilance service that forms an essential part of the general health services must be capable of detecting any possible re-establishment of malaria early and of dealing with it promptly. In some countries, these tasks might be left entirely to the general health services, while in others they might remain for some time with the specialized malaria services. However, whenever possible, they should be incorporated into the general health services keeping in mind the

need for maintaining activities to prevent the re-establishment of local malaria transmission.

The issue of planning *vigilance activities* was addressed in the sixteenth report of the WHO Expert Committee on Malaria [11]. In determining the technical requirements of malaria vigilance, the Committee recommended taking into account:

- the surveillance coverage needed to monitor the danger of resumption of malaria transmission in a given area, defined as the *malariogenic potential*; and
- the methods and techniques available for preventing the spread of malaria transmission.

The interaction of the two main factors, receptivity and vulnerability, determines the magnitude of the malariogenic potential, and each of the factors, as well as the potential itself could be quantitatively assessed. The malariogenic potential should be evaluated for each of the administrative units of the country in which the health service is able to supervise or carry out the basic vigilance activities through its smaller branches.

The feasibility of such an approach was demonstrated, for example, in the USSR, where the malariogenic potential of the country's territories freed of malaria was evaluated through a systematic analysis of various factors determining the distribution of malaria including the environmental and socioeconomic factors [12]. The final result of the exercise was a map showing the malariogenic potential of the whole country.

Finally, the Committee recommended that the malaria vigilance system should become a part of the overall surveillance system for communicable diseases. This should be an organization incorporated at different levels of the general health services, able to carry out well-defined functions on a permanent basis. The pattern of vigilance and its efficiency depend on the specific tasks involved, the speed and intensity of the operations, the coverage obtained in each specific area, and the malariogenic potential.

The report of the WHO Working Group on receptivity to malaria and other parasitic diseases [2] had further identified the

objectives and methods of malaria epidemiological surveillance/vigilance related to different malaria situations.

Thus, during a period of about 20 years, the concept of malaria surveillance underwent a considerable evolution. At the beginning of this process, it was considered part of the vertical malaria eradication programme, aiming both at the monitoring of the malaria situation, planning and implementation of intervention measures, and the assessment of its efficacy. With a change in the approach to malaria eradication, the role and place of malaria surveillance was also changed, giving more and more responsibilities to the general health services, particularly in the field of case detection and treatment. Finally, it was recognized that malaria surveillance should be a part of a national system of epidemiological surveillance. The main objective of this should be monitoring the malaria situation in the country, furnishing this information to the general health services and assisting the latter in malaria and laboratory training of personnel. Furthermore this national surveillance system should be responsible for the assessment of the efficacy of all preventive and curative measures taken up by the general health services and specialized services of the country, and participate in information, education and communication (IEC) activities.

3. Role of malaria surveillance/vigilance in the maintenance of malaria-free status

There are three main functions of malaria surveillance in areas freed of malaria:

- information collection, its analysis and its dissemination;
- epidemiological investigation of foci (if re-established) and cases, and analysis of malariogenic potential;
- assessment of malaria preventive measures through a monitoring process.

In some countries, surveillance within the general health services includes also the participation in the planning and implementation of malaria preventive measures, development of various malaria-related guidelines, training in malaria prevention and laboratory diagnosis, and participation in the health education activities [13]. In other countries, these activities constitute the scope of specialized services [14].

Information collection and analysis

Information collected routinely from national and international sources on the movements of persons and population groups from areas where malaria is endemic, assumes greater importance in countries or areas where re-establishment of malaria endemicity is to be prevented. Such movements constitute a major risk in receptive areas and individuals may themselves be in danger of suffering the severe consequences of the disease if it is not recognized early.

The information system should not be limited to the routine reporting and subsequent analysis of data. It is essential that all echelons of the health services should be aware of the importance of particular indicators of malaria risk defined for each area. They should be required to communicate abnormalities in those indicators to the level capable of generating a rapid and appropriate response. Routine information and trend analyses should be supplemented by properly planned epidemiological surveys or specific studies

conducted by specialized services to confirm, evaluate or study particular problems or situations, especially when an emerging epidemic is suspected.

National information concerning malaria needs to be exchanged between the national health administration and other government departments and the personnel of the health services of the country. The national health services, including the specialized ones, should indicate clearly the areas that are receptive for and vulnerable to malaria, preferably through the development of a map of malariogenic potential, which should be updated every year.

Moreover, advances in computer technology have revolutionized the use of mapping techniques to analyse and present complex risk and vulnerability information. Investment in appropriate hardware and software, and training of national technicians in their use, could become an essential component of modern and effective malaria surveillance. Increasingly, health data are being mapped to assist in planning control programmes at the national, provincial and district levels. In particular, customized software for managing and mapping of health-surveillance data has been developed by the GIS group at the WHO in response to the demands for a geographical information system (GIS) in health services in Africa [15,16]. GIS-generated maps provide visual information concerning the variability in malariogenic potential and the location of vulnerable population groups.

Administrative and environmental data are also being mapped in detail and are often available in other sectors, including agriculture, meteorology, irrigation, mining, military and others. Many malaria risk factors, particularly those related to malaria epidemics, can be mapped, if not directly, then by use of relevant proxy variables. Information on other factors including malnutrition and anaemia can be obtained from other sources. Such indicators from areas with high malariogenic potential, and from epidemic-prone areas can identify high-risk territories months in advance of an epidemic occurring.

Special vigilance may be necessary to prevent re-establishment of malaria endemicity. Information from other government departments may indicate expected movements of population that might present a risk. Frequent and wide dissemination of malaria epidemiological information to all health services personnel in the country would be highly beneficial.

Information dissemination

The exchange of information between different national agencies should be continuous and based on the general awareness of the constant danger presented by malaria. In this connection, appropriate health education of national authorities is necessary. The awareness of the public should be increased and the health staff, both government and private, should be appropriately trained or retrained. Experience in some countries has demonstrated that an awareness of malaria re-introduction among all the layers of the society can be achieved through the organization of an annual "Malaria Free Day" on a national scale, with the full participation of local and national high level governmental officials.

To ensure a greater awareness of the possibility of the re-establishment of endemic malaria and reliability in diagnosis and proper treatment of malaria cases, general practitioners should be kept up to date through the national medical association of the country. When there is insufficient coordination among the different parts of the health system, the probability of incorrect or incomplete notification is greatly increased.

The importance cannot be over-emphasized of the coordination and exchange of information between the health department and the authorities, companies and organizations concerned with immigration, labour, agriculture, municipalities, universities, air transport and shipping, tourism, religion, military and others involved in movements of people to and from malaria endemic areas.

The communication of information at the national level is entirely a national responsibility. The methods by which it is

disseminated and used for preventive or remedial measures depend upon the administrative procedures and level of development of the various services. In that respect, the introduction of computer networks has opened up the potential for a completely new way of performing traditional surveillance activities. If affordable, the main advantage of networking is improved data timeliness that would allow better monitoring of malariogenic potential and the rapid identification of threatening epidemics. The quick return of information to data collectors, together with access to on-line information, could stimulate participation in the system. International information should be disseminated to all governments through relevant WHO publications, such as the *Weekly Epidemiological Record*, *International Travel and Health*, etc.

Malaria border meetings, coordination meetings and regional and inter-regional malaria conferences, held periodically, permit countries to exchange up-to-date information on their respective malaria situations and on the danger of importing malaria cases. Several countries regularly exchange such information. However, such international information is of use only if speedily disseminated within the country, if it reaches all national health establishments that are responsible for preventing the re-establishment of endemic malaria, and if there is a means of national coordination and cooperation to make effective use of it.

Epidemiological investigation

The methods used for the detection of all malaria cases, and their effectiveness, will depend on the structure of the health services of the country and on its malaria history, receptivity, and vulnerability. Epidemiological investigation includes investigation of cases and established malaria foci. Particularly important is the careful classification of each detected malaria case by origin of infection and species of parasite. Special attention should be given to introduced cases that occur after the importation of cases. Contact surveys by blood examination, or by other available means should be done, as well as a follow-up of all cases. Entomological investigation,

to be useful, must be carried out immediately. It should include a search for adult vector anopheline mosquitos, their identification, determination of their density and sensitivity to different insecticides, and if possible, establishment of vectorial capacity. A search for vector breeding sites and the identification of larvae should be carried out regularly within the framework of surveillance.

Assessment of preventive measures

Malaria preventive or remedial measures undertaken by the general health services and/or by specialized services (Annex 1) should be monitored and assessed, with selected indicators (see section 6).

4. Prevention and control of reintroduced malaria

One of the factors responsible for reintroduced malaria is a failure of malaria vigilance. The peculiarity of such epidemics is that they arise from a small reservoir of infective cases, usually imported from abroad [17]. Therefore, it is important that such epidemics are identified at an early stage before a considerable part of the population might become infected.

A malaria vigilance system needs to be carefully planned and well managed to ensure the early recognition and prompt control of introduced cases that might give rise to an epidemic. The most important practical tool for monitoring the malaria situation remains a sustained surveillance of fever cases and the use of various malaria diagnostic methods, the main one of which is still blood film examination. This must be supported by a specific policy decision to sustain the means whereby accurate diagnosis can be made. This includes supervision and retraining of the laboratory technicians and the maintenance of adequate amounts of antimalarial drugs for the treatment of any imported and early secondary cases identified.

The vigilance system should include advice on individual malaria prophylaxis or stand-by treatment to residents travelling to known malarious areas. All the recommended antimalarial drugs should be readily available in the market or through government services. Regular reporting and follow-up of all cases of transfusion malaria from suspected or identified blood donors should be carried out.

In addition to fever surveillance, a few other epidemic warning mechanisms might be considered for practical use. There was a proposal for the quantitative evaluation of four epidemiological factors closely related to the entomological inoculation rate, which determines the degree of malaria transmission. These individual or combined direct factors were identified as:

- daily man-biting rate
- daily vector survival rate

- length of the sporogonic cycle, in days
- gametocyte rate.

In practical terms, these four factors (direct) are interrelated with several independent or combined factors (indirect), such as climate, irrigation, importation of malaria parasite carriers, migration, etc. Precise knowledge of the relationship between direct and indirect factors of transmission would evidently be of considerable interest in forecasting epidemiological developments in malaria, but changes in the indirect factors, detected through a warning system, would have to be taken into account.

Considerable attention to forecasting, early detection, and control of epidemics was given in a comprehensive study [18]. It was stated that malaria epidemics seldom pose problems of recognition at the local level in epidemic-prone areas, where laymen often recognize them. However, in areas which are considered free from transmission, it is common for individual malaria cases to be misdiagnosed and for even the initial stages of an epidemic not to be recognized as being due to malaria. Therefore it must be the rule that any outbreak of febrile disease in potentially malarious areas should be attributed to malaria until proven otherwise. In any case, every fever outbreak requires an epidemiological investigation, and malaria should be suspected whenever ecological or meteorological conditions are such that malaria transmission is possible. Particular attention should be paid to any clustering or increase in fever cases in areas with a past history of malaria epidemics.

Monitoring of direct and indirect factors, interaction of which might result in malaria epidemics, is a very important component of malaria vigilance in areas free of malaria transmission. The results can form the basis for measuring the magnitude of the malariogenic potential of an area. Assessment of the risk of malaria epidemics should become a regular preoccupation of services in all areas with high malariogenic potential. Such assessment might be possible if based on an information system capable of identifying not only high risk-areas, but also high-risk periods and the population groups at risk. Among the latter, individuals with low birth weight, low

immunity, co-infection with certain diseases, poor nutritional status and poor health-seeking behaviour are the most vulnerable groups to malaria.

The most relevant meteorological indicators, like rainfall, humidity and temperature should be monitored. Information on the latter should be used for estimation of the beginning and the end of a possible malaria transmission period in each malariogenic stratum. A system of notification of the start of new development projects and information regarding population movements and environmental change is essential. Health workers in areas with high malariogenic potential should be trained to recognize epidemic indicators, especially significant increases in the number of acute febrile episodes and of the quantity of drugs consumed, as these are two good early warning indicators.

5. Establishment of a malaria early warning system

There is growing recognition of the need to implement programmes to predict and prevent malaria epidemics. A malaria early warning system is an approach that should become one of the most important components of malaria surveillance. Some countries have already started to develop malaria early warning systems using simple transmission risk indicators, such as an increase in rainfall. However, experience shows that the routine use of such information may have serious limitations, mainly because of poor intersectoral collaboration between health and other sectors (including meteorology and agriculture). Another approach used by some countries is the identification of local epidemic-prone areas and risk factors based on the retrospective analysis of the malariometric indicators, including the history of past epidemics and the record of potential risk factors suggested by the ecology of the area. However, all efforts now should be focused on developing a predictive capacity and recognizing that a multisectoral approach is required.

In response to the operational need to develop malaria early warning systems, WHO published a framework proposing the generic concepts and potential early warning and detection indicators for use in such a system [16]. There are three main groups of indicators proposed in order to predict the timing and possible severity of a malaria epidemic.

- *Vulnerability indicators* (e.g. low herd immunity, malnutrition, drug resistance, etc.). These indicators are likely to predict the severity of impact rather than the timing of malaria transmission.
- *Transmission risk indicators* (e.g. an unusual increase in rainfall or temperature and changes in hydrological features). These might predict the timing of a possible malaria transmission 2–4 months before a possible epidemic occurs.

- *Early detection indicators from health facilities* (e.g. increased fever incidence over "normal" seasonal threshold). These indicators can be used to confirm the onset of a probable epidemic.

There is a trade-off between the accuracy and the timing of these indicators. For example, seasonal forecasts are available early in the planning cycle, but the ability to predict the future climate is limited. Surveillance systems that distinguish higher than normal incidence of fevers in particular areas can be a good indicator of a probable malaria epidemic. However, these systems offer little lead-time for effective prevention and control. A systematic approach involves the use of these indicators in a timely fashion to initiate prepared prevention and control plans [19]. The success of such an approach will depend on the strength of the relationship between different indicators and the degree to which such indicators can be routinely monitored under field conditions.

Ideally, the following components should be integral parts of a reliable malaria early warning system:

- Seasonal climate forecasts accurately predict the average season's weather.
- The weather accurately predicts increases in mosquito density and survival
- Vector dynamics accurately predict increases in the entomological inoculation rate (in the case of the availability of a source of infection, an inoculation rate will be a good indicator of malaria transmission, directly related to malaria incidence).

Seasonal climate forecasts can be used as predictive indicators in a malaria early warning system. However, it should be remembered that hydrological variations can provide active vector breeding sites especially where rainfall levels are low, such as in the countries of north Africa. In such situations, an early warning system based on the water levels in rivers or reservoirs may be more valuable. The flooding of rivers will depend on the rainfall distribution and timing in the entire river basin, rather than on local rainfall.

A very important contribution towards the establishment of a malaria early warning system might be the use of data provided by remote sensing and Geographical Information Systems (GIS). Such information is particularly useful in relation to the monitoring of environmental factors, like rainfall and flooding, which might affect the transmission processes, especially vector density, vector survival, and gonotrophic and sporogonic cycles [20].

A computer-based GIS permits the collection of data linked to geographical location from different sources, and stores it in a form suitable for subsequent analysis and synthetic presentation in map form. It is not only a system for the production of computerized maps but also, and more importantly, for the integration and spatial analysis of data from different sources such as:

- population distribution (location of towns, villages, hamlets, road networks);
- the environment (physical features, land use, surface water);
- the location of health and other services (hospitals, dispensaries, health posts, schools, post offices);
- epidemiology (morbidity, mortality, drug and insecticide susceptibility);
- meteorology (rainfall, temperature, humidity);
- agriculture (irrigation, main crops, land productivity);
- socioeconomic situation, and many other subjects in which the data are linked to geographical location.

Using these databases, it is possible to establish, confirm and monitor spatial and temporal correlations among the different data, and eventually formulate predictive hypotheses.

The study of epidemic potential should make the best possible use of any existing resources for GIS and stimulate their development where they do not exist. GIS should be integrated into the general epidemiological services of the country, which should define the basic geographical unit of analysis of routine health data, the distribution of responsibilities for reporting, epidemiological analysis, and the communications system. The epidemiologist responsible for malaria prevention and control, whether in a

specialized or an integrated service, should identify the sources of the ecological and socioeconomic data selected for monitoring. Through intersectoral collaboration it will be necessary to ensure the automatic flow of data after agreement has been reached on the timing and points of reception as well as on their use and distribution. The strengthening or the development of GIS for epidemic prevention and control would require financial, human and technical resources for the planning, acquisition, installation and maintenance of equipment and software, for training, supervision and evaluation, as well as for the verification, validation, correction and maintenance of related databases.

To prevent a malaria outbreak/epidemic, caused by the introduction of undetected malaria case(s) into areas freed from malaria transmission, there is a need to establish a monitoring system capable of detecting the earliest indicators, which trigger the chain of determinant events, as well as an emergency preparedness system to respond to them. The effectiveness of preventive action will ultimately depend on the degree of preparedness of the health services to mobilize the necessary resources in the available time. The speed with which an epidemic is triggered depends on whether the crucial factors come together quickly or develop in stages. Knowledge of the local epidemiology, ecology and the biology of the vectors involved is essential for accurate estimates.

Kleischmidt et al [21], described a simple two-stage procedure for producing maps of predicted malaria risk by using logistic regression modelling to determine approximate risks on a large scale, and employing geo-statistical approaches to improve prediction at a local level. Another approach to malaria risk stratification was proposed by using the seasonality of vegetation growth observed with satellite data, in combination with temperature constraints of malaria transmission [19]. Maps produced in this way can be routinely updated with data from environmental monitoring organizations. Such maps might be particularly useful for marginal areas where inter-annual variation in climate/hydrological processes can lead potentially to malaria epidemics.

The availability of the GIS technology and continent-wide data sets of climate "normals" (like long-term mean monthly rainfall and temperature surfaces) in digital format enables the prediction of areas with various degrees of malaria stability, based on the environmental data alone.

6. Indicators for monitoring performance of the system

One of the major challenges for effective monitoring and evaluation of the impact of malaria preventive measures in countries free of malaria transmission is the inaccuracy of the information on detection of imported cases, their classification and places of origin. This usually occurs because of irregular reporting and underreporting, especially at the periphery of the health services. Therefore, there is a need to define a set of a few common indicators for monitoring the outcomes and impact of operations.

The framework and indicators of monitoring should be directly relevant to the programme objectives in each participating country. They should allow the assessment of the impact of the action directed at malaria prevention and enable the monitoring of the principal malaria interventions and related efforts to reinforce the health sector. It is understood that the epidemiology of malaria, prevention strategies and health sector development vary considerably between countries and regions. Therefore, these variations must be taken into account in the development of the specific monitoring methodology.

A general set of indicators can be selected to reflect the major variations in malaria epidemiology and the principal preventive measures. Countries should be encouraged to select only those indicators that are the most appropriate. Some indicators that may be considered are as follows:

- percentage of units/districts/sectors reliably reporting the total number of fever cases, blood slides taken, microscopically examined, and the results of the examination;
- availability of antimalarial drugs: percentage of health facilities reporting no disruption in stock of antimalarial drugs at any point of time;
- preparation for malaria epidemics: proportion of epidemic-prone areas with an epidemic containment plan, adequate stocks of antimalarials, diagnostic supplies and functioning equipment in place or easily accessible;

- intradomiciliary spraying and/or larviciding: proportion of houses or breeding sites covered per total number targeted for operation;
- laboratory diagnosis: proportion of health facilities with laboratory diagnostic capabilities, from which an adequate sample (to be determined by each country) of positive and negative slides has been confirmed by a reference laboratory;
- percentage of health facilities with first-line, second-line and life-saving antimalarials according to the national antimalarial drug policy;
- percentage of facilities with adequate parasite detection services according to the national policy;
- malaria prevention in the primary school curriculum: proportion of primary schools that have introduced malaria prevention as a subject in the school health curriculum;
- environmental malaria risk factors taken into account in the design of development projects;
- percentage of community groups taking action on malaria issues , e. g. participating in larvivorous fish distribution;
- national partnerships established and maintained to ensure sustainable services;
- areas with different malariogenic potential and population groups at risk identified and regularly revised;
- a national policy of prevention of malaria re-introduction has been formulated and made available to all partners and sections of government;
- the national drug policy has been revised and is in use and the percentage of health facilities that strictly follow the recommendations of this policy;
- number of malaria cases thoroughly investigated;
- percentage of epidemiologically classified malaria cases.

7. Diagnosis and treatment of malaria cases

The detection of introduced cases is not easy. The life cycle of some malaria parasites is such that persons may harbour unapparent infections for long periods. Such carriers are potentially infective to mosquitoes and may eventually be responsible for re-establishment of malaria transmission.

One of the problems associated with *P. vivax* and *P. ovale* malaria is the variable latent period between the primary attack and subsequent relapses. Therefore, screening of the person during parasite latency will not reveal the infection. Subsequent episodes of parasite activity may or may not be accompanied by significant symptoms. Relapses may not be prevented by the standard treatment, and the timing and frequency of relapses may depend on the species and strain of parasite and the immune status of the host.

Asymptomatic infections in persons with *P. falciparum* may persist for long periods, particularly in persons with a high degree of immunity. Such persons retain their infectivity for mosquitos as long as their blood contains sufficient numbers of infective gametocytes.

Patterns of infectivity of *P. malariae* are less well known, but the infection is known to persist for more than 40 years, causing persistent low-level asymptomatic infections.

Experience has shown that it is very difficult to prevent the entry of malaria parasite carriers into malaria-free areas. The best that can be done is to identify persons who are particularly likely to be infected through information obtained from national and international sources. The specialized services should establish a case definition of suspected malaria, which can be strictly followed by the staff of the general health services for taking blood slides for microscopic examination. For the initial screening of immigrants, it is essential to know the status of malaria endemicity in the areas from which they come. In addition, the following information should be obtained from immigrants:

- place of origin;
- areas through which they have travelled;

- dates of residence in such areas;
- whether or not they have had malaria or experienced any symptoms suggestive of malaria;
- current health status.

Such information is of help in order to decide whether laboratory examination, chemotherapy or follow-up is necessary. The considerable danger of overlooking malaria when its symptoms are obscured by a more obvious infection of other origin should be stressed.

To alleviate the consequences of imported infectious diseases into the malaria-free countries of Europe, a sentinel surveillance network (Trop Net Europ) has been established. Malaria continues to cause high morbidity among European travellers. A thorough record of the epidemiological and clinical aspects of imported malaria has been shown to be very helpful for detecting new outbreaks and areas of drug resistance. Information has been collected prospectively since 1999. Judging from the data provided by national systems of disease notification, Trop Net Europ covers approximately 10% of all malaria patients seen in Europe. Reports of immigrant and European patients with falciparum malaria are analysed for epidemiological information and clinical features. Data from individual European countries are quite diverse, reflecting the local impact of immigrants and the amount of international travel in the local population. However, it is possible to identify the areas from which importation of falciparum malaria is particularly high, thus indicating a high risk for travellers to that region. In addition, data reported by member sites can contribute to the understanding of epidemiology and clinical characteristics of imported malaria [22].

At present, there are several methods for malaria diagnosis, but blood film examination continues to be the most affordable for many countries, even with its limitations in relation to very low parasite densities, and failure to reveal infection in its latent stage.

Serodiagnostic methods may be of use for detecting carriers in areas cleared of malaria, or in large-scale epidemiological studies to prove interruption of transmission [23,24,25]. Whenever possible, the

serological and parasitological information should be collected and evaluated together. In areas where malaria is no longer endemic, serological tests can be useful for:

- screening blood donors;
- exclusion of a diagnosis of malaria in patients with symptoms such as fever, anaemia, hepatosplenomegaly, nephrotic syndrome and with a negative blood examination for plasmodia;
- detection and identification of the species of malaria parasites during inter-relapse periods when other methods have failed;

The availability of rapid diagnostic tests facilitates the detection of introduced malaria cases, especially those caused by *P. falciparum*, but their relatively high cost confines their use only to certain situations. The reliability of rapid diagnostic tests for the detection of *P. vivax* is still inadequate.

8. Role of the general health and specialized services in the prevention of re-introduction of malaria

Each country might have its own methods for preventing the re-introduction of malaria, but the following are essential for success:

- maintenance of the health service budget at least at the same level as before malaria eradication;
- maintenance or establishment of specialized malaria prevention services within the epidemiological service of the country at the central and at the regional and sub-regional levels;
- continuing education and training of the general health services personnel in malaria diagnosis, treatment and in some vigilance activities;
- refresher training in malaria prevention and control for the staff of the specialized malaria services.

The responsibilities of the professional and managerial personnel of the general health services in regard to malaria include:

- detection of all suspected malaria cases, among the local and migrant populations;
- provision of clinical and laboratory diagnosis;
- administration of radical treatment to each case discovered;
- compulsory notification of cases;
- epidemiological investigation of case and focus;
- implementation—together with the personnel of the specialized services—of proper remedial measures, as required by the entomological situation (e.g. as a precaution, routine antilarval measures may be taken up in receptive and highly vulnerable areas);
- logistic support to laboratories;
- provision of reserve stocks of antimalarials, insecticides, and spraying equipment;
- in collaboration with the personnel of the specialized services, development of curricula and organization of training courses in malaria diagnosis, treatment and individual and community protection and prevention;

- regular dissemination, both nationally and internationally, of information on the malaria situation.

The responsibilities of the specialized services (for malaria, vector-borne diseases or communicable diseases) include:

- implementation of all activities of the malaria surveillance system;
- analysis of the malaria situation in all areas with the potential for the re-establishment of malaria transmission;
- development of the national plan of action on malaria prevention;
- calculation of the resource requirements to meet the objectives of this plan (financial, human and material);
- assessment of the effectiveness of its implementation;
- development, implementation and assessment of all malaria training activities among the personnel of the general health services and private practitioners in the country;
- together with the personnel of the general health services active participation in the development of various health education materials and organization of seminars, conferences and lectures for the general population;
- particular attention to the organization, implementation and assessment of entomological observations;
- participation of entomologists in the planning and assessment of all activities related to development projects, particularly irrigation and dam construction;
- routine entomological surveillance including an inventory of all breeding places of *Anopheles* species in areas of high malariogenic potential, and seasonal observations of mosquito larvae and adult densities and species;
- close collaboration with entomologists and epidemiologists, particularly at the moment of epidemiological investigation of malaria case and/or malaria foci;
- collaboration with entomologists and epidemiologists in the development of a national plan of action for malaria prevention

and control, particularly in relation to the activities directed against malaria vectors.

9. Emergency preparedness

Emergency preparedness for possible malaria epidemics should be part of the general organization of emergency health services, which in turn should be an integral part of every health system. Under certain circumstances, preparedness plans for malaria epidemics and for emergency health services should be included in the national disaster preparedness plan, particularly in areas where there is a recognized risk of natural disasters, such as earthquakes, volcanic eruptions, hurricanes, cyclones and floods.

Preparedness for malaria epidemics should be based on an understanding of the epidemiology of malaria and of the epidemic risk factors. The more complete that understanding and the more developed the information system and the monitoring of risk factors, the higher will be the level of preparedness, the more accurate the forecasting and the more adequate the preventive response. An immediate response should be possible if the appropriate human resources, supplies, equipment and logistical arrangements are ready to be brought into action. Malaria preparedness should therefore include the identification of these resources and the mechanisms required for their rapid mobilization. In general, the establishment of stocks of insecticides, spraying equipment and antimalarial drugs is highly desirable.

10. Role of the government to maintain the malaria free status

All by-laws related to malaria and its control issued by the government prior to malaria eradication in the country should be retained, in particular the obligatory notification of malaria cases. If the need arises, some of them should be reinforced and new ones introduced, such as the obligatory screening of all refugees, asylum seekers, foreign students and foreign workers arriving from malaria-endemic countries. Contractors employing labour from malaria-endemic areas, or from potentially malaria-endemic areas, should be held responsible for ensuring that they are screened for malaria. They should also be held accountable for the creation of potential mosquito breeding places in construction sites.

To maintain the malaria-free status in the country the government should retain the services of experienced and qualified malaria personnel in a specialized service within the national epidemiological services, or a service for the prevention and control of vector-borne and parasitic diseases. As noted previously, the existing malaria control budget should not be reduced, so that all the requirements for malaria vigilance activities, procurement of drugs, reserve stocks of insecticides, spraying equipment, laboratory equipment and reagents, training and health education activities can be met. The government should ensure that screening for malaria and radical treatment is free of charge for all suspected malaria patients, irrespective of their civil status, in all governmental health facilities, in the interests of public health.

Considering that in some cases malaria eradication might occur in the whole country, while malaria transmission continues in neighbouring territories, the government should initiate (if it has not already done so) regular—at least annual—malaria border meetings. It should also ensure that the ministries of health of both countries, through their specialized services, develop joint plans of action for malaria prevention and control. These should be jointly implemented in terms of time, place and method/material selected. There should

also be a full and regular exchange of information on movements of population groups and on the susceptibility and resistance of malaria vectors to insecticides.

One of the main tasks of the Ministry of Health in the maintenance of malaria-free status is to coordinate all activities aimed at the prevention of malaria in the country among the interested parties, particularly departments of education, agriculture, industry, forestry, immigration, tourism, defence and municipalities. It should also maintain close links with the private sector. It is equally important to obtain, by means of appropriate information, education and communication and social mobilization, the collaboration of the entire population, especially in areas where uncontrolled immigration may occur, so that adequate vigilance measures can be instituted. Information and advice, through the media, should be given to persons entering or leaving malarious areas regarding the dangers to which they may be exposed. The Ministry of Health should regularly furnish information on malaria status in the whole country to WHO for global dissemination.

11. Training

Malaria training must continue in all countries as long as the disease persists in any part of the world. Since the prevention of re-establishment of malaria is primarily an epidemiological problem, malaria service personnel could be usefully re-trained and assigned to epidemiology sections/services of the general health services. In countries that have eradicated malaria, such training and re-training of medical and paramedical personnel is subject to the following considerations:

- the need to integrate malaria services and staff into the general health system, which might involve the assignment of staff to more comprehensive duties for which special training or retraining may be required;
- diminished interest in malaria on the part of politicians;
- probable decrease in resources, even though these are essential for the maintenance of vigilance and for the development of efficient epidemiological services;
- a sense of frustration among staff trained to deal with a disease that no longer exists in the country;
- public demand for other types of health care and the establishment of other priorities.

Proper training and re-training of medical and paramedical personnel, including laboratory workers, is indispensable to prevent the re-introduction of malaria. Such training should be appropriate to the state of development of each country, its receptivity to malaria, and its health priorities. When developing the curricula for such training, attention should be given to their past experience and future duties and it should be polyvalent. Training programmes should also be provided for health administrators, to ensure that they are alert to the need for malaria vigilance, further development of the health services, particularly rural health services, and consequent administrative and budgetary implications.

An important role of a retained specialized malaria service would be training and continuing education in malaria. It would also

be responsible for keeping the public informed of the dangers of the re-introduction of the disease, involving teachers and schoolchildren. Training in malaria should be specific and practical, emphasizing not theory but individual protection and community prevention, case detection, treatment, and notification.

For physicians in malaria-endemic and malaria-free but threatened countries, malaria training should begin in medical schools, which should retain malaria in the curriculum and among the subjects for examination. Special seminars should be provided to the physicians who are to work in receptive areas, where malaria cases are likely to occur, or in health services at ports, airports, and border-crossing posts. As part of the routine examination of patients, physicians should ask specific questions on travel abroad. They should enquire where the patient has been during the last weeks, months and years. The orientation of physicians in this respect should begin in medical schools.

Supervision and re-training of health service laboratory technicians, especially those employed in haematology laboratories, is necessary, since only some of them might have been properly trained to detect malaria parasites and to identify the species. Moreover, the examination of large numbers of negative slides by malaria microscopists for surveillance purposes may cause frustration, thereby reducing their efficiency. The role of the reference laboratory in that case is to provide all laboratories with a set of reference slides and coloured charts, and to regularly supervise the performance of laboratory technicians.

It is very important that the quality of training and re-training is constantly monitored and the results evaluated, so that any shortcomings may be corrected.

12. Operational research

The malaria prevention service, as part of the national epidemiological service, should have the capacity to conduct operational research to ensure that its activities are more effective and adaptable to changing epidemiological situations. Such research should be relevant to the programme objectives, addressing not only the effectiveness of preventive measures but also social, economic, cultural and behavioural factors that might affect programme activities. Such factors can either help or hinder the efforts of health services and other collaborating sectors to implement cost-effective and sustainable malaria prevention, and could influence communities as they assume greater responsibilities for maintenance of malaria-free status.

The research capabilities of national malaria programmes vary greatly. Some countries have maintained a capability for operational research within the programme or in collaboration with national research institutes, universities and groups from industrialized countries. However, in others, the commitment and capability to conduct research has diminished as the malaria burden was reduced. In yet others, even when these countries have national biomedical research institutions/organizations, there is often little communication or collaboration between these and the disease control programmes. Thus, the orientation of operational research may often be quite different from the priority needs of the country's changed malaria situation.

To overcome such a situation, there is an urgent need to advocate that operational research is incorporated into and funded as part of all national plans of action for malaria prevention. This will not only help to ensure that operational research is in line with programme needs, but will also provide a system by which programmes can commission urgent operational research.

The translation of results into practice will be facilitated at the national level if national bodies are established and/or strengthened to develop research priorities and strategies in line with those of

malaria prevention. Training in developing standard protocols for operational research has been provided by WHO, and these are now increasingly being used. Training must be an integral part of operational research if national capabilities in this field are to be increased. Information exchange is being facilitated by the development of various web sites on the internet, and the production of an electronic register of controlled trials by the Cochrane Infectious Disease Group [26]. Although access to computer-based information on malaria is increasing, there is still a need to increase the flow of information by traditional means, especially to policy-makers and programme managers.

13. Experience in preventing malaria re-introduction

The experience from a number of countries in the Eastern Mediterranean and European Regions in applying preventive measures has revealed that malaria transmission may be re-established by the entry of infected persons, the importation of infected anopheline mosquitoes or by undetected parasite carriers.

For practical purposes infected persons entering a country may be grouped into three classes:

- Nationals returning from long-term residence in malarious areas abroad. Some countries provide advice to such persons prior to departure on the protective measures they can take. Upon their return they may be screened at the port of entry and, if necessary, visited at home and given radical treatment. Some countries with overseas malarious territories may examine blood films from all persons before their departure from such territory to the mainland, and administer radical treatment to all those found to be infected.
- Arriving foreigners and international travellers. In some countries, at the port of entry, such persons are only advised on malaria prevention. In others, foreigners arriving from malaria-endemic countries and having fever at the moment of entry, are subjected to blood slide screening for malaria and are given presumptive treatment. In some cases, a fever survey is carried out among the passengers of a ship arriving from a malaria-endemic country, and in addition to that, a mass blood survey may be carried out.
- Various groups who are more dangerous than others as potential importers of malaria, particularly refugees, seasonal workers, nomads etc. In some countries, such groups may be subjected to special preventive measures. Servicemen returning from overseas military duty may pose a special threat. It is, therefore, important to have complete coordination between the military and the civilian health services.

Other useful facts that have emerged are summarized below.

- Good cooperation between the health services and immigration and quarantine services is very useful for acquiring information on the entry of possibly infected sources.
- Customs and police reports of illegal entry are another source of information.
- Nomads, refugees and immigrant workers from malarious countries are a major source of imported cases in many countries.
- Immigrant workers from malarious countries may not reside at the addresses they declare at ports of entry; they move around looking for work, aggravating the problems of surveillance.
- In some regions, countries with contiguous borders hold periodic meetings to discuss the problem of imported malaria, particularly into areas where malaria transmission has long been interrupted.
- Recommendations from such meetings are usually directed towards concerted preventive measures to be implemented simultaneously on both sides of the border, such as the prevention of invasion of *A. arabiensis*.
- The screening of persons arriving from malarious areas, and the provision of suppressive and sporontocidal antimalarial drugs, has produced positive results in some countries.
- Such screening and the provision of treatment has proved to be costly and of uncertain value, as compared with other efficacious methods of detecting imported cases by the general and specialized health services.
- Vigilance based on multi-purpose home-visiting has been necessary in some areas.
- Some countries in which malaria transmission used to be seasonal, have increased their preventive activities seasonally.
- According to the International Health Regulations, all aircraft arriving from malarious areas are subjected to spraying against insects. However, in spite of this precaution, the phenomenon

of airport malaria continues to exist in countries with interrupted malaria transmission.

- In some situations, it might be difficult to establish whether resumption of transmission was the result of spread from an imported case or from a persisting, previously unrecognized infection. This might be the case particularly in respect of *P. malariae*.
- Malaria is a notifiable disease in most countries of the two regions.
- Without involvement of the staff of the general health services and the private sector in malaria prevention and control, it is impossible to achieve the level of obligatory notification required, but it is essential to maintain and strengthen the requirement.
- Confirmed malaria cases are given radical treatment in all countries, and epidemiological investigations are made in the surrounding population. These investigations include examination of blood films from an appropriate number of people, and entomological study of the vector in the area. Appropriate precautionary measures are taken where necessary.
- Additional steps taken to prevent the re-introduction of malaria include local measures against mosquitoes in general, and anti-anopheline measures in areas of high receptivity in particular, both antilarval and imagicidal (when indicated).
- Seaports and other popular tourist spots are subject to the threat of repeated importation of malaria.
- Areas where water is impounded and those where labour forces are gathered may also be highly receptive.
- Cooperation in the identification of malaria cases on the part of the general health services varies from country to country; laboratories are generally adequate in numbers, but in some instances failure to diagnose malaria and delays in diagnosis have been noted. The responsibility for adequate diagnostic support should be shared between the medical staff and the

laboratory services. Adequate training of medical personnel, and retention in service of personnel skilled in all aspects of malaria control are most important.

- Apart from the public health implications of imported malaria, it is essential to remember that a delay in diagnosis may result in severe illness and even death of the patient.
- Adequate briefing for travellers and the availability in the market of recommended antimalarials is most important. This aspect, however, has been somewhat neglected in many countries.

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Annex 1
Malaria prevention activities

Activities	Malaria situation		
	No cases	Imported only	Secondary cases from introduced
Early detection of cases:			
ACD	-	+	+
PCD	+	+	+
Treatment of cases	-	+	+
Investigation of foci	-	+	+
Classification of cases	-	+	+
Demographic monitoring	+	+	+
Climate monitoring	+	+	+
Mosquito density monitoring	+	+	+
Mosquito larvae monitoring	+	+	+
Inventory of breeding sites	+	+	+
Assessment of probable transmission season	+	+	+
Insecticide resistance monitoring	+	+	+
Parasite resistance monitoring	-	+	+
Bio-environmental management	+	+	+
Intradomiciliary spraying	-	-	+
Larviciding	-	+	+
Training	+	+	+
Health promotion	+	+	+
Operational research	+	+	+