Malaria surveillance, monitoring and evaluation

A reference manual, second edition

World Health Organization

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Abbreviations and acronyms

ACD	active case detection
ACT	artemisinin-based combination therapy
AL	artemether–lumefantrine
ANC	antenatal care
AS–AQ	artesunate–amodiaquine
AS–MQ	artesunate–mefloquine
AS–PY	artesunate–pyronaridine
AS+SP	artesunate + sulfadoxine–pyrimethamine
CHW	community health worker
C-SUM	cumulative sum
DHA–PPQ	dihydroartemisinin–piperaquine
DTI-R	diagnosis, treatment, investigation and response
ENSO	El Niño Southern Oscillation
G6PD	glucose-6-phosphate dehydrogenase
HMIS	health management information system
IDSR	Integrated disease surveillance and response
IPTi	intermittent preventive treatment of malaria in infancy
IPTp	intermittent preventive treatment of malaria in pregnant women and girls
IRS	indoor residual spraying
ITN	insecticide-treated net
LMIS	logistics management information systems
LSM	larval source management
MDA	mass drug administration
MTaT	mass testing and treatment
NMDR	national malaria data repository
NMP	national malaria programme
PACD	proactive case detection
PCD	passive case detection
PCR	polymerase chain reaction
PDMC	post-discharge malaria chemoprevention
Pfhrp 2/3	*P. falciparum* histidine-rich protein 2 and 3
PfPR	*P. falciparum* parasite rate
PMC	perennial malaria chemoprevention
RACD	reactive case detection
RDA	reactive drug administration

RDT	rapid diagnostic test
RACD	reactive case detection
RACDT	reactive case detection and treatment
SD	standard deviation
SMC	seasonal malaria chemoprevention
SNP	single nucleotide polymorphism
SOP	standard operating procedure
SST	sea surface temperature
TDA	targeted drug administration
TES	therapeutic efficacy study

Glossary

case, imported	Malaria case or infection acquired outside the area in which it is diagnosed
case, index	A case of which the epidemiological characteristics trigger additional active case or infection detection. The term "index case" is also used to designate the case identified as the origin of infection of one or more introduced cases.
case, indigenous	A case acquired locally with no evidence of importation and no direct link to transmission from an imported case
case, induced	A case the origin of which can be traced to a blood transfusion or other form of parenteral inoculation of the parasite but not to transmission by a natural mosquito-borne inoculation *Note:* in controlled human malaria infections in malaria research, the parasite infection (challenge) may originate from inoculated sporozoites, blood or infected mosquitoes.
case, introduced	A case acquired locally, with strong epidemiological evidence linking it directly to a known imported case (first-generation local transmission)
case, locally acquired	A case acquired locally by mosquito-borne transmission *Note:* locally acquired cases can be indigenous, introduced, relapsing or recrudescent; the term "autochthonous" is not commonly used.
case, malaria	Occurrence of malaria infection in a person in whom the presence of malaria parasites in the blood has been confirmed by a diagnostic test *Note:* a suspected malaria case cannot be considered a malaria case until parasitological confirmation. A malaria case can be classified as indigenous, imported, introduced, induced, relapsing or recrudescent (depending on the origin of infection); and as symptomatic or asymptomatic. In malaria control settings, a "case" is the occurrence of confirmed malaria infection with illness or disease. In settings where malaria is actively being eliminated or has been eliminated, a "case" is the occurrence of any confirmed malaria infection with or without symptoms.
case, presumed	Number of cases presumed to be malaria in the absence of a diagnostic test. Diagnosis is based on clinical symptoms and cases are subsequently treated with antimalarials. *Note:* the term "presumed malaria case" is used only when a parasitological diagnostic test cannot be performed. In such instances, cases are diagnosed and treated with an antimalarial based on clinical evaluation. This differs from suspected malaria cases, where individuals are considered by a health worker to possibly have malaria but still require further assessment and testing for confirmation.
case, relapsing	Malaria case attributed to activation of hypnozoites of *P. vivax* or *P. ovale* acquired previously *Note:* the latency of a relapsing case can be > 6–12 months. The occurrence of relapsing cases is not an indication of operational failure, but their existence should lead to evaluation of the possibility of ongoing transmission.
case, suspected	Illness suspected by a health worker to be due to malaria, generally based on the presence of fever with or without other symptoms, before a diagnostic test is performed

case detection	One of the activities of surveillance operations, involving a search for malaria cases in a community *Note:* case detection is a screening process in which the indicator is either the presence of fever or epidemiological attributes such as high-risk situations or groups. Infection detection requires use of a diagnostic test to identify asymptomatic malaria infections.
case detection, active	Detection by health workers of malaria cases at community and household levels, sometimes in population groups that are considered at high risk. Active case detection can consist of screening for fever followed by parasitological examination of all febrile patients or as parasitological examination of the target population without prior screening for fever. *Note:* active case detection may be undertaken in response to a confirmed case or cluster of cases, in which a population potentially linked to such cases is screened and tested (referred to as "reactive case detection"), or it may be undertaken in high-risk groups, not prompted by detection of cases (referred to as "proactive case detection").
case detection, passive	Detection of malaria cases among patients who, on their own initiative, visit health services for diagnosis and treatment, usually for a febrile illness
case investigation	Collection of information to allow classification of a malaria case by origin of infection (i.e. indigenous, imported, introduced, induced, relapsing and recrudescent) *Note:* case investigation may include administration of a standardized questionnaire to a person in whom a malaria infection is diagnosed and screening and testing of people living in the same household or surrounding areas.
drug resistance	The ability of a parasite strain to survive and/or multiply despite the absorption of a medicine given in doses equal to or higher than those usually recommended *Note:* drug resistance arises as result of genetic changes (mutations or gene amplification) that confer reduced susceptibility.
entomological inoculation rate	Number of infective bites received per person in a given unit of time, in a human population *Note:* this rate is the product of the "human biting rate" (the number of bites per person per day by vector mosquitoes) and the sporozoite rate (proportion of vector mosquitoes that are infective). At low levels of transmission, the estimated entomological inoculation rate may not be reliable, and alternative methods should be considered for evaluating transmission risk.
epidemic	Occurrence of a number of malaria cases highly in excess of that expected in a given place and time *Note:* seasonal increases in the incidence of malaria should not be confused with epidemics.
focus, malaria	A defined circumscribed area situated in a currently or formerly malarious area that contains the epidemiological and ecological factors necessary for malaria transmission *Note:* foci can be classified as active, residual non-active or cleared.
malaria elimination	Interruption of local transmission (reduction to zero incidence of indigenous cases) of a specified malaria parasite in a defined geographical area as a result of deliberate activities. Continued measures to prevent re-establishment of transmission are required. *Note:* the certification of malaria elimination in a country will require that local transmission is interrupted for all human malaria parasites.

malaria eradication	Permanent reduction to zero of the worldwide incidence of infection caused by human malaria parasites as a result of deliberate activities. Interventions are no longer required once eradication has been achieved.
malaria reintroduction	Malaria reintroduction is the occurrence of introduced cases (cases of first-generation local transmission that are epidemiologically linked to a confirmed imported case) in a country or area where the disease had previously been eliminated *Note:* malaria reintroduction is different from re-establishment of malaria transmission (see definition).
malaria stratification	Classification of geographical areas or localities according to epidemiological, ecological, social and economic determinants for the purpose of guiding malaria interventions
malaria-free	Describes an area in which there is no continuing local mosquito-borne malaria transmission and the risk for acquiring malaria is limited to infection from introduced cases
mass drug administration	Administration of antimalarial treatment to all age groups of a defined population or every person living in a defined geographical area (except those for whom the medicine is contraindicated) at approximately the same time and often at repeated intervals
monitoring and evaluation	Monitoring is a continuous process of gathering and using data on programme implementation (weekly, monthly, quarterly or annually), with the aim of ensuring that programmes are proceeding satisfactorily, and making adjustments if necessary. The monitoring process often uses administrative data to track inputs, processes and outputs, although it can also consider programme outcomes and impacts. Evaluation is a more comprehensive assessment of a programme; it is normally undertaken at discrete points in time and is focused on the longer-term outcomes and impacts of programmes. The overall goal of monitoring and evaluation is to improve programme effectiveness, efficiency and equity.
population at risk	Population living in a geographical area where locally acquired malaria cases have occurred in the past 3 years
prevention of re-establishment	Re-establishment of transmission is defined as the occurrence of indigenous malaria cases (cases of second-generation local transmission) in a country or area where the disease had previously been eliminated. WHO's operational definition of re-establishment of transmission is the occurrence of at least three indigenous malaria cases of the same species per year in the same focus for three consecutive years.
receptivity	Receptivity of an ecosystem to transmission of malaria *Note:* a receptive ecosystem would have, for example, the presence of competent vectors, a suitable climate and a susceptible population.
recrudescence	Recurrence of asexual parasitaemia of the same genotype(s) that caused the original illness, due to incomplete clearance of asexual parasites after antimalarial treatment *Note:* recrudescence is different from reinfection with a parasite of the same or different genotype(s) and from relapse in *P. vivax* and *P. ovale* infections.
reservoirs of infection	Any person or animal in which Plasmodia live and multiply, such that they can be transmitted to a susceptible host
severe malaria	Severe malaria is a life-threatening condition caused by *Plasmodium falciparum* (and occasionally *P. vivax*, *P. knowlesi* or *P. ovale*) when malaria parasites lead to severe organ dysfunction or high parasite loads.

surveillance	Continuous, systematic collection, analysis and interpretation of disease-specific data and its use in planning, implementing and evaluating public health practice. *Note:* surveillance can be done at different levels of the health care system (e.g. health facilities, the community), with different detection systems (e.g. case-based: active or passive) and sampling strategies (e.g. sentinel sites, surveys).
surveillance, entomological	The regular, systematic collection, analysis and interpretation of entomological data for risk assessment, planning, implementation, monitoring and evaluation of vector control interventions
transmission, re-establishment of	Renewed presence of a measurable incidence of locally acquired malaria infection due to repeated cycles of mosquito-borne infections in an area in which transmission had been interrupted *Note:* a minimum indication of possible re-establishment of transmission would be the occurrence of three or more indigenous malaria cases of the same species per year in the same focus, for 3 consecutive years.
transmission, residual	Persistence of malaria transmission following the implementation in time and space of a widely effective malaria programme *Note:* the sources of and risks for "residual transmission" may vary by location, time and the existing components of the current "effective malaria programme".
uncomplicated malaria	Symptomatic malaria parasitaemia without signs of severity or evidence of vital organ dysfunction *Note:* malaria-associated disease can be defined more specifically by criteria for the degree of fever (e.g. temperature > 37.5 °C) and level of parasitaemia (e.g. > 5000 parasites/μL).
vectorial capacity	Number of new infections that the population of a given vector would induce per case per day at a given place and time, assuming that the human population is and remains fully susceptible to malaria
vulnerability	The frequency of influx of infected individuals or groups and/or infective Anopheles mosquitoes *Note:* also referred to as "importation risk". The term can also be applied to the introduction of drug resistance in a specific area.

Executive summary

Malaria surveillance, monitoring and evaluation: a reference manual, second edition provides comprehensive guidance on integrating malaria surveillance as a core intervention across all malaria transmission settings, aligning with the principles of the *Global technical strategy for malaria 2016–2030*. It emphasizes the importance of transforming surveillance into a dynamic tool that informs programmatic decision-making, resource allocation and intervention planning. By leveraging surveillance data, national malaria programmes (NMPs) can efficiently target interventions and resources to high-burden areas, prevent outbreaks and guide the transition to elimination, while mitigating the risk of re-establishment in areas that have achieved malaria-free status.

Key components of the guidance include the establishment of robust surveillance systems capable of detecting malaria cases, monitoring intervention coverage, and evaluating programme performance. The document outlines methodologies for data collection, analysis and reporting tailored to varying transmission intensities. It also provides strategies for integrating surveillance data with broader health information systems, ensuring sustainability and responsiveness to emerging challenges, such as climate change and drug resistance. Practical tools, including standardized indicators, data visualization methods and case studies, are included to support implementation at national and subnational levels.

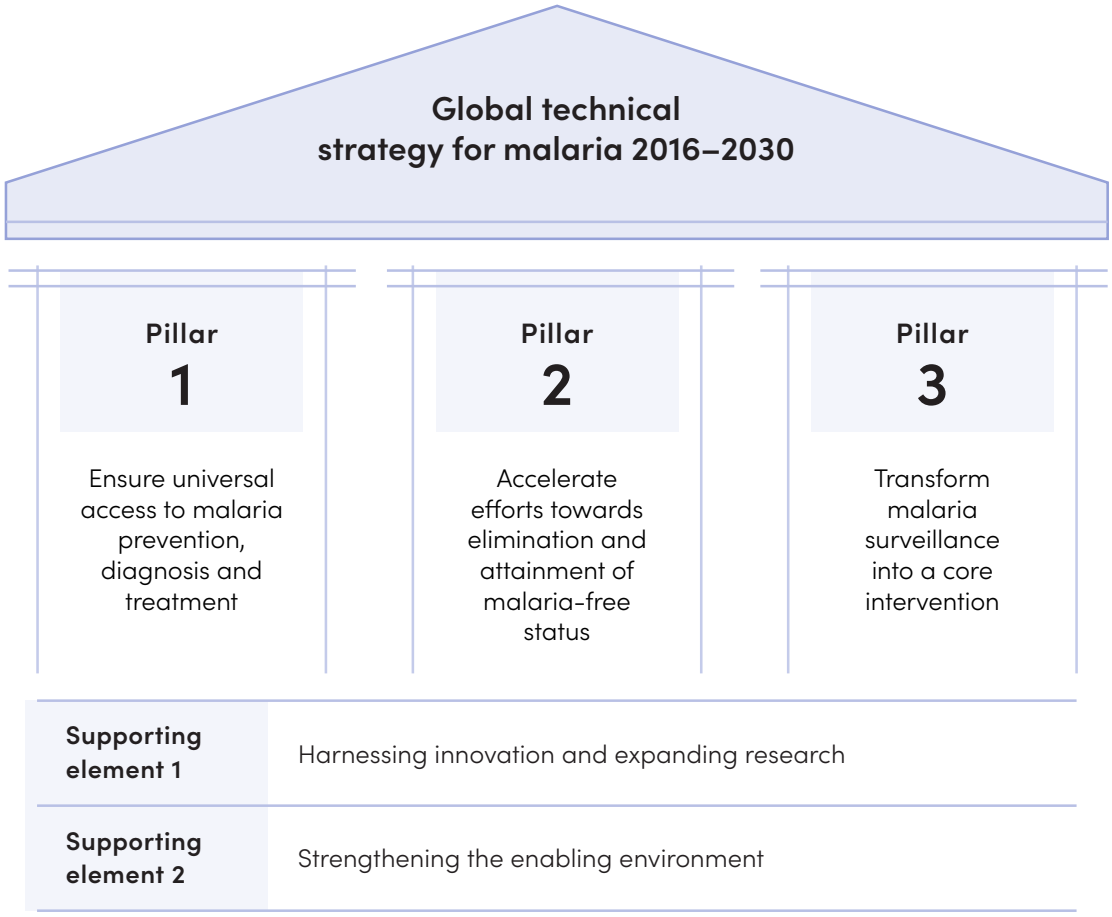
The guidance addresses critical gaps in current surveillance practices, offering solutions to challenges such as weak data quality, incomplete case detection and inadequate epidemic preparedness. It underscores the importance of stakeholder collaboration and capacity-building, emphasizing that well-functioning surveillance systems are essential for reducing malaria burden, achieving elimination goals and maintaining malaria-free status. By adopting the recommendations in this document, countries can enhance their malaria programmes and contribute to global efforts towards a malaria-free world.

1. Malaria surveillance as a core intervention

1.1 Introduction

Surveillance is the continuous and systematic collection, analysis and interpretation of disease-specific data, and the use of that data in the planning, implementation and evaluation of public health practice *(1)*. Pillar 3 of the World Health Organization (WHO) *Global technical strategy for malaria 2016–2030 (2)* is transformation of malaria surveillance into a core intervention in all malaria endemic countries and in those countries that have eliminated malaria but remain susceptible to re-establishment of transmission (Fig. 1).

Fig. 1. *Global technical strategy for malaria 2016–2030*: strategic framework – pillars and supporting elements



Surveillance is therefore the basis of operational activities in settings of any level of transmission. Its objective is to reduce the burden of malaria, eliminate the disease and prevent its re-establishment. In settings in which transmission remains relatively high and the aim of the national malaria programme (NMP) is to reduce the burdens of morbidity and mortality, malaria surveillance is often integrated into broader routine health information systems to provide data for analysis of trends, stratification and planning of resource allocation. In settings in which malaria is being eliminated, the objectives of surveillance are to identify, investigate and eliminate foci of continuing transmission, prevent and cure infections, and confirm elimination. After elimination,

the role of surveillance becomes that of detecting any new infection and preventing re-establishment of transmission.

A malaria surveillance system comprises the people, procedures, tools and structures necessary to generate information on malaria cases and deaths. The information is used for planning, implementing, monitoring and evaluating malaria programmes. An effective malaria surveillance system enables programmes to:

- identify and target areas and population groups most severely affected by malaria, deliver the necessary interventions effectively and advocate for resources;
- regularly assess the access, quality and impact of interventions and progress in reducing the disease burden, and help countries decide whether adjustments or combinations of interventions are required to further reduce transmission;
- detect and respond to epidemics in a timely way;
- provide relevant information for certification of elimination; and
- monitor whether the re-establishment of transmission has occurred and, if so, guide the response.

1.2 Updates of past guidance

In 2018, WHO published the first edition of *Malaria surveillance, monitoring and evaluation: a reference manual*, which combined, updated and expanded content from two operational manuals from 2012 – one for control *(3)* and the other for elimination *(4)*. The first edition responded to a growing need for an integrated surveillance framework applicable across the transmission continuum, from high-burden to elimination settings. It was informed by a review of WHO technical documents, country surveillance practices, expert consultations, and evolving malaria program strategies globally. This second edition of the reference manual includes the following modifications, additions and updates. It reflects feedback from countries and partners using the first edition, new normative guidance developed by WHO, and operational learning since 2018. The revision process included expert consultations, technical reviews, and alignment with new forthcoming WHO resources.

- The revised manual is aligned with several new resources under development, including the second edition of the WHO framework for malaria elimination *(5)*, the global framework on prevention of re-establishment of malaria transmission *(6)*, the field manual on malaria control in emergencies, the tailoring of malaria strategies and interventions subnationally: a reference manual, and the Malaria Surveillance Assessment Toolkit implementation reference guide.
- **Section 1** has greater emphasis on equity, emphasizing age- and sex-disaggregated data and the need to consider social factors, such as literacy and language (explicitly listed within principles of surveillance).
- **Section 2** has been updated to focus on digitalization, including reporting via District Health Information System version 2 (DHIS2) and the introduction of master lists to improve georeferenced health data and resource allocation. The section also emphasizes routine data quality assessments to enhance trust and decision-making,

and addresses surveillance for high-risk populations, such as pregnant women and girls, and at-risk populations in urban areas.

- **Section 3** provides expanded guidelines on reactive interventions and strategies, particularly for low-transmission and elimination settings.
- **Section 4** has a broader scope, with molecular markers of drug resistance included alongside therapeutic efficacy studies.
- **Section 5** has shifted towards question-based entomological surveillance, focusing on designing projects that inform intervention planning. It includes enhanced entomological surveillance indicators to better guide national programmes in vector control monitoring.
- **Section 6** has new sections that address the integration of forecasting and early warning systems with climate data to mitigate epidemic risks. The section provides improved guidelines for epidemic detection, preparedness and response across various transmission settings.
- **Section 7** provides priority indicators as well as approaches to improve programme accountability and responsiveness at all levels. Standardized guidance and examples of subnational tailoring for malaria programmes and carrying out routine surveillance assessments (using the Malaria Surveillance Assessment Toolkit) are included.
- The list of indicators for malaria in Annex 19 has been significantly updated. Data collection forms (for example, for case investigations) have been replaced and expanded (Annexes 1–4).

1.3 Target readership and use of this manual

The target readership of this manual is staff in ministries of health, specifically in NMPs and health information system units, partners involved in malaria surveillance and WHO officers who advise countries on malaria surveillance.

The manual covers subjects relevant to settings where the burden of malaria is being reduced, and to elimination and prevention of re-establishment. A glossary of important terms is provided in the preliminary pages. Section 1 presents the general principles of malaria surveillance systems. Subsequent sections provide general guidance for: establishing a surveillance system (Section 2); the concepts and practice of malaria surveillance systems in all settings (Section 3); integration of drug efficacy assessments into routine surveillance during elimination (Section 4); entomological surveillance for routine monitoring and focus investigation (Section 5); forecasting, early warning, early detection and response to epidemics (Section 6); and recommended practices for monitoring and evaluating programmes based on data from surveillance and other health information systems (Section 7).

This manual is intended to serve as a reference document for guidance on strengthening malaria surveillance systems. It provides information that can be used to develop national standard operating procedures (SOPs) in the following areas:

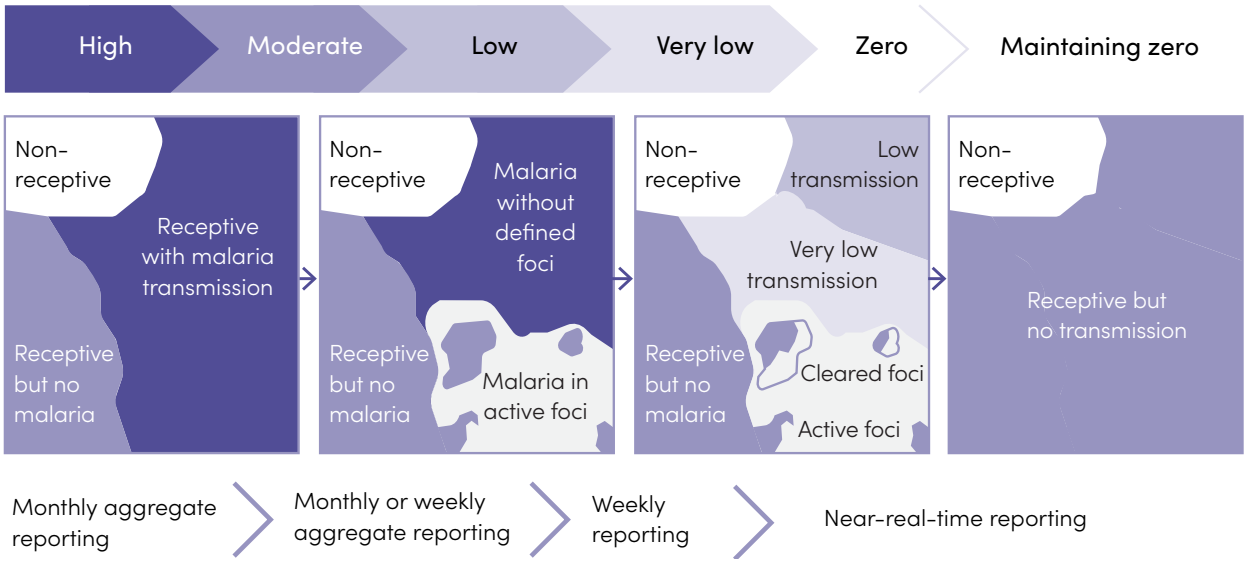
- surveillance of malaria cases and deaths in settings of malaria burden reduction, elimination and reintroduction (**Sections 1–3**);
- drug efficacy surveillance in elimination settings, especially in areas where each case is followed up in routine surveillance (**Sections 3–4**);
- entomological surveillance in settings of malaria burden reduction and elimination (**Sections 3, 4** and **5**);
- epidemic detection, preparedness and response, especially in low- to moderate-transmission settings of burden reduction (**Sections 2, 3** and **6**); and
- monitoring and evaluation of programmes and surveillance systems in all endemic settings (**Section 7** and relevant parts in other sections).

1.4 Malaria surveillance on the continuum

The design and intensity of malaria surveillance systems – in terms of recorded details, promptness of reporting and investigations, frequency of analysis, and response – depend on: the intended use of the surveillance data; the level and heterogeneity of malaria transmission; and the resources available for surveillance. The natural heterogeneity of malaria and the variable impacts of interventions and socioeconomic and environmental changes mean progress is often achieved at different speeds in different parts of a country and against different parasite species. Hence, a country may decide to conduct elimination activities in one part and to focus on reducing the number of deaths and disease in another. The *Global technical strategy for malaria 2016–2030 (2)* therefore uses the concept of a continuum (Fig. 2), whereby progress towards malaria elimination is considered to be a continuous process rather than a set of independent stages. By extension, countries are advised to establish surveillance systems appropriate to their heterogeneous epidemiology.

Fig.2. Malaria heterogeneity across the transmission continuum

As transmission decreases, malaria becomes focal, and the intensity and frequency of reporting increase. Surveillance systems evolve from reporting aggregate case data by month over large geographical areas (e.g. district) to weekly reporting when transmission is very low approaching zero and immediate notification when transmission is expected to be zero (or very nearly zero) in small areas (transmission foci).



As transmission decreases, the epidemiology of malaria is likely to change.

- The number of uncomplicated malaria cases and related fevers will decrease.
- The number of severe cases and deaths will decrease, although the proportion of severe to uncomplicated disease may increase.
- Malaria transmission will become more focal.
- Populations will become less immune as a consequence of decreased exposure, and the risk of epidemics and the associated case fatality ratio will increase if interventions are interrupted. Due to the decrease in natural immunity, all age groups may experience severe disease if infected, as opposed to primarily children under 5 years old, as seen in high transmission settings.
- The age of peak incidence will increase and shift upwards from children under the age of five to older school children or even adults.
- In some settings, certain occupations become important in identifying populations at higher risk of disease, such as forest work, for example, as mosquitos are more prevalent in forested areas. This occupational risk is often higher among adult men, who more commonly work in forests.
- Imported cases may represent an increasing fraction of the overall burden.
- In countries with both *Plasmodium falciparum* and *P. vivax* malaria, the proportion of *P. vivax* infection will gradually increase; the transmission of *P. falciparum* can be reduced faster with current interventions, while *P. vivax* infection includes a hypnozoite stage that will evade detection with current standard diagnostics.

The goals and possibilities of surveillance, monitoring and evaluation also evolve during this transition, as outlined throughout the manual.

- In areas of high transmission, programme monitoring and evaluation are based mainly on aggregate numbers, and actions are designed to ensure that the entire population has access to services and there are no adverse disease trends.
- In areas with low or moderate transmission, the distribution of malaria is more heterogeneous, and it is important to identify the population groups that are most severely affected by the disease and to target interventions appropriately. This will be facilitated by mapping areas of ongoing transmission and analysis of case distribution at the community level.
- As transmission is reduced, the risk of epidemics increases; thus, cases at health facilities must be analysed more frequently to ensure early detection of a potential outbreak.
- As progress is made towards elimination, it is critical to ensure efficient detection of and response to new cases and foci. Individual cases of infection or clusters of cases should be investigated to identify risk factors, eliminate foci of transmission through targeted response, and maintain malaria-free status. As surveillance systems become more complex and resource-intensive, additional skills, training and activities are required. However, as the number of cases is reduced and a country nears elimination, the frequency of case investigations will decrease, thereby eventually reducing the costs of surveillance.

1.5 Principles of the design and establishment of malaria surveillance

The core principles of the design and establishment of malaria surveillance systems are listed below.

- Accurate parasitological diagnosis of a malaria case is the foundation of malaria surveillance. Diagnoses should be made with either quality-assured malaria microscopy or WHO-recommended rapid diagnostic tests (RDTs) (see **Box 1**).
- All major components of a malaria surveillance system should be integrated into broader health management information systems (HMIS), including, where applicable, systems for reporting notifiable diseases. In settings where a vertical system is used, the system should allow communication with and eventually be integrated into the HMIS for sustainability. The HMIS should be responsive to the promptness and granularity of data required for effective malaria surveillance.
- National SOPs and policies for surveillance should be based on a country's needs and WHO recommendations. For elimination, regulations should be enacted through appropriate national mechanisms so that, by law, malaria becomes a notifiable disease in all relevant sectors of the health system. In settings of burden reduction, all health sectors must also report data to the national HMIS.
- Regardless of the malaria burden, front-line staff involved in the detection, recording and reporting of cases should also be the first users of data. Analytical capacity to understand and use malaria surveillance data should therefore be available at all levels. The type of training required to make the best use of the data will vary by level. Some examples of training include: examining and evaluating data from surveillance of both disease and operations, monitoring programme progress, tailoring and targeting interventions, analysing and interpretating data and detecting problems with case management, resource allocation or data quality that require action.
- Surveillance systems should address the heterogeneity of malaria within a country's boundaries. For example, monthly aggregate case reporting may be sufficient in areas with a relatively high malaria burden, but, as the caseload diminishes, aggregated data should be reported weekly; then, individual cases should be reported weekly; and, once an elimination goal with a defined time frame has been set, individual cases should be reported immediately (see **Fig. 2**). In elimination settings, cases should be linked to the village (or focus) and household of origin, where further case detection, treatment, classification, investigation, management and clearance of foci of transmission can be undertaken as appropriate. Across settings, relevant age and sex disaggregation should be included to aid understanding of health disparities and inform appropriate policies and services.
- Necessary investments in surveillance and system transition, including in human resources and their capacity, should be made to respond to the anticipated changes in malaria epidemiology and reduction in disease burden. For instance, surveillance systems that allow for immediate case notification, investigation and response should be in place before a country embarks on elimination.

- All surveillance data must be linked to a decision at some level of the health system, even if the decision results in no immediate change in interventions. Where appropriate, surveillance data should be combined with other data from the programme and the population to improve decision-making: In settings with a high or moderate burden of malaria, important markers of progress are trends in childhood deaths from all causes and from malaria, the proportions of *P. vivax* and *P. falciparum* malaria where the latter was dominant before the intervention, and changes in the age distribution of the disease. In elimination settings, surveillance is linked to specific responses that should allow the detection of all cases of malaria infection by microscopy or WHO-recommended RDT (including symptomatic and asymptomatic infections) as early as possible; the prevention of onward transmission from each case through prompt, radical treatment and vector control; and the identification, investigation and management of all transmission foci, with appropriate measures for interrupting transmission as soon as possible.
- In all transmission settings, case detection information must be disseminated to relevant decision-makers and stakeholders through different mechanisms, such as open-access surveillance bulletins. A concerted effort must be made to include cases detected in other sectors (e.g. in private and other nongovernmental health care facilities), as well as those detected in public health facilities. In elimination settings, cases detected in all sectors must be reported and investigated.
- After the interruption of transmission, surveillance for malaria may become the broad responsibility of general health services. Nevertheless, the surveillance system should be supported by regular training and monitoring in a national programme to ensure identification of changes in malaria receptivity (i.e. suitability of the ecosystem for transmission of malaria) and the vulnerability of the population or importation risk (i.e. the frequency of influx of infected individuals or groups and/or infective *Anopheles* mosquitoes). Compulsory, immediate notification, diagnosis with quality-assured RDTs and microscopy must be maintained.
- Like most other health interventions, surveillance is likely to benefit from innovation and advances in technology. The choice of new technology should be based on proven additional benefits, cost, scalability and sustainability, as determined by empirical evidence.
- Good understanding of the biology and behavioural ecology of vector species is essential for making programme decisions and monitoring and evaluating vector control interventions, including quality assurance. The efficacy of the antimalarial drugs used for treatment of parasite infection should also be monitored regularly. Data from entomological and drug efficacy surveillance should be interpreted in conjunction with epidemiological data as a basis for programme decisions.
- Surveillance systems should be systematically and routinely assessed to ensure their accuracy, reliability, completeness, precision, timeliness and integrity. Assessment should also include the appropriateness of actions taken in response to the results of surveillance.

Box 1. Advantages of focusing on confirmed cases of malaria

A considerable proportion of cases of fever are not due to malaria, even in high-transmission settings *(7)*. In the past, however, most countries endemic for malaria based diagnosis of the disease on fever only. With increasing access to RDTs for malaria, it is now easier to quickly test febrile patients for malaria and to treat them with effective drugs if they are positive for malaria infection. This not only ensures accurate management of febrile patients and reduces wastage of antimalarial drugs but also increases the quality of surveillance data. The graph below is a simple illustration of the relationship between suspected malaria and confirmed infection.

The graph suggests that in higher transmission settings a large proportion of febrile patients may be suspected of having malaria, the system may not have the capacity to diagnose all of them, and, among those who are tested, only a moderate proportion may have malaria. As transmission decreases, fewer patients are suspected of having malaria, but the system can confirm all cases, and very few have malaria. When cases are detected actively, however, everyone in an area may be tested for malaria, with or without a suspicion that they are infected. In such situations, caution is required in quantifying test positivity rates for suspected cases.

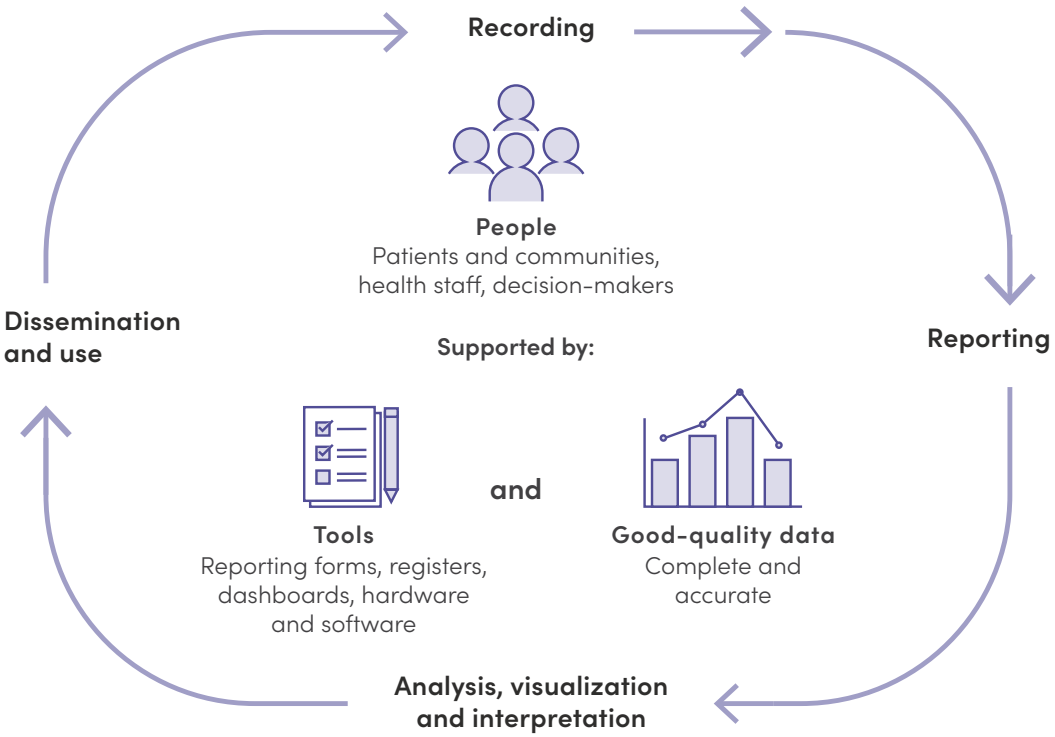
2. Establishing malaria surveillance systems

Health information is one of the six building blocks of a health system *(8)*, and surveillance is the main component of a national HMIS. It comprises the people, procedures, tools and structures required to generate information for planning and targeting interventions and monitoring and evaluating malaria programmes.

- The **people** include the patients and communities whose details are registered, the health staff who gather and/or use the data and the decision-makers – both inside and outside the health service – who use data from the surveillance systems.
- The **procedures** include case definitions, reporting frequency, pathways of information flow, data quality assessments, incentive schemes, data analysis, mechanisms for reviewing performance, methods for and frequency of disseminating results, using data for making decisions about appropriate responses, supervision and planning, and action planning.
- The **tools** include report forms, tally sheets, registers, patient cards, dashboards, computer hardware and software, documentation and training materials.
- The **structures** include how staff are organized to manage, develop and use the system.

A functioning, integrated and sustainable surveillance system addresses each of these areas. Deficiencies in any of these components may limit the capacity of a malaria control programme to undertake effective surveillance. The health information cycle shown in Fig. 3 is relevant to all malaria transmission settings, but the frequency and intensity of activities along the cycle will increase on the pathway to elimination.

Fig. 3. The health information cycle, centred on a competent, adequately resourced health workforce with appropriate tools and good-quality data



2.1 Requirements and processes

Progress against malaria may be more rapid in some parts of a country than in others; hence, the information (and its frequency) required to inform response and interventions will vary. In settings in which the main objective is to reduce the burden of malaria disease and deaths, the surveillance system is part of the routine HMIS. In elimination settings, a malaria-specific surveillance system may be in place, although important components must be integrated into the HMIS.

Fig. 4 illustrates a broad framework for malaria surveillance in different transmission settings. It is aligned with the *Global technical strategy for malaria 2016–2030 (2)* and the forthcoming second edition of the WHO framework for malaria elimination *(5)*.

Fig. 4. Surveillance system processes and requirements along the continuum of malaria transmission settings[a]

Pillar 3 of the GTS: Transform malaria surveillance into a core intervention	High: ≥ 35% PfPR or ~ 450 per 1000 PAR[b]	Moderate: 10–35% PfPR or 250–450 per 1000 PAR[b]	Low: 1–10% PfPR or 100–250 per 1000 PAR[b]	Very low: > 0 but < 1% PfPR or < 100 per 1000 PAR[b]	Zero: No transmission	Maintaining zero
Case detection	Passive case detection			Passive and active case detection[c]		
Recording	Outpatient and inpatient registers		Individual patient forms	Extensive individual patient forms		
Reporting frequency	Monthly		Weekly	Immediate case notification		
Resolution of reported data	Aggregate cases by sex and age category		Case report, age, sex, residence, travel history and case classification			
Data analysis: health facilities	Monthly		Weekly	Immediate		
Data analysis: intermediate levels	Monthly		Weekly			
Data analysis: national	Monthly or quarterly		Weekly			
Response time	Monthly or quarterly		Weekly	Case investigation within 24–48h, focus investigation within 1 week		
Feedback frequency to upper and lower levels	Monthly or quarterly		Weekly			
Surveillance system monitoring	Every 2–5 years		Annually or more frequently			

PAR: population at risk; PfPR: *P. falciparum* parasite rate.

[a] It should be noted that categories (high, moderate, low, very low, zero and maintaining zero) based on malaria incidence should not be rigid. For example, if a country has the capacity and resources, and it aligns with national malaria elimination goals, case-based data collection and weekly reporting may be initiated in higher transmission settings.

[b] Number of confirmed malaria cases during a predefined period (usually 1 year) per 1000 population at risk.

[c] Active case detection includes both reactive case detection (RACD) triggered by an index case and proactive case detection (PACD) (see Section 3.2).

2.1.1 General processes

In most areas in which transmission remains moderate to high and the main goal of national programmes is to reduce the burden of disease, there are often so many malaria cases that each confirmed case cannot be examined individually. Instead, the analysis is based on aggregated numbers obtained from routine health information systems, and action, such as determining suitable interventions and increasing coverage, is taken at the population level. The initial focus will be on ensuring good-quality data, which is based on the following.

- All people with suspected malaria are examined with a diagnostic test.
- Cases are correctly classified according to the test result and treated with nationally recommended antimalarials.
- The quality of both microscopy and RDTs is controlled.
- Registration and reporting from health facilities are complete and consistent.
- The coordinates of all points of care are known so that their location can be shown on a map (**Box 2**).
- A system is in place for assessing the surveillance system, including auditing of data quality.
- There is a process of analysing and using the surveillance data for response and for monitoring and evaluating programmes.

Box 2. Improving disease surveillance through core geographical data: master lists

Master lists can help resolve commonly faced challenges in data use *(9–11)*. A master list is an authoritative set of uniquely coded, georeferenced active records that serves as a single source of truth across government programmes. It has a defined governance structure and documented processes for maintenance, storage and management. In the context of malaria, it identifies facilities diagnosing and treating malaria (all known points of care, operational units such as localities, villages and other geo-objects of interest), and thus supports effective resource allocation, monitoring and planning.

The absence of a master list leads to several challenges that prevent effective disease surveillance, including inability or difficulty in:

- confidently measuring and interpreting trends, because of unknown reporting completeness and incomplete indicator denominators (i.e. suboptimal data quality);
- visualizing and understanding spatial heterogeneity in reported morbidity and mortality data, because of missing geographical information;
- accurately identifying and addressing gaps in access to care, because of missing data; and
- cross-tabulating variables reported through different information systems that are important for the interpretation of trends or impact of intervention (testing rates and RDT stocks, cases and vector control coverage), because there are multiple lists without unique identifiers.

Establishment of a master list follows a general set of steps.

- **Complete a current-state assessment of the people, processes and technology involved in collecting and maintaining geospatial data.** Include scoping of existing geospatial data and list quality, completeness, availability, storage, governance, ownership and partner landscape.
- **Establish and document a governance structure for each master list.** For example, there may be an individual master list for health facilities, for community health workers (CHW) and for villages.
- **Complete the data dictionary and georeferenced list(s)** (e.g. for health facilities, CHWs, villages).
- **Integrate the list(s) with HMISs or house them in a linked common georegistry** (e.g. GeoPrism) *(9, 10)*.
- **Define and disseminate SOP documentation for maintenance, storage and management.**

Master lists improve data quality, confidence in data and accessibility to data for decision-making. Examples of success could be an improvement in the number of points of care that can be mapped and included in planning activities, higher match rates when linking data from different information systems or decreases in missing data when reviewing trends.

Master lists are foundational for effective data-informed decision-making, alongside other core geographical data such as administrative boundaries and population. Accurate and regularly updated master lists enable effective monitoring of spatial and temporal malaria trends, targeting of interventions to at-risk places and people, assessment of intervention impact, identification of gaps in access to care, and optimal allocation of resources.

Measuring success, and impact on public health outcomes

The conditions for good-quality data must be in place before countries transition to complex case-based surveillance systems. The parasite rate and malaria incidence thresholds presented in the framework in Fig. 4 should be used as broad measures of the transition of a surveillance system and are not prescriptive. The aim is to highlight the notion of a continuum of transmission within a country and the need for a surveillance system that reflects the heterogeneous epidemiology. The ability to implement surveillance depends not only on the level of transmission but also on factors such as the strength of the health system and available financial, human and other relevant resources. Most countries conducting elimination activities may consider that a malaria incidence of 100 per 1000 population is a relatively high threshold for starting case and focus investigations and may find a lower caseload to be more practicable.

As transmission is progressively reduced, it becomes increasingly possible, and necessary, to track and respond to individual cases. The thresholds of transmission are not fixed; therefore, some surveillance strategies, especially in lower-transmission settings, could be initiated earlier if the resources are available. The frequency of reporting initially increases from monthly to weekly and then to immediate notification, and the resolution of data increases from aggregated cases to a line listing of

patients. In elimination settings, however, it is critical that the surveillance system allow immediate notification of individual cases, followed, where appropriate, by prompt case and focus investigation and response.

In all settings, the quality of surveillance systems must be monitored continuously by:

- maintaining an up-to-date master list of operational health facilities and other notification sources;
- making sure that all core and support functions of the systems are in place;
- keeping track of which facilities have submitted the required reports and their completeness and timeliness;
- tracking the proportion of cases and foci investigated where applicable;
- following up on missing, incomplete and delayed reports;
- reviewing the quality of data submitted and following up on incomplete or erroneous data;
- providing constructive feedback to all health facilities, including those that submit timely, complete, accurate data; and
- ensuring a system for up-to-date training of surveillance staff.

Data from surveillance must be interpreted carefully to identify any weaknesses in systems. During analysis and interpretation of surveillance data, information from other sources, such as surveys, civil and vital registration systems and censuses, should be included, as appropriate. In situations where more than one system is used for malaria data collection, concordance between existing systems collecting the same data should be assessed.

2.1.2 Data quality

A standard set of metrics (**Table 1**) and methods can be used to determine the quality of malaria data. Tested methods include desk-level assessments (retrospective analysis of data collected at the national or subnational level) and service-level assessments (comparison of data between central databases and data collected at the service-delivery level). In addition to their use in structured assessments of surveillance systems, data quality assessments are routinely conducted as part of programme implementation; for example, data quality review of case management variables that may inform targeting of routine supervision at the health facility level.

Table 1. Data quality metrics

	Metric	Definition
1	Consistency of case definitions	Definition of malaria case consistent with the definition in *WHO malaria terminology, 2021 update (12)*
2	Completeness of facility reporting	Proportion of expected reports that were received in a specified period
3	Timeliness of facility reporting	Proportion of expected reports received by the reporting due date in a specified period
4	Completeness of core variables within reports	Proportion of reports in which all expected variables are complete, received in a specified period
5	Consistency between core variables	Proportion of reports in which all consistency checks between core variables are passed, received in a specified period; that is, there is a valid relationship between related indicators For example: confirmed cases < cases tested
6	Consistency over time for core indicators	Proportion of core indicator trends that are consistent for a specified period (suggested minimum is 3 years) This may include investigation of outliers Consistency (i.e. what is considered consistent) should be defined by the country.
7	Concordance between electronic reporting systems	Proportion of all core variable values that match between two reporting systems (e.g. a malaria surveillance system versus HMIS, IDSR or laboratory) in the same specified period
8	Concordance between source data and the reference electronic reporting system	Proportion of all core variable values that match between the malaria surveillance system or HMIS and the source data (e.g. patient registers or case investigation forms), in a specified time period

ACT: artemisinin-based combination therapy; HMIS: health management information system; IDSR: integrated disease surveillance and response.
Various other data quality metrics (such as precision that refers to the degree to which a data point aligns with the true value) can be assessed in addition. Data quality metrics are further described in the WHO Malaria Surveillance Assessment Toolkit *(13)*.

All data quality assessments should link to actionable next steps and interventions that address specific data quality issues. Continuous review of data quality and efforts to improve data enable trust in the data and can create a culture for data-driven decision-making at various levels of the health system.

Example interventions that can improve data quality, and therefore enhance data-driven decision-making, include:

- a clear and consistent set of case definitions across all relevant surveillance tools (e.g. registers, reports, data systems and dashboards) and guidelines;
- establish clear data governance policies;
- formulate and roll out data quality guidelines and SOPs;

- train all relevant parties who interact with malaria information on data quality guidelines and SOPs (e.g. health care workers, health information officers and managers, database managers and surveillance managers);
- design, deploy and institutionalize electronic information systems that include data validation algorithms and dashboards to prevent data quality issues and/or make them more transparent to relevant decision-makers (e.g. through a data quality dashboard); and
- institutionalize routine data review meetings that implement a standardized data quality review process (e.g. review of data quality metrics using dashboards) and development of actionable follow-up plans (Box 3).

Box 3. Data review meetings focusing on data quality

Data review meetings bring together national, subnational and service-delivery level stakeholders to review and monitor data quality, verify data sources, analyse malaria indicators against targets, develop action plans to inform interventions for improving data quality and health services, and document key learnings and achievements.

Best practices when conducting data review meetings are as follows.

- Data review meetings are best conducted periodically, aligning with timelines that enable follow-up corrective actions.
- Results from data quality analyses should be converted into dashboards or presentations that allow participants to visualize trends in data quality indicators over time and by geography.
- Emphasis should be given to developing action plans that address data quality and performance issues in a timely manner.
- Monitoring and evaluation processes should be in place to ensure accountability in the use of analytical outputs for implementing data quality interventions, and to inform future priorities for improving data quality.
- Data-to-action principles should be followed.
  - Data should be accessible to all relevant stakeholders and decision-makers (**transparency**).
  - Responsibilities for the use of data in decision-making should be clearly defined and meet the needs of the target population. This may promote **accountability** by allowing stakeholders to monitor the decision-making approach and the outcomes of decisions.
  - Data access should be appropriate to parties involved in analysis and use of the information (**accessibility**).
  - **Ownership** for data use should exist at different levels of the health system; for example, subnational ownership is necessary to ensure dashboards and data tools are used where they matter most.
  - While external financial and technical inputs are of significant value, it is the staff at all levels of a health system who will ensure the **sustainability** of outcomes achieved.

2.2 People-centred surveillance

The basis of a surveillance system is the community being served and the health workers who attend to their health needs. The front-line health workers and volunteers who are usually responsible for patient care and data recording and reporting must feel recognized and rewarded for their efforts through regular feedback, training and overall good staff management. At all levels of the information cycle, adequate investment must be made in infrastructure and the development of human resource capacity (through hiring and training practices that consider differences in literacy, language and other social factors of relevant stakeholders) to operate and maintain surveillance systems and enable effective use of information for decision-making.

As countries reduce their malaria burden, the intensity, resolution and frequency of surveillance will increase. For positive malaria cases, surveillance will shift from aggregated reporting to case reporting and analysis. An aggregated approach to data will be maintained for individuals attended and tested. Case and focus investigation will require specialized field teams and greater analytical capacity.

Sufficient person-time is required at district, provincial and national levels for data acquisition from health information departments; importing, merging, cleaning and analysing data; mapping; and producing surveillance bulletins and reports. Regular, unbiased feedback will be required, not only to other levels of the health sector but also to communities. Ministries of health, NMPs and partners should ensure that the necessary human capacity is in place and that national SOPs support all surveillance activities.

Disease surveillance requires epidemiological, statistical and computer skills and, at district and higher levels, experience in monitoring and evaluation. It is usually advantageous to link training in malaria surveillance with other training activities to save costs and to make more effective use of health workers' time. When possible, training in malaria surveillance, including analysis and use of data, should be given at the same time as training in HMIS or malaria case management, particularly in the use of diagnostic testing. The pre-service curricula of medical, nursing and pharmacy schools should be updated to reflect the latest requirements for disease surveillance, noted in **Section 2.1**. Countries should ensure that not only the public sector but also nongovernmental organizations and the private sector participate in surveillance systems by reporting data, providing feedback and engaging in joint training, especially in elimination settings, to ensure all cases are captured.

2.3 Data recording

The annexes to this manual provide suggested registers and forms that can be adapted for use by countries. Registers should provide space for recording essential data elements, such as suspected cases, test results and relevant age and sex

disaggregation, and no unnecessary elements, as the more data there are in registers and forms, the less likely it is that the forms will be completed accurately, if at all.

When possible, forms should reflect current guidance, such as that provided in standard treatment guidelines, surveillance SOPs and monitoring and evaluation manuals, with a clear justification of how the variables collected will be used.

In countries where the burden of malaria is substantial and the caseload is such that individual case investigation may not be possible, malaria surveillance systems are often part of broader communicable disease surveillance or the HMIS. These systems should be adapted to include the basic data elements suggested in this manual. In low-transmission settings in which malaria is relatively rare and confined to specific locations, there may be a separate malaria reporting system, which allows timely response to individual cases and can be adapted according to the recommendations in this manual. These separate surveillance systems should communicate as much as possible with the HMIS, and the main components should preferably remain integrated into the HMIS to ensure long-term sustainability.

It is important to involve all relevant stakeholders in discussions about revising a system, especially those involved in data collection in health facilities, who can provide valuable information about the constraints they face and practical suggestions for improvement. An inclusive process creates a sense of ownership and accountability, and encourages the adoption and use of forms. New and revised forms should be tested on a small scale (e.g. in one administrative unit for 6 months) before they are used widely. After the final adjustments have been made, the documentation on use of the forms should be updated and data collectors trained in their use. When the new forms are supplied to health facilities, the old ones should be removed or destroyed to ensure that health workers do not use previous systems (e.g. because of a disruption in the stationery supply or lack of familiarity with the new forms). A regular supply of forms should be ensured to alleviate this problem. When possible, an electronic system with the required backup should be used to minimize the cost of data recording and improve the efficiency of the system. The data required, by level of malaria surveillance system, are listed in **Table 2**. Refer to **Fig. 4** for the transmission thresholds for the three broad classifications used in Table 2.

See **Annexes 1–3** for an examples of individual case notification, case investigation and focus investigation forms, **Annex 4** for updating registration of foci, **Annex 5** for focus mapping, **Annex 6** for an example of a register for health facilities, **Annex 7** for forms for recording outpatient attendance, **Annex 8** for daily and weekly records of outpatient attendance at health centres and hospitals, **Annex 9** for a discharge register for inpatient departments of health centres and hospitals, **Annex 10** for reports from health posts and CHWs to health facilities, **Annex 11** for reports from health facilities to district level, **Annex 12** for line lists of malaria cases and deaths among inpatients to be reported at district level in low-transmission settings, **Annex 13** for line lists of all confirmed malaria cases to be reported at district level in low-transmission settings and **Annex 14** for a supervisory checklist for countries with high or moderate transmission.

Table 2. Data recorded by level of the surveillance system and goal of the programme

Level	Burden reduction (high, moderate, low)	Elimination (very low or zero)	Prevention of re-establishment[a,b]
Field (household and focus)	When transmission is relatively high and the goal is to reduce the burden, case and focus investigation may be applicable only rarely and among high-risk groups, such as internally displaced populations and migrants or during outbreaks. The information recorded in case and focus investigations will be similar to that in elimination settings. Additionally, threshold graphs and intermediate-level (e.g. district) situation reports and post-epidemic assessment reports are required in epidemic detection and response. Regular community household surveys are useful to track changes in parasite prevalence and intervention access and coverage.	In **case investigations**, the following should be recorded for the index case and other cases seen in the community during active case detection (ACD): • case and household identification number • when possible, contact information, such as a telephone number • longitude and latitude of household • date of testing, address, age and sex • fever history (if used for screening), including date of onset of symptoms • type of diagnostic (RDT or microscopy) • test results by parasite species, including date of diagnosis • date of notification • treatment given, including date and follow-up • nationality • occupation • travel history • likely period of infection and location during this period • other potential risk factors (e.g. sleeping habits) • ownership and use of ITN (e.g. number of individuals that slept under a ITN last night) • household receipt of IRS • date of intervention (ITN distribution or IRS) • date of case investigation • case classification (local or imported; in elimination settings, cases should be further classified into indigenous, introduced, induced, relapsing or recrudescent). In **focus investigations**, the following should be recorded: • focus location • date of investigation • number of cases seen during ACD by case classification • information on factors associated with transmission • focus classification • focus response including date • date and type of response.	Same data elements as during elimination; focus investigations should be done only if the case is locally acquired (i.e. indigenous or introduced) or an imported case has been reported in a highly receptive focus (see Section 3.6).

Level	Burden reduction (high, moderate, low)	Elimination (very low or zero)	Prevention of re-establishment[a,b]
Health posts and CHWs (as a point of service delivery)	**Registers** should record: • date of attendance • patient's name, age and sex • patient's village of residence • whether a new attendance or a repeat visit for the same episode • presence of malaria symptoms (e.g. fever) • type of diagnostic (RDT or microscopy) • malaria test result by parasite species • treatment given.	**Registers** should record: • date of attendance • patient's name, age and sex • patient's village of residence • when possible, contact information, such as a telephone number • whether a new attendance or a repeat visit for the same episode (usually within a 7-day window) • presence of malaria symptoms (e.g. fever) • type of diagnostic (RDT or microscopy) • malaria test result by parasite species, including date of diagnosis • date of notification • treatment given, including date • travel history • likely period of infection and location during this period • location of work • date of case investigation • preliminary case classification (local or imported).	Same data elements as during elimination

Level	Burden reduction (high, moderate, low)	Elimination (very low or zero)	Prevention of re-establishment[a,b]
Health centres and hospitals	For **outpatients**, registers should record: • date of attendance • patient's name, age and sex • patient's village of residence • whether a new attendance or a repeat visit for the same episode • presence of malaria symptoms (e.g. fever) • type of diagnostic (RDT or microscopy) • malaria test result by parasite species • treatment given. **Inpatient discharge** or ward registers should contain: • date of admission • patient's name, age and sex • patient's village of residence • type of diagnostic (RDT or microscopy) • malaria test result by parasite species • treatment given • length of stay • reason for leaving (discharged, referred, died, transferred or absconded).	For **outpatients**, registers should record: • date of attendance • patient's name, age and sex • patient's place of residence • when possible, contact information, such as a telephone number • whether a new attendance or a repeat visit for the same episode • presence of malaria symptoms (e.g. fever) • date of onset of symptoms • type of diagnostic (RDT or microscopy) • malaria test result by parasite species, including date of diagnosis • date of notification • treatment given, including date • travel history • likely period of infection and location during this period • location of work • date of case investigation • preliminary case classification (local or imported). **Inpatient discharge** or ward registers should contain: • date of admission • patient's name, age and sex • patient's village of residence • type of diagnostic (RDT or microscopy) • malaria test result by parasite species, including date of diagnosis • date of notification • treatment given, including date • length of stay • reason for leaving (discharged, referred, died, transferred or absconded) • travel history • location of work • date of case investigation • preliminary case classification (local or imported).	Same data elements as during elimination

Level	Burden reduction (high, moderate, low)	Elimination (very low or zero)	Prevention of re-establishment[a,b]
Intermediate level (e.g. district)	**Monthly or weekly reports** of the numbers of: • suspected malaria cases • malaria tests performed • confirmed cases, by parasite species • outpatient attendances • inpatient discharges and deaths • inpatient malaria discharges and deaths, by parasite species Data in the reports should be disaggregated by health facility (see also Annex 19 for further suggested disaggregation). **Annual records** of: • malaria programme interventions, structures by type and staff by group • maps showing the distribution of confirmed cases, inpatients and deaths by health facility catchment area, village or administrative boundary, to be updated annually • an entomological database of *Anopheles* species • all reports and analyses produced by staff at intermediate level (e.g. district) during the previous 5 years and submitted to higher levels.	From all sectors (public, private and community), **weekly reports** of the numbers by PCD and ACD of: • suspected malaria cases • malaria tests performed and confirmed cases, by parasite species and classification • number of cases notified on time • number of cases investigated on time • number of foci investigated on time • number of foci classified • types of response by type of focus. Data disaggregated by health facility and focus. **Monthly records** of: • malaria programme interventions, structures by type and staff by group • malaria case notifications (Annex 1) • malaria case investigation forms, including the results of ACD (Annex 2) • focus investigation forms (Annex 3) • a list of foci with changes in class over time (Annex 4) • an entomological surveillance database.	Same data elements as during elimination
	Create an NMP-owned vector control and intervention database containing information on IRS coverage, number of ITNs, ACTs and RDTs distributed, chemoprevention (SMC, IPTp or IPTi, as applicable), larval control (biological and chemical larviciding, and environmental management activities), drug efficacy surveillance, surveillance of *Pfhrp 2/3* deletions, commodity tracking and "behaviour change communication" activities. Mechanisms such as technical working groups can be leveraged to centralize data. File and keep all periodic and annual reports and district analyses produced by staff during the past 5 years and submitted to higher levels. Collate feedback and other information from higher levels. The team should analyse aggregated and case-based data. Clear illustrative mapping should be routine. Electronic dashboards should be the norm for display of data and analysis.		

Level	Burden reduction (high, moderate, low)	Elimination (very low or zero)	Prevention of re-establishment[a,b]
National	Same as intermediate levels but recorded for all intermediate levels. National reports and data aggregation for global monitoring.	Same as intermediate levels but recorded for all intermediate levels. Data recorded will include: • national malaria case register – a consolidated list of all malaria cases supported by case investigation forms • malaria focus investigation data – all data from the malaria focus investigation form (Annex 3) • list of foci with changes in class (Annex 4) – the status (category) of each focus is re-evaluated after each new confirmed case and at least at the end of each transmission season • NMP health structures and staffing • national malaria laboratory quality assurance data • reports of activities of specially assigned mobile teams • entomological surveillance data • vector control activities and interventions • chemoprevention (as applicable) • drug efficacy surveillance • surveillance of *Pfhrp 2/3* deletions • commodity tracking • malaria surveillance reports and analyses sent by intermediate levels (e.g. districts) • national annual malaria surveillance reports and analyses.	Same data elements as during elimination

ACD: active case detection; ACT: artemisinin-based combination therapy; IRS: indoor residual spraying; IPTi: intermittent preventive treatment of malaria in infancy; IPTp: intermittent preventive treatment of malaria in pregnant women and girls; ITN: insecticide-treated nets; ; NMP: national malaria programme; PCD: passive case detection; *Pfhrp 2/3: P. falciparum* histidine-rich protein 2 and 3; RDT: rapid diagnostic test; SMC: seasonal malaria chemoprevention.

[a] In areas of elimination and prevention of re-establishment, patients should be followed up to ensure adherence to treatment and complete cure (see Section 3).

[b] Additional indicators relevant to a prevention of re-establishment setting which may require collection of additional data elements are outlined in the global framework on prevention of re-establishment of malaria transmission *(6)*.

2.4 Data reporting

Depending on the transmission context, aggregated data (from areas where the focus is reducing the malaria burden) or line-listings of patients (in very low transmission and elimination settings) are expected to be submitted routinely throughout the surveillance system. Health facility case data should be supported by information on the number of CHWs expected to report and the actual number who do so; this information can be written on the health facility reporting form. In some countries, the data from health facilities and CHWs may be kept separate so that data can be interpreted according to the point of care that provides it. Reporting from lower-level facilities or CHWs may be done in batches, which can create a false impression of trends. For example, if several late reports are received from health posts at once, the sudden increase in cases could be misinterpreted as an outbreak.

As the caseload decreases, case-based data should be aggregated and reported weekly. Case reporting is easier when electronic data systems are linked to a central database. The system can be further simplified by using electronic patient registers and a mechanism to automate data aggregation.

During elimination, cases must be notified immediately to the field team, and data may be transmitted as a patient line listing almost daily. This is increasingly possible with open-source software such as the District Health Information System version 2, which is a platform that can be used via an Android smartphone app, or with tablets or computers *(14)*. The platform allows for both offline and online real-time data capture and enables uploading of retrospectively collected data (**Box 4**).

Box 4. DHIS2 packages for aggregate and case-based reporting

WHO, in collaboration with partners, has developed several digital solutions to support the strengthening of national routine surveillance, including country reporting and analysis for both aggregate and case-based reporting *(15)*. Each package includes standardized metadata, defining data elements, indicators, visualizations and curriculum materials. The packages are readily available for download, customization and installation in countries that use DHIS2.

Aggregate reporting module

The aggregate reporting module supports routine reporting and analysis of service delivery, treatment and other activities, such as continuous ITN distribution from public facilities, private facilities and CHWs. Datasets and indicators for burden reduction and elimination settings can be selectively deployed at subnational level according to stratification. The module also includes a data quality dashboard for NMPs, district-level dashboards, and analyses for triangulating facility stock data with service delivery data. As part of an integrated HMIS, new interventions such as malaria vaccines are also supported in DHIS2 as part of an integrated immunization module and can be triangulated with routine malaria surveillance data.

Case-based reporting and foci investigation module

The case-based reporting and foci investigation module can be used for case notification, investigation and response, and for focus investigation and response. These tools make it easy for health workers to enter data on new malaria cases, and investigation teams to register and monitor foci. As the data are captured, investigative teams are notified – they can also use the module to record case data and investigation data during their surveillance activities. Simultaneously, the quality of the data can be validated and corrected, with duplicates being detected and removed as data are captured. Data can be visualized in graphs, charts, tables and maps, to guide an effective response.

Surveillance officers should immediately notify the district (or equivalent) team and the NMP of all confirmed cases of malaria by telephone, SMS or email. The notification should include the patient's name, village or neighbourhood and district (or equivalent) of residence, date of malaria diagnosis, type of test and *Plasmodium* species. The NMP should immediately alert the local field investigation team, which should plan to investigate the case and, if necessary, focus. It may be reasonable to reduce the intensity of further case or focus investigations for cases that are clearly imported and occur in a non-receptive area where imported cases are common. The expected frequency of reporting and the detail of the data to be reported are shown in Fig. 4 according to the epidemiology of the area of interest.

2.5 Data analysis, visualization and interpretation

Data from malaria surveillance systems are important for tracking geographical and temporal trends in disease incidence, detecting epidemics, assessing progress towards programme targets and evaluating the impact of interventions and the quality of the surveillance system.

Routine use of surveillance data is expected to improve both local and national-level programme decision-making and the surveillance system as gaps in data completeness and quality are identified and addressed. Most national surveillance systems now use electronic systems, and programmes should use digital dashboards for analysing key indicators and trends. Details of data analysis, interpretation and use in the context of malaria outbreaks and epidemics are given in Section 6 and in the context of programme monitoring and evaluation are given in Section 7. Additionally, guidance on what charts to develop and how to make interpretations of routinely collected health facility data is provided in the WHO Academy course: Malaria: Harnessing the power of routine facility data *(16)*.

Two examples (Boxes 5 and 6) are provided to highlight some considerations in analysing surveillance data. Box 5 describes the transformation of malaria case counts into incidence.

Box 5. Adjusting for population size: calculating incidence rates

Absolute numbers of malaria cases, inpatients and deaths can be used to estimate trends over time and to identify places in which the problem of malaria is greatest. Absolute numbers are less useful for assessing which populations are at highest risk for acquiring malaria because most geographical units have different population sizes. For example, it is not immediately clear whether 500 cases in a population of 17 000 represents a higher risk for malaria than 300 cases in a population of 8500. To facilitate comparison of populations, the number of cases is usually expressed for a standard population of 1000 or 10 000, by dividing the number of cases by the population size and multiplying by the standard size of population desired.

Population A:

$$\frac{500 \text{ cases}}{17\,000 \text{ population}} \times 1000 = 29.4 \text{ cases per } 1000 \text{ population}$$

Population B:

$$\frac{300 \text{ cases}}{8500 \text{ population}} \times 1000 = 35.3 \text{ cases per } 1000 \text{ population}$$

Adjustment to a standard population can also consider the growth of populations over time, which may be significant if trends in cases are examined over an extended period such as 10 years.

The denominator is generally the population at risk for malaria, which is defined as the population in areas in which there is ongoing transmission. People travelling to such areas may acquire malaria, but they are not usually included in the population at risk. For international comparisons and other situations in which information on the overall risk to populations is desired (including the risk of those not exposed to malaria), the total population of a country may be used as the denominator. If cases are broken down by age, sex or occupational group, the sizes of these groups should be used as the denominators. In elimination settings, the use of the populations at risk in foci of transmission to quantify national incidence may result in incorrect classification of a country as having a high malaria incidence. In such situations, it may be better to use case counts, but care should be taken in using these data in trend analyses, as the counts may change with increasing case detection as countries undertake active surveillance. Programme managers may be interested in knowing the size of other populations, such as those living in areas where vectors are circulating or target populations for interventions, but these figures are generally not used in calculating incidence rates. Estimates of population size published by a relevant government department should be used; such departments include a statistical office, planning bureau or census office. The estimates are usually based on projections from censuses undertaken at intervals of about 10 years; population growth rates between censuses are used to project population sizes after the latest census. Thus, as the time of the next census approaches, the population projections may differ considerably from the actual population sizes, particularly at local level. When new census results are released, the projected populations calculated for previous years must be updated to consider the latest – and more accurate – counts.

In the last stages of elimination and in post-elimination settings, the use of the annual malaria incidence is of little value and the programme should use actual case counts.

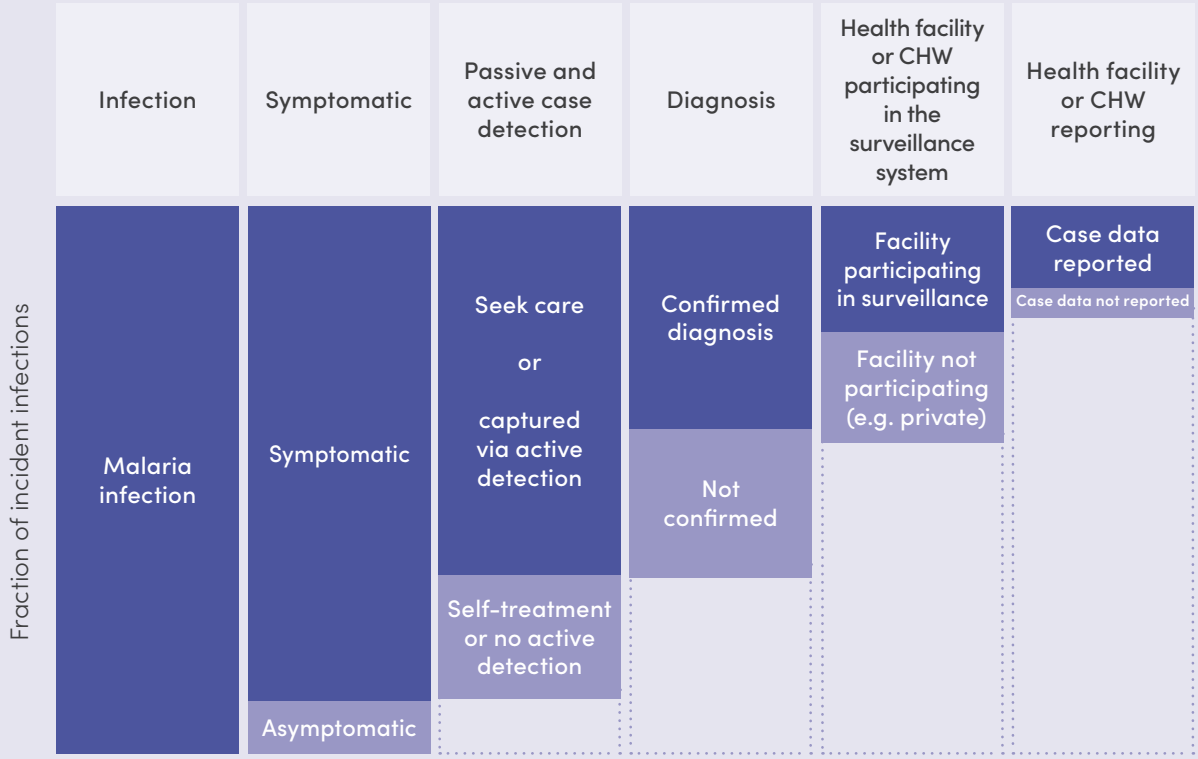
Box 6 shows the influence of health facility attendance, diagnostic testing and reporting rates on the computation of malaria incidence rates.

These issues are common, especially in areas where the goal is burden reduction – the surveillance system may not capture all malaria cases, and complete malaria confirmation with RDTs or microscopy has not yet been achieved.

Box 6. Influence of health facility attendance, diagnostic testing and reporting rates on reported malaria incidence rates

Crude incidence rates derived by surveillance of malaria cases take into account the size of the population but may not reflect the true incidence of malaria in a population because, as shown in the surveillance cascade:

- most reports are from the public health sector;
- the proportion of patients with suspected malaria who attend public health facilities (from which most data are derived) may differ by area and over time;
- the proportion of people attending public health facilities who have a diagnostic test may differ by area and over time; and
- health facility reporting rates may differ by area.



The example below shows the results for two districts, one urban and one rural, with different rates of malaria. The crude incidence rate in the urban district is half that in the rural district, but in the urban district a larger proportion of patients seek care in public health facilities, a larger proportion receive a diagnostic test, and a larger proportion of health facilities submit monthly reports. Because of these factors, the reported incidence of malaria is higher in the urban district (14 per 1000) than in the rural one (12 per 1000).

		Urban district	Rural district
A	True number of cases per 1000 population	50	100
B	Cases attending public health facilities (%)	60	40
	Cases potentially detected per 1000 (A × B)	30	40
C	Attendees receiving a diagnostic test (%)	60	50
	Cases potentially detected per 1000 (A × B × C)	18	20
D	Health facilities that report (%)	80	60
	Cases potentially detected per 1000 (A × B x C × D)	14	12
Percentage of all cases detected		29	12

Thus, when areas with better access to health facilities report a higher incidence of malaria than areas with limited access, it is advisable to examine other indicators (overall health facility use rate, percentage of people who receive a diagnostic test and completeness of health facility reporting) in interpreting the data. It may also be useful to examine other indicators, such as rates of diagnostic test positivity.

If the rates of facility use and reporting are known, incidence rates based on the number of malaria cases seen in health facilities can be adjusted for these factors to provide a more representative estimate of incidence *(17)*. When computing incidence, it is important that cases be linked to their places of origin and of diagnosis, especially when the burden is very low and many cases may come from outside the location of the nearest health facility.

2.6 Data dissemination and use

Decisions about programme policies, strategies, approaches, structures and priorities must be based on the best available data to ensure that maximum impact is achieved with the available resources, to improve the results that programmes can achieve and to enhance accountability. To produce data for decision-making, a NMP must constantly monitor critical components of programme performance, including process indicators (e.g. the number of commodities distributed and where), input indicators (e.g. the fraction of targeted households that received IRS and the number of ITNs purchased), intermediate indicators (e.g. impact of an intervention on vectors) and outcome indicators (e.g. malaria incidence). Processes should be set up for regular validation and analysis of the collected data and the programmes adjusted in response.

Data should be collected and analysed regularly at all levels of the malaria programme and used at each level to inform actions or decisions. For example, central programme managers need information on overall performance to track progress and report to their government and donors. They also need measures to ensure the timely distribution of pharmaceutical products and avoid stock outs. At provincial, state or district levels, malaria managers require analysis of intervention coverage to identify gaps, adjust strategies to cover underserved areas, identify the true focus of transmission and evaluate the effectiveness of interventions. Feedback to individual health facilities should, for example, indicate their testing and reporting rates and how these rates compare to comparable facilities. Digital dashboards and regular surveillance bulletins are effective ways of monitoring these metrics. Health facilities should clearly define the extent of their catchment areas (e.g. distance and time to facility, population density and geographical boundaries) to link disease counts to the population accurately.

All staff should be trained in recognizing the importance of data and how they are used in decision-making. The results of analyses should be shared with those who collected the data so that they become aware of the value of the data. **Box 7** outlines approaches for disseminating and using data and information for planning. The use of data for decision-making is further discussed in **Section 7**.

Box 7. Approaches to disseminating data

Formal data review and use meetings. If the data generated by a surveillance system are to be used to improve the operation of an NMP, managers must ensure regular opportunities for review. A schedule of meetings at all levels of the health system should be established to review malaria trends and develop actionable plans, which might include:

- community with health facility staff – monthly or quarterly;
- health facility staff with malaria control programme staff at intermediate level (e.g. district) – monthly;
- intermediate-level staff with NMP staff – quarterly performance review (meetings might have to be held less frequently or regionally in order to create opportunities for national staff to meet all intermediate staff during a year); and
- NMP staff with other governmental decision-makers and partners as needed.

Supervision. Supervision by national and intermediate levels is required to build an information system and to ensure the completeness of reporting, analysis and discussion of data and follow-up of recommended actions. During visits to health facilities (and CHWs) and intermediate-level team offices, supervisors should check that registers are up to date, with all fields completed; that the data on report forms correspond to the information in registers and tally sheets; that core analysis graphs and tables are up to date; and that discussions are held on interpreting trends and potential action (see Annex 14 for an example of a malaria surveillance supervisory checklist). Health facility staff (and CHWs) should be encouraged to investigate all inpatient malaria cases and deaths.

Feedback. Intermediate-level managers should prepare feedback for health facilities (and CHWs) monthly or quarterly, and should include private health facilities that provide data. The feedback should reflect not only the data submitted by the health facility but also comparisons with other facilities in the same administrative unit and summary statistics for the unit, including responses. A regular bulletin could be produced in a standard format for presenting district results (based on control charts) and comparisons of health facilities. Feedback can also be part of the supervision process. An example of a monthly bulletin for high- and moderate-transmission countries is shown in Annex 15.

As transmission is reduced, mapping could be extended to subunits, to present more detailed epidemiological information on remaining affected locations and population groups, and eventually to foci. The bulletin should be widely circulated, not only as feedback to health staff but also as information for the public, other government departments, institutions, partners and neighbouring areas or countries. Elected leaders should also be sent the bulletin on malaria, possibly with the malaria situation shown according to political boundaries, to instil improved understanding and support for malaria control at the highest level.

2.7 Structure of surveillance systems

2.7.1 Systems, functions and coordination

Structures for disease surveillance differ by country and by programme goals. In some countries, data functions are undertaken by an integrated HMIS unit rather than by separate programmes. This arrangement can ensure good coordination in system design and reduce duplication in requests for data. Malaria programme managers must liaise closely with health information staff to ensure prompt access to relevant data. In other countries, most data management is undertaken by programme staff. In these cases, coordination with information units is necessary to ensure the use of common datasets, such as population projections, health facility lists and coding systems. Opportunities should be created for consolidating the analysis of information with other programmes so that progress in malaria control can be put into perspective.

To coordinate system developments across programmes, a health information system development committee might be established, with representatives from various health programmes and senior management. The committee could ensure that the information system prepared by the ministry of health is coherent, rather than incompatible, unnecessary or unsustainable. Table 3 lists the various components of HMIS, and general issues related to each component.

Table 3. Components of HMIS relevant to malaria surveillance

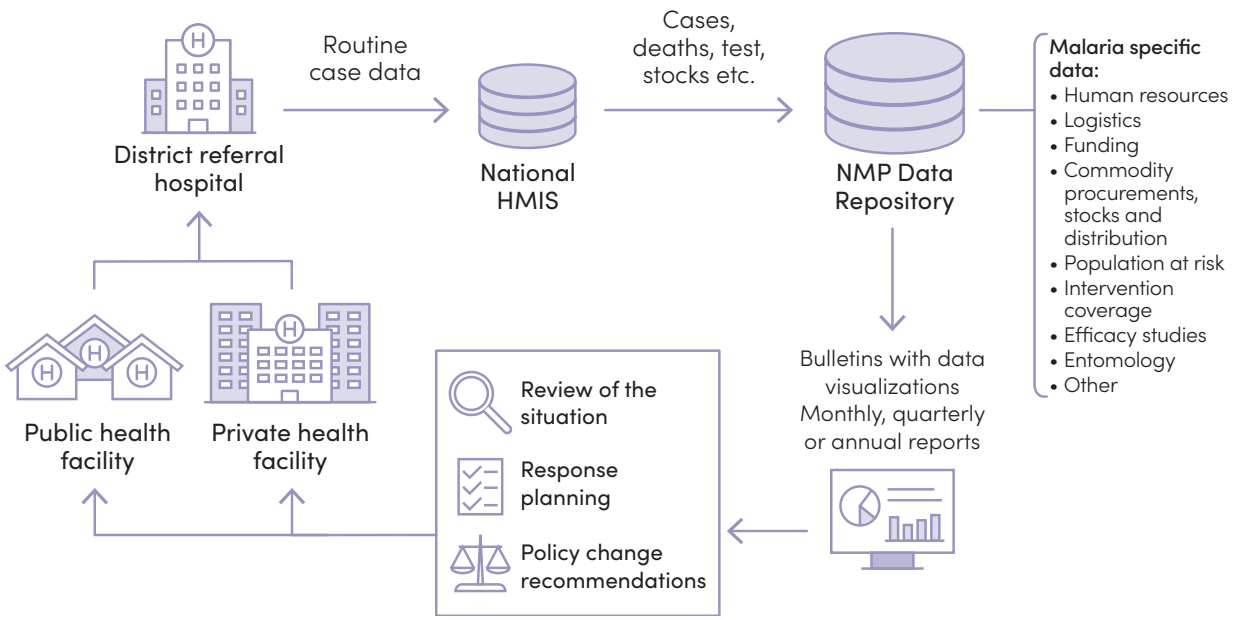
Component	Elements	Description
Resources for health information systems	Legislative, regulatory and planning framework, personnel, financing, logistics, information technology and communication systems.	Resources comprise everything the system requires, from office supplies to computer systems, staff and their capacity and policies that allow the system to operate. The system of each country should be designed to make the best use of available resources and meet the country's needs.
Recording	Essential indicators, data elements, definitions, paper and/or electronic registers, data storage, data verification, training and mentoring.	See Section 7 and Annex 19 for indicators to be monitored and evaluated. Some of the indicators are derived from population surveys and censuses and can be used in identifying country indicators.
Data reporting	Data storage repositories, timely transmission and completeness, quality of data verification and adjustment, data verification.	The frequency of data reporting is determined by the programme objectives and resources (see Fig. 4). In settings where the goal is burden reduction, aggregated monthly or weekly data should be sufficient to estimate trends and make relevant decisions. In elimination settings, immediate notification of individual cases is required.

Component	Elements	Description
Data analysis and presentation	The transformation of data into information requires capacity for basic statistical analysis, preparation of analytical and standard graphs, risk and intervention stratification (see Section 7), surveillance bulletins, and reports and presentations.	User dashboards, reports, queries and alerts give access to the information resulting from data analysis.
Interpretation and evaluation	Data may be used to assess disease trends, detect epidemics and determine the response, quantify and forecast resource requirements, assess programme performance and adjust interventions.	National information can be used in day-to-day management of a malaria control programme. Greater value should be placed on information collection, management, feedback and use (see Section 7).

Source: *Adapted from Framework and standards for country health information systems, second edition (18).*

Fig. 5 illustrates the typical data and information flow in an HMIS and the linkages with national programme databases used for decision-making.

Fig. 5. Data flow and analysis, from national HMIS to NMP decision-making



HMIS: health management information systems; NMP: national malaria programme.

The steps in strengthening HMIS, in most situations building on existing systems *(19)*, are as follows.

- Review the existing system.
- Define the data needs of relevant units in the health system, such as the community, health facility, intermediate and central levels.
- Determine the most appropriate, effective data flow.

- Design the data collection and reporting tools.
- Develop the procedures and mechanisms for data processing.
- Develop and implement a training programme for data providers and data users.
- Pilot test and, if necessary, redesign the system for optimal data collection, data flow, data processing and data use.
- Monitor and evaluate the system.
- Prepare effective data dissemination and feedback mechanisms.
- Continuously strengthen the HMIS.

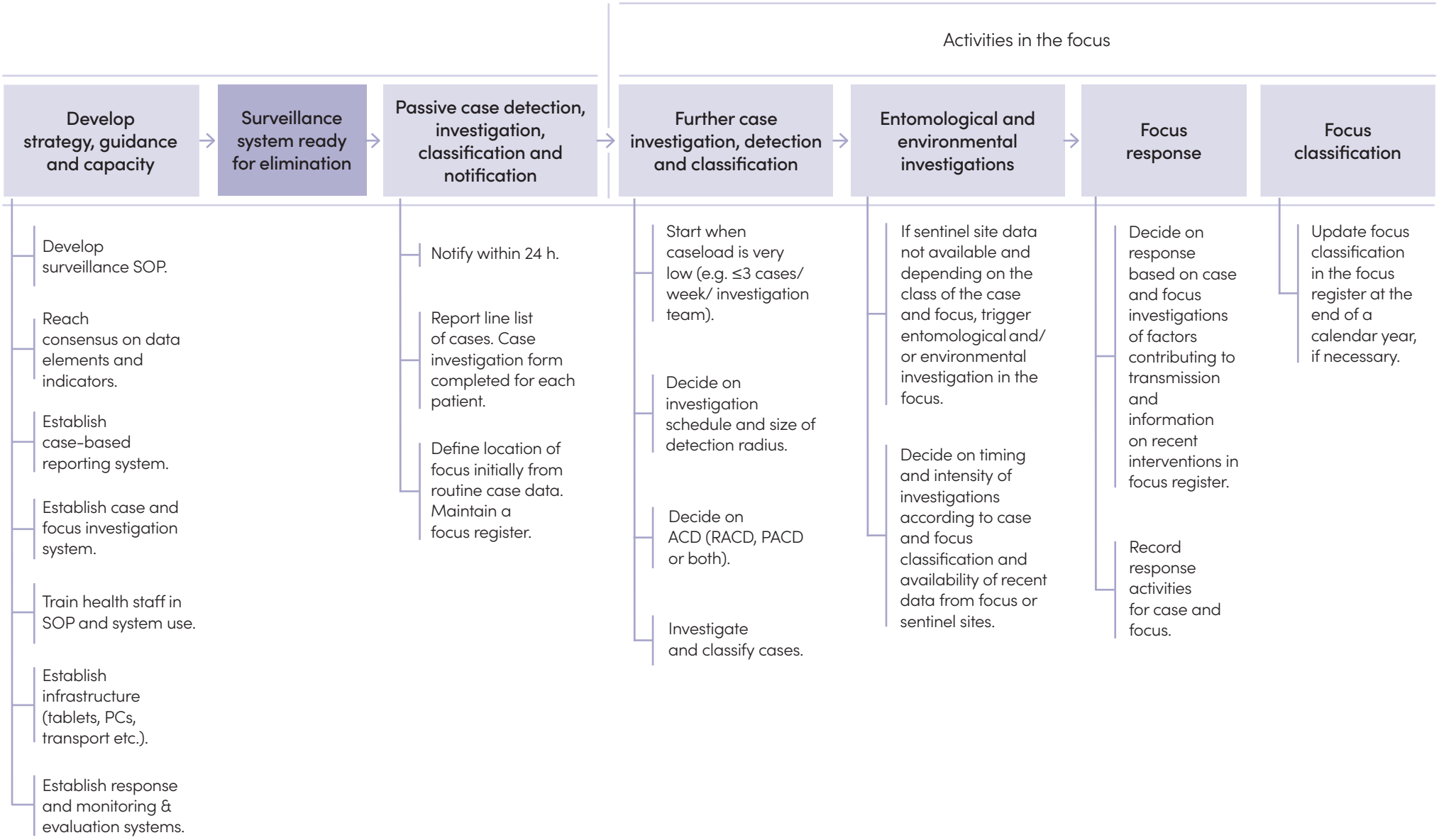
Establishing a surveillance system for elimination takes more time, as it often requires updating legislation and policies, establishing new system components (for case and focus investigations, and laboratory quality control), training and recruiting staff, and educating the public. Lessons learned from the establishment of surveillance systems in various epidemiological settings should be used to prepare gradually for active elimination countrywide. The preparatory activities should be supported by changes to legislation to ensure that malaria is a mandatory notifiable disease and all health sectors, including the private sector, are required to use similar case definitions and participate in all aspects of surveillance.

Because they involve more intense activities, surveillance systems for elimination require additional staffing, sometimes with new or revised responsibilities.

- Staff at the national level are responsible for policy-making and decision-making, coordination, supervision, monitoring and evaluation of programme management and progress. The staff should preferably include clinicians, epidemiologists, parasitologists, entomologists, laboratory experts, communication experts and information technology specialists (including data managers and geographical information systems technicians). The national reference laboratory will provide support to the ministry of health in establishing quality assurance systems for diagnostic testing.
- At intermediate levels (provinces, regions and districts), depending on the public health structure and the size of the country, epidemiologists, parasitologists, entomologists and data managers may be required, particularly in areas with active foci and repeated imported cases. These staff members are responsible for all aspects of malaria surveillance, including data collection and analysis, monitoring and early recognition of outbreaks or changes in disease trends. They may also lead a well-trained case and focus investigation team.
- At health facilities, case investigations may require trained staff who can rapidly and effectively investigate new cases of malaria to classify them appropriately.
- The NMP should try to provide all laboratory diagnostic services free of charge to patients at public facilities and, if possible, at private facilities. All laboratories that conduct testing for malaria should be part of a quality management network, and data should be reported to the national surveillance system.

Surveillance should include the private sector, CHWs, and mobile and migrant populations, and address the specific needs of urban settings. Fig. 6 illustrates the process of surveillance for malaria elimination and the activities at each stage.

Fig. 6. Processes and activities for establishing malaria surveillance for elimination



ACD: active case detection; PACD: proactive case detection; RACD: reactive case detection; SOP: standard operating procedure

2.7.2 Surveillance in the private sector

Health services in the private sector may be delivered for profit or not for profit. The not-for-profit sector is often run by faith-based or public–private initiatives, which in many countries may also be registered as public health facilities. Surveillance for malaria by the private sector should, in principle, be identical to that in the public sector, using similar forms and reporting the same core data elements at the same frequency (**Table 2**). In many malaria endemic countries, however, the private sector is less well-regulated than the public sector and has limited capacity for accurate diagnosis and reporting; some private health services may not recognize the value of reporting data *(20)*. Thus, surveillance in the private sector is often inconsistent, with limited reporting to the national HMIS. Nevertheless, in sub-Saharan Africa, nearly 40% of patients seek treatment in the private sector, and this figure exceeds 50% in some countries outside Africa *(17)*; the proportion is often higher in urban areas, and remote rural areas are often served by an informal private sector. However, with enforced recommendations and clear policy directives in place, an increase in private-sector reporting can be attained.

National dialogue, coordination, incentives, regulation and accreditation should be used to encourage the private sector to report to the surveillance system. Improved public health sector service delivery and better access are also likely to reduce reliance on the private sector, thereby increasing the proportion of cases identified in the public sector.

In settings in which the goal is to reduce the burden of malaria, data from passive case detection (PCD) in the private sector may be aggregated, whereas in elimination settings they should be case-based. Nevertheless, case-based reporting should be encouraged in areas for burden reduction if the electronic system is advanced enough to include case details without adding to the health worker workload.

The private sector has no mandate for case investigation but should be required by law not only to treat patients according to national guidelines and notify each case but also to refer all cases (before or after treatment) to the public sector for further investigation and classification. The increasing availability and flexibility of mobile and internet technology will improve surveillance in the private sector *(21)*.

The following general guidelines should help countries to improve malaria surveillance in the private sector.

- Map private health sector providers by type (formal or informal), location (urban or rural), regulation (registered or unregistered), level of reporting, connectivity to a mobile and/or fixed internet network and other relevant characteristics.
- Set up a database (preferably geocoded as described in **Box 2**) of private health care providers who manage malaria cases.
- Explore approaches to strengthening regulation and compliance. In high-burden settings, legal provisions should require that entities involved in malaria diagnosis and treatment are registered with the relevant authorities and that their licenses are renewed regularly. In elimination settings, health

legislation should ensure that all health care providers report confirmed malaria cases as part of notifiable disease surveillance.

- Conduct studies to determine the appropriate approaches and incentives to improving malaria case management and surveillance in the private sector. Develop strategies for engaging informal providers (e.g. drug shops) who may be more challenging to regulate but still play a significant role in malaria diagnosis and treatment, particularly in rural areas.
- Foster close, routine interaction among the ministry of health, NMP and private health sector through dissemination of information, regular visits, supportive supervision, peer-to-peer learning and training. Promote the establishment of public–private partnerships to enhance cooperation between the private sector and the ministry of health and NMP, facilitating resource-sharing, co-investment in surveillance infrastructure, and collaborative research.
- Include guidelines for monitoring the performance of private-sector reporting, evaluating the quality of data, and ensuring that private-sector surveillance aligns with national standards.
- Provide the private sector with simple, inexpensive reporting materials and systems, including mobile and internet applications.
- Ensure consistent feedback to facilities in the private sector that report data to the national system.
- Help the private sector to obtain subsidized or free diagnostics and case management commodities, or provide the private sector with minimal financial incentives. If this is done, regulatory frameworks should be developed and implemented to limit the sale of free drugs.
- Emphasize the importance of training private health providers on surveillance guidelines, diagnostic accuracy, treatment protocols, and data reporting, ensuring they are well-equipped to contribute to national malaria control efforts.

2.7.3 Surveillance by CHWs

CHWs extend public health services to hard-to-reach areas or underserved populations to expand diagnosis and treatment. Often, CHWs are designated to a health facility, the staff of which provide oversight of their activities, supervision and training, and health commodities. The CHWs report cases and use of commodities to the health facility. In areas with relatively high caseloads, CHWs may report aggregated data monthly. In elimination settings, they should be capable of immediate diagnosis, treatment and case notification and, when possible, participate in ACD, case and focus investigations.

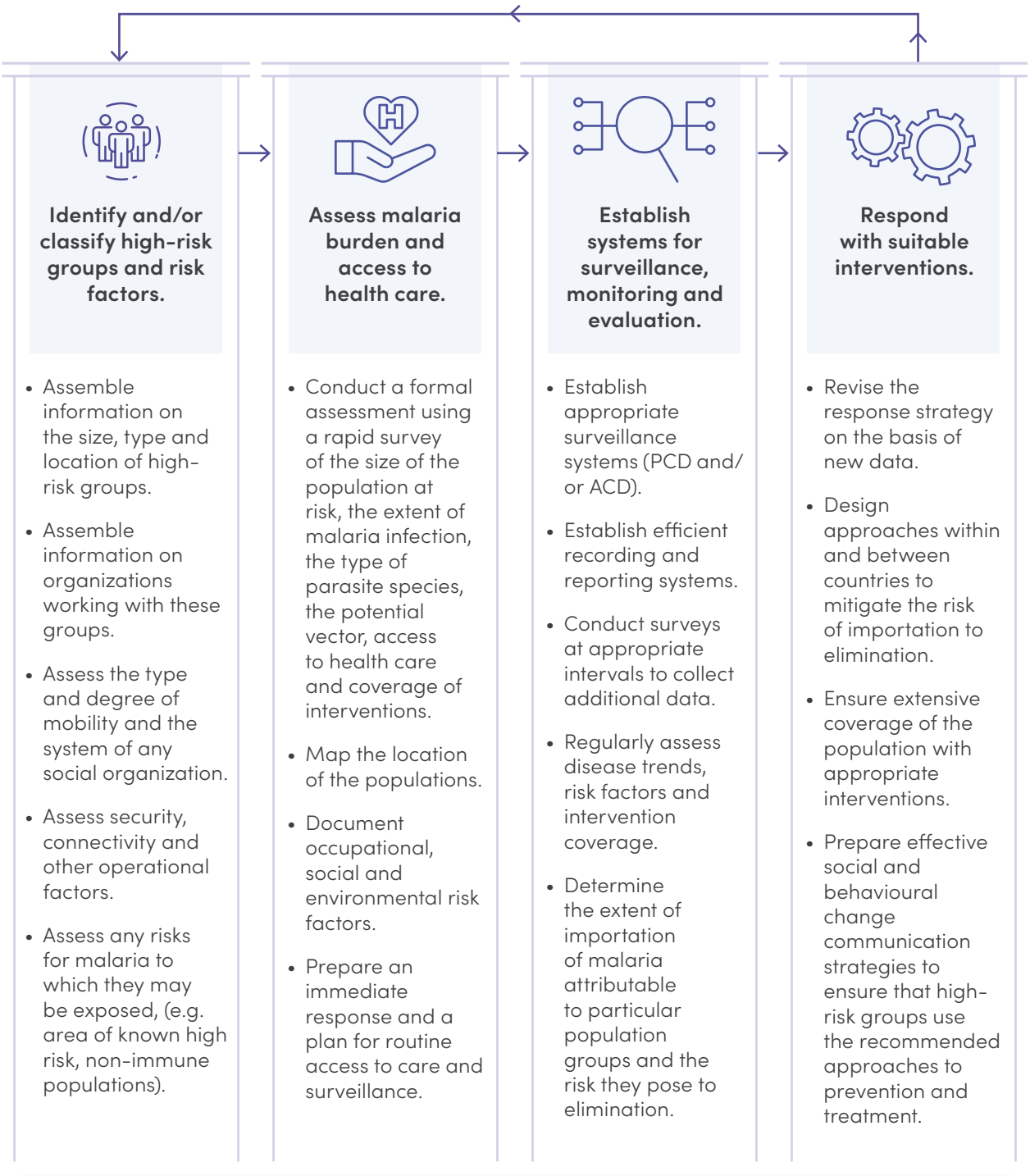
The minimum data collected during community surveillance are the same as those collected at health posts (**Annex 6**). Cases detected passively through the routine system should be reported separately from those detected actively in the community (see **Section 3.2**). In settings in which CHWs are well established and the data they report are unlikely to change trends, CHW data may be aggregated into health facility reports. Smartphone applications have made it possible to establish efficient surveillance systems involving CHWs and volunteers *(22)*.

2.7.4 Surveillance of migrant and mobile populations

Populations that are at higher risk for malaria than the general population may be present in all settings. Migrant and mobile populations – including those in specific occupations (e.g. forest workers, road constructors) or livelihoods (e.g. nomadic pastoralists), illegal and/or undocumented immigrants, refugees and internally displaced persons, and tourists *(23)* – may be at higher risk for malaria infection and disease *(24)* and may serve as residual reservoirs of infection, contributing to sustaining or the re-emergence of transmission. The characteristics of these populations that expose them to higher risks include their mobility, occupations that result in frequent contact with the vector, poor access to health prevention and treatment, poverty, displacement and cultural factors that result in marginalization. Mobile populations could import malaria infection from endemic to non-endemic but receptive areas within and across international boundaries. Conversely, populations moving or migrating from malaria-free areas to endemic areas could be at high risk of disease because of a lack of immunity. These high-risk populations tend to organize themselves, and identification of such organizing systems will indicate the best way to improve access and surveillance. As some migrant and mobile populations may wish to remain undetected for legal reasons, a trustworthy, safe environment should be created to ensure access to interventions and surveillance.

The surveillance strategies used in such situations should maximize case detection and response, and the main goal should be improved access to health services. Fig. 7 illustrates a stepwise approach to documenting high-risk populations, conducting surveillance and responding. Mapping of migration routes is important for designing appropriate surveillance of mobile populations and updating information on those at the highest risk, as the risk factors and populations may change over time. Collaboration with other government departments, stakeholders and the community is needed to define these populations, and develop and implement appropriate strategies.

Fig. 7. An approach to surveillance and response for high-risk populations, such as migrant and mobile populations



ACD: active case detection; PCD: passive case detection

2.7.5 Surveillance in pregnant women and girls

Malaria infection during pregnancy has substantial risks for pregnant women and girls, the fetus and the newborn child. For pregnant women and girls, malaria infection can lead to severe disease and death, and placental sequestration of the parasite, which can lead to maternal anaemia. It also puts the mother at increased risk of death before and after childbirth and is an important contributor to stillbirth and preterm birth. Placental infection can also lead to poor fetal growth and low birth weight, which in turn can lead to retardation of child growth, and poor cognitive outcomes; it can also be a major risk factor for perinatal, neonatal and infant mortality *(25, 26)*. To avert the consequences of malaria infection for pregnant women and girls and their children, WHO recommends – in combination with other interventions – the use of intermittent preventive treatment in pregnancy (IPTp) with sulfadoxine–pyrimethamine (SP) as part of antenatal care (ANC) in malaria endemic areas. Health programmes often use data from ANC visits to monitor coverage of IPTp with SP and the distribution of ITNs. Access to preventive treatment throughout pregnancy remains low in many countries due to difficulties in delivering IPTp when women and girls do not attend ANC, especially in high-burden or underserved areas. This leads to challenges in interpreting these data. Reliance on ANC visit data as the denominator for calculating coverage of IPTp could lead to overestimation of coverage if treatment coverage is high but overall access to ANC is poor. The reported or estimated number of pregnant women and girls in the catchment area is a more appropriate population denominator, although this can be more difficult to obtain. The coverage of IPTp with SP could be improved by using a community-based delivery approach *(27)*.

Where access to ANC is good, routine ANC visits provide an opportunity for both strengthening malaria surveillance and improving access to diagnosis and treatment among pregnant women and girls. WHO currently recommends malaria testing of all symptomatic patients, including pregnant women, and treating based on test results. ANC-based malaria screening requires testing all pregnant women and girls at the first ANC visit, regardless of symptoms. WHO is in the process of reviewing recent evidence supporting the use this data as a proxy for malaria prevalence surveys, particularly in regions where such surveys are not regularly conducted *(28–30)*. The analysis of these data over time may provide indications of changes in trends in malaria transmission , provided that the criteria for malaria screening in pregnant women does not change over time. Moreover, comparing ANC-derived data with prevalence survey results from the same regions enables cross-validation, enhancing the reliability of estimates and facilitating adjustments *(31)*.

2.7.6 Surveillance in urban areas

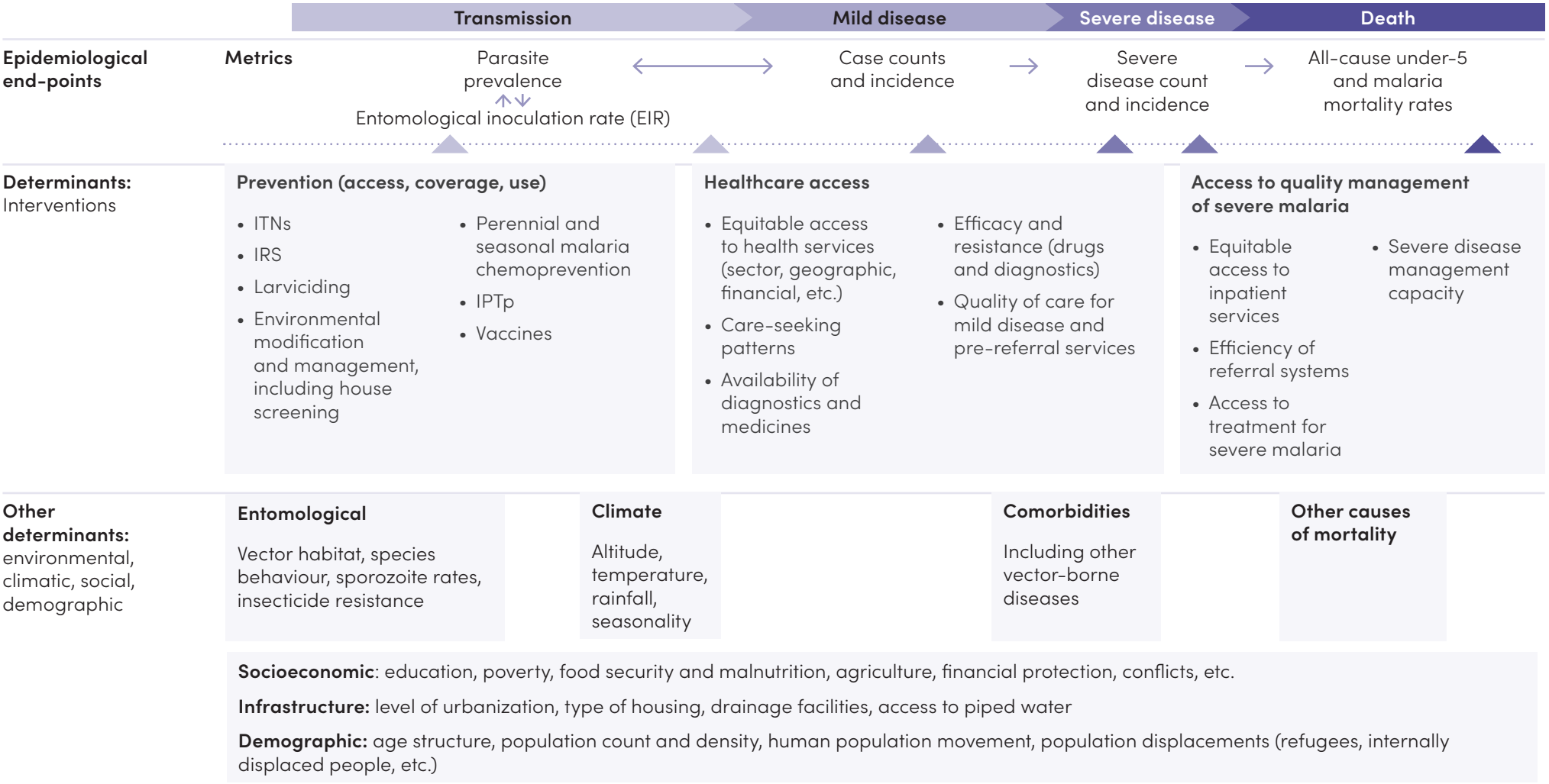
Urban malaria surveillance may require a granular approach due to the heterogeneous nature of transmission in urban settings. Urban areas typically have varied housing, water management systems and artificial breeding sites, such as construction sites and poorly managed drainage systems, which contribute to localized transmission. The higher population density and complex human movement patterns further complicate malaria control and elimination efforts.

Surveillance systems in urban areas must therefore collect detailed, high-resolution data (**Fig. 8**) to identify and monitor transmission hotspots, track potential importation routes, and manage scattered mosquito breeding sites *(32)*.

The schematic in **Fig. 8** can be adapted to settings with different transmission intensities *(32)*. Using this schematic and other guidance documents, countries are advised to identify the core information needs for their context and develop systems to capture, report and analyse this information.

The ability to capture fine-scale data allows for tailored and adaptable interventions that can target areas of high transmission risk while effectively managing the urban malaria burden. Integration of spatial data and the use of modern geospatial technologies should be emphasized to enhance surveillance and response strategies in urban environments. Interdepartmental and multisectoral participation is important. In many urban settings, the private sector plays a critical role in diagnosis, treatment and surveillance reporting. Integrated databases that allow joint analysis of different indicators can support effective decision-making.

Fig. 8. Schematic for the identification of core data needs to tailor malaria intervention for specific urban areas



EIR - entomological inoculation rate is an estimate of the number of infective bites from malaria mosquitoes received by an average person during a malaria season or year.

IPTp: intermittent preventive treatment during pregnancy; IRS: indoor residual spraying; ITN: insecticide-treated net.

2.8 Digitalization of malaria information systems

Effective, user-centred digitalization can address several surveillance gaps around the quality of data, completeness of information, timeliness of reporting, accessibility of data by stakeholders, and translation of data to trigger a response.

- **Data recording and reporting** into an electronic information system helps ensure fewer reporting errors, enhances data completeness and timeliness, and guarantees instant availability and visibility of data to all levels of the health system through online portals.
- **Data integration** is also enabled by digital information systems, through both consolidating reporting workflows into select core platforms and through enabling interoperability between different systems used for distinct purposes.
- **Digital data visualization and analytics** enable the automated transformation of raw data reported to a digital information system, into decision-ready visualizations and notifications displayed on user-friendly dashboards or in reports. This reduces the time lag between data collection and the generation of analytical outputs, saves considerable malaria programme staff time and effort when it comes to data analysis, and ultimately empowers staff to better focus their time on reviewing and responding to data.

Digitalization is now an essential component of malaria data management to support each step in the data pipeline from recording to response.

2.8.1 Optimizing systems for malaria programme needs

Ministries of health have conventionally developed HMIS for routine data from health facilities. As digital transformation advances, other systems are emerging, such as logistics management information systems (LMIS) for supply chains, electronic integrated disease surveillance and response for epidemic notifications, and electronic medical records for patient clinical files. These systems are designed to support multiple health programmes, providing a streamlined data entry point for health care workers. In an HMIS, workers aggregate data across services such as ANC, immunizations and infectious disease treatment, submitting reports with key epidemiological indicators. For malaria, this typically includes reporting variables such as total fevers, malaria tests conducted, positive malaria cases diagnosed, malaria treatments given, and preventive measures (e.g. IPTp delivered), all with decision-relevant disaggregations such as by age and sex.

These systems are typically designed, developed and managed by the information systems department (or equivalent) within the ministry of health and require expertise in software development and system administration. Close collaboration and active participation from NMPs are required to ensure malaria-relevant components (e.g. collecting the right data at the right resolution, incorporating logical data validation rules, providing visualizations that are decision-relevant) are effectively integrated into the system.

Insufficient involvement of NMPs in the design, testing and maintenance of systems can result in inefficient reporting forms, unhelpful dashboards, and disorganized data catalogues, ultimately limiting data use and reducing trust in the data.

To optimize HMIS, LMIS and other systems for malaria programming, the NMP should designate a focal point to liaise with the information systems department. This focal point and champion should take responsibility for:

- roll-out – lead the deployment of digital tools, providing training that integrates malaria-specific activities, indicators and workflows with system functionality;
- monitoring and evaluation – develop a framework to periodically assess the digital system's performance and identify areas for improvement, often in conjunction with other evaluations;
- user feedback – gather and organize feedback on system usability, including reporting forms, dashboards and operational barriers, ensuring continuous improvements based on user input;
- data quality and use – monitor data quality and system adoption, addressing gaps through collaboration with the information systems department and facilitating improvements via action plans and review meetings; and
- programme priorities – engage closely with the information systems department to ensure malaria priorities are incorporated into health systems, overseeing the development and implementation of new features.

WHO has released data standards, tools and packages to support countries in the design of digital tools for some thematic areas *(15)*. This includes DHIS2 metadata packages (**Box 4**), though it is important to note that these packages must be carefully tailored to meet the specific country context, needs and user workflows.

2.8.2 National malaria data repositories

While cross-cutting systems such as HMIS, electronic integrated disease surveillance and response, LMIS, and electronic medical records meet many routine data needs (e.g. identifying gaps in case management using data from HMIS or stock outs using data from LMIS), NMPs require additional data for effective programming (e.g. campaign data, entomological surveillance and supervision data).

A national malaria data repository (NMDR) is a conceptual system in which all decision-relevant malaria data are integrated into a single platform for broad analysis across all NMP areas. Development and implementation of an NMDR includes six aspects: groundwork, design, development, testing, roll-out and institutionalization (**Fig. 9**).

Fig. 9. Development and implementation of an NMDR

SOP: standard operating procedure.

The NMDR should be designed around the programme's data use and decision-making needs. This process begins by identifying target users, mapping decision-making requirements for each stakeholder, and selecting relevant indicators through a data-to-action framework. Once indicators are selected, they must be mapped to their originating data sources, which typically reveals a mix of formal systems, such as HMIS and LMIS, and informal or siloed tools. A clear process for integrating data into the NMDR – whether

through direct reporting, periodic imports or system integration – should be developed, ensuring that operational changes and necessary technical expertise are addressed.

Rather than attempting to integrate all existing systems, stakeholders should focus on consolidating tools and retiring unnecessary ones. This reduces fragmentation and builds sustainable integrations with select systems, avoiding the complexity and maintenance challenges of connecting every data source. The development of an NMDR is a multistep process that requires close collaboration with the ministry of health's information systems department. The NMP should play an active role throughout, designating a focal point to lead the project and ensure the system meets malaria-specific needs.

Successful implementation of the NMDR depends not only on technology but also on effective governance and clear SOPs. Users need training, operational support, and well-defined guidelines to ensure smooth system usage. Monitoring and evaluation should be regularly conducted to measure the system's performance and value, and ongoing improvement should be driven by a dedicated digital focal point. Periodic assessments can be integrated with broader programme evaluations to ensure the NMDR continues to meet emerging needs.

Comprehensive guidance, templates and case studies are available in the WHO's guidance document on establishing an NMDR *(33)*.

2.9 Surveillance for elimination

Malaria elimination is defined as the interruption of local transmission (reduction to zero incidence of indigenous cases) of a specified malaria parasite in a defined geographical area as a result of deliberate activities *(12, 34)*. A well-functioning surveillance system – including surveillance assessments (detailed in **Section 7.4**) – must be in place to detect and respond to any new cases. Surveillance and response strategies such as the 1-3-7 strategy implemented in China and the diagnosis, treatment, investigation and response (DTI-R) framework used in the Pan America Health Organization emphasize timely case detection, investigation and response required in elimination settings. **Section 3** provides guidance on malaria elimination surveillance activities. Because elimination hinges on the ability to differentiate between indigenous and imported cases, enhanced surveillance methods such as genotyping (detailed in **Sections 3** and **4**) should be considered as countries approach elimination.

In addition to monitoring the number of indigenous cases, when there are approximately 10 or more malaria cases, composite indicators such as local-to-imported ratio may be useful. As countries approach elimination, the local-to-imported case ratio should ideally shift towards more imported cases and fewer local cases. This shift indicates that indigenous transmission has been largely interrupted, and the primary threat comes from reintroduction via imported cases. Countries can establish thresholds for the ratio to trigger intensified surveillance or interventions.

- At the local level, if the local-to-imported case ratio is high, additional efforts may be directed to find and treat secondary cases associated with recent malaria cases.

- At a country level, if the local-to-imported case ratio is high for a sustained period, a review of elimination strategies, new investment in malaria interventions or policy changes may be required to support elimination.

Countries that have no indigenous human malaria cases in the past 3 years and have a fully functional programme for preventing re-establishment of indigenous transmission throughout the country can apply to WHO for certification of malaria elimination. Obtaining this certification involves a review of national documentation and field visits to recent transmission foci to verify the absence of indigenous malaria cases. A field evaluation is mandatory to confirm that the national surveillance system could detect local transmission should it occur and that a funded programme for prevention of re-establishment is in place.

The Technical Advisory Group on Malaria Elimination and Certification reviews the national elimination report and strategy for preventing re-establishment, followed by an independent evaluation mission undertaken by a subset of individuals from the Technical Advisory Group. The final certification decision is made by the WHO Director-General.

The complete list of documents required for certification is available in *A framework for malaria elimination, second edition (5)* and *Preparing for certification of malaria elimination, second edition (35)*. The documents related to surveillance during the malaria certification process are:

- current guidelines and SOPs for malaria epidemiological and entomological surveillance with an appropriate strategy to prevent re-establishment of transmission;
- comprehensive malaria case-based data from the past 10 years;
- annual malaria surveillance reports with complete information on cases and active malaria foci shown in the focus register in the 5 years before the last identified indigenous case (by parasite species), with supporting maps;
- reports and relevant data on the assessment of the risks posed by *Plasmodium knowlesi* (WHO certification requires the elimination of the four main human parasite species – *P. falciparum*, *P. vivax*, *P. ovale* and *P. malariae*; certification might be granted to countries where cases of other *Plasmodium* species are reported if the risk to humans is assessed negligible *(35)*; when countries are reporting hundreds or thousands of *P. knowlesi* cases, certification of malaria-free status maybe postponed);
- the national malaria case register, with case investigation forms for all cases for at least the past 5 years;
- reports of quality assurance of diagnostic methods; and
- detailed reports on entomological and vector control activities for the past 5 years.

After WHO certification, information on malaria cases detected, by species, classification and origin, and brief histories of all reported introduced and indigenous cases, if any, should be submitted to WHO annually to prove that transmission has not been re-established.

Subnational verification of malaria elimination is an option for large countries and those with subnational goals that have achieved interruption of local transmission in certain parts of their territory, such as major cities or geographically isolated territories (e.g. islands) *(36)*. Subnational verification enables large countries to "shrink the map" of malaria endemicity by epidemiological stratum. Although subnational verification means that parts of a country can be declared malaria-free by the government, WHO does not certify subnational elimination.

2.10 Surveillance during prevention of re-establishment

Re-establishment of transmission is defined as the occurrence of indigenous malaria cases (cases of second-generation local transmission) in a country or area where the disease had previously been eliminated. WHO's operational definition of re-establishment of transmission is the occurrence of at least three indigenous malaria cases of the same species per year in the same focus for three consecutive years *(6)*.

Countries and subnational areas that have eliminated malaria must prevent the re-establishment of transmission. A robust surveillance system that will allow early detection of all malaria cases and the identification of the emergence of transmission is paramount to timely, tailored and targeted response. Surveillance practices implemented in the final years before transmission interruption, such as mandatory and immediate case notification and stringent case classification – which requires all suspected cases to be tested, and all positive cases to be classified as indigenous, imported, introduced or induced (**Section 3**) – should be continued.

Genotyping, explained further in **Sections 3** and **4**, is a valuable tool for detecting the origin of the parasite – if malaria reappears, genotyping data, used in combination with epidemiological data, can reveal whether the new cases are due to the re-emergence of previously circulating strains (suggesting a relapse or resurgence) or the introduction of new strains) *(6)*.

General health services should be empowered and capacitated to take responsibility for case detection. A national unit must be responsible for reviewing case notifications, ensuring the quality of diagnosis and case classification, analysing trends, and monitoring the performance of the general health services. This unit should guide responses to any situation with a risk of transmission or an active focus; however, it need not be dedicated solely to malaria. Collaborating with other sectors, such as migrant associations, and active community engagement are key strategies to enhance case detection.

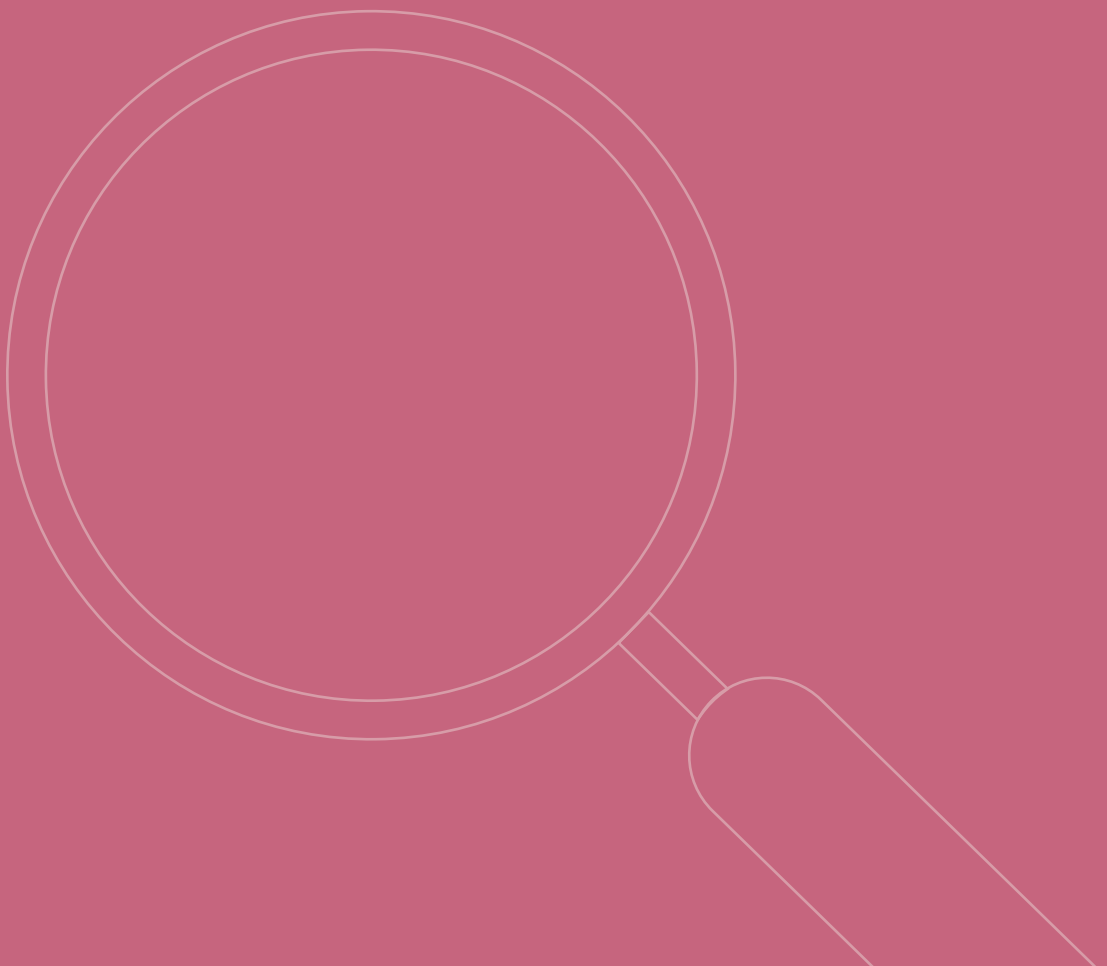
Many countries have established emergency operations centres as centralised hubs for monitoring, coordination and rapid response for emergent health events. Such centres or hubs enable cross-sectoral collaboration and allow for swift resource

mobilization, which can be leveraged for malaria outbreaks. By integrating data from various sources, emergency operations centres guide targeted interventions and adjust strategies to prevent the re-establishment of transmission.

Early detection and prompt treatment of imported malaria cases that could result in onward transmission and re-establishment and monitoring of changes in receptivity and importation risk should be priorities. The probability that malaria will become re-established differs by area.

- When the receptivity or importation risk of an area is zero, there is no risk for re-establishment of transmission.
- In areas with low receptivity and importation risk, early case detection by a vigilant health service – complemented by epidemiological investigation of every suspected local case and focus of origin, and rapid, appropriate curative and preventive measures – is sufficient to prevent re-establishment of transmission. Targeted and effectively implemented cross-border surveillance and control activities, as well as data sharing, will reduce risks of importation.
- In areas with higher receptivity and importation risk, ACD – though not typically used post-elimination – may be considered if there are clearly defined risk groups that have been identified. To optimize costs and efficiency, ACD should be integrated with other routine activities, such as house visits. The detection of imported cases in receptive areas might warrant entomological investigation, depending on the need to reassess the receptivity level and inform the response, particularly if the entomological data are outdated.
- In localities that are highly receptive and have high importation risk, timely, targeted vector control measures (IRS and, where applicable, larviciding) can reduce the risk of re-establishment. These interventions should be implemented based on continually updated information on the local situation. The use of sentinel sites may be considered for monitoring the effectiveness of vector control measures. In addition, where an outbreak has occurred, targeted interventions such as vector control and or mass drug administration (MDA) may be implemented *(34)*. In the longer term, interventions that durably reduce the risk for transmission in these areas should be considered; however, repeated exposure to harmful chemicals must be avoided.

3. Concepts and practice of malaria surveillance



This section provides information on malaria case definitions and classifications; the different approaches to case detection and their appropriateness on the pathway to elimination; and case and focus investigation, classification and response.

3.1 Case definitions

A suspected case of malaria is one in which an individual has an illness suspected by a health worker of being due to malaria, generally based on the presence of fever with or without other symptoms. This suspicion triggers the process of parasitological confirmation by microscopy or RDT and a subsequent decision about whether to treat the individual for malaria. *All suspected malaria cases should be confirmed parasitologically (34).* When malaria diagnosis by microscopy or RDT is not possible, but the individual is treated for malaria based on clinical symptoms, the case should be reported as a presumed malaria case. Criteria must be established in national treatment guidelines for defining which patients who attend health facilities (public or private) or CHWs should be given a parasitological test. *All suspected, presumed, tested and positive cases must be reported through the surveillance system.*

Common criteria for suspecting malaria include:

- for residents of endemic areas (high to low transmission) and active foci in elimination areas – patients with fever or a recent history of fever; and
- for residents of non-endemic areas with very low transmission or maintaining zero transmission – patients with unexplained fever and a history of travel to an area at risk of malaria, either within the country or abroad.

More specific categories in areas of elimination are:

- all febrile patients in active foci, especially during the transmission season;
- people with a history of malaria in the past 3 years and fever or recent history of fever;
- people who had fever within 1 year of visiting a malaria endemic area (domestic or foreign), sometimes extended to 3 years for areas of risk for *P. vivax*;
- patients with fever, malaise and chills;
- people with anaemia of unknown cause;
- patients with fever of unknown etiology;
- patients with hepatomegaly or splenomegaly (or both); and
- recipients of blood donations who have fever during the 3 months after transfusion.

The established criteria should be disseminated to all health providers and the public, and the programme should provide periodic reminders.

Uncomplicated malaria is a case in a patient who has a positive parasitological test (microscopy or RDT) but with no features of severe malaria *(34)*.

- In areas where the main aim is to reduce the burden of disease and deaths, a malaria case is often considered to be that in a person with malaria infection, confirmed by microscopy or RDT, accompanied by clinical symptoms such as fever.

- Febrile illness may be due to other causes. In populations that have acquired immunity to malaria and in areas where there is little malaria transmission, most fevers are not due to malaria. A case of fever and parasitological confirmation by microscopy or RDT should always be classified as malaria. If a concurrent disease is suspected, it should be further investigated and treated.
- Data on confirmed cases recorded in outpatient registers are used as a proxy for uncomplicated malaria for surveillance purposes (though there are instances when patients with severe malaria before receiving inpatient care are recorded in outpatient registers). In addition, individuals with malaria infection who do not have severe symptoms detected during ACD are considered to have uncomplicated malaria. In areas of elimination or where zero transmission has been achieved and the prevention of re-establishment is being maintained, all malaria infections are important because they may lead to onward transmission. A more conservative approach should be taken – all patients with parasitaemia should be considered "malaria cases", regardless of whether clinical symptoms are present. Some patients who test negative by microscopy or RDT may have very low levels of parasitaemia that are detectable only by more sensitive techniques, such as polymerase chain reaction (PCR), a highly sensitive test for detecting very small amounts of genetic material from parasites. Such levels of parasitaemia are generally considered not to be clinically significant in most settings and their contribution to sustaining transmission remains inconclusive. Tests might have to be repeated if no other cause of fever is identified and the symptoms continue.

Severe malaria is a case in a person with the clinical and laboratory features listed in Section 7 of the *WHO guidelines for malaria (34)*.

- For surveillance purposes, inpatient malaria cases are considered a proxy for severe malaria. Some countries with low transmission and in the elimination phase might, however, admit uncomplicated malaria cases to hospital to ensure full adherence to treatment or radical cure.
- A death primarily caused by complications of severe malaria is considered a death due to malaria.
- The numbers of inpatient malaria cases and deaths should be taken from the register of discharges in which malaria is the confirmed primary diagnosis or from ward books if discharge registers are not available.
- In settings in which the aim is to reduce the burden, some malaria cases and deaths that occur in the community may be missed if health care seeking is low.
- In all transmission settings, malaria deaths should be notified to higher levels (such as vital registration systems *(37)* of the health system for investigation and response. In countries where these systems are strong, vital registration data can used to monitor malaria deaths. In areas of elimination, all cases and deaths must be notified and investigated immediately.

Appropriate quality-assured diagnostic and laboratory support must be available for accurate management and classification of malaria. Further details are provided in *Parasitological confirmation of malaria diagnosis (38)*, *Malaria microscopy quality assurance manual (39)* and *Methods manual for product testing of malaria rapid diagnostic tests (40)*.

3.2 Case detection

Cases can be detected across the transmission continuum by PCD, when patients seek care for their illness from health workers, and/or by ACD, which includes testing for malaria or screening for symptoms followed by testing in high-risk groups or locations in the community. Based on the criteria listed in Section 3.1, all suspected malaria cases should be confirmed with a high-quality diagnostic test. Confirmed cases should be recorded and reported following confirmation with microscopy or RDT.

> **Passive case detection (PCD)** is detection of malaria cases among people who go to a health facility or a CHW on their own initiative to get treatment, usually for fever.

> **Active case detection (ACD)** is detection by health workers of malaria cases in the community and in households, sometimes among population groups who are considered to be at high risk. ACD can be conducted as fever screening followed by parasitological examination of all febrile patients or as direct parasitological examination of the target population.

3.2.1 Passive case detection

If the population has good access to health services (public, private, nongovernmental organization or community services), most cases will be identified early by PCD and treated to reduce the risks of severe disease and death and this may also contribute to reducing transmission. PCD should be the backbone of surveillance along the transmission continuum. Improving the robustness and effectiveness of the PCD system so that it can detect most, if not all, cases should be a priority in all settings. In elimination settings, PCD should cover the whole population, including those living or working in remote areas or who are hard to reach, to ensure coverage with rapid testing, treatment and reporting. During the prevention of re-establishment, a strong PCD system ensures the sustainability of malaria surveillance.

High-quality coverage with PCD is therefore a critical prerequisite for reducing the burden of and eliminating malaria. Programmes should map or otherwise determine whether there are communities located in receptive areas (i.e. with competent vectors, a suitable climate and a susceptible population) that are far from public health facilities and add additional health posts, CHWs or volunteers to those locations to extend the reach of the PCD network. Optimizing PCD should be a priority of NMPs in terms of access to care and surveillance.

3.2.2 Active case detection

ACD is an important strategy for malaria elimination programmes, aiming to detect symptomatic cases not detected by PCD, as well as asymptomatic cases in the community. ACD's effectiveness depends on the context, particularly whether high-risk groups can be identified and targeted. Although the outcomes of ACD are unlikely to interrupt transmission, it offers advantages in some contexts. ACD:

- extends health care to hard-to-reach populations, improving surveillance coverage;

- increases surveillance sensitivity, identifying a higher proportion of malaria infections;
- enables community sensitization and care-seeking knowledge;
- provides valuable data on risk factors and transmission drivers, guiding intervention targeting; and
- reduces importation risks by detecting cases among travellers or at borders.

A framework for malaria elimination, second edition (5) provides further details on these benefits and outlines ACD's role in extending surveillance coverage and addressing asymptomatic carriers.

ACD surveillance systems, with case detection, notification and investigation, should be established in all elimination areas, when the caseload is very low, and in prevention of the re-establishment of malaria areas, but should not be considered a substitute for optimizing PCD. As in PCD, all cases identified by ACD should undergo full quality-assured testing and treatment, be followed up to confirm clearance of the infection and be reported to the HMIS.

ACD is conducted intermittently outside health facilities (including village health posts) by health workers who visit patients at their houses, workplaces, schools or other locations, such as markets. Thus, periodic (e.g. monthly) visits to mining camps by a health team would be considered ACD, as there is no fixed facility and no regular service between health worker visits. Cases detected by CHWs are considered to be detected passively if the patients visit a CHW's home for consultation but detected actively if they are identified by a CHW at regular visits to patients' houses. ACD may involve parasitological examination of everyone in a targeted population, whereas in PCD usually only symptomatic cases are tested. In some countries, pregnant women and girls may be routinely tested for malaria at ANC clinics, even when they have no obvious symptoms; any case identified should therefore be considered to be passively detected.

ACD is further classified into proactive case detection (PACD) and reactive case detection (RACD).

- PACD is undertaken in populations that have limited access to facilities or inadequate health-seeking behaviour and in high-risk groups (e.g. remote and/or migrant populations, refugees, armed forces, forest workers, and long-distance drivers). PACD is not prompted by an index case and is performed regularly at specific times (mainly during the transmission season) to confirm active local transmission in target populations and to detect cases early.
- RACD is undertaken in response to an index case, the epidemiological characteristics of which trigger additional ACD, in which a household or a population potentially linked to the case is tested or screened for symptoms and tested before treatment. Index cases are usually seen at a health facility.

ACD for *P. vivax* and *P. ovale* malaria may still miss a substantial proportion of cases because hypnozoites cannot be detected with current testing methods. As most relapses occur within the first 3 months of infection with *P. vivax* or *P. ovale*, it is advisable to combine RACD with PACD conducted at appropriate intervals, especially during peak transmission seasons.

The latest evidence must guide decisions to implement resource-intensive strategies such as RACD and PACD. While both approaches can enhance surveillance coverage, provide insights into the drivers of transmission, and help reach marginalized or hard-to-reach populations, recent studies indicate that RACD is ineffective at interrupting transmission, especially when compared to alternative strategies such as reactive drug administration. RACD's limitations should be considered and alternative or complementary strategies, such as reactive MDA as an effective elimination accelerator, may be required to achieve transmission interruption *(41–44)*.

When PACD and RACD are determined adequate, all members of households within a circumscribed area (around the index case in the case of RACD) would receive a parasitological test on the basis of a history of fever, other malaria-related symptoms and travel history. If the index case is imported, RACD should also be done among fellow travellers and in receptive localities where the imported case may have slept in the past 14 days (incubation period in the mosquito and human). **Box 8** provides guidance on conducting ACD during house-to-house visits in transmission foci.

Box 8. Organizing ACD by house-to-house visits

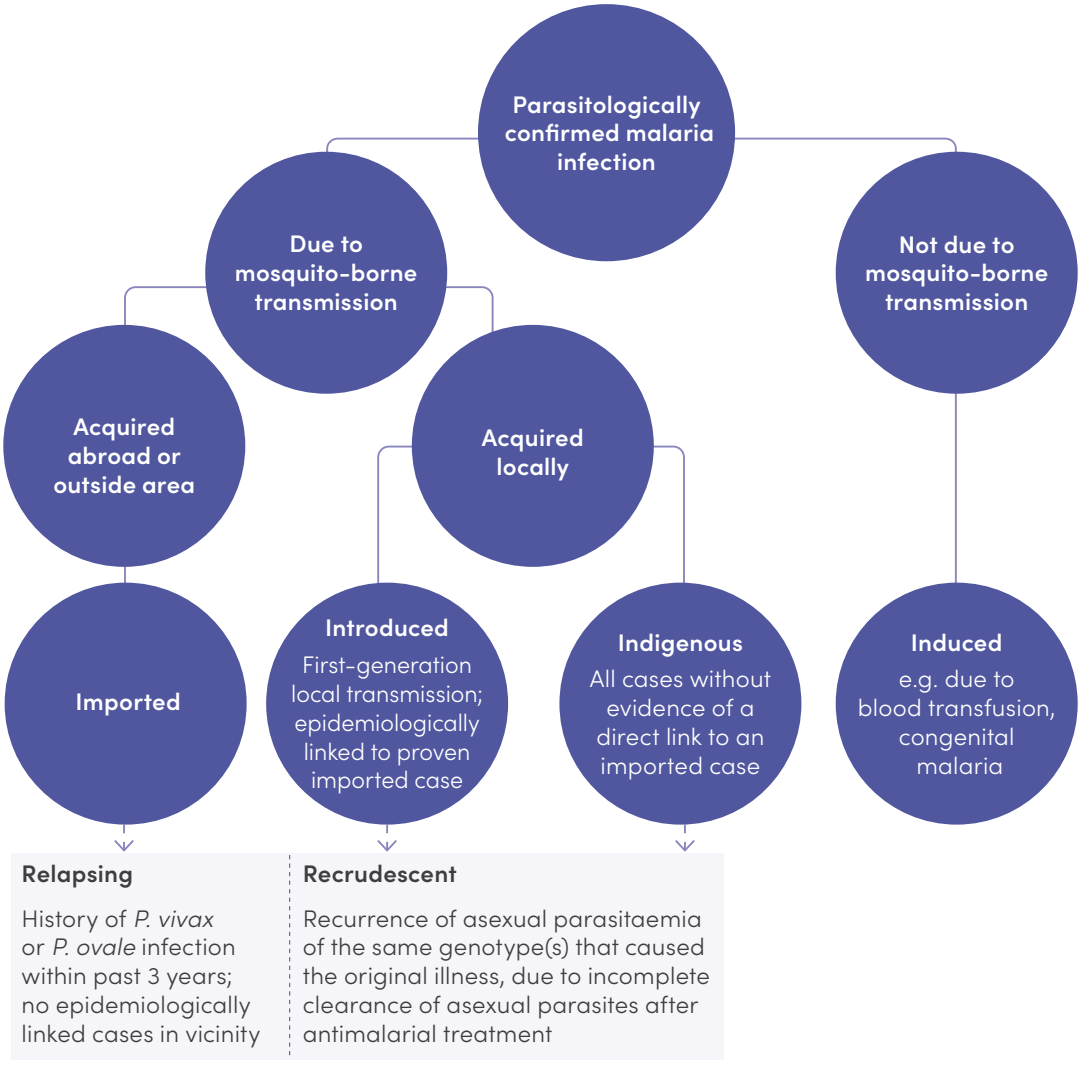
- **Triggering visits:** in RACD, a visit may be triggered by the report of a single index case or a cluster of index cases in a focus. For PACD, visits are made intermittently to determine the presence and extent of transmission among identified high-risk groups in areas with ongoing transmission or populations living in highly receptive foci where transmission has recently been interrupted. PACD can complement RACD in areas where *P. vivax* is the dominant parasite or where *P. ovale* is present, to ensure timely identification of as many relapsing cases as possible.
- **Low caseloads:** RACD is done when there are few cases (e.g. no more than three cases per week per investigation team) and few remaining foci of transmission.
- **Population mapping:** local health care providers or mobile teams list the targeted population by household (and map them with a global positioning system when possible), with the assistance of local authorities. For RACD, the target population may be determined as that within a radius around the index case.
- **Visit planning:** it is important to obtain community participation and support for ACD through visits, and contact with local leaders and the mass media.
- **Timing of visits:** ACD is conducted when family members are most likely to be at home (i.e. before or after work, in the early evening) or at school. Markets, religious places and other community structures might be used to cover the whole targeted population.
- **Testing procedures:** ACD is usually conducted by testing of household members. Testing is done with a RDT or microscopy. When this is not operationally feasible (e.g. when diagnostic and human resources or drugs are limited) or justified (as in near-elimination settings when the vast majority of cases are symptomatic), household members may be asked about recent fever, and those with a history of fever or who are febrile on the day of the visit are tested. There is no fixed rule for the recall period; 14 days (currently used in standardized surveys for malaria control) is probably suitable in most settings. Body temperature can be recorded, but this is not essential.
- **Case management and follow-up:** any person in a clinically severe state should be assisted in obtaining medical care, whether or not they have malaria. People found to have malaria are treated immediately, and in elimination settings cases and foci are investigated epidemiologically. Treated cases are followed up to ensure complete cure.

- **Data collection:** a register of all people whose blood was taken during ACD is completed. The register includes the identification number of the household and, for the head of the household, address, name, age and information on risk factors (e.g. occupation, ownership and use of an ITN, and IRS in the past year), date blood taken, type of testing and results (species, and where possible stage, density and presence of gametocytes).

3.3 Case classification

Case classification becomes important very low transmission settings where there are elimination goals and is a primary reason for case investigations. Once a case has been investigated (see Section 3.6.1), it is classified into one of the categories shown in Fig. 10, described in *A framework for malaria elimination, second edition (5)* and the *WHO malaria terminology, 2021 update (12)*, as locally acquired, imported or induced. Box 9 provides further information for classification.

Fig. 10. Classification of malaria cases



Source: From *A framework for malaria elimination (5)*.

3.3.1 Locally acquired cases

A locally acquired case is one that is due to mosquito-borne transmission and is acquired within the area of investigation (e.g. country, district or focus). The two types of locally acquired malaria cases are:

- indigenous – any case acquired locally, with no strong evidence of a direct link to an imported case; and
- introduced – any case acquired locally, with strong epidemiological evidence linking it directly to a known imported case (first generation from an imported case; i.e. the mosquito was infected by a patient classified as an imported case). There is limited practical value in classifying cases as introduced in areas of known transmission.

It is difficult to differentiate between introduced and indigenous cases. Both indicate local transmission, showing that malaria control was not strong enough to interrupt transmission. Indigenous transmission is more serious because it indicates that neither prevention nor treatment contained the spread of malaria beyond the first-generation (introduced) case. Prompt treatment may not prevent first-generation transmission in all circumstances but should prevent second-generation transmission by destroying gametocytes.

The following criteria are used to classify a case as "introduced".

- The case can be linked to a single imported case. Generally, the imported case will have been identified during PCD or case investigations in the focus.
- The incubation period for all confirmed cases by type of parasite are determined by investigators during case investigations.
- If the patient is considered to have a recent infection but has no travel history that suggests importation and resides in the same household as an imported case or within a 1-km radius (or equivalent *Anopheles* mosquito flight range) of an imported case, the case can be classified as introduced.
- If in doubt, cases should be classified as indigenous. In active foci with a relatively large number of cases, there is limited value in determining whether a case is introduced, and all cases should be considered indigenous.

Some locally acquired cases may be relapsing or recrudescent and thus not indicate ongoing local transmission. Due to technical, practical and financial limitations (e.g. requirements for advanced equipment and specialized laboratory infrastructure), some countries may not be able to genotype the parasites in all infected individuals to define recrudescence. For operational purposes, in very low transmission settings it may be sufficient to consider a case as recrudescent if the episode of malaria is due to the same species as the first episode and occurred within 30 days (for *P. falciparum*) or 60 days (for *P. vivax*) of documented noncompliance with treatment with the first-line medicine. Countries should take into account the latency period of local *P. vivax* strains, which may be shorter, if such information is available. A case occurring outside transmission season with a history of previous infection is more likely to be a relapse. The chance of a relapse increases following incomplete treatment or in the absence of primaquine radical curative treatment. During transmission season there is more uncertainty, particularly if there are epidemiologically linked cases. Whenever there is

uncertainty, a case should be classified as indigenous. If genomic data are available that provide evidence that the current and previous infections are the same, then the case can be more confidently classified as recrudescent. If genomic data show that the infections are not the same then the case should be classified as indigenous.

3.3.2 Imported cases

An imported case is one that is due to mosquito-borne transmission and that is acquired outside the area in which it was detected, in a known malarious area to or from which the patient has travelled outside the elimination area. In areas with ongoing local transmission, elimination programmes should reserve the category "imported" for exotic parasite species and recent arrivals from endemic countries. For all other cases occurring during the transmission season, it is prudent to assume a local origin of the infection, unless there is strong evidence to suggest otherwise.

Uncertainty may arise in classifying cases as imported rather than introduced or indigenous when the patient has a dubious travel history or suffers a relapse of a *P. vivax* or *P. ovale* infection that was acquired earlier and was not radically cured. If the evidence is unclear, the classification that reflects more local transmission should be assigned; for example, cases should be classified as introduced or indigenous rather than imported. This conservative classification ensures that malaria elimination programmes are more responsive to possible renewed transmission on their national territory. Often, the investigative skills of the lead epidemiologist are put to the test in determining where and when in the country an infection was acquired. Guidance provided in **Box 9** may help the investigation team in case classification. In this scheme, "imported" includes locally imported cases; that is, cases in which infection occurred in areas outside the focus but in the same country. For global reporting, such as to WHO, cases should be classified as imported only if the infection was acquired in another country.

A common mistake is to assume that a case is imported because the patient visited a country or area known to be endemic for the parasite species in question. Most malaria endemic countries, however, contain large areas in which there is no risk of transmission and seasons during which no transmission takes place. It is essential to determine exactly where the patient stayed and when before concluding whether he or she could have been exposed to malaria abroad. Detailed information on the malaria endemic status of the country visited is available in the public domain from the WHO Global Health Observatory *(45)* or the most recent World Malaria Report. The NMP can request the assistance of WHO to obtain information at the subnational level in countries with heterogeneous transmission to determine the risk in the exact area visited.

Box 9. Operational aspects of classification of cases

Correct epidemiological classification of malaria cases is crucial in malaria elimination when there are very few cases, because it is the basis for classifying foci and for selecting surveillance and other control measures.

Distinguishing between imported and local cases

The probability that a case was imported is associated with several factors, which should be weighed in making the final assessment, as outlined below.

- The timing of travel to and from endemic areas to determine how long they stayed:
  - The usual delay between an infectious mosquito bite and a primary clinical attack is 7–30 days. The minimal incubation period (i.e. from inoculation to onset of symptoms) of malaria in humans is about 7 days for *P. falciparum* and 10 days for *P. vivax* infection. Thus, detection of malaria parasites within 0–7 days for *P. falciparum* or 0–10 days for *P. vivax* of arrival in a country would indicate that the person was infected before arriving.
  - People who have lived in malaria-free areas for 2 or more years and have low immunity to malaria are highly likely to have clinical symptoms shortly after the usual incubation period.
  - When the time between returning from travel to an endemic area and detection of malaria infection increases beyond 6 months, the probability that the case is truly due to an imported infection starts to decrease and the probability that the case is due to local transmission increases.
- The parasite species:
  - *P. falciparum* infections can last for 18–24 months, but several febrile episodes would be expected during that period because parasite density increases intermittently to cause fever or symptomatic illness. Predominantly asymptomatic long-term infections are unlikely to occur in people with low antimalarial immunity, but they are possible.
  - *P. vivax* infections due to activation of hypnozoites can cause infection up to 5 years after the previous infection or clinical episode but are most likely within 3 years. Experience in many countries shows that nearly 50% of imported cases occur within 1 month of arrival back in the country of residence and up to 75% by 3 months *(23)*.
- The probability of local transmission in the areas of residence and occupation of the patient:
  - If a person lives and works in a place in which there has been no local malaria transmission for many years, with adequate surveillance, and the person travelled to an area of known transmission within 6 months of documented infection, classification of the case as imported is straightforward.
  - If the area has had no malaria for more than 3 years and has reasonable surveillance or has no known appropriate vectors, local transmission is unlikely.
  - If the malaria patient lived in a focus with recent local transmission (classified as "residual non-active" focus), the probability that the case is truly imported is lower.
  - Cases in areas with local transmission (classified as "active" foci) should rarely if ever be classified as imported. However, in cross-border areas with frequent population movement, especially for routine treatment-seeking, it may be programmatically useful to ensure careful classification of importation, even in active foci, to alert authorities across the border.

- The extent of surveillance in the area in which the case was detected and the extent and quality of the field investigation around the home and work area of the case:
  - Consistently negative test results from strong previous surveillance and extensive blood sampling during the field investigation decrease the probability of local transmission.
  - Place of diagnosis may be different from place of infection.

3.3.3 Induced cases

An induced case is one that is not due to mosquito-borne transmission but to a blood transfusion, other form of parenteral inoculation of the parasite or through mother-to-child transmission (congenital malaria). Such cases are easy to classify if the person lives and works in an area in which there has been no known transmission for many years and has a history of blood transfusion or other exposure to blood that could have transmitted malaria. The incubation period (i.e. the delay before the onset of clinical symptoms) after contamination with infected blood from a needle-stick injury ranges from 4 to 17 days, with a median of 12 days. Induced cases never give rise to clinical relapses, because there are no liver-stage parasites.

3.4 Focus classification

The heterogeneity of malaria across the continuum of transmission results – in most settings – in spatial clusters of relatively higher transmission, which can be referred to practically as foci of transmission. For malaria surveillance, however, the term "focus" is used mainly to refer to the few definable areas in which transmission persists during the final stages of elimination.

> A **"focus"** is a defined circumscribed area situated in a currently or formerly malarious area that contains the epidemiological and ecological factors necessary for malaria transmission.

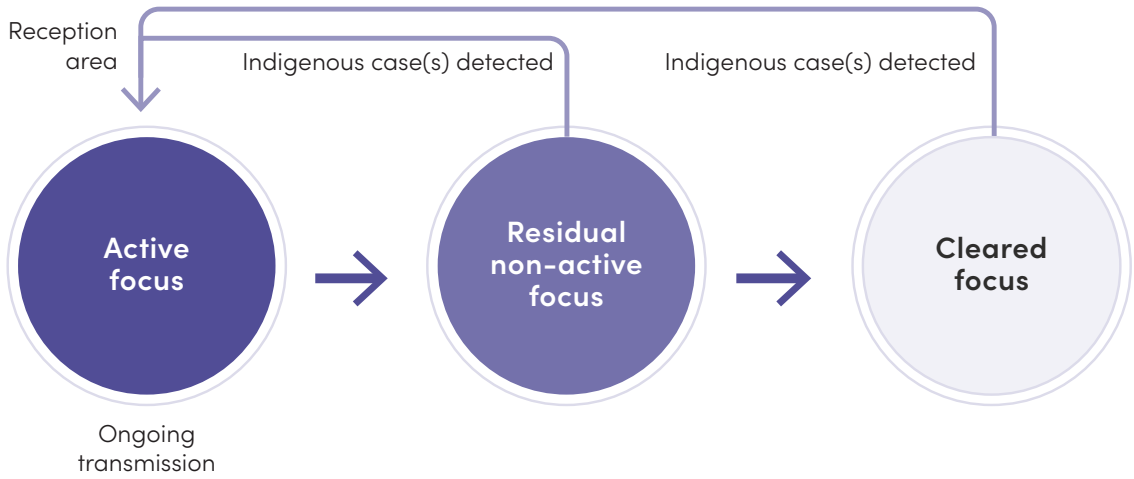
A focus can be classified into one of three types (**Table 4**); the relations among different types of focus are shown in **Fig. 11**. Focus classifications should be updated periodically. In countries with seasonal transmission, focus classifications are often reviewed at the end of each malaria transmission season or annually. The status of a focus should also be reviewed as new cases appear and field investigations are undertaken. The results of focus investigations are maintained at subnational and national levels (comprising a focus "register"), and a summary of the status of foci is updated at least annually (**Annex 4**). Where an indigenous case is reported in a cleared or residual non-active focus, the focus should immediately be classified as active to ensure additional surveillance activities and trigger prompt response (see **Fig. 11**).

Table 4. Focus classification recommended in *A framework for malaria elimination*

Classification	Definition	Operational criteria
Active	A focus with ongoing transmission	Indigenous case(s) have been detected within the current calendar year.
Residual non-active	Transmission interrupted recently (1–3 years previously)	The last indigenous case(s) was detected in the previous calendar year or up to 3 years earlier.
Cleared	A focus with no local transmission for more than 3 years and which is no longer considered residual non-active	A focus with no indigenous case(s) for more than 3 years, where only imported, relapsing or recrudescent, or induced cases occur in the current calendar year.

Source: Adapted from *A framework for malaria elimination, second edition (5)*.

Fig. 11. Classification of malaria foci



Source: Adapted from *A framework for malaria elimination, second edition (5)*.

3.5 Routine activities in malaria elimination surveillance and response

A variety of activities underpin the elimination of malaria in a focus (Fig. 12).

Fig. 12. Routine activities in focus-based surveillance and response

	Prevention	Passive case detection	Active case detection	Community mobilization	Drug efficacy surveillance	Entomological surveillance	Monitoring and evaluation
Active	Universal coverage of IRS or ITNs. Larviciding and other environmental management activities[a]. MDA[b].	High coverage of routine case management services. High-quality diagnosis and treatment. CHWs or volunteers in settings where access is low (> 2 h travel time). Individual case reporting and notification in place. Case investigation form completed at health facility, case classification implemented.	Monthly PACD during high-transmission season (especially for *P. vivax* and *P. ovale* where relapse is a problem) or during time periods when high-risk groups travel to higher-risk areas. Case investigation and RACD (and RDA) when there are few cases (e.g. fewer than three per week per investigation team). Investigate all cases during RACD. RACD (and RDA) radius limited to households of index case(s) or immediate neighbours. Case classification completed where required. All cases followed up to ensure adherence to treatment and complete cure.	Routine community engagement and knowledge transfer on malaria prevention, treatment and environmental management. Use ACD process for supplementary community engagement. Work with institutions that train the health workforce to ensure maintenance of good clinical and laboratory practice as malaria becomes rare. Work with all sectors to support communication activities.	Efficacy surveillance linked to case follow-up of index cases and others detected in the community during RACD. (See **Section 3** for more information.)	Maintain active entomological surveillance in sentinel sites. Conduct spot checks in focus as necessary. (See **Section 5** for more information.)	Register all foci. Ensure all households are mapped. Update population data by age and sex category. Update interventions implemented in foci. Update focus case reports by PCD, ACD, parasite species, age range and sex. Reclassify foci annually, if necessary. Evaluate intervention coverage using routine investigations. Analyse disease trends. Evaluate quality of interventions, including case management, routinely. Evaluate quality of passive and active surveillance systems routinely. (See **Section 7** for more information.) Ensure that a local team is in charge of microplanning and monitoring and evaluation for each foci that is identified.
Residual non-active	Universal coverage of IRS or ITNs. Larviciding and other environmental management activities.		PACD only for high-risk groups. Case investigation and RACD for all cases. RACD (and RDA) in the whole focus if case is locally acquired.				
Cleared	Universal coverage of IRS or ITNs. Larviciding and other environmental management activities.	High coverage of routine case management services. High-quality diagnosis and treatment. Infected patients may be admitted for directly observed treatment. Individual case reporting and notification in place. Case investigation form completed at health facility, case classification implemented.	RACD (and RDA) only for household of index case or immediate neighbours and fellow travellers if imported. All cases followed up to ensure adherence to treatment and complete cure. Case classification completed where required. No need for RACD if cleared focus is not receptive.				

ACD: active case detection; CHW: community health worker; IRS: indoor residual spraying; ITN insecticide-treated net; MDA: mass drug administration; PACD: proactive case detection; PCD: passive case detection; RACD: reactive case detection.

[a] Larval source management should be used where vector breeding sites are few, fixed and findable. Routine sentinel entomological surveillance should be maintained in all transmission settings. For entomological surveillance during focus investigation, see **Section 5**.

[b] See WHO recommendations and MDA field manual *(46)* for further guidance.

These routine foci activities include:

- scale-up of appropriate preventive and treatment interventions, such as:
  - optimization of access to routine malaria case management at health facilities and, where appropriate, through CHWs; and
  - elimination accelerating strategies such as reactive drug administration;
- implementation of case investigation and prompt case notification through the PCD system whether or not case investigation and RACD happen in the community;
- implementation of PACD among high-risk groups or during high-risk periods (high-transmission season) if cases are still too many to implement RACD;
- implementation of RACD when cases are few (e.g. no more than three cases per week per investigation team) (see **Section 3.6**);
- desk review, focus investigation and response microplanning as necessary (see **Sections 3.6** and **3.7**);
- continuous community mobilization to participate in elimination activities and communication to raise awareness;
- follow-up of cases once a case investigation and/or a RACD approach is in place to ensure adherence to treatment and complete cure (see **Sections 3.6** and **4**);
- regular entomological surveillance through representative sentinel sites, supplemented with spot checks during focus investigation as necessary (see **Section 5**);
- annual monitoring and evaluation activities to track trends in malaria and drivers of transmission, to ensure optimization of interventions including surveillance systems, and to reclassify foci as necessary.

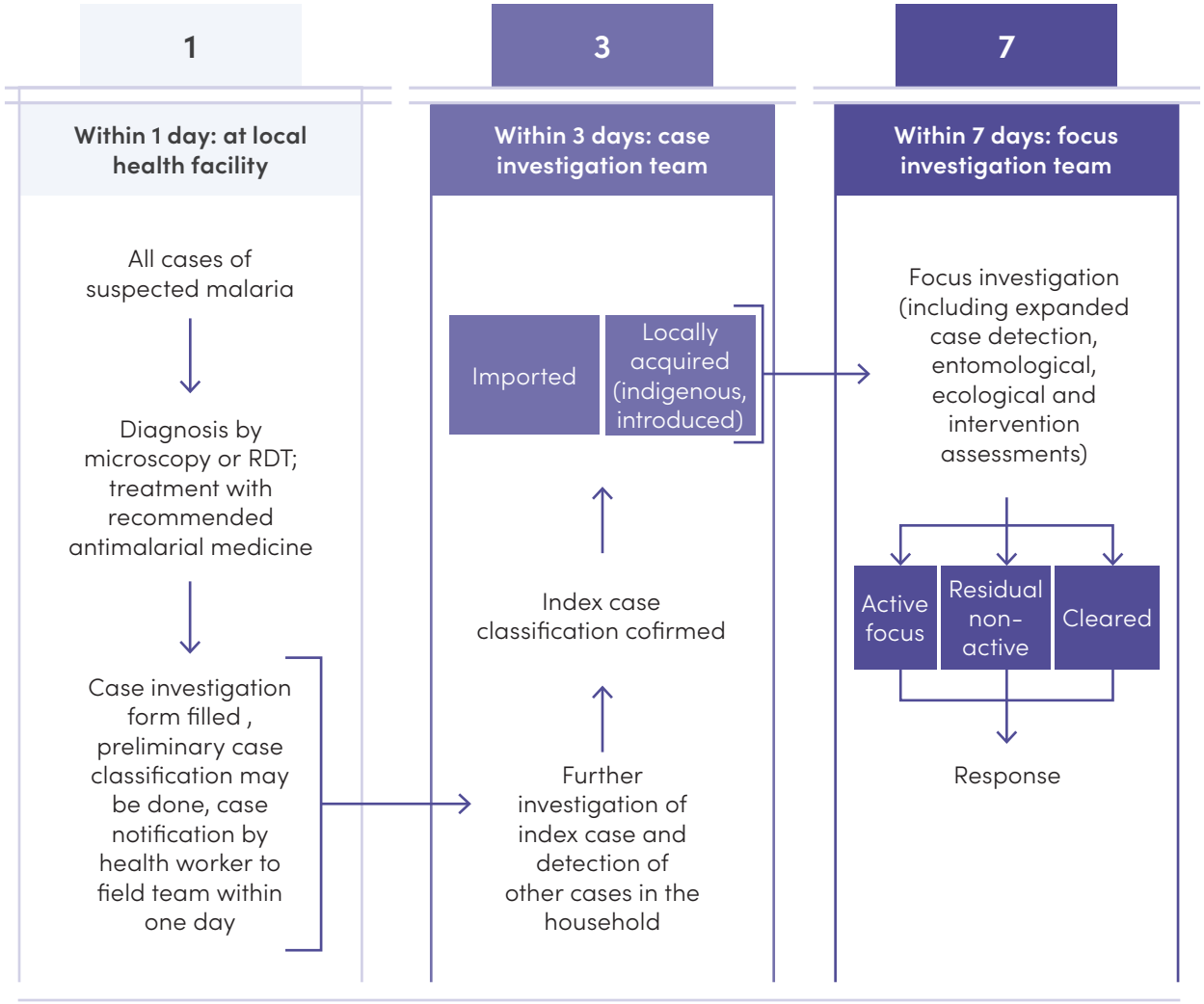
3.6 Reactive surveillance activities in the focus

Case investigation, detection and focus investigation are elimination surveillance activities that are interconnected and are important for reliable determination of source of infection and classification of cases (**Section 3.3**) and foci (**Section 3.4**) to inform appropriate response (**Section 3.7**).

For planning purposes, national SOPs should define a suitable schedule for case investigation, case detection and focus investigation. **Fig. 13** illustrates elimination surveillance with the examples of case notification within 1 day, case investigation within 3 days and focus investigation within 7 days, a "1–3–7" approach adopted from the guidance in China *(47)*.

Fig. 14 provides a detailed description of process and activities from the moment an index case is identified until a decision on focus response is made. For illustrative purposes a separation is made between community case investigation, ACD and focus investigation. However, in practice, investigation and detection of cases in the focus are part of the broader focus investigation, while detection of cases may also include additional investigations to determine causes of transmission.

Fig. 13. Case notification and case and focus investigation systems according to the "1–3–7 days" approach



RDT: rapid diagnostic test.

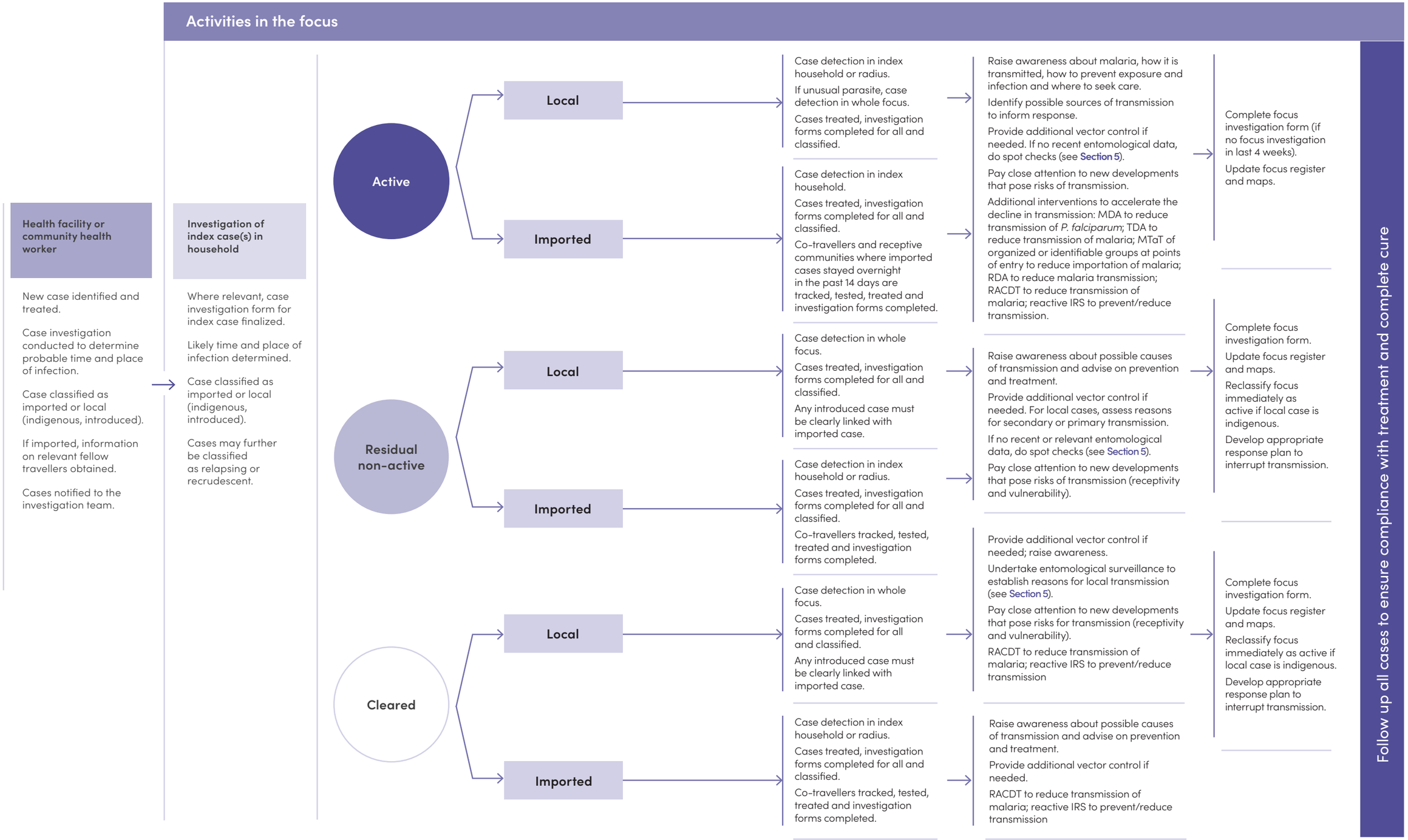
Indigenous and introduced cases may further be classified as relapsing (*P. vivax* or *P. ovale*) or recrudescent. It is practically more difficult to classify imported cases as relapsing or recrudescent. Induced cases are rare. See **Section 3.3** for case classification.

A case and focus investigating team may comprise:

- a health worker – at a health facility or the intermediate-level (e.g. district) malaria focal point – who is usually the head of the team, understands the epidemiology of malaria and has experience in field investigations of malaria cases;
- a skilled laboratory technician, if microscopy is the main diagnostic tool, or any health worker with good training in RDTs when these tests are used for surveillance;
- an epidemiologist, who is often a focal point;
- entomological staff from intermediate or central levels when entomological surveillance is required during focus investigation; and
- local health facility personnel and village health volunteers who know the area.

1 Surveillance as core intervention 2 Establishing surveillance systems 3 Concepts & practice of surveillance 4 Drug efficacy & resistance
5 Entomological & vector control monitoring & evaluation 6 Detection, preparedness & response 7 Monitoring national programmes ▸Annexes

Fig. 14. Reactive surveillance and response activities



IRS: indoor residual spraying; MDA: mass drug administration; MTaT: mass testing and treatment; RACDT: reactive case detection and treatment; RDA: reactive drug administration; TDA: targeted drug administration

- In cases of relapse and recrudescence, no further case detection or focus investigation is required.
- In residual non-active and cleared foci, locally acquired cases should be further classified into introduced and indigenous. Although this will not affect the investigation or response, it is required for focus reclassification.

- RACD and related activities in cleared foci is similar to that in settings of prevention of re-establishment of transmission.
- There are situations where it is not possible to make a definitive case classification after investigation of the index case at the household. This may require additional investigation in the focus.

3.6.1 Case investigation

Case investigation aims to determine whether an infection was acquired locally and the likely location of infection, and therefore whether there is indigenous malaria transmission or factors that may lead to onward transmission. The collection of a detailed history of an index case at a fixed point of care (health facility or CHW) is the basis of case investigation (**Fig. 14**). Recording of detailed patient history is an integral part of surveillance for elimination and should be implemented at the fixed points of care even when a case will not be followed up in the community.

If required, further investigation of cases in the focus should be done when the total case burden in a country is very low (e.g. no more than three cases per investigation team per week), there are few foci of transmission and adequate resources are available; in particular, skilled personnel are required at the district level, with adequate transport and malaria commodities.

The timing of case investigations depends on the dominant parasite species; patients with *P. vivax* infection may develop gametocytes and be infectious to the mosquito before symptoms appear, requiring rapid intervention. The investigator should be aware that some patients may have hypnozoites and the case may be due to relapse. Countries should decide on the best timing of investigations, recognizing that delays in case notification and in case and focus investigations and response could result in severe disease and death, increased transmission or reintroduction of transmission, depending on the focus class and type of parasite. The investigation team should ideally initiate an investigation within 1–3 days of notification of a malaria case at the home or workplace of the index case.

Once the case investigation is complete (either at the health facility when there is adequate information, or at the household of the index case if further follow-up is required), a determination is made of the likely source and time of infection and the case is classified (**Fig. 14**).

3.6.2 Reactive case detection

RACD may be triggered by the identification and notification of an index case. After the investigation and classification of the index case, RACD may be implemented within the household of the index case, over a radius around the household, or within the whole focus (**Fig. 14**). While is it unlikely that RACD will work as a single strategy to interrupt transmission, it may be undertaken for the following reasons:

- to investigate an outbreak (an above-normal number of index cases) in any type of focus;
- in active foci, to ensure high coverage of case management;
- in all types of focus when a local case is due to an unusual parasite, which was either previously eliminated or is new to the focus;
- to identify locally acquired or imported cases in residual non-active or cleared but receptive foci; and
- to reclassify cases (and eventually foci) from active to residual non-active to cleared and to verify that elimination has been achieved subnationally or nationally.

The process of RACD involves the following steps.

- **Gather existing data:** obtain epidemiological data on previous cases in the same focus and the index case(s) which should be available from existing records.
- **Register residents**: register all residents of households in which RACD is to be conducted.
- **Identify index case household:** identify the household (or other likely origin/location of infection) of the index case using information from villagers, village health volunteers and the map of the focus.
- **Sensitize the community:** sensitize the household (or co-workers) about malaria, its symptoms, cause, prevention and where to seek care.
- **Complete a case investigation form:** complete a case investigation form for each confirmed malaria case (see example in Annex 2). The form must record the dates of all aspects of the travel and clinical history. An assessment of the likely location and source of infection is made and the case is classified.
- **Obtain vector information:** obtain information on potential malaria vectors in the vicinity of the case, if available sentinel site data are not sufficient (see Section 5).
- **Conduct ACD:** undertake ACD in populations considered likely to harbour parasites, usually those within a defined radius of the index case. When resources permit, the whole focus should be covered, as there may be cases of malaria outside the immediate vicinity of the index case. Fever could be used to screen populations for testing. Similarly, when feasible, RDA should complement RACD. PACD may be repeated each month after RACD during the peak transmission season to ensure all new infections are detected and treated.
- **Consider imported cases:** where evidence shows no receptivity to malaria, there is no need to investigate imported cases at community level; however, fellow travellers of the imported index case might be tracked to provide treatment. If co-travellers are from a focus outside of the operational area of an investigation team, the appropriate authority should be informed to investigate these cases.

3.6.3 Focus investigation

A focus investigation is conducted to identify drivers of transmission, including the populations at greatest risk, the rates of infection or disease, the distribution of vectors responsible for malaria transmission and the underlying conditions that support it. Such an investigation therefore involves demographic, epidemiological, entomological and environmental surveillance (see Section 5.2.4) and monitoring of intervention coverage and quality (Section 7).

The delineation of transmission areas into foci is of practical value only if it results in few foci of relatively small size, so that their investigation is operationally feasible. Delineation that results in hundreds of foci in an area probably indicates that malaria transmission is still widely established, and the area may not be suitable for focus investigation or response. For operational purposes during elimination, a focus is of the same size as a small village, where households are separated by short distances.

This allows completion of a focus investigation in a day or two. Urban foci may be smaller, given the high density of population per area.

Before conducting field visits, a comprehensive desk review should be undertaken for each suspected malaria focus to assess potential drivers of transmission (Box 10). This review may include simple mapping of classified malaria cases alongside data on contributing factors, such as vector breeding sites and recent vector control efforts. Findings of desk reviews should be systematically documented and updated to aid future investigations. For example, in addition to tracking where a focus is active, residual non-active or cleared, the drivers of transmission and interventions implemented should also be recorded. The primary goal of the desk review is to develop hypotheses explaining the epidemiological situation in the focus, and to ensure that field investigations are data-driven and targeted. Additionally, the desk review enables effective planning of logistic and resource requirements, helping field teams understand their role and the specific issues they need to investigate.

Box 10. Desk review prior to conducting foci investigations

1. Collect available data

- **Historical data on malaria transmission:** review malaria cases over past years, focusing on case incidence, geographical distribution and seasonality in the focus area. Examine trends to identify potential patterns of transmission.
- **Health facility reports:** gather reports from local health facilities regarding malaria case detection, treatment and reporting accuracy. Include data on diagnostic tools used (RDTs, microscopy) and treatment outcomes.
- **Surveillance data:** obtain data from surveillance systems, including the number of cases reported, time to detection and case classification (imported versus indigenous). Check the completeness and timeliness of reporting.
- **Demographic data:** collect population data of the focus area, including migration patterns and information on high-risk groups (e.g. mobile populations, seasonal workers).
- **Environmental data:** examine ecological factors such as rainfall, temperature and potential mosquito breeding sites, as these can influence vector dynamics and malaria transmission.

2. Map malaria cases

- **Case mapping:** use geographical information system or other mapping tools to visualize where recent malaria cases have occurred within the focus area. Mapping cases helps identify clusters or hotspots of transmission.
- **Risk areas:** overlay vector breeding site, infrastructure and population movement data with case locations to identify areas of higher risk.

3. Review recent interventions

- **Vector control measures:** gather data on recent vector control activities, such as IRS campaigns, distribution of ITNs and larval source management (LSM). Note the coverage and timing of these interventions.
- **Case management:** review whether the area had effective malaria case management programmes in place, including the availability of diagnostic tools and appropriate treatment.
- **Community engagement:** assess the extent of community health education and engagement activities carried out to raise awareness and compliance with malaria prevention measures.

4. Develop hypotheses

- **Formulate hypotheses:** based on the data review, formulate hypotheses about potential drivers of malaria transmission in the focus. Consider factors such as importation risk, gaps in vector control, or pockets of asymptomatic infections.

5. Identify gaps

- **Data gaps:** identify gaps in the available data, such as missing reports, incomplete surveillance, or areas where interventions were insufficient or not implemented.
- **Operational gaps:** highlight logistic challenges, such as areas with limited access, seasonal migration, or inconsistent intervention coverage that may affect transmission.

6. Plan logistic and resource requirements

- **Logistic needs:** based on the findings from the desk review, determine the logistic needs for the field investigation. This includes identifying necessary human resources, transportation, diagnostics, and coordination with local health workers or other stakeholders.
- **Resources:** ensure that targeted resources are ready for rapid deployment during the field investigation phase.

7. Generate preliminary recommendations

- **Recommendations:** based on the desk review, provide preliminary recommendations that will guide the field investigation. These should include priority areas to investigate, specific hypotheses to confirm, and any potential high-risk zones identified through data analysis.

8. Prepare investigation tools

- **Tools:** develop field tools based on the desk review, such as checklists for case investigations and vector surveillance, and community surveys. Tailor these tools to the suspected drivers of transmission identified during the desk review.

9. Brief field teams

- **Field teams:** before going into the field, brief the field investigation teams on the desk review findings. Ensure that all teams understand the focus of the investigation, the suspected causes of transmission, and the areas where data needs to be collected or verified.

The process of case investigation at the household level and RACD or PACD in the community are epidemiological components of a focus investigation. However, focus investigations may not involve community case investigations or detection and could be implemented on their own to understand entomological, environmental

and intervention determinants of transmission. In general, the following conditions necessitate further focus investigations:

- an unusual increase in cases, to determine the causes;
- RACD when cases are very few (see **Section 3.6.2**) to determine if additional response is required (if an investigation was undertaken in an active focus recently, for example within the past 4 weeks, it may not be necessary to conduct a full focus investigation in response to an index case);
- identification of a rare parasite in the focus, to determine the extent and cause of transmission;
- the identification of a local case in a residual non-active or cleared focus, to determine the extent and cause of transmission; and
- the need to monitor coverage of interventions (ideally informed by a drivers of transmission analysis) in a focus.

The timing of a focus investigation depends on the parasite species. ACD linked to an index case should preferably be initiated within 7 days of case notification. During a focus investigation, the relevant form should be completed (**Annex 3**). The district- or intermediate-level malaria focal point is responsible for ensuring that all foci are investigated and that reports for all foci (sometimes called "focus passports") are available and kept up to date. In some settings, the focus investigation team may be in a health facility. If a focus encompasses the boundaries of two or more districts, provinces or even countries, collaboration will be required to eliminate transmission. "Straddling foci" are often the most puzzling for epidemiologists, because administrative boundaries may make the sources of infection difficult to determine.

A map should be produced, with standard and recognizable keys, to show:

- geographical features relevant for malaria transmission (e.g. rivers, rice fields, dams, ponds, forests, roads, altitude);
- the locations of all households, highlighting those in which cases have been detected in the past 3 years (with the parasite species responsible for each case);
- vector breeding places and possible sites of transmission, especially when LSM is used;
- the location of test and treatment sites, including areas and households where ACD has been undertaken; and
- distribution and coverage of vector control interventions.

Paper and electronic maps can be used, but the latter is more flexible and easier to update, given the increased availability of mapping technology (including on mobile devices) and the extension of routine information systems to be "map enabled". Additional features relevant to malaria transmission and control, such as the location of health facilities, should be added.

Geolocation is used to gather the coordinates of a specific location. Addition of mapping or geolocation capability to a surveillance system makes case and focus investigations more efficient and the products of data analysis more visually powerful, so that they can reveal potentially important geographical variations in

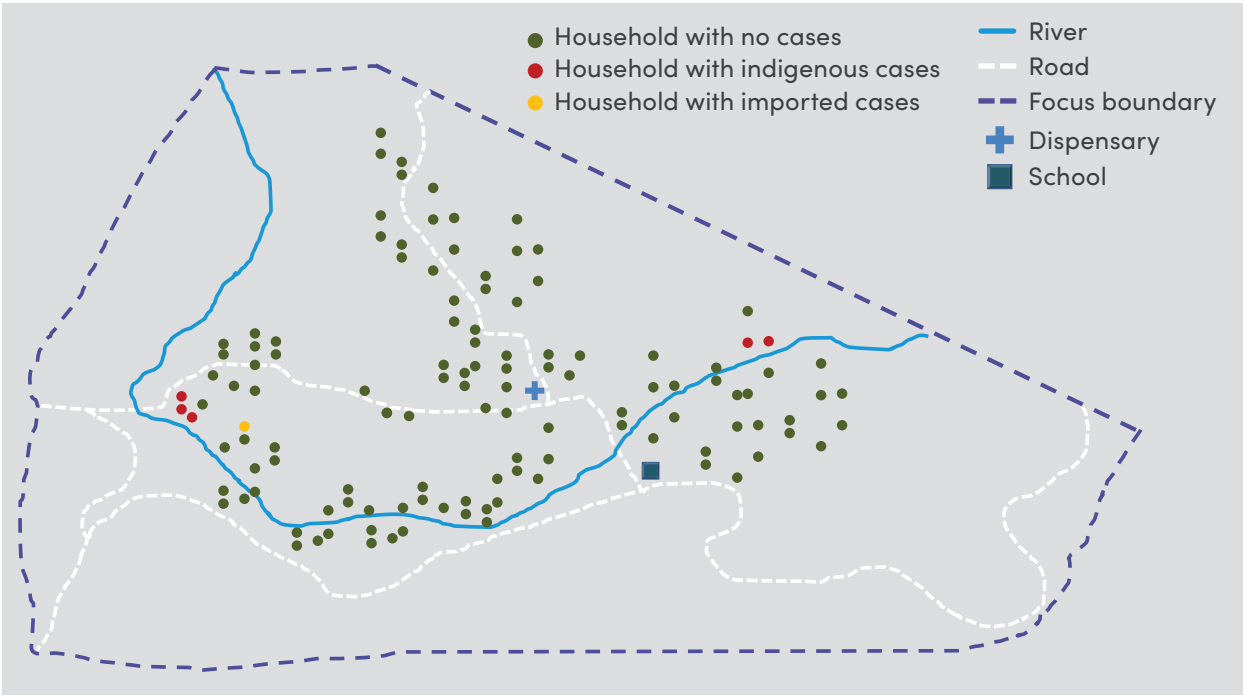
both risks and risk factors. Methods used to geolocate and map malaria cases to household level include:

- integrating a malaria surveillance system with an automated mapping system to geolocate detected cases in known locations;
- collecting the coordinates of the site of infection of individual malaria cases with a device enabled for the global positioning system and geolocating the residence, regardless of the location of infection, as the patient may have infected vectors before receiving radical treatment; and
- if case coordinates cannot be acquired, obtaining information from the patient about relevant location(s), such as residence, work or other places in which he or she may have been infected, which can then be plotted on a map and the coordinates read; geolocation with this method is less certain than the other two approaches.

Mapping of geolocated malaria cases helps identify possible transmission areas and classify cases and foci to guide further targeted investigations. The boundaries of a focus should include the area in which transmission is occurring if the focus is active and the area in which there is a risk for onward transmission from the detected case(s), whether locally acquired or imported. Geographical reconnaissance involves gathering detailed data for planning and implementing responses and ensuring optimal coverage of all activities, especially vector control within the focus. Annex 5 lists the stages, purposes and activities at each stage of geographical reconnaissance and focus mapping with geographical information systems.

An example of a map of a focus showing the global positioning system locations of households and the malaria cases detected is shown in Fig. 15.

Fig. 15. A focus map showing the distribution of households geolocated by global positioning system, roads and river



Once the case and focus investigations have been completed, the following actions are necessary.

- The malaria focal point and the entomologist determine whether local transmission is occurring and decide on a final classification of the case and focus.
- The malaria focal point, in consultation with district and national experts, prepares a response plan based on the results of the field and focus investigations, including the entomological evaluation when relevant.
- Copies of the completed case forms and the results of the investigation (including from ACD) and foci register are distributed to the NMP, the national malaria laboratory, the reporting district team and the reporting health facility.

The maps and household checklists produced during focus mapping should be used to target responses in the transmission focus (e.g. treatment or vector control). All the information should be in the form of both a visual guide for field officers to reach the locations where work is required and a checklist for field officers to ensure that all populations, structures and other features (e.g. potential breeding locations) are reached or covered.

Data on field activities should be recorded on household checklists and map data. The data can then be updated and analysed in applications such as geographical information system software to assess and evaluate the coverage of interventions and activities conducted (as illustrated in Fig. 5). Data should include the locations of additional malaria cases detected by RACD, the coverage of vector control activities or the location of breeding sites. Programmes should maintain and regularly update inventories of transmission foci. Customized applications (e.g. integrated malaria surveillance systems) could be designed to permit malaria programmes to analyse intervention data rapidly and automatically, to ensure that all activities within the transmission focus are conducted with optimal coverage and on time.

3.7 Focus response

Most interventions in a focus are implemented routinely (based on evidence of likely transmission identified during focus investigation) (Fig. 13) and the response to an index case or PACD are mechanisms to optimize these interventions or respond to unusual situations. Providing treatment to infected individuals, supplementary vector control and increasing community awareness are part of a targeted focus response. The responses in active, residual non-active and cleared foci are similar but have important differences.

- Vector control measures, such as reactive IRS, are assessed for their appropriateness, coverage and use in accordance with the local context of malaria, with particular attention to the receptivity of the area.
- PCD services are accessible to all members of the population throughout the year and are supported by supervision at defined intervals.

- In active foci, there are several options. High coverage of appropriate vector control should be ensured. Population-wide treatment (MDA), targeted treatment (TDA) or possibly PACD (with screening and testing or with testing alone) could be considered at appropriate intervals, especially just before or during the transmission season. If a testing approach is chosen but no cases are found after several rounds of PACD, the frequency may be reduced or the strategy changed to RACD, as necessary.
- In residual non-active foci, PACD may be used at key times (e.g. mid and late transmission season or when high-risk populations move to at-risk areas) to screen the people most likely to have malaria (e.g. those with fever, migrant labourers and those who do not use prevention) to identify local cases indicative of ongoing transmission. RACD is then conducted to follow index cases. If indigenous cases are identified, the focus is reclassified as active (see **Fig. 14**).
- In cleared foci, the programme should rely on the surveillance system to rapidly identify any malaria cases and determine whether local transmission has resumed. Depending on the receptivity of the cleared focus, RACD can be conducted after the identification of an index case. If new indigenous cases are identified, the focus is reclassified as active (see **Fig. 14**).

Monitoring and evaluation of focus response is essential for ensuring the effectiveness of interventions aimed at interrupting malaria transmission in identified foci. Continuous tracking of the implementation of response activities, such as vector control, case management and community engagement, should be led by a dedicated team and systemized to ensure they are conducted timely and according to plan. Key metrics to monitor include reduction in case numbers and vector density, and the progression of the focus from active to cleared status. Monitoring and evaluation is important because it helps detect early signs of re-establishment in prevention of re-establishment settings, assesses the adequacy of interventions, and identifies gaps or delays that need correction. By regularly evaluating the focus response, malaria programmes can adapt strategies in real time, allocate resources more effectively, and ensure that elimination efforts are sustained.

4. Surveillance of antimalarial drug efficacy and drug resistance

4.1 Introduction

Information on the efficacy of recommended malaria treatment is critical for ensuring progress towards elimination and ensuring that patients receive efficacious treatment. WHO has prepared a standard protocol for therapeutic efficacy studies (TES) and data analysis and monitoring tools, including template checklists, for quality control of TES *(48)*. TES are considered the gold standard for assessing antimalarial drug efficacy, and the resulting data are used to inform national malaria treatment policy in malaria endemic countries. TES are designed for monitoring the efficacy against both *P. falciparum* and *P. vivax* of any of the recommended first- and second-line medicines as well as any medicine that is to be assessed before possible introduction into the treatment policy.[1]

In areas with very few malaria cases, it will be difficult to recruit enough patients to obtain interpretable information on drug efficacy. If these areas are pursuing malaria elimination, their surveillance systems will likely have been strengthened to improve case detection, increase case reporting from all sectors (private and public), ensure that all patients receive the full, supervised, recommended treatment (including radical cure) and confirm complete cure by following up patients at regular intervals *(5)*. In these areas, monitoring of drug efficacy can be integrated into the routine surveillance system (see **Section 4.4.2**).

Chemoprevention is the use of medicines, either alone or in combination, to prevent malaria infection and its consequences. WHO has published the malaria chemoprevention efficacy study protocol for monitoring the protective efficacy of antimalarial medicines used for chemoprevention *(49)* (see **Section 4.5**).

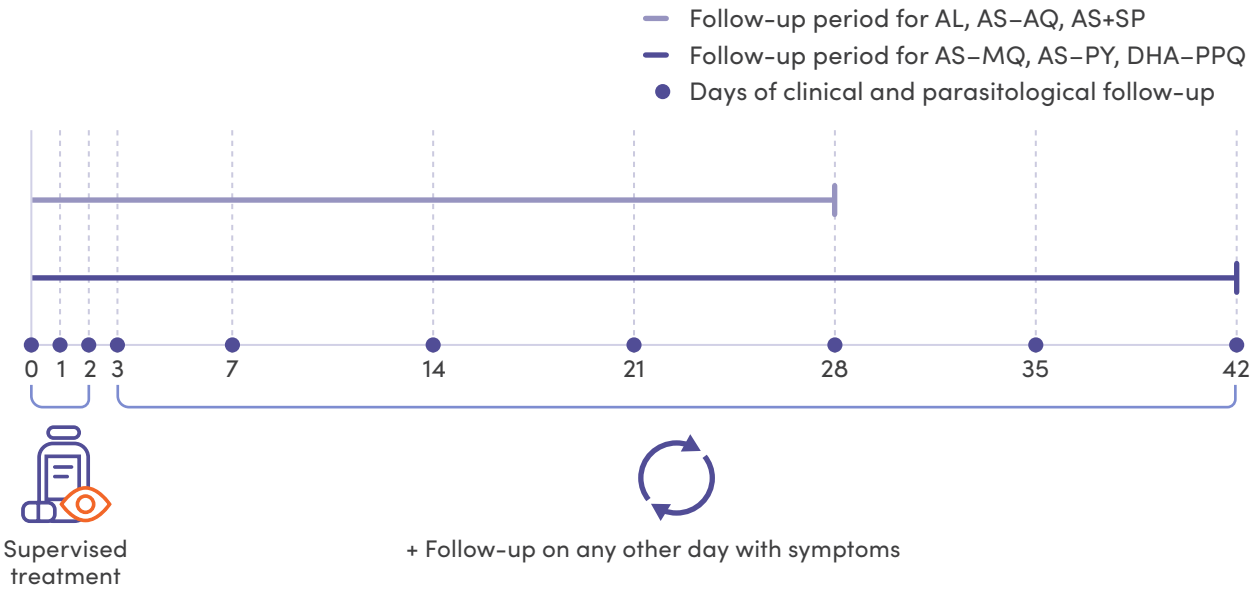
4.2 Therapeutic efficacy studies

TES are prospective evaluations of patients' clinical and parasitological responses to treatment for uncomplicated malaria. Studies conducted according to the WHO methodology *(50)*, repeatedly at the same sites and at regular intervals, allow early detection of changes in treatment efficacy and comparison of results within and across regions over time.

In TES for *P. falciparum*, clinical and parasitological responses to treatment are evaluated on days 0, 1, 2, 3, 7, 14, 21 and 28, and on days 35 and 42 for some artemisinin-based combination therapies (ACTs). Therapeutic outcomes are assessed on the final day of the study (i.e. on day 28 or day 42). It is recommended that ACTs with a partner drug with a relative short elimination half-life should be followed up for at least 28 days, and ACTs with partner drugs with longer elimination half-lives should be followed up for at least 42 days (**Fig. 16**).

[1] Where there are enough cases, the protocol can also be adapted to other species as needed.

Fig. 16. TES for *P. falciparum*



AL: artemether–lumefantrine; AS–AQ: artesunate–amodiaquine; AS–MQ: artesunate–mefloquine; AS–PY: artesunate–pyronaridine; AS+SP: artesunate + sulfadoxine–pyrimethamine; DHA–PPQ: dihydroartemisinin–piperaquine

Radical cure of patients with acute *P. vivax* or *P. ovale* infections requires effective treatment of both the asexual parasite stages in the blood that are responsible for patency, and the dormant liver stages (hypnozoites) that are responsible for latent infection and subsequent clinical attacks in the weeks and months that follow. Routine TES for *P. vivax* aim to estimate the efficacy of the treatment of the blood-stage parasites only *(51)*.

Resistance to antimalarial drugs (except for partial resistance to artemisinins) is defined by WHO as the ability of a parasite strain to survive or multiply (or both) despite administration and absorption of a drug given in doses equal to or higher than those usually recommended but within the tolerance of the patient. Treatment failure is defined as the inability to clear malarial parasitaemia or prevent recrudescence after administration of a therapeutic regimen of a recommended antimalarial drug regardless of whether clinical symptoms are resolved. Drug resistance is only one of several factors that may cause treatment failure. Although a TES can help to predict the likelihood of resistance to an antimalarial drug, confirmation and characterization of parasite resistance require additional tools (e.g. in vitro or ex vivo tests, analysis of molecular markers and measurement of drug concentrations in the blood).

4.2.1 Protocols in different transmission settings

The standard TES protocol and the inclusion criteria can be adapted to the transmission level to ensure a minimum sample size for a sentinel site (**Table 5**).

Table 5. Inclusion criteria for *P. falciparum* TES in different transmission settings

Transmission level	Standard inclusion criteria
High	Patients with fever, aged 6–59 months and 2000–200 000 asexual parasites/µL
Transmission level	**Standard inclusion criteria**
Moderate	Patients with fever or a history of fever, children ≤ 12 years and 1000–100 000 asexual parasites/µL.
Low	Patients with fever or a history of fever, all age groups and ≥ 250 or 500 asexual parasites/µL
Very low	Patients with fever or a history of fever, all age groups and any level of parasitaemia

4.2.2 Sentinel sites

TES are conducted at sentinel sites, which are carefully selected based on the required number of malaria cases, adequacy of facilities and qualifications of staff. The minimal requirements for establishing a sentinel site are: trained, motivated clinical personnel and microscopists, a laboratory equipped for blood film examination, and knowledge of the level of transmission intensity, as all these factors influence the inclusion criteria. The sentinel site may be in a community or a health facility at district or provincial level.

Patients attending hospitals may have more complex clinical presentations, be more likely to have had previous drug failure and be more difficult to follow up. Thus, whenever possible, monitoring should be done in or close to the community.

Sentinel sites should represent all the epidemiological strata in the country. Preferably, a site should have access to the required sample size. If this is not possible, the required sample size can be obtained by combining data from single-arm studies conducted in several sites in a geographical unit. Thus, what constitutes a sentinel site depends on the transmission setting. It may be:

- a single health facility (health centre, hospital) or temporarily established facility in a community (typically in high-transmission settings);
- a group of health facilities (health centres, hospitals) in the same town or city (typically in high- or moderate-transmission settings);
- a group of health facilities (health centres, hospitals) in the same district (typically in low- to moderate-transmission settings);
- a group of health facilities (health centres, hospitals) in several districts in the same province (typically in low-transmission settings); or
- cross-border health facilities (health centres, hospitals) in two neighbouring countries (rare).

Repeated TES at a few sites are adequate for collecting consistent longitudinal data, documenting trends and informing the national treatment policy. WHO recommends that a TES be performed at each sentinel site at least once every 2 years.

4.2.3 Classification of responses to treatment

In areas with high, moderate or low transmission, genotyping by PCR is required to distinguish between recrudescence (of the same parasite strain) and reinfection (with a different parasite strain). For any patient with parasitaemia on or after day 7, the genotypic profiles of the parasites (on day 0 and the day of parasite recurrence) must be compared and the patient classified according to the PCR findings.

In TES, treatment responses are classified as shown in Table 6.

Table 6. Classification of responses to treatment

Early treatment failure
• Danger signs or severe malaria on day 1, 2 or 3 in the presence of parasitaemia • Higher parasitaemia on day 2 than on day 0, irrespective of axillary temperature • Parasitaemia on day 3 with axillary temperature ≥ 37.5 °C • Parasitaemia on day 3 ≥ 25% of count on day 0
Late clinical failure
• Danger signs or severe malaria in the presence of parasitaemia on any day between 4 and 28 (or day 42) in patients who did not previously meet any of the criteria of early treatment failure • Presence of parasitaemia on any day between 4 and 28 (or day 42) with axillary temperature ≥ 37.5 °C in patients who did not previously meet any of the criteria of early treatment failure
Late parasitological failure
• Presence of parasitaemia on any day between 7 and 28 (or day 42) with axillary temperature < 37.5 °C in patients who did not previously meet any of the criteria of early treatment failure or late clinical failure
Adequate clinical and parasitological response
• Absence of parasitaemia on day 28 (or day 42), irrespective of axillary temperature, in patients who did not previously meet any of the criteria of early treatment failure, late clinical failure or late parasitological failure

4.2.4 Use of TES results for changing treatment policy

The results of TES are used to inform the NMP's national treatment policy. The key outcome indicators of TES are the proportion of patients who are parasitaemic on day 3 (currently used as a warning signal for identifying suspected partial artemisinin resistance in *P. falciparum*) and the proportion of patients with treatment failure by day 28 or day 42. To ensure the efficacy of the malaria treatment selected for national policy, WHO recommends a change in the national malaria treatment policy if the total treatment failure rate is ≥ 10% (as assessed by TES) and that the NMP adopts antimalarial medicines with a parasitological cure rate of > 95%.

4.2.5 Budgeting for TES

To ensure that a country conducting TES has sufficient resources, the following should be budgeted: human resources, travel and transport, equipment and supplies, patient costs, technical assistance, supervision, a quality assurance system, data management, and laboratory support for genotyping. A facility may need to accommodate and ensure complete observed treatment during the first 3 days for all enrolled patients. In addition, provision should be made for training, monitoring to improve the quality of clinical procedures, and data collection, management, validation and reporting, which is usually provided by a consultant over 2–3 weeks. There must be strict adherence to the study protocol to ensure data quality. When drug efficacy monitoring is fully integrated into surveillance activities, the funding, including for recommended activities such as analysis of molecular markers, should be part of the overall surveillance budget. Sufficient funding and human resources must be allocated to both the collection and analysis of data and supervision of the overall system.

4.3 Molecular markers of resistance to antimalarial drugs

Drug resistance is one of the causes of treatment failure, and characterization of the molecular markers of drug resistance is an important means of understanding resistance to antimalarial treatment. Once genetic changes associated with resistance are identified, drug resistance can be confirmed and monitored with molecular techniques. A limited number of genes involved or potentially involved in the resistance of *P. falciparum* to antimalarial drugs have been identified. Mutations in *P. falciparum* chloroquine resistance transporter (*Pfcrt*) confer resistance to chloroquine and piperaquine. Mutations in *P. falciparum* dihydrofolate reductase (*Pfdhfr*) confer resistance to pyrimethamine and proguanil. Mutations in *P. falciparum* dihydropteroate synthase (*Pfdhps*) confer resistance to sulfadoxine. Mutations in cytochrome b confer resistance to atovaquone. Increased copy numbers of *P. falciparum* multidrug resistance 1 protein (*Pfmdr1*), and of *P. falciparum* plasmepsin 2–3 (*Pfpm2–3*) have been associated with *P. falciparum* resistance to mefloquine and piperaquine, respectively. Resistance of *P. falciparum* to artemisinins is associated with point mutations in the propeller region of the *PfKelch13* gene (**Table 7**).

Table 7. Molecular markers for resistance to antimalarial drugs

Chemical family	Drug	Molecular marker
4-Aminoquinolines	Chloroquine	*Pfcrt* SNPs
	Amodiaquine	Molecular marker yet to be validated. Some studies show that amodiaquine selects for *Pfmdr1* (86Y).
	Piperaquine	*Pfpm2–3* increased copy number *Pfcrt* SNPs
Antifolates	Pyrimethamine	*Pfdhfr* SNPs
	Sulfadoxine	*Pfdhps* SNPs
	Proguanil	*Pfdhfr* SNPs
Amino alcohols	Lumefantrine	Molecular marker yet to be validated. Some studies show that lumefantrine selects for *Pfmdr1* (N86).
	Mefloquine	*Pfmdr1* increased copy number
	Quinine	Molecular marker yet to be validated
Mannich base	Pyronaridine	Molecular marker yet to be validated
Naphthoquinone	Atovaquone	*Pfcytb* SNPs
Sesquiterpene lactones	Artemisinin and artemisinin derivates	*PfK13* SNPs

SNP: single nucleotide polymorphism

4.4 Monitoring the efficacy of antimalarial drugs in settings with very low transmission

In areas of very low transmission, it may be impossible to accrue the number of patients required for a TES. If the country has strengthened its surveillance systems for eliminating malaria, surveillance of drug efficacy can be integrated into the routine surveillance system. In some countries with very low transmission, however, the surveillance systems are not yet sufficiently strong for this to be feasible.

4.4.1 Settings without strong surveillance systems

If countries have too few cases for a TES even after the inclusion criteria have been adjusted and data combined from different sites, information on molecular markers of drug resistance can be used to monitor trends. To do this, countries should systematically collect dried blood spots on filter papers for analysis of the known and validated molecular markers (see Table 7). The aim should be to collect data annually and from a sample large enough to obtain significant results.

While molecular markers can be used to monitor trends, clinical data will nevertheless be needed to inform treatment policies. If the molecular analysis shows significant increases in markers of drug resistance for the recommended treatment, all efforts must be made to collect high-quality information on patient treatment outcomes rapidly for a possible change in policy.

4.4.2 Integrated drug efficacy monitoring in areas with strong surveillance systems

Areas pursuing malaria elimination are expected to have a strong surveillance system (**Section 3**). In these areas, monitoring of drug efficacy can be integrated into the routine surveillance system by ensuring that the data collected on all malaria cases in the routine surveillance system can be and are used to generate information about drug efficacy. For this purpose, the surveillance system is expected to have the capacity for:

- good case detection;
- reporting on all cases of malaria, whether detected in the public or the private system;
- ensuring that all patients receive the full recommended treatment (including for radical cure) under supervision; and
- following up patients to confirm complete cure.

In TES, data are collected only on symptomatic cases (with fever or a history of fever). In integrated drug efficacy surveillance, data are collected on all cases, including asymptomatic cases and all species detected by PCD or ACD and subsequently reported to the surveillance system.

The roles of the private sector and community services such as village health workers in detecting cases, providing treatment and following up patients differ by country. In all countries, however, the NMP should be responsible for compiling and analysing data. A good diagnostic quality assurance system, covering all sectors involved in diagnosis, must be in place to generate reliable data. To ensure prompt, appropriate treatment of patients, and thereby support progress towards elimination, the treatment policy must be up to date and both first- and second-line treatments must be available in all facilities providing diagnosis and treatment.

The activities and information required for integrated surveillance of drug efficacy are:

- patient classification and diagnosis
- molecular analysis
- treatment
- patient follow-up
- information on efficacy of first- and second-line treatments
- classification of responses to treatment
- data interpretation and policy considerations
- budgeting for monitoring antimalarial efficacy.

Budgeting was described in **Section 4.2**. The others are described below.

The procedures and the amount of data collated in integrated drug efficacy surveillance depend on the system in place and the resources available. The minimum data that must be collected for analysing drug efficacy are data on all patients collected on the first day of treatment (day 0) and on the specified last day of follow-up. The data to be collected include characterization of the case, such as parasite species, the treatment provided, whether the patient was symptomatic, whether the case was detected by PCD or ACD, whether treatment was supervised and the treatment outcome. The case should also be classified as indigenous, imported, introduced, induced, relapsing or recrudescent. Further details on case characterization are given in the *WHO framework for malaria elimination (5)* (see also **Section 3** and **Table 8**).

The text below and **Table 8** describe the mandatory and additional information suggested for collection in routine surveillance systems for analysis of drug efficacy. It is expected that the mandatory information will already have been collected in elimination settings with strong routine surveillance systems. When possible, the countries should collect all the information suggested below, as more data result in better information to guide policies.

Patient classification and diagnosis

As part of routine surveillance in elimination settings, a detailed case investigation and recording of probable origin are required to classify cases as indigenous, imported, introduced, induced, relapsing or recrudescent. All suspected malaria cases are diagnosed (with species identification) by an RDT and/or microscopy on day 0; microscopy is mandatory for detecting recurrent parasitaemia during follow-up and on the last day of follow-up.

Molecular analysis

Genotyping to distinguish between reinfection and recrudescence is not mandatory – the risk that treated individuals will experience recurrent parasitaemia due to a new infection is very low because of the small number of malaria cases in elimination settings. For this reason, all cases of recurrent parasitaemia will be considered by default true recrudescence (true treatment failure) if treatment is supervised. However, an additional blood sample can be collected on filter paper on day 0 and on the day of parasite recurrence. Blood samples can also be used to confirm parasite species, assess known molecular markers of antimalarial drug resistance and facilitate identification of the geographical origin of parasites.

Treatment

All efforts must be made to supervise all treatment, including primaquine for patients with *P. vivax* infection. It must be recorded whether all doses of the treatment given were supervised. *P. vivax*-infected patients should be tested for glucose-6-phosphate dehydrogenase (G6PD) status. Patients with treatment failure (recurrence of parasitaemia with the same species during the follow-up period; for classification of failure, see **Table 5**) should be given supervised second-line treatment and followed up again until cure is achieved. Hospitalization of patients during treatment is suggested if feasible.

Patient follow-up

All treated malaria patients should be followed up to the last day of the follow-up period appropriate for the parasite species and the treatment administered. Specifically, the follow-up period for patients infected with *P. falciparum* is 28 days for drugs with a short half-life (artesunate + sulfadoxine–pyrimethamine, artemether–lumefantrine, artesunate–amodiaquine) and 42 days for drugs with a long half-life (artesunate–mefloquine, dihydroartemisinin–piperaquine and artesunate–pyronaridine). The follow-up period for individuals infected with *P. vivax* is 28 days for asexual stages and 3 or 8 months for relapses. If human and financial resources allow, the follow-up period for cases of *P. falciparum* infection can be extended to 42 days after administration of a treatment with a short half-life or 56 days after treatment with a drug with a long half-life. In some settings, *P. vivax* patients should be followed up for 1 year.

At a minimum, all infected individuals should receive a clinical consultation and parasitological evaluation on day 0 and on the last day of follow-up (i.e. day 28, day 42 or the day of treatment failure). If fever or symptoms develop at any time during the follow-up period, the patients should undergo parasitological and clinical evaluation. Any consultations, including those that are unscheduled, should be documented. If an infected individual does not attend the mandatory consultation on the final day, intensive efforts must be made to locate them. If feasible, additional follow-up on day 3 and then weekly on days 7, 14, 21, 28, 35 and 42 for patients with *P. falciparum* infection is suggested. Similarly, weekly follow-up on days 7, 14, 21 and 28 and then monthly is suggested for patients with *P. vivax* (or *P. ovale*) infection.

Table 8. Mandatory and additional activities for integrated surveillance of drug efficacy

Activity	Mandatory	Additional
Patient classification and diagnosis		
Patient classification	Classification of case as indigenous, imported, introduced, induced, relapsing or recrudescent Detailed case investigation and recording of likely origin of malaria	
Diagnosis on day 0	Identification of symptoms (uncomplicated, severe) Species identification by RDT and/or microscopy	Parasitaemia by microscopy Gametocytaemia by microscopy PCR
Diagnosis on any additional day of follow-up		Microscopy
Diagnosis on the last day of follow-up	Microscopy	PCR
G6PD	G6PD testing for *P. vivax* patients.	

Activity	Mandatory	Additional
Molecular analysis		
Markers of reinfection or recrudescence		Blood collected on day 0 and day of failure for analysis of markers of reinfection or recrudescence
Markers of drug resistance		Blood collected on day 0 for analysis of markers of drug resistance
Identification of origin		Blood collected on day 0 for genetic analysis to facilitate identification of geographical origin of parasites
Treatment		
Supervision of treatment	Ensure that all treatments are given under direct supervision, including treatment with primaquine for patients with *P. vivax* malaria.	Hospitalization of patients during treatment
Treatment failure	All cases of treatment failure must receive second-line treatment (supervised) and be followed up for an additional full follow-up period	Hospitalization of patients during treatment
Patient follow-up		
Follow-up period: *P. falciparum*	End date 28 days after start of treatment with a drug with a short half-life or 42 days after start of treatment with a drug with a long half-life	42 days after start of treatment with a drug with a short half-life; 56 days after start of treatment with a drug with a long half-life
Follow-up period: other species	End date 28 days and 3 months (for relapses) for *P. vivax*[a] and *P. ovale* Due to limited evidence, follow-up recommended until day 28 for *P. malariae* and 42 days for *P. knowlesi*	Up to 1 year for *P. vivax*
Days of patient follow-up	End date defined as: • final day of follow-up (see above) if cured, or • any day on which the patient presents with recurrent parasitaemia with or without symptoms after treatment (additional full follow-up period required after second-line treatment)	Additional follow-up on day 3 and then weekly on days 7, 14, 21, 28, 35 and 42 (49, 56) for *P. falciparum* and days 7, 14, 21 and 28 and monthly for *P. vivax* and *P. ovale*
Information collected on days of follow-up	Clinical symptoms, temperature, presence of parasitaemia at day 0, end day or any day of recurrent parasitaemia	Clinical symptoms, temperature, asexual and sexual parasitaemia (by microscopy) at follow-up visits. Alternatively, clinical symptoms only may be collected by telephone and additional follow-up visits made if deemed necessary.

G6PD: glucose-6-phosphate dehydrogenase; PCR: polymerase chain reaction; RDT: rapid diagnostic test.

[a] Due to regional differences in *P. vivax* relapses, the recommended minimum follow-up period is 8 months for Northeast Asia, South Asia and Central America, and 3 months for all other areas. The recommended ideal follow-up period for all areas is 12 months.

Information on efficacy of first- and second-line treatments

The objective of TES is to monitor the efficacy of first- and second-line treatments and, if required, that of any newly registered treatment for which information is necessary for a possible policy change. The main objective of integrated surveillance of drug efficacy, including supervision of treatment and patient follow-up, is to ensure patient cure and progress towards elimination. Information on drug efficacy is collected primarily for the first-line treatment given to patients as per the national treatment guidelines; a secondary objective is to inform treatment policy. Data on the efficacy of second-line treatment are collected only for patients with recrudescent infections after first-line treatment.

Classification of responses to treatment

As mentioned above, genotyping to distinguish between reinfection and recrudescence is not mandatory. When genotyping is not available, recurrent parasitaemia in all patients who received the mandatory supervised treatment is considered to be true recrudescence (true treatment failure). If information is available on genotype, the data should be PCR-corrected. If the treatment was not supervised, recurrent parasitaemia cannot be considered a true treatment failure, but it is important that all efforts are made to supervise subsequent treatment and register the outcome. When all the recommended data have been collected, each patient can be classified as per **Table 6** with the following limitations.

- The classification shown in **Table 6** can be used for infections with *P. falciparum* and for the first 28 days' follow-up for *P. vivax* only.
- Any recurrent *P. vivax* parasitaemia in the follow-up period after day 28 must be classified as a relapse.
- Early treatment failure can often not be classified in integrated surveillance, as the data will not be available.
- The category of early treatment failure cannot be used for patients with severe malaria diagnosed on day 0.

Data interpretation and policy considerations

Data must be analysed continually, especially for patients with treatment failure and for programmatic issues, including the number of patients lost to follow-up and whether second-line treatment was given to patients with treatment failure as per the national treatment policy. In addition to continual analysis, a fixed time should be set to review and discuss all data (e.g. an annual evaluation meeting), at which time data can be shared and discussed with WHO. The *WHO guidelines for malaria (34)* recommend that first-line treatment be changed if the total failure rate exceeds 10%; however, efficacy and failure rates should be considered in the context of their confidence intervals. Policy decisions can be informed by additional information, including on molecular markers, especially in very low transmission settings where there may be too few patients to obtain the desired level of precision (5%) and a confidence interval of 95%. In elimination settings, any treatment failure must be investigated, as this represents a potential source of further spread of malaria.

Thailand's integrated drug efficacy surveillance integrates routine malaria case management and follow-up data to monitor drug efficacy and guide policy decisions *(52)*. In 2019, it identified high failure rates of dihydroartemisinin–piperaquine (DHA–PPQ), prompting a policy shift to adopt artesunate–pyronaridine– (AS–PY) as the first-line treatment in affected areas *(53)*. While the system enables timely responses to emerging resistance trends, rising malaria cases continue to challenge its capacity in high-burden and remote regions *(54)*.

4.5 Monitoring chemoprevention efficacy

Chemoprevention is the use of medicines, either alone or in combination, to prevent malaria infection and its consequences. It requires giving a full treatment course of an antimalarial medicine, often at predefined intervals to individuals who have not been diagnosed with malaria. By providing antimalarial medicine to vulnerable populations, existing undiagnosed malaria infections are treated, and the medicine provides a period of protection against new infections.

Chemoprevention strategies currently recommended by WHO include IPTp, perennial malaria chemoprevention (PMC), seasonal malaria chemoprevention (SMC), intermittent preventive treatment of malaria in school-aged children (IPTsc) and post-discharge malaria chemoprevention (PDMC). Information on the efficacy of the medicines as used in these malaria chemoprevention strategies is critical for ensuring that the strategies remain effective in different settings with different levels of drug resistance. Information on treatment efficacy cannot be used as a surrogate for chemoprevention efficacy. Molecular markers of drug resistance are a useful but imperfect tool for predicting the efficacy of chemoprevention strategies.

WHO has published the malaria chemoprevention efficacy study protocol for monitoring the protective efficacy of antimalarial medicines used for chemoprevention indication *(49)*. Chemoprevention efficacy studies aim to evaluate the ability of antimalarial medicines to clear parasitaemia among asymptomatic individuals and prevent parasitaemia for a predefined period of follow-up. Parasitaemia detected during the follow-up period can be caused either by the failure to clear an infection present at the time of enrolment or by the failure to prevent a new infection.

Chemoprevention efficacy studies are intended to be routine studies of the efficacy of medicines used for malaria chemoprevention; their purpose is not to evaluate long-term outcomes for the treated individuals. However, studies that link efficacy and longer-term outcomes could help to inform policy-makers about the likely public health impact of chemoprevention strategies and establish relationships between chemoprevention efficacy and specific outcomes.

Drug resistance is only one of several factors that may reduce chemoprevention efficacy. Other factors include incorrect dosage, poor patient adherence, poor drug quality, drug interactions, poor absorption, rapid elimination (e.g. diarrhoea or vomiting) or poor metabolism of prodrugs. Some of these factors can be ruled out in an efficacy study when drug administration is supervised, and the origin and quality of the drugs are verified. The outcome of the study is influenced by a combination of factors, including those related to the human (e.g. immunity) and parasite (e.g. drug resistance); individual variation leading to differences in the availability of the drug (e.g. pharmacokinetics); and the intensity of malaria transmission.

5. Entomological surveillance and vector control monitoring and evaluation

5.1 Introduction

Globally, vector control has contributed significantly to reducing malaria morbidity and mortality. It remains a critical component of malaria programmes working towards short- and long-term control and elimination targets.

While ITNs, IRS and LSM have been the most widely deployed malaria vector control interventions, others are available or under development. Entomological surveillance and vector control monitoring are critical to guide decision-making for deployment of all interventions.

Entomological surveillance in the context of malaria can be defined as the regular and systematic collection, analysis, interpretation and use of data on mosquito vectors to inform decision-making and action. These data are essential to understand the vector species present and their respective distributions and densities, behavioural characteristics, transmission dynamics, and insecticide resistance profiles, and how these may change in response to interventions. Such data therefore underpin vector control planning and implementation, including selection of specific interventions.

Vector control monitoring is similarly defined as the regular and systematic collection, analysis, interpretation and use of data related to vector control interventions and their implementation to inform decision-making and action. This includes monitoring of:

- product quality prior to deployment (e.g. assessment of quality against established standards for the intervention class);
- baseline situation (e.g. coverage of existing interventions such as ITN access and usage);
- implementation quality (e.g. coverage and other operational indicators); and
- product performance after deployment (e.g. durability of ITNs or residual activity of IRS or larvicide products).

Entomological surveillance and vector control monitoring activities will evolve as vector control tools technologies, approaches and strategies expand.

The evaluation of systematically gathered data on vectors and interventions along with epidemiological data can provide insights into the effectiveness of programme activities and underlying causes of their impact (or lack of impact) on malaria transmission or burden. Data collection should be designed to inform vector control decision-making. Indicators that provide this information are discussed in Section 5.2.3.

The main objective of entomological surveillance and vector control monitoring in NMPs is to help understand the drivers of malaria transmission and monitor the impact of control tools on vector or disease dynamics. Specifically, entomological surveillance and vector control monitoring enable NMPs to decide:

- **Which vector control interventions to use.** Entomological surveillance identifies the major vector species and their bionomics, role in transmission or risk of re-establishment of transmission, and insecticide resistance profile. Vector control monitoring assesses interventions already in use to understand their contribution to controlling malaria and their durability or residual effect under operational conditions.

- **When to use vector control interventions.** Knowing which vector species are present, their relative densities and how they vary due to seasonal and other environmental changes, and in response to effective interventions is critical to guide optimal timing of vector control implementation. Additional factors may also guide timing, such as availability of commodities, logistic considerations (e.g. accessibility of households), the occurrence of emergencies or disasters, or human population movement.
- **Where to use vector control interventions.** Geographical variations in the vector species present, as well as population variations in bionomics, behaviour or resistance profiles, may necessitate a different response in different parts of a country. Human risk factors or behaviours such as acceptance and use of vector control interventions may also vary between regions and mean that specific interventions may be more or less suitable in certain areas. It is essential to gather information that informs locally appropriate vector control.

These basic questions of which, when and where are an important foundation upon which to design entomological surveillance and vector control monitoring activities that will provide data that will improve decision-making and enable optimal planning and implementation. Particular circumstances will give rise to other and more specific questions and programmes should stipulate these when designing surveillance and monitoring activities. Box 11 lists some example questions.

Box 11. Example questions to be addressed through surveillance and monitoring

- Which interventions are currently in use, where and at what level of coverage?
- What is the current susceptibility profile of local vectors to insecticides included in interventions in use or considered for use?
- What is the durability of ITNs?
- What is the residual efficacy of IRS and larvicides?
- What are the gaps in protection of current interventions (e.g. outdoor vector biting) and what new interventions can potentially address those gaps?
- Why is transmission persisting in areas despite existing interventions?
- How does human behaviour affect acceptance and usage of interventions, exposure to vector biting, and consequently influence transmission?

No single activity can address all the questions facing malaria programmes. Design of entomological surveillance and vector control monitoring strategies must prioritize and take into consideration the most important questions to optimize the impact of interventions.

Entomological surveillance and vector control monitoring are iterative processes that can support better decision-making and improved implementation of vector control, in line with *Global vector control response 2017–2030 (55)*.

5.2 Entomological surveillance

Entomological surveillance can include preliminary or baseline surveys, routine sentinel surveys for observation of trends, spot checks for supplementary data collection, and focus investigations in elimination settings or in response to outbreaks (Box 12).

The NMP should direct entomological surveillance to ensure the aims align with national strategic plan objectives. The surveillance approach used in a country will depend on past and present malaria epidemiology, among other factors. The surveillance and monitoring strategy should therefore be appraised periodically and revised if necessary to enable adaptation and ensure cost–effective use of resources.

Careful consideration of surveillance protocols – including sentinel site locations, frequency of surveys and indicators – is essential and ideally will enable linkage of entomological, epidemiological and intervention information. Sufficient data must be collected to answer specific questions, which may require trade-offs where resources are limited. For instance, fewer sentinel sites may be selected to allow for more frequent data collection or measurement of a larger set of indicators. The focus should be on generating quality and informative data, rather than a large volume of data that are not necessarily useful to guide vector control.

Collaboration between the NMP and partners, such as research institutions or central and regional laboratories, may be required to ensure sufficient technical and programmatic support for surveillance and monitoring.

Box 12. Types of surveys for vector control

Preliminary or baseline surveys

Initial, time-limited surveys are used to gather baseline data for planning vector control measures, particularly in areas where recent historical entomological data are not available. They provide information on the vector species present, their resting and feeding habits, changes in species composition by season, types of water bodies used as larval habitats, and vector susceptibility to insecticides. Data from these types of surveys can be used to identify appropriate sentinel surveillance sites and to inform national and subnational stratification.

Routine sentinel surveys

Long-term observations are made regularly, such as monthly, quarterly or annually, in fixed locations. Their purpose is to identify changes in vector species density and composition, behaviour, insecticide resistance profiles and even infection rates, which may provide information to help explain observed epidemiological trends in malaria transmission, and ultimately to indicate the appropriate response. The sample size, frequency of collection and methods used should be appropriate to answer the programme's specific questions. The strength of a sentinel site is that it can provide long-term data and build and maintain local staff capacity.

Spot checks

Ad hoc assessments are carried out in selected locations to answer a key programme question or inform programme adjustment or response. Spot checks may include investigations in areas where: there are suspected problems in the quality of implementation of an intervention; there is reason to suspect a reintroduction or proliferation of a vector species as a result of environmental changes; vulnerable populations are present (e.g. because of displacement, resettlement or migration); or sentinel surveys are not conducted.

Focus investigations

Focus investigations are undertaken in areas of active, residual non-active, or cleared foci of malaria transmission to determine drivers of local transmission. They are short-term, reactive epidemiological investigations in settings of elimination or prevention of re-establishment. The trigger for a focus investigation could be an increase in the prevalence of parasite infections or clinical malaria cases. Where capacity exists, these focus investigations should include entomological surveillance and vector control monitoring.

5.2.1 Selection of surveillance sites

Sites for entomological monitoring should be chosen based on the data necessary for answering the programme's specific questions. Vector control monitoring activities may be coupled with entomological surveillance, and the approach taken should enable interpretation alongside epidemiological surveillance data.

Preliminary or baseline surveys, spot checks and focus investigations

The selection of sites for preliminary or baseline surveys, spot checks and focus investigations will depend on the rationale for the surveillance. Preliminary or baseline surveys are, by their nature, targeted to areas without previous or recent monitoring. Spot check locations will normally be determined by questions about transmission or vector control intervention performance in a specific area, such as where there is anecdotal evidence of mosquitoes resting on ITNs or of transmission occurring outside the home. Site selection may be guided by the epidemiological situation or logistic factors such as accessibility. Focus investigations will usually be targeted at the location where an increase in cases or another noteworthy transmission change was observed, or in active or persistent foci in low-transmission settings.

Routine sentinel surveys

The selection of routine sentinel survey sites is more complex. Locations of sentinel sites may be chosen to represent the range of eco-epidemiological settings in a country, including ecological zones with different malaria vector species and epidemiological regions or zones with different levels of malaria transmission (see **Section 7.4**) *(56, 57)*. Previous guidance has estimated how many sentinel sites are necessary by using human population data or administrative boundaries. However, as noted above, the collection of data should depend on the specific information needed to guide decision-making.

Sentinel surveillance should be conducted on a regular basis and may be guided by national and subnational stratification of malaria risk. The aim of routine sentinel

surveys is to produce data through repeated sampling at specific sites over the longer term to support NMP decision-making. Therefore, sentinel sites should be carefully selected. The location of sites might have to be changed on the basis of epidemiological, entomological and environmental data, using adaptive sampling approaches *(58)* but any relocation of sites should be undertaken cautiously and only if this will support the ultimate purpose of identifying trends relevant to malaria transmission. In areas where transmission has ceased because of effective control, sentinel surveillance can be used to reassess the receptivity of the area.

Staff based at sentinel sites may perform other tasks beyond entomological surveillance and vector control monitoring, depending on the needs of the programme, and their activities should be planned accordingly.

Practical considerations

Depending on the questions being addressed, other characteristics to consider when selecting entomological surveillance sites are summarized in Table 9.

Table 9. Considerations when selecting entomological surveillance sites

Consideration	Relevance to surveillance site selection
Known vector distribution	Where malaria vector species differ across geographical areas, select sites that include principal vector species.
Malaria interventions in use or planned for use	Select sites that represent current or planned intervention types or mixes (e.g. ITNs, IRS, LSM, chemoprevention, vaccine administration).
Agricultural use of pesticides	Include sites in epidemiologically relevant areas where there has been heavy use of agricultural pesticide that may affect malaria vector resistance to public health insecticides in use or planned for use.
Different levels of transmission or receptivity	Select sites in areas that represent the range of transmission levels or align with the stratification plan (or in elimination settings, different levels of receptivity). Historical malaria transmission, such as that prior to interventions, should be considered.
Locations with high risk of importation	Include sites in locations with high risk of importation of cases or vectors (including invasive species), such as ports, border posts or resting stops along major transport routes.
Planned or ongoing major infrastructural developments or land use changes	Include sites in areas with anticipated changes in vector or transmission dynamics, such as where dams or major infrastructure are being constructed or there are major land use changes.[a]
Location and availability of resources, in health facilities and partner institutes	Select sites where sufficient trained personnel (entomologists, vector control technicians and mosquito collectors), facilities (insectaries, laboratories) and equipment (microscopes, test kits) are available or can be provided.
Accessibility for surveys and supply of equipment	Ensure selected sites are likely to be accessible to personnel and equipment during planned survey times, such as periods of high rainfall.

[a] Examples include deforestation and cultivation of natural swamps in the African highlands that resulted in conditions favourable to the survival of *An. gambiae*, deforestation in South America that led to increased populations of *An. darlingi* and *An. aquasalis* and reforestation in India and Southeast Asia that resulted in increases in the numbers of malaria cases due to *An. fluviatilis* and *An. dirus*.

5.2.2 Frequency of surveys

The frequency of vector sampling for measuring entomological indicators depends on the information required to answer the questions being posed, and the resources available. The length of the transmission season and other environmental conditions that influence entomological parameters and malaria transmission should be considered. For example, assessment of vector insecticide resistance is usually best done during the peak malaria season to obtain the necessary number of mosquitoes required for testing, whereas monthly sampling may be required to assess temporal trends in vector density. Further information on frequency by transmission setting is provided below.

5.2.3 Main entomological indicators

Along the continuum of transmission, NMPs should build a strong evidence base on key features of local malaria vectors, as defined by entomological surveillance indicators (**Table 10**; **Annex 19**). The priority and relevance of each indicator depends on the programmatic question(s), transmission setting, and current or planned vector control interventions. Some indicators may be considered to be the minimum essential data needed to support decision-making and action, while others may be useful but not essential. It is important to differentiate, especially in resource-constrained settings.

New or refined indicators and methods to measure them may be required as new vector control tools, technologies, approaches or strategies become available. (A prioritized research agenda for entomological surveillance may be useful to guide the development of these indicators as programmatic priorities change.)

The main entomological surveillance indicators used by NMPs can be categorized into six groups:

- adult vector composition (species occurrence, distribution, and density);
- adult vector behaviour (human blood index, animal blood index, human biting rate, biting time, biting location, resting location);
- vector resistance to insecticides (resistance status, intensity, and mechanisms for adults or larvae);
- immature vector aquatic habitats (habitat availability and occupancy, larval density);
- proxies for transmission (sporozoite rate, entomological inoculation rate, receptivity); and
- exposure risk, which incorporates vector biting behaviour and human behaviour (human-behaviour adjusted biting rate).

Other categories of indicators may be used for specific purposes, such as research evaluating the efficacy or effectiveness of vector control interventions, but are beyond the scope of this manual.

Collection of data on principal vector species should be prioritized with secondary vectors included when possible. Indicators are usually reported by individual vector species, but in some exceptional circumstances may be aggregated for multiple

species, such as where low numbers of vectors are collected or there is limited capacity for species identification. Receptivity aggregates vector data for an area and considers other local factors like climate and human susceptibility.

Table 10. Main entomological surveillance indicators used by NMPs

Indicator	Outputs	Use
Adult vector composition		
Vector occurrence	Geographical distribution of malaria vectors	Identifies vector species occurrence to guide targeted vector control. Detects invasive species.
Vector abundance (or density)	Number of adult female vectors collected per sampling method per unit time Aggregate for all collection methods may be reported.[a]	Identifies vector species and abundance to guide targeted vector control. Combined with infectivity data, it determines primary and secondary vectors. Assesses vector seasonality and geographical variability to optimize intervention timing and deployment. Measures vector control impact, detects invasive species and assesses site receptivity to malaria transmission.
Adult vector behaviour		
Human biting rate	Number of adult female vectors that attempt to feed or are freshly blood-fed, per person (or trap) per unit time	Assesses human exposure to vector populations. Determines vector biting times. Supports calculation of entomological inoculation rate.
Human blood index (host preference)	Proportion of blood-fed adult female *Anopheles* mosquitoes that feed on humans	Measures the extent of human (anthropophagy) and animal (zoophagy) feeding to identify main vector species and guide appropriate interventions. Assesses the effectiveness of human-targeted vector control and detects potential gaps.[b]
Resting location (indoor resting density)	Proportion of adult female vectors collected resting indoors (including in external structures sampled beyond houses)	Assesses endophily (indoor resting) and exophily (outdoor resting). Identifies appropriate interventions to target resting adults.
Vector insecticide resistance[c]		
Insecticide susceptibility frequency	Proportion of adult female mosquitoes that died or were incapacitated after exposure to an insecticide	Tracks insecticide susceptibility to guide selection for vector control interventions. Supports insecticide choice for IRS, ITN, insecticide resistance management plans.
Resistance intensity	Status of resistance of a vector species to an insecticide as having high-, moderate- or low-intensity resistance	Proxy of ability of mosquito populations to survive exposure to operational doses of insecticides. Informs selection of insecticidal and non-insecticidal interventions.
Resistance mechanism(s)	Mechanisms detected or not detected in adult female vectors. Usually test individuals from populations with confirmed resistance or that survive bioassays[d]	Detects mechanisms responsible for observed insecticide resistance. Guides selection of products likely to be effective against resistant populations.

Indicator	Outputs	Use
Immature vector aquatic habitats[e]		
Larval habitat positivity	Proportion of aquatic habitats sampled found to harbour immature Anopheles mosquitoes	Identifies target areas and optimal timing for larval source management. Tracks larval habitat preferences, assesses area receptivity and measures larval source management efficacy.
Larval density	Number of larvae collected or estimated, by individual habitat	Identify important habitats for control (key habitats). Identify most productive habitat types in an area to target for control.
Proxies for transmission[f]		
Sporozoite rate	Proportion of adult female vectors with sporozoites in their salivary glands	Incriminate vector species. Estimate the proportion of infectious mosquitoes in a population. Supports calculation of entomological inoculation rate (see below). Assess the impact of vector control interventions.
Entomological inoculation rate	Number of infective bites by adult female Anopheles mosquitoes received per person per unit of time	To measure malaria transmission intensity which helps to prioritize malaria control interventions (including and beyond vector control).
Receptivity[g]	Classification of areas according to transmission risk (through various methods)	Assesses the presence of competent *Anopheles* vectors, a suitable climate and a susceptible human population. Determines the relative risk of malaria transmission where transmission has been interrupted.

[a] The behavioural characteristics of vector species can bias the numbers collected by different sampling methods. Combination of the results obtained with a variety of sampling methods and comparison by relative abundance can mitigate some of the inherent bias.

[b] Outputs for this indicator are significantly affected by collection site and method.

[c] For further information, see the manual for monitoring insecticide resistance *(59)*.

[d] These can include molecular markers (e.g. kdr, ace-1R), enzyme profiles (e.g. mono-oxygenases, esterases, glutathione *S*-transferase), or other resistance mechanisms.

[e] Relevant for areas in which LSM is in use or being considered for use. Alternative or supplementary indicators may be needed depending on the life stage being targeted and the intervention type.

[f] Estimates of vector fecundity or longevity can be informative for specific purposes but are not usually captured during routine surveillance.

[g] For further information, see the meeting report of the WHO Evidence Review Group on the assessment of malariogenic potential to inform elimination strategies and plans to prevent re-establishment of malaria *(60)*.

Adult vector composition and behaviour

Various sampling techniques can be used to measure adult vector composition, the appropriateness of which depends on the density and behaviour of the vector species and on the inherent bias of each technique. For example, the human biting rate can be derived using different methods which can provide different yields for the same vector population; for example, human landing catches, human-baited traps, human odour-baited traps, CO_2-baited traps and Centers for Disease Control and Prevention (CDC) light traps with a conversion (see **Table 11**).

It is important to recognize the bias of each collection method towards vectors that exhibit certain behaviours or are in certain physiological states. For example, indoor human landing catches preferentially collect vectors that bite humans inside houses, and therefore should not be used to estimate the density of exophagic or zoophilic vectors. If the host preference of vectors is to be calculated, then careful attention must be paid to where and when the mosquitoes are collected, as this can strongly bias the results.

Species identification can often be challenging. Careful identification is important, with occasional molecular confirmation if possible. Surveillance that ensures early collection and correct identification of invasive vectors is critical for rapid implementation of mitigation measures to enable local elimination of the species (see Box 13).

Box 13. Threat of invasive species

Vigilant surveillance should be conducted in areas that are prone to or at high risk of invasive vector species, as malariogenic potential can increase as a result of the incursion of species with high vectorial capacity. Better surveillance tools are required for early detection of invasive vector species to ensure rapid response for containment or elimination before they become established in local environments or spread over wide areas. Priority locations include those at high risk of vector entry, such as major ports, railway stations and rest stops along transport routes linked to endemic countries.

Aggressive vector control, such as focal IRS and LSM to target adults and larval stages, will be required if invasive vectors are detected. In the early phase of mosquito colonization, invasive mosquitoes are often still limited to small foci (generally considered to be around 1 km^2). Countries should conduct entomological investigations in and around the colonized areas to identify options to eliminate the invasive mosquitoes.

Where invasive mosquitoes have become established and can no longer be eliminated, the emphasis should be on preventing disease outbreaks and geographical spread of the vectors. As there is only limited experience with the elimination of invasive mosquitoes, countries should carefully evaluate and document the activities undertaken and their impact, for the benefit of improving guidance and best practice in this area.

Vector resistance to insecticides

Monitoring of phenotypic resistance is essential and should be conducted across the continuum of malaria transmission *(59)*. The NMP should prepare a plan for monitoring and managing insecticide resistance that includes an outline of where, when and how resistance will be monitored *(61)*. Representative sites will be required, the number and location of which should be based on eco-epidemiological stratification, the distribution of important vectors, anticipated heterogeneity in resistance phenotypes, and the types of interventions and situations likely to promote resistance, such as intensive insecticide use in agriculture.

Tests for insecticide resistance should usually be conducted with adult malaria vectors, which are usually reared from gravid females or larvae collected from the field. However, tests may be conducted with larvae when larviciding with chemical or biological agents is implemented or planned. Where insecticide resistance has been confirmed, the intensity of resistance and the underlying resistance mechanisms should be determined *(59)*, as this knowledge can be valuable for making operational decisions, such as the choice of IRS formulations and their use in rotations, mosaics, combinations or mixtures for resistance management. Knowledge of resistance mechanisms is important for understanding cross-resistance, which can occur even between insecticide classes with different modes of action due to target-site, metabolic or cuticular mechanisms. Proper interpretation of data on insecticide resistance requires understanding of the biology and behavioural ecology of the local vector species responsible for transmission (including sibling species where *Anopheles* complexes occur).

Immature vector aquatic habitats

A number of indicators have been defined that are relevant only to surveillance in areas in which LSM is being considered or used. These include surveys of the presence of water bodies that may serve as *Anopheles* oviposition sites and the extent to which they support the development of *Anopheles* larvae and pupae.

Baseline surveys may be conducted to identify highly productive habitats or define key habitat types. Key types are those considered to harbour a high proportion of the immature vector population (based on relative immature productivity and habitat abundance) and therefore are expected to produce the majority of the adult population. (An exception to this is habitats in which ecological factors or interventions limit the development of immatures to adults.) Baseline surveys may also be used when the impact of an intervention (such as larviciding) is to be evaluated.

Surveys must consider vector seasonality, the length of the malaria transmission season, and the expected residual efficacy of any interventions. The frequency of immature sampling usually ranges from weekly to monthly *(62)*.

Proxies for transmission

Sporozoite rates and entomological inoculation rates are useful for estimating transmission intensity in settings where this information is lacking and for determining if interventions reduce transmission. Sporozoite rates are useful for assessing the relative contribution of a particular vector species to malaria transmission, if this has not been established previously. Sporozoite rates also indirectly indicate the age structure of the vector population and, in operational research, can supplement estimates of survivorship from parity rates or ovarian dilatation to monitor the impact of interventions on transmission. The entomological inoculation rate is a measure of the intensity of malaria parasite transmission, which is the number of infective bites received per person in a given unit of time. It is generally not possible to measure sporozoite rates or entomological inoculation rates with any precision when malaria transmission rates are very low, because of either low vector densities or low infection incidence rates.

Receptivity is one component of malariogenic potential, and a number of methods have been used to assess it. Further development of methods is required to ensure these are applicable and informative for programmatic use *(60)*.

Exposure risk

To appropriately target vector control interventions, it is important to understand when and where people are being exposed to mosquito bites. Data from observations of human behaviour integrated with data on mosquito bionomics from the same locations and times can elucidate exposure patterns that help to explain differences in malaria burden for certain demographics or groups (e.g. children, adult men and adult women; nomadic and settled populations). For instance, observational data on when and if people use ITNs can be considered with vector biting time and location data to help identify drivers of transmission, reveal gaps in protection in the context of currently deployed control tools, and guide selection of appropriate interventions. Human behaviours can be highly localized, and therefore may not be representative of broader populations. Further work is required to ascertain the use of exposure risk as a main indicator to guide vector control planning and implementation.

5.2.4 Priorities for entomological surveillance by transmission setting

The utility of survey types and indicators will differ by transmission setting. Transmission proxies that are informative in high-to-moderate transmission areas will be difficult to measure with accuracy in low-transmission settings. Where there are isolated foci of transmission, an adaptive design will be needed. In areas where transmission has been interrupted, ongoing surveillance to detect changes in receptivity or importation risk will be important.

Table 11 provides guidance for priority indicators in different malaria transmission settings and for current or planned interventions. **Table 11** and **Annex 16** include mosquito sampling methods and analytical techniques for each entomological indicator.

High-to-moderate transmission

In settings of high-to-moderate transmission, the density of vectors and the intensity of transmission should be sufficient for calculating many of the entomological indicators listed in **Table 11**. In these areas, routine entomological surveillance can be conducted at sentinel sites augmented by spot checks in areas with specific problems (as described in **Box 12**). For instance, if high-intensity insecticide resistance is confirmed at one sentinel site, additional spot checks can be conducted in neighbouring areas to determine the geographical extent of high resistance. Similarly, if changes in vector species composition or behaviour are observed at a sentinel site, spot checks in places where similar changes could be expected may be useful to guide selection and targeting of vector interventions.

Low and very low transmission

Periodic appraisal of information obtained, appropriate reprioritization of sites and indicators and adjustments to the frequency of sampling will be important in settings of low and very low transmission, particularly where there are limited resources. Sentinel sites should be located where there is ongoing transmission and – if resources allow – in areas with high receptivity. Surveillance might have to be intensified in the event of new, resurgent or persistent transmission, by adding sites, more frequent surveillance or measurement of additional indicators (**Table 11**). Geospatial modelling of historical epidemiological and entomological data as well as covariate remote sensing data can be a useful approach to inform adaptive sampling designs that are responsive to changing contexts. Spot checks will be required when routine surveillance does not provide adequate information or to obtain additional data on a specific situation or risk.

As transmission declines over large areas (e.g. because of effective control), it will become more focalized, and will be limited to small foci as elimination is approached. In these settings, in addition to routine entomological surveillance and spot checks, focus investigations that include entomological and vector control activities might be required. The main purpose of such investigations is to clarify the nature of transmission in the foci to guide the appropriate response to interrupt malaria transmission, such as modification of vector control to enhance its effectiveness.

Additional entomological investigations are justified where there is a possibility of local transmission (i.e. indigenous or introduced cases) in foci where transmission had been interrupted, or in foci where transmission had been reduced to a very low level but there is an upsurge and insufficient entomological data have been collected by routine surveillance or spot checks. A more comprehensive entomological investigation may be warranted if there is an increase in a particular *Plasmodium* parasite species, such as if a new case due to *P. falciparum* is detected where *P. vivax* was thought to be the only endemic malaria parasite species.

Findings from the entomological investigation should also inform the introduction of new interventions, as per the national strategy, to address gaps in protection that cannot be addressed by existing vector control.

Prevention of introduction or re-establishment of transmission

Malaria transmission may be a risk in areas in which there was previously transmission that was interrupted and in areas with no history of transmission, especially with a changing climate. Plans and practical approaches for preventing the introduction or re-establishment of malaria transmission should be developed on the basis of assessment of those risks, which are the combined effect of receptivity and importation risk (see **Section 7.4**).

In areas in which transmission has been interrupted, transmission foci may re-emerge due to factors such as delayed diagnosis and treatment in areas with poor vector control (e.g. low coverage, poor quality of implementation); changes in vector populations that render interventions less effective (e.g. avoidance behaviour, insecticide resistance); increased receptivity (e.g. increased vector density or survival

due to environmental changes); and introduction of infectious vectors or invasive species that are efficient vectors. Focus investigations are required to determine which of these potential factors is the cause of resurgence of transmission and, once identified, to design an appropriate response to re-interrupt transmission.

Past entomological data can be a good baseline of information; priority should be given to determining the occurrence of vector species, with past data used to infer vector behaviour. Routine entomological surveillance and/or spot checks should be used in areas of high receptivity and/or high importation risk; that is, where the risk of re-establishment is significant. Areas in which there are anticipated increases in risk due to human activities should be included, such as increased risk from population movement, land use, environment and weather conditions. These can increase the availability of suitable habitats for malaria vectors, contact between humans and vectors, or incursion of vectors.

In the event of locally acquired cases and insufficient entomological data, spot checks will be required, as outlined in **Box 12**).

Table 11. Routine entomological surveillance by priority in different malaria transmission settings, relevance by intervention, and appropriate vector sampling methods and analytical techniques

Key: • high priority; O moderate priority depending on situation; + relevant; – low priority or not relevant.

Indicator	Priority by transmission setting			Relevance by intervention type(s)				Preferred methods and techniques (see Annex 16)	
	High/ moderate	Low/ very low	Prevention of re-establishment	ITN	IRS	Larval source management[a]		Sampling method(s)	Analytical techniques
						Source reduction	Source treatment		
Adult vector composition									
Vector occurrence	•	•	•	+	+	+	+	1–12	A,B
Vector abundance (or density)	O	O[b]	–	+	+	+	+	1–12	A,B
Adult vector behaviour									
Human biting rate	O	O	–	+	+	–	–	2–5 (or 1 as proxy)	A,B
Human blood index	O	–	–	+	+	–	–	1–6	A,B,C,D
Resting location	•	O	–	–	+	–	–	7–10	A,B
Adult vector insecticide resistance									
Insecticide susceptibility frequency	•	•	O	+	+	–	+[c]	13 (or 2–12)[d]	A,B,E
Resistance intensity	O[e]	O[e]	–	+	+	–	–	13 (or 2–12)[d]	A,B,F
Resistance mechanism(s)	O[e]	O[e]	–	+	+	–	–	13 (or 2–12)[d,f]	A,B,G,H
Immature vector aquatic habitats									
Larval habitat positivity	O[g]	O[g]	O[g]	–	–	+	+	13	A,B
Larval density	O[g]	O[g]	O[g]	–	–	+	+[h]	13	A,B
Proxies for transmission									
Sporozoite rate	O	O[b]	–	+	+	+	+	2–5 (or 1 as proxy)	A,B,I,J,K
Entomological inoculation rate	O	–	–	+	+	+	+	2–5 (or 1 as proxy)	A,B,I,J,K
Receptivity[i]	–	–	•	+	+	+	+	To be determined	

[a] Source reduction includes receptacle elimination, environmental manipulation and environmental modification. Source treatment includes larviciding and biological control.
[b] High priority if an invasive species is being investigated in response to a resurgence of malaria or vector composition has changed, with a secondary vector species suspected of elevated importance in transmission.
[c] For larvae, the usual measures are resistance level (i.e. concentration required to kill 50% or 95% of test mosquitoes, LD_{50} and LD_{95}) and resistance ratio (i.e. LD_{50} for test population / LD_{50} for susceptible strain).
[d] Preferable to test adults reared from either eggs from gravid female adults or from larvae collected from the field.
[e] High priority if vector control is to be targeted on the basis of resistance profiles, such as use of dual active ingredient ITNs or combination of interventions.
[f] Depending on method, should test individuals confirmed as resistant in bioassays (E,F).
[g] High priority only if LSM is being applied or considered for use.
[h] Proportion of adult emergence from pupae should also be measured where insect growth regulators are used or being considered for use.
[i] Useful for malaria risk stratification. See Section 7.

5.3 Vector control monitoring

Depending on the interventions, vector control monitoring can include assessment of:

- product quality prior to deployment;
- baseline situation, such as coverage of existing interventions;
- implementation quality, including coverage of interventions and other progress indicators; and
- product performance under field conditions (including durability and residual activity).

5.3.1 Product quality control monitoring

Malaria vector control products with a prequalification listing that are compliant with WHO specifications[1] should be procured and used *(63)*. Control of the quality of products is essential to minimize any risks associated with their handling and use, and to ensure their stability during storage. Inspection for quality control is conducted before shipment and in some cases after shipment upon arrival to the destination. It involves collection of samples, appropriate storage of these samples until shipment to an independent certified or accredited laboratory, testing against WHO specifications when possible, and reporting by the selected laboratory. Further information is provided in the WHO *Guidelines for procuring public health pesticides (64)*.

5.3.2 Baseline situation assessment

Monitoring coverage of ITNs (including access and use) and IRS is addressed elsewhere in this manual, as this information is usually collected as part of routine programme monitoring (see **Section 7**). ITN distribution and spray operations reports are key information sources, although coverage indicators may also be measured in post-campaign household surveys. They may also be captured in a broader assessment such as a malaria indicator survey, national health survey or national census.

LSM coverage rates are often determined solely from implementation monitoring reports. It can be challenging to determine them through household surveys. Project reports on coverage of new interventions can be examined to determine deployment timings and coverage.

5.3.3 Implementation monitoring

As mentioned above, coverage of ITNs (including access and use) and IRS are usually part of routine programme monitoring (see **Section 7**). Vector control intervention data (ITN and IRS) should be considered alongside information from entomological surveillance and other vector control monitoring to inform the overarching vector control strategy.

[1] WHO specifications define the essential chemical and physical properties associated with the efficacy and the risk of use of a product. When WHO specifications do not exist, any other relevant internationally accepted or national specifications should be considered.

Any concern about poor implementation quality of IRS should be relayed to the operational teams immediately. Remedial measures will depend on the findings of investigations of spraying quality; they may include closer supervision of spray teams, retraining of spray operators, verifying the quality of the IRS products used or respraying houses in the target area.

5.3.4 Product performance monitoring (post-market surveillance)

Once deployed, the performance of vector control products should be monitored to ensure they maintain sufficient efficacy over the expected period. In particular, monitoring should be prioritized in countries where there are no data on ITN, IRS or larvicide product performance under local conditions or there is some indication of poor performance of certain products. This includes assessment of the durability of ITN products and the residual efficacy of IRS or larvicide formulations over time in real-use situations.

The useful life of an ITN depends on its properties and how it is used, which means there can be wide variation between products and locations. Durability of ITNs should therefore be periodically monitored across different settings. This includes assessment of physical status (fabric integrity), insecticidal activity (bio-efficacy) and survivorship (attrition) at specific times during their expected useful life of 3 years. This is best done in a prospective study within a mass distribution campaign *(65)*. Durability data can inform replacement strategies and behaviour change activities aimed at promoting consistent and correct ITN use.

For programmes implementing IRS, the quality of spraying is usually monitored in WHO cone assays conducted immediately after spraying and thereafter once a month throughout the expected duration of residual efficacy of the IRS product. These assessments should focus on efficacy on surfaces that are predominant in the intervention area.

Where larviciding is used, immediate and residual efficacy (if expected) can be determined by monitoring larval and/or pupal densities before and after implementation through repeated sampling over the duration that residual efficacy is expected or being assessed.

Monitoring the quality of interventions usually draws on entomological capacity, such as for assessing bio-efficacy.

Further details of quality assurance are provided elsewhere for ITNs *(66)*, IRS *(67)* and LSM *(62)* although adjustments may be required for products with novel modes of action. For example, products with slow-acting insecticides may require cone assays with extended end-points. Other vector control interventions may require assessment alternative methods, such as housing modifications or spatial repellents. The latest WHO operational guidance should be consulted.

5.3.5 Programme evaluation

Periodic assessment of operations should be conducted for discrete and time-bound vector control activities, such as ITN distribution or IRS spray rounds. This evaluation

will inform adjustments in subsequent rounds that can improve efficiency or effectiveness. Further details are included in WHO operational guidance for specific interventions, such as IRS, ITNs and LSM.

5.4 Enabling factors

There is an expanding range of potential vector control interventions, including ITNs and IRS with novel modes of action, spatial repellents, endectocides, housing modifications and the introduction of genetically modified mosquitoes. When recommendations for these interventions are established and their deployment is being considered by NMPs, appropriate adaptations will be required in entomological surveillance systems. For example, novel surveillance approaches may be needed to assess the spread of gene drive constructs through mosquito populations. Monitoring of existing and new interventions in specific situations such as humanitarian emergencies will also be important. New approaches should be developed and used pragmatically to primarily address programmatic questions.

In addition to new vector control interventions, new approaches to entomological surveillance and vector control monitoring are anticipated. These include mosquito collection systems that leverage community participation through citizen science; data input, visualization or analysis through real-time data entry and online platforms; and, enhanced analyses of mosquito age, infection status or resistance mechanisms with new technology.

Entomological data and information on interventions should have a clear purpose in decision-making, and their use in planning and implementing vector control must be well defined and efficient. Correct interpretation of data is critical, to ensure informative data are collected and that any generalizations are scientifically valid. NMPs need to invest in data analytics for decision-making. Modern tools (e.g. data modelling) can be employed for this purpose.

An expanding range of vector control tools and informed deployment tailored to subnational contexts requires highly qualified, problem-solving public health entomologists and vector control specialists. Personnel who are trained and experienced in implementing a question-based approach to surveillance and monitoring are needed to ensure that vector control continues to be a highly effective malaria prevention tool. Clear career pathways for entomologists and vector control specialists, both within national and subnational programmes and partner research institutes, are needed to ensure that this expertise is maintained to support the development and implementation of data-informed malaria control strategies.

Where possible, the design phase of surveillance and monitoring activities should consider other vector-borne diseases, such as dengue, to determine if there are opportunities for integration of activities to improve efficiency of vector surveillance and control *(55)*.

6. Early warning, detection, preparedness and response to malaria epidemics

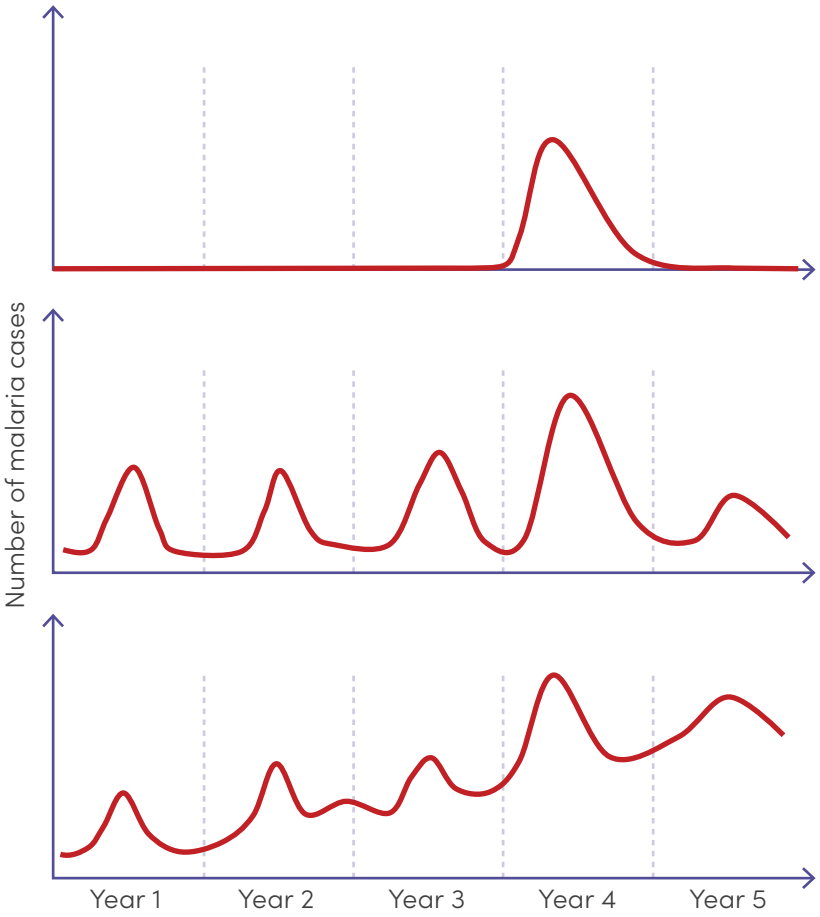
6.1 Definition and classification of malaria epidemics

A malaria epidemic is defined as a sharp increase in the incidence of malaria in populations in whom the disease is rare, or a seasonal increase in areas of low-to-moderate transmission over and above the normal pattern. The normal pattern of malaria is relative, determined for a specific area and established using a threshold computed from historical data (see **Section 6.4.4**). "Normal" occurrence can, however, be defined only for a particular population in a specific area and time. Therefore, malaria epidemics are generally considered to be disturbances of a previous epidemiological equilibrium *(68)*. Malaria epidemics can strike non-immune populations, including communities that have lost their partial immunity due to effective antimalarial measures or people from non-endemic highland areas moving to high-risk areas. These epidemics typically result in higher rates of morbidity and case fatality across all ages compared to areas with strong seasonal malaria transmission. An epidemic can also occur when the malaria caseload surpasses the capacity of health care facilities in areas with a stable population and consistent health service provision. In moderate- to high-transmission countries and territories that experience a sharp decrease in malaria incidence after intensive malaria control, the "normal" conditions against which epidemics are assessed also change and evolve. Moreover, given the impacts of climate change, the thresholds used to define "normal" malaria patterns may need to account for shifting climatic conditions, such as increasing temperatures or unpredictable rainfall, which can extend transmission seasons or introduce malaria into new areas (**Fig. 17**).

A malaria outbreak is often synonymous with a malaria epidemic. To avoid confusion, the term "epidemic" is used throughout this document. However, conventionally, outbreaks are epidemics with small caseloads or a sudden occurrence of malaria in areas that had never experienced the disease before or had eliminated it and are limited geographically. Distinguishing small malaria epidemics from expected seasonal and periodic variations can be challenging.

Countries with areas prone to malaria epidemics or transitioning from burden reduction to elimination should have an epidemic preparedness and response plan integrated into a comprehensive national strategic plan. The plan should clearly delineate the roles and responsibilities of various stakeholders and outline the processes for forecasting, early warning, and early detection, specifying expected actions at each stage and appropriate response activities. Effective malaria epidemic response plans should integrate meteorological data and involve multisectoral coordination to anticipate and mitigate climate-driven outbreaks, with a focus on community-based surveillance for timely action.

Fig. 17. Classification of malaria epidemics, and geographical areas in which they most frequently occur



(a) True epidemics: Infrequent and cyclical outbreaks in relatively non-immune populations associated with climatic anomalies (mainly in arid and semi-arid zones such as eastern Kenya, Ethiopia, Somalia and Sahelian countries).

(b) Strongly seasonal transmission: Variable but relatively predictable transmission influenced by variations in climate, such as in the highland fringes and in the Sahel and southern Africa.

(c) Neglect or breakdown of control: In receptive areas in which malaria re-emerges after scaling down of control activities, e.g. in Madagascar, the former Soviet Republics and Sri Lanka.

Complex emergencies may lead to epidemics when transmission is exacerbated by natural disasters and conflicts that lead to breakdown of services and population movement. These may include classes (a), (b) and (c). This manual does not cover malaria in complex emergencies. For guidance on such contexts, refer to the field manual for malaria control in emergencies *(69)*.

Source: Adapted from WHO *(70, 71)*.

6.2 Epidemic curves of *P. falciparum* and *P. vivax* malaria

The form of epidemic curves differs by parasite species, the entomological inoculation rate and the proportion of the human population that is susceptible *(70)* (**Fig. 18**). In *P. falciparum* malaria, the gametocytes appear in the peripheral blood an average of 10 days after detection of trophozoites (ring form), extending its incubation interval to about 35 days. In *P. vivax* malaria, gametocytes and trophozoites develop simultaneously, so that the incubation is shorter (20 days).

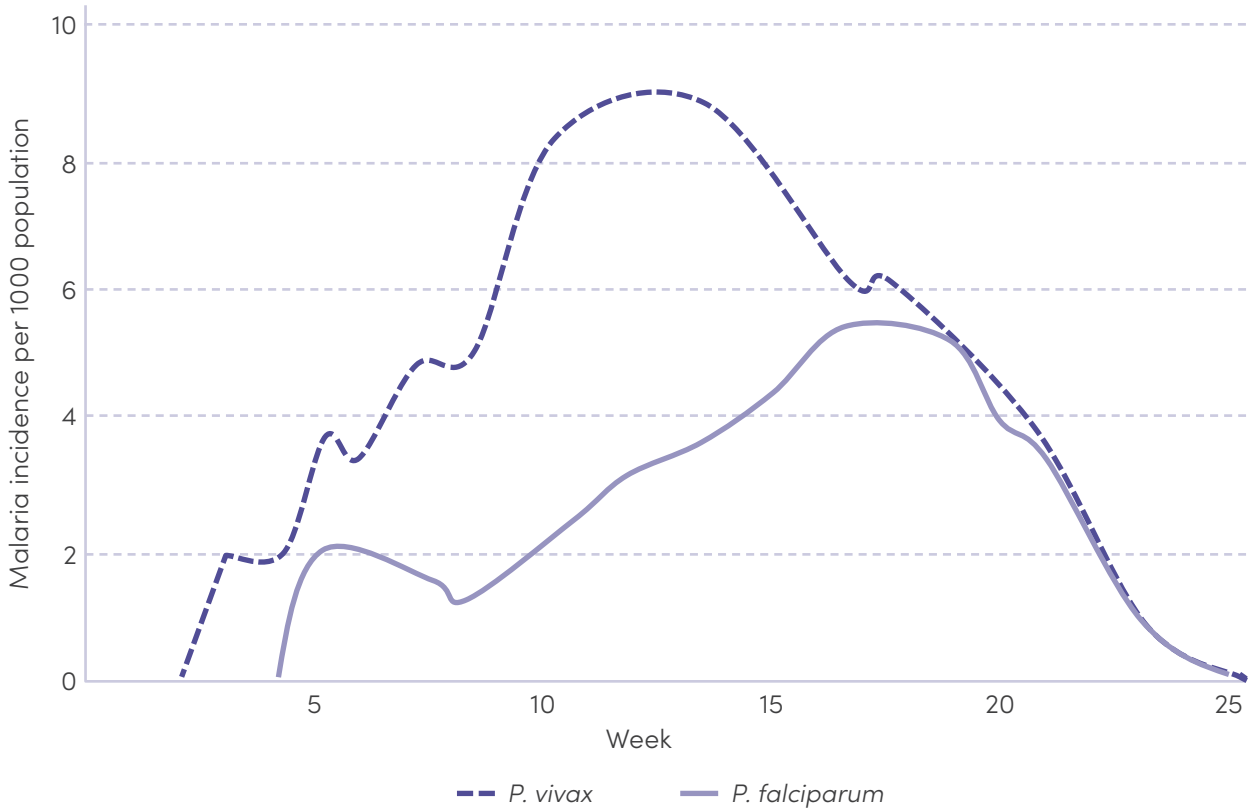
The epidemic curves of *P. falciparum* and *P. vivax* can differ due to several factors related to the biology and epidemiology of each species.

1. **Seasonality:** *P. falciparum* malaria often exhibits more pronounced seasonality, with peaks during the rainy season in many endemic regions. In contrast, *P. vivax* malaria may show less distinct seasonality and can occur throughout the year, especially in areas with stable transmission.

2. **Relapse patterns:** *P. vivax* malaria is characterized by the presence of hypnozoites in the liver, which can lead to relapses months or even years after the initial infection. As a result, *P. vivax* epidemics may have more irregular patterns, with secondary peaks occurring due to relapses.
3. **Severity of disease:** *P. falciparum* malaria is generally associated with more severe disease and higher mortality rates compared with *P. vivax* malaria. Consequently, epidemics of *P. falciparum* malaria may result in more rapid and pronounced increases in cases and deaths compared with *P. vivax* epidemics.
4. **Geographical distribution:** The geographical distribution of *P. falciparum* and *P. vivax* varies, with *P. falciparum* being more prevalent in sub-Saharan Africa and *P. vivax* being more widespread in Asia, the Americas, the Middle East, Ethiopia and Eritrea. This difference in distribution can influence the timing and magnitude of epidemic curves in different regions.

Epidemics due to *P. malariae* and *P. ovale* are rare owing to their very low prevalence and long incubation period.

Fig. 18. *P. vivax* and *P. falciparum* epidemic curves



Source: Adapted from WHO *(70)*.

6.3 Factors that may contribute to malaria epidemics and characteristics of epidemic-prone areas

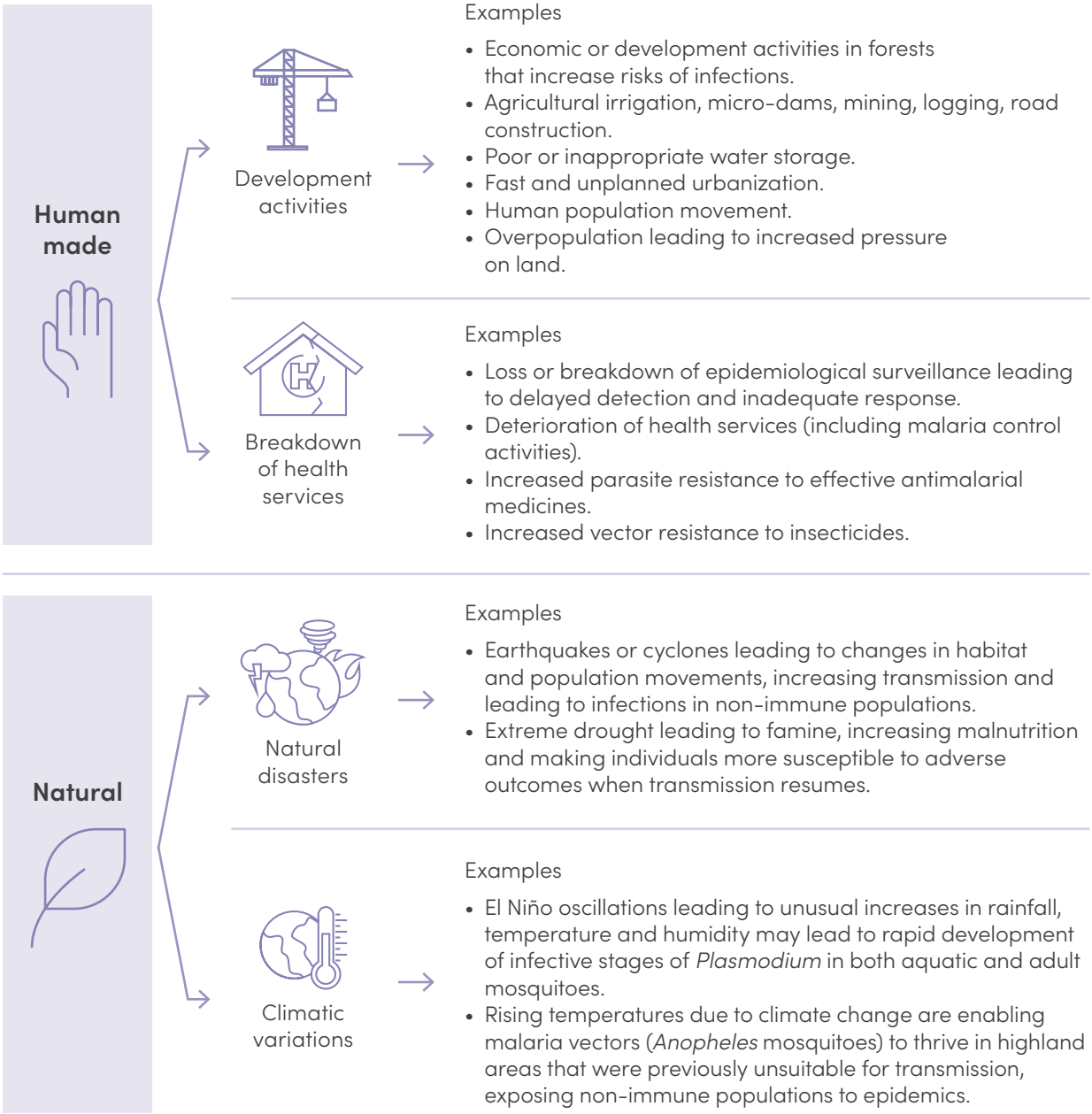
Effective planning and response to malaria epidemics require understanding the factors that contribute to epidemic risk and identifying areas prone to outbreaks. Epidemics typically arise when the balance between infection rates and population immunity is disrupted or when prevention and treatment services are interrupted. In high-transmission areas with stable malaria, partial population immunity usually prevents epidemics, but migration of non-immune people or breakdowns in services can trigger outbreaks.

Populations become vulnerable to malaria epidemics under the following conditions:

- breakdown of prevention and treatment services, often due to conflicts or inadequate resources, especially in highly receptive areas;
- migration of a non-immune population to areas with high malaria transmission rates;
- introduction of parasites and/or suitable vectors to receptive areas with low or non-existent transmission, where the population lacks partial immunity;
- increased population susceptibility following prolonged periods of drought and famine with no malaria transmission, followed by intensive rainfall and creation of suitable environmental conditions for epidemics; and
- resistance of the vectors and parasites to insecticides and drugs, respectively, resulting in protracted epidemics characterized by high incidence and mortality rates.

These conditions may be a consequence of both human-made and natural factors (**Fig. 19**).

Fig. 19. Factors that contribute to malaria epidemics



Information on potential contributing factors may be obtained from various sources, including meteorological offices for weather data, local authorities and humanitarian agencies for population movement, displacement and malnutrition statistics, relevant ministries and the private sector for infrastructure development data, and national surveillance systems for epidemiological and intervention efficacy data.

Identifying and mapping areas at high risk of malaria epidemics in a country, both spatially and temporally, can maximize the capacity of a surveillance system to detect an unusual increase in the number of cases early on. This proactive approach improves the preparedness of the NMP and enables timely response to potential epidemics.

Factors that influence the density of *Anopheles* mosquitoes, their distribution and biting behaviour, as well as the species of parasite they transmit, the availability of infected human hosts, the size of non-immune populations and their degree of exposure to infected mosquitoes all contribute to the risk of malaria epidemics. See Section 7.4 for more details on stratification.

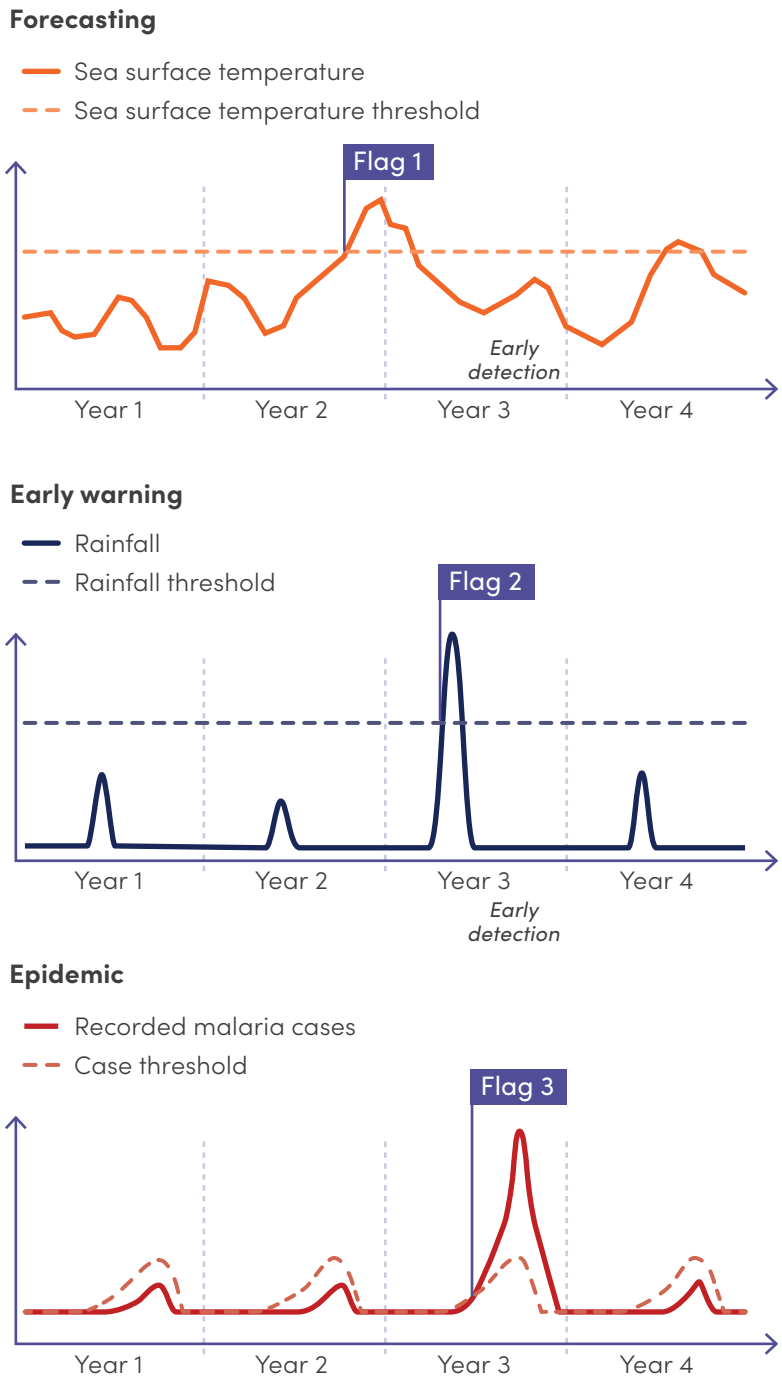
Epidemic-prone areas share some common characteristics.

- The ecology of the area supports low, highly seasonal transmission, and the population has limited immunity. Anomalous climatic or epidemiological conditions could result in greatly increased transmission. Such areas include highlands and arid and semi-arid areas.
- The rate of parasite infection has been reduced by interventions, but receptivity remains high. A reduction in coverage, breakdown of the health system, loss of efficacy of interventions or increased importation rates may lead to a rebound.
- Sudden large-scale movement of infected populations into highly receptive areas or of non-immune populations into areas of ongoing transmission due to conflicts or complex emergencies can result in an epidemic.
- Areas with immunologically naive populations undergoing rapid ecological (including human-made) changes, such as deforestation, irrigation, construction of dams, flooding and earthquakes, can experience malaria epidemics.

6.4 Surveillance system for malaria epidemics

Surveillance of epidemics of infectious diseases comprises forecasting (long range), early warning (medium range), early detection (immediate), confirmation and response. In the case of malaria, climatic and epidemiological parameters are used for forecasting, early warning and early detection of malaria epidemics (Fig. 20).

Fig. 20. Model system for forecasting, early warning and early detection of malaria epidemics



Flag 1: Long-range weather forecasting

- Long lead times, but little specificity
- Warnings at national or regional scale

Possible indicators: ENSO parameters, medium-range weather forecasts
Responses: Ensure that early warning and detection systems are operational; mobilize national resources

Flag 2: Early warning from meteorological indicators

- Shorter lead times and better specificity
- Warnings at district scale

Probable indicators: Meteorological parameters
Responses: Ensure that surveillance systems are functioning and local response reserves prepared

Flag 3: Early detection

- Short lead times and very high specificity
- Detection at sub-district scale

Indicators: Facility data
Responses: Epidemic control measures

ENSO: El Niño Southern Oscillation; SST: sea surface temperature.
Source: Adapted from WHO *(70)*.

6.4.1 Forecasting

Long-term forecasting can predict events 6–12 months or more before the transmission season, using cycles of climatic events such as the El Niño Southern Oscillation. This phenomenon involves irregular fluctuations of Pacific Ocean sea surface temperatures (El Niño) and atmospheric pressure (Southern Oscillation), occurring every 2–7 years and typically lasting 12–18 months *(70)*. El Niño often triggers significant weather shifts that vary by geographical location, including increased rainfall in eastern Africa and droughts in southern Africa. These changes can lead to severe socioeconomic and environmental impacts, sometimes resulting in famine and humanitarian crises. La Niña, a cooler phase, generally produces opposite patterns in the same locations (e.g, drier conditions in eastern Africa and above average rainfall in southern Africa). El Niño events are associated with malaria epidemics, particularly when compounded by drought and famine, as seen in eastern Africa *(72–74)*.

With advancements in climate science, El Niño events can now be predicted with reasonable accuracy, allowing broad forecasting of epidemic risk months in advance across large regions. While El Niño events alone may have limited sensitivity in precisely predicting malaria epidemics, they remain valuable for informing preparedness and response planning, especially for malaria and other health or humanitarian emergencies that may arise as a result.

6.4.2 Early warning

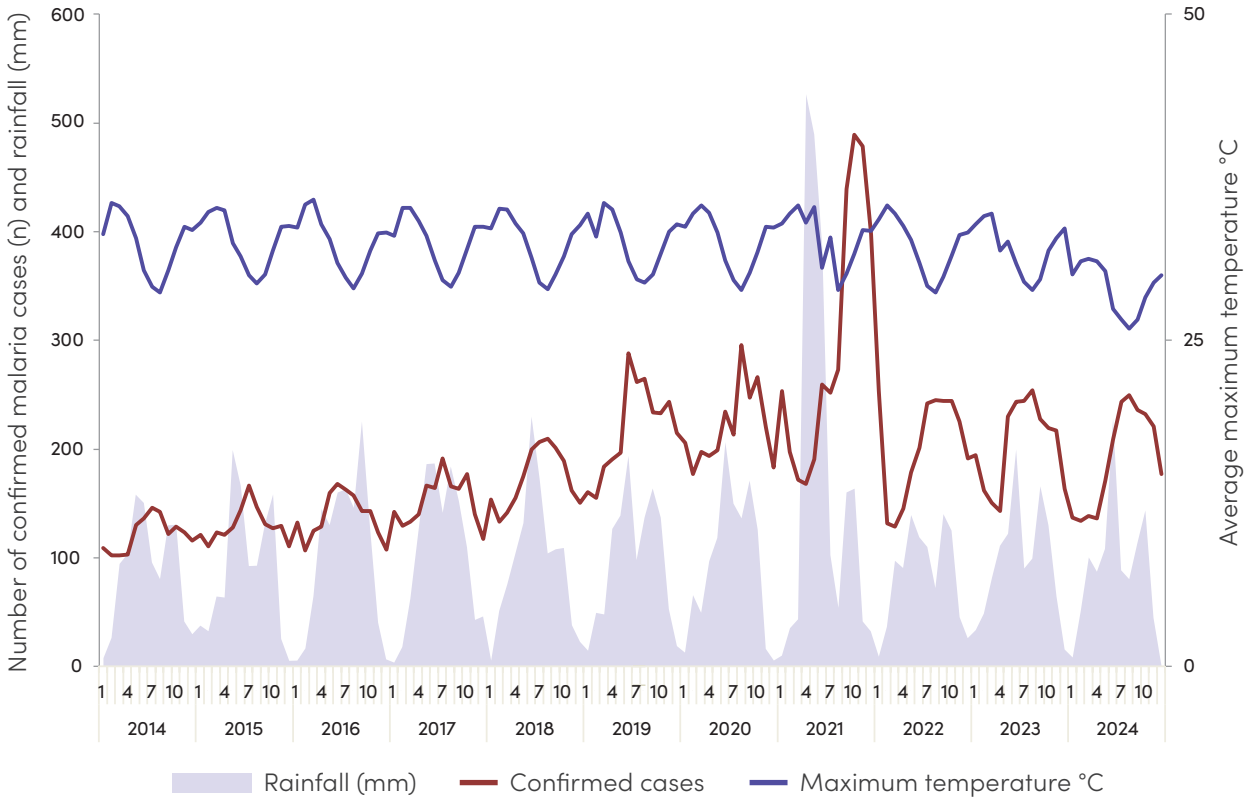
Early warning systems rely mainly on the patterns of rainfall, humidity and temperature, typically measured on a monthly or 10-day basis. These systems usually provide warnings about 3 months before the transmission season, closely linked to the ecology and life cycle of mosquitoes responsible for transmitting malaria. Meteorological departments and online climate libraries are key sources of data for these systems.

Typically, there is a time lag between changes in weather patterns and the onset of increased malaria transmission. This time lag allows for the development and maturation of mosquito populations, as well as the incubation period for malaria parasites within mosquitoes and human hosts. By monitoring climatic indicators several months in advance, early warning systems can identify periods of heightened risk for malaria transmission before the transmission season begins.

Rainfall data is often the most sensitive climatic indicator for early warning systems, particularly when complemented with larval detection. Increased rainfall creates mosquito breeding sites, while higher temperatures accelerate mosquito larvae development and shorten malaria parasite incubation periods. Changes in humidity affect mosquito behaviour and survival. By integrating meteorological data with malaria epidemiology and vector ecology, national early warning systems provide actionable warnings to mitigate malaria epidemics.

Fig. 21 shows an example of the association between climate and malaria epidemics. Other indicators that are useful in predicting the probable severity of an epidemic include mosquito and larval densities, nutritional status, drug and insecticide resistance, loss of immunity because of a recent reduction in population exposure and human population movements in and out of endemic areas *(75)*.

Fig. 21 Example of associations between climatic parameters and malaria epidemics



However, it should be noted that not all seasonal spikes in rainfall lead to malaria epidemics. Other factors – such as humidity, temperature, coverage of preventive measures, the availability of diagnosis and early treatment services, and the capacities of the NMP in responding to malaria epidemics – play crucial roles. This is particularly common in moderate- to high-transmission settings.

During the early warning period, programmes should initiate concrete planning, including:

- enhancing surveillance activities;
- increasing preventive measures;
- obtaining effective antimalarial drugs;
- ensuring that there are no stock outs of diagnostics or drugs during the transmission season;
- ensuring equipment such as spray tanks are functional and response teams are well trained in insecticide spraying, ITN distribution and other preventive and curative activities;
- informing local administrative authorities of the increased risk and ensuring funding;
- informing health workers and communities of the increased risk; and
- reactivating epidemic preparedness and response committees at national, provincial, district and lower levels to ensure readiness.

6.4.3 Early detection

Early detection involves recognizing the onset of a malaria epidemic by observing changes in local disease incidence or number of cases, primarily through surveillance data. The purpose is to detect the likelihood or the occurrence of an epidemic and detect and respond early. There is typically only a brief window of a few days or at most 2 weeks to detect whether an epidemic is underway. Recognition is quickly followed by verification and, if an epidemic is confirmed, response activities must be initiated promptly to avert or reduce excess morbidity and mortality *(71, 76)*. Epidemic thresholds that are appropriate to the epidemiological context of the area should determine their occurrence.

In epidemic-prone areas with immunity, all age groups are susceptible to malaria. If most people attending most health facilities with fever and subsequently confirmed as having malaria are under 5 years of age or are pregnant women and girls, the region is probably endemic with stable transmission.

The key data elements for monitoring epidemics at all levels include:

- weekly number of cases tested (using RDT or microscopy)
- weekly number of cases positive (using RDT or microscopy)
- weekly test positivity rate.

The key data elements for monitoring epidemics in higher-level health facilities include:

- weekly number of inpatient malaria cases (admissions)
- weekly number of malaria-related deaths.

Malaria epidemics escalate rapidly and last 3–4 months on average. Monthly reporting may not capture the upsurge of malaria cases early enough for timely deployment of control resources by the programme. Therefore, weekly reports on the aforementioned data elements are necessary to detect and control epidemics within 2 weeks of onset.

In elimination settings with high-quality case-based surveillance and rapid notification systems, malaria epidemics are easier to detect early. However, the main requirement is the implementation of an analytical system, capable of comparing cases with the epidemic threshold and issuing immediate alerts.

In most moderate- to high-transmission countries with pockets of epidemic-prone areas, however, the HMIS often reports monthly aggregated data, which may not be suitable for early epidemic detection. In such cases, data on both malaria and other febrile notifiable diseases, such as meningitis, cholera and yellow fever, reported weekly through the integrated diseases surveillance and response system are more useful. Additionally, information from other sources, such as media reports, community reports or rumours, may also contribute to early malaria epidemic detection efforts.

6.4.4 Malaria epidemic threshold detection system

The epidemic threshold is the critical level at which the reported counts of cases or deaths in a given space and time are higher than would be considered normal. Once this threshold is breached, it indicates the presence of a malaria epidemic, prompting authorities to implement necessary control and response measures promptly. By recognizing and responding to epidemics early, public health officials can mitigate the spread of disease and minimize its impact on communities.

The computation of an effective threshold requires use of a variety of data.

- *Weekly data on confirmed malaria cases:* these data help to capture fluctuations in malaria incidence more accurately and timely. Caution must be exercised where the apparent increase in cases is partly or wholly due to improved confirmation rates or access to health services.
- *Area-specific threshold:* in epidemic-prone settings, the threshold needs to be tailored to the specific characteristics of each area or administrative unit. Malaria transmission can vary significantly even within relatively small geographical areas due to factors such as climate, geography, vector ecology, and human population and behaviour. A national threshold should not be applied subnationally.
- *At least 5 years of weekly data:* these data should be used to define the expected "long-term" weekly caseload as the baseline threshold, which is crucial for distinguishing between normal fluctuations and malaria epidemics. In highly endemic areas the baseline threshold could possibly be established with fewer years of data. In contrast, in areas where malaria transmission is more sporadic or seasonal, more years of data (5–10 years or more) are often needed to account for fluctuations in transmission.
- *Consideration of the latest years for updating the epidemic threshold:* sharp decreases in transmission due to recent interventions necessitate removing past data from high-transmission periods and focusing on the latest 3 years with lower incidence. Conversely, sharp increases from failing control programmes should consider the latest 3 years with higher incidence. This ensures the threshold accurately reflects current malaria transmission, facilitating timely detection and proportionate response to epidemics in removal of past data, which could bias trends.
- *Calculation of two thresholds:* a less sensitive threshold for early alerting aids preparation, and a highly sensitive epidemic threshold for early detection facilitates early response. The line between these two thresholds denotes the "normal" trend.
- *Exclusion of the year of interest from calculation of a threshold:* this helps ensure that the threshold accurately reflects historical patterns and is not influenced by the epidemic year being monitored.

Several approaches, which are often complex, can be used to calculate thresholds. For operational purposes, four relatively simple methods are recommended:

- constant case count
- mean ± 2 SD
- medium + upper third quartile
- cumulative sum method.

Where there are few data to estimate thresholds, an epidemic may be suspected from a noticeable, rapid increase in weekly numbers, a high case fatality ratio (due to late appropriate treatment at community level), overwhelming of health services (e.g. shortage of health staff and drugs) or closure of nearby health facilities. See Table 12 and subsequent worked examples for details of the methods for computing thresholds for early detection of malaria epidemics. Table 13 gives an example of weekly malaria data from 2019–2024 and Fig. 22 illustrates the data plotted by the various methods for computing thresholds to assess whether an epidemic of malaria occurred in 2024.

Table 12. Methods for calculating thresholds for early detection of malaria epidemics

Method	Explanation	Advantage	Disadvantage	Reference
Constant case counts	Based on past data, constant case counts use absolute weekly case counts in health facilities to detect early epidemic stages and trigger responses. Various cut-off numbers can be applied across different levels (village, district, province, national).	• Simple to apply and communicate promptly at all levels • Easy to implement, in resource-limited settings • Appropriate in elimination settings with few cases predicted per season or given period	• The thresholds may be arbitrary and vary widely over time and place. • Inflexible and less applicable in high burden areas • Low sensitivity, limited predictive value • Does not account for seasonality	*(71)*
Mean + two standard deviations (2 SD)	Mean + two standard deviations (2 SD) calculates the long-term mean of weekly data of past years – typically the last 5 years (excluding the year of interest and any year in which a sharp decrease or increase due to control efforts was reported) – to detect epidemics. It sets an epidemic threshold at twice the standard deviation of the mean. Weeks exceeding this threshold are declared epidemic weeks.	• Less sensitive to minor peaks and does not result in overreaction in stable transmission areas with minor seasonal fluctuations	• May miss important epidemics, especially in areas of low and very low transmission • Highly sensitive to large numbers of cases	*(72–74)*
Median + upper third quartile	Median + upper third quartile calculates two thresholds based on the median and the upper third quartile (75th percentile). The calculation is based on weekly data from previous years – typically the last 5 years – to detect epidemics. This approach is only valid if no sharp decrease or increase due to control efforts were reported in previous years. It is suitable for accommodating seasonal peaks in moderate- to high-transmission areas. An initial alert is issued when cases exceed the median, while an epidemic is declared if cases surpass the third quartile for 2 consecutive weeks. It is advised not to choose thresholds beyond the 75th percentile as they result in ineffective responses.	• Seasonal adaptability • Moderately sensitive and less influenced by abnormal counts or outliers, unlike the mean + 2 SD • Values are easier to calculate, as numbers are not weighted by facility • Simple interpretation with median and upper third quartile being intuitive thresholds for alert and epidemics • Early alert triggered when cases exceed the median, allowing for early response • Most suitable for moderate- to high-transmission settings.	• May miss important epidemics, especially in areas of low and very low transmission or where malaria transmission has decreased rapidly • Lower sensitivity in areas where transmission rates fluctuate significantly • Limited predictive value in anticipating future epidemics	*(72–74)*
Cumulative sum	The Cumulative sum (C-SUM) method calculates weekly averages from the same time period over the past 5 years. This method assumes that there have been no major disruptions – such as large-scale interventions or outbreaks – that would have significantly altered case numbers during those years. If such changes occurred, the baseline may no longer be reliable. The expected number of cases in a specific week is usually calculated using the average of that week plus the weeks immediately before and after. Advanced applications include adding a 95% confidence interval to identify when observed case numbers exceed normal variation. If weekly data are not accessible, monthly data can suffice.	• An advantage of the C-SUM method is that it smooths out artificial variations in weekly reported data that are due to late reporting and other errors inherent to the surveillance system. • Highly sensitive and can identify even minor epidemics • Early detection and allowing for prompt response • Most suitable in very low-transmission settings where elimination activities are initiated, and any resurgence is recognized as an epidemic • Values are easier to calculate, as numbers are not weighted by facility	• Relatively complex to compute in resource-limited settings • Very sensitive, including to outliers, and may raise false alarms in areas of moderate transmission • Less suitable for settings with highly seasonal malaria • Subjectivity in threshold selection	*(72–74)*

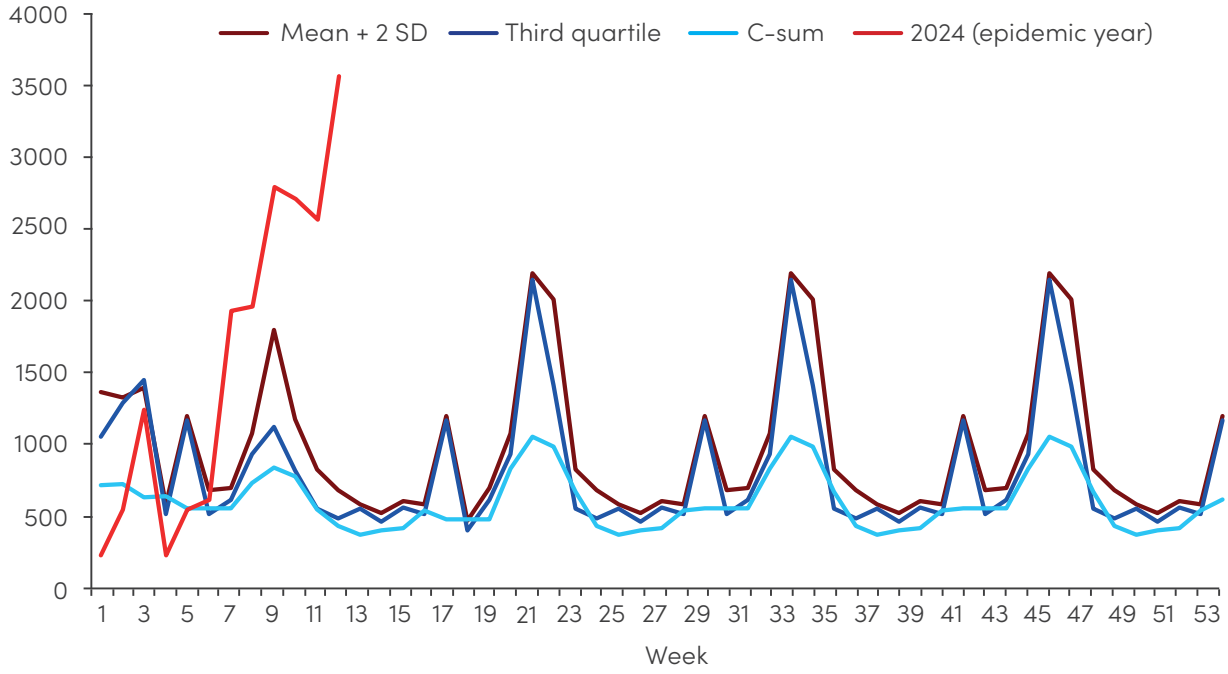
Table 13. **Weekly numbers of confirmed malaria cases and thresholds for the period 2019–2023 as compared with the trends for 2024 (suspected epidemic year) in a district of country X**

Week	2019	2020	2021	2022	2023	2024 (suspected epidemic year)	Mean + 2 SD	Third quartile	C-sum
1	402	304	1 750	1 125	300	341	1 420	1 125	801
2	559	331	1 500	1 350	276	640	1 383	1 350	807
3	509	446	1 500	1 502	251	1 308	1 451	1 500	720
4	399	470	353	744	616	341	678	616	727
5	1 232	466	362	1 319	743	640	1 260	1 232	649
6	611	490	505	884	550	704	769	611	651
7	714	100	434	706	653	1 959	783	706	648
8	1 290	704	476	1 007	606	1 987	1 146	1 007	818
9	2 311	1 190	485	797	800	2 784	1 830	1 190	914
10	373	1 461	461	849	902	2 706	1 241	902	855
11	325	647	583	567	1 069	2 564	908	647	645
12	567	-	580	556	736	3 520	770	580	535
13	402	304	300	649	735		680	649	477
14	559	331	275	555	612		619	559	505
15	509	446	503	747	655		696	655	518
16	399	470	353	744	616		678	616	638
17	1 232	466	362	1 319	743		1 260	1 232	577
18	256	490	505	145	550		567	505	578
19	714	100	434	706	653		783	706	576
20	1 290	704	476	1 007	606		1 146	1 007	909
21	2 311	1 190	485	797	2 165		2 205	2 165	1 114
22	373	1 461	461	849	2 540		2 031	1 461	1 055
23	325	647	583	567	1 069		908	647	754
24	567	-	580	556	736		770	580	535
25	402	304	300	649	735		680	649	477
26	559	331	275	555	612		619	559	505
27	509	446	503	747	655		696	655	518
28	399	470	353	744	616		678	616	638
29	1 232	466	362	1 319	743		1 260	1 232	649
30	611	490	505	884	550		769	611	651
31	714	100	434	706	653		783	706	648
32	1 290	704	476	1 007	606		1 146	1 007	909

Week	2019	2020	2021	2022	2023	2024 (suspected epidemic year)	Mean + 2 SD	Third quartile	C-sum
33	2 311	1 190	485	797	2 165		2 205	2 165	1 114
34	373	1 461	461	849	2 540		2 031	1 461	1 055
35	325	647	583	567	1 069		908	647	754
36	567	-	580	556	736		770	580	535
37	402	304	300	649	735		680	649	477
38	559	331	275	555	612		619	559	505
39	509	446	503	747	655		696	655	518
40	399	470	353	744	616		678	616	638
41	1 232	466	362	1 319	743		1 260	1 232	649
42	611	490	505	884	550		769	611	651
43	714	100	434	706	653		783	706	648
44	1 290	704	476	1 007	606		1 146	1 007	909
45	2 311	1 190	485	797	2 165		2 205	2 165	1 114
46	373	1461	461	849	2 540		2 031	1 461	1 055
47	325	647	583	567	1 069		908	647	754
48	567	-	580	556	736		770	580	535
49	402	304	300	649	735		680	649	477
50	559	331	275	555	612		619	559	505
51	509	446	503	747	655		696	655	518
52	399	470	353	744	616		678	616	638
53	1 232	466	362	1 319	743		1 260	1 232	706

C-SUM: cumulative sum; SD: standard deviation.

Fig. 22. Epidemic thresholds for 2019–2023 as compared with the suspected epidemic year 2024 from data in Table 13



Cumulative sum is clearly the most sensitive threshold, followed by the third quartile and then mean + 2 SD. If the district staff were to use the cumulative sum, all the seasonal peaks would be categorized as epidemic. This method should therefore be used only in areas where small increases in the number of malaria cases may be considered an epidemic, as in low-transmission settings.

In calculating a numerical threshold, it is important to control for wide variation in case counts stemming from factors such as counting small catchment areas or short periods, such as weekly reporting from village health clinics. Additionally, changes in diagnostic methods, treatment availability, introduction of new service providers such as CHWs and changes in reporting systems can also influence case counts. The threshold should be "smoothed" to prevent substantial changes from week to week. This ensures consistency and avoids unnecessary alerts caused by minor fluctuations in case counts. In areas where malaria prevalence varies widely across regions, such as those implementing subnational elimination, the method used to calculate the threshold should be tailored to suit the specific epidemiological characteristics of each area. This approach ensures that surveillance systems accurately reflect the local malaria situation and are effective in detecting outbreaks while minimizing false alarms.

6.4.5 Investigation and verification of a malaria epidemic

Investigation and verification of a malaria epidemic are essential for an effective public health response. This process confirms the outbreak as a real public health threat, justifies resource allocation, and allows for the rapid deployment of control measures. It also strengthens surveillance for early detection and tracking, and helps build public trust through transparent communication, which encourages community adherence to preventive actions.

A district management team or equivalent should be established in epidemic-prone areas, consisting of a medical officer, an epidemiologist, an entomologist and a trained laboratory technician to verify cases in the field. This is especially important in areas with poor parasitological diagnosis coverage, where malaria may be mistaken for other causes of fever. Combining verification of a malaria epidemic with confirmation of other febrile diseases ensures a prompt response to all relevant diseases, ideally by aligning with integrated disease surveillance and response practices.

The steps in verification of a detected malaria epidemic are as follows.

1. *Initial assessment:* conduct an initial assessment to determine the scope and severity of the suspected epidemic.
2. *Case confirmation:* confirm reported cases through laboratory testing to ensure accuracy and identify parasite species.
3. *Epidemiological investigation:* conduct an epidemiological investigation to identify patterns, use of intervention, risk factors and potential sources of transmission.
4. *Entomological surveillance:* conduct entomological surveillance to assess vector abundance, behaviour and insecticide resistance.
5. *Community engagement:* engage with local communities to gather information, raise awareness, and encourage participation in control measures.
6. *Data analysis:* analyse collected data, disaggregated by age and sex, to determine the magnitude and geographical spread of the epidemic.
7. *Threshold comparison:* compare case counts with established epidemic thresholds to confirm if the situation exceeds expected levels.
8. *Notification:* the district or equivalent monitoring team immediately notifies the national emergency unit centre if the team determines that there is an epidemic (based on established decision tree described in Fig. 25).

6.5 Preparedness and response

As global efforts against malaria intensify, many endemic countries experience epidemiological transitions. Even in high-burden countries, transmission intensity becomes heterogeneous, leading to segments of the population losing partial immunity and areas experiencing unstable transmission, making them vulnerable to epidemics. Similarly, countries that have achieved low transmission also face challenges, with most of their populations losing partial immunity, rendering them highly susceptible to epidemics. Considering the effects of climate change, all endemic countries, regardless of malaria burden, are at high risk for malaria epidemics.

Therefore, it is essential for all endemic countries to have costed epidemic preparedness and response plans for malaria, with clear timelines and delineated roles and responsibilities of stakeholders. The epidemic preparedness and response plans should be developed annually and integrated into national health and malaria strategic plans. Annual epidemic preparedness and response plans for the current

year should be based on epidemiological analysis of preceding years. Resource mapping and mobilization, and procurement of logistics, for the following year should be prepared at least 6 months in advance.

Developing a national SOP for malaria epidemic preparedness and response is crucial for several reasons.

1. *Consistency:* the SOP ensures standardized procedures across the country.
2. *Clarity:* the SOP provides clear guidance on roles and responsibilities.
3. *Timely response:* the SOP allows for rapid and efficient action during outbreaks.
4. *Resource optimization:* the SOP helps allocate resources effectively.
5. *Coordination:* the SOP promotes better collaboration among stakeholders.
6. *Capacity-building:* the SOP supports training and skills development.
7. *Adaptability:* the SOP allows for flexibility to address local needs and changes in the situation.

6.5.1 Preparedness for malaria epidemics

Preparedness at national level

Costed epidemic preparedness and response plans integrated into national health and malaria strategic plans should be developed and SOPs should be in place, as described above. Further preparedness steps at national level (flags 1 and 2 in **Fig. 20**) are as follows.

1. *Risk assessment:* conduct a comprehensive risk assessment to identify areas at highest risk for malaria epidemics based on factors such as historical data, climate conditions and population vulnerability. Additionally, list and rank epidemic-prone villages, districts and regions based on historical data, environmental risks and population vulnerability. An example of a questionnaire for pre-epidemic assessment is given in **Annex 17**.
2. *Resource mobilization:* identify and make available resources matching the costed epidemic preparedness and response plan.
3. *Predisposition of logistics:* procure logistics well in advance, ensure that logistics, including emergency stocks of medicines and other supplies, are pre-positioned in epidemic-prone areas and transportable to facilitate rapid response in case of an outbreak.
4. *Training of health workforce:* provide cascaded training and mentoring for health care workers on epidemic preparedness and response protocols outlined in the SOPs. This should include case management, surveillance and analytical capacity, vector control measures, and community engagement strategies.
5. *Community mobilization:* engage with communities to raise awareness about malaria prevention and symptoms, and the importance of early treatment. Mobilize community leaders and volunteers to support surveillance activities and encourage timely reporting of suspected cases.
6. *Regular simulation exercises:* conduct regular simulation exercises to test the effectiveness of the epidemic preparedness and response plan and SOPs

in realistic scenarios. This helps identify gaps and areas for improvement in preparedness and response efforts.

7. *Establish a national coordination and communication team:* for a predicted epidemic, dispatch a coordination and communication team to ensure effective coordination among relevant stakeholders, including government agencies, health care providers, nongovernmental organizations and community leaders. Establish clear communication channels for sharing information and coordinating response activities.
8. *Regular monitoring and evaluation:* conduct regular monitoring and evaluation at all levels to assess the effectiveness of preparedness measures and identify areas for improvement.

By focusing on these preparedness steps, countries can enhance their ability to detect, respond to, and mitigate the impact of malaria epidemics, ultimately reducing morbidity and mortality associated with the disease.

Preparedness at district or intermediate level

Preparedness steps at district or intermediate level (flag 2 in **Fig. 20**) are as follows.

1. *Train health workers:* focus on case management, vector control and surveillance.
2. *Strengthen surveillance:* compile data and establish or update thresholds, and list epidemic-prone villages for response.
3. *Conduct entomological assessment if necessary:* in addition, correlate epidemiological data with other relevant indicators, such as meteorological data, population movement or socioeconomic activities.
4. *Establish district-level response teams:* ensure clear roles and responsibilities are assigned to coordinate epidemic response activities and ensure effective communication channels.
5. *Monitor:* check health facility level trends and thresholds regularly.

Preparedness at peripheral health facility level

Preparedness steps at peripheral health facility level (flag 3 in **Fig. 20**) are as follows.

1. *Establish reporting:* establish a weekly reporting system and monitor (electronic or printed).
2. *Enhance surveillance:* conduct simple analysis and graphing of weekly data, including notification to the district management team.
3. *Ensure peripheral health facilities have adequate stocks:* ensure adequate stocks of essential supplies, including antimalarial medicines, diagnostic tests, insecticides and ITNs.
4. *Engage the community:* engage with the communities served by peripheral health facilities to raise awareness about the risks, malaria prevention, symptoms and timely treatment-seeking.
5. *Communication and coordination with higher-level health authorities:* ensure communication and coordination with district health offices, regional malaria control programmes and other authorities as appropriate.

6.5.2 Response to malaria epidemics

Response to malaria epidemics is multisectoral and multidisciplinary in nature. Following the COVID-19 pandemic, many countries established national disaster preparedness and response mechanisms to coordinate all disaster responses, ensuring a whole-of-society approach. For example, one such mechanism is a national taskforce under the ministry of health to coordinate emergency health responses, including malaria epidemics. Coordination mechanisms for malaria epidemics should be adapted to each country's situation, aiming to maximize coordination, optimize resources and amplify impact. In circumstances where the magnitude of the epidemic is beyond the capacity of the NMP or ministry of health, countries may opt to activate the national disaster preparedness and response mechanism.

To ensure an effective and well-coordinated malaria epidemic response, robust monitoring and evaluation mechanisms must be in place to assess intervention effectiveness, guide resource allocation and optimize response strategies. Monitoring and evaluation is crucial at all levels of epidemic response, as it enables timely assessment of intervention effectiveness, guides resource allocation, and ensures that response strategies are continuously optimized to control the outbreak efficiently.

Response at national level

Response steps at national level (flag 2 in **Fig. 20**) are as follows.

1. Activate the national epidemic response, integrated into the broader national system.
2. Release financial, human and logistic resources needed for an effective response, including emergency funding, trained personnel and essential supplies.
3. Deploy rapid response teams to affected areas to conduct case investigations, and provide support to subnational levels for treatment and vector control activities.
4. Communicate using official channels and media platforms to inform the public about the epidemic, its risks and prevention measures.
5. Continuously monitor and evaluate response activities to assess their effectiveness and identify areas for improvement. Adjust strategies and interventions based on ongoing surveillance data and feedback from the field.
6. Collaborate and regularly report on the status of the epidemic and response activities to relevant national and international authorities.
7. Engage in cross-border collaboration with neighbouring countries for joint response efforts, especially in elimination settings or areas where malaria has been eliminated.

Response at district or intermediate level

Response steps at district or intermediate level (flag 2 in **Fig. 20**) are as follows.

1. Activate the district-level or intermediate national-level epidemic response plan, aligned with the national framework.
2. Deploy rapid response teams to affected areas to conduct case investigations, support peripheral health facilities to strengthen surveillance, provide treatment, and implement vector control measures.
3. Engage the community including leaders and volunteers to raise awareness, support surveillance activities and promote behaviour change interventions.
4. Implement targeted vector control interventions such as IRS and distribution of ITNs to reduce malaria transmission in epidemic-affected areas.
5. Evaluate effectiveness of vector control and treatment based on the stage of the epidemic.
6. Consider MDA if transmission is high and widespread (making interventions like IRS and ITNs less effective) and access to diagnosis and treatment is limited. MDA is not typically recommended as a primary strategy for malaria outbreak response, but may be considered in these circumstances.

Response at peripheral health facility level

Response steps at peripheral health facility level (flag 3 in **Fig. 20**) are as follows.

1. Ensure diagnostics (either microscopy and RDTs) and antimalarials are available at the health facility.
2. Conduct quick verification with either microscopy or RDTs.
3. Enhance prompt case detection and confirmation of suspected malaria cases.
4. Identify and prioritize the most vulnerable populations (e.g. the non-immune population).
5. Initiate prompt treatment with effective antimalarial medicines.
6. Continue the weekly reporting system and monitor progress.
7. Conduct simple analysis and graphing of weekly data, including listing and ranking of villages, and report to the district management team.

The type and scope of the response – whether at the peripheral or district level only or involving all levels – will vary depending on when the epidemic is detected. However, the overarching goal is to reduce transmission and mortality by treating infected individuals and preventing new infections. If epidemics are confirmed and preventive interventions were not sufficiently deployed, prioritizing mortality reduction through early diagnosis and effective treatment is crucial.

During malaria epidemics, all levels of response should adhere to the guiding principles of interventions, including treatment and vector control measures, listed in **Box 14**.

Box 14. Strategies for diagnosis, treatment and vector control during epidemics

Diagnosis and treatment

To reduce onward transmission:

- where possible, use a drug that is gametocidal;
- when prevention with either IRS or ITNs is inadequate or logistics are not in place, consider using MDA with a long-acting drug, (if feasible), to reduce transmission. Ensure, good adherence and coverage of at least > 80% (MDA should only be used under certain conditions – see the WHO recommendations and MDA field manual *(34, 46)*; and
- use radical cure with primaquine (7-day regimen) in epidemics due to *P. vivax*.

To reduce mortality:

- consider MDA, ensuring high coverage of the affected population;
- if the epidemic occurs in a remote area with poor access to health care, establish new or temporary health posts (mobile clinics);
- ensure early management of severe cases either at peripheral level (early pre-referral or full treatment) or in referral health facilities; and
- in malaria epidemics compounded by complex emergency situations, manage malnutrition and other comorbidities alongside malaria case management.

Vector control, targeting adult mosquitoes

To reduce transmission:

1. operationally, vector control options are viable if epidemic-prone districts are well prepared, and emergency stocks are pre-positioned and maintained;
2. biologically, vector control options are feasible when implemented at an early stage of an epidemic;
3. IRS can be conducted within 2 weeks of epidemic onset and is feasible when coverage rate > 85% and the vector rests indoors;
4. use of ITNs is feasible, but requires prior behavioural change in the community and impact is less immediate than IRS; and
5. in complex emergency situations, where refugee camps can be established, use of ITNs and IRS in available structures are highly effective and, in some situations, larval habitats can be readily identified and appropriate larval source reduction can be used.

Malaria epidemics may affect several countries or territories within a country at the same time. Therefore, exchange of information and data and cross-border collaboration should be part of the response. Examples of operational responses to different stages of malaria epidemics are given in **Annex 18**.

6.6 Post-epidemic assessment

A post-epidemic assessment is essential for evaluating the effectiveness of interventions and the performance of early warning, detection and response systems. By analysing successes and failures, lessons can be gleaned and applied to enhance

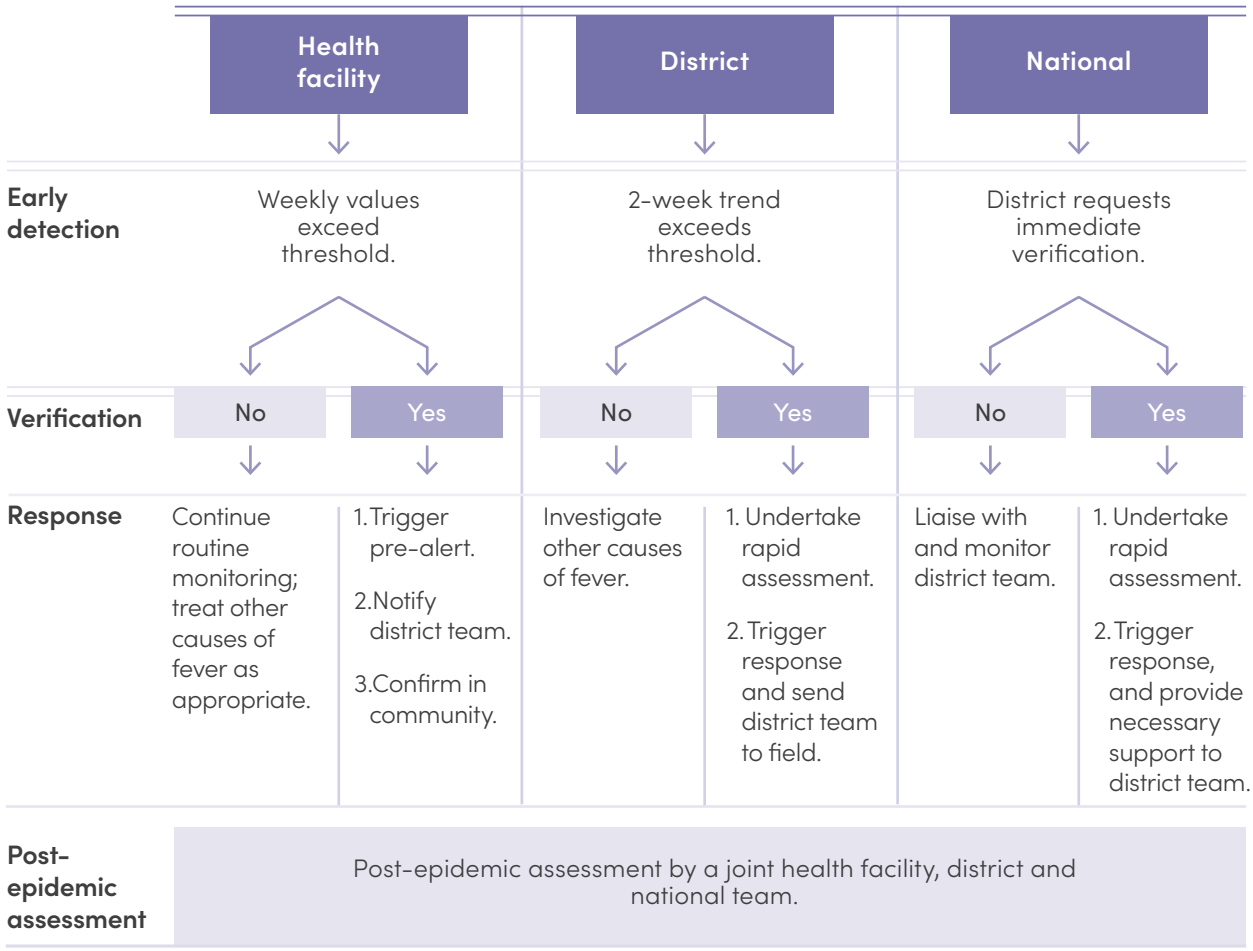
preparedness plans for future epidemics. To facilitate this process, a post-epidemic working group should be established, comprising experts in epidemiology, entomology, clinical practice, laboratory science and statistics from district and national levels. This multidisciplinary team will retrospectively assess various aspects of the epidemic, including its impact, the effectiveness of the response, verification methods, early detection mechanisms, and forecasting accuracy.

The findings of the post-epidemic assessment should be widely disseminated to higher levels of authority to inform decision-making and advocate for necessary support at all levels of response. By actively engaging in this evaluation process, stakeholders can contribute to improving future epidemic preparedness and response strategies.

In summary, the working group should focus on assessing and enhancing systems for forecasting, early warning and detection, while gathering data from surveillance and health records. They should analyse the epidemic's impact on malaria indicators, evaluate response efforts and resource allocation, and review case verification and surveillance methods. Additionally, they should identify key lessons, develop recommendations for future preparedness, and share findings with policy-makers, health authorities and partners.

An example checklist for a post-epidemic assessment is provided in Annex 17 and one for a quick assessment report in Annex 18. Fig. 23 illustrates the process of early detection, verification, response and post-epidemic assessment.

Fig. 23. Early detection, verification, response and post-epidemic assessment



7. Monitoring and evaluation of national programmes

7.1 Aims of monitoring and evaluation

The goal of monitoring and evaluation is to improve the effectiveness, efficiency and equity of programmes, taking into consideration background changes in other malaria risk determinants. Monitoring and evaluation are critical to achieving the goals of NMPs and tracking progress towards the objectives of the *Global technical strategy for malaria 2016–2030 (2)*. Once the malaria situation in a country or area has been assessed, plans are made to ensure the most effective use of resources to either eliminate malaria or reduce its public health impact. As plans are implemented, they should be reviewed periodically to determine whether the programme activities are achieving the desired outcomes or whether they should be adjusted (**Fig. 24**).

High-quality, timely, granular information is essential for programme planning and implementation, and the information can also be used to lobby internal and external stakeholders for the necessary resources. The performance of malaria programmes can also be improved by making information on programme planning and monitoring more widely accessible. Public disclosure of information allows policy-makers, patients and other citizens to monitor the services they are financing and encourages managers to be more responsive to their clients' needs (see **Box 15**).

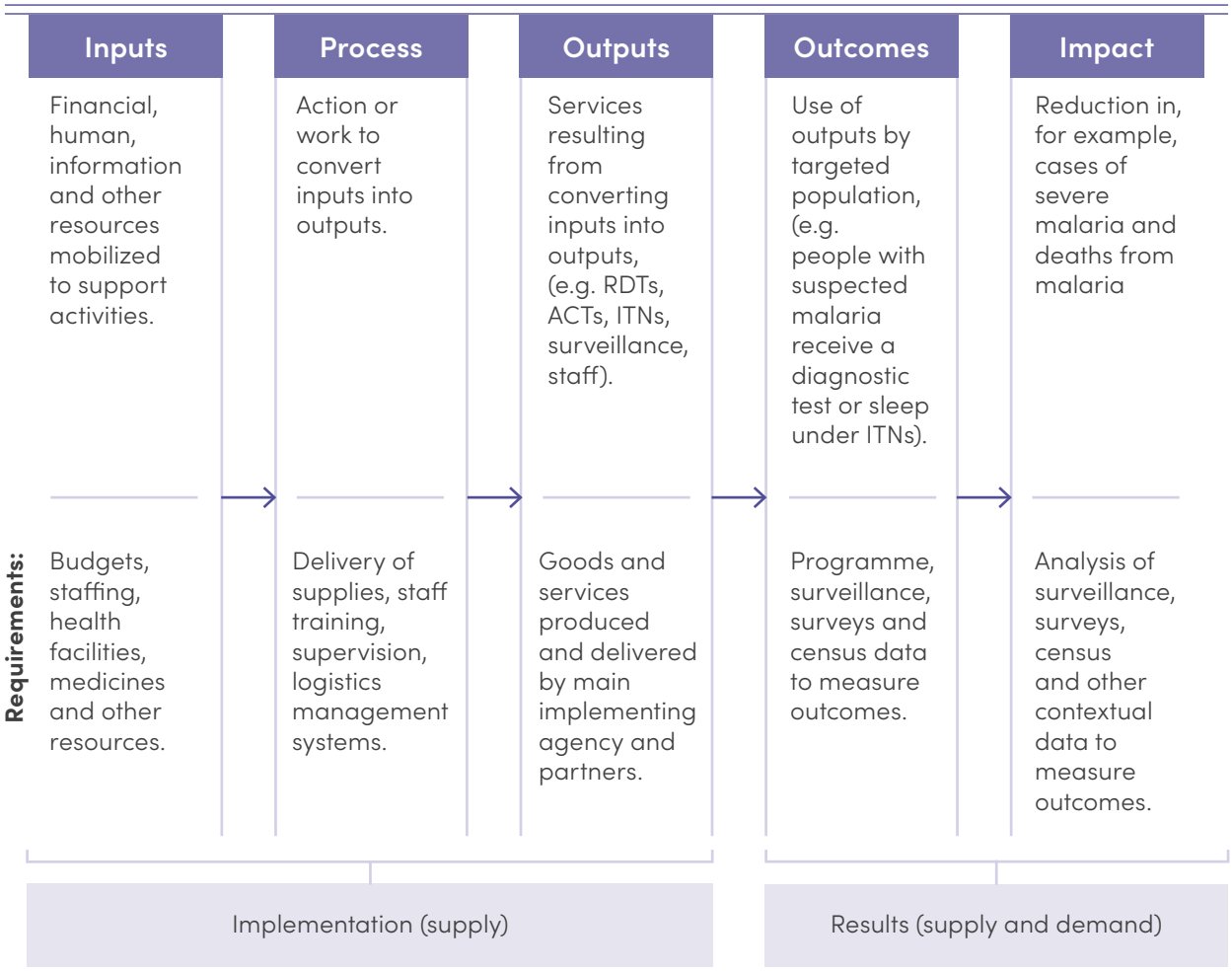
The primary purpose of collecting data on malaria programmes is for decision-making and action at the local level. Information generated at country level is also used to inform progress at the international level, for example through reports produced by WHO. The data inform international financiers of malaria programmes and are an important determinant of future funding.

Box 15. Major functions of monitoring and evaluation

Monitoring and evaluation can accelerate progress towards malaria elimination if used to:

- regularly assess whether plans are progressing as expected or whether adjustments are required to the scale of the intervention or combination of interventions;
- evaluate whether the programme objectives have been met and to learn what has worked and what has not, so that more efficient, effective programmes can be designed;
- inform the process of subnational tailoring of interventions to identify the most appropriate mixes of interventions for the national strategic plan and to rationally allocate available resources to the populations most in need, in order to achieve the greatest possible public health impact *(81)*;
- account for the funding received to allow the public, their elected representatives and donors to determine whether they are obtaining value for money;
- advocate for investment in malaria programmes in accordance with the malaria disease burden in a country or subnational area; and
- track progress across the spectrum of malaria goals, including burden reduction, elimination and prevention of re-establishment.

Fig. 24. Monitoring and evaluation framework: from input to impact



ACT: artemisinin-based combination therapy; ITN: insecticide-treated net; RDT: rapid diagnostic test.

7.2 Types of information required for monitoring

Information may be informal, semi-formal or formal.

- Informal information is learned by observation, talking to health staff or community leaders and other informal means.
- Semi-formal information is obtained, for example, from policy documents, consultants' reports, supervisory visit reports, focus group discussions, official circulars and minutes of meetings.
- Formal information is acquired from structured systems for recording and reporting information, such as routine health information and surveillance systems, accounting systems and surveys.

Formal information for programme monitoring can be obtained from:

- routine health information systems, including routine clinical data and surveillance indicators, which may cover multiple programmes that may or may not be specific to malaria or be limited to certain activities (e.g. laboratory services, interventions, distribution, surveillance);

- health facility surveys, which usually address whether facilities have the physical and human resources necessary to provide services (especially chemoprevention, diagnostic testing and treatment), and may include whether patients receive diagnostic testing and appropriate treatment;
- household surveys, which usually cover several health interventions, especially for children under 5 years of age and women of reproductive age, although malaria-specific surveys are also common;
- operational research, which usually addresses specific questions of relevance to the malaria programme, may rely on household or health facility surveys and may include studies of drug or insecticide efficacy;
- entomological surveillance, for understanding the distribution of the main malaria vectors, their behaviour and changes in their biting habits in response to the intervention – part of sentinel surveillance by national programmes and often including vector resistance to insecticides;
- data from TES on the efficacy of antimalarial treatments, the presence of drug-resistant parasites and treatment failure rates, guiding evidence-based updates to malaria treatment policies;
- data from supervision of health services (central, intermediate, health facility and health worker levels);
- financial data to track how resources are allocated, spent and managed for malaria programme activities; and
- contextual data, which are not collected routinely or during operational research but are useful for further understanding and explanation of changing trends in the malaria burden, and include population censuses and climate and socioeconomic data.

Data for programme monitoring are usually obtained from routine HMIS. Data from health facility and household surveys may complement those from routine systems (e.g. to compare values of indicators obtained in routine systems and health facility surveys). When routine systems work well, they can provide information continuously from every district or equivalent in a country and, if other factors are constant, they can be used to detect changes in intervention coverage over time and space or serve as alerts for a possible epidemic.

Incomplete coverage of health information systems can result in a biased sample of the services used by communities (see **Box 1** and **Box 6**). Often, they do not include private clinics and other nongovernment facilities or cases treated by village health workers or at home. In addition, routine systems seldom function optimally; there is often inconsistent application of reporting definitions and irregular reporting from health facilities and districts to central level. Trends in indicators of malaria burden and intervention coverage are therefore prone to variations in reporting rates. It is important to track the completeness of reporting, not only as an indicator of the functioning of the information system but also for interpreting trends in other indicators.

7.3 Roles of routine systems and surveys

Many data sources are used in monitoring and evaluating NMPs, including routine information systems, household and health facility surveys, sentinel sites and special data collection (Box 16). The role and relative importance of these data sources change as programmes proceed from high transmission to malaria elimination.

Box 16. Information obtained from routine health information systems, health facility surveys and household surveys

Routine health information systems capture information at the most granular spatial and temporal level possible on:

- trends in malaria cases and deaths
- health facility resources
- use of health services, and patients treated by CHWs
- distribution of commodities such as ITNs
- indicators of data quality, coherence and completeness.

Health facility surveys provide information on:

- the availability of staff, equipment and consumables
- verification of health facility service statistics (proportion of patients tested and treated with appropriate antimalarial medicines)
- the quality of case management.

Household surveys capture information on:

- population coverage of services (e.g. ITNs, ACTs)
- patients who do not use government health services
- population prevalence of infection or anaemia
- knowledge, attitude and practices with regard to malaria.

Sentinel sites and special studies provide information on:

- drug resistance and treatment efficacy
- entomological surveillance
- demographic surveillance.

7.3.1 Routine systems

In high-transmission settings, malaria accounts for a large proportion of attendance at health services, and key indicators to track clinical malaria information are captured within national HMIS. Where malaria is a notifiable disease, malaria cases are captured within the integrated disease surveillance and response component. Simple, efficient recording and reporting systems are required to track vector control activities, notably ITN distribution and IRS coverage; however, these are not typically recorded within routine surveillance systems. Systems are also required to track consumption of diagnostic tests and antimalarial drugs; for example, LMIS to manage stock levels, procurement, distribution and consumption of health commodities. In settings with

lower transmission or seeking to achieve elimination, malaria-specific reporting systems are required for the additional information demands for targeting and monitoring interventions in particular risk groups and foci.

7.3.2 Surveys

Information obtained from routine information systems is complemented by data from health facility and household surveys. Surveys can provide data on indicators that cannot be measured from programme data, particularly for indicators that require population-level denominators, such as coverage of interventions and parasite prevalence. Surveys can enrich the interpretation of information from routine systems, such as in ascertaining the percentage of patients with a febrile illness who attend public sector health facilities, thus providing information on the coverage of surveillance systems. Surveys may also be used to validate or triangulate data collected in routine systems. They also provide information on child mortality from all causes, which can be related to trends in malaria interventions, incidence and parasite prevalence to illustrate the potential impact of investment in malaria.

The design of surveys depends on the intensity of malaria transmission. In high-transmission settings, nationally representative surveys allow the assessment of programme coverage and parasite prevalence throughout the country. In settings with lower transmission, it may be preferable to survey only the populations at greatest risk *(24)*. Surveys in elimination settings should be limited to foci of transmission.

The relevance of indicators and the feasibility of obtaining information through a survey also depend on malaria transmission intensity. For example, the prevalence of parasites among children under the age of 5 years is a relevant indicator in high-transmission settings because they are at high risk for acquiring malaria. It is also practicable to obtain information on children under 5 years because they are more likely to be at home during a household survey and available for a malaria test. In low-transmission settings, measuring parasite prevalence in children under 5 years of age may be less informative because, in general, these children are not a high-risk group. It may therefore be preferable to determine the prevalence in all age groups in these settings, although it might be more difficult to obtain a representative sample of schoolchildren and working adults, because they may not be at home when a survey is done. When transmission is low, however, a much larger sample is required to measure prevalence, and household surveys are no longer cost-effective. The incidence of symptomatic cases is therefore determined from routine health information systems.

A decision about whether and when to measure parasite prevalence, and at which spatial level and in which age groups, depends on the potential benefits of obtaining the information and thus more precisely identifying the population groups most affected by malaria. These benefits should be weighed against the cost of the survey (i.e. the large sample required), the available diagnostic tools, whether specific population groups can be reached and the other uses to which such resources could be put.

7.4 Use of information

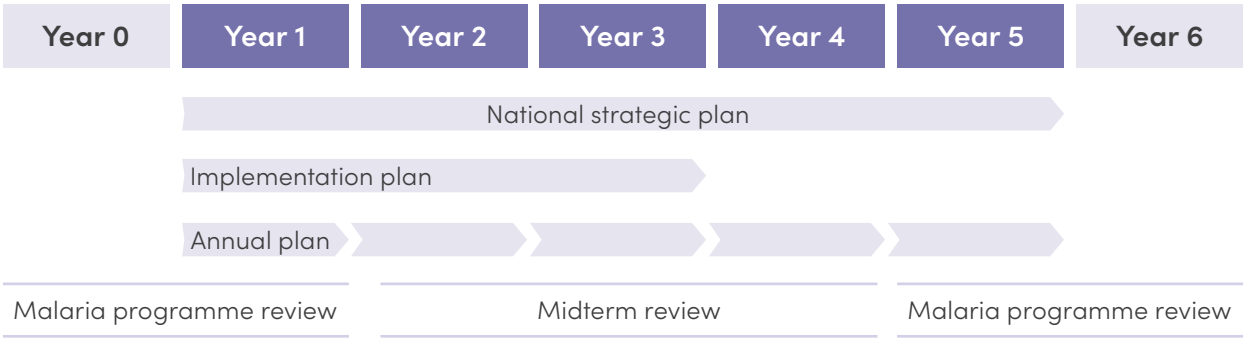
Malaria control may progress more rapidly in some parts of a country than in others, and the strategies for surveillance will vary. For example, some districts may report only aggregated cases, while others may add details of individual cases. Some parts of the country may be pursuing elimination and must identify the origin of each case to intensify control measures in specific localities and ensure that transmission is halted at the earliest possibly opportunity.

The information collected must be used to improve the impact of the programme. Two major uses of this information are for planning programmes and for monitoring and evaluating them.

7.4.1 Programme planning

A principal use of information is in preparing a national strategic plan that defines the goals and objectives of a malaria programme, how they will be achieved and the resources required. The plan should include the roles of different stakeholders in its implementation and set targets for monitoring progress and ensuring accountability. Resources should be allocated to the most effective interventions and to the populations in greatest need to maximize reductions in malaria incidence and mortality and minimize wastage of resources. An approach to optimizing responses to malaria in a country or territory is subnational tailoring of interventions, whereby the area is divided into smaller units in which different combinations of interventions and strategies are delivered to achieve maximum impact. A strategic plan for malaria typically covers 5 years (Fig. 25). It is usually preceded by a review of the malaria situation in the country to identify the population groups most severely affected by malaria, changes in disease incidence, coverage of malaria interventions, contextual factors and the most appropriate mixes of interventions and resources for achieving the targets, as discussed below.

Fig. 25. Time frame of a national strategic plan for malaria and programme reviews



Stratification and population at risk

Stratification is the process of geographically (and temporally) classifying malaria risk and its determinants into meaningful categories to inform the tailored targeting of the intervention under consideration. The methods to obtain each layer of information at the specified geographical and temporal unit of analysis can range from simple descriptive analyses to varying statistical and geospatial modelling approaches.

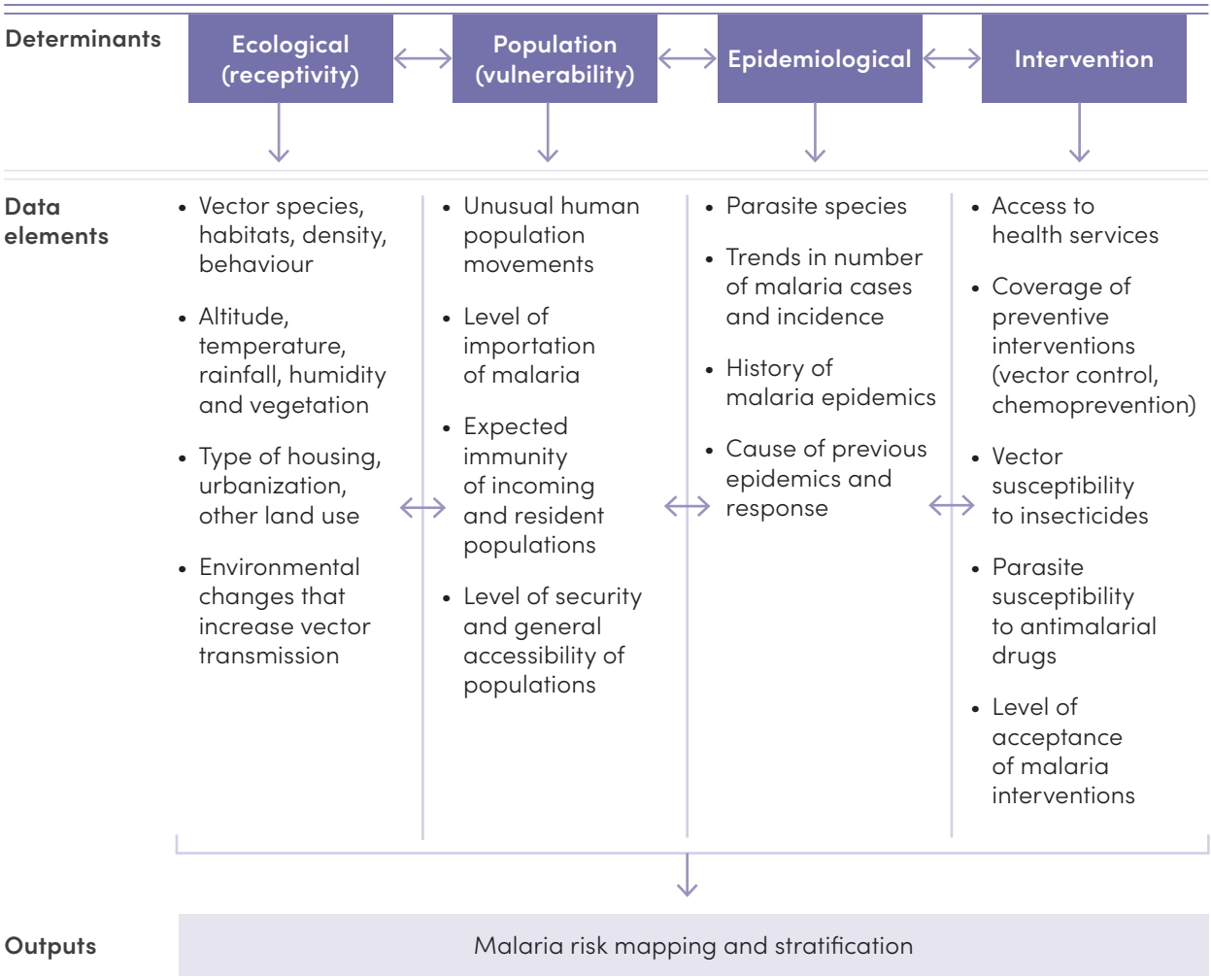
Understanding the baseline and the current risk of malaria is one of the key requirements to determine whether to implement or remove certain interventions at a given point in time. The baseline risk of malaria, defined as the level of malaria intensity observed before major effective malaria control measures were implemented in an area (the case in most countries in Africa before the year 2000), indicates the level of receptivity to malaria under the assumption that no major environmental modifications have taken place. Conversely, the transmission intensity levels observed in an area at present represent the transmission equilibrium reached in that area after the implementation of specific malaria control measures. Commonly stratified indicators of malaria risk include annual malaria incidence (crude or adjusted for factors that affect routinely collected data, such as access to care, reporting rates or testing rates), parasite prevalence, or all-cause under 5 mortality.

The stratification of other relevant malaria transmission determinants for decision-making is also important to subnationally tailor malaria interventions. Commonly stratified determinants include historical intervention coverage; entomological information (e.g. vector abundance, behaviour, insecticide resistance); temperature, rainfall and seasonality patterns; levels of urbanization and socioeconomic conditions (e.g. poverty and occupation); demographic factors (e.g. age and sex, presence of vulnerable populations); and access to health care (Fig. 26). This information can be presented as tables, graphs and maps.

The data elements and indicators stratified are determined by the targeting criteria for each intervention and strategy that a country is interested in implementing and subnationally tailoring. Intervention-specific criteria are defined based on the *WHO guidelines for malaria (34)* and adapted to the local context. Once all relevant layers of information are stratified, countries identify the areas eligible for each intervention according to the specified criteria, leading to the development of the most appropriate intervention mix to achieve optimum impact on transmission and burden of disease at the strategic level.

The costed strategic plan should then be used as the basis for rational prioritization of investments to maximize impact, if resources are insufficient. This can be done once there is clarity on the available resources, and it is usually the most challenging part of the process. Further stratification of determinants can be used to identify priority areas for one or several interventions, and additional prioritization scenarios may arise. Mathematical modelling can be helpful at this point to guide and assess the impact of the various prioritization decisions.

Fig. 26. Framework for stratifying malaria risk



An example of stratification of adjusted annual malaria incidence in Guinea and Togo can be found in Fig. 27. These maps, in combination with additional stratified information, informed the tailoring of specific interventions for their national strategic plan and the budgeted, prioritized, plan. Data and potential sources of data for stratifying malaria risk are listed in Table 14.

Understandably, malaria risks are affected by highly variable situations such as conflicts and complex emergencies that may lead to epidemics. These require a more dynamic approach, with several data elements for key determinants. Common geographical information system methods can be used to map epidemic risk with this framework. National programmes that do not have geographical information system capacity should consult WHO and local partners for assistance.

Fig. 27. District-level stratification by annual malaria incidence in Guinea and Togo

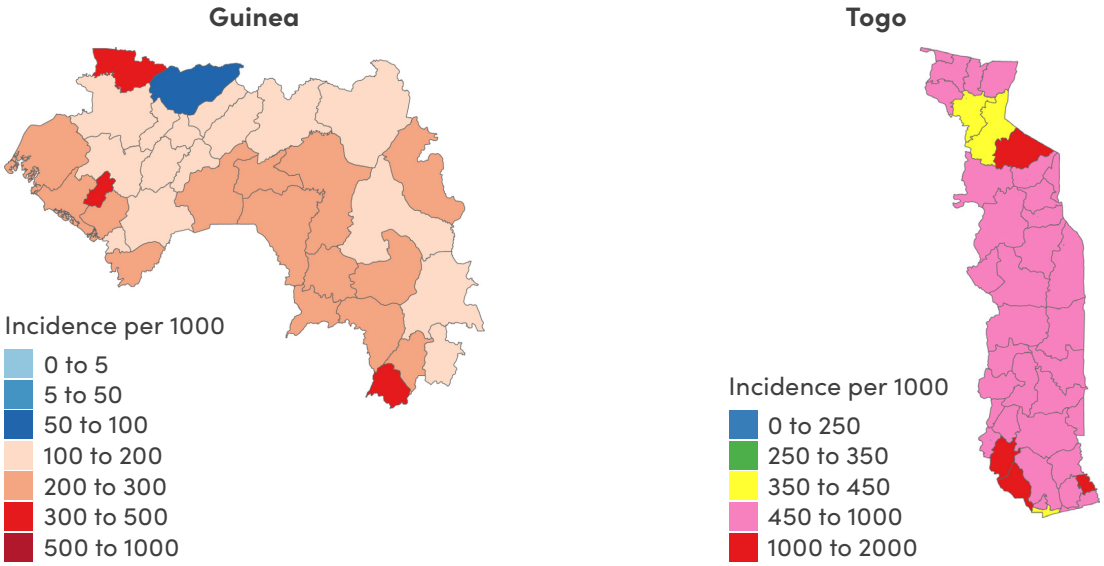


Table 14. Data elements and potential sources of data for stratifying malaria risk

Determinant	Data element	Data source
Ecological (receptivity)	Vector species, habitat, density	Entomological surveillance data
	Altitude, temperature, rainfall, humidity and vegetation	Meteorological offices, freely available satellite data
	Type of housing, urbanization	Household surveys, national censuses, relevant government ministries
	Rainfall and case seasonality patterns	Surveillance data, environmental agencies, satellite data
	Environmental conditions and changes that may increase transmission	Environmental agencies, satellite data, private sector, local communities
Population (vulnerability)	Unusual human population movement	Relevant government ministries, humanitarian agencies, local communities
	Level of importation of malaria	Surveillance data, humanitarian agencies, local communities
	Expected immunity of incoming and resident populations	Surveillance data, research institutions, malaria prevalence geospatial estimates
	Level of security and vulnerability of specific population groups	Relevant government ministries, humanitarian agencies, local communities
Epidemiological elements	Parasite species	Surveillance and other epidemiological data (including community surveys)
	Annual estimates and trends in prevalence, malaria cases, incidence and mortality in the area	Surveillance data
	History of malaria epidemics	Surveillance data
	Causes of previous epidemics and subsequent response	Past surveillance and response reports

Determinant	Data element	Data source
Intervention	Access to health services	Distribution of ministry of health facilities, latest information on antimalarial products, household surveys
	Coverage of preventive interventions (vector control, chemoprevention, immunization) and quality of care	National malaria programme intervention data, household surveys
	Vector susceptibility to insecticides	Entomological surveillance
	Parasite susceptibility to antimalarial drugs	Therapeutic efficacy surveillance, preventive efficacy studies

When interpreting geographical variation in routinely reported malaria incidence or mortality rates, account must be taken of the variation in the proportion of the population that uses public health facilities and that are seen by CHWs, the extent of diagnostic testing and reporting rates, and the number of new health facilities and CHWs that are operational. Hence, it may be useful to tabulate or map general patient attendance, annual blood examinations and health facility reporting rates with tables or maps of disease incidence and adjust crude incidence accordingly.

If available, data from household surveys can provide information on:

- whether and where patients seek care for fever and thus the extent to which routine surveillance systems capture all malaria cases;
- parasite prevalence, to identify the populations most severely affected by malaria; and
- particular risk factors associated with areas of higher incidence or mortality, including predominant vector and parasite species and population behaviour.

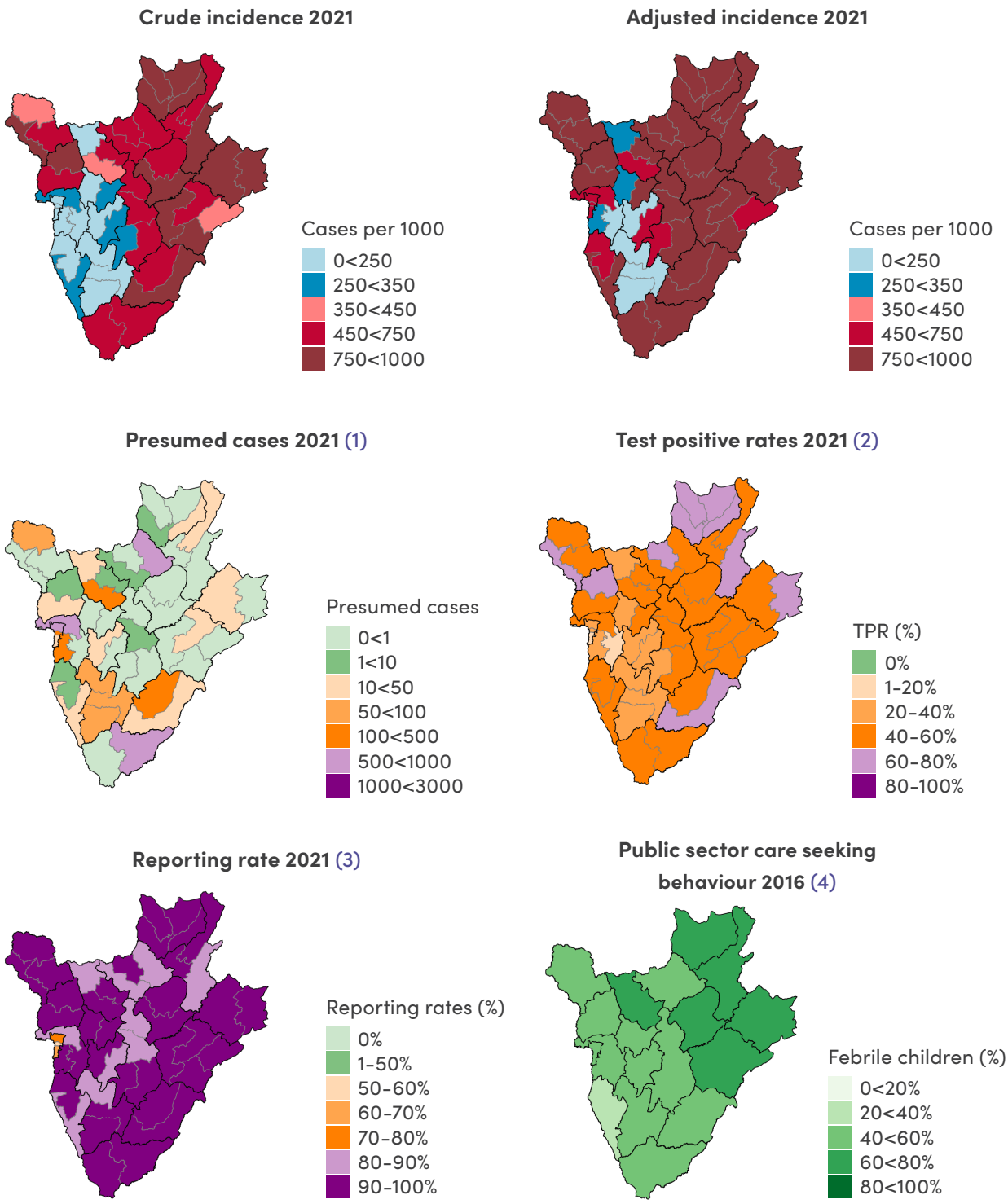
Fig. 28 presents the example of Burundi to show how the geographical distribution of malaria can be examined. Mapping of indicators allows programme managers to assess whether programme performance or malaria trends vary by geographical area and to determine whether malaria prevention, testing or treatment activities should be focused in certain areas. Regional differences in the crude reported numbers of cases and deaths due to malaria might reflect the underlying epidemiology, the extent of malaria interventions or care seeking and access, and diagnostic and case reporting practices.

In Fig. 28, the programme of Burundi explored the key indicators that affected the routine malaria data, and therefore crude clinical malaria incidence. The factors considered included:

1. number of presumed cases reported per district, as a representation of testing patterns;
2. test positivity rates observed per district, as an indication of the prevalence of infection among the untested cases;
3. reporting rates of confirmed malaria cases by the health facilities expected to report per district; and
4. proportion of children under 5 years of age who seek care for a fever in the public health sector.

After adjusting for all these factors, the adjusted clinical malaria incidence shows a different pattern of transmission compared to the crude incidence.

Fig. 28. Maps produced in 2022 for the subnational estimation of malaria incidence in Burundi using routine data from 2021 with care seeking behaviour information from the latest available survey at the time, from 2016



The administrative units shown on these maps correspond to the administrative divisions in effect prior to the change that took place on 1 July 2025, in Burundi.

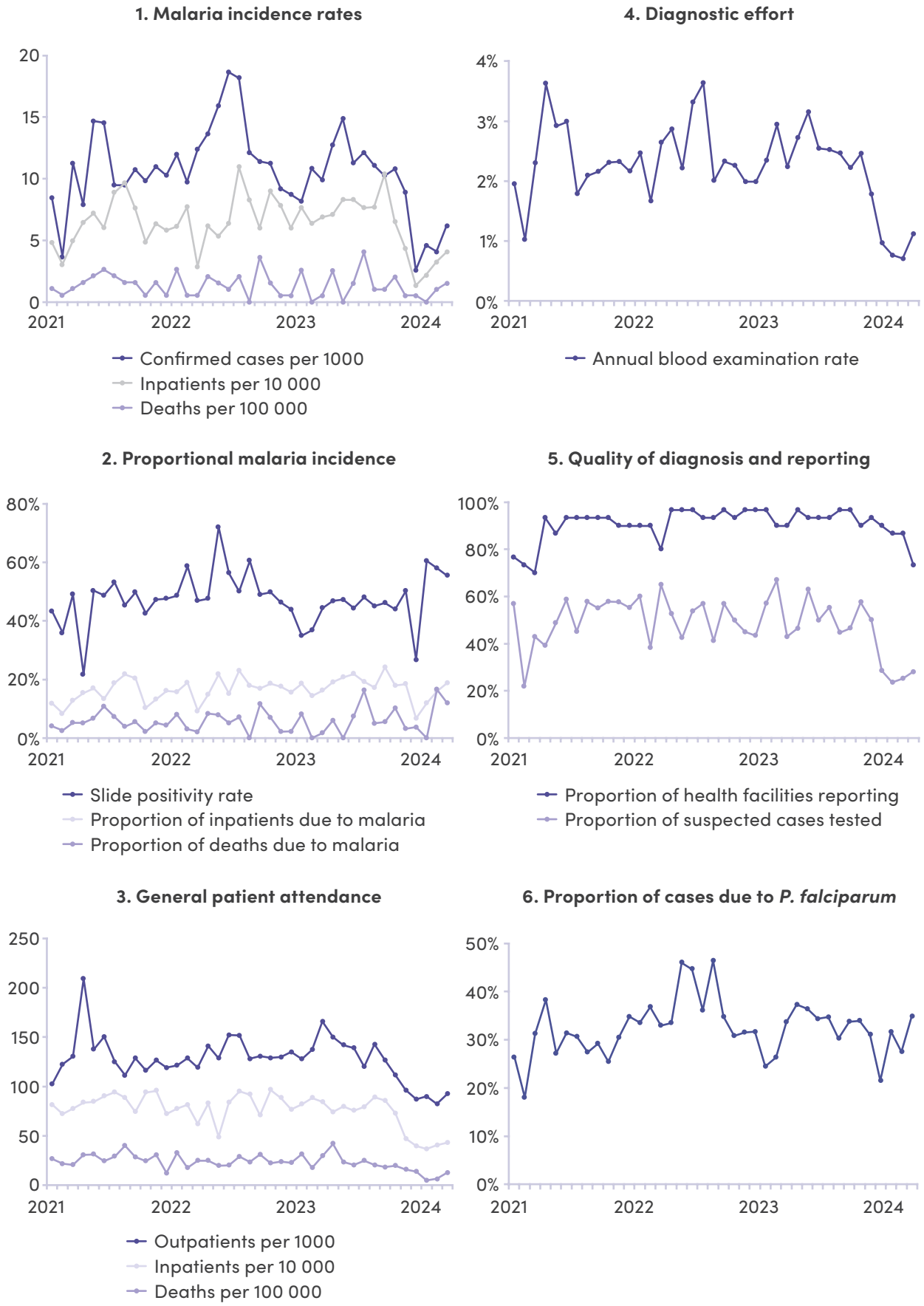
An example of a surveillance bulletin is provided in **Annex 15**.

Changes in disease incidence

Trends in the number of malaria cases, admissions and deaths reported may reflect changes in malaria transmission and disease incidence in the population. As trends can be influenced by changes in access to health services, diagnostic testing practices and health facility reporting, WHO recommends examining a set of six "control" charts that show not only changes in malaria incidence but also factors that might influence the observed trends (**Fig. 29**). If there are too many gaps in routinely reported data to assess trends in malaria, a study might have to be undertaken to retrospectively examine the records of patient attendance in a sample of health facilities. If available, data from ≥ 2 household surveys spanning the period of interest provide information on changes in care-seeking behaviour and parasite prevalence.

Fig. 29 shows various charts of malaria trends. It is useful to examine trends in general patient attendance, annual blood examination rate, health facility reporting rates and new health facilities with trends in malaria disease incidence. It is also useful to examine trends in test positivity rates or proportional malaria attendance, as these may be less distorted by changes in general patient attendance, diagnostic testing or health facility reporting rates. In the example in Fig. 29, there are fewer malaria cases, inpatients and deaths in the most recent months (graph 1); however, this trend could be due to less reporting and diagnosis in the same period (graphs 4 and 5). Such a pattern is common, suggesting that the timeliness of reporting should be improved. Furthermore, the proportion of patients with suspected malaria who receive a diagnostic test should be increased.

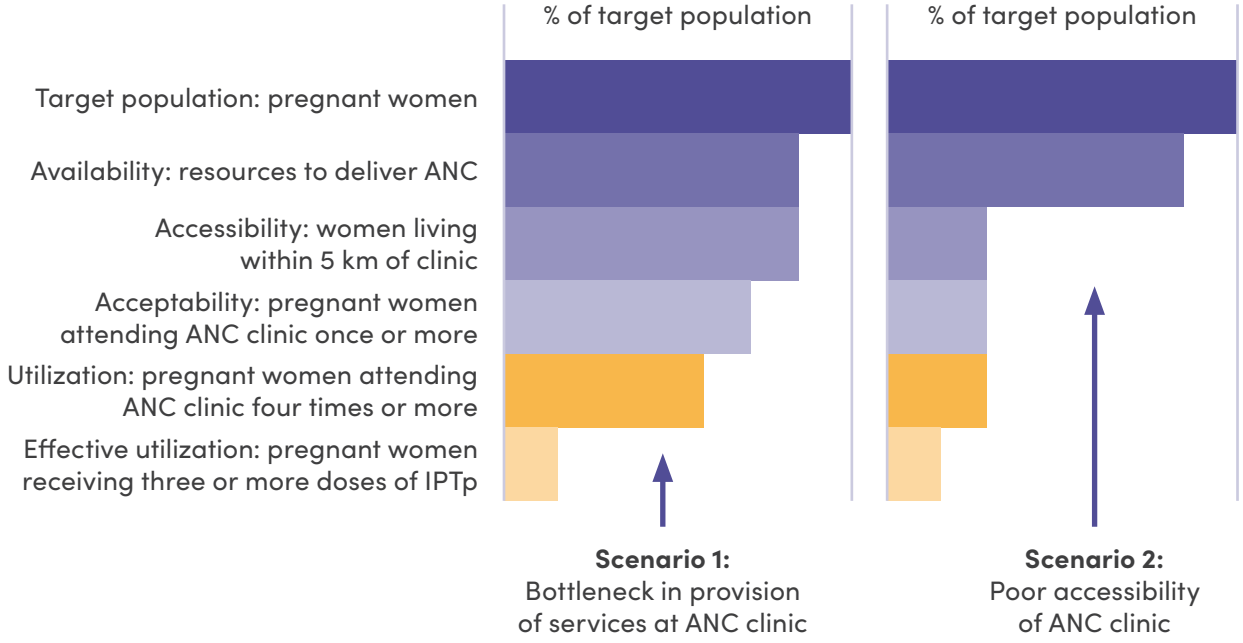
Fig. 29. Charts for analysis of malaria trends



Coverage of malaria interventions

Once appropriate interventions have been identified, it is useful to determine intervention coverage by geographical area or population risk group, to assess whether interventions have been implemented appropriately. It is also useful to examine different stages in the delivery of interventions to identify any bottlenecks that hinder service provision. In the two scenarios shown in Fig. 30, the proportions of pregnant women and girls receiving four or more doses of IPTp are the same – and low, but the reasons for the low coverage differ. In the scenario on the left, although use of ANC services is good, women do not receive multiple doses of preventive treatment, suggesting that the services offered at antenatal clinics should be improved. In the second scenario, access to antenatal clinics is poor, suggesting that more fixed or mobile antenatal clinics should be provided. Information on the coverage of malaria interventions can be obtained from routine reporting systems, household surveys and health facility surveys.

Fig. 30. Identifying bottlenecks in malaria programmes



ANC: antenatal care; IPTp: intermittent preventive treatment in pregnancy

Resources required and available for achieving programme targets

Information on programme financial resources should include both domestic and international financing, ideally at the subnational level. All malaria-specific expenditure should be included; for example, on commodities (e.g. ITNs, RDTs and ACT), equipment (e.g. microscopes and vehicles), staffing (malaria managers and indoor residual sprayers) and activities (e.g. training and supervision). If expenditure that is shared with other programmes can be readily apportioned to malaria programmes, they should be added to malaria-specific expenditures. If not, a focus on malaria-specific expenditures is often sufficient for assessing trends in malaria investments and their impact on programme coverage. It is also useful to examine programme financing by geographical area or population risk group.

7.4.2 Programme monitoring and evaluation

The national malaria strategic plan should be monitored at regular intervals to assess coverage of interventions and their impact, and determine whether programmes are proceeding as intended or adjustments are required. Managers at national level should review the indicators at least every quarter. Annual reviews should also be undertaken before budgets are prepared, mid-term reviews may be conducted to assess interim progress, and a final programme review should be undertaken before the next strategic plan is developed. The final malaria programme review (and mid-term review) benefits from data from health facility surveys, household surveys and other special studies; therefore, these surveys and studies should be timed to contribute to the review(s).

In reviewing indicators, managers should ask specific questions regarding the progress of malaria programmes. The precise questions will depend on the local operational context *(82)*, but are likely to include the following:

- Are programme coverage targets being met, or are particular interventions (e.g. target for percentage of suspected cases tested) experiencing problems? Are there stock outs of commodities?
- Have there been important changes in the values of indicators over time? For example, has there been a decrease in the number of children receiving ITNs through immunization clinics? Of particular interest is whether the numbers of cases and deaths are being reduced or whether problems are being experienced in some locations, necessitating modification of the programme. Managers should also be alert to potential epidemics.
- Are there particular bottlenecks in the delivery of services? For example, is there a large difference in the number of pregnant women and girls receiving first and third doses of IPTp?
- Are some health facilities or geographical areas experiencing problems (e.g. low testing rate, prescription of inappropriate drugs, low reporting rates) and why (e.g. due to inadequate and inconsistent staff training)?
- Is the surveillance system working well, or are there problems in case detection, reporting completeness, timeliness and coverage, or registration of foci?
- Are there management and human resource challenges at all levels of the programme?

These questions can be answered easily if data are presented in such a way that indicators can be compared with targets, across time, with other indicators and between geographical areas. Other comparisons may also be informative; for example, those between different types of facilities or providers of services.

Managers at health facility and district levels should review indicators each month, or more frequently in the case of elimination. Feedback on the status of selected key indicators should be communicated to districts and health facilities weekly, monthly or quarterly, depending on the epidemiological context, and should include private health facilities when possible. Data-informed action plans should be routinely developed and operationalized at all relevant decision-making levels.

Health facility and intermediate-level (e.g. district) teams should be engaged in data analysis, presentation and interpretation to improve their involvement, performance and programme capacity. Data should be summarized in ways that allow staff in health facilities and districts to readily assess their facilities' performance. Data may be presented on a dashboard, by ranking districts or facilities or by colour-coding indicators according to their value.

Programmes should not be monitored only by malaria programme managers and implementers. Other government departments, elected leaders, community members and donors have a stake in ensuring the high quality of malaria programmes and should be able to assess the operations they are supporting. When these stakeholders are involved in the review process, they can help to ensure that malaria programmes are responding to the population's needs and that malaria control and elimination are promoted as a development priority.

7.4.3 Monitoring and evaluation of surveillance systems

Surveillance systems that function well are the backbone of effective malaria interventions at all levels of transmission intensity. Surveillance systems support planning, budgeting, evaluation and tracking of programme activities and monitoring of disease trends. The better the surveillance system, the more likely it is that a programme will have an impact for the resources invested.

The purpose of monitoring and evaluating surveillance systems; done systematically by carrying out a surveillance assessment, is to identify key surveillance gaps, evaluate the ability of the surveillance system to collect complete, timely and accurate data on malaria cases and deaths and identify the bottlenecks that impede the efficiency and effectiveness of the surveillance system. The results of malaria surveillance assessments can be used to provide actionable and prioritized recommendations on how to strengthen surveillance systems and update or develop national, and subnational, strategic and operational plans. In elimination settings a surveillance assessment can help the country to prepare documentation and check the quality of data prior to certification.

Monitoring and evaluation involves a critical assessment of the performance of a surveillance system, contextual and technical attributes, and behavioural aspects (**Table 16**).

Monitoring and evaluation of surveillance should be used to determine whether the objectives and approaches defined in the national surveillance SOP have been achieved. The SOP should include the broad governing structures of the surveillance system, the processes, sources of information, methods and frequency of data collection, data quality and analysis and use of information and should be specified in the monitoring and evaluation plan.

7.4.4 Malaria Surveillance Assessment Toolkit

The Malaria Surveillance Assessment Toolkit was launched by WHO in August 2022 *(13)* and comprises a set of standardized tools (Table 15) and a step-by-step implementation reference guide *(83)* to help countries assess the ability of the malaria surveillance system, or integrated disease surveillance system, to accurately capture malaria cases and deaths across all transmission settings, and use data for decision-making.

Table 15. Contents of the Malaria Surveillance Assessment Toolkit

Function	Tools and features	Accessed through platform	Description
Define scope	Assessment Framework	Yes	A set of key objectives, subobjectives and indicators that can be used to quantify and qualify strengths and weaknesses in the surveillance system. This framework should be used as the starting point in an assessment to define the scope of the assessment, the approach and the indicators to be included.
	Concept note and protocol	No	A template for the outline of a short concept note for refining the scope, methods, expected outputs and outcomes of an assessment, and a more detailed protocol outline required for comprehensive assessments.
	Surveillance assessment planning tool	No	A budgeting template to assist countries in developing a costed plan to undertake a comprehensive assessment.
Collect and analyse data	Desk Review Tool	Yes	A set of questions, tables, graphics and diagrams used to collect information and summarize what is known about malaria surveillance through document and data review, and optional interviews with surveillance programme staff and other relevant supporting partners. Priority indicators are automatically assigned a score as met, partially met or not met based on a defined set of criteria which differs for each indicator. Information is included on how to assess each indicator.
	Data quality assessment and analysis tools	Yes	Tools and guidance for collecting and analysing data to specifically assess data quality at national, regional, district and service-delivery levels.
	Question Bank	Yes	A library of questions that can be used to develop survey questionnaires for data collection at regional/district, service-delivery and community levels. Anonymous self-assessment questionnaires are also included for some indicators. Questionnaires are automatically generated and exported based on the questions selected from the question bank. A set of shell tables in Microsoft Excel that are used to summarize the results of analysis from the survey. Shell tables are automatically generated based on the selected questions.

Function	Tools and features	Accessed through platform	Description
Develop and prioritize recommendations	Technical brief and report outline Visual tools	No	A report template for organizing, visualizing and interpreting results from the assessment. A technical brief is used to highlight a subset of priority results, whereas the report includes all assessment results.
	Scorecard	Yes	A scorecard capturing whether assessed priority indicators have been met, partially met or not met from the desk review, DQA and the survey. Overall scores are also provided for subobjectives and objectives.
	Dashboards	Yes	Dashboards are automatically generated from the scorecard to compare indicators between countries (country dashboard), subobjectives between WHO regions (regional dashboard) and objectives between countries (global dashboard). Countries may opt out from having their data displayed on these shared dashboards.

The toolkit is based on an assessment framework consisting of four objectives: (1) measure the system's performance, (2) assess context and infrastructure, (3) assess technical and processes and (4) assess behavioural aspects of malaria surveillance that affect performance (Table 16). Each objective has a set of associated subobjectives and a standardized set of indicators used to measure the performance of the surveillance system. Users can select indicators, which provides countries with the flexibility to tailor the assessment to the country context and the transmission setting. Each assessment, however, must include a minimum set of priority indicators which provides a set of standard outputs that can be compared between different regions within countries, between countries, and over time. The toolkit also provides a high-level assessment of malaria control interventions and strategies (including entomological surveillance) with the purpose of understanding what information is collected, and whether all relevant data are integrated and used along with routine surveillance data on malaria cases and deaths.

Table 16 provides the complete list of tools that can be used as part of broader HMIS assessments. The toolkit has been designed to enable countries to conduct different types of assessments:

1. a rapid assessment is focused on priority indicators and primarily done at the national level;
2. a tailored assessment includes priority indicators and a few context-specific, additional indicators; and
3. a comprehensive assessment is a longer review, including both a desk review and a survey to assess indicators at multiple levels of the health system.

Table 16. Overview of the Assessment Framework

Objective or sub-objective	Name	Description	Number of indicators
	Malaria surveillance outputs/performance		
1	**Performance**	**Measure the performance of the surveillance system**	**30**
1.1	Surveillance system coverage	Assess whether malaria cases and deaths are accurately captured by surveillance at each level of the health system	9
1.2	Data quality	Measure the quality of data collected at the service-delivery level, and reported to subnational and national levels (completeness, timeliness, concordance and consistency)	14
1.3	Data use	Identify evidence of data-informed programme planning and use of data for decision-making	7
	Malaria surveillance inputs/determinants of performance		
2	**Context and infrastructure**	**Describe and evaluate contextual and infrastructural aspects of the surveillance that may influence performance. This includes an assessment of health sectors reporting, whether minimum data are captured for malaria control and interventions and strategies implemented in the country, information systems used, availability of and adherence to guidelines, human and financial resources, and infrastructure.**	**17**
2.1	Surveillance sectors and strategies	Describe surveillance for malaria control strategies and sectors reporting core indicators at each level of the health system, and evaluate definitions and algorithms used	4
2.2	Information systems	Describe information systems used for malaria surveillance, and evaluate their flexibility, acceptability, functionality and interoperability/integration	6
2.3	Guidelines and SOPs	Evaluate the availability and content of key documents (guidelines, procedures, manuals and regulations) for malaria surveillance	2
2.4	Resources	Identify the staff, equipment and infrastructure required for malaria surveillance, and evaluate what is available at all levels of the health system	4
2.5	Financial support	Describe the budget available for malaria surveillance and identify any gaps	1
3	**Technical and processes**	**Describe and evaluate processes and technical aspects of the surveillance system that may influence performance. This includes assessing processes, tools and personnel involved with the flow and use of data, from recording to response.**	**22**
3.1	Case management	Evaluate case management, including standardized use of case definitions and adequate commodities for testing and treatment	3

Objective or sub-objective	Name	Description	Number of indicators
3.2	Recording	Describe and evaluate the data recording processes (e.g. tools, personnel and frequency for each point-of-care type)	4
3.3	Reporting	Describe and evaluate the flow of information through the surveillance system (e.g. tools, personnel and frequency at each level of the health system)	5
3.4	Analysis	Describe and evaluate the analysis process and expected outputs	3
3.5	Quality assurance	Describe and evaluate the activities, feedback processes and mechanisms in place to ensure data quality (e.g. data cleaning, supervision, data quality assessments, data review meetings, checking for duplicates and internal consistency)	4
3.6	Data access	Describe and evaluate access to data in the surveillance system (e.g. accessing database or requesting access, personnel, frequency)	3
4	**Behaviour**	**Describe and evaluate behavioural aspects of the surveillance system that may influence performance. This includes assessing governance structures and promotion of an information culture, as well as proficiency, motivation and accountability of staff involved in malaria surveillance within a country.**	**12**
4.1	Governance	Determine the governance structures in place for malaria surveillance, including documented planning, targets, organizational structure and external oversight	3
4.2	Promotion of an information culture	Determine the processes in place to promote a culture of data use and resulting perceptions among surveillance staff (e.g. whether staff are encouraged to use data, whether staff are motivated to produce quality data)	2
4.3	Supervision	Describe and evaluate the processes in place for supervision and management of surveillance staff	3
4.4	Surveillance staff proficiency	Determine the processes in place and resulting perceptions of job competence among surveillance staff (e.g. whether staff are competent in designated surveillance tasks; how staff gain competence, such as through training and job aids)	4

SOP: standard operating procedure.

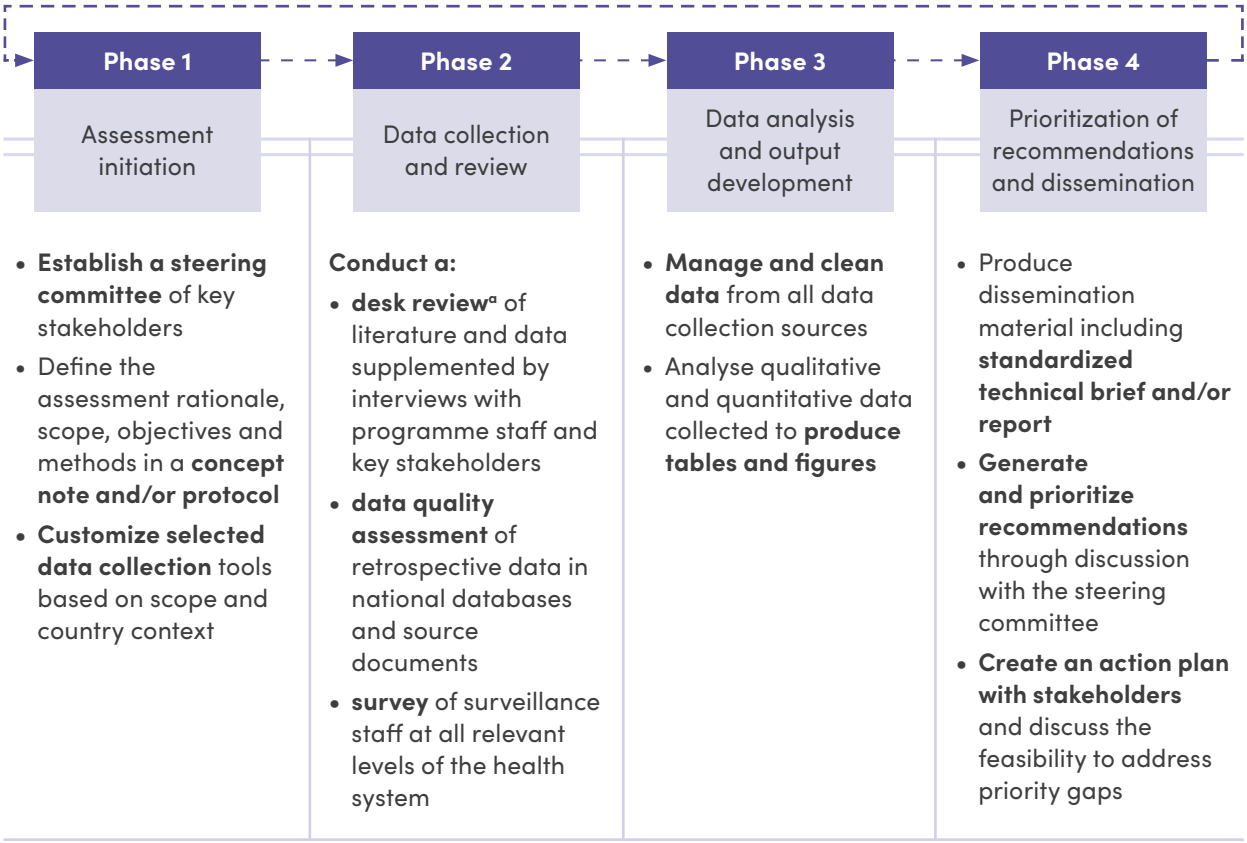
All assessments include a data quality assessment, which is a critical component. Guidance and tools to assess the quality of malaria indicators are provided (this complements broader data quality assessments for HMIS) *(84)*. Once the assessment type and indicators have been selected, the content of the tools is automatically selected to capture information only on those indicators.

The comprehensive assessment is more resource intensive in terms of time (9–12 months), money and human resources compared with a rapid assessment (4 weeks to 4 months). The type of assessment that can be conducted will depend on the resources available. To make this decision, countries should first determine the purpose of the assessment; for example, to get a rapid overview of key gaps and challenges, which will allow high-level planning and budgeting for surveillance system strengthening, or to have a more in-depth understanding of challenges with performance at local levels, which will assist in the development of tailored subnational strategic and operational plans to address specific issues. In elimination settings, surveillance assessments can be used as part of subnational verification or as evidence of robust systems and good data quality which are required for certification. The purpose of the assessment should help countries to plan for the required resources in advance.

A malaria surveillance assessment should be implemented in a country in four phases, as described in **Fig. 31**. During planning, decide on the scope of the assessment and the general timing, and explore the broad resource requirements for the assessments. The preparatory stage includes deciding on the indicators to be measured and the assessment protocol, methods and tools. Quantify in greater detail the resources required according to the type of assessment, and identify people to conduct the assessment. The assessment should be led by the NMP, but a steering committee should be established consisting of key stakeholders and supporting partners to ensure technical rigour and follow-up activities in terms of financial and technical support.

The initial assessment stage (for all types of assessments) includes a desk-level assessment at the national level, in which documents and data are reviewed and a data quality assessment is carried out on data extracted from the national surveillance databases. The desk review will often also require interviews with NMP staff and with other governmental staff responsible for HMIS, integrated disease surveillance and response and vital registration as well as with other nongovernmental organizations or organizations involved in malaria surveillance. A comprehensive assessment includes a survey implemented at the service-delivery and subnational levels, consisting of a questionnaire and a data quality assessment where data extracted from the national surveillance system is compared with source documents at the service-delivery level, for example, outpatient department, inpatient department or laboratory registers. The survey is carried out at randomly sampled sites, based on a defined sampling frame, which means results are nationally representative. Following the survey data cleaning, verification and analysis are required to produce final graphs, tables and maps for interpretation and translation of results into actionable recommendations.

Fig. 31. Implementation phases of a malaria surveillance assessment conducted using the toolkit



[a] The desk review may begin in phase 1 to inform the protocol or concept note.

At the final stage, a summary report of the assessment is prepared, which includes the background of the evaluation, objectives, methods, results, conclusions and recommendations. The recommendations can be prioritized in terms of impact and feasibility of implementation. The steering committee and all relevant stakeholders involved in next steps should be part of the recommendation iteration process. Recommendations should be focused on activities that will strengthen surveillance for decision-making that is most relevant for malaria programmes. Examples of how results from surveillance assessment have been used include:

- in Burkina Faso, findings about fragmented datasets informed the design of a malaria repository and custom dashboards; and
- in the Democratic Republic of the Congo, findings about overreporting of cases informed scale-up of routine data quality assessment processes and training *(85)*.

The status of surveillance systems should be assessed periodically – at least every 2–5 years in settings in which the burden of malaria is being reduced, and once a year in elimination settings, if not more frequently. This will provide input for effective systems for surveillance, monitoring and evaluation. It is recommended that an assessment is implemented as part of key NMP planning milestones such as a malaria programme review and development of a national strategic plan. This is to ensure that key recommendations and associated activities for surveillance system strengthening are adequately prioritized and resourced by incorporating them into national strategic plans and funding applications.

7.5 Recommended indicators on the continuum to elimination

This document defines priority indicators that can be used to track progress towards malaria programme targets. **Annex 19** outlines a comprehensive set of priority indicators for malaria surveillance, monitoring and evaluation. Each indicator is clearly defined with specified numerators (e.g. confirmed cases) and denominators (e.g. population at risk), where applicable, and draws data from sources such as routine health registers and population data. Suggested disaggregations such as age, sex and geography are provided. The indicators are designed for use at district or operational unit levels. These indicators aim to monitor trends, assess intervention impacts, and identify high-risk populations, thereby supporting targeted and effective malaria control and elimination efforts. **Table 17** provides a shorter list of critical indicators required specifically for monitoring trends in malaria cases and deaths. Data sources, relevant transmission setting and the purpose of each indicator are included.

Table 17. Recommended indicators for monitoring progress on the continuum to elimination[a]

Indicator name	Definition	Numerator	Denominator	Data sources[b]	Transmission setting[c]	Purpose
Incidence						
Malaria incidence	Number of confirmed malaria cases during a predefined period (usually 1 year) per 1000 population at risk	Number of confirmed malaria cases x 1000	Number of people at risk for malaria infection during 1 year	N: Routine outpatient, outpatient + inpatient, or laboratory registers D: Census and population projections	Burden reduction and elimination	Tracks morbidity over time and across areas, informing intervention targeting and effectiveness measurement.
Inpatient malaria incidence	Number of malaria cases admitted as inpatients during a predefined period (usually 1 year) per 10 000 population at risk	Number of inpatient malaria cases x 10 000	Number of people at risk for malaria infection during 1 year	N: Routine inpatient register D: Census and population projections	Burden reduction and elimination	Tracks trends and burden of severe malaria, informing targeting of resources needed to manage severe disease. Tracks health facility case fatality rate when used together with inpatient malaria deaths. Measures the success of vaccination in preventing severe disease in defined age groups when used together with vaccination coverage.
Confirmed malaria cases	Number of malaria cases in which the parasite has been detected by a diagnostic test (i.e. microscopy or RDT)	Number of positive microscopy cases + number of positive RDT cases	None	N: Routine outpatient, outpatient + inpatient, or laboratory registers	Burden reduction and elimination	Tracks morbidity and incidence, informing targeting and response. In the latter stages of elimination, where cases are less than 10 000 per year for example, it is advisable to use absolute numbers of confirmed cases instead of incidence rates.

Indicator name	Definition	Numerator	Denominator	Data sources[b]	Transmission setting[c]	Purpose
Presumed malaria cases	Number of cases suspected of being malaria that are not confirmed by a diagnostic test Diagnosis is based on clinical symptoms and cases are subsequently treated with antimalarials. The term "presumed malaria case" is used only when a parasitological diagnostic test cannot be performed. In such instances, cases are diagnosed and treated with an antimalarial based on clinical evaluation. This differs from suspected malaria cases, where individuals are considered by a health worker to possibly have malaria but still require further assessment and testing for confirmation	Number of presumed cases Or Total malaria cases (confirmed + presumed) – number of confirmed malaria cases	None	N: Routine outpatient register	Burden reduction	Where parasitological diagnosis is not consistently available, tracks stock outs of tests, total malaria cases treated and diagnostic rate, and helps adjust total cases using testing rates (test positivity rate x presumed cases). Note: clinical suspicion should be based on national guidelines and could include fever and/or the presence of other malaria symptoms.
Total malaria cases (confirmed + presumed)	Malaria cases (confirmed and presumed) from all reporting sectors (public/private/community) throughout the country	Number of presumed cases + number of confirmed cases	None	N: Routine outpatient, outpatient + inpatient, or laboratory registers	Burden reduction and elimination	Tracks morbidity and informs targeting and response.
All-cause outpatients	Patients attending an outpatient department for any cause, including malaria	Number of all-cause outpatients	None	N: Routine outpatient register	Burden reduction and elimination	Tracks the number of patients attending outpatient departments, which can indicate an increase in malaria cases that is due to an increase in all-cause outpatients (e.g. as a result of improved access to care) or due to an increase in another illness which may have symptoms similar to malaria.

Indicator name	Definition	Numerator	Denominator	Data sources[b]	Transmission setting[c]	Purpose
All-cause inpatients	Patients admitted to hospital for any cause, including malaria	All-cause admissions or discharges	None	N: Routine inpatient register	Burden reduction and elimination	Tracks changes in severe disease trends. If severe malaria trends change while non-malaria severe diseases remain stable or exhibit a different trend, it suggests other factor, such as transmission intensity, are influencing malaria trends.
Mortality						
Malaria mortality rate	Malaria deaths per 100 000 people per year	Number of deaths due to malaria x 100 000	Number of people at risk for malaria infection during reporting year	N: Routine inpatient register or data from a well-functioning vital registration system including all deaths (hospital and community) D: Census and population projections	Burden reduction and elimination	Tracks malaria mortality trends (comparing them with other causes of death). Tracking under-five mortality is key to assessing the impact of malaria vaccines. Note: while most countries report only hospital deaths, ideally all malaria deaths (hospital and community) should be counted.
Deaths from indigenous malaria cases	Deaths resulting from malaria cases acquired locally with no evidence of importation and no direct link to an imported case	Number of indigenous deaths	None	N: Case investigation form	Elimination and prevention of re-establishment	Tracks progress towards certification.
Diagnostic testing						
Proportion of suspected malaria cases tested	Proportion of patients with suspected malaria who received a parasitological test (microscopy or RDT)	Number of suspected malaria cases who received a parasitological test (microscopy or RDT)	Number of suspected cases of malaria	N and D: Routine outpatient, outpatient + inpatient, or laboratory registers	All	Low testing coverage indicates weak quality of care and surveillance, helping identify health facilities where additional tests, human resources or training for diagnostics are needed. Note: a key goal of the NMP should be to ensure all cases are parasitologically diagnosed.

Indicator name	Definition	Numerator	Denominator	Data sources[b]	Transmission setting[c]	Purpose
Test positivity rate	Proportion of positive results among all tests performed by microscopy or RDT	Number of microscopy and RDT positive malaria cases	Number of people tested with microscopy or RDT	N and D: Routine outpatient , outpatient + inpatient, or laboratory registers	Burden reduction and elimination	Helps assess malaria transmission, surveillance quality and case detection. A high test positivity rate suggests ongoing transmission or underdiagnosis, while a decline may indicate improved control. Test positivity rate highlights diagnostic and treatment gaps, guides intervention strategies and allows for trend comparisons.
Proportion of *P. falciparum* cases	Proportion of malaria cases caused by *P. falciparum*, detected by RDT or microscopy	Number of malaria cases due to *P. falciparum*	Total confirmed malaria cases with a known species	N and D: Routine outpatient , outpatient + inpatient, or laboratory registers	All countries with other *Plasmodium* species in addition to *P. falciparum* detected	Tracks the proportion of *P. falciparum* cases. As transmission declines in areas with both *P. falciparum* and *P. vivax*, *P. falciparum* cases decrease first due to easier control.
Proportion of *P. vivax* cases	Proportion of malaria cases caused by *P. vivax*, detected by RDT or microscopy	Number of malaria cases due to *P. vivax*	Total confirmed malaria cases with a known species	N and D: Routine outpatient, outpatient + inpatient, or laboratory registers	All countries with *P. vivax* cases detected	Tracks the proportion of *P. vivax* cases. As transmission declines in areas with both *P. falciparum* and *P. vivax*, *P. falciparum* cases decrease first due to easier control. Over time, the focus shifts to *P. vivax* control.
Case and foci investigation						
Proportion of confirmed cases notified	Proportion of confirmed malaria cases notified to national level within X days after confirmation (X being defined in the national guideline) out of total number of confirmed malaria cases through PCD	Number of cases notified in X days	Total number of confirmed malaria cases reported through PCD	N: Case notification form D: Routine health information or surveillance system	Elimination and prevention of re-establishment	Tracks programme surveillance readiness to ensure all cases are notified for follow-up where relevant. Note: immediate notification is a crucial requirement in elimination settings.

Indicator name	Definition	Numerator	Denominator	Data sources[b]	Transmission setting[c]	Purpose
Proportion of confirmed cases investigated	Proportion of confirmed malaria cases investigated within X days after confirmation (X being defined in the national guideline) out of total number of confirmed malaria cases through PCD	Number of confirmed malaria cases investigated within X days after confirmation	Total number of confirmed malaria cases reported through PCD	N: Case investigation form D: Routine health information or surveillance system	Elimination and prevention of re-establishment	Tracks the programme's ability to follow up on cases, identify transmission foci and implement interventions. Note: this indicator reflects national surveillance strength. Completing health facility forms is the first step in case investigation. Since case investigations are challenging, they should be prioritized when case numbers are low.
Proportion of cases classified	Proportion of cases classified as indigenous/introduced/ imported/induced/relapsing/ recrudescent out of all confirmed cases	Number of confirmed cases classified	Total number of confirmed malaria cases reported through PCD	N: Case investigation form D: Routine health information or surveillance system	Elimination or prevention of re-establishment	Tracks whether malaria cases are locally transmitted or imported, informing focus classification, response strategies and malaria-free certification. Note: this is a key elimination indicator. Periodic independent assessments ensure accurate classification. A country is eligible for certification after 3 consecutive years of zero indigenous cases.
Number of cases classified as indigenous/ imported/ introduced/ induced/ relapsing/ recrudescent	Number of cases classified as indigenous/imported/ introduced/induced/relapsing/ recrudescent	Number of cases classified	None	N: Case investigation form	Elimination and prevention of re-establishment	Tracks whether malaria cases are locally transmitted or imported, guiding focus classification, response efforts and malaria-free certification. Note: this is a key elimination indicator. Periodic independent assessments ensure accurate classification. A country becomes eligible for certification after 3 consecutive years of zero indigenous cases.

Indicator name	Definition	Numerator	Denominator	Data sources[b]	Transmission setting[c]	Purpose
Proportion of foci with response	Proportion of foci detected as new and investigated within X days after confirmation (X being defined in the national guideline) out of all foci detected as new	Number of foci with response within X days of diagnosis	Total number of foci detected as new (eligible for response)	N and D: Foci investigation data	Elimination	Tracks the timeliness of focus response based on national SOPs.
Treatment						
Proportion of malaria cases treated with a first-line treatment course	Proportion of patients with confirmed malaria who received first-line antimalarial treatment according to national policy	Number of patients with confirmed malaria who received first-line antimalarial treatment according to national policy	Total malaria cases, found by both passive and active surveillance	N: Routine outpatient data, routine health information or surveillance system, health facility surveys. D: Routine surveillance system	All	Tracks case management practices to identify areas needing additional training and resources. Note: proper malaria treatment is crucial for outcomes, preventing uncomplicated cases from progressing to severe disease and death.
Proportion of *P. vivax* cases treated with primaquine (or tafenoquine)	Proportion of *P. vivax* cases treated with primaquine (or tafenoquine) out of all *P. vivax* infections	Number of *P. vivax* cases treated with primaquine (or tafenoquine)	Number of *P. vivax* cases	N and D: Routine health information or surveillance system	Burden reduction and elimination	Tracks case management practices to identify areas needing additional training and resources. Note: proper malaria treatment is crucial for preventing progression to severe disease and death.
Proportion of inpatient malaria cases that received appropriate malaria treatment according to the national guidelines	Proportion of inpatient malaria cases that received appropriate malaria treatment according to the national guidelines	Number of inpatient malaria cases that received appropriate treatment	Number of inpatient malaria cases	N and D: Routine health information or surveillance system	All	Tracks case management practices to identify areas needing additional training and resources. Note: proper malaria treatment is crucial for preventing progression to severe disease and death.

Indicator name	Definition	Numerator	Denominator	Data sources[b]	Transmission setting[c]	Purpose
Commodities						
Proportion of health facilities without stock outs of RDTs	The percentage of health facilities that did not experience a stock out of malaria diagnostics (RDTs or microscopy supplies) during a specified reporting period (e.g. past 3 or 6 months)	Number of health facilities without stock outs of RDTs during the reporting period	Total number of health facilities reported	N and D: Routine health information or surveillance system, LMIS	Burden reduction and elimination	Tracks stocks and identifies areas for improving stock management. Tracks overall readiness of health facilities to diagnose malaria
Proportion of health facilities without stock outs of antimalarials	The percentage of health facilities that did not experience a stock out of first-line antimalarial treatments (e.g. ACTs) during a specified reporting period (e.g. past 3 or 6 months)	Number of health facilities without stock outs of antimalarials during the reporting period	Total number of health facilities reported	N and D: Routine health information or surveillance system, LMIS	Burden reduction and elimination	Tracks case management practices to identify areas needing additional training and resources. Note: proper malaria treatment is crucial for preventing progression to severe disease and death.
Proportion of health facilities without stock out of ITNs	The percentage of health facilities that did not experience a stock out of ITNs during a specified reporting period (e.g. past 3 or 6 months)	Number of health facilities without stock outs of ITNs during the reporting period)	Total number of health facilities reported	N and D: Routine health information or surveillance system, LMIS	Burden reduction and elimination	Tracks case management practices to identify areas needing additional training and resources. Note: proper malaria treatment is crucial for preventing progression to severe disease and death.
Vector control						
Proportion of households with at least one ITN for every two people	Proportion of households surveyed that own at least one ITN for every two people	Number of households with at least one ITN for every two people	Total number of households surveyed	N and D: Household survey	Burden reduction and elimination	Measures the proportion of households with enough ITNs to protect all members. Used alongside ITN ownership to assess gaps in coverage. Large gaps may indicate the need to revise distribution strategies. Geographical analysis helps target and refine control efforts.

Indicator name	Definition	Numerator	Denominator	Data sources[b]	Transmission setting[c]	Purpose
Proportion of population that slept under an ITN the previous night	Proportion of surveyed population that slept under an ITN the previous night	Number of individuals who slept under an ITN the previous night in surveyed households	Total number of individuals who spent the previous night in surveyed households	N and D: Household survey	Burden reduction and elimination	Assesses and monitors ITN usage to identify protection gaps. Low use should prompt social and behaviour change interventions. Used with ITN access data to distinguish behavioural gaps (people with access but not using ITNs) from ownership gaps (not enough ITNs). Analysis of disaggregated data (e.g. by age and sex) helps target social and behaviour change efforts.
Number of ITNs distributed	Total number of ITNs (all net types) distributed either through mass campaigns or through routine distribution channels	Number of ITNs distributed or the sum of ITNs distributed through mass campaign and other routine distribution channels	None	N: Routine surveillance of vector control activities	All Burden reduction and elimination	Tracks ITN distribution as a vector control intervention and to calculate coverage. Note: should be compared with epidemiological outcomes to assess ITN impact
Data quality						
Completeness of reporting *(83)*	Percentage of expected reports received in a specified period	Number of reports received from health facilities in a specified period x 100	Number of reports expected from health facilities in the same specified period	N and D: Routine health information or surveillance system	Burden reduction	Tracks reporting completeness, a key requirement for strong surveillance systems and high-quality data. Ensures effective operational response by identifying and addressing reporting challenges. Note: the reporting is a useful factor in adjusting routine data to estimate incidence. Where resources and data permit, reporting completeness could be assessed on the basis of specific indicators.

Indicator name	Definition	Numerator	Denominator	Data sources[b]	Transmission setting[c]	Purpose
Population						
Population census/ estimated population	A population census is the official count of all individuals within a country or a specific area, conducted at regular intervals (typically every 10 years). An estimated population is a projection of the current population based on the most recent census data, birth rates, death rates and migration trends.	Population estimated per census and projected population for those years without a census	None	N: Census population data	Burden reduction and elimination	Quantifies populations to estimate malaria burden, intervention needs, access, targeting and overall planning
Population at risk	Population living in a geographical area where locally acquired malaria cases have occurred in the past 3 years	Population in areas with ongoing malaria transmission	None	N: Census population data, maps of transmission, endemicity or incidence	Burden reduction and elimination	Quantifies populations at risk to estimate malaria burden, intervention needs, access, targeting and overall planning

ACT: artemisinin-based combination therapy; ANC: antenatal care; ITN: insecticide-treated net; PCD: positive case detection; PCR: polymerase chain reaction; POR: prevention of re-establishment; RDT: rapid diagnostic test; SOP: standard operating procedure.

[a] Details on frequency of monitoring and suggested disaggregations along with a more comprehensive list of indicators for monitoring malaria programme targets are provided in Annex 19.

[b] N: numerator; D: denominator; sources may vary depending on the country.

[c] Burden reduction, elimination or prevention of re-establishment

7.6 Use of information at regional and global levels

A good surveillance system is required to be able to assess global and regional progress towards reducing malaria mortality and morbidity and its eventual elimination. Progress can be monitored using the indicators listed in Table 17 and Annex 19. Countries and partners are encouraged to ensure that data for these indicators are available at appropriate times during implementation of the *Global technical strategy for malaria 2016–2030* by ensuring adequate investment in routine information systems and in household and health facility surveys *(2)*.

WHO and other partners will support countries that are endemic for malaria in strengthening their surveillance, monitoring and evaluation systems, in line with the requirements of the global technical strategy. The aim of the support will be to improve the quality, availability and management of data on malaria and to optimize use of such data in decision-making and programmatic responses. Countries will also be supported in identifying nationally appropriate targets and indicators for subregional monitoring of progress.

WHO, in line with its core role, will monitor regional and global trends in malaria and make these data available to countries and to global malaria partners. WHO will monitor implementation of the global technical strategy and regularly evaluate progress towards the milestones and goals for 2020, 2025 and 2030 (Table 18) in annual and other periodic reports. It will also support monitoring of the efficacy of medicines and vector control interventions; to this end, WHO will maintain global databases on the efficacy of antimalarial medicines and insecticide resistance. These data will be regularly updated and made available on the Malaria Threats Map *(86)*. WHO will regularly report to the regional and global governing bodies of WHO, the United Nations General Assembly and other United Nations bodies.

Table 18. Goals and milestones of the *Global technical strategy for malaria 2016–2030*

Vision - a world free of malaria

Goals	Milestones		Targets
	2020	2025	2030
1. Reduce malaria mortality rates globally compared with 2015	≥ 40%	≥ 75%	≥ 90%
2. Reduce malaria case incidence globally compared with 2015	≥ 40%	≥ 75%	≥ 90%
3. Eliminate malaria from countries in which malaria was transmitted in 2015	At least 10 countries	At least 20 countries	At least 35 countries
4. Prevent re-establishment of malaria in all countries that are malaria-free	Re-establishment prevented	Re-establishment prevented	Re-establishment prevented

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Annexes

Annex 1. Example of individual case notification form

1. Health facility information

Reporting health facility:

Name of the responsible person completing notification form:

Date of sending notification:

2. Patient profile

Case ID: Name of the patient:

Date of birth: Sex:

Residential address:

Permanent home address (if different):

Occupation:

Contact phone number:

Date of onset of symptoms: Number of days with symptoms:

Date of first visit to medical facility: Date of diagnosis:

3. Diagnosis

Date of visit to medical facility:

Diagnostic method:

if microscopy:

Date of blood sample collection: Date of reading the blood test:

Date of final diagnosis – laboratory confirmed:

Plasmodium species identified: Parasite count:

4. Treatment

Treatment prescribed:

Admission status

Outpatient ☐ Hospitalized ☐

Signature of the responsible person

Annex 2. Example of individual case investigation form for a national malaria case register

Section 1. Information about case investigator

Name and title of responsible officer who investigated the case:

Location where case investigation is conducted (municipality/village/locality/focus):

Date of case investigation:

Facility:

Section 2. Characterization of the case

Malaria Case ID:

Is this case linked to a larger focus?

Yes ☐ No ☐

If yes, indicate the ID number of the focus:

Patient name: Sex: Occupation:

Present home address, including contact details:

Permanent address, if different:

Main symptoms:

Date of onset of first symptoms:

Date of confirmation of malaria diagnosis:

Date of notification of malaria case:

Method of case detection (passive case detection, active case detection, mobile malaria clinic, other):

Test used (microscopy or RDT):

Parasite species (if microscopy is used: parasite density and presence of gametocytes reported):

Treatment (drugs, dosage, dates):

Treatment outcome (follow-up visits, confirmation of clearance, dates):

Cured ☐ Treatment failed ☐ Death ☐

Previous malaria diagnosis (date, parasite species and treatment):

Recent travel history within the country, i.e. to other malaria-endemic settings (past one year):

Location 1

1. Region/District:

2. City/village/locality:

3. Date of arrival:

4. Date of departure:

Location 2

1. Region/District:

2. City/village/locality:

3. Date of arrival:

4. Date of Departure:

Location 3

1. Region/District:

2. City/village/locality:

3. Date of arrival:

4. Date of departure:

Location 4

1. Region/District:

2. City/village/locality:

3. Date of arrival:

4. Date of Departure:

Recent travel history outside the country to malaria-endemic settings (past one year)

Location 1

1. Region/District:

2. City/village/locality:

3. Date of arrival:

4. Date of departure:

Location 2

1. Region/District:

2. City/village/locality:

3. Date of arrival:

4. Date of Departure:

Location 3

1. Region/District:

2. City/village/locality:

3. Date of arrival:

4. Date of departure:

Location 4

1. Region/District:

2. City/village/locality:

3. Date of arrival:

4. Date of Departure:

Blood transfusion within past three months:

Recent contact with known malaria case(s), provide details:

Possible origin of malaria infection (place where malaria infection is likely to have been acquired) with GPS coordinates, if possible:

Section 3. Case classification:

Parasite species:

P. falciparum ☐ *P. vivax* ☐ *P. malariae* ☐ *P. ovale* ☐ *P. knowlesi* ☐

Mixed (specify):

Other (specify):

Classification:

Imported* ☐ Introduced** ☐ Indigenous ☐ Relapsing ☐

Recrudescent ☐ Induced ☐ Other*** ☐

Comment on evidence used for case classification:

** Outside the district/province, from other country (please specify):*

*** Please link to imported case ID:*

****This may be poor compliance or failure to follow up.*

Section 4: Household and neighbourhood

Household location (GPS, if possible): Household members listed:

Travel history of household members (please indicate if household members travelled together with the case during likely period of infection):

Recent history of fevers among household members (list):

Household members tested for malaria:

List of household members testing positive, if any:

Neighbourhood household locations (GPS, if possible):

Neighbourhood household members listed:

Recent history of fevers among neighbourhood household members (list):

Neighbourhood household members tested for malaria:

List of neighbourhood household members testing positive, if any:

Section 5: Follow up of the case

Vector control and preventive measures taken, if any:

If yes, coverage:

Recommended activities:

Annex 3. Example of individual focus investigation form for a national malaria case register

Section 1: Focus details

Focus investigation team members:

Name, title and signature of responsible officer who completed the form:

Focus name:

Location of focus (district/municipality/village/locality)
(GPS, if possible) and health facility catchment area:

Size of population, and number of structures/households:

Date and time of focus investigation:

Section 2: Characterization of the focus

Malaria focus ID:

List all case ID numbers that are part of this focus ID:

Geographical map of the focus

Administrative map of focus showing houses, heath facilities, other important structure, access routes, location of cases

Distribution of parasites (species, number and location of infections identified):

Distribution of vector species within the focus (principal and secondary malaria vectors and their behaviour, including breeding sites with presence or absence of larvae):

Environmental features (urban or rural population, altitude, main geographical features, environmental changes as a result of development, original and current endemicity, and vulnerability close proximity to endemic areas within the country or across international border, refugees, etc.) within the focus:

Population characteristics (occupation, migration patterns, presence and numbers of temporary workers, typical travel histories, health inequalities, health literacy):

Summary of malaria epidemiology in focus for the past 5 years
(including malaria surveys, active case detection results):

Summary of entomological data in focus for the past 5 years (primary and secondary vectors, breeding and feeding behaviors, resistance data, and breeding sites):

Vector control intervention coverage for the past 5 years (IRS/LLINs coverage):

Summary of weather data for the past 5 years
(including minimum and maximum temperatures and rainfall patterns):

Section 3. Classification of the focus

Focus classification

Focus classified as:

Parasite species:

P. falciparum ☐ *P. vivax* ☐ *P. malariae* ☐ *P. ovale* ☐ *P. knowlesi* ☐

Mixed (specify): Other (specify):

Classification of the focus at time of detection (date):

Active ☐ Residual non-active ☐ Cleared ☐ Other ☐

Comment on evidence used for focus classification:

Classification at time of specified follow up (date):

Active ☐ Residual non-active ☐ Cleared ☐ Other ☐

Comment on evidence used for focus classification:

Relation of the focus to the malaria case that prompted focus investigation (in time, space and circumstance, e.g. the person in residence, work, etc.)

Location and total number of households with inhabitants where malaria cases were registered within the focus

Section 4. Follow-up of the focus households and neighbourhoods, and response

Likely cause of continued, increased or resumption of transmission in focus:

Drivers of transmission:

Summary of Focus micro-response plan (including the recommended reactive strategies to be implemented, responsible authorities, timelines):

Follow-up actions taken (provide details):

Neighbourhood visits (done, dates, map)

Household locations (GPS)

Household members listed, screened (e.g. fever), tested, results

Household members treated (case management, prevention)

Vector control and preventive measures taken, if any:

Other follow-up measures taken, if any:

Reference numbers to relevant focus investigation records and case investigation records:

Name and signature of responsible officer who completed the form

Annex 4. Form for updating registration of foci

Focus ID	Focus Name	Province	District	Latitude	Longitude	Population count	Number of household	Number of structures for IRS	Number of ITN distributed	Number of structures sprayed	Date of ITN distribution	Date of last cycle of IRS	Date focus investigated	Classification		
														Active	Residual non-active	Cleared

Note: the data fields presented here are not exhaustive and additional information may be included in focus register as appropriate.

Annex 5. Geographical reconnaissance during focus investigation

Stage	Purpose	Activities
Planning	Identify the target area to conduct the mapping operations	Assemble baseline GIS data layers, including administrative boundaries, topographic (e.g. waterways and elevation) and infrastructure (e.g. roads) and potential breeding sites. Acquire paper topographic maps from local mapping authorities or ministries to confirm identification of target areas for geographical reconnaissance, especially if electronic maps do not give a clear picture. Digitize paper maps when possible, including any maps showing distribution of previous cases and focus limits. Draw maps showing the preliminary limits of the focus on the basis of these geographical features and the excepted flight distances of the main vector, to delimit the extent of the focus.
	Data collection considerations	Select the appropriate data collection hardware (e.g. smart-phone, tablet, GPS) and associated data collection software. Identify the data collection forms; include a unique household ID field in each form. Upload data collection forms and field maps to the hardware chosen; test the system before field work. The data should include the distribution and classification of previous cases, interventions (ITNs, IRS, larviciding) and entomology within the focus. If portable computers are not available, use paper forms and maps, or collect coordinates with a GPS and record them on paper forms.
	Operational planning	Select field workers (field officers, supervisors and data managers). Prepare a detailed schedule for field work, including timelines for data submission. Prepare training modules, and train field workers before starting investigation. Provide the appropriate equipment, materials, transport and accommodation. Prepare a budget for the above items.

Stage	Purpose	Activities
Field investigations	Notify communities and authorities.	Contact local health and administrative authorities to inform them of the planned activities. During the focus visit, contact village leaders to discuss the purpose of the visit and the benefits to the community; once a relationship has been developed with communities, residents will become used to further focus investigations.
	Initial reconnaissance and assessment of village(s)	Walk around the focus or village to familiarize the field team with the environment and to validate field maps.
	Geographical reconnaissance and enumeration activities	Acquire coordinates, and use unique identifiers for each household or dwelling. Record the number, and make line lists of people in each household or dwelling. Identify and map additional important structures (e.g. health facilities and schools) and significant geographical features (e.g. ponds and roads).
	Data back-up and storage	Establish procedures to back-up and store data collected in the field (depends on hardware and software selected for geographical reconnaissance); real-time submission of data is possible with good Internet connectivity.
Mapped products	Display geographical data on maps, showing the limits of the focus.	Produce a map illustrating: • all households and other significant structures within the focus; • relevant environmental features such as rivers, streams, bodies of water and mountains; • relevant infrastructure, including roads, walking tracks and ports; and • location of recent and past malaria cases. Prepare summaries of households and population for planning response activities. Prepare detailed lists of households for implementation and evaluation of response activities.
Analysis	Refine the limits of the focus.	Use the new mapped information to refine the limits of the focus.
	Risk factor analysis	Use GIS to analyse the distribution of cases within foci, by classification in relation to risk factors
	Analysis of case clustering	Use GIS to analyse the distribution of imported cases relative to natural breeding sites, to assess the risk of onward transmission

GIS: geographical information system; GPS: geographical positioning system; IRS: indoor residual spraying; LLIN: long-lasting insecticidal net.

Annex 6. Proposed register for community health workers, health posts and outpatient departments in health centres and hospitals

No.	Date	Name	Residence (village, neighbourhood)	Sex	Age in years	Provisional diagnosis	New visit?	Malaria test result	Final diagnosis	Treatment
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										

No.	Date	Name	Residence (village, neighbourhood)	Sex	Age in years	Provisional diagnosis	New visit?	Malaria test result	Final diagnosis	Treatment
14										
15										
16										
17										
18										
19										
20										
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)

(6) Age in years: age should be recorded as < 1 or 0 for children aged < 1 year.

(7) Provisional diagnosis: may be amended in column 10 if the result of a malaria diagnostic test result is negative.

(9) Malaria test result: the result should be recorded as +ve, –ve or not done. If more than one species might be involved, the parasite species (P.f., P.v., P.m. or P.o.) should be recorded for positive test results.

(10) Final diagnosis: will include presumed malaria cases if no test was performed.

(11) Treatment: specify whether antimalarial treatment was given and whether the case was referred.

The number of suspected malaria cases can be derived from column 7. The number of confirmed cases can be derived from column 9. The number of presumed malaria cases can be derived by subtracting the number of confirmed malaria cases in column 9 from the number of malaria diagnoses in column 10, Counts should apply only to new visits, which are indicated in column 8; sometimes, columns for repeat visits are added to the right of column 11.

Annex 7. Tally sheet for outpatient attendance at health centres and hospitals

Patient attendance											Total	Male	Female
Suspected malaria	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØOOO OOOOO	47		
Microscopy													
Patients tested by microscopy	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØOOO OOOOO	OOOOO OOOOO	42		
P. falciparum	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	16		
P. vivax	ØØØØØ OOOOO	ØOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	6		
P. malariae	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO			
P. ovale	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO			
Mixed	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO	OOOOO			
Positive tests (confirmed malaria) <5	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	12		
Positive tests (confirmed malaria) ≥5	ØØØØØ OOOOO	ØØØØØ OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	10		

Patient attendance											Total	Male	Female
Rdt testing													
Patients tested with RDT	ØØØØO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	4		
Positive tests (confirmed malaria) <5	ØOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	1		
Positive tests (confirmed malaria) ≥5	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO			
Treatment													
Confirmed cases receiving antimalarial	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØØØ OOOOO	ØØØOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	22		
Presumed cases receiving antimalarial (presumed cases = cases not tested)	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO	OOOOO OOOOO			

A tally sheet can be used to make counts from records in registers or to keep a running total of patients in clinics. Each circle can be viewed as a patient's head, and a circle is crossed when a patient satisfies particular criteria. The tally sheet can be used for daily or weekly totals. At the end of the day or week, the crossed circles are added and the totals transferred to a daily or weekly summary book or chart.

The tally sheet should be locally adapted. For example, if there is no *P. vivax* or *P. ovale* malaria, those can be removed. In settings where a multi-species RDT is used, the RDT section should be adapted to report those results.

Annex 8. Daily and weekly records of outpatient attendance at health centres and hospitals

Month: April 2012	1	2	3	3	4	6	7	Weekly	8	9
Day:	S	M	T	W	T	F	S	Total	Male	Female
Patient attendance										
Suspected malaria	8	59	47							
Microscopy										
Patients examined		56	42							
P. falciparum		18	16							
P. vivax		3	6							
P. malariae										
P. ovale										
Mixed										
Positive tests (confirmed malaria) <5		8	12							
Positive tests (confirmed malaria) 5+		13	10							
Rdt testing										
Patients tested with RDT	8	2	4							
Positive tests (confirmed malaria) <5	2	0	1							
Positive tests (confirmed malaria) 5+	1	0	0							

Month: April 2012	1	2	3	3	4	6	7	Weekly	8	9
Day:	**S**	**M**	**T**	**W**	**T**	**F**	**S**	**Total**	**Male**	**Female**
Treatment										
Confirmed cases receiving antimalarial	2	0	1							
Presumed cases receiving antimalarial (presumed cases = cases not tested)	1	0	0							

RDT, rapid diagnostic test

Totals from tally sheets can be copied into a daily and weekly summary book, so that there is a permanent record of the daily counts of outpatient attendance. These can be used to assess daily or weekly changes in the incidence of disease and to calculate monthly totals, to be transcribed onto a monthly report. The order of rows and their height should be the same as those of the tally sheets to facilitate transcription. The tally sheet should be locally adapted. For example, if there is no *P. vivax* or *P. ovale* malaria, those can be removed. In settings where a multi-species RDT is used, the RDT section should be adapted to report those results.

Annex 9. Discharge register for inpatient departments of health centres and hospitals

No.	Date	Name	Residence (village, neighbourhood)	Sex	Age	YMD	Diagnosis	Length of stay (days)	Reason for leaving
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									

No.	Date	Name	Residence (village, neighbourhood)	Sex	Age	YMD	Diagnosis	Length of stay (days)	Reason for leaving
16									
17									
18									
19									
20									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)

(7) YMD (years, months, days): units in which age is recorded; days should be used for children aged < 1 month, months for children aged < 1 year, and years for children aged ≥ 1 year.
(8) Diagnosis: should follow the International Classification of Diseases (ICD) as far as possible; some facilities may add a column for the ICD code
(10) Reason for leaving: discharged, died, transferred or absconded.
The total number of malaria inpatient cases should be the number discharged plus those who died (i.e. excluding transferred and absconded), as a final diagnosis will not have been made.

Annex 10. Reports from health posts and community health workers to health facilities

Community worker or health post	Patient attendance	Total	Male	Female
	Suspected malaria			
	Testing			
	Patients tested with RDT			
	Confirmed malaria in child < 5 years			
	Confirmed malaria in person ≥ 5 years			
	Treatment			
	Confirmed malaria treated with antimalarial medicine			
	Cases not tested treated with antimalarial medicine			
	Cases referred			

The number of variables to be reported each month should be kept to a minimum to ensure the completeness and quality of reporting. All health workers should understand the terms used; for example, cases of "confirmed malaria" are cases of suspected malaria with a positive test. Notes can be placed at the bottom of a form and in standard treatment manuals as reminders.

Annex 11. Reports from health facilities to district level

		Total	Male	Female
Areas with *P. falciparum* only				
	Outpatients			
	Suspected malaria			
	Total outpatients			
	Testing			
	Patients tested by microscopy			
	Confirmed malaria <5 years			
	Confirmed malaria 5+ years			
	Patients tested with RDT			
	Confirmed malaria <5 years			
	Confirmed malaria 5+ years			
	Discharges			
	Malaria <5			
	Malaria 5+			
	Total discharges <5			
	Total discharges 5+			
	Deaths			
	Malaria <5			
	Malaria 5+			
	Total deaths <5			
	Total deaths 5+			

		Total	Male	Female
	Treatment			
	Confirmed malaria treated with antimalarial medicine			
	Cases not tested treated with antimalarial medicine			
	Case negative but treated with antimalarial medicine			
Areas with more than one species of Plasmodium				
	Outpatients			
	Suspected malaria			
	Total outpatients			
	Testing			
	Patients with microscopic slide examination			
	P. falciparum			
	P. vivax			
	P. malariae			
	P. ovale			
	Mixed			
	Total confirmed malaria <5 years			
	Total confirmed malaria 5+ years			
	Patients tested with RDT			
	Confirmed malaria <5 years			
	Confirmed malaria ≥5 years			
	Discharges			
	Malaria <5			
	Malaria ≥5			
	Total discharges <5			
	Total discharges ≥5			

		Total	Male	Female
	Deaths			
	Malaria <5			
	Malaria ≥5			
	Total deaths <5			
	Total deaths ≥5			
	Treatment			
	Confirmed malaria treated with antimalarial medicine			
	Cases not tested treated with antimalarial medicine			
	Case negative but treated with antimalarial medicine			

RDT, rapid diagnostic test

The number of variables to be reported each month should be kept to a minimum to ensure the completeness and quality of reporting. All health workers should understand the terms used; for example, a case of "confirmed malaria" is a case of suspected malaria with a positive test. Notes can be placed at the bottom of a form and in standard treatment manuals as reminders.

The tally sheet should be locally adapted. For example, if there is no *P. vivax* or *P. ovale* malaria, those can be removed. In settings where a multi-species RDT is used, the RDT section should be adapted to report those results.

Annex 12. Line lists of malaria cases and deaths among inpatients to be reported to district level in low-transmission settings

Monthly line list of inpatient malaria cases and deaths									Malaria prevention			Antimalarial treatment					
No.	Date admitted	Name	Residence (village, suburb)	Sex	Age	Pregnant (Y/N?)	Type of test (RDT/ micr.)	Species	ITN owned by household (Y/N)?	ITN used in 2 weeks before admission all nights (some/none)?	House received IRS (Y/N)?	Date of onset of symptoms	Date contacted health system	Received antimalarial treatment (Y/N)	Date started	Medicines used	Reason for separation (discharged, died, absconded, transferred)
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Monthly line list of inpatient malaria cases and deaths									Malaria prevention			Antimalarial treatment					
No.	Date admitted	Name	Residence (village, suburb)	Sex	Age	Pregnant (Y/N?)	Type of test (RDT/ micr.)	Species	ITN owned by household (Y/N)?	ITN used in 2 weeks before admission all nights (some/none)?	House received IRS (Y/N)?	Date of onset of symptoms	Date contacted health system	Received antimalarial treatment (Y/N)	Date started	Medicines used	Reason for separation (discharged, died, absconded, transferred)
11																	
12																	
13																	
14																	
15																	
16																	
17																	
18																	
19																	
20																	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)

(7) Type of test: rapid diagnostic test (RDT), microscopy or none.

(8) Species: if only *P. falciparum* is present, this column is not needed. If more than one species might be involved, the parasite species (P.f., P.v., P.m., P.o.) should be recorded for positive test results.

(9–10) ITN: insecticide-treated mosquito net.

(11) IRS: indoor residual spraying.

(16) Medicines used: specific details to be provided to determine possibility of expired or counterfeit medicines.

Annex 13. Line lists of all confirmed malaria cases to be reported to district level in low-transmission settings

Monthly line list of malaria cases								Malaria prevention			Antimalarial treatment				
No.	Date admitted	Name	Residence (village, suburb)	Sex	Age	Type of test (RDT/micr.)	Species	ITN owned by household (Y/N)?	ITN used in 2 weeks before admission (all nights some/none)?	House received IRS (Y/N)?	Date of onset of symptoms	Date contacted health system	Received antimalarial treatment (Y/N)	Date started	Type of treatment (ACT, CQ, others)
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															

Monthly line list of malaria cases								Malaria prevention			Antimalarial treatment				
No.	Date admitted	Name	Residence (village, suburb)	Sex	Age	Type of test (RDT/micr.)	Species	ITN owned by household (Y/N)?	ITN used in 2 weeks before admission (all nights some/none)?	House received IRS (Y/N)?	Date of onset of symptoms	Date contacted health system	Received antimalarial treatment (Y/N)	Date started	Type of treatment (ACT, CQ, others)
13															
14															
15															
16															
17															
18															
19															
20															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)

(6) Type of test: rapid diagnostic test (RDT), microscopy or none.

(7) Species: if only *P. falciparum* is present, this column is not needed. If more than one species might be involved, the parasite species (P.f., P.v., P.m., P.o.) should be recorded for positive test results.

(8–9) ITN: insecticide-treated mosquito net.

(10) IRS: indoor residual spraying.

(15) ACT, artemisinin-based combination therapy; CQ, chloroquine

Annex 14. Supervisory checklist for countries with high or moderate transmission

During visits to health facilities, supervisors should check that registers are kept up to date, with all fields completed, that data on report forms correspond to information in registers and tally sheets, that core analysis graphs and tables are up to date and that interpretation of the trends and potential action has been discussed. Health facility staff should be encouraged to investigate all malaria inpatient cases and deaths. **An example of a supervisory checklist for surveillance for malaria is shown below.**

Record keeping	Not present	Present but not up to date	Present and up to date	Present, up to date and no mistakes
Outpatient register				✓
Discharge register				✓
Daily attendance summary book				✓
Monthly attendance summary book				✓
Graph of suspected cases	✓			
Graph of number of tests performed	✓			
Graph of number of confirmed cases				✓
Graph of test positivity rate			✓	
Reporting	None	1	2	3
Number of monthly reports sent on time in last 3 months				✓
Number of monthly reports with complete variables for age, sex and diagnosis				√
Number of monthly reports with accurate data on age, sex and diagnosis			✓	
Investigations performed in past 3 months	Not done	Done	Done and action taken	
Malaria deaths			✓	

Record keeping	Not present	Present but not up to date	Present and up to date	Present, up to date and no mistakes
Malaria inpatients			✓	
Malaria cases	✓			
Disease or progamme delivery issues that need attention				
Large number of inpatient cases still from Lacienda village.				
Recommendations				
Calculate test positivity rates as demonstrated.				
Work with Laceienda village chief to encourage residents to use LLINs and attend health centre promptly if ill with fever. **Verify monthly reports against registers to ensure accuracy. Consider having a second person perform this check for added reliability.**				

Annex 15. Model monthly surveillance bulletins for countries with high or moderate transmission

A national feedback bulletin should be produced each quarter, with data by district. The bulletin should be widely circulated, not only as feedback to districts but also as information for other government departments and institutions. Elected leaders should also be given the bulletin on malaria, possibly showing the malaria situation according to political boundaries, to instil understanding and support for malaria control at the highest level of leadership.

Bulletins can draw on the control charts shown in **Fig. 26** but should be tailored to country circumstances, such as programme priorities or availability of data. In addition to surveillance charts, country bulletins should include some measure of intervention coverage. An example of the first page of a country bulletin is shown on the following page (other pages give tables of indicators calculated for districts). The format allows sharing of a large amount of information in a small space. It should be noted that figures with more than three trend lines may be difficult to interpret.

Annex 16. Sampling methods and analytical techniques in entomological surveillance

List of vector sampling and analysis techniques with associated codes referred to in Table 9

Vector sampling method		Vector analysis technique	
1.	CDC light trap	A.	Morphological identification from Anopheles keys
2.	Human landing catch	B.	Molecular identification, such as by polymerase chain reaction (PCR) or barcoding
3.	Human-baited trap	C.	Blood-meal host detected by enzyme-linked immunosorbent assay (ELISA)
4.	Human odour-baited trap	D.	Blood meal host detected by PCR
5.	CO_2-baited trap	E.	WHO susceptibility assay or CDC bottle bioassay with discriminating concentration (1x) of insecticide
6.	Animal-baited trap, such as with a cow	F.	WHO susceptibility assay or CDC bottle bioassays with intensity concentrations (1x, 5x, 10x) of insecticide
7.	Indoor resting collection by pyrethrum spray catch	G.	WHO susceptibility assay or CDC bottle bioassay with discriminating concentration (1x) of insecticide and pre-exposure or non-exposure to synergist
8.	Indoor resting collection by aspiration	H.	Molecular and/or biochemical assay(s)
9.	Outdoor resting collection by aspiration	I.	Salivary gland dissection and examination for sporozoites under microscope
10.	Outdoor resting collection by other method, such as pit trap, barrier fence, ceramic pot	J.	Circumsporozoite protein detection by ELISA
11.	Gravid trap for oviposition-seeking females	K.	Plasmodium spp. detection by PCR
12.	Window exit trap		
13.	Larval survey by dipping		

Entomological indicators can be estimated by various vector sampling and analytical techniques (**Table 9**). The characteristics of the vectors collected with each sampling method should be considered. For example, older Anopheles mosquitoes are likely to be overrepresented in light traps, resulting to higher sporozoite rates than from human bait catches *(1,2)*.

Data should ideally be collected in a standardized way at all sites and times to ensure comparability. Techniques that can be used to mitigate bias include use of automated sampling techniques whenever possible, rotation of sample collectors among sites and separation of teams conducting interventions from those conducting surveillance.

References

1. Onyango SA, Kitron U, Mungai P, Muchiri EM, Kokwaro E, King CH et al. Monitoring malaria vector control interventions: effectiveness of five different adult mosquito sampling methods. J Med Entomol. 2013;50:1140–51.
2. Wong J, Bayoh N, Olang G, Killeen GF, Hamel MJ, Vulule JM et al. Standardizing operational vector sampling techniques for measuring malaria transmission intensity: evaluation of six mosquito collection methods in western Kenya. Malar J. 2013;12:143.

Annex 17. Example of questionnaire for assessment before and after a malaria epidemic

The following questionnaire should provide an analytical framework to assess the level of preparedness or success in responding to the epidemic.

1. **Epidemic-prone areas:**
   a. Demarcated? If yes, is/was the epidemic in a high-risk area?
   b. Is/was the epidemic in refugee camps?
   c. Is/was the epidemic related to population movement?
2. **Forecasting and warning systems: with El Niño, real-time and satellite weather data:**
   a. Are/were forecasting data made available, used and shared by national teams?
   b. Do/did the data predict a possible epidemic in the region?
   c. Is/was the regional malaria control station aware of the risk?
   d. Is/was this information disseminated to all levels of malaria control?
   e. Are/were early warning indicators validated over space and time?
   f. Is/was there adequate planning for source reduction measures if the predictions were confirmed?
3. **Early detection system:**
   a. Is/was a well-functioning surveillance system in place for early detection in epidemic-prone districts?
   b. Are/were these data recorded, analysed with set-up thresholds at district level with regular feedback/update to peripheral health care facilities?
   c. Are/were records of previous years available for comparison?
   d. What method is/was used to analyse anomalies and define/validate thresholds (i.e. mean + two standard deviations, third quartile, cumulative sum, etc.)?
   e. Are/were these data regularly reported to a central facility?
   If yes, communication channels used.
4. **Recognition of anomalies and preliminary action taken at the periphery:**
   a. Are/were anomalies detected at the periphery and action immediately taken?
   b. If yes, what action was taken at the periphery first and then at district level?
   c. How was the verification process? Fast enough (in days)?
   d. How is/was notification to district made? and lag time (days)? If more than 2 days, what caused the delay?

5. **Preparedness plan of action:**
   a. Is/was there a plan of action?
   b. If yes, is/was it technically and operationally appropriate?
   c. Are/were partners involved in preparing the plan of action? If yes, list.
   d. Is/was a budget allotted for malaria epidemic response?
   e. Is/was the budget translated into actual disbursements for response?
   f. Are/were adequate drugs and medical supplies pre-positioned at district level for rapid distribution? Specify the missing commodities.
   g. Are/were there sufficient trained personnel to handle the epidemic?
6. **Response:**
   a. Is/was there effective communication between the local and district level and above?
   b. What is/was the lag time between confirmation of the epidemic and local response?
   c. Were there sufficient trained personnel to handle the epidemic?
   d. Which vector control measures are/were applied?
   e. Is/was mass drug administration considered for transmission reduction? If yes, specify the type of medicine, coverage in the affected population.
   f. Are/were community mobilization and engagement activities adequate?
7. **Disease and economic burden:**
   a. Length of the epidemic in weeks?
   b. Population size affected?
   c. Lives lost (excess number of deaths) over the threshold?
   d. Morbidity (excess number of cases) over the threshold?
8. **If the situation required mobilizing national emergency support:**
   a. What was the time lag for communication between district and national levels?
   b. Who alerted the national level to stimulate a national response (district office, newspaper or other media, other source)?
   c. Was national support necessary? Was partners' support necessary?
   d. If so, was it effective in curbing the epidemic? [give some rationale]

Annex 18. Examples of operational responses to various stages of a malaria epidemic

No.	Intervention or operational measure	Starting epidemic	Accelerated epidemic	Epidemic peak
1	Ensure that all clinics and health facilities are operational and have sufficient drugs, equipment and trained staff.	✓	✓	✓
2	Establish treatment centres (temporary clinics or mobile clinics) where access is a problem or health facility coverage is low.	✓	✓	✓
3	Ensure that the correct diagnosis and treatment are provided at all health facilities and at community level.	✓	✓	✓
4	Promote proactive case detection and management or referral.			
5	Reinforce referral system and consider introduction of artesunate suppositories and intramuscular artemether as temporary measures when these are not already used.	✓	✓	✓
6	Intensify or maintain effective preventive measures for pregnant women.	✓	✓	✓
7	Reinforce health information systems for reporting and epidemic monitoring, preferably weekly.	✓	✓	✓
8	Conduct specific epidemic health education campaigns.	✓	✓	✓
9	Organize regular press releases, press conferences and articles for public information.	✓	✓	✓
10	Conduct IRS if the area was previously sprayed.	✓ With high coverage and quality of IRS	✓ Same as for starting epidemics Change chemicals for IRS if observed susceptibility is low.	✓ Less public health impact at this stage if the previous spraying was not effective.

No.	Intervention or operational measure	Starting epidemic	Accelerated epidemic	Epidemic peak
11	IRS in areas previously not sprayed.	✓ Malaria epidemiology, type of houses or structures, rapid deployment of logistics and effective IRS in target areas.	✓ Same as for starting epidemics	X
12	ITNs	✓ If there is a history of ITN use in the area or capacity to enforce a programme in a short time.		

IRS, indoor residual spraying; ITN, insecticide-treated net

Annex 19. Core indicators for malaria surveillance, monitoring and evaluation

This Excel table *(1)* presents a comprehensive set of priority indicators required for malaria surveillance, monitoring, and evaluation across the different transmission settings (high-burden, elimination and prevention of re-establishment). Indicators are organized into thematic categories – including incidence, mortality, diagnostic testing, case and foci investigation, epidemics, transmission intensity, treatment, commodities, chemoprevention, vector control, entomology, data quality, population, social and behaviour change, and financing. Each indicator has a clear definition and a numerator and denominator (if applicable) as well as suggested data sources, the relevant transmission setting, the lowest geographical level for intended use, possible disaggregation and the purpose. Together, they enable malaria programmes to track and understand trends in malaria incidence and mortality, assess intervention coverage and impact, monitor surveillance system performance, and guide strategic decision-making, operational planning and resource allocation.

Reference

1. Core indicators for surveillance, monitoring and evaluation. Geneva: World Health Organization; 2025 (https://www.who.int/publications/m/item/core-indicators-for-malaria-surveillance-monitoring-and-evaluation).

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