THE MANAGEMENT OF MALARIA OUTBREAKS

GUIDELINES

Malaria Working Group MSF

Preface

These guidelines are meant for use by staff members at headquarters and in the field, confronted with a malaria outbreak alert, or a suspected or confirmed malaria outbreak due to Plasmodium falciparum. They can also be used in the framework of emergency preparedness and related training.

As there is no clear-cut definition of a malaria epidemic, these guidelines provide an overview of the different elements that need to be taken into account when assessing and interpreting a suspected outbreak in order to determine the relevance of an intervention and the appropriate course of action in the event of an outbreak.

The recommendations in this paper, prepared by the Malaria Working Group of Medecins Sans Frontieres (MSF), are based on extensive field experience mainly in MSF settings. This document is not aimed at directly addressing malaria in complex emergencies brought about example by major population displacements, or conflict and natural disasters; guidance on this can be found in the intersectional manual "Malaria Control in humanitarian emergencies, an interagency field handbook" (see recommended reading), prepared with a large input from MSF. Similarly, malaria control in areas with a permanently high burden of malaria is not addressed either. This requires a different approach, with different time perspectives.

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Abbreviations

ACT	artemisinin based combination therapy
CFR	case fatality rate
HQ	headquarters
HRP2	histidin rich protein-2
IPD	inpatient department
IRS	indoor residual spraying
LN	long lasting insecticide treated net
MSF	Médecins Sans Frontières
OPD	outpatient department
Pan pLDH	pan parasite lactate dehydrogenase
P.*f*	Plasmodium *falciparum*
RDT	rapid diagnostic test
SD	standard deviation
SMC	seasonal malaria chemoprevention
TFC	therapeutic feeding center
WHS	water hygiene and sanitation

Recommended reading

Malaria Control in humanitarian emergencies, an interagency field handbook
http://www.who.int/malaria/publications/atoz/9789241548656/en/

Public Health Engineering in precarious situations, second edition, MSF 2012

THE MANAGEMENT OF MALARIA OUTBREAKS GUIDANCE PAPER

Malaria Working Group, December 2014

CONTENTS

1. Malaria epidemics, seasonal peaks and permanent high burden of malaria

Usual definition of an epidemic:
An epidemic, or outbreak, is an acute exacerbation of disease out of proportion to the normal, to which the community is subject

Definition of a malaria epidemic:
There is no universal definition of a malaria epidemic. The general consensus is that a malaria epidemic constitutes a sharp increase in malarial incidence among populations in which the disease is rare, or an unusual seasonal increase in malaria incidence in areas of low to moderate transmission.

Malaria epidemics, or outbreaks, need to be distinguished from:

- *seasonal malaria peaks (highest incidence during the malaria transmission season, linked to the rainy season)*
- *variations in morbidity and mortality in permanently high malaria burden regions*

NB. Seasonal peaks tend to vary from year to year, and areas with permanently high transmission rates may also experience some level of seasonal variation.

Figure 1 indicates how malaria peaks can be classified.

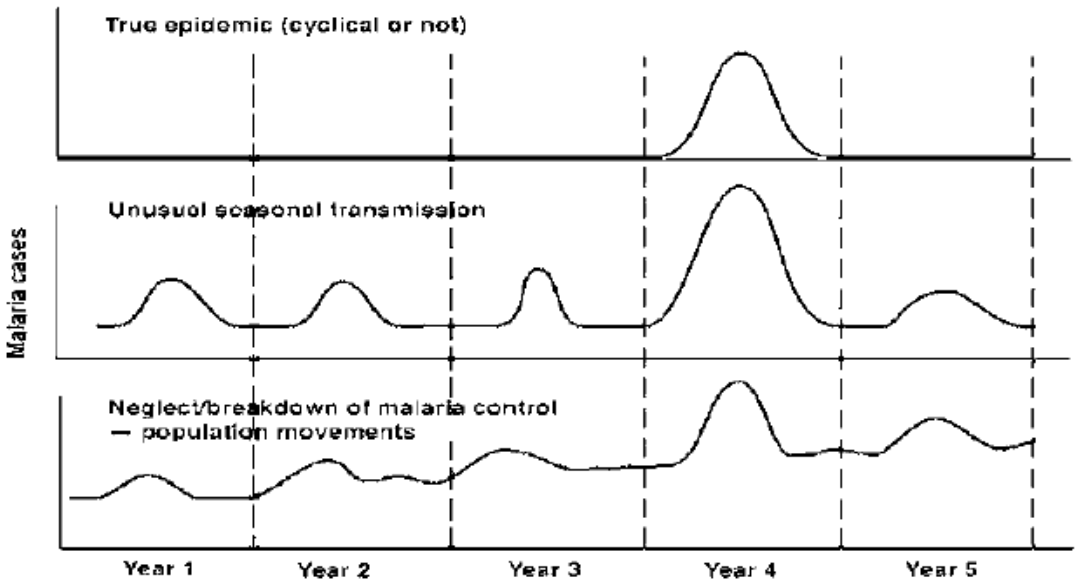


Figure 1. Classification of major epidemic types

(Source: WHO, 2002)

Stratification according to the level of endemicity, based on the prevalence of parasitaemia among children (usually based on microscopy, and including children 2-9 years)

- Hypoendemic: <10 %
- Meso-endemic: 11-50 %
- Hyperendemic: 51-75 %
- Holo-endemic: 76-100%

In hyper- en holo-endemic areas there is a permanently high malaria burden (also corresponding to "stable malaria") which is not the case in hypo-endemic areas (also corresponding to "unstable malaria"), with the meso-endemic situation in between.

Other situations and challenges to be considered:

- The prevention and management of an outbreak in specific populations, for example non-immune populations displaced to a malaria endemic area
- The management of malaria risk in complex emergencies

Why is this difference relevant?

- The population at risk is different :
  - In an outbreak or epidemic, the whole population is at risk of malaria disease and mortality.
  - In a high burden region, children under five are mainly at risk, while the rest of the population is less vulnerable secondary to developing semi-immunity.
- The interventions and management are different:
  - For example, in the case of an epidemic, a large scale intervention with control interventions (including vector control ***and*** curative interventions) may be needed and provided in a parallel/substitutive way, eventually through a vertical approach, where timeliness is of the essence.
  - In permanently high burden settings, first and second level health care capacity needs to be reinforced and malaria control activities have to be sustained over a long(er) period of time.

This document focuses on Plasmodium falciparum (Pf) malaria outbreaks and epidemics.

2. The evaluation of a situation in which a malaria outbreak is suspected

The evaluation has several components:

- *An evaluation of the likelihood of there being a malaria epidemic: is the area prone to outbreaks? Have there been previous outbreaks? Could hotspots of transmission be identified in previous outbreaks?*
- *A review of routinely collected data on malaria-related indicators, including retrospective data over several years*
- *Data collection on malaria-related indicators through a targeted investigation*
- *Collection of qualitative information, based on observations in the health care services and in the community*
- *Identification of the presence of potential triggering factors*
- *An investigation into the breeding and biting behavior of the malaria transmitting mosquitoes within the risk area*

Where routine data on malaria-related indicators are available, including historic data, these will provide a first basis for the assessment, even if the data are not considered to be fully reliable (as is often the case in malaria endemic countries). In the absence of routine data, qualitative information as well as quantitative information, collected for the purpose of the evaluation, will form the main basis of the assessment.

2.1. Is the region prone to epidemics?

An epidemic implies a malaria risk for the whole community *(see definition of an epidemic)*. Regions with a permanently high burden of malaria (where malaria is usually by far the most common cause of morbidity) are not considered to be at risk of epidemics as a large proportion of the population will have developed semi-immunity and will therefore be less vulnerable to disease, especially severe disease and mortality. And although seasonal variations are generally observed in regions with a permanently high malaria transmission rate, malaria transmission remains relatively high even in the "low" season. The same is applicable, albeit to a lesser extent, in areas with a high rate of seasonal transmission that lasts for a substantial part of the year, (e.g. six months of the year).

Areas at highest risk of a malaria epidemic are semi-arid and highland areas, where low levels of transmission during a limited number of months in the year do not allow for the development of a sufficient level of immunity in the population.

Figure 2 below shows the relationship between length of malaria transmission season (i.e. the level of endemicity – map on the left) and the risk of malaria epidemics (map on the right): the higher the level of endemicity, the lower the risk (and the potential impact) of malaria epidemics.

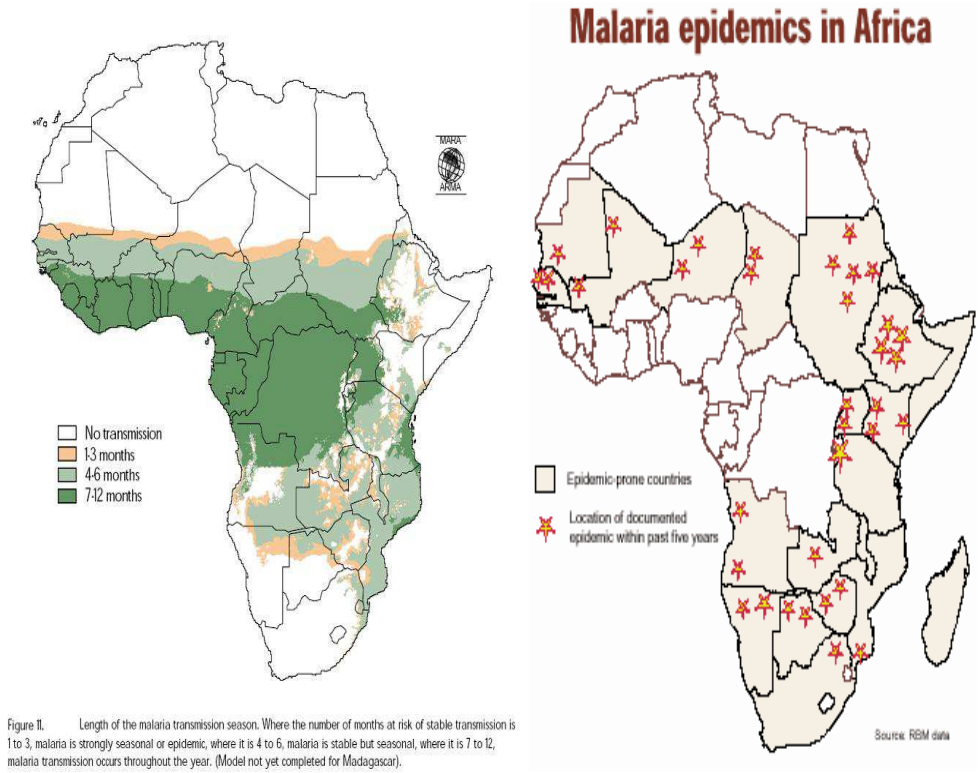


Figure 11. Length of the malaria transmission season. Where the number of months at risk of stable transmission is 1 to 3, malaria is strongly seasonal or epidemic, where it is 4 to 6, malaria is stable but seasonal, where it is 7 to 12, malaria transmission occurs throughout the year. (Model not yet completed for Madagascar).

Figure.2:Level of endemicity, epidemic prone countries and reported outbreaks

The evaluation of a potential malaria epidemic should take into account previous malaria epidemics in the area.

Information on transmission levels and periods, as well as areas prone to epidemics can be found at http://www.map.ox.ac.uk/explore/countries/.

2.2. Data analysis

Retrospective data related to malaria (such as the number of malaria cases and mortality rates) are often incomplete and/or unreliable. These data should therefore not be the only source of information used to determine whether there is a malaria epidemic or not. Moreover, the different methods used to evaluate malaria outbreaks are by no means perfect, thus an evaluation should always take into account both quantitative and qualitative information.

If routine data are available, including retrospective data, these should be analyzed to determine if the pattern observed is considered « normal/usual » or « abnormal/unusual ». Initial observations - such as a substantial increase in the number of malaria cases or the mortality rate - may give some indication of an unusual situation. However, taken in isolation, this information can be misleading as it does not take into account year-to-year variations. To evaluate « how unusual » the situation is, calculation of a threshold based on the mean number of malaria cases in the preceding years, and using the standard deviation technique, is recommended. To calculate these thresholds, weekly or monthly data from the five preceding years are taken (excluding any exceptional years – i.e. epidemic years or years with

largely incomplete data), and the mean and the standard deviation are calculated (using Excel formulae). Weekly data are preferred over monthly data.

- **The mean plus one standard deviation can be used as the *alert threshold***
- **The mean plus two standard deviations can be used as the *epidemic threshold***

Utilizing data from the five preceding years is considered to be the ideal. If retrospective data of less than five years are used these data may not fully capture and take account of year-to-year variations in malaria incidence. Likewise, if older data are used (i.e. data from more than five years ago), there is a higher chance that factors such as population demographics or access to health services might have changed significantly, thus reducing the value of these data in predicting a possible malaria epidemic. That said, if data are largely incomplete for any of the five preceding years, it may be necessary to use data that are more than five years old.

For the analysis and interpretation, factors such as ruptures in diagnostic tests or malaria drugs, a change of case definition (clinical versus parasitological confirmed diagnosis) or changes in the number of structures reporting malaria cases, should be taken into account.

Given the shortfalls of this methodology, and the usual weaknesses in data collection, these thresholds should be interpreted in combination with other quantitative and qualitative information that is gathered.

- **In any case, when defining and evaluating thresholds, headquarter advice is mandatory.**
- **It is strongly recommended that as soon as an abnormal increase in the number of malaria cases is observed, the mission informs and involves headquarters.**

Example: use of thresholds in a malaria-outbreak in Burundi, 2009-2010 (see annex 2 for the more developed example)

In this example (Figure 3), the number of monthly cases (black line) is plotted against two thresholds:

- *the mean of the five preceding years, plus one standard deviation (mean+1SD, dotted line) – the proposed alert threshold*
- *the mean plus 2 standard deviations (mean +2SD, dashed line) – the proposed epidemic threshold*

In this case, the alert threshold (mean + 1SD) detects the outbreak two months earlier in 2009 than the epidemic threshold (mean + 2SD).

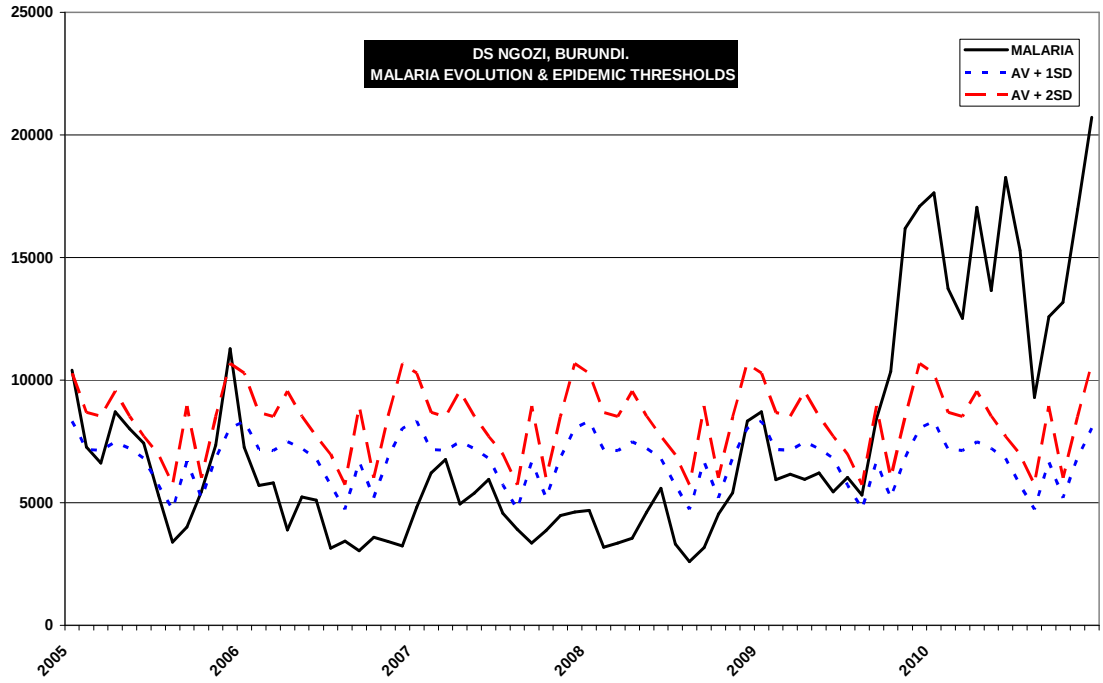


Figure 3: Monthly cases of malaria in Burundi between 2005 and 2010 and related alert and epidemic thresholds

2.3. Are there triggering factors?

The most common triggers are:

- ***Increased vector related transmission*** because of environmental factors influencing the breeding and biting behavior of malaria transmitting mosquito species.
  - Abnormal ***high temperatures*** favor the speed of an Anopheles becoming infective after a blood meal on a malaria-infected individual. The faster a mosquito becomes infective, the greater the number of infective bites that it can inflict within its lifespan of about 21 days. The graph below shows the link between the temperature and the duration of sporogony (the sexual phase of the parasite cycle, from infection of the mosquito to the presence of the infectious sporozoites in the salivary gland of the mosquito).

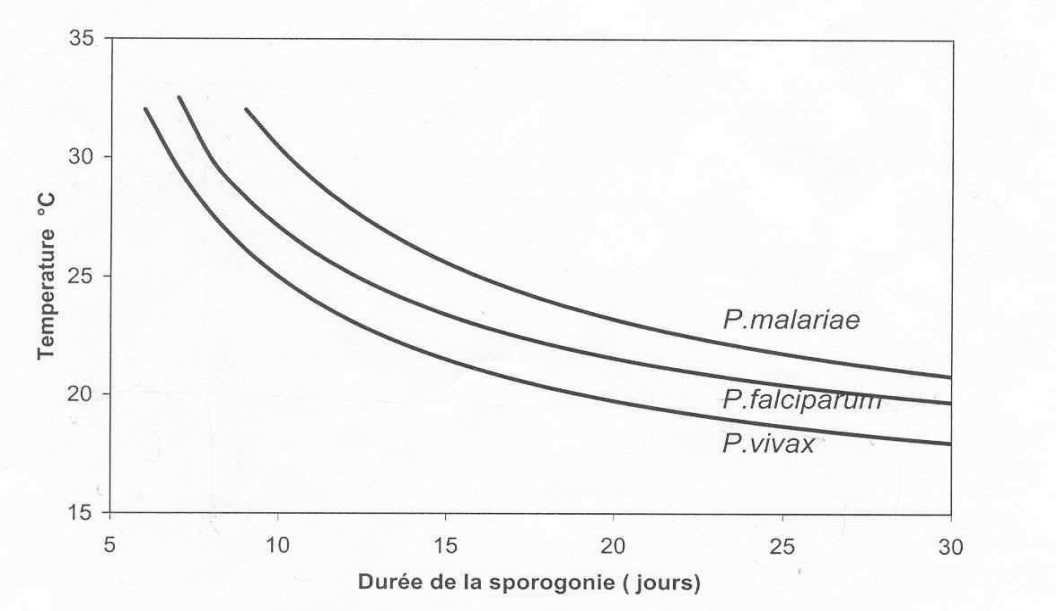


Figure 4: Link between temperature and sporogony duration for different malaria parasites

- ***Abnormal rain patterns*** can influence malaria transmission in different ways.

  In Wajir, Kenya, a protracted drought with high temperatures followed by heavy rains or floods favored creation of multiple breeding sites and rapid proliferation of the malaria vector (Figure 5)

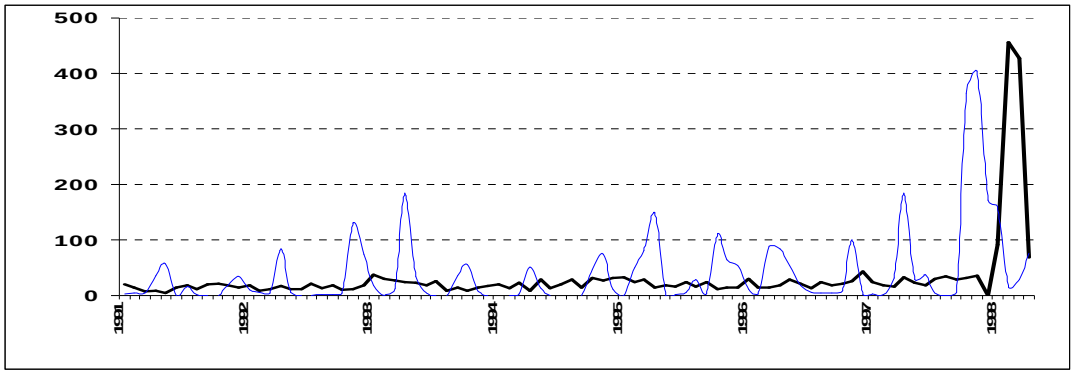


Figure 5: Monthly rainfall in mm (thin line) and number of malaria admissions to Wajir Hospital (bold line), Kenya: January 1991 – December 1998

The reverse can also be the case. In the highlands of Karuzi, Burundi, the heavy precipitations of November 2000, following a hot dry season, were associated with a significant decrease in malaria transmission during a major outbreak (Figure 5 and 6).

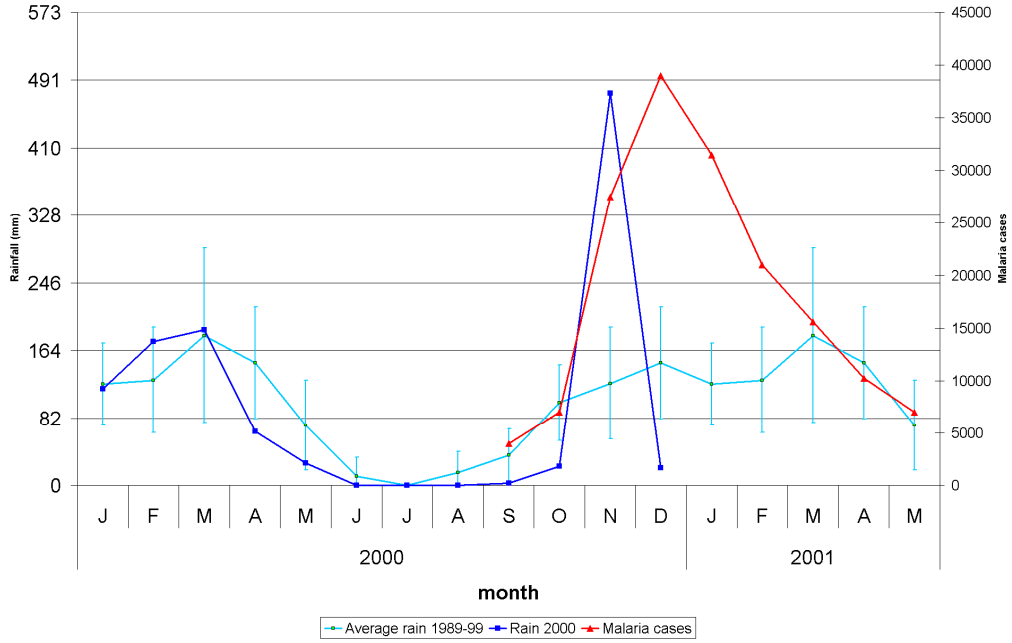


Figure 6: Monthly average rainfall, rainfall and malaria cases in Karuzi, Burundi; January 2000 – May 200.

Abnormally heavy rainfall in November 2000 was responsible for washing out and destroying the breeding sites of the malaria transmitting mosquito population. This impaired the renewal cycle of the mosquito population and as a result the number of malaria cases started to drop about one month later - a period that correlates with the longevity of the anophelines in this context. Moreover, because of the abundant rainfall the temperature dropped as well, leading to a longer sporogony cycle.

- A **tsunami** can significantly increase the number of brackish water bodies in the affected area. Certain malaria transmitting mosquito species breed in brackish water and the increase in breeding sites can lead to a massive increase in vector density and related malaria transmission (this was the case with *Anopheles sundaicus* in the Aceh tsunami)
- Changes in ***agricultural activities*** can also lead to higher or lower malaria vector densities.
- Installation of a ***leaking water supply*** network in an arid and otherwise low malaria transmission area, can trigger a malaria outbreak amongst the population living in this area. Other factors leading to stagnant water/breeding site such as a new type of roof can also lead to an increase in malaria transmission (this was the case in Afghanistan).
- Absence of or reduction in previously existing ***vector control measures*** such as the expiry of the protection afforded by indoor residual spraying (IRS) or long lasting insecticide-treated nets (LLINs).
- Increased ***resistance to the insecticide*** that is integrated in the LNs or applied with IRS.
- The ***end of the dry season*** can pose an environmental pressure on mosquitoes, leading to longer living mosquitoes and, in turn, a higher probability of the number of infective bites (this was the case in the Rusuzi plains in Burundi).

- ***Population movements***
  - People moving from high malaria endemicity areas to areas with low malaria transmission and introducing malaria (with eventually a different resistance pattern).
  - Displacement of a non-immune population into a malaria endemic area.

- ***Break-down of health services***, leading to a lack of preventive interventions (resulting in more cases and more transmission) and/or curative interventions (resulting in more cases of recrudescence and more severe cases).

- Widespread ***malnutrition or other disease epidemics*** - such as large measles outbreaks - can render the population more vulnerable, leading to a higher mortality.

- **Decreasing efficacy** of first line malaria treatment.

- **Decreasing efficacy of the most widely used insecticides (usually pyrethroids)**

2.4. Additional data to be collected and evaluated

As a starting point, it is important to ensure that the case definition for malaria is properly followed in the health facilities.

Additional data to be collected at the health facility level (for both <5 and ≥5 age-groups)

- ***At the OPD level, number of (confirmed) malaria cases and the total morbidity***. In cases where malaria is diagnosed clinically, there is a need to confirm malaria by RDT or microscopy (in order to exclude other possible causes). For the purpose of extrapolation (i.e. estimate the expected number of cases in that health structure) a sample of at least 100 patients is recommended.

- ***At the OPD level, the proportion of the number of new cases (NC) of malaria/ total cases.*** An increase in the total number of NC may reflect improved access or an increased coverage of malaria services.

- ***Number of severe malaria cases and malaria related deaths in hospital***.

- ***Proportion of number of NC of severe malaria / total number of NC in the hospital(s), as well as the proportional malaria mortality***

- ***RDT positivity* rate** (number of positive RDTs/total number of RDT performed). Although there is no specific threshold for this rate which is indicative of a possible outbreak, a positivity rate that is notably higher than usual, confirms that malaria is the main cause of the increased case-load, and provides further evidence of a possible epidemic.
    - RDT positivity should be measured among both the under-five and the five and over age groups

- ***Proportion of malaria cases in < 5 and ≥5 year age group*** (or 5-15 years if available). If the age distribution of the cases corresponds to the normal age pyramid of the country/region, this indicates specific vulnerability (non-immunity) of the older age groups.
  NB. Differences in healthcare access (for example free care for under-fives) can influence this proportion.

Example Burundi outbreak 2009-2010, data from mobile clinics (January-June 2010 intervention)

- Ngozi: Among 47,734 confirmed malaria cases, 12.352 were under-five cases, i.e. 26 % of all confirmed cases were under-fives
- Kayanza: Among 46,956 confirmed malaria cases, 10,834 were under-five cases, i.e. 23 % of all confirmed cases were under-fives

→ These proportions mirror the normal distribution of under-fives (20%) in the population of interest, indicating equal vulnerability to malaria among different age groups, the whole population being at risk.

- ***Case fatality rate* (CFR) related to malaria**: Number of severe malaria attributed deaths in the IPD/total number of severe malaria cases admitted to the IPD). The CFR is an indicator of quality of care and the coping capacity of the health facility.

- ***RDT data from screening activities*** (e.g. asymptomatic pregnant women coming for ANC, children admitted to nutritional centers) can provide additional information and can also be a first indication of an increasing number of cases that might be missed at health centers due to access barriers such as user-fees. If this is the case, only the better-off may be consulting (incidentally this is the population sub-group that are also more likely to have better access to preventative interventions).

- ***Demographic data should*** be collected such as the total population, the proportion of <5, the catchment area and the population per health structure. This information will allow indicators such as malaria incidence to be calculated, and can be used to orientate interventions.

2.5. Active Investigation

2.5.1. Data gathering

If the available data are incomplete or insufficient, active data gathering during a field assessment is indicated.

Confirmation of diagnosis by RDT
Confirmation of diagnosis by RDT is essential if data on malaria cases are based on clinical diagnosis, and recommended, if RDT use is questionable (i.e. if RDTs are supposed to be used but there is uncertainty around whether they are actually used, are used correctly, or whether the RDT results are taken into consideration).

The RDT-positivity rate can be determined for different groups:

- At Health Facilities:
  - among all patients with suspected malaria according to the case definition (fever or history of fever)
  - among all patients attending a health center (screening in waiting room), as this can be done rapidly

- At Community level:
  - ***Collective Screening Approach***:
    - Identify and invite all patients with a fever or a history of fever in the preceding 48 hours to have a RDT. Treatment should be provided for any patients testing positive.
    - Calculate the RDT-positivity rate (i.e. the number of patients with a positive RDT divided by the total number of patients presenting with fever or history of fever).
    - This strategy also gives an idea of the possible patient caseload that might be expected if mobile clinics were to be launched in these locations.
  - ***Random Selection at the Community level***: to determine the malaria prevalence in a village, a sample of at least 100 individuals should be randomly selected and screened (to be discussed with epidemiologist or malaria advisor).

2.5.2. Vector related information

- **Mosquito behaviour:** Several aspects of mosquito behavior are relevant for vector control - resting location, feeding time and location, host preference, flight range and choice of egg laying site. Efforts should be made to collect information about this behavior, using available literature and local observations. Most, but not all malaria transmitting Anopheles mosquitoes, feed at night with some preferring to feed inside houses and others outside. After feeding, a female mosquito needs somewhere to rest while she digests the blood and develops the eggs. Some species remain indoors after feeding, while others go to find a resting place outdoors. Vector control of mosquitoes is easiest for those mosquitoes that bite at night and feed and rest indoors as this can be addressed using IRS and/or LN's. In Sub Saharan Africa this can be assumed to be the case unless

proven otherwise. Species that have a strong preference for feeding on humans, over feeding on animals, tend to be the most dangerous vectors because they are most likely to pick up and pass on malaria parasites.

- **Meteorological information:** In most settings, meteorological information is available which will allow unusual rain and/or temperature patterns to be identified based on comparisons with previous years. Information from the community about unusual rainfall can be useful as well.

- **Availability and use of LNs:** When visiting communities, the availability of LNs first needs to be evaluated. Often the nets are too old (more than three years) or badly damaged (holes) or in some cases, regular nets, rather than LNs, are being used which need impregnation every six months. It is also important to determine whether the LNs are being used properly or not.

- **IRS**: Depending on the surface sprayed, IRS remains effective for 3 to 6 months, and this therefore has to be taken into consideration when deciding if previous episodes of IRS are still affording any protection.

- **Insecticide resistance:** It is important to try to determine if there is any resistance to insecticides in the affected area (HQ advice needed).

2.5.3. Observations are crucial!

Data and figures are important but should always be complemented by information and observations derived from the health structures and the community. Activities and areas of enquiry to consider include:

Health structure related:

- A mapping of all health facilities in the area (hospitals, health centers, community workers)
- The caseload at the hospital and health centers: Is there a visible overload?
- The diagnostic and treatment strategies used by local care providers: What are the first and second-line treatments being used? How are cases of severe malaria being treated? Are fixed dose combinations being used? Is there a functional referral system? What does the national protocol recommend?
- Observed trends in malaria related mortality in the hospital: Ask medical staff of all levels about malaria related mortality in the hospital (data collected in registers are not always reliable)
- Access to treatment: Is there good access to (free) treatment for under-fives, five-and-overs and pregnant women?
- Perception of health care staff: How do (senior) health staff perceive the situation compared to other years?

Presence of triggering factors

- Triggering factors: According to the community, are there any triggering factors such as changing agriculture practices, population displacement, changing rain patterns etc.?

Community linked factors: health seeking behavior and perception

- Adherence to treatment: Which measures are in place to enhance adherence?
- Perception and expectations of the population: Do they trust and use the health care system?
- The extent to which traditional medicine or private practitioners are used
- Perception of local and national authorities: How collaborative are the authorities? Is there an opportunity for synergy or is there a level of conflict? Does a specific Task Force exist?

Present capacity

- Existence of other actors in the region involved in malaria control
- Coping capacity of the health system dealing with the outbreak, can the system cope? (this is crucial to establish) Is there capacity for the scale-up of activities and to what extent?

Note on coping capacity

An analysis of the local and/or national coping capacity is important so that the MSF intervention can be appropriately orientated. It may be that MSF needs to implement the whole spectrum of outbreak related activities; alternatively the focus may be on filling existing or expected gaps.

Capacity to increase case management

- to mobilize/reorient human resources and supply (first and second line treatment, diagnostics, adjuvant treatment, transfusion)
- to open/reorient hospital beds
- the possibility to extend opening hours
- the capacity to launch mobile clinics where indicated
- logistic capacity for referrals (ambulances etc.)

Capacity to increase or target preventative interventions (relevance depending on the phase of the outbreak and on the preventative measures already in place)

- availability and distribution capacity for LN
- capacity to implement IRS (i.e. staff, skills, material)
- Staff and supplies to implement pharmaceutical prevention where relevant

Management capacity

- situational and epidemiologic analysis
- prioritization, organizational capacity

Summary table of factors indicating the likelihood of a malaria outbreak

	Outbreak likely	Outbreak unlikely
Region with permanent transmission and high malaria endemicity		√
Region with low malaria endemicity or seasonal transmission	√	
Unusual increase in n malaria cases, uncomplicated and complicated - objectively, based on threshold calculation - based on other information	√	
Presence of triggering factors leading to increased vector related transmission (population movement, break-down of services, resistance to treatment or insecticides, etc.)	√	
Increase NC of malaria is proportional to an increase in total NC in OPD		√
Low proportion of adults among malaria patients		√
Unusually high positivity rate of RDT among all patients, among fever cases, among population	√	
Where no data available, perception of "exceptional situation" among staff and population	√	

NC, new cases; OPD, outpatient department; RDT, rapid diagnostic test

- **An assessment requires:**
  - ✓ **visits to several primary health care centers**
  - ✓ **visits to (referral) hospital(s)**
  - ✓ **visits to several villages, hills,..**

This can be done with a team equipped with basic materials such as RDTs, first line ACT and basic medical supplies for emergency cases (perfusions, artesunate injections)

Conclusions

As a framework for the interpretation of the different data and findings, an operational definition of an outbreak justifying an intervention, can be proposed:

An unusual increase in malaria cases, based on data and information gathered, which overwhelms the coping mechanisms of the local health care services, in a region prone to malaria epidemics.

In some cases, qualifying a situation as an epidemic, versus a strong seasonal peak, is of academic interest only. In other situations however it can have practical implications whereby local regulations may stipulate that in the case of an epidemic there is free care for all, material from stocks are released, extra staff are deployed etc.

At the end of an evaluation, the conclusion will be to either:

- Intervene
- Not intervene, for example if:
    - It is a false alert
    - The local coping mechanisms are sufficient, or
    - It a permanently high malaria burden region, where a mid-term structural project would be more appropriate

If an intervention is not deemed necessary, a plan for future monitoring is recommended.

3. Intervention

Each malaria outbreak intervention includes a full package of vector control, health promotion and curative interventions (appropriate diagnosis and case management). All these activities are crucial for having an impact on the malaria outbreak.

3.1. Define the case definition

Suspected malaria: fever or history of fever in the preceding 48 hours

Confirmed malaria: suspected malaria confirmed by RDT (or microscopy, although less relevant in emergency situations).

***Severe malaria*:** in addition to the above, a patient presenting with one or more of the following complications (see Clinical guidelines):

- Impaired consciousness, delirium or coma
- Seizures, generalised or focal (e.g. abnormal eye movements)
- Prostration (extreme weakness; in children: inability to sit or drink/suck)
- Respiratory distress: rapid and laboured breathing or slow, deep breathing
- Circulatory collapse (shock): cold extremities, weak or absent pulse, slow capillary refill time (> 3 seconds), cyanosis
- Jaundice (check mucosal surfaces of the mouth, conjunctivae and palms)
- Haemoglobinuria: dark red urine
- Abnormal bleeding: skin (petechiae), conjunctivae, nose, gums; blood in stools
- Acute renal failure: urine output < 12 ml/kg/day in children and < 400 ml/day in adults, despite adequate hydrationj

Suspected treatment failure: a patient returning within two weeks of completing a full course of ACT for confirmed malaria, (and the patient confirming that the ACT has been taken correctly).

- If the number of suspected treatment failures is high, please ask headquarters for further advice.

3. 2. Vector control

3.2.1. The place of vector control measures in outbreaks

Appropriate vector control measures of proven efficacy should be implemented in MSF projects in malaria endemic zones and in epidemic-prone contexts, as per MSF's malaria policy paper (see the recommendations available in the Public Health Engineering In precarious Situations-2012, second edition).

Vector control measures are crucial in a malaria outbreak intervention; any response to a malaria outbreak that only involves a curative component will have a sub-optimal impact on mortality and morbidity. This sort of approach has been adopted by MSF in the past, but it is not acceptable to repeat this during future interventions. A vector control component is an important part of any response.

Appropriate vector control measures should also be implemented in an outbreak that is ongoing. Only in emergencies, when an outbreak is in clear decline, is the relevance of certain vector control measures questionable. Distribution of long lasting insecticidal bed nets (LNs) remains appropriate as the protection that they afford lasts 3-5 years i.e. extends beyond one malaria season. Indoor Residual Spraying (IRS), on the other hand, is less relevant in the declining phase of an outbreak, as the protection that this intervention affords lasts only 3-6 months.

3.2.2. Which type of vector control measures have a place in outbreaks?

In emergencies, the choice between Indoor Residual Spraying (IRS) and long lasting insecticidal bed nets (LN) distribution is based on the context: most importantly, the possibility of rapid deployment and specific characteristics of the population. **IRS** is preferred if LNs are not rapidly available, or if there is a justified fear that LNs might lead to looting (e.g. of the warehouses, or of the villages after LN distribution). IRS is futile for mobile populations; in practice it is most often limited to refugee/IDP camps. If **LNs** are rapidly available, and distribution can be effectively organized in a timely manner, this is the preferred option as the protection afforded by LNs extends beyond one malaria season.

In open settings (outside refugee camps), vector control must be planned properly and with the help of advisors as there is no 'one-size-fits-all' vector control intervention for these sorts of settings. HQ advice is mandatory to ensure that efforts are not wasted by implementing inappropriate methods.

Most Anopheles mosquitoes do not fly more than 3 km from where they begin their lives. Malaria risk can thus be reduced by ensuring that refugee camps are set up more than 3 km from breeding sites. Individual species that tend to choose a narrow range of egg laying sites can be tackled with **larviciding** campaigns.

3.2.3. Implementation of vector control measures

When **IRS** is used, both the insecticide and the spraying equipment must be WHO Pesticide Evaluation Scheme (WHOPES) approved, and the personnel carrying out the IRS must be fully protected. MSF is not in favour of the use of DDT, as safer efficient alternatives are available. When deciding what strategy to implement, available information on insecticide resistance should be taken into consideration.

Where MSF uses **LNs**, these must also be WHOPES approved. LNs provide good personal protection. If high coverage (at least 80-100 % of the population at risk) can be achieved, a mass effect on transmission can be expected as well.

- Universal LN coverage of the whole community, aimed at one LN per 1.8 people should be the objective. This level of coverage can and has been implemented by MSF during malaria outbreaks using mass distribution of LNs or a LN catch-up campaign (this as per the malaria policy paper). High coverage of LNs significantly increases impact through reduction of population size and longevity of the adult mosquito population. The latter generates a mass effect in addition to the personal protective effect of a LN when used correctly. If insufficient LNs are available, step-by-step LN distribution should be implemented that preferentially targets high risk groups in the population, for example:
    - All beds/patients in hospitals and therapeutic feeding centres (TFC), and households of TFC patients on discharge.
    - Pregnant women and children under five years of age, provided the population has previous experience of using nets.
    - Populations living in areas of high transmission (so-called "hot spot" transmission zones) that have the highest number of cases/highest incidence.

In specific contexts such as those where the community is hill residing, LN distribution can be preferentially targeted to ensure high coverage in the valleys where the mosquitoes breed, but lower overall coverage among the whole community (cf. Burundi experience, *fig 7)*

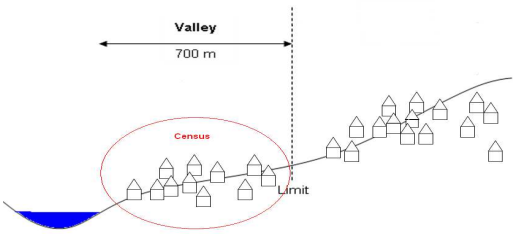


Figure 7: Valleys to be covered by malaria vector control measures

Nonetheless, the effectiveness of LNs is dependent on the willingness of community members to use them correctly. As such, appropriate education and promotion is essential, and a robust monitoring system should be in place.

There are a number of LN distribution strategies that are effective in emergencies including mass distribution to beneficiaries from a central location. This approach requires a context appropriate follow-up campaign to ensure LN retention and effective use by the end users. Another approach is the "hang-up and use" distribution where LNs are installed on site by the team during the distribution. This labor intensive approach takes longer to implement but has a positive effect on retention and use, and is the preferred distribution strategy in a closed setting, such as a refugee-camp.

Evaluation of LN coverage and use is recommended if the opportunity arises, for example by including (a) question(s) on this in eventual mortality or access to care surveys.

If LNs and IRS are both used, LNs being based on pyretroids, spraying should be done with carbamate to avoid development of insecticide resistance.

3.2.4. Quantification of LNs need

In planning procurement quantities, the aim should be to distribute enough LNs to achieve 100% coverage. There must be a clear plan of action as to how this is to be achieved at the household level. A recommended strategy is to distribute nets to households at the rate of one net for every two household members, rounding up for households with an odd number of members (e.g. for a household of five, three LNs would be provided). In a population with a mean household size of five this implies a procurement ratio of 550 LN for 1000 population, or one LN for 1.8 persons

3.2.5. Other impregnated material

There is a need for new vector control tools in acute emergencies that enable a more timely intervention to be delivered and which have a substantial impact in humanitarian emergencies in a variety of contexts. Such tools include Insecticide-treated plastic sheeting (ITPS), impregnated tents, clothing and hammock nets, and spatial repellents. Advantages of these new impregnated tools include the following:

- They put little or no extra burden on implementing agencies
- They can be stockpiled over the long term
- They require little behavioural change among implementers and users.

3. 3. Diagnostic strategy

The standard recommendation that each case of suspected malaria should be confirmed by RDT or microscopy may not be appropriate in the case of an outbreak with a high caseload.

- If RDT's are widely available and there are sufficient staff to continue testing each case of suspected malaria, then systematic confirmation of cases should continue as this allows better epidemiological follow-up. It also means that patients testing negative for malaria can be managed (usually referred) and treated for the real cause of their fever.

- However, if systematic testing leads to an overload of work and this has a negative impact on the overall quality of case management (errors and confusion, long waiting times, patients returning home without being seen at all), AND if the positivity rate is very high (in outbreaks, often > 80%) it is acceptable to base treatment on clinical diagnosis (i.e. a patient's symptoms).

- In the latter case, regular testing of samples of patients with RDT (for example all consecutive patients seen over the course of one morning, or 20 consecutive patients seen per week in selected centers) should be carried out for epidemiological follow-up. When the RDT

positivity rate starts to fall, and when capacity allows for this, systematic confirmation of suspected cases should be reintroduced.

Note on the choice of tests

In areas where less than 5 percent of the malaria cases are caused by species other than P.*f*, the standard RDT should be based on the **HRP2 antigen**. This choice is based on the highest sensitivity (and panel detection score in the WHO/CDC/FIND product evaluation) of this type of RDT, the best documented heat stability, and the availability of several validated sources.

In areas where more than five percent of the malaria cases are caused by species other than P.*f*, a "**combo-test**" is used. This is a three-line test which, aside the control and the HRP2 lines, also has another line detecting the pan p LDH antigen that is produced by all four species. As such this combo-test can give any of the following results: i) P.f; ii) P.f or mixed infection and iii) species other than Pf. NB. "a mixed infection" cannot be distinguished from a P.*f*-only infection.
The disadvantage of a HRP2 based RDT is the remaining antigen circulation leading to a positive test result, up to several weeks after the elimination of the parasites (Malaria WG study/Epicentre study 2012: the mean time to become negative is six weeks).

The alternative test that can be considered is a test based on the **pan pLDH** antigen (a two-line test -a control line and a pan pLDH line). Pan pLDH is produced by all species, and becomes negative a few days after elimination of the parasites (mean time to becoming negative: two days). The pan pLDH based tests have a marginally lower sensitivity at low parasitaemia levels and there have also been concerns over heat stability. To date however, these tests have been improved such that they have a heat stability level similar to the HRP2 based test and score well in the WHO/FIND/CDC product evaluation (albeit still demonstrating a marginally lower panel detection score at low parasitaemia levels). To date (July 2014), the main concern is linked to the lack of suppliers that can guarantee quality and sufficient supply (only one supplier with temporary validation is currently available).

Given the short time to becoming negative after elimination of parasites, pan pLDH tests will likely become the test of choice during outbreaks.
Pan pLDH tests can be used today, but until one or more suppliers have full validation, HQ advice on availability is mandatory before opting to use these tests.

Note: the pan pLDH line on a combo-test should not be used to distinguish between an acute infection and remaining HRP2 positivity after elimination of parasites, as this pan pLDH line on the currently available combo-test is less sensitive than in the pan pLDH-only test. When a combo-test is used and gives a positive HRP2 result with a negative pan pLDH line, the patient should still be treated as a P.*f* patient.

3. 4. Treatment strategy

Treatment should be based on:

- The first line ACT
- An alternative ACT to be used if:
    - There are contra-indications to the first line ACT
    - There is suspected treatment failure

- Artesunate injections (preferably IV or IM if IV is not feasible) for severe cases: pre-referral treatment, treatment initiation, treatment. Factors to note:

    - If injectable artesunate is not available, or administration not feasible, artemether IM can be used.
      Artesunate and artemether should not be used in the same project or structure – this to avoid the erroneous administration of artemether intravenously.
    - Artesunate rectocaps should be used as pre-referral treatment if the first line care providers are not trained to use injections.

- Supportive treatment (paracetamol, ORS, diazepam, folic acid etc.)
- Safe transfusion capacity
- Treatment for concomitant pathologies (antibiotics, therapeutic food, albendazole, etc.) (see MSF clinical guidelines http://refbooks.msf.org/msf_docs/en/clinical_guide/cg_en.pdf,)

Management strategy for re-consultation cases

Where quality microscopy is available, this is the recommended diagnostic for patients returning with malaria symptoms within one month after treatment. This is because the HRP2 based tests take a relatively long time to show a negative result after elimination of the parasites.

Where RDTs based on ***pan pLDH*** are being used, the diagnosis of a patient who re-consults with symptoms of malaria can be based on the RDT result as the mean time to become negative after elimination of parasites is only 2 days.

Where quality microscopy is not available (or not feasible given the high workload at front line facilities), and only the ***HRP2 based RDTs*** are available, the management strategy for patients that re-consult with suspected malaria following a course of treatment, has to be defined taking into account the context.

If a patient returns within two weeks of being treated with ACT, a RDT - especially an HRPII based RDT - cannot be used (considering the long persistence of the antigens). In such a case, the following is recommended:

- If the patient presents with fever or a history of fever and indicates that he/she has not adhered to the 3-day course of ACT (or has vomited tablets), a new course of the first line ACT should be prescribed.
- If the patient indicates that he/she has taken the ACT correctly, then the presenting symptoms are most likely indicative of another disease, especially if the first line treatment was artemether-lumefantrine (which has a very high efficacy). In such a case, it is reasonable to assume that the patient does not have malaria and to treat accordingly. If the first line treatment received by the patient was artesunate-amodiaquine (ASAQ) in a setting where ASAQ efficacy is unknown, or is known to be low, use of artemether-lumefantrine is recommended for these suspected treatment failure cases.

If a patient returns more than two weeks after being treated with a full course of ACT, this could be as a result of re-infection with malaria or due to another disease. An RDT can be performed, but it is important to be aware that the test can remain positive for several weeks after elimination of the parasites. If the test is positive, prescribing an ACT is indicated, accepting eventual overtreatment for malaria. As such it remains important to consider differential diagnoses and to treat accordingly.

Where treatment failure is confirmed by microscopy or a pan pLDH based RDT *despite indications of good adherence to the prescribed ACT*, an **alternative ACT** can be recommended (e.g. artemether-lumefantrin in case of suspected failure of artesunate-amodiaquine)

3.5. Service delivery strategy

Access to appropriate diagnosis and treatment within 24 hours of the onset of symptoms is key

- Optimize the functioning of the ***PHC structures*** (health posts, health centers, reference health centers): adapt patient flow, ensure sufficient working hours and days (7/7), ensure supply and give the primary dose as directly observed therapy (DOT). Consider organizing specific "malaria corners" where the treatment is explained, the first dose administered and the patient observed for (half) an hour.

- Where relevant, organize ***mobile clinics*** to increase coverage, and also to remain in touch with the population at the community level. The following factors should be considered:
    - Mobile clinics should visit their designated locations a minimum number of times a week (at least 3 times a week), otherwise there is a risk that patients delay their health

seeking (i.e. patients wait for the arrival of a mobile team rather than making the effort to seek care at a health centre).
    - There is good experience in MSF with teams composed of a nurse supervisor, a driver (who also deals with crowd control), an (aid) nurse or lab technician for intake and performing RDTs, a nurse for basic clinical evaluation and treatment prescription (e.g. assessing the symptoms of severity, identifying other obvious diseases that might need referral, identifying contraindications to treatment etc.), and a person from the community to administer drugs to children (DOT) and convey standard messages to patients or their caretakers.

- If a ***community based system*** is in place (community health workers, malaria village workers), boost or reinforce this

- Ensure a proper ***referral system*** between primary and secondary level facilities.

- ***Hospital*** level
    - Ensure financial, organizational, geographical access (free care, optimized patient flow, ambulance system)
    - It may be relevant to open a temporary « malaria ward » which allows a vertical approach to be adopted that is reinforced with adequate medical supplies and human resources.
    - Ensure there is adequate blood transfusion capacity - crucial for life saving.

- Upgrade primary health care centers to reference Health Centers and also consider the capacity for patient observation.

- If there is a functional and reliable ***laboratory*** available, use of microscopy can be considered in the following situations:
    - Follow-up of severe cases
    - Cases with suspected treatment failure (microscopy can be used to confirm treatment failures and enable closer follow-up, especially if there is no up-to-date information on the efficacy of the first line ACT)
    - Further *minimum* tests to be provided: Hb/Hct and Glycemia. If qualitative laboratory services are available, consider monitoring plasma bicarbonate, blood gases, urea/creatinine or electrolytes.

Appropriate Health Promotion at the community level

It is crucial to include Health Promotion activities to ensure that the population
- Is aware of the exceptional health situation
- Is informed about the health services provided (such as mobile clinics)
- Makes timely use of the health services
- Is aware about the importance of prevention
- Knows the importance of LNs and how to use them correctly

3.6. Note on pharmaceutical prevention and intermittent treatment

In several contexts, certain forms of intermittent or preventive treatments are being used or tested. For example, to address the seasonal peak in the Sahel countries, seasonal malaria chemoprevention is recommended and implemented, consisting of a monthly course of SP+amodiaquine.Strategies using ACT with a long half-life of the partner drug (mainly dihydroartemisinin/piperaquine) are also being piloted. Similar strategies could be considered in emergencies such as population displacements from low to high transmission areas - in this situation, one or more rounds with antimalarials could buy time for implementing the necessary malaria control strategies. There is only limited experience with pharmaceutical prevention strategies in emergencies and as such this cannot yet be recommended as part of a standard package of interventions. Several approaches are possible including different drugs, different intervals, different target age groups. These strategies should be discussed on a case-by-case basis with the malaria advisor at HQ.

Factors to be taken into consideration include the resistance profile in the area, potential interference with the first line treatment, duration of the transmission season, dynamics of the population that needs to be protected, access to that population, other prevention measures already in place etc..

If intermittent or preventative treatments are considered, advice from the HQ malaria advisor is mandatory.

4. Monitoring and evaluation

4.1 Active surveillance

Surveillance throughout the intervention is crucial in order to follow its evolution and also that of the epidemiology of malaria in the area. Surveillance must be carried out at different levels: village or outpatient clinic, antenatal and nutrition services, and inpatient services (hospital, Therapeutic Feeding Center…), on a weekly basis. The data collected will allow the team to assess the outcomes of the medical intervention, and will provide an indication as to whether the intervention should be up -or downscaled.

Data to collect (ideally for the three age groups: *<5 years, 5-14y and ≥15y*, or at the very least: the under and over fives):

- *Number of confirmed simple malaria cases (or number of suspected cases in case patients are treated on a clinical basis), to construct the epidemic curve.*
- *Number of severe malaria cases*
- *Malaria proportional morbidity in the OPD*
- *RDT/microscopy positivity rate (number of positive tests/number of tests carried out)*
- *Case Fatality Rate in the IPD, Malaria attributed mortality*
- *Incidence rate, attack rate*

4.2. Monitoring

Various components of the intervention can be monitored with specific indicators to assess the quality of the outbreak intervention.

Quality Indicators with suggested references:

1. Access indicators
    a. the **proportion of patients having access to healthcare within the first 24h after the onset of symptoms** (through fixed or mobile clinics) – for example 70 % can be a realistic target
    b. **the proportion of indicated referrals (for severe malaria, for other pathologies) that are assured**, for example for >90% of the cases who need referral
2. The number of **stock ruptures**: there should be no stock ruptures throughout the intervention
3. Diagnosis, treatment and management of all malaria cases in the area are **free of charge**.
4. The percentage of malaria patients that are **diagnosed and treated according to protocol** (simple and severe malaria), for example 95%. For the purpose of evaluation, the emphasis can be on one aspect of care, such as admission criteria for severe cases, adherence to treatment, RDT-checklist, etc.
5. The transfusions that are administered according to MSF protocols, with **transfusion safety in place.**

Vector control monitoring

The quality and potential effectiveness of a LN distribution should be assessed at the following time points: the time of LN distribution (to track coverage), one month after distribution and 6-12 months after distribution, depending on the transmission season. Monitoring after 6-12 months is done to i)

confer accountability, ii) evaluate the appropriate use and retention of the LNs, iii) reinforce community sensitization, and iv) enable critical reflection (i.e. lessons learned).
Concerns about the burden of the monitoring component should not become an excuse for not launching a timely distribution.

LN distribution can be monitored using the following indicators:

a) Coverage = number of LNs distributed/target population size (%).
b) Utilization rate = number of people using LNs/number of people given LNs (%).
c) Retention rate = number of people retaining LNs/number of people originally given LNs (%).
d) Deterioration rate = average number of holes per LN.
e) Indicator about how key messages on how to look after nets, their benefits etc. are imparted or understood

IRS can be monitored using the following indicators:

a) Coverage = number of structures sprayed / number of structures in the target areas (%)
b) Amount of insecticide used per structure = amount of insecticide used / number of structures sprayed (%). This is one measure of the efficiency and the correct utilization of the insecticide.
c) Acceptability of spraying = % of households that refused to have their homes sprayed.
d) The % of pumps that were correctly maintained and remained in a state of good function at the end of the campaign.
e) Acceptability after IRS = % of heads of households who complained after a spray campaign.

4.3 Exit criteria

There are often a lack of reliable baseline or retrospective data on the pre-intervention malaria situation that allow us to accurately determine the impact of our intervention. Using the criterion 'a return to the *normal* situation' is not necessarily useful therefore, and as such, defining exit criteria is often a somewhat arbitrary exercise.

Below is one ***example*** of quantitative criteria that could be used to evaluate the impact of an intervention and/or decide whether it is appropriate to end a malaria outbreak intervention.

- An observed ***decrease over four consecutive weeks*** of the following indicators:

    1. ***Absolute number of confirmed simple malaria (or malaria incidence if denominator is known)***
    2. ***RDT positivity rate***
    3. ***Proportion of malaria morbidity (as a proportion of the total morbidity)***
    4. ***Number of severe malaria admitted in IPD/total IPD cases***

These indicators should be combined with other qualitative information such as:

- *The coping capacity of the health structures and/or authorities*
- *The presence of other actors for handover*
- *The presence of sufficient diagnostic tests, treatments and properly trained staff*

For some of the quantitative indicators in bold above, there should be an observed decrease over the course of a certain period (e.g. four weeks). For other indicators, we are looking for them to fall below predefined thresholds or to return to the pre-outbreak level. Ideally, these indicators should be calculated and evaluated per health structure or per mobile clinic, rather than aggregated for a whole intervention. If possible, indicators should be calculated for each of the different age groups (<5 and ≥5).

- Various other indicators should stay ***below specific thresholds for four consecutive weeks***. These

thresholds often depend on the malaria endemicity in the area of intervention and can be defined in collaboration with the section malaria advisor. If accurate data on the baseline situation are available, a return to the pre-existing situation can be considered as well.

1. ***Absolute number of confirmed simple malaria cases below alert threshold (= mean + 1SD);***
2. ***RDT positivity rate****, that drops back down to the pre-epidemic level*
3. ***Proportion malaria morbidity (as a proportion of the total morbidity)*** *e.g. ≤50%*
4. ***CFR for severe malaria in hospital*** *(<10%)*

- Vector Control indicators and criteria
  - > 80% of the target population uses the bednet correctly or one bednet /1.8 people at risk has been distributed

  OR
  - IRS of >80% of the households unless the peak of the outbreak has passed.

Annex 1: example of a checklist for collecting qualitative information

INFORMATION TO BE GATHERED BEFORE SENDING AN ASSESMENT MISSION	
Is the region prone to malaria epidemics (geography, transmission pattern,.)? Have there been outbreaks in the past? If so when and in which areas?	
What information has been received warranting an alert? What is the source of this information?	
Has it been confirmed that it concerns malaria? Have the cases been confirmed (by RDT, by microscopy,..?)	
Are there data from previous years (locally available? from MoH? other actors?)	
What is the proportion of malaria confirmed cases < and > 5 years of age? (from data? impression from health care providers ?)	
Is there information on malaria related mortality? Is there a significant increase compared to XX?	
Has there been any unusual rainfall (according to weather forecast services, according to the community?)	
Has there been any significant population movement in the area in the previous XXX months (from where to where, high/low prevalence area?)	
Are there vector control measures in place? Since when? When was the last LN distribution (by whom? general distribution or targeted to vulnerable groups?) IRS rounds? Other?	
What is known about vector type and behavior (literature, expert advice,…)?	
Is there any other major health problem in the area (malnutrition, measles,…)?	
….	
INFO TO BE GATHERED DURING FIRST ASSESSMENT – AT HEALTH STRUCTURES	
In health structures: have the (senior) staff seen significant increases in malaria cases, compared to other years? Uncomplicated, severe? Malaria related mortality ?	

Information from the registers (n cases, age distribution, referrals, mortality,…)	
Observations on services: case definition? Confirmation of diagnosis done, how? Information from pharmacy (consumption, stocks,..), laboratory, transfusion capacity, referral strategy and capacity? Availability of treatment, diagnosis etc.?	
General observations: waiting lines, condition of waiting patients, bed occupancy, drug distribution procedure, overburdened staff…	
…	
INFORMATION TO BE GATHERED FROM THE COMMUNITY	
Perception of the situation (usual? exceptional?)	
Information on possible malaria related deaths in the community? Unusual?	
Access to treatment, barriers (user fees, prices?), perception of the quality of the health services, why did ill people not go… ? Have there been recent changes (free care, extra -or less- staff or services,…)?	
Use of private/informal sector	
LN coverage, perception, use, status of nets	
Information on (assumed) mosquito breeding sites? Biting habit of the mosquito?	
Are there other relevant actors active?	
…	

EXAMPLE OF CALCULATING ALERT & EMERGENCY THRESHOLDS FOR MALARIA

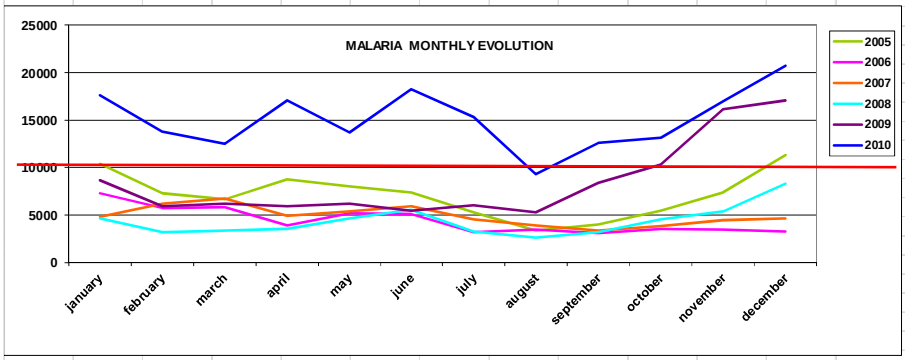
1

Collect the weekly or monthly number of confirmed malaria cases of the past 5 years.

DS NGOZI BURUNDI												
	january	february	march	april	may	june	july	august	september	october	november	december
2005	10416	7277	6625	8714	8017	7428	5312	3393	4015	5452	7359	11276
2006	7262	5713	5814	3896	5236	5102	3148	3433	3051	3593	3424	3235
2007	4824	6213	6766	4957	5390	5953	4568	3921	3355	3864	4485	4620
2008	4689	3185	3360	3560	4606	5589	3315	2600	3179	4542	5408	8339
2009	8709	5934	6163	5955	6218	5438	6037	5309	8406	10347	16182	17099
2010	17645	13739	12517	17055	13654	18271	15292	9304	12590	13173	16979	20721

2

Exclude exceptional months (here: more than 10,000 cases), epidemic years and non reliable data from the calculation of means and standard deviation.



DS NGOZI BURUNDI												
	january	february	march	april	may	june	july	august	september	october	november	december
2005	10416	7277	6625	8714	8017	7428	5312	3393	4015	5452	7359	11276
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2010	17645	13739	12517	17055	13654	18271	15292	9304	12590	13173	16979	20721

3

Calculate average for each month using the 'average' application in excel

Calculate the standard deviation for each month using the "stdev' application in excel

Calculate average + 1SD and average + 2SD

DS NGOZI (threshold calculated based on last 5 years 2005 - 2010)												
	january	february	march	april	may	june	july	august	september	october	november	december
AVERAGE	6371	5664	5746	5416	5893	5902	4476	3731	4401	4363	5169	5398
1SD	1956	1510	1386	2070	1319	906	1251	1001	2269	829	1670	2639
AV + 1SD	8327	7175	7132	7486	7212	6808	5727	4732	6671	5191	6839	8037
2SD	3913	3021	2772	4139	2638	1812	2501	2002	4539	1657	3340	5279
AV + 2SD	10284	8685	8518	9556	8531	7714	6977	5733	8940	6020	8509	10677

4

Put the number of malaria cases, the average + 1SD and 2SD in a graph

	2005											
MALARIA	10416	7277	6625	8714	8017	7428	5312	3393	4015	5452	7359	11276
AV + 1SD	8327	7175	7132	7486	7212	6808	5727	4732	6671	5191	6839	8037
AV + 2SD	10284	8685	8518	9556	8531	7714	6977	5733	8940	6020	8509	10677