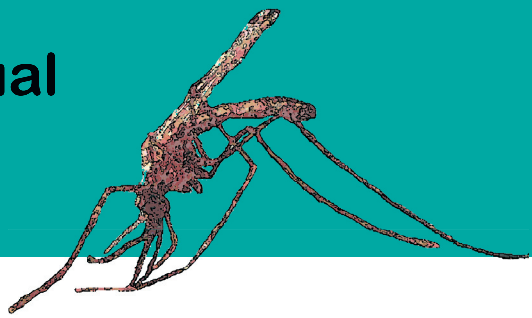
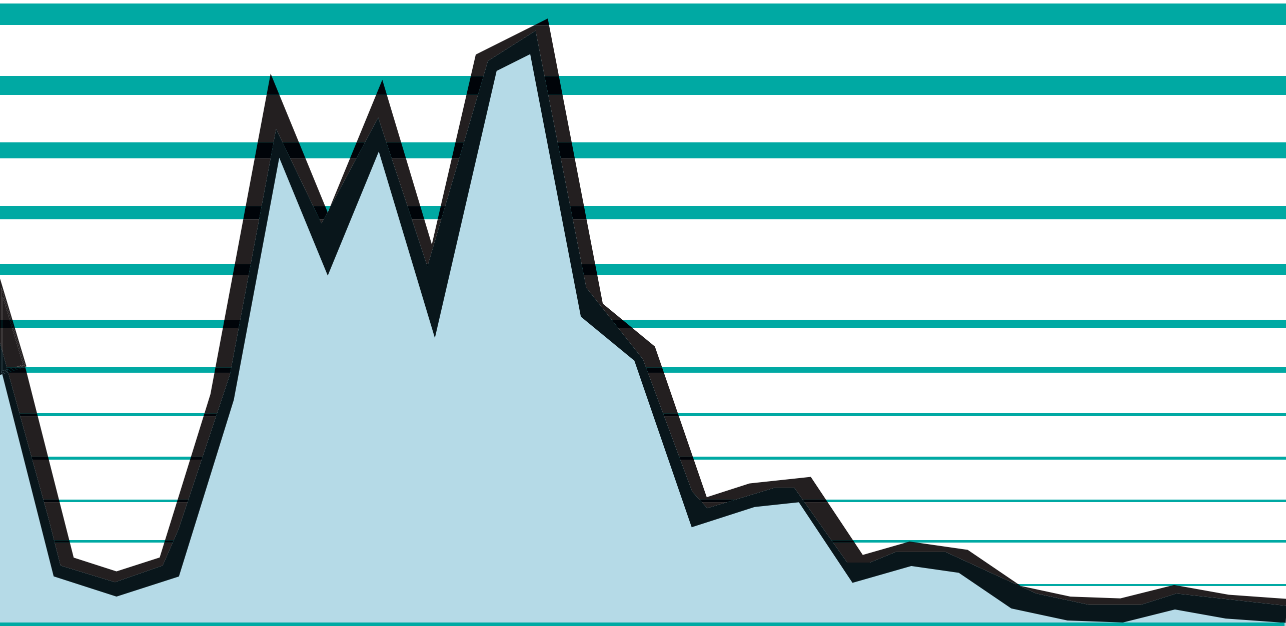
EMRO Technical Publications Series 33

Guidelines on the elimination of residual foci of malaria transmission





World Health Organization

Regional Office for the Eastern Mediterranean

EMRO Technical Publications Series 33

Guidelines on the elimination of residual foci of malaria transmission

World Health Organization
Regional Office for the Eastern Mediterranean

WHO Library Cataloguing in Publication Data
WHO Regional Office for the Eastern Mediterranean
Guidelines on the elimination of residual foci of malaria transmission / WHO Regional Office for the Eastern Mediterranean
p. .- (EMRO Technical Publications Series ; 33)
ISBN: 978-92-9021-576-9
ISSN: 1020-0428
1. Malaria – prevention and control 2. Malaria - transmission 3. Malaria – epidemiology 4.Communicable Diseases 5. Guidelines I. Title II. Regional Office for the Eastern Mediterranean III. Series
(NLM Classification: WC 765)

Cover design by Ahmed Salah Mostafa

Printed by WHO Regional Office for the Eastern Mediterranean, Cairo

Contents

Preface

Elimination of the residual foci of malaria transmission is a dynamic process, taking place mainly during the late stage of the attack and consolidation phases of malaria elimination. This approach is suitable for countries or areas that are targeting interruption of malaria transmission in their territories. Countries can plan for a selective elimination of *P. falciparum* foci in the first stage, to be expanded to *P. vivax* at a later stage when more resources and a stronger programme are available.

During the past 15 years several national malaria programmes in the Eastern Mediterranean Region adopted elimination strategies: Oman (1990), north African countries (1999), Saudi Arabia (2004), Islamic Republic of Iran (2005) and Iraq (2005). Elimination was also targeted in some endemic countries at certain geographical areas (Socotra Island, Yemen (2002) and Khartoum and Gezira State, Sudan (2002). It is the vision of the WHO Regional Office for the Eastern Mediterranean to expand malaria-free areas at sub-regional level (e.g. north Africa, Arabian Peninsula) and to support new initiatives in other countries wherever feasible (e.g. northern part of Afghanistan bordering Tajikistan).

To address the immense needs of the countries for guidance on elimination, particularly the new generation of malaria managers, the Regional Office developed these guidelines on elimination of malaria transmission foci. The guidelines provide scientific information for identification of foci of malaria transmission, epidemiological classification, selection and application of appropriate measures and monitoring and evaluation of implemented interventions. It is targeted at policy and decision makers, malaria control programme managers at national and sub-national levels and field staff. It 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 Andrew Beljaev for his work on development of these guidelines and to acknowledge the valuable contributions 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 in the sixth intercountry meeting of national malaria programme managers (Cairo, 2006) who reviewed, respectively, the first and final drafts.

1. Introduction

Elimination of malaria foci is the main activity during the late attack and consolidation phases of malaria eradication/elimination campaigns, when malaria transmission becomes less widespread and is gradually coming to an end in most of the areas, while remaining entrenched in a few localities. This includes making an inventory of foci, diagnosing their functional status, selection, and application of measures and evaluation. This is a dynamic process, the status of foci being revised as a result of the evaluation.

The process does not stop after the very last case of locally transmitted malaria has been detected and dealt with, and the programme has entered the maintenance phase. Activities must continue, at the required scale, to prevent the re-establishment of malaria transmission. The now inactive foci require the same monitoring of status, and it is essential that every case of malaria is detected and classified. Generally, such an attention to foci is not warranted in malaria control programmes that do not explicitly aim at the interruption of malaria transmission. However, it may be warranted, where elimination of a sizeable focus is of economic importance.

In countries where local transmission of *Plasmodium falciparum* occurs, the initial goal may be a selective elimination of this more important pathogen by monitoring and elimination of foci. Consequently, countries freed from local *P. falciparum* transmission may find that *P. vivax* continues to be endemic, at a low level. This was the scenario in Europe, south-west Asia and north Africa, which in some cases lasted for decades.

The difference between these two species of human malaria, from the point of view of malaria control may be summarized as follows:

- *P. vivax* is adapted to lower temperatures, because of a lower threshold of development in the mosquito and a mechanism of dormancy in the form of hypnozoites;
- Unlike *P. falciparum, P. vivax* easily infects vectors from geographically remote areas;

- *P. vivax* is better controlled when case detection and treatment are the main tools, due to a better sensitivity to drugs, disappearance of gametocytes soon after administration of blood schizontocides and the short life span of gametocytes;
- *P. vivax* is less easily controlled when antivector measures are the main tool, due to mechanisms of dormancy and longer duration of the infection;
- *P. vivax* is of less public health importance due to a lesser severity, near absence of mortality and absence of lasting sequelae;

These guidelines are concerned with residual malaria, and therefore assume that:

- Only *P. vivax* is endemic in the country, at a low level, sometimes with exacerbation of transmission;
- There were frequent prior attempts to interrupt malaria transmission that failed;
- National resources (finance, workforce, logistics) are sufficient for large-scale measures;
- The support of WHO and international cooperation agencies is assured, not decisive, but catalytic;
- There is a long-term experience of malaria control which is reasonably well-documented.

In conclusion, before embarking upon a large-scale programme to eliminate residual foci of malaria, which in effect is eradication, the government must ensure that sufficient resources will be made available. Furthermore, the judicial use of support from WHO and other agencies can be catalytic in accomplishing the goal.

2. Definition of a focus

In the context of the WHO Malaria Eradication Programme a malaria focus was considered to be "a defined and circumscribed locality situated in a currently or formerly malarious area and containing the continuous or intermittent epidemiological factors necessary for malaria transmission" [1]. This was considered the minimum unit for antimalarial action. The definition is important for classifying types of malaria epidemiology and for devising stratification, hence providing the means for standardizing action according to the local situation.

Monitoring the status of foci, with precise identification of their functional status (active or non-active, new or residual), is a cornerstone for success in interrupting malaria transmission and preventing the reintroduction of malaria where potential foci (foci with imported cases, but without proof of a local transmission) may be present. Many of the European and a number of the Eastern Mediterranean Region countries are currently faced with this situation.

The above definition of a focus as a territory may be handy, but it does not consider many important facets of a focus. An ecological definition is more meaningful, describing a focus of malaria as a system consisting of an abiotic part (territory) interacting with living organisms in the transmission of the parasite. Beklemishev [2] indicated that such an approach had been used by malariologists intuitively, and extended it to the case of tick-borne encephalitis and further to other infections. The following is the definition formulated just before his death in 1962 and published posthumously [3]: *"A focus of infection is an integration of the populations of the parasite and populations of hosts and vectors that support its existence."*

Populations are understood to be sets of interacting individuals of the same species that occupy the same territory. In other words, the notion of territory is implicit in the definition of a focus. Consequently, the ecological definition does not contradict the definition of WHO [1], but deepens it. A focus, although corresponding to a definite territory, is more than a mere territory, it is an integral part of an ecosystem as a whole.

This definition is applicable to any infectious disease, but is particularly useful when applied to complex parasitic systems like malaria that may include dozens of interacting species of parasites and hosts. A focus of malaria is tied down to a biotope, which centres around a locality, but also includes mosquito breeding, feeding and resting places related to the settlement, and places frequented by people during their activities, especially at night.

In Figure 1, populations are represented by parts of circles overlapping with each other. Even in this very simplified form (e.g. assuming that there is one vector species, whereas they are usually several, and only one parasite species) this figure illustrates several important facts:

- The population of a vector consists of two "hemi-populations", aquatic and airborne, and only the latter is in contact with human and other animal hosts.
- Although animal hosts do not usually harbour human-pathogenic malaria parasites, they may play an important role as a component of a focus supporting the vector population.

The major component of the malaria parasite population is harboured by humans.

Territorial boundaries of a focus are not always well defined due to the unpredictable behaviour of the hosts. Thus assuming that an inhabitant belongs only to the recognized place of residence may lead to a serious misjudgement. There are many instances when transmission of malaria regularly takes place outside the house or even outside the village.

The more precisely the status of the system is studied, the more disturbed becomes this system and the less realistic are the results. Heisenberg's principle of uncertainty is probably applicable to the focus. The principle says that it is impossible to make simultaneous measurements of both the position and the momentum of a subatomic particle, thus establishing a limit to an "objective"

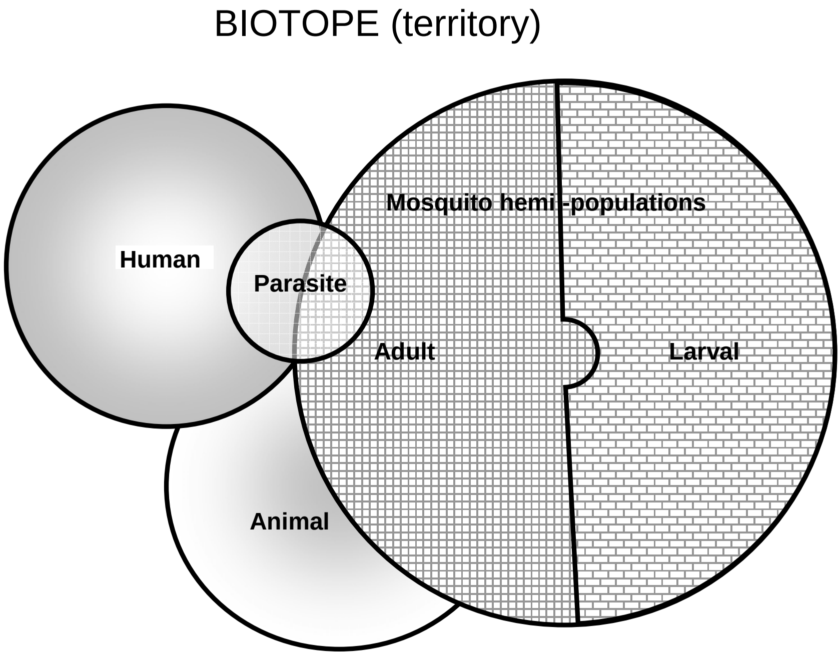


Figure 1. Focus of malaria as an ecosystem

scientific observation. Hawking calls it "a fundamental, inescapable law of the world" [4]. Not only subatomic particles, but also the Universe in general cannot be observed without disturbance. For example, even in the absence of antimalarial measures, an observation of a focus would imply examination of the blood and this would affect the level of malaria by creating awareness of the people and giving opportunities for treatment. The more active the observation, the more disturbed becomes the focus. It follows from this principle that drawing exact boundaries of a focus is impossible, although realistic approximations are always feasible.

Foci are seldom isolated. They interact through an exchange of hosts. They may, on the one hand, be independent, in which case they will remain at the same level of activity even when isolated from the neighbouring foci. On the other hand they may be dependent in which case they would wane or disappear if the supply of parasites from outside stops. An extreme degree of dependency is represented by a pseudofocus in which there are no conditions for transmission and where malaria exists only because it is imported from the outside.

It is essential to emphasize that a focus centres on a locality of any size, even a house with a single family, provided that it is separated from the neighbouring localities by distances or physical barriers. This makes an exchange of mosquitoes difficult and interaction within the focus considerably easier than between the neighbouring localities. Care must be taken not to equate a malaria focus with a village. Such "villages" may in fact be groups of households more or less separated from each other by considerable distances or physical barriers that make intermixture of mosquito populations difficult or practically impossible and where the transmission goes on more or less independently. This is especially the case where in mountainous areas the same "village" may consist of parts lying at different altitudes, some below and some above the altitude limit of malaria.

In some situations, subunits may be recognized within the focus, which are called microfoci. This may be of a practical interest when a full cycle of breeding and feeding of mosquitoes is possible within a single household. Such situations can be observed in semi-arid areas where villagers store water in pits, or have wells inside the house, in virtually every household. When such pits or wells can support mosquito breeding (*An. sacharovi* in Azerbaijan, *An. stephensi* in the Islamic Republic of Iran), female mosquitoes rarely leave the household. If malaria was imported into such a microfocus, it would spread mostly within it. This leads to a clustering of cases, a feature not very common in malaria, and a patchy distribution of malaria within a focus.

3. Information on foci

Overview

Countries that are ready to embark on an elimination of foci usually have a long history of malaria control and a wealth of information on malaria. The problem is often a redundancy of information, and how to retrieve data of high epidemiological significance and predictive value. Early on in a control programme, obtaining exhaustive information on every focus is impossible due to their multitude. Thus, extrapolated data from a few typical, representative stations is normally used. However, if the programme is successful, the number of active foci decreases and this makes it more feasible and mandatory to thoroughly examine each focus.

The information needed may be subdivided into general (physiography, meteorology, population) and epidemiological (vectors, parasite, clinical cases). This information may relate to the past (background information) or present (current information), which is monitored in real time. The main use of this information is:

- determination of the current functional status of a focus;
- identification of problems that may hamper progress towards control or elimination;
- prognosis of the evolution of the status of a focus according to the various control approaches used;
- selection and standardization of appropriate measures for each type of focus.

Monitoring a multitude of all conceivable factors that may have a relation to malaria would exceed the capacity of any surveillance system. Only meaningful factors should be evaluated and followed up, to avoid redundancy. Since most natural and sociological parameters are inter-linked and evolve in parallel, increasing their number would not necessarily improve the forecast.

Monitoring some factors requires a prohibitive amount of effort, whereas other factors are very variable in space and/or in time. Hence the data obtained from observational posts will not always be representative of what is being monitored. For example, monitoring humidity is often recommended. However, this factor strongly depends on rainfall and temperature; in other words, these two meteorological factors already contain most of the information required. Moreover, humidity is very variable depending on biotopes, and the data obtained from a meteorological station may not be representative.

Many causally related factors for malaria are not always measurable directly. Quite often, it would be more practical to substitute them with proxies, i.e. other factors that are easier to observe and measure. This is the concept of indicators that is now widely used for evaluation purposes. An indicator may be defined as any factor that is conspicuous, easily obtainable and which is closely associated with the condition in question. This association is not necessarily causally determined; sometimes both the condition and the indicator are independent of each other, but both are caused by a third, hidden factor, and hence they develop in parallel.

It is important that these indicators are easily available (e.g. from a map, census report, meteorological record) and more or less independent from the other selected indicators (to reduce redundancy).

General information

Physiography

One of the most important indicators of malaria is the altitude. Its relationship with malaria is indirect, mostly through the temperatures that impede development of sporozoites due to the extreme cold at high altitude or, sometimes, extreme heat at low altitude levels. Use of altitude is simpler than that of a meteorological record, since data on altitude are available for any geographic point and may be easily read from topographic maps or using a global positioning system (GPS). Temperature data on the other hand are obtained from a relatively rare network of meteorological stations. Moreover, the altitude determines not only the temperatures, but also some other factors that may be related to malaria, such as rainfall pattern and type of breeding places. Therefore, the altitude, as an indicator, contains more information than the temperature alone.

Thus, the altitude above the sea level should be retained as an obligatory characteristic of any focus. This is, however, not a trivial matter in mountainous countries, where a focus sometimes may occupy a gradient of a few hundred metres, which would imply an elevated malaria risk in lower parts and a low or zero risk in the upper parts. This occurs when the villages are on top of the hills, and the agricultural land is mostly in fertile valleys 200–300 metres below, such as one finds in Nepal. In such conditions, a burst of malaria incidence often occurs at the time of planting and harvesting, when people start spending nights near the fields to protect their crops. The lowlands may be much less malarious than adjoining areas with an altitude of about 200–600 metres, due to very high temperature and low rainfall in the plains. Thus, malaria is closely associated with particular types of landscape.

Hydrology and entomological information

The presence, type, and distribution of water bodies are an important indicator of malaria. By the time malaria control reaches the stage of elimination of foci, there is usually abundant information about local vector species, their bionomics, types of preferred breeding places, susceptibility to insecticides, and other relevant features. The significance of particular types of water body varies from one part of the world to another depending on the vector species, distribution and their breeding preferences.

The distribution of water bodies in relation to the locality is of great importance. When there is one large breeding place at some distance from the locality, the cases tend to be scattered. This is because the time needed for maturation of sporozoites is 3 to 4 times longer than the gonotrophic cycle. This means that a mosquito that became infected on a case is bound to visit the breeding site 3 or 4 times before it becomes able to transmit an infection and is unlikely to return to the same spot where it took the infective blood meal. At the same time, cases tend to concentrate in the parts of the locality that are nearest to the breeding place.

When there are many small breeding places dispersed within the locality, mosquitoes need to make only short-distance trips during the gonotrophic cycle and are more likely to return to the same place they started from. Secondary cases are likely to concentrate near the source of infection. There is a mosaic of cases: sometimes several in the same household, and none in many. In such cases foci have a marked microfocal structure.

When the objective is the elimination of foci, every breeding place of each focus should be registered in an inventory. When it is impossible to monitor each of them, this may be done in typical breeding places. However, if larviciding is the main tool, monitoring of every breeding place is obligatory. Breeding places should be also considered in a wider ecological context, with reference to the types of vegetation, presence of larvivorous predators and mosquito pathogens. A decision should be made about each breeding place: whether it is useful in any sense, or may be eliminated by filling or draining.

Mapping

In the past, classical geographic reconnaissance included the collection of information on the number, type, location and means of access of all houses and field shelters, as well as on communications, health units, vehicle-repair facilities, population movements, and other relevant factors. The purpose was mostly to organize the insecticide spraying campaign that was the main attack measure at that time. Today its scope is wider.

The results are reflected in a series of maps:

- small-scale maps showing the location of all the foci (active, non-active, potential, cleared-up, and pseudo) in the administrative area covered by a malaria unit; hydrological features and networks, landscape divisions, hypsometry (altitude), roads and health facilities should be added;

- large-scale maps showing the location of each house should be available at least for foci active at present or in the recent past.

Cartographic support is much better now than during the time of the WHO malaria eradication campaign when the technique of geographical reconnaissance was being developed. Plans of villages are often available today. If not, large-scale topographic maps may be used as a base on to which the situation of each house, breeding place and other relevant details may be entered, using recognized keys. Each household and breeding place should be assigned a reference number.

Geographical reconnaissance needs to be updated periodically. GPS is now an affordable tool to determine coordinates of any point, link them to events and visualize the information on a grid map. Electronic maps that are components of a computerized geographic information system (GIS) are extremely helpful. However, the present electronic maps do not contain all the information needed for malariology, and additional layers related to ecology need to be created.

Meteorology

Careful monitoring of meteorological events, which used to be a trademark of successful malaria control programmes from the 1920s onward, was discontinued when the eradication campaign was abandoned in the 1970s. As a result, the wealth of meteorological information that exists today, especially in the ministries of agriculture in any country is not exploited sufficiently for malaria control. High temperatures, changes in rainfall patterns or floods are good predictors of epidemics, but these parameters are seldom used in the epidemiological context although they are becoming more relevant as a result of the global climatic changes that are now occurring.

Temperature

Temperature is the major factor influencing development of mosquitoes and malaria parasites within them. The former are less sensitive to temperature. In northern Eurasia, Anopheline mosquitoes can breed in water at temperatures above 10°C, and may bite at 7°C (*An. messeae)*. The lower threshold of development of *P. vivax* sporozoites is much higher, 16°C, although sporozoites can survive for a few days at lower temperatures, but without development. This means that temperature would act as a limiting factor through the parasite, not the vector.

Due to a better adaptation of *Anopheles* to the cold, "Anophelism without malaria" occurred in parts of northern Europe and northern Asia in the pre-eradication era. When the temperature is slightly above the threshold of development of the parasite in the mosquito, sporogony is so slow that only a few mosquitoes survive up to the infective stage. For example, at average daily temperatures of 18°C the development of *P. vivax* sporozoites takes about 30 days which is well beyond the median life span of the vector mosquitoes. In this case, malaria transmission cannot be excluded, but may occur at a very low level.

About 20 temperature indicators are used by meteorologists. Out of them, only the average daily temperature (ADT) should be retained, since the relationship between this variable and the rate of development of *Plasmodia* of different species is well known.

Rainfall

Rainfall is important for the availability of vector breeding sites.

The effect of rainfall depends on the breeding habits of mosquitoes. It may boost the proliferation of species that breed in running water and suppress those that prefer stagnant water and small pools. Most spectacular is the effect of heavy rainfall in semi-arid and arid areas. It may be followed by epidemics that start 3–4 weeks after the rain, an event that has been observed in Khartoum (Sudan) and Djibouti.

Not only is the overall amount of precipitation essential, but also the rate. Heavy rainfall produced within a few hours would flush out breeding places, whereas the same amount spread over a few days would facilitate breeding. Thus rainfall should be monitored on a daily basis, and good indicators are the total rainfall and the number of rainy days.

A lack of rain by itself is not critical for malaria if there are permanent springs, rivers, wells and underground cisterns. Typically, malaria used to be present in desert oases, where, by definition, the amount of rainfall is less than 200 mm per year. Malaria endemicity might be high and fairly stable in oases. In north African countries, the oases in the Sahara Desert were the last refuges of malaria when the remainder of the country had been freed from transmission (Algeria, Egypt, Libyan Arab Jamahiriya and Tunisia).

In arid areas, an important indicator is the level of water in rivers. Its rise due to rainfall occurring hundreds of kilometres away has been known to produce epidemics, for example in Khartoum in Sudan, and in the valleys of Juba and Shebelle in Somalia.

Phenology

Phenology is "the study of the times of recurring natural phenomena, especially in relation to climatic conditions". Examples of such times are when plants bear fruit, the leaves fall from the trees in autumn, new leaves appear in spring, and the arrival, nesting and departure of birds. It applies also to the timing of events in the life of malaria vectors. The most important for temperate areas are:

- the date of the first emergence of females after hibernation;
- the date of the mass emergence of the first generation of mosquitoes; and
- the date of mass retreat of female mosquitoes in the diapause into hiding places.

Most programmes designed to eliminate malaria foci are in areas with seasonal malaria transmission due to marked variations in temperature. In such situations, Moshkovsky [5] proposed a method to assess the most critical phenological features of a malaria season, which are:

- the date of commencement of the period of effective infectivity, i.e. the period during which effective development of parasites in the vector species, to complete maturation, is possible;

- the date of the first mosquito–man transmission in the current season;
- the date of the last effective infection of the vector species.

The concept of agricultural science holds that the growth of a plant is dependent on the total amount of heat to which it is subjected during its lifetime, accumulated as degree-days. By analysing the speed of development of *Plasmodia* in controlled experiments, Moshkovsky discovered that the same concept is applicable to the developmental stages of the parasite in mosquitoes. He therefore calculated the critical parameters for *P. falciparum*, *P. vivax* and *P. malariae*. For each parasite species, the fundamental parameters are threshold temperature (temperature below which the parasite does not develop), base temperature and the "sums of temperatures" above the base temperature required for completion of sporogony (Table 1).

At the threshold temperature, the development of the parasite takes an indefinitely long time. Practically, the development of *P. vivax* requires at least 16°C, and that of *P. falciparum* and *P. malariae* 17–18°C. However, in temperatures above 30°C, the conditions for the development of the parasite worsen, and at 37°C sporogony becomes impossible.

Table 1 Temperature requirements of sporogony

Species	Lower threshold of development A	Base temperature B	Required sum of temperatures above the base temperature, degree-days C
P. vivax	16°C	14.5°C	105°C
P. falciparum	18°C	16°C	111°C
P. malariae	18°C	16°C	144°C

To calculate the number of days for the complete maturation of sporozoites to be achieved, at any given average daily temperature, the following formula can be used:

Duration (in days) = **C** / (average daily temperature – **B**)

For example, at 19°C, the development of *P. vivax* would take

C/(19 – **B**) = 105/(19 – 14.5) = 23 days.

Here 19 – 14.5 = 4.5°C is the effective temperature, which is accumulated by the parasite during a day. At variable temperatures, the effective temperatures are calculated for each day and added together. Only days with temperatures above the threshold (**A**) are counted, i.e. above 16°C for *P. vivax* and above 18°C for other species. When the sum of temperatures comes up to the required sum, this signals the completion of the maturation of sporozoites.

This method may be a useful tool for epidemiological analysis, however there are several uncertainties that affect the results. The initial basic measurements were made on a limited number of strains. There is no absolute certainty that tropical strains would behave in the same way as strains in temperate climates. Temperatures used are from the nearest meteorological station, not from the mosquito resting places and the average daily temperatures indoors and outdoors may differ by several degrees. The impact of a temporary drop in temperature below the development threshold has not been fully quantified. However, it is known that sporozoites recover and continue their development after a short drop of temperature. Sporozoites of *P. vivax* are more tolerant to a fall in temperature than those of *P. falciparum*. Sporozoites near maturity are more tolerant than early sporozoites; deeper temperature drops kill more sporozoites.

Practical use of meteorological data

In countries, where an interruption of malaria transmission is feasible there is usually a good network of meteorological stations. However, information for specific foci is, as a rule, unavailable and needs to be interpolated from the data of the nearest stations. Such interpolated information may be dependable in plains but not in mountainous areas where the altitude and orientation of slopes greatly modify the climate. If the difference in altitude between the given place and the meteorological station is known, a correction may be made by assuming that the temperature drops by 1°C with every rise of 300 m of altitude.

The minimum meteorological parameters required for practical purposes are average daily temperatures for the period that temperatures are above the lower threshold of sporozoite development and daily rainfall from which monthly rainfall and number of rainy days can be calculated. In addition to real time measurements, averages over the past 10–20 years are to be considered the normal values against which current values can be compared to observe any anomalies.

Additionally, meteorological patterns should be known for the past years during which epidemics took place. This will help to identify similar patterns in real time, which might be a warning sign that the conditions are propitious for an epidemic. Time-wise, information obtained for the current year through prospective monitoring needs to be compared with the normal seasonal situation in order to be able to judge whether the meteorological features are advanced or delayed.

Human factors

In addition to general information on the population and their activities, which is needed by any health programme, information that is more specific to malaria is needed at the level of foci, as follows:

- use of water resources such as for domestic purposes, fishery, irrigation;
- availability of tap water, which would reduce the need to preserve rainwater in households, thus reducing the risk of mosquito breeding;
- condition of wells, whether they are suitable for mosquito resting and whether there is water spillage which may serve as breeding places;

- irrigation, its seasonal patterns, condition of the irrigation network;
- timing of agricultural activities, especially during the harvest;
- any economic activities requiring spending evenings and nights outside the houses;
- sericulture (rearing silkworm) and apiculture (rearing bees), as this may interfere with the acceptability of insecticide use
- migration patterns, daily, seasonal;
- sleeping habits, time and place;
- using of mosquito nets or screening;
- illegal activities, such as smuggling and cultivation of narcotic plants, as these make people secretive and lead to clandestine migration;
- attitude to malaria, such as whether it is considered an important disease, and whether vectors are recognized;
- malaria treatment habits, especially self-treatment, which at the stage of elimination of foci seriously interferes with the case detection;
- attitude to spraying, such as whether it is welcome or regarded as a nuisance, and whether it is the practice to re-plaster or paint the walls after spraying.

The presence of various groups of people that may not be included in the normal surveillance mechanism should be specifically noted. These may be:

- groups that are not adequately covered by health services: nomads, newly arrived settlers and squatters, migratory workers, especially seasonal ones;
- groups that have their own health services, often far away from the places of their work such as maintenance workers (railway, communications), police personnel, jail population, border patrols and, especially, the military;

  Note: The presence of military camps in the area is a serious risk factor for malaria, because of the secretive character of their activities and far-flung displacements of their personnel unknown to the civil administration.

Epidemiological information

Overview

When the programme has reached the stage of elimination of foci, the cases should be relatively few. In this situation the conventional malariometric indicators, like API (annual parasite incidence) or SPR (slide positivity rate) become practically meaningless in the epidemiological analysis. The indicators used must determine whether malaria transmission is continuing. The measures to be implemented must be selected accordingly.

All cases detected in the area should be subjected to a thorough epidemiological investigation. This procedure is not mandatory and may even be counterproductive in areas where the interruption of transmission is not envisaged. The resulting epidemiological diagnosis of the case should include place, time and source of the infection. The presence of particular classes of cases is the basis for classification of foci and, consequently, the selection of antimalarial measures for individual foci. Case detection processes at this stage include active and passive case detection, with emphasis on the latter.

Whereas establishing collection quota is seldom productive, the annual blood examination rate (ABER) should be at a sufficient level of about 10%. Insufficiency of regular blood collection cannot be compensated by mass blood collection. Blood examined from such collections should not be included in the ABER. The principle of total coverage is still valid. Even the smallest localities ought not to be neglected. It is an established fact that malaria tends to disappear more slowly in the smallest places.

Epidemiological investigation of cases as a basis for classification of foci

Definitions

For this purpose, a malaria case is "a person in whom, regardless of presence or absence of clinical symptoms, malaria parasites have been confirmed by microscopy".

A fever case is a person whose axillary temperature is raised beyond 37.5°C. In *P. vivax* malaria, the temperature is often elevated only during a fraction of the two-day cycle of development of the parasite. Thus, when the patient is in contact with a health worker the temperature may actually be normal. Such cases should also be considered fever cases. Fever cases in endemic situations are often diagnosed as "clinical malaria"; however, at the stage of elimination of foci only parasitologically confirmed cases are accepted as malaria cases.

At present, some cases are detected by one of the rapid diagnostic tests. A blood smear from all such cases should, as standard practice, be examined microscopically by an experienced person, and only then recorded as a confirmed case.

The epidemiological investigation is an integral part of a surveillance operation. It is concerned with ascertaining the origin and means of acquisition of all malaria cases discovered. It is also to determine the existence and nature of any malaria foci in the neighbourhood and establish whether transmission is taking place and, if so, its source.

Five categories of malaria case are recognized [1] on the basis of mode of transmission (by blood or by mosquitoes), place (in a particular locality or area, or outside it), time of transmission (recent or not), and source of infection (Annex 1). These are:

- induced case, a case induced by contamination with infected blood;
- imported case, a case contracted outside a given place;
- relapsing case, a case contracted locally some time ago (maximum admissible period = natural life-span of *P. vivax* or *P. ovale* in the human host) or a recrudescence of *P. falciparum* or *P. malariae* after a period of unrecognized latency;
- introduced case, a case contracted locally from an imported case; and
- indigenous case, a case contracted locally from any other category of cases, including other indigenous cases.

In most instances sufficient information is not available to differentiate between relapsing, introduced and indigenous cases, therefore these 3 categories are usually grouped together in one category which is called "autochthonous", that is, cases due to local transmission by mosquitoes.

The notion of place of contracting infection is relative. At the level of a locality, any case contracted in a neighbouring village would be an imported case. At a district level, the same case would be an indigenous case of the district. Similarly, imported cases are often distinguished as internally imported, that is from one to another locality of the same district, or from one to another district of the same province, or externally imported, i.e. from abroad.

Epidemiological information is rarely complete. For example, it is still practically impossible to demonstrate, by examining blood specimens, that a source for a given case was another known case, unless the case is induced by contaminated blood. When there are only two cases in a locality, one imported, another emerging after sufficient time for the extrinsic development of the parasite, the probability that the former is the source of infection of the latter is high. However, even if it very is high indeed, it is not 100%. There might be always a possibility that the source was a third case that remained unknown.

In case of serious uncertainty, the principle is to accept a graver category. It is always good practice at this stage of a programme to err on the safe side. That means accepting that the case is indigenous if there is no reliable proof that it is introduced, for instance based on the timing and temperature. The principle of accepting a more serious hypothesis is in the interests of success.

It should be noticed that the above classification does not cover all the conceivable categories. Those not taken care of are:

- cases of transmission by migrant infected mosquitoes, as in cross-border malaria and cases of "airport and sea port malaria", in which infected mosquitoes are imported by aircraft or ship; and

- cases of infection by mosquitoes in laboratories, which may be sometimes intentional, sometimes accidental.

The latter category has probably not much significance, but the former is an important epidemiological phenomenon. This category has neither a specific name nor a place in the case classification as yet (Annex 1).

Common errors of identification

Although the principle of accepting a more serious hypothesis is in the interests of successful control, it is often not accepted by decision-makers who want to demonstrate the success of the programme. Hence, unfortunately, it is not uncommon for indigenous cases to be called introduced cases without proper justification.

The category of "cryptic case" (unknown origin) is sometimes misused on the same grounds. It is better to exclude this category altogether, since its existence contradicts the above principle.

Confusion often arises in relation to the relapsing case, probably because of its name, which leads to a confusion between a clinical relapse and a relapse of a focus activity.

A relapse in a clinical sense is any repeated manifestation of a disease in an individual. In the context of malaria, however, the term "relapse" is reserved to a renewed manifestation of an infection arising after temporary latency from the activation of hypnozoites. It is therefore limited to infections with *P. vivax* and *P. ovale.* Renewed manifestations of infections with *P. falciparum* or *P. malariae* are termed recrudescences since they originate from latent blood forms. In epidemiological terms, however, a relapsing case is a renewed manifestation of a focus. The purpose of this category during the WHO malaria eradication campaign was to distinguish cases that were contracted before the interruption of transmission from cases that emerged because of a renewed transmission. This was necessary because *P. vivax* and *P. malariae* especially may emerge after several years of latency. Thus, "relapsing" is a case of a pre-existing infection, as shown by the history of the case and the absence of any associated cases in the neighbourhood. If it is suspected that the relapse refers to an infection contracted after the period in which transmission was said to be interrupted then the case should not be classified as relapsing, but as indigenous" [6]. The existence of a relapsing case can be proven only in areas with no transmission. If transmission continues, there is no way to prove that a given case is not indigenous or introduced due to recent transmission.

Operational classification of foci

A WHO classification of malaria foci [1] classifies foci depending on their age (residual or new), and presence of malaria transmission (non-active, active or potential). As a result, four types of foci may be distinguished:

- residual non-active: transmission interrupted, no indigenous cases, but possible occurrence of relapsing ones;
- residual active: transmission not interrupted;
- new potential: presence of imported cases, no evidence of transmission but its renewal is possible;
- new active: renewed transmission—first degree, only introduced cases present, or second degree, malaria established and indigenous cases are present.

This classification leaves out the localities that were formerly malarious and where transmission has not existed for a long time. It also does not distinguish between residual foci with a diminished level of transmission, as the word "residual" implies, and foci in which malaria has returned to its primordial state. That is why it seems justifiable to add two more categories, which may be called "cleared-up" and "endemic".

For completeness of the picture, pseudofoci should be also added to the list. Passive case detection should be organized in such localities as well. It so happens that cases detected in pseudofoci can lead to the detection of continuing transmission in some of the neglected foci in the malarious area. If this is done, then every locality of the area may be categorized. A key for the identification of foci is given in Annex 1.

The status of every focus should be periodically reviewed and re-categorized when necessary. The basic assumption is that in areas with seasonal malaria transmission the overwhelming majority of vivax cases emerge during the summer and autumn of the year when transmission has taken place (short incubation) and during the next year, from March to October (long incubation and relapses). It is extremely rare for the duration of the primary latency to exceed 18 months. In other words, if there are no secondary cases from an imported one by the end of the next year, it is likely that no transmission took place at all. All this is applicable only to foci where surveillance is adequate.

The status should be revised immediately when new malaria cases of any sort appear. The focus should be re-categorized from a cleared-up into a potential or a new active, if the conditions for transmission of malaria exist during the presence of the cases in the focus.

By the end of a year, potential foci without cases during the period of effective infectivity of the last and current year, may be re-categorized into cleared-up ones. The same applies to residual active foci which may be re-categorized into residual non-active. Residual non-active foci may be re-categorized into cleared-up foci after one or two years without evidence of transmission. Individual programmes may adopt longer periods, based on their experience. Figure 2 depicts the transition of the functional status of a focus depending on the local situation.

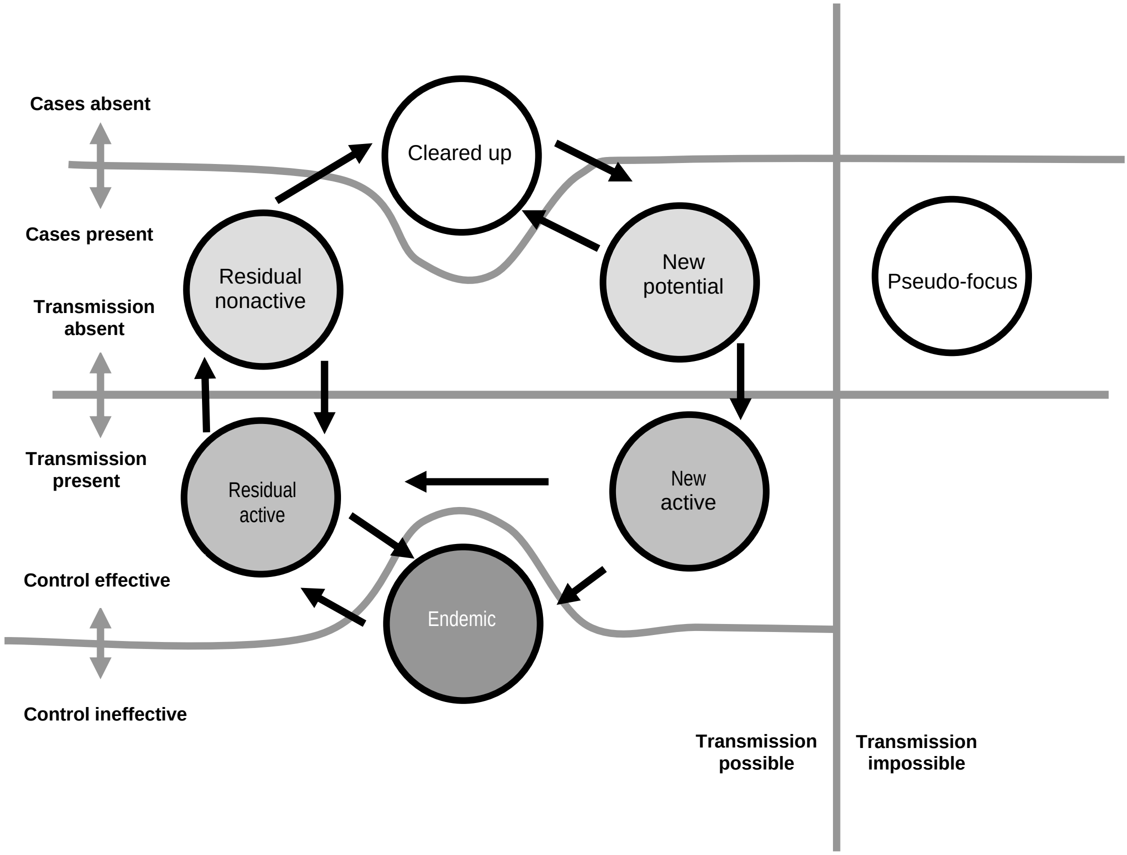


Figure 2. Transition of functional status of a malaria focus depending on the situation

4. Selection and application of measures

Overview

The purpose of antimalarial measures at the stage of elimination of foci is to:

- achieve a sustainable interruption of malaria transmission;
- deplete the reservoir of infection; and
- prevent the re-establishment of malaria from the same area, from the same country or from abroad.

The action to interrupt transmission should be swift, energetic and occupy a minimum of time. At the same time, prevention of reintroduction of malaria is a long-term policy that requires continuous investment of funds and personnel, albeit on a smaller scale than before the elimination of transmission. The relevant mechanisms should be integrated into the primary health care system, but guided by specialized units at national, provincial and sometimes district level and developed before the interruption of transmission. For interruption of malaria transmission, a two-pronged action is required aimed at disease management (alleviation of symptoms and prevention of infection of mosquitoes) and disease prevention through vector control.

Since at this stage of malaria control, usually only transmission of the relatively benign species *P. vivax* takes place, emphasis is placed on the early elimination of the source of infection. Chloroquine, the drug of choice in most endemic areas, is active against gametocytes and inactivates them within hours. Chloroquine clears also asexual parasitaemia (provided the parasite is fully sensitive to it) leading to a cessation of symptoms within 2–3 days, thus taking care of both problems.

The main aim of vector control is to reduce the longevity of female mosquitoes to below the time required for development of sporozoites which is often (but not always) tantamount to a reduction in the densities, or even elimination, of the vectors. Reduction of man–vector contact, and strengthening of personal protection are other means of vector control.

There is no all-purpose prescription for antimalarial measures applicable to all ecological conditions and all stages of foci elimination. Selection and application of antimalarial measures has to be based on an epidemiological approach that takes into consideration the natural pattern of transmission and ecological conditions of the area in question. It should also take into account the history of antimalarial activities in the area, their success and failures. Several different types of measures will have to be used, but not too many, in order to be operationally feasible and amenable to evaluation.

The following parameters should be considered when selecting measures:

- expected effectiveness;
- cost;
- operational applicability, which depends on the accessibility, logistics, etc.;
- ecological compatibility (minimal side-effects that might be harmful to people and/or the environment);
- suitability for the local epidemiological conditions;
- acceptability by the population; and
- administrative applicability, which depends on the availability of organizational structure, trained personnel, financing, transportation, legal support, professional direction and public information.

Detection and treatment of cases

Case detection should be enhanced in residual active foci that show signs of refractoriness. Additional health posts may need to be established to improve passive detection. A mechanism should exist to recognize people who were contacted at health facilities (passive detection) in order to guide the active case detection. A computerized database would be the best solution.

Active detection should emphasize quality rather than numbers of blood slides collected. Qualitatively adequate active case detection implies visits to every house at the time most members of the household are at home. Every effort should be made to visit the houses that have been missed, or were locked. An attempt should be made to contact people who were absent during the visit, even if there was somebody in the house that could have responded by proxy. This may necessitate revisiting the village.

The norms may be less rigid in foci that have demonstrated a good response to the measures that have been implemented.

The principle of total coverage should be applied to case detection. All the inhabited houses need to be visited, even if their population is said to be covered by autonomous health services, such as those of railways, large industry etc. A good rapport has to be established with the military medical services, especially if military camps are located in the area. Military personnel should be subjected to case detection in a synchronized manner based on the same policy. The same applies to jails and similar institutions.

Special emphasis should be placed on the smallest and most remote villages and groups of houses. It is well known that malaria tends to take refuge in such places, as they are often neglected and not adequately covered by the health services.

The indication for a blood examination for malaria is any febrile disease (history of fever or presentation with fever) with no other obvious explanation. Slides should be examined on the spot (passive centres and mobile teams) or promptly dispatched to a laboratory for rapid examination. In practice, this is often a big problem; delays of 1 or 2 weeks are common, even in the more successful programmes.

To neutralize the source of infection and prevent infection of mosquitoes, presumptive treatment has been recommended. Presumptive treatment usually consists of an administration of the first curative dose of chloroquine, which suppresses parasitaemia for a number of days. Administration of 25 mg of pyrimethamine as a sporontocide has also been advocated. Such a dose does not suppress the clinical symptoms, but will deactivate gametocytes for a period of about a week.

However, concern has been expressed that by the time the programme has reached this stage, the number of malaria cases is so low, that the majority of fever cases would receive the drug unnecessarily. It may be agreed that there is really no need for presumptive treatment if the laboratory diagnosis can be made within the same day, but if not then there is no serious alternative. However, the cost of this approach versus the use of a rapid test to detect *P. vivax* malaria antigen should be considered, bearing in mind the frequency of false positives and negatives. Whereas the former do not present a problem, the latter require confirmation by microscopy which increases the cost of running both systems in parallel.

Radical treatment of vivax malaria is usually by a combination of chloroquine for 3 days and primaquine for 14 days. Both drugs may be given concurrently, i.e. chloroquine with primaquine during the first 3 days and primaquine only for the remaining 11 days. Uncomplicated malaria cases usually do not need to be hospitalized. However, the treatment should be supervised by a health worker. This is important since many patients do not feel that they need to take medicine for about 10 days after they have apparently been cured. Many think also that chemical drugs may harm them. Another point is that primaquine may produce haemolysis in patients with G6PD deficiency. Whereas such haemolysis is self-limiting if the drug has been stopped, it may be dangerous if the drug is continued. Therefore, health workers observing the treatment should enquire whether the colour of urine remains normal.

There are numerous deviations from the above suggested practice and in some countries, the following have become the norm.

1. Chloroquine only is given during the first 3 days, followed by 14 days of primaquine. There is no evidence to justify this practice which unnecessarily increases the period of treatment and the risk of non-compliance.
2. Hospitalization of malaria patients is mandatory for the whole period of treatment, including that with primaquine. The rationale is to improve compliance. However, this may be counterproductive. People who know the symptoms of malaria

and the drugs to be taken to stop fever avoid contacting the health personnel altogether, out of fear of being unnecessarily hospitalized for two weeks or more, which could be disastrous to the family, their work, business or schooling.

3. Shorter courses of primaquine are prescribed (5 days). Such courses may be effective in some geographical areas since it is known that there is a wide variation in the response of different populations of *P. vivax* to primaquine. However, careful studies should be undertaken to substantiate this practice.
4. A "consolidation treatment" is given which means administration of additional courses of treatment, usually after a few months or at the beginning of the transmission season. Such practices need to be justified with good scientific evidence.

Ensuring the supervised treatment of all *P. vivax* cases with primaquine may be cumbersome at the community level. If there are many cases during the season there would be always somebody undergoing treatment, and a health worker would be permanently busy with supervision. However, from a technical point of view it is not necessary to give the primaquine concurrently with, or immediately after chloroquine, provided the control programme is still at a relatively early stage. Primaquine targets hypnozoites, which would normally lie dormant for several months after the primary attack. That is why the treatment with primaquine may be delayed if this is advantageous from the operational point of view. However, it may be difficult to find the patient after some time, especially nowadays with increased population movements. Nevertheless, should such an approach be adopted, the cases may be accumulated, and treatment given concurrently to all the patients after the end of the transmission season. In this case, eventual cases of reinfection would be taken care of as well.

Mass drug administration

Mass drug administration using a radical treatment regimen of chloroquine and primaquine (14 days) has been used to achieve a rapid depletion of the reservoir of hypnozoites. The rationale is that cases of long incubation are many and there is no way to detect these people during the period of latency. The mass treatment is given to all those who resided in a focus during the last transmission season. It is applied just before the beginning of the next transmission season.

Mass treatment has proved to be very effective in briskly curtailing an epidemic. However, its implementation requires large numbers of drug distributors and supervisors, which may interfere with the routine health activities of these workers. It requires a very high degree of performance, a coverage approaching 100% and a very strict discipline. Cases of haemolysis, although rare, may create fear among the people about the safety of this measure. Therefore, this measure is considered justifiable in an emergency only.

So-called seasonal chemoprophylaxis consists of weekly administration of chloroquine or pyrimethamine to all the population during the season of transmission. This may lead to a decrease in or even elimination of clinical cases during the season of transmission. However, late manifestations will appear at high frequency during the next year. The cost-effectiveness of this method is questionable. The drug pressure may select for parasite resistance, whereas pre-seasonal (anti-relapse) treatment harbours such danger to a lesser extent.

Antivector measures

Antivector measures are indicated in the case of continuous transmission.

Antilarval measures

Larval control is indicated under specific conditions when breeding places are well-defined and limited in size, particularly in arid and semi-arid areas. This measure is costly because of the need for many repetitive applications during the season. It requires the use of insecticides that are not toxic for non-target organisms and vegetation, such as the chemical temephos (Abate®) and the biological agents *Bacillus thuringiensis* or *Bacillus sphericus*.

Distribution of larvivorous fish may be a good additional measure in subtropical and tropical environments where fish such as *Gambusia, Tilapia* and other mosquito predators are part of the local ecosystem.

A more long-lasting effect may be obtained through environmental projects (drainage, clearing of drains, flushing, drying out). However, many breeding places are of economic, recreational or aesthetic value and cannot be disposed of easily.

Furthermore, the reduction of mosquito breeding may decrease malaria transmission, but only exceptionally to the extent required for its cessation.

Indoor residual spraying

This is the most effective method. Indoor residual spraying selectively eliminates mosquitoes feeding on potential parasite carriers, without affecting much the zoophilic part of the mosquito population. It has, however its limitations such as resistance of the human population, concern (often unfounded) about adverse ecological impact, and high cost of and resistance to insecticides. Its application is almost impossible in big cities. This increases the role of larval control in urban malaria, which is facilitated by the fact that there are not many suitable breeding places for Anophelines, in contrast to Culicine mosquitoes which can thrive in highly polluted environments. Paradoxically, improved sanitation and a decrease in pollution may lead to an increased proliferation of malaria vectors in highly urbanized areas.

Personal protection

Personal protection, in the form of insecticide-treated mosquito nets is very much advocated for control of malaria in endemic conditions. It effectively decreases the number of infective bites and diminishes the severity of malaria. This method alone, however, cannot lead to an interruption of malaria transmission.

Role of general and specialized health services and other sectors

Elimination of malaria transmission requires inputs from, and cooperation of, all health sectors. As detection of every malaria case is of paramount importance at this stage, ensuring full collaboration of the private health sector is extremely important.

However, even in integrated health services, a specialized antimalaria component should exist. Its role is to plan, guide and monitor strategy implementation and to perform evaluation and interpretation of results. At the same time, most of the work in the field is to be done by the general health services. This includes case detection, clinical and parasitological diagnosis, the provision of treatment, advocacy and health education. Every health worker at the first level of contact needs to be well trained in how to recognize potential cases of malaria on clinical grounds and where to refer cases for diagnosis and treatment.

Control of malaria vectors should be part of an integrated vector control programme and a specialized component of the public health services.

It will not be possible to achieve and sustain interruption of malaria transmission without intersectoral collaboration. Some of the services that should be involved in antimalarial activities are:

- public works services, to assist environmental management and help prevent the creation of new breeding places through careful planning and implementation of construction projects, such as dams, reservoirs, roads and other public works activities;
- meteorological services, to provide the meteorological information needed for epidemiological analysis and as part of an early warning system to signal a change in malariogenic potential and to avert the occurrence of epidemics;
- agriculture sector, to promote safe irrigation and agricultural methods, for instance in rice cultivation;
- Education sector, to incorporate the dissemination of information on malaria and its prevention into the school and university curricula;

- communication services, to be instrumental in organizing transfer of blood slides from the field to laboratories, prompt transmission of epidemiological information and provision of connectivity by radio, telephone and internet; and
- military, to promote malaria prevention and control among the service personnel, contribute to the surveillance system, and exchange epidemiological information with the general health services;
- tourism and travel sector, to increase awareness of malaria among travellers.

5. Evaluation and monitoring

Monitoring and evaluation are inseparable, being a continuous process that:

- measures accomplishments and checks the achievement of operational targets;
- helps to establish priorities for resource allocation and programme activities;
- determines effectiveness, highlighting strong and weak points and the reasons for success and failure;
- determines and controls costs;
- enhances efficiency, performance and quality;
- provides information for re-planning that would lead to corrective actions; and
- contributes to modifying programme technology.

An evaluation component has to be an integral, built-in feature of any strategy for malaria control. Planning, implementation, evaluation and re-planning must be a continuous cyclical process. Evaluation methods must be related to the objective, which in this case is the interruption of malaria transmission. Evaluation tools should be selected with attention to simplicity, cost and validity of the information obtained.

Evaluation concentrates on three issues:

- appraisal of the operational aspects of the programme to ensure that the activities lead in the right direction towards achieving the operational targets and objectives;
- the epidemiological status that derives from the activities implemented; and
- the interpretation of the results in the light of the operations performed.

Evaluation of impact should demonstrate whether interruption of malaria transmission has been achieved and, if not, how close the programme has approached this objective. The indicator will be the distribution of the foci by categories, with special reference to the active foci. Transition of foci should be monitored, with an emphasis on new potential and new active foci. Another form of the same impact indicator would be the absence or presence of cases due to recent transmission (indigenous, introduced), provided that adequate coverage in space and time has been assured.

The indicators for control programmes that are important at an earlier stage of implementation, such as incidence of malaria, proportion of severe cases and mortality due to malaria, become less important at this stage.

Regarding the **quality of information on foci**, the following questions should be answered satisfactorily.

- Is the list of foci complete?
- Are there any foci missing?
- Are visits by the malaria control team to update the status of the foci regular?
- Are all the foci adequately and regularly covered by blood examination, judging by monthly blood examination rate?
- Are all the cases subjected to an epidemiological investigation?
- Is this investigation conducted correctly?
- What is the percentage of incorrect epidemiological diagnoses and classifications?

Similarly, the following questions should be answered satisfactorily for the **case detection and treatment:**

- Are all fever cases tested for malaria parasites in the blood?
- Does the quality of the laboratory examination meet the accepted norms?
- Is the detection of the cases timely?
- Was the quality of the treatment in terms of dose, duration, completeness, supervision, and follow-up in accordance with established guidelines?

Concerning **timeliness of case detection**, this may be answered by measuring the average spans between the dates of the events listed below. Such a detailed analysis will allow the calculation of the average delay between the onset of symptoms and inactivation of the source of infection by treatment. It will also give some indication of the location of any bottlenecks, at the level of the patient, transport, laboratory and other key points.

- Date the symptoms began
- Date of first contact with the health services
- Date of the first collection of blood for malaria diagnosis
- Date the blood specimen arrived in the laboratory
- Date the blood was examined
- Date the results were made known to the attending doctor/nurse
- Date radical treatment was given

Concerning **mass drug administration,** the following questions are relevant.

- Is mass drug administration technically justified?
- Was the population coverage per round, with reference to age, gender, and acceptance rate satisfactory relevant to the strategy?
- Concerning larviciding, it is essential to know the following.
- Is the operation justified?
- Are there any missed breeding places, and if so their location and percentage of the total?
- What are the frequency, regularity and dosage of the larviciding application (chemical or biological)?
- What is the frequency of finding anopheline larvae following insecticide application?
- What is the regularity and coverage of entomological monitoring of the breeding places?
- Are the larviciding techniques being applied correctly?

Concerning **indoor residual spraying** it is essential to know the following:

- Is the operation justified?
- Is the selection of the insecticide, dosage and timing of application sound?
- Is the quality of the spraying up to standard, as determined by spot checks of dosage and date of application of insecticides?

- Is the coverage sufficient in terms of the number of structures (human dwellings, cattle sheds) sprayed in relation to the targets?
- Is the spraying accepted by the people, as reflected in the refusal rate?
- What is the re-plastering rate inside the houses?
- Are the vectors susceptible to the insecticides being used?
- What is the impact of the spraying on the age structure of the adult mosquitoes as evidenced by the proportion of nulliparous specimens and the presence of mosquitoes that are of an epidemiologically dangerous age?
- What is the regularity and coverage of entomological monitoring of adult mosquitoes, and the correctness of the techniques used?

6. Conclusions

Despite technical problems in malaria control, such as resistance of vectors to insecticides and of malaria parasites to drugs, effective tools for the elimination of malaria transmission are still available. With these tools, elimination of active foci of malaria is achievable and sustainable in a number of geographic areas.

Essential prerequisites for success are: political commitment, well managed and effective health systems in place, a functioning health infrastructure, well designed and managed epidemiological and management information systems, capacity for operational and health systems research, adequate funding, careful planning based on an epidemiological approach, trained human resources and good programme management.

References

1. *Terminology of malaria and of malaria eradication: report of a drafting committee*. Geneva, World Health Organization, 1963.
2. Beklemishev VN. The problems of epidemiology and epizootology of tick-born encephalitis. *Med. Parazitol. Parazit. Bolezni*, 1959, 28:310–318 [in Russian].
3. Beklemishev VN. Spatial and functional structure of foci of infections with special reference to malaria and tick-borne encephalitis In: *Biocenologicheskie osnovy sravnitel'noj parazitologii.* "Nauka", Moscow, 1970, 466–469 [in Russian].
4. Hawking SW. *A brief history of time.* London, Bantam books, 1988.
5. Moshkovsky ShD. 1946 On the dependency of the speed of development of *Plasmodia* of malaria on the temperature. Part 1. *Med. Parazitol. Parazit. Bolezni,* 1946, 15:19–28 [in Russian].
6. Pampana E. *A textbook of malaria eradication.* London, Oxford University Press, 1969.

Annex 1

Classification

a) Key to the epidemiological classification of cases

1. HOW was the case contracted?

• By blood	induced
• By mosquito	go to 2

2. WHERE was the case contracted?

• Outside this place	imported
• In this place	go to 3
• In this place	autochthonous

The process of classification may be stopped at this point. For more detailed classification (which is not always possible, due to insufficiency of information), two additional questions are asked, to subdivide autochthonous cases into three subcategories (see pp. 25-26):

3. WHEN was the case contracted?

• Long ago (e.g. > 2 years)*	relapsing
• Recently	go to 4

4. FROM WHOM was the case contracted?

• From an imported case	introduced
• From any other case	indigenous

b) Key to the operational classification of foci

1. Availability of conditions for transmission of malaria
   - No, throughout the year — pseudofocus
   - Available, for a period which is sufficient for the maturation of sporozoites — go to 2
2. History of a recent transmission (e.g. during the last 2 years)*
   - No — go to 3
   - Yes (presence of introduced and/or indigenous cases) — go to 7
3. Presence of cases
   - Present — go to 4
   - Absent — cleared up
4. Effective infection of mosquitoes
   - Possible — go to 5
   - Impossible (e.g. an imported case arrived during a seasonal break of transmission and having received an antigametocyte treatment before the onset of the effective infectivity) — cleared up
5. Categories of cases present
   - Only induced or imported or relapsing cases — new potential
   - Other categories also present (introduced and indigenous) — go to 6
6. Presence of indigenous cases
   - No — new active grade 1
   - Yes — new active grade 2

* * *

7. Presence of indigenous cases
   - No — residual non-active
   - Yes — go to 8
8. Effectiveness of control**
   - Transmission is effectively controlled — residual active
   - No effective control — endemic

Notes:
* the exact duration of the period should be decided by the programme
** criteria for the effectiveness of control should be specified by the programme

Elimination of the residual foci of malaria transmission is a dynamic process, taking place mainly during the late stage of the attack and consolidation phases of malaria elimination. This approach is suitable for countries or areas that are targeting interruption of malaria transmission in their territories. Countries can plan for a selective elimination of *P. falciparum* foci in the first stage, to be expanded to *P. vivax* at a later stage when more resources and a stronger programme are available. During the past 15 years several national malaria programmes in the WHO Eastern Mediterranean Region adopted elimination strategies. It is the vision of the Regional Office for the Eastern Mediterranean to expand malaria-free areas at sub-regional level and to support new initiatives wherever feasible. These guidelines on the elimination of malaria transmission foci provide information on identification of foci of malaria transmission, epidemiological classification, selection and application of appropriate measures and monitoring and evaluation of implemented interventions. The publication is targeted at policy and decision makers, malaria programme managers at national and sub-national levels, and field staff. It can also be used in training courses on planning and management of malaria elimination.

9 789290 215769