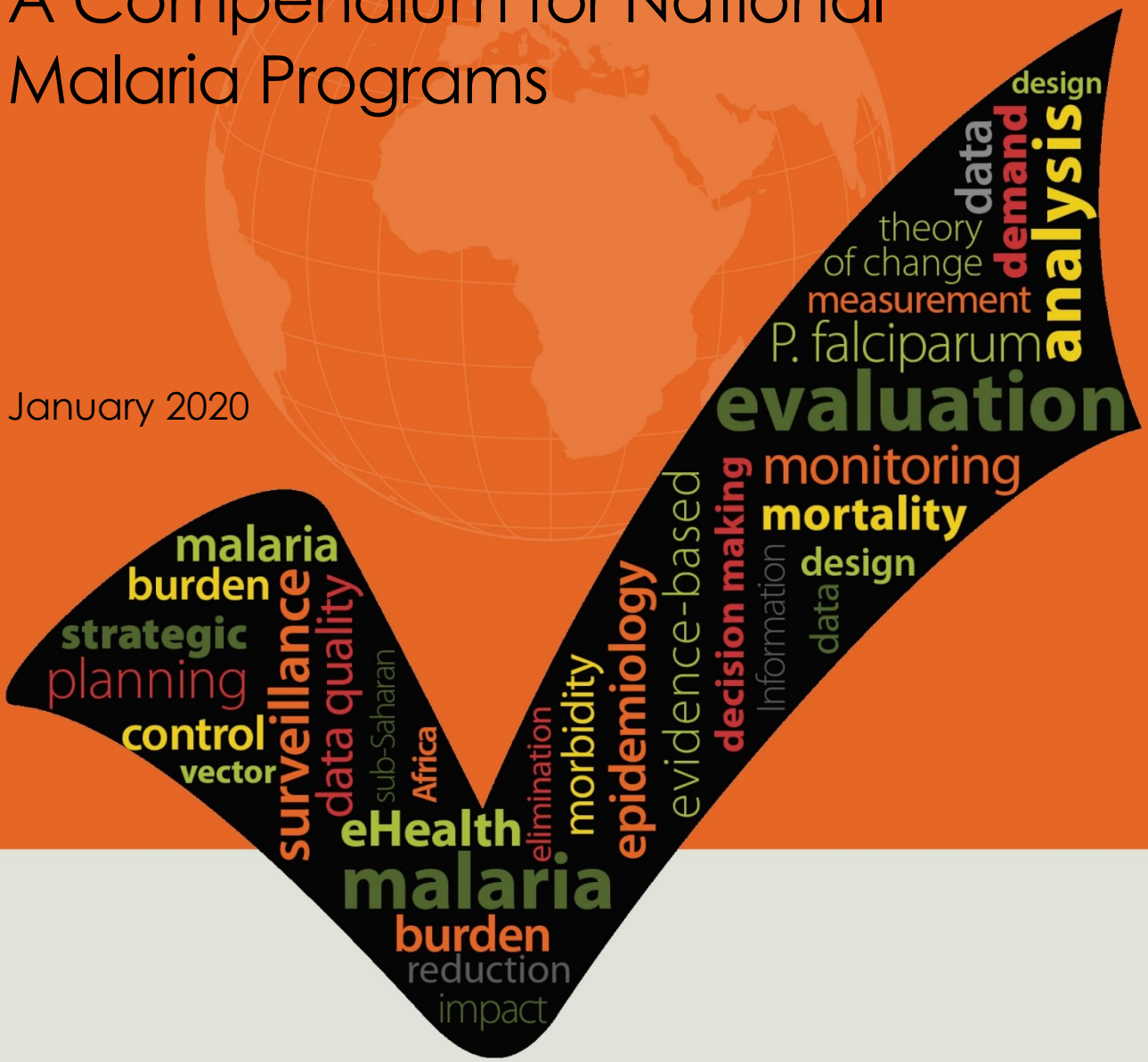
Facilitating Surveillance, Monitoring, and Evaluation in Malaria-Endemic Countries:

A Compendium for National Malaria Programs

January 2020



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Facilitating Surveillance, Monitoring, and Evaluation in Malaria-Endemic Countries:

A Compendium for National Malaria Programs

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January 2020

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Preface

Concerted efforts in malaria control have led to a significant decrease in the disease burden globally and specifically in sub-Saharan Africa (SSA). Countries there have scaled up proven malaria interventions, such as insecticide-treated nets (ITNs), indoor residual spraying (IRS), diagnostic testing, prompt and effective treatment of malaria cases, and intermittent preventive treatment in pregnancy (IPTp). A strong surveillance, monitoring, and evaluation (SME) system is needed to measure progress and achievement to inform future efforts and investments. This compendium is designed for national malaria program (NMP) personnel, who need to learn SME skills quickly and apply them immediately to their work. It is also intended to be a valuable resource for implementing partners working on malaria projects, students taking an SME course in an MPH program, and scientists interested in malaria SME. Relevant documents and guidance materials are referred to throughout the document. Readers are encouraged either to read through the compendium in its entirety or reference specific chapters, as needed.

Chapter 1 introduces the concepts of malaria SME. Chapters 2 and 3 look at the global burden of malaria and global efforts to control malaria. Chapter 4 discusses the role of data for decision making. Chapters 5 through 8 describe the development of an SME plan and a plan's components: frameworks, indicators, and data sources. Chapter 9 discusses malaria surveillance—a concept particularly important as malaria transmission decreases and NMPs need to track each case closely. Chapter 10 describes key methods used for evaluating NMPs and provides references to key indicators, data sources, and practical examples. Chapter 11 discusses the nuts and bolts of data quality, data management, and data analysis. Chapter 12 focuses on what is needed to present, interpret, and use data correctly. Finally, Chapter 13 presents ethical concerns to think about in malaria SME.

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Abbreviations

ACT	artemisinin-based combination therapy
AIM	Action and Investment to Defeat Malaria 2016–2030
ANC	antenatal care
API	annual parasitic incidence
BCC	behavior change communication
CDC	United States Centers for Disease Control and Prevention
DDT	dichloro-diphenyl-trichloroethane
DHIS2	District Health Information Software, version 2
DHS	Demographic and Health Survey
DID	difference-in-difference
DFID	Department for International Development
DQA	data quality assessment
DRC	Democratic Republic of the Congo
GIS	geographic information system
Global Fund	Global Fund to Fight AIDS, Tuberculosis and Malaria
GMAP	Global Malaria Action Plan
GTS	Global Technical Strategy for Malaria 2016–2030
HDSS	health and demographic surveillance system
HIS	health information system
HMIS	health management information system
IDSR	integrated disease surveillance and response
IPTp	intermittent preventive treatment in pregnancy
IR	intermediate result
IRB	institutional review board
IRS	indoor residual spraying
ITN	insecticide-treated net
LLIN	long-lasting insecticidal net
M&E	monitoring and evaluation
MDA	mass drug administration

MICS	Multiple Indicator Cluster Survey
MIS	Malaria Indicator Survey
NMCP	national malaria control program
NMEC	national malaria elimination center
NMP	national malaria program
NMS	National Malaria Strategy
NMSP	national malaria strategic plan
PMI	U.S. President's Malaria Initiative
*Pf*PR	*Plasmodium falciparum* parasite rate
RBM	Roll Back Malaria Partnership
RDT	rapid diagnostic test
RHIS	routine health information system
RTS,S	RTS, S/AS01
SDGs	Sustainable Development Goals
SMART	specific, measurable, appropriate, realistic, and time-based
SMC	seasonal malaria chemoprevention
SME	surveillance, monitoring, and evaluation
SO	strategic objective
SP	sulfadoxine-pyrimethamine
SSA	sub-Saharan Africa
SWOT	strengths, weaknesses, opportunities, and threats
UN	United Nations
USAID	United States Agency for International Development
VA	verbal autopsy
WHO	World Health Organization

Glossary of Key Terms

Term	Definition
All-cause child mortality rate	Probability of dying from any cause between the first and fifth birthday per 1,000 children who survived to age 12 months
Cerebral malaria	Severe *P. falciparum* malaria with impaired consciousness (Glasgow coma scale <11, Blantyre coma scale <3) persisting for more than one hour after a seizure (World Health Organization [WHO], 2016)
Confidentiality	"The obligations of those who receive information to respect the privacy interests of those to whom the data relate" (Cohn, 2006)
Confirmed malaria case	Suspected malaria case in which malaria parasites have been found in a patient's blood by microscopy or a rapid diagnostic test
Contextual factors	Nonmalaria programs and other factors, such as rainfall, socioeconomic status, and policy changes that could confound the association between scale-up of the intervention and its potential health impact or could modify the effect of the intervention, and thus affect the conclusion
Direct malaria mortality	Deaths in which malaria was the underlying cause
eHealth	The use of information and communication technologies for health (WHO, n.d.)
Endemic malaria	Ongoing malaria with a measurable incidence of cases and mosquito-borne transmission in an area over a succession of years (WHO, 2012)*. Also known as "stable malaria."
Epidemic malaria	Occasional malaria outbreaks in normally malaria-free regions; a particularly severe malaria season in a normally low-risk area. Also known as "unstable malaria."
Evaluation	Periodic assessment of whether objectives are being achieved, often requiring special surveys or studies (Gertler, et al., 2011)
Health facility-based malaria morbidity indicators	Indicators of morbidity based on data from surveillance and routine information systems, such as health facility registries or health management information systems (e.g., malaria outpatient visits or cases, hospital inpatient admissions, and outpatient visits and hospitalizations for severe anemia in young children in high-endemic settings)
Health informatics	Defined by the U.S. National Library of Medicine as "the interdisciplinary study of the design, development, adoption, and application of information technology-based innovations in healthcare services delivery, management, and planning" (Healthcare Information and Management Systems Society, n.d.)
Implementation	The initiation of a program in a defined area over a specified time period with the intention to accomplish stated objectives
Indirect malaria mortality	Deaths in which malaria was a contributing cause, and the death was categorized as a nonmalaria death. Examples are deaths from the combined effects of malaria-associated anemia and pneumonia, in which the cause was categorized as pneumonia; deaths linked to low birthweight caused by malaria in the mother during pregnancy; deaths resulting from consequences of clinical management, such as HIV exposure from a blood transfusion for malaria-related anemia or sequelae of a malaria infection, such as epilepsy caused by cerebral malaria) (Snow, et al., 2003)*.

Term	Definition
International Classification of Diseases	The global health information standard for mortality and morbidity statistics, increasingly used in clinical care and research to define diseases and study disease patterns, and to manage health care, monitor outcomes, and allocate resources
Malaria intervention	Intervention to reduce malaria-related morbidity and mortality (e.g., insecticide-treated bed nets, indoor residual spraying, intermittent preventive treatment during pregnancy, case management)
Malaria parasite prevalence	Proportion of children ages 6 to 59 months with malaria parasite infection (Roll Back Malaria, 2009)*
Malaria-related mortality	Deaths in which malaria was the underlying cause or a contributing cause; the sum of direct and indirect malaria mortality (Rowe, et al., 2007)*
Malaria transmission	Spread of malaria by completion of a full transmission cycle (person→mosquito→person)
Malaria transmission intensity	Measured as entomological inoculation rate: the number of infectious mosquito bites a person is exposed to in a certain time period, typically a year
mHealth	Use of mobile wireless technologies for public health (World Health Organization, n.d.)
Monitoring	Ongoing tracking of progress toward an objective, often using routinely collected data
Parasitemia	Presence of parasites in the blood; number of parasites per volume of blood
Personally identifiable information	Data relating to an individual who can be identified directly or indirectly by the data or by linking the data to other information reasonably available (United Nations Development Group, 2017)
Plausibility argument	An assumption that mortality reductions can be attributed to programs if improvements are found along the causal pathway between intervention scale-up and mortality trends (Habicht, et al., 1999; Morgenstern, 1982; Ye, et al., 2017)*
Population-level malaria morbidity indicators	Indicators on malaria morbidity collected through population-based surveys (e.g., malaria parasite prevalence, anemia)
Privacy	"An individual's right to control the acquisition, uses, or disclosures of his or her identifiable health data" (Cohn, 2006). This includes any information the person wants to keep private.
Security	"Physical, technological, or administrative safeguards or tools used to protect identifiable health data from unwarranted access or disclosure" (Gejibo, 2015)
Sensitive data	All personal data relating to religious, philosophical, political, and trade union opinions and activities, as well as to sex life or race, health, social measures, legal proceedings, and penal or administrative sanctions (African Union, 2014)
Surveillance	Continuous, systematic collection, analysis, and interpretation of disease-specific data and their use in planning, implementing and evaluating public health practices Note: Surveillance can be done at different levels of the healthcare system (e.g., health facilities, the community), with different detection systems (e.g., case-based, active, passive) and sampling strategies (e.g., sentinel sites, surveys) (WHO, 2016).
Under-five mortality	Probability of dying before the fifth birthday per 1,000 live births

Term	Definition
Verbal autopsy	A method for determining cause of death in which a knowledgeable person in the household where a deceased person lived is asked about signs and symptoms of the terminal illness, usually one to six months after the death (Garenne & Fontaine, 1990; Anker, et al., 1999; Soleman, et al., 2006). To attribute causes of deaths, interviews are analyzed by an algorithm or clinicians who decide on causes by majority vote (Rowe, et al., 2007).*

*Source: Unless otherwise noted, definitions are adapted from the following:

Mortality Task Force, Monitoring and Evaluation Reference Group, Roll Back Malaria Partnership. (2014). *Guidance for evaluating the impact of national malaria control programs in highly endemic countries.* Chapel Hill, NC, USA: MEASURE Evaluation, University of North Carolina. Retrieved from https://www.measureevaluation.org/resources/publications/ms-15-100

1 Chapter 1. Introduction to Surveillance, Monitoring, and Evaluation for National Malaria Programs

This chapter discusses the need for SME to compare effort outcomes to performance targets. It covers the concepts of SME; defines frequently used terms; delineates the differences among surveillance, monitoring, and evaluation; and shows how SME can be applied in various programs.

1.1 Background

In 2018, World Health Organization (WHO) estimates showed that nearly half of the world's population was at risk of malaria, with 87 countries and territories reporting 219 million malaria cases in 2017. The burden is the highest in SSA countries, with 92 percent of malaria cases and 93 percent of malaria deaths, globally, reported from 43 of the 45 SSA countries. SSA countries have shown progress; between 2010 and 2017, the malaria incidence rate in these countries decreased, from 278 to 219, and the malaria mortality rate decreased, from more than 70 percent to 40 percent (WHO, 2018d).

To accelerate progress toward global targets, WHO developed the Global Technical Strategy for Malaria 2016–2030 (GTS), which provides endemic countries with a technical framework and goals for reaching malaria control and elimination (WHO, 2015b). Chapter 3 provides more detail on this strategy.

1.2 Surveillance, Monitoring, and Evaluation: What Is It?

Surveillance, monitoring, and evaluation are not interchangeable terms. Each has a different meaning and answers a different question.

Is it surveillance, monitoring, or evaluation?

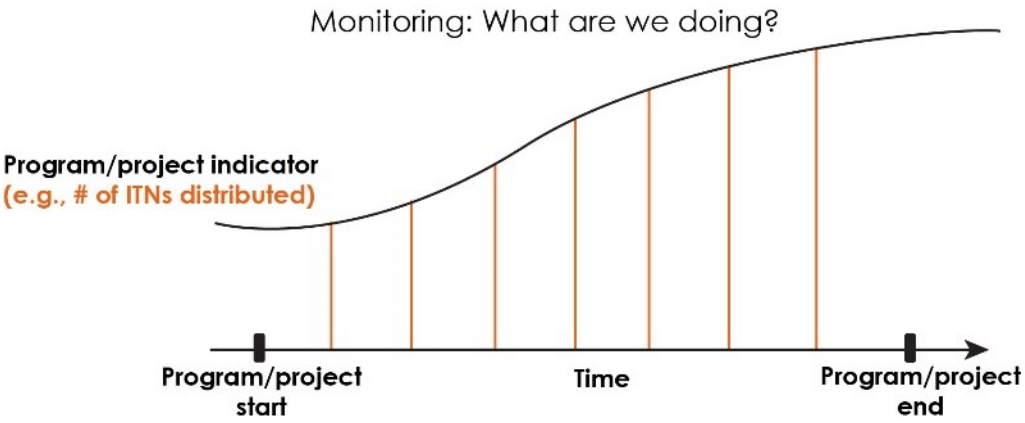
Monitoring: What are we doing?
Evaluation: What have we accomplished?
Surveillance: What are we tracking?

Monitoring answers these questions: What are we doing? Were activities implemented as initially planned? It is the process of measuring progress toward program or project objectives through tracking activities conducted, resources used, and outputs generated. The focus is on tracking changes in program performance over time, as shown in Figure 1. Monitoring is an ongoing process throughout a program or project. It helps track variations in the implementation from site to site and provides suggestions on ways to make needed course corrections or make the program or project more efficient to keep it on track to meet objectives.

Potential monitoring questions:

- Were inputs made available to the program or project in the quantities and at the time specified by the workplan?
- Were scheduled activities carried out as planned?
- How well were they carried out? Did the expected changes occur at the program or project level, in terms of people reached and materials distributed?

Figure 1. Example of monitoring



Evaluation assesses the effectiveness of program or project activities on specific indicators. It answers these questions: What have we accomplished? Were the expected results achieved? Evaluation systematically, thoroughly, and objectively measures results and impact of programs on the behavior or health of a population. In other words, evaluation can determine what changed over the period of program implementation, assess whether the program plausibly contributed to those changes, and attribute changes in impact measurements directly to program activities and their adequacy and design. Figure 2 shows an illustrative example of a project focused on ITN distribution, using ITN ownership as an indicator. In this example, it is expected that ITN ownership would increase from the start of the program to the end; therefore, a comparison of the pre- and post-evaluation results would show the expected improvement. Figure 3 provides a summary and comparison between monitoring and evaluation.

Potential evaluation questions:

- Did the expected change occur at the population level?
- How much change occurred?
- Did the target population benefit from the program and at what cost?
- Can improved health outcomes be attributed to program efforts?

Evaluation uses epidemiological and social research methods and often requires specific study designs, which are covered in more detail in Chapter 10.

Figure 2. Example of evaluation

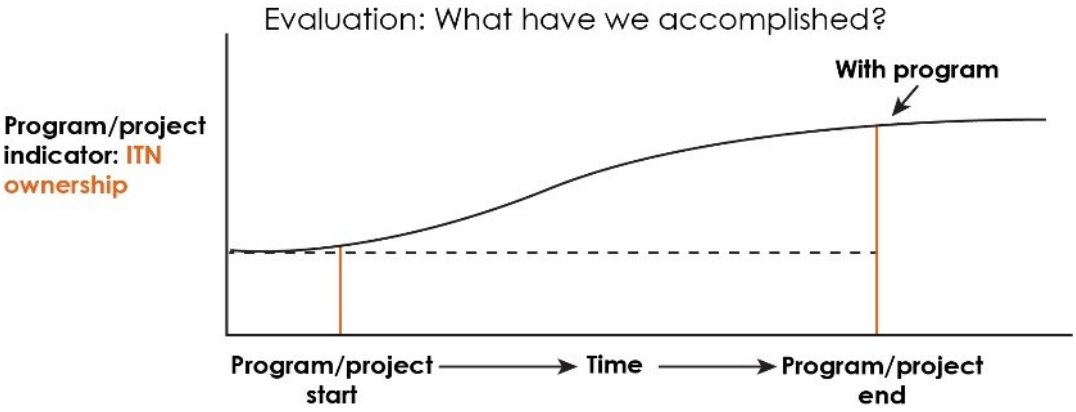
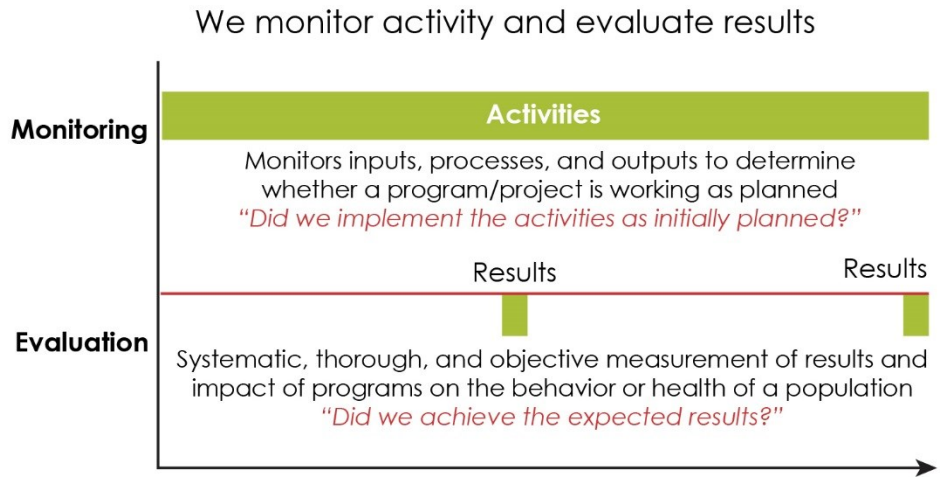


Figure 3. Summary and comparison of monitoring and evaluation



Surveillance is the systematic and continuous process of collecting, aggregating, analyzing, interpreting, disseminating, and using data. Effective surveillance can improve information, which can be used for action. Surveillance answers this question: What are we following or tracking? Events related to health problems, such as morbidity, mortality, and drug resistance, are tracked using surveillance. Chapter 9 discusses malaria surveillance in more detail.

1.3 SME in National Malaria Programs

SME of malaria control interventions has the following three objectives:

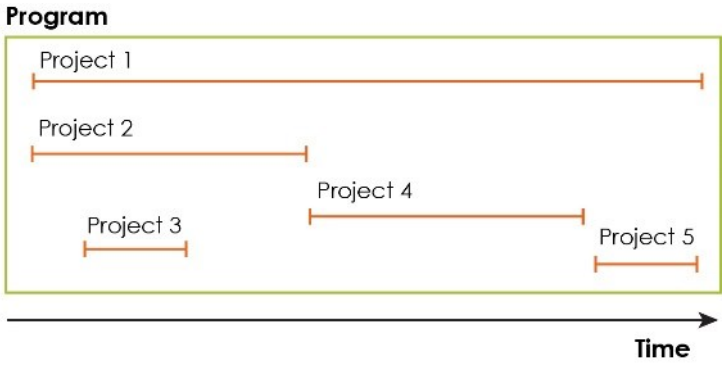
- To increase the effectiveness of malaria control implementation based on program data and evaluation
- To guide NMP decision making on allocation and use of resources that are funded by national stakeholders, such as ministries of health and global funding partners

- To attain national and global goals to control and eliminate malaria

Both NMPs and projects require SME. An NMP contains all projects designed to promote malaria control and elimination. NMPs are often coordinated by a ministerial department and have defined goals and operational processes to achieve those goals.

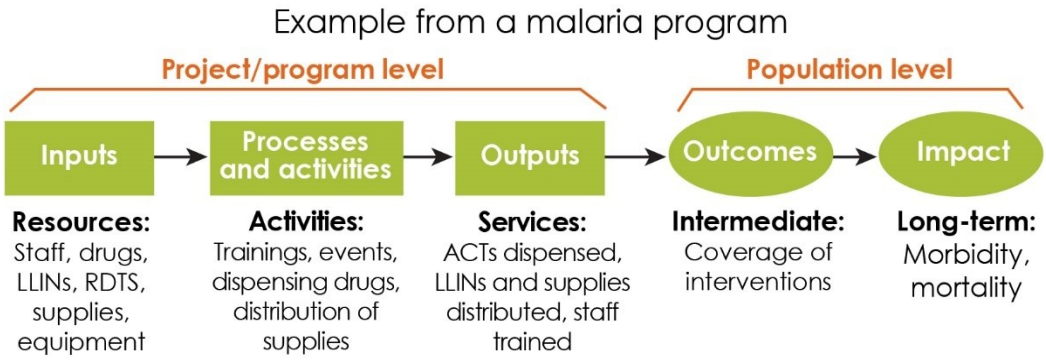
Malaria projects vary from programs in that they contain a subset of specific targets and activities that contribute to the overall objectives of the program. Projects cover a target population and include well-defined activities, with human, material, and financial resources. Projects also differ from programs because they have a start and end date, while programs are ongoing (Figure 4).

Figure 4. Program versus project



Program and project components (inputs, processes or activities, outputs, outcomes, and impact) (Figure 5) are key concepts in SME, and each component influences policies. Inputs, processes or activities, and outputs are measured through monitoring at the project or program level. Outcomes and impact are analyzed through an evaluation at the population level.

Figure 5. Main components of NMPs



LLIN=long-lasting insecticide-treated net, RDT=rapid diagnostic test, ACT=artemisinin-based combination therapy

The following are definitions of each of these five main components and examples of each in NMPs.

Inputs: Resources used to make the project or program function, such as funding, staff, and materials like artemisinin-based combination therapies (ACTs), ITNs, rapid diagnostic tests (RDTs), and laboratory supplies

Processes and activities: Implementation of activities and interventions, such as distributing ITNs, providing health talks in communities, and conducting workshops and training programs

Outputs: Services delivered through implementation of activities and interventions, such as the number of ACTs and ITNs distributed, the number of health talks provided, and the number of staff trained

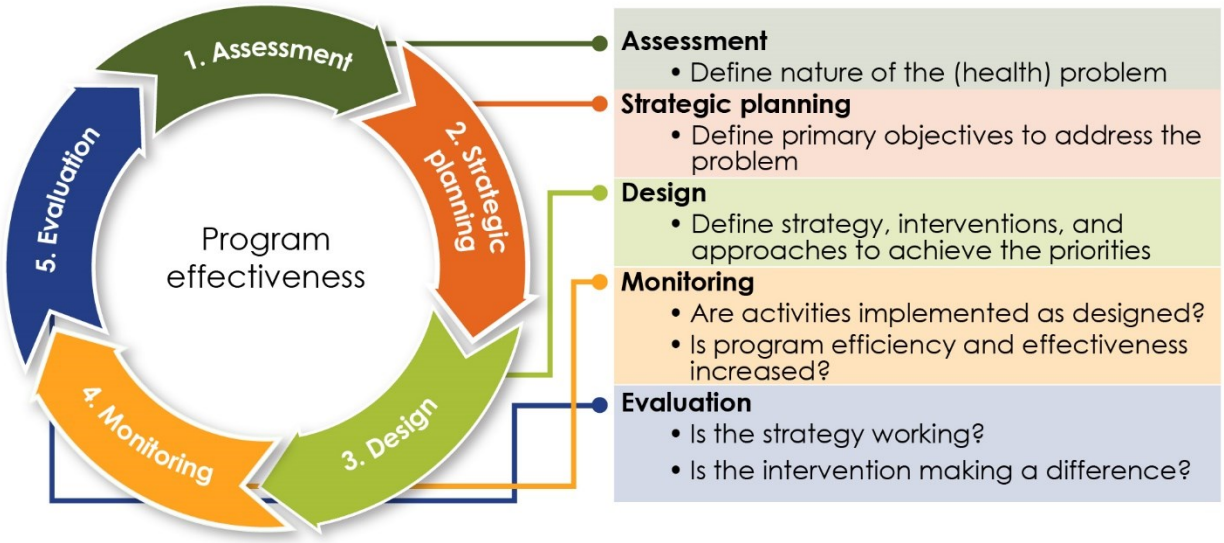
Outcomes: Changes that occur as a result of the outputs, most often measured as changes in knowledge, attitudes or beliefs, behaviors, and practices. For example, outcomes measured in malaria programs may include change in the proportion of children under five sleeping under ITNs, change in the proportion of caregivers who know the cause of malaria, and change in the proportion of fever cases tested with RDTs at health facilities.

Impact: Measures the effect of program activities. Measuring impact implies a measure of causality—did the activity or intervention *cause* the change? Can the change (or outcome) observed be *attributed* to the activity or intervention? Changes in malaria mortality and morbidity are measures of impact.

SME is a continuous process throughout the life cycle of a program (Figure 6). The process begins when the program establishes objectives. Based on its objectives, the program adopts a set of indicators to monitor, establishes data collection procedures and a data collection schedule, sets reporting deadlines, and provides for quality assurance measures.

Understanding how M&E fits into a project life cycle is important to a successful program. First, an assessment should be done to determine the nature of the problem that the program intends to address. Strategic planning then defines the primary objectives that the program needs to address the problem. Strategic planning informs the design of strategies, interventions, and approaches to achieve the objectives. Monitoring at various intervals determines whether activities are being implemented as they were designed, how much implementation varies from site to site, and how the program can become more efficient. Finally, evaluation is used to show whether the strategy is working to make a difference in the outcome of interest. This is a continuous cycle as information is collected through monitoring and evaluation to inform the next assessment, strategic planning, and design.

Figure 6. M&E in the life cycle of an NMP



Test your knowledge—Is it monitoring or evaluation?

See next page for answers.

1. The Ministry of Health wants to know how many RDTs have been used in health facilities for a year.
2. The Ministry of Health wants to know whether the programs being carried out in Region A are increasing ITN use among pregnant women and children under five in that region.
3. The government wants to know how many long-lasting insecticide-treated nets (LLINs) were distributed during the first round of the campaign in each state.
4. The government wants to know whether its campaign to distribute LLINs has increased net use in the distribution districts.
5. The national malaria elimination program would like to see whether there have been changes in the under-five mortality rate since the implementation of its LLIN campaign three years ago.
6. The national malaria elimination program wants to know how many patients were treated with ACT in each district.

Test your knowledge—Is it monitoring or evaluation?

Answers

1. Monitoring—This is not related to program impact.
2. Evaluation—ITN use is an outcome of the program.
3. Monitoring—This is not related to program impact.
4. Evaluation—This is an example of a process evaluation.
5. Evaluation—Under-five mortality is an impact of the program.
6. Monitoring—This is not related to program impact.

2 Chapter 2. Malaria's Global Burden

As Chapter 1 stated, SSA countries account for 92 percent of malaria cases and 93 percent of malaria deaths—the largest malaria burden in the world (WHO, 2018d). This chapter summarizes malaria epidemiology in SSA and describes the malaria transmission cycle, the burden of malaria on the people and economies of SSA countries, and the challenges faced in assessing the malaria burden.

2.1 Background

Malaria is a potentially fatal blood disease caused by a parasite transmitted to human hosts by the *Anopheles* mosquito. *Anopheles gambiae* is the main vector transmitting malaria in SSA. Malaria is caused by *Plasmodium* parasites, which are spread to people through the bites of infected female *Anopheles* mosquitoes, called "malaria vectors." Five parasite species can cause malaria in humans, and two of these species, *P. falciparum* and *P. vivax*, pose the greatest threat.

To effectively prevent, control, and eliminate malaria, NMPs need information about the malaria vectors present in their countries and the parasites they carry; in SSA, these are most typically *Anopheles* mosquitoes and *P. falciparum*. Vector control is the primary method to prevent and reduce malaria transmission. Two forms of vector control are effective: (1) ITNs and long-lasting insecticide-treated nets (LLINs) and (2) IRS. To effectively implement these vector control strategies, NMPs need some basic information on malaria vectors, such as preferred breeding grounds, length of incubation, and optimum temperature and humidity during the mosquito life cycle. Microscopy and some RDTs can determine the species of the parasite—*P. falciparum* or *P. vivax*—that the vector is transmitting.

2.2 Malaria Epidemiology

After an *Anopheles* mosquito bites a person and infects the human bloodstream with the malaria parasite, the parasite invades the liver cells and multiplies. The parasites then spread out of the liver and into the bloodstream, where they infect red blood cells, causing symptoms such as fever, chills, fatigue, and the muscle and joint pain that are characteristic of malaria.

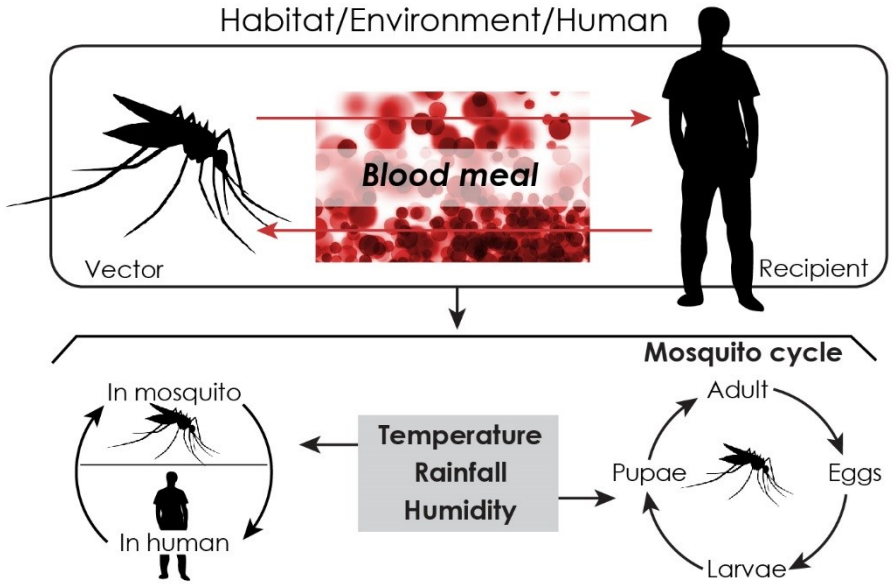
Different species of *Anopheles* mosquitoes differ in their capacity to transmit malaria, depending on their biology and behavior. Mosquitoes in the *Anopheles gambiae* group are the most efficient malaria vectors in the world, and they are found only in Africa. In fact, the higher incidence of malaria in Africa, compared to other parts of the world, is due mainly to the efficiency of these mosquitoes in transmitting the parasites.

Malaria control and prevention depend on a working knowledge of the conditions favorable to mosquito breeding and the method of parasite transmission. The following paragraphs summarize the malaria transmission cycle and the ecological factors that affect this cycle.

Malaria Transmission Cycle

The malaria transmission cycle begins with the *Anopheles* mosquito life cycle, which has four stages: (1) egg, (2) larva, (3) pupae, and (4) adult (Figure 7). The duration from egg to adult varies considerably among species and is strongly influenced by ambient temperature. Mosquitoes can develop from egg to adult in as little as five days, but usually it takes 10 to 14 days in tropical conditions.

Figure 7. Malaria transmission cycle



Source: Yé, 2008

Eggs: An adult female lays between 50 and 200 eggs at a time in a water source. Eggs are laid singly, directly on unpolluted water, and the eggs are not resistant to drying. Eggs hatch within two to three days, although hatching can take longer in cooler climates. *Anopheles* larvae have been found in freshwater or saltwater marshes, mangrove swamps, rice fields, grassy ditches, the edges of streams and rivers, and small, temporary rain pools, including ruts in roads. An often overlooked water source is discarded debris, such as metal cans and old tires (United States Centers for Disease Control and Prevention [CDC], 2012; Okogun, et al., 2005; Behrens, Neave, & Jones, 2015).

Larvae: Larvae come to the water surface frequently to breathe and dive below the surface only when they are disturbed. They feed on algae, bacteria, and other microorganisms.

Pupae: The pupal stage of the life cycle lasts a few days before the adult mosquito emerges.

Adult: Adult mosquitoes usually mate within a few days after emerging from the pupal stage. Males live for about a week, and females live for one to two weeks or even up to a month, depending on climatic conditions. After obtaining a full blood meal, the female rests a few days to digest the blood meal, and the eggs develop. This process depends on the ambient temperature, but it usually takes two to three days in tropical conditions. The female *Anopheles* mosquito obtains the *Plasmodium* parasite from the blood cells of an infected human during blood meals. Then the parasite reproduces inside the mosquito. When an infected

mosquito bites another human, it pumps the parasite into the human blood, beginning the transmission cycle (CDC, 2018).

In humans, the parasites grow and multiply, first in liver cells and then in red blood cells through asexual multiplication. As additional broods of parasites grow inside the red cells and destroy them, daughter parasites are released and continue the cycle by invading other red blood cells. These blood-stage parasites cause malaria symptoms. Some blood-stage parasites picked up by a female *Anopheles* mosquito during a blood meal start another, different cycle of growth in the mosquito. After 10 to 18 days, the parasites are in the host mosquito's salivary glands and are transmitted to another human when the mosquito takes her next blood meal, thus starting another cycle of malaria infection through sexual multiplication (CDC, 2018).

Ecological Factors Affecting Malaria Transmission

A variety of ecological factors affect the malaria transmission cycle, including climate and population migration.

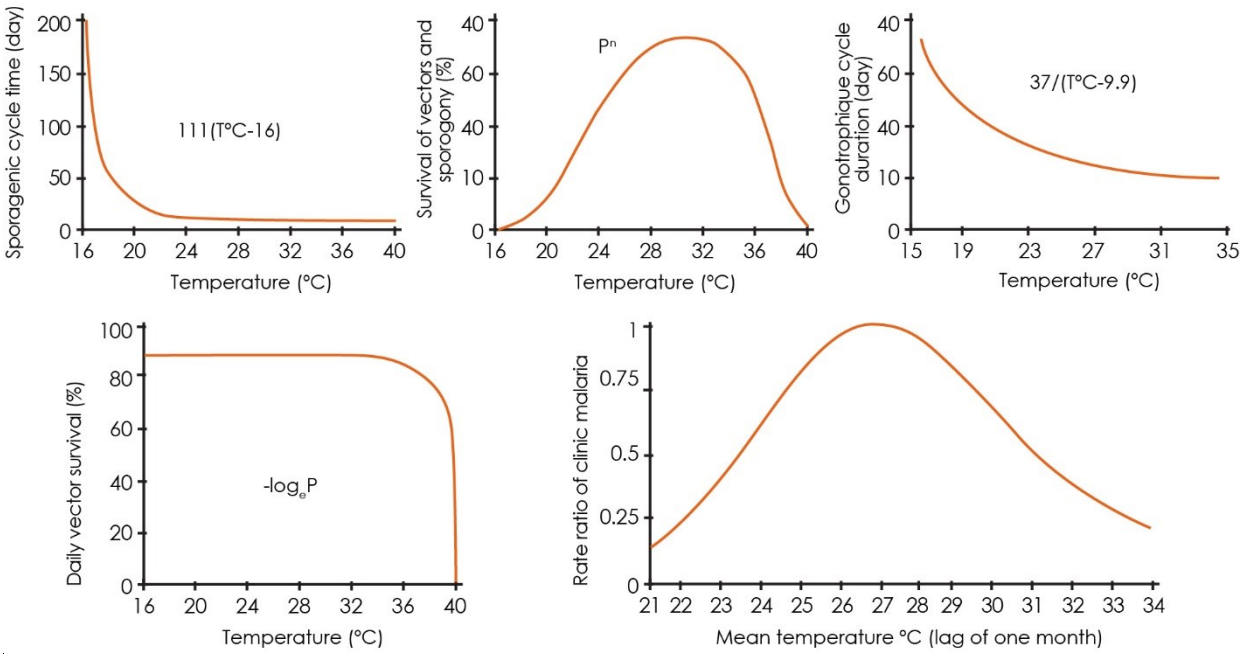
The main climate factors that affect malaria transmission—and make Africa, especially SSA, the location of the highest malaria burden in the world—are temperature, rainfall, and humidity.

Temperature

Temperature affects the evolution of the parasite, the frequency of a mosquito's blood meals, mosquito survival, and larval development. The parasite takes about 10 days to complete its development in the gut of the host mosquito, depending on the ambient temperature. The optimal temperature for parasite development is between 20 and 30 degrees Celsius. The time needed for development decreases to less than 10 days as the temperature increases. Higher temperatures also increase the number of blood meals the mosquito takes and the number of eggs laid, increasing the number of mosquitoes in an area.

Through its effect on temperature, altitude influences the distribution and transmission of malaria indirectly. As altitude increases, temperatures decrease; highlands are cooler and lowlands are warmer. Figure 8 provides models showing the relationship between temperature and the vector.

Figure 8. Models showing the relationship between temperature and vector



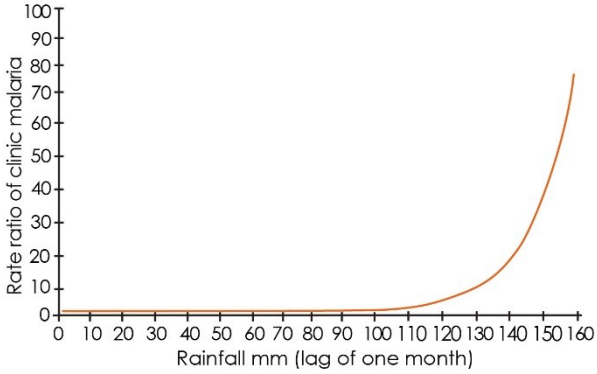
Source: Macdonald, 1957; Detinova, 1962; Martens, 1997; Yé, et al., 2007

Rainfall

Anopheles mosquitoes breed in water, but different species prefer different types of water bodies or water collections. *Anopheles* mosquitoes that transmit malaria do not breed in foul-smelling, polluted water. Freshwater rain collections are an important breeding ground, whether they are clear or muddy.

Places with lower rainfall, and even drought areas, can also foster mosquito breeding sites and consequent malaria transmission because delayed rainfall or no rain creates pooling. Malaria vectors breed mainly in stagnant water collections, rarely in slightly moving water, and never in rapidly flowing rivers and streams.

Figure 9. Example of the relationship between rainfall data and clinical malaria in Burkina Faso



Source: Yé, et al., 2007

Relative Humidity

The amount of moisture in the air also affects the activity and survival of malaria parasite-carrying mosquitoes. Adult *Anopheles* mosquitoes need more than 60 percent humidity to survive and must live at least 8 to 10 days to be able to transmit malaria. Therefore, relative humidity plays a significant role in the mosquito life span and population size.

Combined Effects of Climatic Factors

As temperatures go up and rainfall creates standing water sources, mosquito breeding conditions improve and the rate of malaria transmission increases. Temperatures between 16 to 30 degrees Celsius with a relative humidity of 60 percent or more provide an ideal climate for mosquito survival, new larvae development, and the evolution of the parasite inside the mosquito. A health information system (HIS) that includes systematic monitoring of temperature and rainfall with monthly malaria cases provides the information needed by malaria programs to take action and improve malaria control efforts.

Human Factors Affecting Malaria Transmission

In addition to climate conditions, several human population-driven factors can affect the pattern of malaria transmission and its severity, such as biological differences in human hosts, population migration, and economic activities.

Human Host Biological Differences

Differences in human hosts affect malaria transmission and the severity of the disease. People are either immune or nonimmune to malaria. People with immunity often have a better chance of tolerating the effects of malaria and surviving the disease than people with no immunity. Immunity to malaria develops slowly after several infections. In highly endemic areas, children under five are the most at risk because they have not yet developed immunity to malaria infection. Pregnant women are also particularly vulnerable to malaria during pregnancy because malaria can cause anemia and negatively impact intrauterine growth.

In areas of constant, high transmission—endemic areas—immunity develops rapidly, and many people, including children, may be infected with the parasite without showing outward symptoms. These asymptomatic infections contribute to transmission and affect the overall health status by contributing to anemia or a weakened ability to fight off other infections. In epidemic-prone areas, all age groups are susceptible.

Some genetic red blood cell characteristics protect against some types of malaria. The sickle cell trait provides some protection against *P. falciparum* malaria, historically the leading cause of malaria death in Africa. As a result of the sickle cell trait, much of the population in Africa and with African ancestry has better immunity to *P. falciparum* malaria than other population groups. *P. vivax* infections are not found as much in SSA, due to negative Duffy antigens, which are resistant to *P. vivax,* found in the majority of the African population. Finally, individuals with a glucose-6-phosphate dehydrogenase deficiency have been found to be protected against malaria. Genetic factors continue to be studied, and research findings will likely play a larger role in future malaria elimination efforts (CDC, 2012).

Population Migration

Seasonal migration of laborers from low-risk areas to malaria-endemic areas generally occurs during planting and harvesting, when malaria transmission is at its peak. Seasonal migrants from low-risk areas lack acquired immunity against malaria and may have less knowledge of malaria transmission and where to seek effective treatment. Risk of malaria may be exacerbated by poor living conditions and inadequate healthcare. Migrants often live in temporary living conditions without adequate vector control and lack adequate healthcare,

making it more difficult to get timely treatment. Migrant workers who return to their low-risk or malaria-free villages often take the parasites with them, and, if conditions are right for vector breeding, local transmission can be established.

Large population displacements resulting from war and political unrest or natural causes, such as drought, famine, flooding, and earthquakes, can result in similar changes in malaria transmission. A population displaced from a low transmission setting to a high one is at increased risk for infection. Conversely, a displaced population from high malaria areas can carry the parasite into areas that have been low risk for malaria, and sometimes even introduce new parasite species.

Travelers from nonmalaria areas to malaria-endemic areas contribute to imported malaria cases upon return from the malaria area. Contributing factors to imported malaria in travelers include inconsistent preventative treatment guidelines from health professionals in nonmalaria areas, nonadherence or improper use of chemoprophylaxis, and misperceptions of immunity by travelers.

Economic Activities

Economic activities affect the pattern of malaria transmission and its severity. Increasing areas in SSA are being mined to extract raw materials, which changes the landscape and creates new man-made mosquito breeding areas. Nearby populations are then more vulnerable to malaria. Although some mining companies have created small-scale programs to provide malaria interventions to their mining staff, their families, and the local populations, illegal mining activities leave individual small-scale miners unprotected and vulnerable to malaria.

Agriculture practices can also change malaria transmission. Irrigation systems provide new mosquito breeding areas. Pesticides over-used for farming introduce mosquitoes that are resistant to insecticides used in ITNs and IRS, reducing the effectiveness of key malaria control interventions.

Finally, urbanization affects malaria transmission in a positive way, reporting decreased rates of malaria transmission due to lower vector densities. As SSA becomes more urban, with more than half of the population living in urban settings today, decreases in malaria incidence are expected (Hay, et al., 2005; Snow, 2014).

2.3 The Malaria Burden in Africa

WHO and other large global organizations track and report on the global malaria burden—morbidity and mortality, economic costs, and social impacts. The ability to measure the global malaria burden in standardized specific metrics is limited by the number of national HIS that provide data and the quality of the data available. Morbidity and mortality statistics are further complicated by the use of nonstandardized indicators and the lack of national vital statistics registration systems. Even the ability to monitor outcomes in national health systems and evaluate the available data varies greatly by country.

Morbidity and Mortality

In 2018, the WHO *World Malaria Report* estimated that nearly half of the world's population—3.2 billion people—is at risk of being infected with malaria. The largest malaria burden is in SSA. Of the estimated

219 million global malaria cases in 2017, 200 million (90%) occurred in SSA. Countries in SSA with the highest malaria burden are Burkina Faso, Cameroon, the Democratic Republic of the Congo (DRC), Ghana, Mali, Mozambique, Niger, Nigeria, Uganda and the United Republic of Tanzania (WHO, 2018a).

Among the 435,000 global malaria deaths in 2017, 93 percent occurred in SSA. Although the malaria mortality rate in SSA has decreased significantly, from more than 70 deaths per 100,000 population at risk in 2010 to 44.1 deaths per 100,000 population in 2017, it remains four times higher than the world's mortality rate of 11.7 in 2017. More than half of all malaria deaths come from six SSA countries (Nigeria, DRC, Burkina Faso, the United Republic of Tanzania, Sierra Leone, and Niger) and India. (WHO, 2018d).

Socioeconomic Burden

Countries with the highest malaria rates are also among the poorest. The Voices for a Malaria-Free Future organization estimates that the economic impact of malaria in Africa alone costs $12 billion every year. This figure factors in costs of healthcare, absenteeism from the daily activities of productive living and income generation, days lost in education, decreased productivity, and loss of investment and tourism. Malaria restricts economic development, which is compounded over time—the poor get poorer—compared to countries that do not suffer suppressed development. Immediate costs of malaria result from lost work time, economic losses associated with infant and child morbidity and mortality, and the costs of treatment and prevention, which are typically estimated to be higher than 1 percent of a country's gross national product (Voices for a Malaria-Free Future, n.d.). Malaria affects household poverty by causing absenteeism from the daily activities of productive living and income generation. Malaria also prevents many children from attending school and thus diminishes their capacity to realize their full potential.

2.4 Challenges in Measuring the Malaria Burden

Climate suitability, malaria transmission intensity, population density, exposure to interventions and treatment practices, variable definitions of epidemic and endemic, and problems in defining the magnitude of the effect and the population at risk are all factors that make assessing the malaria burden in SSA complex. Longer-range outcomes, such as impaired brain and neurological functions, malarial anemia, severe respiratory complications that lower national productivity, lost education opportunities, and compounded economic losses caused by poverty, make assessments of the malaria burden even more complex.

Government policies and resources determine the structure of the national HIS, and the quality of the data collected and reported by the national HIS varies. The resulting analyses are only as good as the data provided, and comparisons among SSA countries are valid only if they compare like indicators. Until standardization of national HIS and the indicators used is possible and the institution of vital statistics registration is universal, assessment results are no better than intuitive estimates. More information about indicators and their appropriate data sources are covered in Chapters 7 and 8. Chapter 11 discusses data quality.

Snow (2014) wrote about the difficulty in accurately assessing the global malaria burden:

> *In the absence of reliable civil and health registration systems across a large part of stable endemic sub-Saharan Africa there are two things we can measure: whether someone has died (Millennium Development Goal 4) and whether someone is infected with the malaria parasite (not included in any development goals). The former encompasses the complex array of all risks posed by infection with malaria parasites; the latter is the etiological risk factor for premature mortality. Both are measurable with an acceptable degree of certainty. Yet it remains impossible to provide a single figure of the number of deaths or clinical events resulting from P. falciparum infection; or more importantly, how many of these events have been averted since the launch of unprecedented overseas development assistance since 2000.*

2.5 Summary

Many factors affect malaria morbidity and outcomes: location and season, host immune status, age, and pregnancy status. Variations in symptom severity, from nonsevere malaria fevers to severe anemia, high fever, and respiratory complications that require hospitalization, can affect healthcare-seeking behavior and thus delay early treatment.

Understanding malaria epidemiology and how the malaria transmission cycle works in SSA is essential to informing malaria control strategies to control and eliminate malaria. Malaria is caused by *Plasmodium* parasites, spread to people through the bites of infected female *Anopheles* mosquitoes. The two most threatening species are *P. falciparum* and *P. vivax*. *P. falciparum* is the most prevalent in SSA and causes the most deaths due to malaria.

Ecological factors affect the malaria transmission cycle, including climate (temperature, rainfall, relative humidity) and population migration. Biological factors can also affect malaria transmission and the severity of the disease. In 2017, 90 percent (200 million) of malaria cases and 93 percent (435,000) of malaria deaths occurred in SSA. This burden severely effects country and individual economic costs and social impacts.

Measuring the malaria burden is complicated and challenging. The information systems that are put in place to measure the malaria burden are essential to guide national malaria control and elimination strategies. Robust systems that are well documented and regularly updated will be key to informing decision making.

3 Chapter 3. Global Efforts to Control Malaria

This chapter summarizes the history of malaria control; presents global strategies, goals, and targets; describes current malaria intervention strategies; and discusses changing contexts and flexible responses.

3.1 History of Malaria Control

Populations worldwide have created strategies to protect themselves from malaria for more than 4,000 years. The origin of the word "malaria" is from the Italian "mal'aria," meaning "bad air," because it was initially thought that malaria was caused by polluted air. After the discovery of the parasite and its link to mosquitoes in the 1880s, scientific studies of malaria became possible, which led to new discoveries in malaria control (Cox, 2010).

The Early Efforts

Malaria eradication has been a global interest since the 1950s and an international goal for the past 20 years. In 1952, malaria was eliminated in the United States, largely through the use of an insecticide called dichloro-diphenyl-trichloroethane (DDT). Based on the successful use of that chemical, WHO established the Global Malaria Eradication Program in 1955, relying solely on interrupting transmission through vector control to eliminate malaria in targeted regions and countries. That program, however, excluded SSA and other highly endemic countries, and it relied heavily on DDT (Tanner & de Savigny, 2008; University of California San Francisco, 2011). The WHO malaria elimination program cast aside other strategies, such as antimalarial drug interventions, malaria research, community participation, and surveillance. The program failed when vectors developed DDT resistance and the epidemic resurged, and it was discontinued in 1969 as a result of recognition of the chemical's environmental harm (Nájera, González-Silva, & Alonso, 2011).

No global malaria control programs were undertaken in the 1970s and 1980s, although some countries continued implementing their own malaria control strategies (Nájera, González-Silva, & Alonso, 2011). The need for research into effective malaria control and treatment became increasingly critical as morbidity and mortality increased. The first-line drug treatment, chloroquine, had been highly successful, but it also lost effectiveness when the parasite developed resistance to it.

Global Cooperation Begins

In the 1990s, new antimalarial drug therapies and ITNs offered hope for global malaria control. The global community reunified in 1998 with the establishment of the Roll Back Malaria Partnership (RBM), led by WHO, UNICEF, the United Nations Development Programme (UNDP), and the World Bank, with an ambitious goal to reduce malaria incidence and mortality by half by 2010. RBM was quickly followed by several global actions, such as the United Nations (UN) launch of the Millennium Development Goals during the Abuja Declaration in 2000, which targeted a halt and reversal of malaria incidence by 2015. In 2002, the establishment of the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund) prioritized funding to reduce the global burden for these three infectious diseases. These global bodies collectively united the global community with shared goals and objectives and provided funding to be used toward their achievement. The result has been the largest decrease in the global malaria burden in history, a decrease of 48 percent since 2000 (WHO, 2015c).

New interventions and policies were developed and rolled out between 2000 and 2015. In 2001, ACT became the recommended first-line malaria treatment. In 2005, the World Health Assembly adopted a target of 80 percent worldwide coverage of ITNs and ACTs by 2010. Additional funding came through 10-year programs established in 2005, such as the U.S. President's Malaria Initiative (PMI) and the World Bank's Booster Program. In 2008, the first Global Malaria Action Plan (GMAP) 2008–2015 outlined global and regional strategies for short-term malaria reductions, with the eventual goal of eradicating malaria (RBM Partnership, 2008; University of California San Francisco, 2011).

In 2015, the UN launched a new strategy, the Sustainable Development Goals (SDGs), which established 17 goals to end poverty, protect the planet, and ensure prosperity for all by 2030. Goal 3 addresses global malaria burden reduction. Two global malaria initiatives were released to align with the SDGs 2016–2030: (1) the WHO GTS and (2) the RBM Partnership for Action and Investment to Defeat Malaria 2016–2030 (AIM).

The Results Today

Since 2000, there has been encouraging progress in malaria elimination, but this seemed to have plateaued in 2016, and the fragile gains made during the previous two decades are now threatened by resistance, human migration, and global economics. The *Anopheles gambiae* mosquitoes that transmit malaria in Africa are becoming widely resistant to the insecticide used on bed nets. Successful efforts may have a double-edged sword: with the lowered exposure to the malarial parasite, teens and adults may be losing the partial immunity previously acquired from multiple occurrences of malaria infection. As control efforts result in significant case reductions, funding partners are shifting priorities and relying on country governments to sustain the efforts made, yet globally funded programs are not sustainable without clear transition strategies. Compared to the required yearly health expenditure needed to achieve GTS goals of $6.5 billion, total annual funding so far has simply not been enough.

WHO (2018c) summarizes the current impact of malaria:

- In 2017, there were an estimated 219 million cases of malaria in 87 countries, an increase of 3 million cases over 2016.
- Malaria deaths reached 435,000 in 2017, a decrease from 451,000 in 2016.
- SSA carries a disproportionately high share of the global malaria burden. In 2017, the region was home to 92 percent of malaria cases and 93 percent of malaria deaths.
- Total funding for malaria control and elimination reached an estimated US$3.1 billion in 2017. Contributions from governments of endemic countries amounted to US$0.9 billion, representing 28 percent of funding.

Coordinated efforts in Zambia

The Zambia National Malaria Elimination Centre (NMEC) is an example of how one country is succeeding in sustaining malaria control efforts. NMEC resolved to intensify its efforts by developing a national plan to improve coordination, data collection, partner involvement, and rapid scale-up of interventions to meet the national malaria targets. The Zambia NMEC initiated several interventions to improve M&E to demonstrate progress in malaria control. Zambia's strengthened capacity to demonstrate progress in lowering the malaria burden is proving the success of a sustainable control program, with one possible disadvantage: the progress in lowering the malaria burden may be discouraging the continued commitment of partner support as resources are redirected to other pressing health challenges.

The Zambia example demonstrates the value of setting bold national goals, the merits of a health system with centralized governance and decentralized implementation, the importance of multiple coordinated interventions, and the use of data as a tool for measuring outcomes, planning, and fundraising.

(National Malaria Elimination Centre, Ministry of Health, 2017)

3.2 Current Global Strategies, Goals, and Targets

As the goals of control, elimination, and eradication have proven elusive, reality has shown that one solution will not work alone; indeed, the incremental goals must incorporate various simultaneous multilateral approaches. What has been proven is that these efforts will continue to need massive funding and cooperative strategies. The following subsections outline the current global strategies.

Sustainable Development Goals, 2016–2030

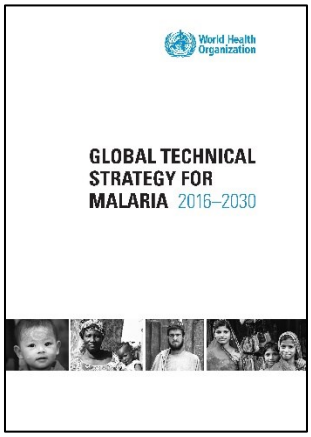
In 2016, the WHO GTS set new goals that recognize the need for sustainability, and RBM AIM raised its support to more than $2.7 billion per year, which still falls short of the estimated $6.5 billion required to protect the 3.2 billion people living at risk of malaria in 91 countries.

With increased knowledge about changing malaria epidemiology, improved diagnostics to detect emerging hot spots, and more widespread efforts to control and treat infections also came the realization that significantly more support is needed to provide new research and tools. Additional resources are also needed to improve surveillance to detect developing insecticide resistance and emerging new species of vectors, expand training for healthcare workers, conduct awareness campaigns, strengthen healthcare information systems and monitoring, and ensure the strategic distribution of commodities.

Also emerging from the SDGs is an acknowledgment of the need for flexibility to set realistic goals and surveillance guidelines according to the malaria burden distribution—one set of guidelines does not fit all countries—while also still setting policies for strict monitoring and reporting. Extensive collaboration continues among scientists and global malaria stakeholders and across international borders.

In parallel to the revised global strategic plans, efforts are being made to establish national HIS and provide training for healthcare workers and NMP staff in the collection and reporting of quality data. These advances are needed to guide informed decisions on control efforts, focused where the need is most critical.

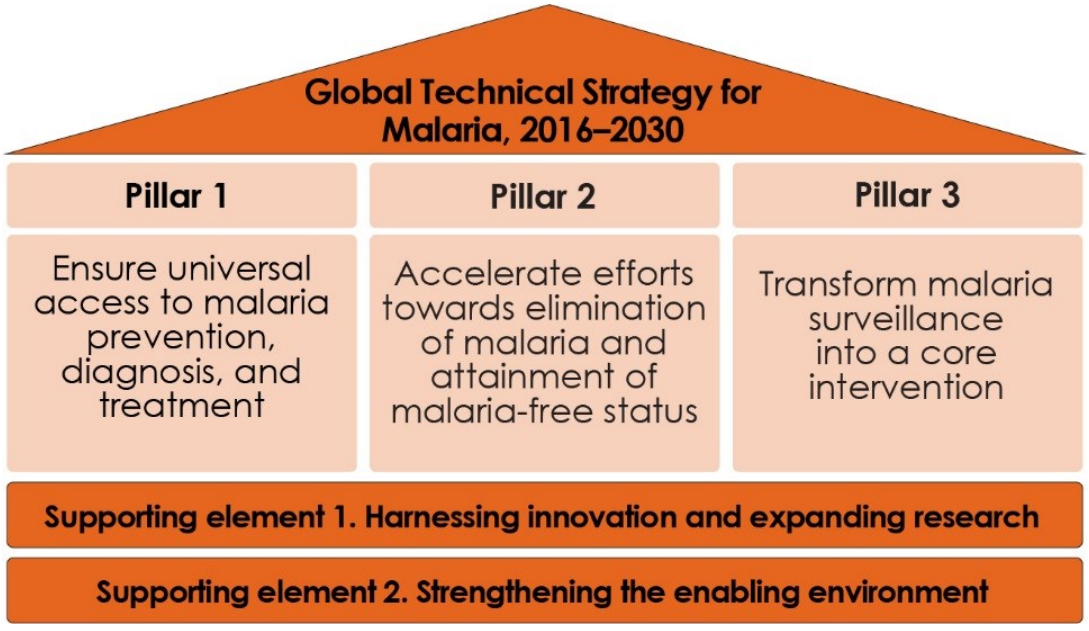
WHO GTS



Adopted in May 2015 by the World Health Assembly, the WHO GTS is a technical framework for malaria-endemic countries to guide and support regional and national programs as they work toward malaria control and elimination. The four GTS targets are as follows: (1) to reduce malaria case incidence by at least 90 percent by 2030, (2) to reduce malaria mortality rates by at least 90 percent by 2030, (3) to eliminate malaria in at least 35 countries by 2030, and (4) to prevent a resurgence of malaria in all countries that are malaria free.

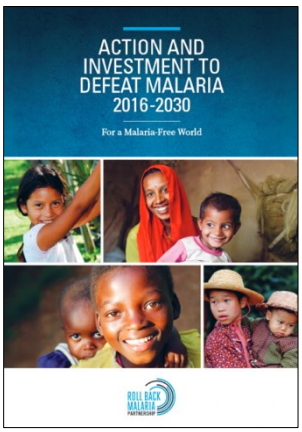
The three main pillars for this strategy, illustrated in Figure 10, are as follows: (1) ensure universal access to malaria prevention, diagnosis, and treatment; (2) accelerate efforts toward elimination of malaria and attainment of malaria-free status; and (3) transform malaria surveillance into a core intervention. To do this, the strategy stresses innovation and research on implementation methods for vector control, diagnostic testing and treatment, malaria vaccines, and surveillance for elimination. Strengthening the enabling environment through political commitment and sustained funding streams is also essential to achieving the GTS targets. The strategy suggests increased international and domestic funding, improved health systems for robust health sector responses, strengthened capacity in the health workforce, ensured sustainability of malaria responses, improved government stewardship and cross-border collaboration on malaria programs, strengthened multisectoral collaboration, encouragement of private sector participation, and promotion of community and nongovernmental organization engagement.

Figure 10. Framework for the WHO GTS



Source: WHO, 2017 (p. 13)

Roll Back Malaria Partnership AIM



The RBM Partnership AIM is a guide that builds on the success of the GMAP 2008–2015 and links the malaria agenda to the global SDGs and the GTS. This document summarizes achievements made between 2000 and 2015 and provides an outlook for progress from 2016 to 2030, emphasizing the need for continuing investments in malaria control, mobilizing resources, strengthening collaboration between sectors and countries, keeping people at the center of the response, strengthening the enabling environment, promoting innovation, and ensuring progress and accountability by monitoring results and seeking partnerships.

The WHO GTS and the RBM AIM were developed to be complementary, with shared goals to reduce the global malaria burden, and to contribute to achievement of the SDGs. They also share a common timeline, 2016–2030 (RBM Partnership, 2015).

High Burden to High Impact: A Targeted Malaria Response

In 2018, WHO and RBM released the High Burden to High Impact approach to accelerate slowed progress in malaria control efforts in 10 SSA countries (Burkina Faso, Cameroon, DRC, Ghana, Mali, Mozambique, Niger, Nigeria, Uganda, and the United Republic of Tanzania) and India. This country-led approach comprises four key elements: political will to reduce malaria deaths; strategic information to drive impact; improved guidance, policies, and strategies; and a coordinated national malaria response. Successful implementation of this approach is expected to achieve GTS targets (WHO, 2018a).

3.3 Current Malaria Intervention Strategies

The most effective malaria strategies to date have encompassed three focal area interventions: (1) vector control, (2) chemoprevention, and (3) case management. In 2015, the GTS added malaria surveillance as the newest intervention.

Vector Control

Vector control is still the first line of malaria suppression—preventing mosquitoes from acquiring parasites or passing on an infection—and it remains one of the most effective control methods worldwide. ITNs are the most popular strategy in vector control because they are highly effective in reducing malaria morbidity and mortality and are affordable at the country level. ITNs began initially as commercial commodities sold individually, but countries soon adopted them and used antenatal care (ANC) visits and routine health services for distribution to protect pregnant women and children. The development of LLINs met the demand for a stronger product that can maintain effective levels of insecticide for at least three years. LLINs are relatively accessible and less expensive than other control methods; however, they have a life expectancy of three to five years, and funding must be planned for their replacement. WHO recommends full household ITN coverage with one net for every two people in endemic areas. Many SSA countries have adopted free mass ITN distribution campaigns as strategies to increase ITN access for all people, not just vulnerable groups. In SSA, the proportion of households with at least one ITN has increased, from 47 percent in 2010

to 72 percent in 2017; however, only 40 percent of households have sufficient ITNs for all household members (WHO, 2018d).

Another effective vector control strategy is IRS, which involves spraying residential walls and roofs with long-acting insecticides. This older control strategy was used during the Global Malaria Eradication Program in the 1950s and 1960s in Asia, Europe, the Americas, and Southern Africa, but not in the rest of Africa. This intervention was controversial because it used DDT, which is harmful to humans, animal life, and the environment and has been banned in numerous regions. New insecticides have since been developed and used for IRS, but IRS is expensive, so it is used in targeted areas and alongside other control interventions. New species of vectors are resistant to IRS insecticides and new insecticides are costly, which has led to a decrease in the proportion of the at-risk population protected by IRS from 5 percent globally in 2010 to 3 percent in 2017 and 10.1 percent in SSA in 2010 to 5.4 percent in 2017 (WHO, 2018c; Innovative Vector Control Consortium, n.d.).

Chemoprevention

Chemoprevention uses drugs to suppress and prevent infections in humans and has been an effective technique in malaria control. IPTp and seasonal malaria chemoprevention (SMC) are the most effective chemoprevention strategies.

IPTp uses sulfadoxine-pyrimethamine (SP) to reduce maternal malaria infections, maternal and fetal anemia, placental parasitemia, low birth weight, and neonatal mortality. IPTp policies have been adopted in 36 African countries. Recommended in moderate to high malaria transmission areas, IPTp is administered at ANC visits during the second and third trimesters. Since 2012, WHO recommends that a woman receive at least three doses during each pregnancy; however, the number of doses is tied to how early a woman seeks ANC. In 2017, 22 percent of eligible pregnant women in 33 countries with sufficient data received three or more doses of IPTp, up from 6 percent in 2010 (WHO, 2018d). As more countries promote early antenatal visits, the number of women receiving three or more doses will increase.

SMC is a prophylaxis treatment, first recommended by WHO in 2012, to protect children ages 3–59 months from malaria during the rainy season in highly seasonal malaria transmission settings, such as the Sahel subregion. As of 2017, 12 African countries had adopted SMC policies: Burkina Faso, Cameroon, Chad, Gambia, Ghana, Guinea, Guinea Bissau, Mali, Niger, Nigeria, Senegal, and Togo. SP plus amodiaquine is administered to children monthly at the start of the transmission season up to a maximum of four doses during the rainy season. SMC objectives are to reduce the incidence of clinical malaria cases by 80 percent and avoid malaria-caused childhood deaths. SMC is a challenging intervention that requires mobilizing resources monthly to remote areas during the rainy season. In 2017, NMPs treated an estimated 15.7 million children eligible for SMC; however, an additional 13.6 million children could have also benefited from the intervention if more funding was available. To date, SMC has shown promise in specific countries, but estimates vary significantly across countries (WHO, 2018d).

Case Management

Case management is being used effectively in healthcare facilities and community health programs to decrease transmission and improve health outcomes. The strategy implements protocols to assess, diagnose, and treat

infections. WHO recommends testing protocols for suspected malaria cases, and these require testing before treatment for every suspected malaria case, using either microscopy or RDT. In SSA, malaria diagnostic testing has increased, from 35 percent of suspected malaria cases tested in 2010–2012 to 74 percent of cases tested in 2015–2017 in the public sector (WHO, 2018d). In the private sector, testing has also increased, from 41 percent in 2010–2012 to 63 percent in 2015–2017 (WHO, 2018d). The ease and accessibility of RDTs, originally intended for use in remote areas where good quality microscopy is limited, have contributed to increased testing rates.

By 2014, 81 countries had adopted ACT as the first-line treatment recommended for diagnosed positive, uncomplicated *P. falciparum* malaria. Confirmed cases in low transmission areas can also add a single low dose of primaquine. Confirmed cases of *P. vivax* malaria in areas without chloroquine-resistant *P. vivax* should be treated with ACT or chloroquine. Injectable artesunate is recommended for 24 hours in cases of severe malaria, followed by ACT.

Malaria Surveillance

The most recent strategy in the suite of malaria interventions, released as Pillar 3 in the 2015 WHO GTS, is malaria surveillance. The goal of this intervention is to detect all malaria infections, investigate each case of infection, and ensure that each detected case is treated promptly to prevent secondary infections (WHO, 2015a). In early 2018, WHO released the *Malaria Surveillance, Monitoring, and Evaluation: A Reference Manual,* providing global guidance on strengthening malaria surveillance systems in countries. Countries are designing manageable ways to put this strategy into operation, and implementation varies according to the transmission zone. Malaria surveillance in high and moderate transmission areas is done at the population level to ensure access to healthcare. Malaria surveillance in low transmission areas investigates individual cases to gain an understanding of the risk factors and eliminate the foci of transmission. Chapter 9 goes into a deeper discussion of malaria surveillance.

Interventions Under Development

Other intervention strategies are emerging, and some are under development or in the pilot stages in a few countries. These strategies include mass drug administration, mass screening and treatment, focal screening and treatment, therapeutic efficacy surveillance, sensitive polymerase chain reaction testing, vaccines, larvicide at breeding sites, new insecticides, and new approaches to outdoor biting mosquitoes. Mass drug administration and other approaches, such as mass screening and treatment and focal screening and treatment, are receiving increased interest among experts as ways to detect trends and take early preventive action to halt transmission.

Several malaria vaccines are currently under development for protection against malaria. An effective vaccine would be an additional tool to be added to the suite of existing WHO-recommended preventative, diagnostic, and treatment interventions. After showing partial protection against the *P. falciparum* parasite in children and infants in seven SSA countries during Phase 3 trials from 2009 to 2014, the RTS, S/AS01 (RTS,S) vaccine was recommended by WHO for pilot introduction in Ghana, Kenya, and Malawi in 2019 (WHO, 2018b).

3.4 Changing Contexts, Flexible Responses

Numerous factors contribute to the spread, control, prevention, and treatment of malaria. With global ecological shifts, population migration, and new technologies, malaria transmission and control contexts continue to evolve. For example, as discussed in Chapter 2, new species of host mosquitoes are demonstrating insecticide resistance and environmental tolerance, but vectors and parasites are localized, so one control strategy will not work in all locations.

Effective monitoring on carefully defined indicators is yielding large quantities of information that can be transmitted rapidly, thus increasing the scientific knowledge base of epidemiology. These increased capabilities also mean that additional training is necessary to provide a workforce skilled in data collection, processing, evaluation, and storage.

The rapidly changing context of malaria requires flexible responses to effectively prevent, control, and eliminate the disease. The global malaria control community offers the following elements as critical to efforts to controlling malaria.

Adapt to changing contexts. Increase the quality of data in health management information system (HMIS) and make the HMIS available to a broader spectrum of users. Adapt survey and research tools for better data collection. Improve and intensify health facility surveys to gather and relay timely information. Develop monitoring tools based on advanced diagnostic procedures to track malaria transmission. Improve long-term data to help define malaria transmission risk levels. Use monitoring results to activate rapid response to reduce transmission risks. Increase regional and local data use in control and elimination operations. Refine epidemic trend detection and plan rapid responses. Focus on capacity building and training. Equip national malaria control stakeholders with the tools, methods, and technical skills needed to assess progress. Prepare countries to report on their progress toward the SDG goals and targets.

Increase global interventions. Meet funding challenges, such as meeting the required yearly health expenditure needed to achieve GTS goals and ITN replacements as they reach life expectancies. Recognize the vulnerabilities to delayed infections as interventions, such as SMC for children under five, prevent acquired immunity.

Balance a decrease in the malaria burden with sustained global partner support. Maintain the decrease in malaria burden, but also maintain funding from global donors until the last case of malaria is recorded. Conduct malaria surveillance and plan responses for strict control efforts that recognize cost increases as prevalence decreases.

Push forward on malaria elimination by strengthening programs and seeking supporters. Engage private and public donors in continued funding efforts to reach malaria elimination. Move from donor-funded support to country-owned programs and responsibility. Write transition roadmaps to guide shifting administration, resources, and responsibilities for long-term sustainability.

3.5 Summary

The history of malaria control has shaped today's global malaria landscape. Through collaboration, the global malaria community has created the current strategies, goals, and targets to achieve malaria control and elimination. Trusted interventions are being used to implement malaria control strategies, such as vector control, chemoprevention, case management, and malaria surveillance. New interventions, such as vaccines, are under development and will likely be added to the suite of existing effective interventions in the near future.

Substantial reductions in the malaria burden in SSA over the last decade have proven successful, and they must be sustained with carefully orchestrated efforts to control the transmission, treatment, and prevention of infections.

Transmission: Insecticides and environmental measures will continue to reduce vector reservoirs, and increased scientific observation and monitoring will be needed to detect new vector species and insecticide resistance. The use of new technology, such as using modeling of geographic information system (GIS) data and environmental changes to predict likely areas with epidemic conditions, can provide information on preventive steps to take before infections spread.

Treatment: Health system performance will play a major role in maintaining progress. Effective, timely treatment with antimalarial drugs can help prevent further transmission and lessen the far-reaching socioeconomic effects of lost employment productivity and educational opportunities. Health system performance is hampered because many patients with malaria do not seek care, especially if they are asymptomatic, and too often healthcare providers do not or cannot comply with treatment guidelines. Patients do not necessarily receive the correct treatment and prevention regimens. Even if the correct regimen is administered, some patients do not adhere to instructions, and others receive counterfeit or substandard medications. Awareness campaigns and strict monitoring of resource distribution can help alleviate these problems, but they are costly.

Prevention: Essential components in prevention programs are carefully monitoring for emerging trends in infections and evaluating the healthcare system based on standardized case management indicators for treatment seeking, provider compliance, patient adherence, and quality of medication. Monitoring can be extended with malaria surveillance; however, developing surveillance guidelines for both high and low malaria burden areas is costly and politically charged. Extensive collaboration and cooperation are needed among experts and stakeholders to develop and carry out these guidelines.

The U.S. National Institutes of Health National Center for Biotechnology Information provides an example of M&E of health system performance (Galactionova, et al., 2015):

"We apply systems effectiveness concepts that explicitly consider implications of health system factors such as treatment seeking, provider compliance, adherence, and quality of medication to estimate treatment outcomes for malaria case management. We compile data for these indicators to derive estimates of effective coverage for 43 high-burden sub-Saharan African countries. Parameters are populated from the Demographic and Health Surveys and other published sources. We assess the relative importance of these factors on the level of effective coverage and consider variation in these health systems indicators across countries. Our findings suggest that effective coverage for malaria case management ranges from 8% to 72% in the region. Different factors account for health system inefficiencies in different countries. Significant losses in effectiveness of treatment are estimated in all countries. The patterns of inter-country variation suggest that these are system failures that are amenable to change. Identifying the reasons for the poor health system performance and intervening to tackle them become key priority areas for malaria control and elimination policies in the region."

4 Chapter 4. The Role of Data in Decision Making

Global strategies promote malaria research that produces knowledge and evidence, but results must be introduced and adapted in a format that is accessible and understandable to decision makers to bridge the transfer of knowledge. Raw data are collected and transformed into useful information to inform decisions. This information provides valuable input that decision makers use to understand problems and determine possible solutions. This chapter clarifies the differences between data and information, describes what decision making is, explains the importance of including stakeholders, defines data demand and use in malaria control, and shares different ways that NMPs use decision making to improve health outcomes.

4.1 Data vs. Information

Data are like a raw material and can exist in any form. They are facts and figures—pieces of information but not information itself. Sometimes data can be usable in their raw form, but often they need to be processed to be useful. Data must be properly compiled according to current methods and practices and must meet the needs of users. Examples of data include number of health facilities, number of malaria cases, number of mosquito nets available in a household, and number of pregnant women who received three doses of IPTp during their last pregnancy.

When data are processed, interpreted, organized, structured, or presented in a certain way to be meaningful, they become information. Information is valuable knowledge that is used to better understand problems. Good information provides context for data and answers questions such as "who," "what," "where," and "when" (Bellinger, Castro, & Mills, 2004). In the context of malaria control, health data are collected in the form of indicators, which are then processed, organized, and interpreted as information, which is then used by decision makers to make decisions and resolve problems. In the example shown in Figure 11, health data are collected on annual deaths for children under five. The pieces of data are then compiled and interpreted to provide information, such as the mortality rate for children under five. By looking at this information over a period of time, users can determine whether the mortality rate has changed. Is the mortality rate increasing, remaining the same, or decreasing? Looking at how the information has changed over time can prompt decision makers to find out what is happening and implement processes to improve the situation.

Figure 11. Health data becomes information

4.2 What Is Decision Making?

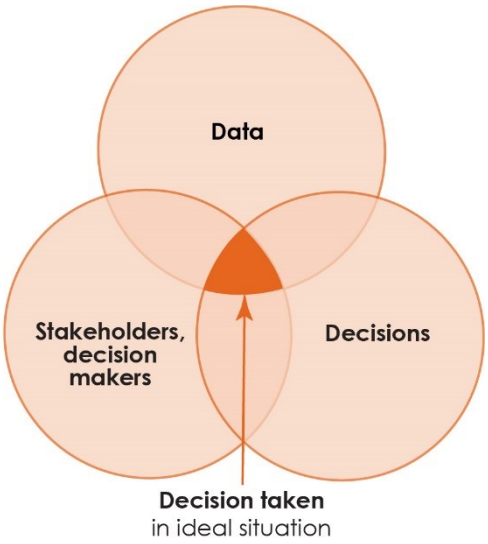
Evidence-based decision making in NMPs relies on the availability of high-quality, timely, and relevant data that have been analyzed to generate context-specific information. Stakeholders in NMPs have specific data needs, and malaria data that are collected, processed, and analyzed should provide information to inform and address those needs.

To provide facts for evidence-based decisions:

- Identify and involve all stakeholders
- Pursue quality in data collection, compilation, and analysis
- Know the alternatives and options

Decision making is the process of choosing among various alternatives using information for a given objective. It must involve all stakeholders affected by the decision and involved in implementation and must be based on proven data or information from the data. The process involves these steps: (1) identifying and involving appropriate stakeholders to ascertain their information needs; (2) using standardized quality data collection, compilation, and analysis techniques; and (3) knowing decision alternatives and understanding the options. All three elements are equally important in making evidence-based decisions. By triangulating these three elements, decision makers are able to make decisions that lead to better health outcomes (Figure 12).

Figure 12. Context of decision making



For example, in 2006, WHO released the first guidelines for the treatment of malaria, which recommended that countries use ACTs instead of monotherapies for front-line malaria treatment. Since then, two more editions of the WHO guidelines (2010 and 2015) have been updated with new evidence generated from worldwide data collection, quality assessments of the evidence, and systematic reviews. This evidence informed the updated guidelines and resulted in all countries with *P. falciparum* updating their malaria treatment policies from monotherapies to ACTs by 2015. (WHO, 2015b).

Involving Stakeholders in Decision Making

Stakeholders, or decision makers, have different information needs and should be involved in decision-making processes to identify information needs and gaps. All stakeholders are interested in the effectiveness of interventions and programs, but different kinds of stakeholders may focus on different elements of those interventions and programs. For example, NMP program managers and implementing partners are concerned with the efficacy, quality, and coverage of their interventions. Policymakers may have a narrower focus on how the policy implications of an intervention or protocol can be adjusted to improve effectiveness, quality, sustainability, and cost efficiency. By engaging all stakeholders, information can be produced that meets their needs and informs action.

Stakeholders for NMPs are decision makers who are responsible for acting at any level, from global leaders to parents of a sick child. Decision makers need answers to these questions:

Community members ask: Is this NMP working for me and my family? What will this program do to help my household?

Community leaders and local government officials ask: Does this NMP deliver effective services? Does it provide necessary services equally to the people in the community? Is it improving conditions?

Program managers, implementation partners, and partner agencies ask: Is this NMP effective? Is this program providing quality activities that are improving conditions? Is this program cost efficient?

National and global policymakers ask: Does this program follow the nation's strategic plan for malaria control? Is this program sustainable? Is this program cost efficient and effective? Is this program improving health outcomes in the population?

Most NMPs have a long list of stakeholders, as shown in Figure 13. An early task in planning and implementing an NMP is to identify the stakeholders and their needs. Emphasis is often not placed on quality data collection and reporting, but discovering who needs the information and why can guide the process and yield higher-quality data.

Figure 13. Malaria program stakeholders and their information needs

Stakeholders, decision makers	Information needs
Beneficiaries	Effectiveness of program or intervention, quality of services provided
Community leaders, local government officials	Effectiveness of program or intervention; quality, equity, and coverage of services provided; who are the clients
Program managers, implementation partners	Effectiveness of program or intervention; who are the clients; quality, equity, and coverage of services provided
Policymakers	Quality and equity of services, cost-efficiency and effectiveness of program or intervention, information relevant for correcting and improving policy
Partner agencies	Effectiveness of program or intervention, policy implications, sustainability of program, cost-efficiency and effectiveness
Data producers	All of the above

4.3 Data Demand and Use in Malaria Control

Evidence-based decision making is the outcome of data demand and use, a process that uses proven data in the context of an objective to reach decisions, make changes, or take specific actions to improve outcomes. **Data demand** is the value a decision maker places on data, regardless of whether the data are actually used to make a choice. **Data use** is where and how stakeholders use the information generated from data to make decisions.

Data demand. To identify the source of the demand for data, all program stakeholders should be identified and consulted to discover their needs for information and how they plan to use it. For example, the need could be to inform managerial or policy directives, increase or decrease resource allocations, or strengthen staff capabilities.

> **Data demand** is the value the decision maker places on the data, regardless of whether he or she actually uses the data.

Data use. Data are numbers, and without context the numbers are not useful in guiding action. Analysis is a calculation to organize the data to show results, and evaluation puts the results into a meaningful context with objectives. Raw data are not evidence, but they are useful to data users who determine the value of the information and how they will use it. Data can be used to inform decisions in an NMP through the following:

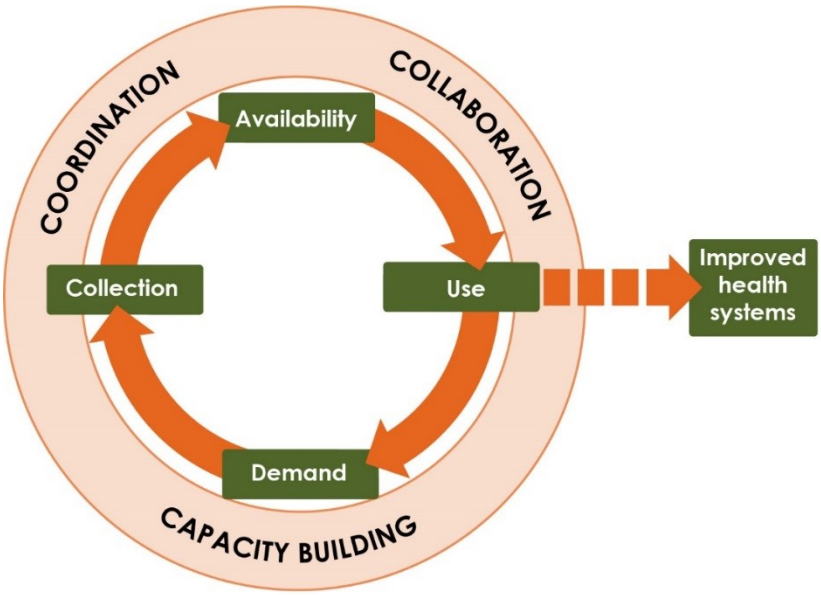
- Strengthening programs and improving results
- Informing policies and plans
- Raising additional resources
- Ensuring accountability and reporting
- Improving the quality of services provided
- Contributing to global lessons learned

> **Data use** is the decision-making process or any action taken on the basis of existing data.

> **Relevant questions to inform data use**
>
> How will data be used?
>
> Is the stakeholder explicitly aware of the decision that needs to be made?
>
> Does the decision involve at least two possible alternative courses of action?
>
> Will the stakeholder consider the relevant information in making the decision, even if the data are outweighed by other factors?

Data demand and use is a cyclical process. Stakeholders need information to help reach decisions, make changes, or take other specific actions to improve outcomes. SME data collection and analysis fulfill this need and deliver information to decision makers in the format and time frame needed, and the value of the information for decision making encourages further use to improve health systems. Figure 14 illustrates the cycle from demand to use, with decision making embedded throughout the cycle. The cycle requires continued coordination, collaboration, and capacity building among stakeholders.

Figure 14. Data demand and use process



Source: MEASURE Evaluation

4.4 Decision Making for NMPs

As NMPs work toward improving health outcomes and achieving their program targets, decision making becomes important for strategic planning, policymaking, program management, and resource allocation.

Strategic Planning and Policymaking

Malaria SME systems yield large quantities of data. After analysis and evaluation, those data help guide deliberate, thoughtful decisions on when, where, and how to implement malaria control activities to achieve NMP targets. Data reflect program effectiveness and progress toward meeting strategic goals. SME data can also provide information about the adequacy of resources and summarize healthcare usage and treatment statistics.

At the global level, SME data and national surveys quantify the global malaria burden, providing data on national mortality rates, maternal mortality rates, and children under five mortality rates among other data. These data are used at different levels. Governments and large nongovernmental organizations use these statistics to build strategic policies and direct funding. Governments use these statistics to direct NMP activities and budget resources. District and local area governments use data to plan activities and evaluate their effectiveness. Funding partners use data to evaluate the effectiveness of their investments. When decision makers have access to quality data and have confidence in those data, they are more likely to use the data to inform strategic planning and policymaking.

Program Management and Resource Allocation

Evidence-based decision making can also be used as a program management tool, such as for scheduling staff support supervision and monitoring. For example, a program manager uses data to determine how many

health facilities need supervision, find out how many trained supervisors are available, and examine the results from previous supervision visits. Resource allocation for NMPs depends heavily on evidence-based decisions for planning for the use of drugs and commodities, human resources, and infrastructure and equipment.

Malaria data collected through SME inform program management at various levels. Routine malaria data can be used to identify hot spots or epidemics. Program managers can then redirect human resources, medicines, and supplies to that region to reduce or stop malaria transmission in that area. For this to work effectively, the quality of the data must be good, and program managers must have confidence in the data. Data quality for NMPs is discussed in more detail in Chapter 11.

Role of SME Personnel

SME personnel are responsible for providing quality data and information needed for decisions; however, their jobs do not stop there. With targeted dissemination, SME personnel can reach specific audiences with key messages and recommendations. SME personnel can also help decision makers understand what kinds of questions they should ask, which will improve the decisions being made and the data being requested.

Although not all staff members in NMPs see the financial, policy, and operations decision-making process in action, every member of the team is vital to the process of supplying information. The daily activities of SME staff have a large financial impact, and each staff member is responsible for one or more parts of the multi-faceted process of collecting, disseminating, and using data and information. It is easy to lose sight of the data users and the decisions they make. SME staff should be sensitive to different information needs and be responsive to data and reporting requests from various stakeholders.

Data use for informed decisions in Ghana

When Ghana changed its drug policy for uncomplicated malaria in 2005 to promote treatment with ACTs by supplying ACTs rather than chloroquine, the National Malaria Control Program crafted this policy change by using the following: data on antimalarial efficacy, malaria morbidity and mortality, and cost effectiveness; a benefit analysis of drug options; malaria in pregnancy survey results; and WHO guidelines. The National Malaria Control Program analyzed the data with user-friendly charts and graphs and compared the results with WHO guidelines to determine which drug to choose and what resources would be needed to make the change. Program staff communicated the data to stakeholders through a series of fora. Ultimately, the stakeholders made an informed decision to change from chloroquine to ACTS as first-line malaria treatment.

(Ghana Ministry of Health, 2009a)

4.5 Constraints to Data Use

Potential barriers to data use include internal constraints faced by SME staff and external barriers influenced by stakeholders. Constraints faced by SME staff may include insufficient funding for SME training and support; inadequate physical infrastructure and limited technology that hamper comprehensive data collection; delayed reporting, resulting in outdated information; low staff motivation that results in low-quality data and poor analysis; unclear organizational structure that delays the data flow; lack of technical skills among staff that results in errors; and unsustainable and inadequate ad hoc training.

External constraints may include insufficient financial and human resource allocation, competing priorities, obscured reporting schedules and data flow, stakeholders or a broader culture that does not value data-driven decision making, and political pressure that affects the dissemination of information.

Any of these challenges can affect the reliability of data and, consequently, their use. If decision makers cannot trust the information, they soon avoid using it, and underutilization undermines SME programs.

Ways to Improve the Use of Good-Quality Data

NMP SME units can increase data use by ensuring data quality, reliability, and timeliness and by delivering data in a format that is appropriate for the data users. An effective way to increase data quality is through training in data collection methods, data input, data assessment, and reporting procedures.

Data use has two criteria: (1) it must meet its intended purpose, and (2) it must meet the user's needs. The information generated from the data must provide what the user is seeking, not more or less. The delivery format must match the user's capability to process it. Meeting the user's purpose and fulfilling the user's needs determines whether the stakeholder will use the data for decision making. Users who are skeptical of data quality likely have had experiences with unreliable data, and they are unlikely to use or seek further information from that data source.

Data quality is only as good as the weakest link in the SME data process. Here are some examples of weak links: if the collection forms are not filled out correctly, every step in the process that follows is flawed; typing mistakes during the transfer of information from collection forms to digital entry means the results are invalid; and late reporting affects usefulness because the information is outdated. Addressing these kinds of issues will improve data quality and ultimately data use.

4.6 Summary

NMPs amass large quantities of SME data to be generated into information that is used to inform decisions about program activities, including allocation of resources and budget planning, and inform the development of and updates to malaria control policies and regulations.

Evidence-based decisions rely on quality and timely data, and on experience. Countries use data to develop strategic plans for NMPs, which in turn strengthens funding and targets intervention activities in areas that need it most. Local program managers use evidence-based decision making as a management tool to direct staff activities and allocate resources. For example, a program manager needs data to determine the distribution of staff supervisory visits to health facilities, based on the results from previous supervision visits. NMP resources are allocated based on previous needs, such as drugs and commodities, human resources, and infrastructure and equipment. Decision makers use data to add context when comparing alternatives. The use of data in decision making has many applications as a tool to guide planning, policies, and program strategy.

Many factors contribute to low data use. Unreliable data can be a result of insufficient funding for SME training; insufficient staff capability to produce timely, reliable information; or a lack of quality in data collection and assessment. Delayed data reporting could mean decisions are based on outdated information. If organization roles and responsibilities are not clearly defined, staff may suffer from a lack of supervision

and motivation. Physical barriers and limited technology may hamper comprehensive data collection and timely reporting. Political pressures can result in unclear reporting requirements and data flow.

SME units can increase data use by delivering reliable data in a timely manner and in a format that the data user needs. The surest way to increase data quality is through staff training in data collection methods, data input, data assessment, and reporting procedures.

5 Chapter 5. Designing an SME Plan for National Malaria Programs

This chapter defines what an SME plan is, identifies the essential components, describes the development and preparation process, and explains the role of the SME unit. It also dives deeper into how to develop a problem statement and objectives for an SME plan, which are essential. Finally, it shares country examples and practical experiences to provide insight. This chapter is not exhaustive and some concepts on malaria surveillance will be developed further in Chapter 9.

5.1 What Is a Malaria SME Plan?

A malaria SME plan is a comprehensive document that comprises a description of the malaria program's goals and objectives, activities the program needs to undertake to achieve the objectives, and procedures for implementing the plan. An SME plan also specifies the key indicators and their targets and lists data needed and data collection tools and analysis methods. It describes how the information will be used to document program achievements and the resources needed to disseminate the information. It also describes how the SME unit will be accountable to all stakeholders, including beneficiaries, implementers, policymakers, and donors. An SME plan is not a stand-alone document; it works in line with a national strategic plan.

SME Plan Functions

An SME plan has four functions: (1) to state how the program will monitor indicator data to measure achievements; (2) to document the data collection and reporting processes, roles, and responsibilities; (3) to generate reliable, comparable, and standardized evidence that guides implementation; and (4) to preserve institutional memory by documenting each step in the process. Data collection methods should be comprehensive and realistic, and conducted in a legal and ethical manner, showing respect for beneficiaries and others from whom data are collected. The information produced under the SME plan must be accurate and technically sound.

SME plan requirements

- Outline program objectives and the stakeholders responsible.
- Explain the accountability structure to reach the achieved results.
- Show program results by program objectives.
- Document consensus through transparency and responsibility.
- Specify the data needed, collection process, analysis methods, and reporting path.
- Describe dissemination methods to inform all stakeholders of program results.

An SME plan is a living document that is adjusted when a program is modified, interventions are added, problems are encountered, or priorities are shifted. Often programs are modified based on lessons learned or funding availability, and the SME plan must adjust the data collection and processing to continue to meet users' needs and accurately capture program accomplishments.

Components of an SME Plan

An SME plan includes eight main components: introduction, program description, indicators, data sources and reporting systems, strategies for demonstrating program outcome and impact, dissemination plans and information use, analysis of data quality constraints and potential solutions, and an implementation plan. Although every SME plan does not conform to this outline, these elements represent the essential components. An overview of these plan elements follows.

Introduction. The introduction to an SME plan provides background information, describes how the plan was developed, identifies resources allocated, and reviews how the SME system works. It summarizes the NMP's purpose, suggests ways to engage stakeholders in discussions with the SME unit to gain consensus, and sets the scope for implementation. The introduction also identifies NMP partners, donors, and stakeholders with designated roles and responsibilities. Updates to SME plans often share findings from recent SME system reviews in the introduction. SME system reviews may include a strengths, weaknesses, opportunities, and threats (SWOT) analysis—a useful strategic planning tool that helps match goals, programs, and capacities to the NMP's operating environment.

Conducting a SWOT analysis

A **SWOT analysis** generates information that is helpful in matching an organization's or a group's **goals, programs,** and **capacities** to the social environment in which it operates.

Factors affecting an organization can usually be classified as:

Internal factors:

Strengths: Positive **tangible** and **intangible** attributes, internal to an organization. **They are within the organization's control.**

Weaknesses: Factors that are **within** an organization's control that detract from its ability to attain the core goal. **In which areas might the organization improve?**

External factors:

Opportunities: External attractive factors that represent the reason for an organization to exist and develop. **What opportunities exist in the environment that will propel the organization**? Identify them by their **"time frames."**

Threats: External factors, beyond an organization's control, which could place the organization's mission or operation at **risk.** The organization may benefit by having contingency plans to address them should they occur. Classify them by their "**seriousness**" and "**probability of occurrence.**"

Program description. This section defines the nature of the NMP goals. It defines a problem statement that presents the program rationale, identifies the program goals and objectives, and clearly links expected outputs and outcomes.

More details on developing a problem statement are provided in Section 5.2. The program description includes a conceptual framework, which is a graphic representation of how program activities lead to achieving program objectives. This section also includes SME unit activities for targeted populations and activity duration. An SME plan usually includes a logic model or logical or results framework in this section. More details on framework design and use for NMPs are presented in Chapter 6.

Indicators. This section of the SME plan lists indicators used to monitor and evaluate the NMP. These indicators should reflect data needs of stakeholders, feed into the results framework, and align with global standards for measurement and comparability. Indicators may be grouped by input, process, output, outcome, and impact. Indicators are summarized in an indicator matrix and are accompanied by indicator reference sheets that present indicator definitions, guidance for data standardization, measurement criteria,

including numerator and denominator specification, and levels of disaggregation. Chapter 7 provides more information on indicators.

Data sources and reporting systems. This section of the SME plan outlines the methodology for data collection, processing, analysis, and reporting. It lists the sources of data for each indicator, data collection tools, and information sources, such as patient records or registers, survey instruments, commodity management forms, and periodic surveys and evaluations. This section also describes how the various data sources and reporting systems are managed and designates roles and responsibilities for SME staff. Chapter 8 presents detailed information on data sources and reporting systems, and Chapter 11 covers data quality, management, and analysis.

Strategies for demonstrating program outcome and impact. This section of the SME plan lays out the methodology for measuring program outcomes and impact. The strategy described in this section should make the methodology and SME processes measurable and replicable to compare program achievements over time and across programs. Protocols for special studies, such as mid-term assessments and end-of-project evaluations to gauge outcome and impact, are discussed under this section. Chapter 10 presents a comprehensive background on evaluation methods, with special focus on measuring NMP impact.

Plans for dissemination and information use. This section informs how, and with whom, program results will be disseminated and used. Data collected, information generated, and results observed through SME processes are used to guide NMPs. The SME plan, therefore, should include a summary of how the information will be disseminated to stakeholders. This includes how and where information is stored, and the formats used for dissemination. Depending on stakeholder needs, information can be shared through in-person meetings, reports, bulletins, media coverage, conferences, and scientific publications. Chapter 12 provides for a thorough review of data presentation, interpretation, and use.

Analysis of data quality constraints and potential solutions. Data quality is a serious concern that must be discussed early during SME planning and stakeholder engagement. The SME plan should describe quality control mechanisms and how data quality will be assessed. The plan should also include avenues for feedback and solutions to possible obstacles.

SME implementation plan. This section of an SME plan is a road map that describes key competencies of SME staff needed to implement the SME plan and specifies the roles of personnel responsible for carrying out program actions, activities to accomplish data collection and processing, and a time frame. This section also addresses estimated implementation costs and resources required.

Standards

Standards used to govern the accuracy, feasibility, integrity, and utility of the SME plan are set during plan development. Accuracy means that the data are trustworthy and of high quality, and that the data processing yields an accurate representation of program accomplishments. Feasibility means that the SME plan is realistic in its data sources and collection methods and that it is within a prudent budget. Integrity means that the SME program is conducted legally and ethically, and that the data are securely stored and used in a way that ensures the privacy of participants. It also means that participants are treated with respect, and that their privacy is protected. Utility means that the results serve the practical information needs of the intended users.

5.2 Developing and Preparing an SME Plan

Preparing, writing, and implementing an SME plan requires careful assembly of a list of program goals and objectives, needs, and resources available. A good understanding of NMP guidelines and policies is essential to SME plan development. Stakeholder buy-in is equally important.

Figure 15. Steps of an SME plan

Preparing for an SME plan involves collecting facts. The first step is canvassing stakeholders to determine their information needs. Different stakeholders have widely divergent needs. Next is assessing any existing plans, reviewing data sources, assessing staff capacity to carry out SME tasks, considering available technology, and reviewing infrastructure resources and constraints. This groundwork provides the means to assemble the plan document.

Writing an SME plan is a process of setting priorities, organizing the facts, consulting stakeholders for additional information, and establishing a framework for indicators, reporting structure, and roles and responsibilities. An SME plan should be developed in sections to address each facet of the overall plan, with some interdependencies between sections. For example, indicators for measurement cannot be finalized before the conceptual framework and logic model are developed. The final plan should be an approved comprehensive document that describes the SME system, which includes the elements necessary to carry out the plan activities.

Implementing the SME plan involves assigning staff to roles and ensuring that all staff members have the skills necessary to conduct their assigned responsibilities. The national SME unit is responsible for obtaining consensus among stakeholders and coordinating data management, reporting, auditing, and disseminating results. It is also responsible for ensuring that team members receive the training needed to fulfill their roles.

Assembling, writing, and implementing an SME plan requires eight steps, as described in the box below.

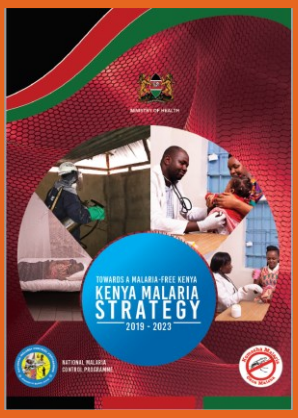
Eight steps to SME plan development

1. Identify NMP stakeholders. Develop a strategy for stakeholder involvement in planning, drafting, and reviewing the SME plan.
2. Assess the strategic data needed to measure program SME progress.
3. Assess any existing plan and staff capabilities to provide the strategic data needed. This includes ensuring sufficient funding, staff capacity, and technology and infrastructure. If the current systems are inadequate for SME plan activities for data collection and processing, explore alternatives.
4. Review program indicators and identify their data sources. Identify data collection tools. Seek stakeholder input to ensure that all information needs are included.
5. Prepare a proposed budget for SME plan implementation.
6. Write the draft SME plan. Seek stakeholder review, incorporate feedback, and achieve consensus on a final plan.
7. Seek stakeholder commitment for the approved SME plan, including the following: (a) resources for implementation; (b) indicators and their definitions; (c) processes for data collection, analysis, and processing; (d) structure, timeline, and format for reporting; and (e) roles and responsibilities of stakeholders.
8. Implement the plan by assigning staff to roles and following through with staff supervision.

Developing a malaria SME plan: A case from Kenya

Kenya's National Malaria Strategy (NMS) has evolved over the years, becoming more comprehensive and inclusive of M&E over time. Kenya's first NMS, 2001–2010, included a three-page chapter dedicated to M&E. Subsequent documents included separate NMS and M&E plans.

In 2019, Kenya launched a new five-year NMS and M&E plan for 2019–2023 focused on six objectives: vector control in malaria risk areas, malaria case management, established systems for malaria elimination, social behavior change, communication and use for malaria interventions, SME and operational research, and program management and partnership (Kenya Ministry of Health, National Malaria Control Programme, 2019a; Kenya Ministry of Health, National Malaria Control Programme, 2019b).



Preparing for this plan included bringing together stakeholders, such as National Malaria Control Program (NMCP) program officers, representatives from the Ministry of Health and other relevant ministries, county health officers, WHO technical leads, and partners. The NMCP led a malaria program review to document achievements and identify future priorities, which included getting political commitment, requesting technical assistance from WHO, and completing a protocol and budget.

Thematic review teams based on the six objectives, with each area led by a consultant, reviewed the literature and assessed what had been achieved in the previous strategy. An Excel-based technical performance assessment tool, developed by WHO, was used to assess the performance of the previous M&E plan. Each team prepared a thematic report based on the findings.

The next step was external validation by WHO reviewers. External validation critiqued the thematic reports and focused on challenges and recommendations. Field validation included visiting national offices and nine counties to observe what happened on the ground. The results of the desk reviews and field visits were shared with county health directors for further inputs and validation. Because counties are focused on service delivery, one of the recommendations was to include program management capabilities alongside service delivery.

A national malaria forum was held for the research community to contribute to the malaria program review process by presenting new data and discussing gaps between research and policy. A final report of the malaria program review was published, which identified issues and recommendations and informed development of the new plan.

A new goal and strategic objectives for the new plan were developed, which included identifying strategies by thematic area, mapping their measurement, and defining appropriate indicators. The NMCP separated the NMS and the M&E plan into two documents and shortened the period to five years: 2019–2023. Thematic teams, led by their respective consultants, developed the first draft of the strategy, which was reviewed by a WHO technical lead. NMCP and partners critically reviewed the final draft of the strategy for publication. The new NMS and M&E plan were disseminated first at the national level and then cascaded regionally and countywide.

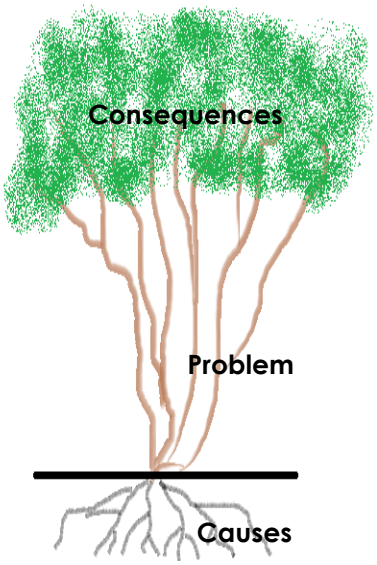
Information provided by Sophie Githinji, MEASURE Evaluation, ICF

Role of the SME Unit

An SME unit plays many important roles in an NMP, and the unit staff need to coordinate SME activities with the overall program implementation. First, the unit must build consensus among program stakeholders, participants, program managers, policymakers, and partners. The unit is responsible for managing data entry, analysis, and interpretation and for reporting program results to stakeholders in a user-friendly, easily accessible format. Emphasis should be placed on the importance of data quality, and the SME plan should include a provision for a data quality audit. Data processing and analysis require specific skills, and SME staff may need to receive training to build their capacity in these SME tasks.

Developing an SME Plan Problem Statement and Objectives

Developing a problem statement for an SME plan can cause confusion and must be clearly established before subsequent steps are taken. A problem statement summarizes the problem, describes its consequences, lists the probable causes, and identifies the people affected. It concludes with a proposed solution.



Source: Elizabeth Ivanovich, 2011

The SME plan problem statement answers the following questions: What is the current situation? What is the problem? Is there a gap? What are the causes of the gap?

One way to create a problem statement is to do a problem tree analysis. This analysis uses a tree, divided into three parts. The roots represent the causes, the branches represent the problem, and the leaves represent the consequences. In this analogy of a tree, the size and growth of the tree depends on what happens over time. The roots (causes) affect the problem, which would then affect how well the tree grows (consequences). The amount of sunlight and water represent the causes, which affect tree growth and determine the health of the tree. A lack of sunlight and water (causes) affect the tree's growth (problem) and its ability to bear leaves and fruit (consequences). A tree that is planted in good soil, watered regularly, and exposed to sunlight (causes) grows strong and tall (problem), and bears leaves and fruit (consequences). Linking this analogy to a problem statement means first describing the situation as it is, and then identifying the causes that lead to the expected consequences or outcomes.

SME unit problem statement questions

An NMP SME unit might answer the following questions in its problem statement:

- What is the scope of the malaria burden in country X?
- How many people are affected by malaria in country X?
- Why does malaria exist in country X? Is there more than one cause?
- What are the consequences of the malaria burden in country X?
- Are there political, cultural, and economic effects?
- Who will use the SME products?
- What is the benefit to the NMP?

A problem statement can also begin with the ideal or expected situation, and then describe the current situation. The statement points out the differences or gap and describes possible improvements.

Problem statement from the Ghana National Malaria Control M&E Plan 2008–2015

Malaria is hyper endemic in all parts of Ghana, with all the 23 million population at risk. Transmission is year round, with only slight seasonal variations from April to July during the rainy season. The northern parts of Ghana, however, have marked seasonal variation, with a prolonged dry season from September to April. Over the past 5 years, between 3.1 and 3.5 million cases of clinical malaria have been reported in public health facilities annually, of which more than 900,000 cases are children under-5 years (NMCP Annual Report 2006). Everyone is at risk of having a malaria infection, but children under-5, pregnant women, and non-immune visitors are at the greatest risk.

Presumptively, diagnosed malaria cases account for 37.5% of all outpatient illnesses, 36% of all admissions, and 33.4% of all deaths in children under-five years. Amongst pregnant women, it accounted for 13.8% of all Outpatient Department (OPD) attendances, 10.6% of admissions and 9.4% deaths. The groups most vulnerable to the disease are children under-five years and pregnant women who constitute 20% and 4% respectively of the general population.

The main parasite species causing malaria in Ghana are P. falciparum (80-90%), P. malariae (20-36%), and P. ovale (0.15%). Mixed infections of P. falciparum and P. malariae are not uncommon. The crude parasite rates range from 10 to 70%. The principal vectors are the Anopheles gambiae complex and Anopheles funestus, accounting for 95% of all catches. Anopheles gambiae s.s. of the complex predominates and transcends across the country. Characteristically, these species are highly anthropophilic, biting mostly late in the night, and are commonly found wherever there are breeding sites.

The overall goal of RBM in Ghana was to reduce the malaria disease burden by 50% by 2010. This goal was to be achieved through overall health sector development, improved strategic investments in malaria control, and increased coverage of malaria treatment and prevention interventions, especially at the community level.

The specific targets by the end of 2010 are:

- 80% of caretakers and parents in rural areas and 90% in urban areas will be able to recognise early symptoms and signs of malaria. (Milestone: 60% rural, 70% urban by year 2005).
- 80% of caretakers and parents in rural areas and 90% in urban areas will respond appropriately to cases of malaria they identify. (Milestone: 60% rural, 70% urban by 2005).
- Quality of health care services for the management of all cases of malaria will be improved in 90% of health facilities. (Milestone: 70% by year 2005).
- Physical accessibility to basic services (5 km from nearest health facility) will increase from about 60% to 90% (Milestone: 75% by year 2005).

(Ghana Ministry of Health, 2009b)

Goals and Objectives

SME plans need stated goals and objectives. Goals describe the outcome a program wants to attain. Objectives are the steps required to reach the goal for the desired, long-term outcome. The steps are a roadmap to clearly defined objectives, which should be written to be SMART—**S**pecific, **M**easurable, **A**ppropriate, **R**ealistic, and **T**ime-based.

Write SMART objectives

- **S**pecific: identifies concrete events or actions that will take place
- **M**easurable: quantifies the amount of resources, activity, or change to be expended and achieved
- **A**ppropriate:* logically relates to the overall problem statement and desired program effects
- **R**ealistic:** sets a realistic result for an objective that can be achieved with the available resources and implementation plan
- **T**ime-based: specifies a time limit for achieving the objective

*Sometimes the letter "A" in SMART stands for attainable.
**Sometimes the letter "R" in SMART stands for relevant.

5.3 Summary

A malaria SME plan is a comprehensive document, used alongside the national strategic plan, which describes the goal and objectives of an NMP and its SME activities. It has four functions: states how the SME program will measure achievements in the NMP; documents where and how data are collected, shows the path of data through processing, and assigns responsibility to the roles that generate the data; guides implementation by standardizing the process and coordinating across the program; and preserves institutional memory by documenting each step in the process.

An SME plan has eight main components: introduction, program description, indicators, data sources and reporting systems, strategies for demonstrating program outcome and impact, dissemination plans and information use, analysis of data quality constraints and potential solutions, and an implementation plan. Preparing, writing, and implementing an SME plan requires careful assembly of a list of program goals and objectives, needs, and resources available.

Strong SME plans have a problem statement that summarizes the problem, describes its consequences, lists probable causes, identifies people affected, and concludes with a proposed solution. Goals describe the program outcome, and objectives identify the steps required to attain it. SMART objectives for the SME plan are **S**pecific, to identify concrete events or actions that will take place; **M**easurable, to quantify the resources and activities needed to achieve the desired program outcome; **A**ppropriate, to logically relate SME unit activities to the NMP goals and objectives to report outcomes; **R**ealistic, to provide data collection and processing within the available resources; and **T**ime-based, to specify a schedule for delivering the information to data users and stakeholders.

SME plan actions

Take these actions:

- Start early.
- Involve stakeholders at all stages in the process.
- Assess current capacity, use available resources, and budget adequately.
- Provide specific training for SME tasks and encourage supervisory visits to ensure quality.
- Report results on time in a format that data users need and can understand to encourage data use in decision making.

Avoid these actions:

- Avoid collecting data that are not relevant to the program. Avoid duplicating data collection and reporting.
- Do not underestimate the importance of stakeholder buy-in or neglect to foster ownership in the SME plan at each step of the process.
- Avoid choosing indicators that have no data source or that omit specific criteria needed for calculation and reporting.

Chapter 6. Frameworks

This chapter describes four different types of frameworks and focuses on how NMPs construct frameworks and the components that go into them.

6.1 Understanding Frameworks

All NMPs are built on plans that have stated goals and objectives and follow standard practices with established components. The progress of program implementation can be diagrammed as a framework that shows how the components relate to each other and the processes used to accomplish goals and objectives. The framework helps the program monitor progress, identify challenges, and address those challenges accordingly to improve effectiveness.

Frameworks provide the theoretical basis for strategic planning in SME. They are structural diagrams that show the components of a program and the relationships among them. They illustrate the process sequence to accomplish program goals and objectives and act as a roadmap for activities and budgeting. Not all programs use the same type of framework, but they all have core components in common—inputs, processes, outputs, outcomes, and impact. Frameworks are based on program goals, according to individual program characteristics and circumstances. Generally, they are designed to (1) clearly state a program's objectives and the expected results; (2) outline the activities needed to reach those objectives; and (3) define the relationships among inputs, processes, outputs, outcomes and impact. Frameworks help establish and implement a coherent SME plan.

6.2 Types of Frameworks

Frameworks can be divided into four main types: (1) conceptual, (2) results, (3) logical, and (4) logic models. Program characteristics and circumstances guide the choice of which of the four types to use. The choice considers strategic plan emphasis, the type of SME planned, and stakeholder requirements. The following paragraphs summarize the framework characteristics and their uses.

Conceptual Framework

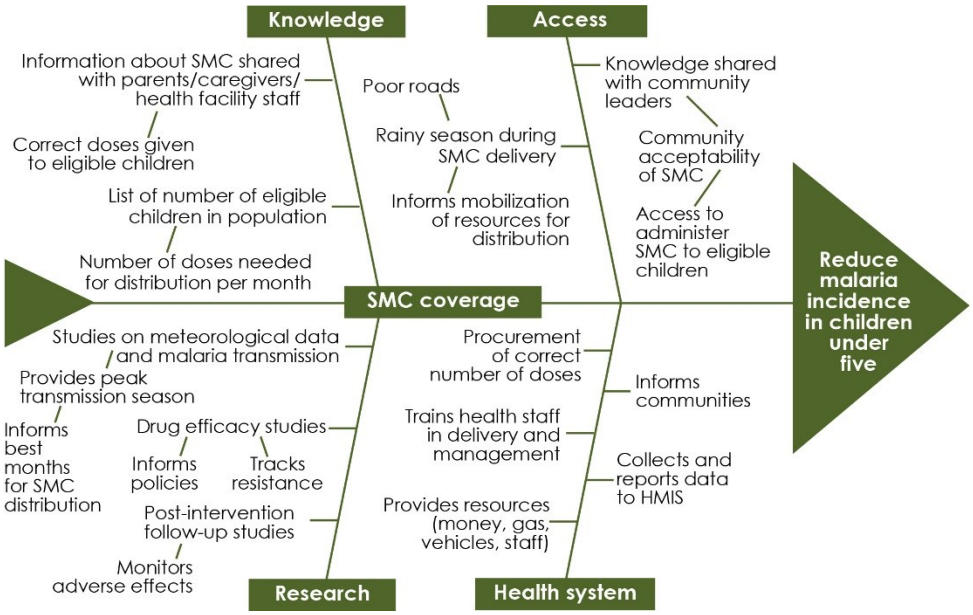
A conceptual framework is built to reflect a program's theoretical approach by showing the relationships among the components and salient factors that influence its operation and outcomes. Also known as a theoretical or causal framework, a conceptual framework connects the program's objectives with its processes and activities to clarify the "why" and "how" of program operations. This framework organization depends on underlying program assumptions built into the program goal and guides the selection of appropriate indicators to measure achievements.

The advantage of a conceptual framework is that it considers all the elements that affect a program and demonstrates how the program fits into a wider environment. A conceptual framework helps reveal assumptions and identify indicators to measure results. It also shows causal pathways that can guide an impact analysis at the end of the program.

Many different tools can be used to develop a conceptual framework. Common tools are the problem tree analysis, as described in Chapter 5, or the fishbone diagram. The fishbone diagram, also known as the cause

and effect or Ishikawa diagram, is a tool used during brainstorming to identify potential causes that contribute to an effect. The fish head represents the effect, and the fish bones represent the causes that contribute to the effect. They connect from the head and branch above and below the head. Figure 16 shows an example of a fishbone diagram used to describe the cause and effect of scaling up an SMC program to reduce malaria incidence in children under five. In this example, the relationship between four key elements—access, health system, knowledge, and research—contributes to SMC coverage, which leads to a reduction in malaria incidence in children under five. Beneath each of these elements is a list of details that could affect the success of SMC. For example, the knowledge "fishbone" shows that providing knowledge to a community can lead to the correct doses given to eligible children because the community is informed and accepts the intervention. Creating a list of the number of eligible children in a population can also inform the number of doses needed for each month of SMC distribution. Access, another "fishbone" in the diagram, can negatively cause logistical challenges in the supply of commodities during the rainy season. It can also positively affect SMC coverage when community leaders provide acceptability of SMC in a community and access to administer SMC to eligible children.

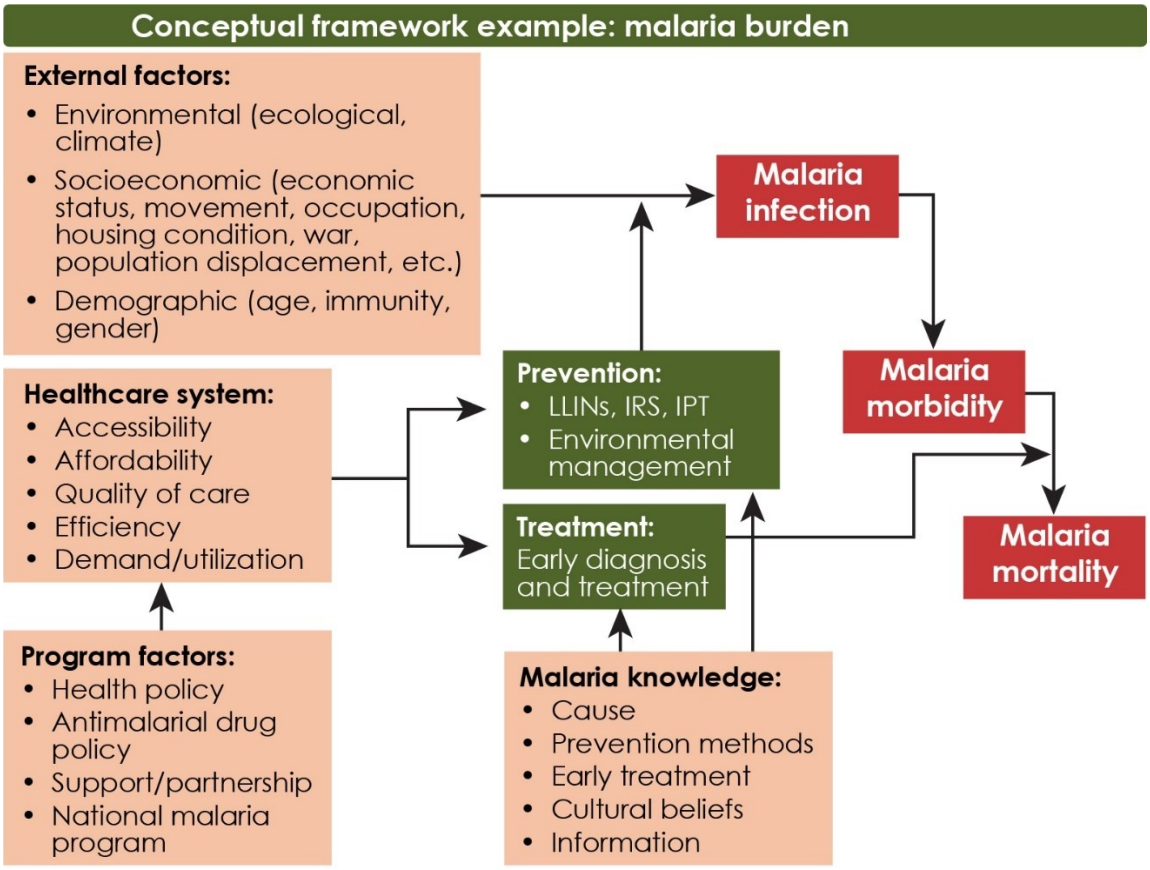
Figure 16. Example of a fishbone diagram for scale-up of SME



Source: Ashley Garley, MEASURE Evaluation, 2019

Figure 17 illustrates how a conceptual framework diagrams the organization of an NMP with a goal to reduce malaria morbidity and mortality. The program has two objectives: (1) to use vector control strategies for prevention and (2) to promote early diagnosis and seek prompt treatment. Some of the salient factors that will affect the program are the epidemiology of malaria in the area and the risks of acquiring infection due to the environment, the population demographics and socioeconomic status, and other malaria control programs working in the area. The expected program outcome is based on the assumption of adequate global and national support. Program activities include delivering LLINs, using indoor and outdoor spraying to suppress the progression of malaria-causing parasites, supplying clinics with rapid diagnostic testing equipment and stocking an appropriate treatment drug, and canvassing the area to determine whether other efforts are being made in the area to suppress and treat malaria.

Figure 17. Example of a conceptual framework for an NMP to reduce morbidity and mortality

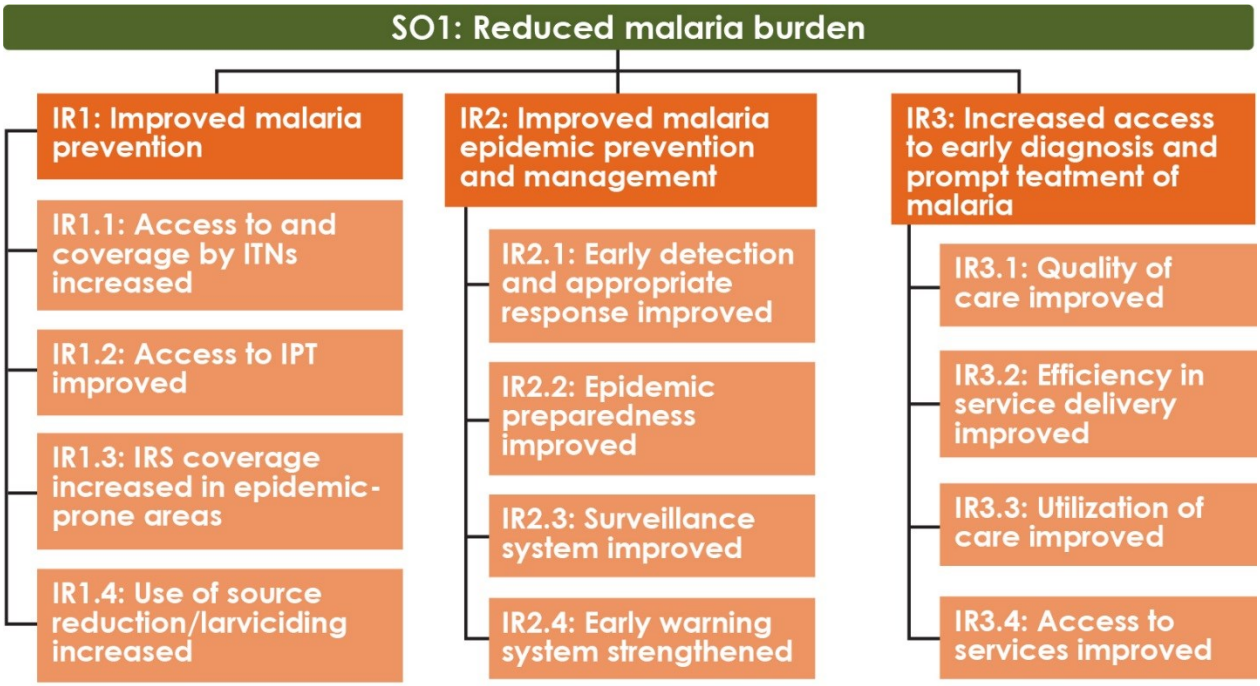


Results Framework

A results framework, also known as a strategic framework, identifies different stages of intervention activities needed to achieve strategic objectives. The stages are results, intermediate results, and subordinate intermediate results. A results framework also illustrates the causal relationships that link incremental achievement of results to program impact. Results frameworks measure the effectiveness of project activities at various steps as the project goes along and can be revisited and updated as interventions change.

Figure 18 shows a results framework for an NMP with a goal, or strategic objective (SO), to reduce the malaria burden—the mortality, morbidity, and economic losses—in the country. To accomplish that goal, the NMP organizes activities under three themes, or intermediate results (IRs): (1) improved malaria prevention, (2) improved malaria epidemic prevention and management, and (3) increased access to early diagnosis and prompt treatment. For example, four program activities that would improve malaria prevention are grouped under IR1—increase access to ITNs, promote IPTp, expand IRS, and limit transmission through larvicides. NMPs use this framework as a guide for SME program activities to reduce the national malaria burden by comparing program activity results at various stages and making adjustments.

Figure 18. Example of a results framework for an NMP



USAID usually uses a performance monitoring plan based on a results framework to show causal relationships that connect incremental achievements to the comprehensive program impact. This type of strategic organization clarifies program mechanics and the relationship of other factors to objectively measure the results desired (USAID, 2010).

Logical Framework

A logical framework, also known as a logframe matrix, uses a table format to summarize the project and its logic. It is designed to show underlying program assumptions and summarize how program intentions will be achieved and how outputs will be monitored and evaluated for intended outcomes and impact. Logical frameworks help set clear program objectives and define indicators that will be measured for achievements. They also outline critical assumptions, similar to a results framework; however, a logical framework includes additional information to account for the resources required to implement the program, activities to be undertaken, and the means necessary to verify project accomplishments.

Logical frameworks are similar to results frameworks; they are program management tools that manage by results. Although USAID introduced the use of logical frameworks to international development work, the agency now uses performance monitoring plans similar to results frameworks. Logical frameworks are still commonly used by projects funded by the United Nations and other donor agencies, such as Australian Aid, the United Kingdom's Department for International Development (DFID), and the Canadian International Development Agency. Logical frameworks vary according to organizations and program intent; there is no one right way to create a logical framework.

A logical framework contains all the elements that are important to the program—its goal, purpose, and objectives; the outputs as measurable results produced; and the activities and processes that will be carried out to achieve the outputs sought. Performance indicators are specified for each of these and how they will be measured. The last column in the logical framework lists assumptions made for each program element (Australian Agency for International Development, 2005).

Table 1 provides an example of a logical framework matrix for an NMP. The first column lists program descriptions for the goal of reducing the malaria morbidity and mortality burden, the overall objective of achieving universal coverage of malaria control interventions, and the component objective of achieving universal coverage and increasing the use of ITNs.

The second column of the logical framework lists performance indicators that will be used to measure the initiative's accomplishments. In this case, the indicators are malaria prevalence and the all-cause under-five mortality rate. The third column lists the sources for the baseline information, which are large-scale population surveys, such as the Demographic and Health Survey (DHS), Multiple Indicator Cluster Survey (MICS), and Malaria Indicator Survey (MIS). The right column lists the assumptions that are relevant to the initiative's goal, objectives, and component objectives, such as environmental and political stability.

Table 1. Example of a logical framework for an NMP

Project description	Performance indicators	Means of verification	Assumptions
Goal: To reduce malaria morbidity and mortality by 50 percent by 2015	• Malaria prevalence • All-cause under-five mortality rate	• Annual reports • Surveys • Health and Demographic Surveillance System • DHS	• Political stability • Environmental stability (no natural disasters)
Overall objective: To achieve universal coverage of malaria control interventions	• Percentage of individuals with access to an LLIN in their household	• Annual reports • Surveys • Record reviews	• Availability of effective and affordable LLINs
Component objective: To achieve universal coverage and increase use of LLINs	• Percentage of individuals with access to an LLIN in their household • Percentage of individuals who slept under an LLIN the previous night	• Population-based survey • Health facility surveys • Community surveys	• Strong political support • Availability of LLINs
Outputs: LLINs distributed to target population LLIN use demonstrated to individuals in target population	• Number of LLINs distributed to target population • Number of individuals who observed demonstration of LLIN use	• Activity reports • Program records	• Funds available for distribution and communication campaign • Community support
Activities: LLIN distribution campaigns LLIN use demonstrations	• Number of LLIN distribution campaigns • Number of LLIN use demonstrations	• Activity reports • Program records	• Funds available for distribution and communication campaign

Logic Model

A logic model illustrates linear relationships among program inputs, processes, outputs, outcomes, and impact. Inputs and resources affect the processes and activities, and the activities produce outputs or intermediate results. Ultimately, the intermediate results lead to longer-term outcomes and broader end results.

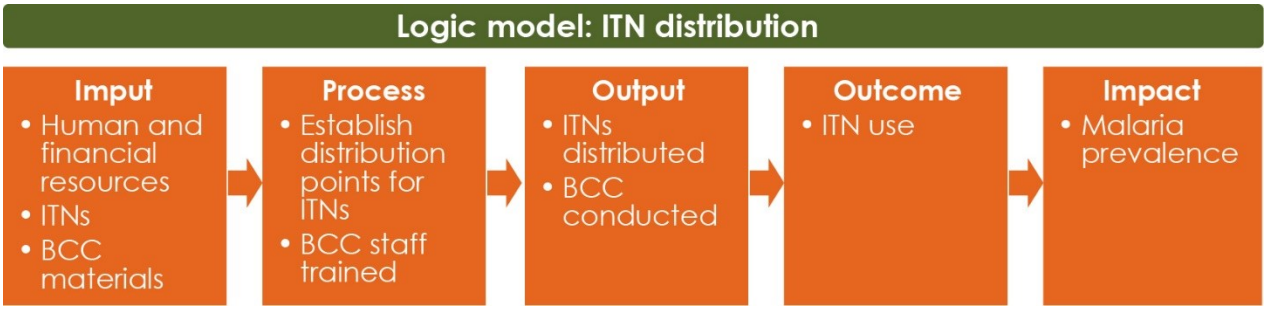
A logic model provides a streamlined interpretation of how resources are used to meet the desired results and clarify program assumptions on relevant factors (CDC, n.d.a). Table 2 defines the linear components in a logic model—inputs, processes, outputs, outcomes, and impact.

Table 2. Linear components in a logic model

Component	Description
Inputs	Resources invested in an intervention: *technical assistance, financial resources, infrastructure, and equipment*
Processes	Activities carried out to achieve the intervention's objectives: *training and outreach*
Outputs	Immediate results achieved by activities: *providers trained and bed nets distributed*
Outcomes	Results in the target population: *changes in people's knowledge, attitudes, or behavior*
Impact	Long-term effects and end results: *changes in health status*

Figure 19 shows an example of a logic model for an NMP to distribute ITNs. Inputs are human and financial resources, a supply of ITNs, and the materials to conduct a behavior change communication (BCC) campaign. The processes used to deliver these inputs are to establish distribution points and train the communications staff on methods to conduct a BCC campaign. Outputs are the number of ITNs distributed and an established BCC campaign. The implementation outcome is increased ITN use. The impact is a reduction in malaria prevalence.

Figure 19. Logic model for an NMP to distribute ITNs



6.3 Summary of Frameworks

The four frameworks discussed in this chapter—conceptual, results, logical, and logic model—are used to diagram SME plans to show the relationships among various plan components and set up indicator tracking. Frameworks are essential in SME plans, and most plans include a conceptual framework and one other framework, such as results, logical, or logic model.

Conceptual frameworks theoretically connect program objectives with processes and activities to clarify the "why" and "how" of program operations. Results and logical frameworks outline the relationships of program components—inputs, processes, outputs, and outcomes—with consideration of factors that affect outcomes. USAID-funded programs tend to use results frameworks; other programs, such as DFID and UN programs, use logical frameworks. Logic models help show the logical linear connections among the inputs, processes, and activities to reach program objectives—outcomes—and the goal—impact. NMPs should use a framework type that best accomplishes the goals and objectives sought.

Frameworks help clarify assumptions, goals, and component interrelationships for a project or program. Some frameworks include factors that affect the outputs and outcomes, based on the initiative's intention. Frameworks organized by components show the relationships among the goal and objectives, the activities and processes to accomplish the objectives, and the outputs and outcomes sought. Some frameworks list indicators to measure performance, which become the basis for an NMP.

7 Chapter 7. Indicators

This chapter describes how SME indicators for NMPs are selected, where the data come from, and how the resulting information is used. It also provides guidance on how to calculate and interpret coverage indicators and offers resources for estimating standard population-level indicators.

7.1 Introduction to SME Indicators for NMPs

Indicators are variables that measure each aspect of a program to track progress in activities and the impact on the target population. Indicator results provide data that guide program strategies and direct resources to ensure that program activities are effective. A baseline survey collects data on indicators as a reference point, and then tracks program activities as services are delivered. Results are compared to the reference point data at intervals in the program, such as midline and end line. An indicator focuses on a single, narrowly defined aspect of a program. That aspect may be an input, a process, an output, or the outcome or impact of a program and its related metric, which will also be a narrowly defined result. A full set of indicators—key indicators—includes at least one indicator for each program activity to give an overview of progress toward program goals and objectives.

7.2 Anatomy of an Indicator Metric

An indicator is a metric relationship expressed as a **numerator** and a **denominator** or just a count number. The numerator represents a portion of the whole—the number being counted. The denominator represents the whole—the total number of parts. The following is an example of an indicator metric for an NMP that is intended to calculate the proportion of households in the target population that have at least one ITN. In the metric, the numerator is:

Number of households surveyed with at least one ITN

The denominator is:

Total number of households surveyed

The indicator metric is calculated by dividing the numerator by the denominator:

$$\frac{\textit{Number of households surveyed with at least one ITN}}{\textit{Total number of households surveyed}}$$

This common indicator metric—Proportion of households in the target area with at least one ITN—is expressed as a percentage.

Indicators can be described using the following common metrics.

Ratios: Percentages, rates, or ratios that compare numbers, such as the number of healthcare providers who are trained, with the total number of workers in the program target area. Examples are the under-five mortality rate, the case fatality rate, and the annual blood examination rate.

Counts: A specific number that indicates how many or the frequency of a program activity. Examples are the number of households sprayed in a target area, the number of children under five who receive care for fever at a health facility, and the number of women who receive intermittent malaria prevention and treatment drugs during antenatal care visits.

Composite measures and indices: Sum of the scores on quality indicators in the target population. A composite index is an average of a large number of factors that represent an overall sector. The UNDP uses the Human Development Index to measure the "average achievements in a country in three basic dimensions of human development: a long and healthy life, access to knowledge, and a decent standard of living" (UNDP, n.d.). Indices are sequential lists of scores on a set of indicators, such as a wealth index, which measures cumulative household living standards. The wealth index is calculated from data about a household's ownership of selected assets, such as bicycles, cars, and televisions; dwelling characteristics, such as flooring and roofing materials; sources of drinking water; and toilet and sanitation facilities.

Thresholds: A value set that triggers an action or a cutoff point, based on a presence, absence, or set level or standard. Thresholds provide a reference point, such as malaria prevalence rates and transmission settings. For example, WHO classifies malaria prevalence for *P. falciparum* on a continuum (see Figure 28) using thresholds to categorize malaria prevalence into four groups: (1) high, 35 percent or more; (2) moderate, 10–35 percent; (3) low, between 1 and 10 percent; and (4) very low, more than 0 but less than 1 percent. Thresholds are used by NMPs to classify malaria epidemic prone areas and provide appropriate action according to the threshold level.

7.3 Characteristics of Good Indicators

Indicators are chosen to measure a program's goals, objectives, activities, resources, and expected outcomes. Strong indicators collect specific information to guide program decisions. Indicators that are too broad, vague, or irrelevant cannot measure a program's successes or areas that need strengthening. Each program activity needs specific indicators that have certain characteristics in common, such as being valid, reliable, precise, measurable, timely, and programmatically relevant.

Valid: The information is an accurate measure of a behavior, practice, or task. A valid indicator measures what it is supposed to measure. For example, parasite testing would be a valid measure for parasite prevalence because it is measuring exactly what it says it is measuring. Fever would not be a valid measure of malaria because fever can be caused by other diseases.

Reliable: The information is measurable consistently, in the same way by different observers.

Precise: The information is defined in clear terms, so that even people who are not experts can understand what is being measured.

Measurable: The information is quantifiable using available tools and methods. For example, anemia and parasitemia are measured using diagnostic tests. Compliance with antimalarial treatment is only measurable if observed.

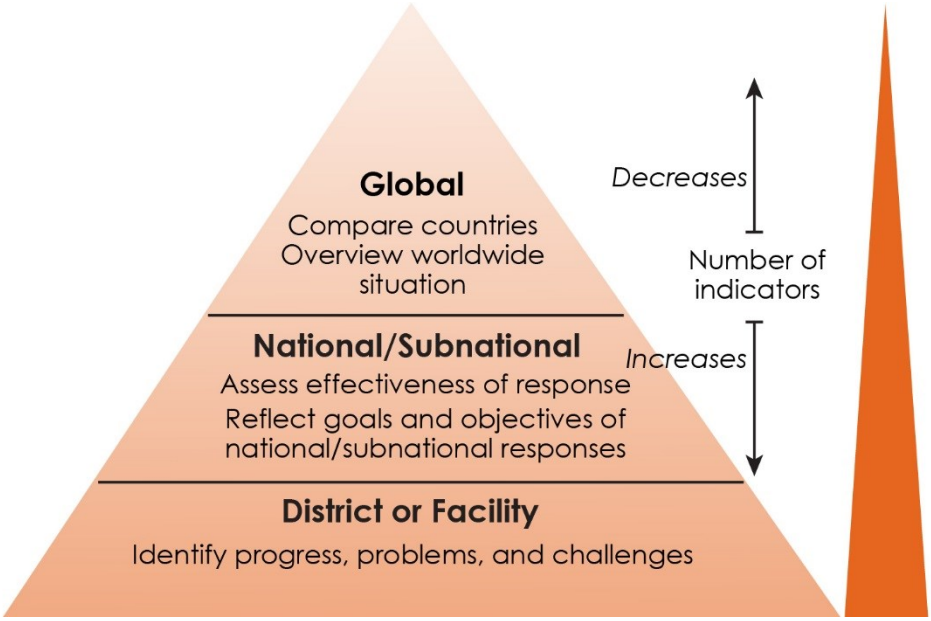
Timely: The information is available or can be gathered with enough time to act, and it provides a measurement at time intervals relevant to program goals and activities. It is important to note that reporting schedules, recall periods, and survey schedules can affect the timeliness of an indicator. An example of a key indicator is the timeliness of monthly malaria routine report submission by a health district to the central level.

Programmatically relevant: The information is linked to a public health impact or achieving objectives toward a goal. For example, a good indicator for a program increasing access to ACTs using community-based health workers would look at the number of community-based health workers providing ACTs. It would not look at the number of ACT sales points because these might also include shops as well as health workers, which are not relevant to the program goal. The program is trying to measure the added value of using community-based health workers to increase ACT access, so the measurement must focus on community-based health workers.

Factors in Indicator Selection

Reports on indicator results can be tailored to reach different information users; not every decision maker will be interested in all key indicator results. The level of decision making—global, national, subnational, and district or facility—determines which results are useful (Figure 20). As the level of decision making gets higher, fewer indicators are needed. For example, SME programs can provide the following indicator results: results on adequate supplies and drugs for decision makers in healthcare centers, results on facility usage rates and population served for district managers, results on the malaria burden for NMPs, and results on quality of care and usage for partner organizations. International agencies can make global comparisons of programs based on standard key indicators to better understand global health trends and resources to guide their decision-making process.

Figure 20. Indicator pyramid



Key program indicators are defined on indicator reference sheets that clearly state the numerator and denominator (Figure 21). These precise definitions make it possible for anyone who uses the data to arrive at the same indicator values and allow data users to compare performance with other programs. The indicator reference sheets should also specify the collection method and frequency and any data collection tools needed. The indicator reference sheets also list responsibilities for data collection, procedures for collection and analysis, and reporting frequency.

Figure 21. Example of an indicator reference sheet

Name of Indicator
DESCRIPTION
Rationale
Definition of the indicator: • Numerator: • Denominator:
Measurement:
Frequency:
Interpretation:
Data sources:
Strengths:
Limitations:
This sheet last updated on:

Key indicators should also be organized in an indicator matrix that lists each indicator, where data are collected, how frequently data are collected, who will be responsible, which collection tools will be used, and when and how data will be reported through a chain of levels (Figure 22).

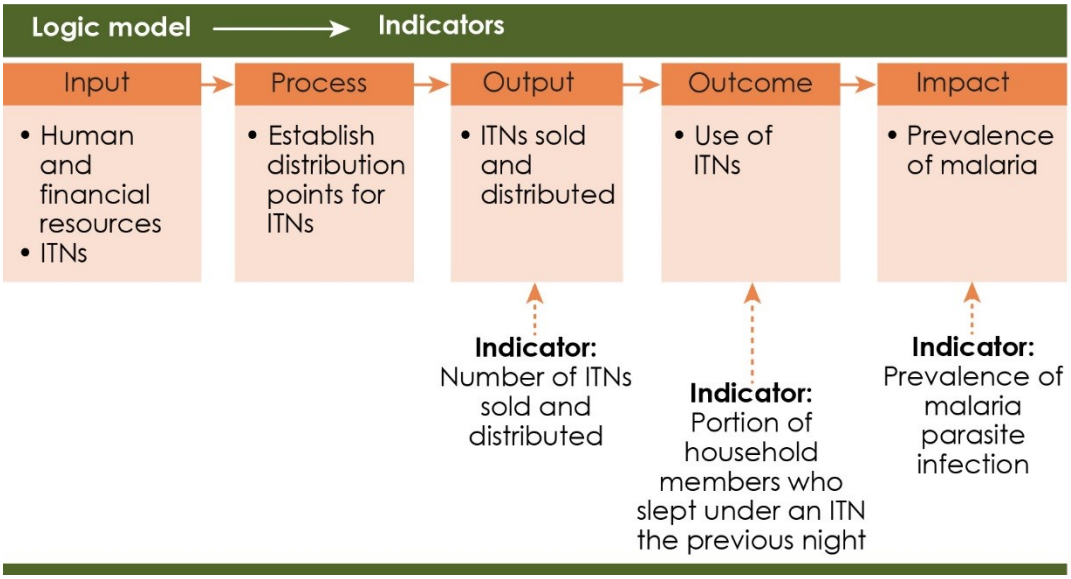
Figure 22. Example of an indicator matrix

	Data source	Frequency	Level	Responsible persons
Output				
Number of health personnel and community healthcare agents trained in case management	Program records	Quarterly	Facility	District SME personnel
Proportion of children under five years old who slept under an ITN the previous night	Representative household survey (e.g., DHS, MICS, MIS)	Periodic (every 1–5 years)	National	Survey personnel

7.4 Linking Indicators to Frameworks

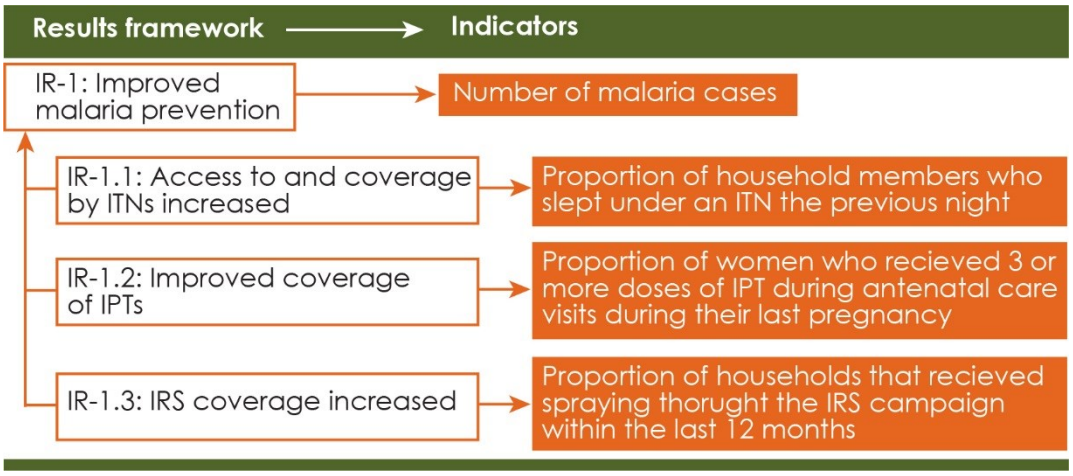
Good indicators link easily to frameworks, strengthen an SME plan, and measure specific objectives. For example, indicators should be designed to measure the output, outcome, and impact components of a logic model. Figure 23 shows examples of indicators at various levels of an ITN program.

Figure 23. Example of output, outcome, and impact indicators linked to a logic model



In a results framework, indicators are mapped to each result area. As the indicators are measured, programs can identify which results are progressing well and which ones need to be improved. The results framework in Figure 24 shows four results areas in a malaria prevention program and their corresponding indicators.

Figure 24. Example of indicators linked to intermediate results in a results framework



7.5 Common Challenges in Indicator Selection

Selecting key indicators can be challenging. SME program goals and objectives should have reasonable, feasible targets, and the indicators should be carefully defined according to the program objectives. Targets that are too low will not reflect program accomplishments, and targets that are too high will indicate more weaknesses than successes. Several sources can guide setting indicator targets: past trends, client and donor expectations, expert opinions, research findings, and accomplishments of similar programs. The indicators must accurately measure a program's accomplishments. The paragraphs that follow describe several common challenges in selecting indicators.

Indicator not linked to program activities: One of the common pitfalls in selecting indicators is to choose an indicator that program activities cannot affect. For example, decision makers for a program that planned to train healthcare providers in the correct rapid treatment of diarrhea to reduce mortality reviewed some WHO documents and selected indicators that seemed important. The intention was to report the proportion of healthcare facilities with adequate conditions to provide care. The decision makers did not take into account that many factors affect that indicator, such as supervision, supplies, equipment availability, and treatment protocols, which the program did not intend to address directly. The global indicator that was selected was not related to the local program activities. A better indicator would have been the number of clinicians trained or the number of facilities with a trained provider to address acute diarrhea in children.

Indicators should provide feedback to a program so that decision makers can change activities to more effectively reach program objectives. If an indicator is unaffected by program activities, it is measuring something irrelevant that cannot be used to measure program performance. For example, a program with the expected intermediate result "to expand access to malaria treatment services," has an activity to train providers in current clinical protocols. An inappropriate indicator would be "percentage of facilities with adequate conditions to provide care" because the objective is not to affect facility conditions but rather to improve provider skills. Better indicators would be the number of clinicians trained and the number of facilities with a trained provider.

Using outputs to measure outcomes: A common mistake is using indicators that are outputs, rather than the intended outcomes. Outputs, which are narrower in scope, are usually counts of activities performed. Outcomes, which have a broader scope, are usually percentages of change resulting from activities. Programs often collect data from participating households in the implementation target area, such as the number of people in a household who slept under a bed net in the last 24 hours. That is an output indicator for three program activities measured in counts: (1) to increase the number of households that are aware of the need to use bed nets, (2) to increase the number of households with bed nets available, and (3) to increase the household use of bed nets. These outputs come under the framework outcome goal "to increase the use of bed nets in the target population," measured as a percentage.

One output indicator for this program is a count of the number of households that have bed nets available. The metric to calculate the outcome uses one of the outputs as the numerator—how many households have bed nets available—and the denominator—the total number of households in the target population. The outcome is the percentage of households that use bed nets, the numerator divided by the denominator.

Data needed for indicator are unavailable: Another common mistake is selecting indicators that rely on routine data without verifying that the data are available as defined. For example, a program that seeks to increase the availability of drug supplies in healthcare facilities cannot select "the number of days without stockouts" as an indicator unless health facilities collect those data monthly. If data on stockouts are collected quarterly, rather than monthly, and the data are recorded as "stock available, 'yes' or 'no'," the meaning is not the same as stockouts on "number of days." A better indicator would be the number of facilities that had drug stockouts at some time during the last quarter. The indicator definition must match how the data are recorded.

Indicator poorly defined: Another common mistake is to choose an indicator that is vague. It is difficult to understand the intent of an indicator unless the terms of the numerator and denominator are clearly defined. For example, continuing the example of the indicator "the number of people in a household who slept under a bed net in the last 24 hours," a clear definition is needed for how a behavior change is measured in a program activity that seeks "to increase the use of bed nets in the target population." An indicator that includes "to increase awareness" in the target population is poorly defined and does not indicate how the change is measured. For valid results, the outcome of an activity indicator for a behavior change campaign needs to define precisely how that increased knowledge can be measured, such as "the proportion of the population that demonstrates knowledge that bed nets help limit the transmission of malaria."

Here is another example of a poorly defined indicator. An appropriate indicator for a program that intends to provide access to effective treatment for children under five with confirmed malaria infection is "percentage of children under five who were diagnosed with malaria in the past two weeks and who received ACTs." Inappropriate indicators are "percentage of children under five who received ACTs for malaria infection" or "percentage of people who received ACTs for malaria infection who are children under five." These are inappropriate because they do not indicate an increase or a decrease in the percentage of children under five who were diagnosed in the past two weeks and who received treatment, and therefore, the results do not reflect the desired program outcome.

Too many indicators: A frequent question about indicator selection is how many indicators are needed. The answer is that it depends on the complexity of the program goals, the cost of data collection and analysis, and the benefits and use of the SME results for all levels of stakeholders. A general guide is to use one or two indicators for each result, depending on the detail of the results. At least one or two indicators are needed for each significant activity. The purpose of an SME program is to monitor program performance and evaluate outcomes compared to objectives. On the other hand, too many indicators become a burden. Here are some suggestions to use as a guide in selecting the number of indicators.

- Every activity does not need an indicator; only key activities need indicators. If three outputs lead to one outcome, it may be sufficient to report information on only one of those outputs.
- Each framework outcome should have at least one indicator.
- If an indicator will not be used to guide program management decisions to improve performance, effectiveness, or efficiency, there is little justification to spend program resources collecting the information.
- Data sources for indicators should vary. All indicators should not rely on program records or stakeholder data collection. Secondary sources, such as surveys, and data collected by a program

observer can provide a more objective overview of progress. Also, unexpected events can disrupt an SME plan, and a good strategy is to diversify data sources to ensure that some indicators can be tracked over the life of the project.

To summarize, indicator selection should include at least one or two indicators for each key activity or result, and the indicators should have different data sources. Core SME program activities, such as ITN distribution, IRS, training, and behavior change campaigns, should have at least one indicator and a mix of data collection strategies and sources. Each area of significant program focus should be limited to 8 to 10 indicators.

7.6 Sources of Indicator Data

Data for malaria indicators come from two sources: (1) routine data collected through disease surveillance and monitoring at facilities and reported through HIS and (2) population-based surveys. Facility surveillance and monitoring track the incidence of diseases and symptoms, case diagnoses, and the treatments provided at regular time periods either weekly, monthly or quarterly. For example, a healthcare center tracks the number of children under five who seek care for fever or diarrhea, the number of RDTs administered to determine positive cases of malaria, and the number of pregnant women who receive treatment to prevent malaria. NMPs routinely collect data on indicators, provide timely information, and detect and correct problems in service delivery. Unfortunately, if the routine data are not trusted due to errors, poor data quality, incompleteness, dual reporting systems, and the exclusion of private sector data, they are unlikely to be used for evidence-based decision making.

Survey data yield national-level and sometimes subnational-level information on technical SME strategies, such as the effectiveness of ITN distribution programs and the knowledge people show about the causes of malaria and ways to prevent it. Survey data are often trusted more than routine data because of rigorous sampling methods that establish set denominators. Survey data also include population-based information, which cannot be captured through routine systems; however, surveys are expensive and occur every few years, and the survey timing can affect coverage rates.

Predefined Indicators

The epidemiology of malaria, intervention strategies, and health sector development vary considerably among countries and regions, but several organizations have developed standardized indicators to monitor and evaluate malaria intervention outcomes and impact. Various institutional donors and RBM partners, such as the U.S. Government, the World Bank, the Bill & Melinda Gates Foundation, and the Global Fund, are all undertaking evaluations of their efforts in malaria control. They agree that the need for rigorous analytic methods is critical to evaluate the effects of expanded interventions and to consistently use reliable measures of impact. In 2009, to provide guidance for all partners so that each can contribute consistently to the larger effort, RBM developed *Guidelines for Core Population-based Indicators,* a general framework to account for the variations in epidemiology. The guidelines seek to ensure consistency in the types of data collection methods used and to outline a set of indicators that reflect variations in malaria epidemiology and the principal interventions.

In 2013, RBM released the *Household Survey Indicators for Malaria Control,* which provides further guidance on standardized indicators collected through household surveys and the various data collection methods used in

countries. These guidelines were further revised in 2018 to accommodate changes in the malaria landscape. The guidelines are intended to provide country partners with technical guidance on the detailed specifications of the core indicators that can be measured through household surveys, the data required for their construction, and the issues related to their interpretation. The guidelines also address the data collection methods required for estimating these indicators through national-level household surveys to maximize internal consistency of indicators and comparability across countries and over time.

Core indicators for SME and entomological surveillance indicators are also available in the *WHO Malaria Surveillance, Monitoring, and Evaluation: A Reference Guide.* More information on this guide is provided in Chapter 9: Malaria Surveillance.

Another resource for predefined indicators is the Global Fund *Monitoring and Evaluation Toolkit,* which provides monitoring tools for HIV, tuberculosis, malaria, and health system strengthening. As part of its grant application process, the Global Fund asks implementers to select their program indicators from a list of core indicators that are drawn from the latest technical guidance, based on commonly used measures to promote a common understanding of SME and to reduce the reporting burden for countries. Selected output and outcome indicators are listed for prevention, case management, health system strengthening, and impact indicators for mortality and morbidity. These indicators are considered at the national, population, and facility levels.

RBM also offers the *Malaria Social and Behavior Change Communication Indicator Reference Guide,* which provides guidance and best practices to programs for measuring the contribution of BCC to malaria control and elimination efforts.

One advantage of using these predefined indicators is that they make it easier to compare programs with similar initiatives, and they establish a consistency across phases and follow-on activities. Often these predefined indicators have been tested for accuracy and ease of understanding. Some indicators are considered norms for malaria initiatives.

Indicator reference guides

Global Fund Monitoring and Evaluation Toolkit, 2011, Part 1: The Global Fund M&E Requirements: https://reliefweb.int/sites/reliefweb.int/files/resources/ME_MonitoringEvaluation_Toolkit_en.pdf
Part 4: Malaria: https://reliefweb.int/sites/reliefweb.int/files/resources/ME_Part2Malaria_Toolkit_en.pdf

RBM Guidelines for Core Population-based Indicators, 2009, https://reliefweb.int/sites/reliefweb.int/files/resources/AC719D00E5DE6F5D492575B3001BE5A3-RMB-guideline-20009.pdf

RBM Household Survey Indicators for Malaria Control, 2013, https://data.unicef.org/wp-content/uploads/2015/12/HouseholdSurveyIndicatorsForMalariaControl_179.pdf

RBM Household Survey Indicators for Malaria Control, 2018, http://www.malariasurveys.org/documents/Household%20Survey%20Indicators%20for%20Malaria%20Control_FINAL.pdf

RBM Malaria Social and Behavior Change Communication Indicator Reference Guide, 2017, https://www.pmi.gov/docs/default-source/default-document-library/tools-curricula/roll-back-malaria-malaria-social-and-behavior-change-communication-indicator-reference-guide.pdf

WHO Malaria Surveillance, Monitoring and Evaluation: A Reference Manual, 2018, https://www.who.int/malaria/publications/atoz/9789241565578/en/

7.7 Calculating and Interpreting Coverage Indicators for Malaria Programs

Measuring coverage indicators allows us to track progress and achievements in an NMP and determine how effective a program is. Coverage indicators can also identify underserved areas or regions and determine whether one target group has been effectively reached compared to another.

To estimate a coverage indicator, the numerator reports the population reached by an intervention or population affected by a given health risk. Generally, the numerator is expressed as a number and is relatively easy to measure or define. The denominator is also expressed as a number and represents the population exposed to an intervention or given health risk.

Estimating Coverage Indicators from Routine Data

Coverage indicators collected from routine data provide information on numerators and sometimes denominators. Routine data provide information on a timely basis and show trends over time. The data can be traced to the lowest level of the healthcare system and can be used to make actionable changes in service delivery. Routine data often have challenges with data quality and completeness, however, and may provide limited information on the target population. Obtaining data to define a clear denominator is difficult, and private sector data are rarely included in routine data.

Examples of numerator data collected from routine data include number of houses sprayed with IRS, number of LLINs distributed through ANC, and number of pregnant women receiving at least three doses of SP during ANC visits.

Denominators collected from routine data include the population targeted by a given intervention, such as a regional population, pregnant women visiting ANC, and children under five with fever.

Routine data are used to estimate population size and target population, and to define a population at risk.

Estimating Population Size

Population size estimates are calculated at the national and subnational levels using routine data collected from the national statistics offices. National estimates can also be obtained from the UN and the World Bank. Countries should use official estimates and make projections only if these estimates are not available.

Routine data are used to estimate the target population in a community. For example, an SMC program needs to define the target population of children under five to determine how many doses of prophylaxis are needed during the upcoming high transmission season. Routine data estimates indicate that the community includes 20,000 people and around 18 percent of the community are children under five. These routine data can estimate the annual target population:

Annual target population=20,000x0.18=3,600 children

This shows that an estimated 3,600 children would be eligible for SMC in the community.

A monthly target population can also be estimated:

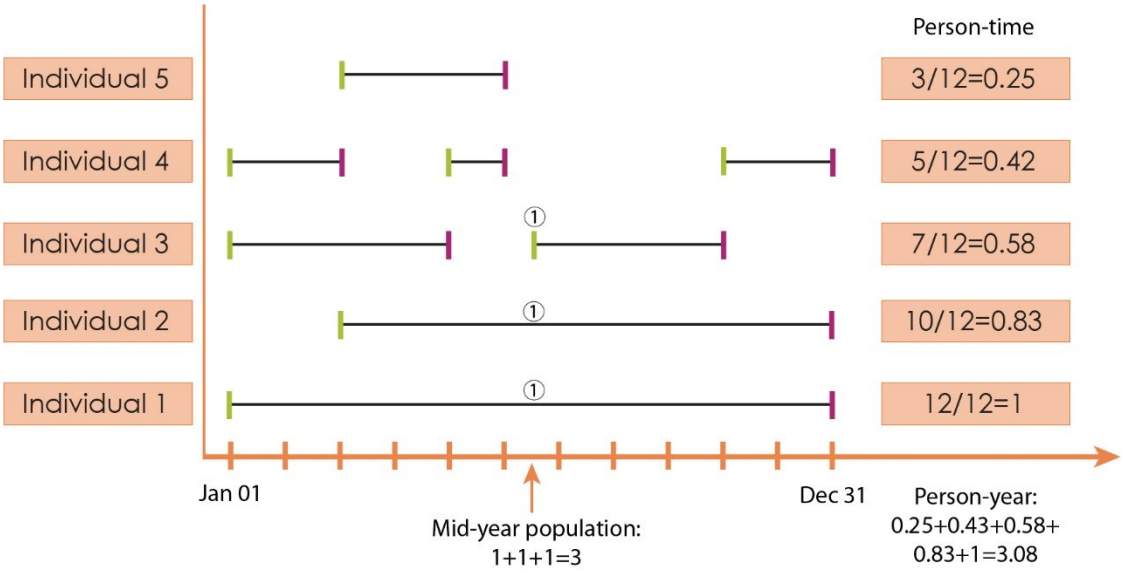
Monthly target population=3,600/12=300 children

This estimate is helpful for determining the number of SMC doses needed per month during peak transmission season.

Defining a Population at Risk

Routine data can be used to define a population at risk—a group of people who share a characteristic that causes each member to be susceptible to a particular event. This can be calculated as the mid-term population expressed at the middle of a year or by person-time, which is an estimate of the actual time at risk in years, months, or days that all persons contributed to the period under an intervention. This can be calculated only by following up on individuals. Figure 25 shows how mid-term population and person-time population estimates are calculated.

Figure 25. Example of calculating mid-year population and person-year estimates using routine data



Estimating Coverage Indicators from Survey Data

Survey data provide information for numerators and denominators from various population data sources, such as the DHS, MIS, MICS, facility surveys, and campaigns. Survey data are often relied upon more than routine data because of rigorous sampling methods that establish a set of denominators. Survey data also include community-based information. Survey timing may influence coverage rates, however. For example, conducting an MIS during the rainy season is recommended to capture the most representative malaria data,

but logistically, it may be difficult to get survey teams to the field and funding mobilized before the rainy season begins. Chapter 8 provides more detail on various data sources used by NMPs.

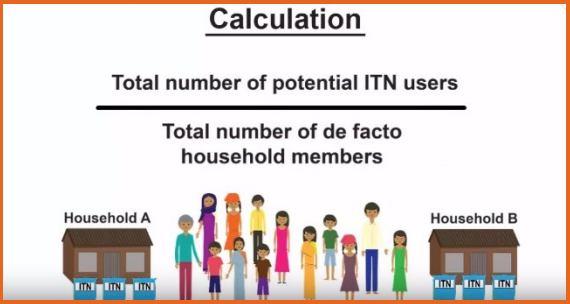
Calculating ITN access

The following video provides more information about how ITN access is calculated:

In English:
https://www.youtube.com/watch?v=YfTXcc13GOI

In French:
https://www.youtube.com/watch?v=MNFekfY9MJs

Source: The DHS Program



Another tool for calculating coverage data is STATcompiler, developed by the DHS Program. This online database tool accesses malaria and population and health indicators published in DHS and MIS reports and allows users to compare coverage data across numerous countries and hundreds of indicators. STATcompiler is available at http://www.statcompiler.com.

7.8 Summary

Progress in NMPs is usually monitored based on indicators that show quantitative changes in services offered and used and the malaria burden. Healthcare indicators provide uniform measurements to assess the progress of activities toward program goals and objectives. The data for the assessment come from SME of program activities.

An indicator focuses on a single narrowly defined aspect of a program. That aspect may be an input, an output, or the outcome of an objective, and its related metric will also be a narrowly defined result. Indicators are grouped by variables to show that program activities are carried out as planned or that a program activity has resulted in a change or made a difference in the target population. A full, appropriate set of indicators—key indicators—includes at least one indicator for each program activity. Combining key indicator results gives a broad picture of a program's performance in meeting program objectives, targets, milestones, and coverage, based on a program's framework.

A metric for an SME program is a calculated or composite measure—a quantitative indicator—based on two or more indicators or measures to put them in relationship with a program framework. A metric relationship is expressed as a **numerator** and a **denominator.** The numerator represents a portion of the whole—the number being counted. The denominator represents the whole—the total number of parts.

Key program indicators are precisely defined on indicator reference sheets that clearly state the numerator and denominator. The values should be easy to interpret and explain. SME program indicators should be comparable across relevant population groups, geography, and other program factors. The indicator reference sheets should also specify the collection method and frequency and any data collection tools needed.

Responsibilities for data collection are assigned, procedures for collection and analysis are explained, and reporting frequency is established.

Key indicators are organized in an indicator matrix that lists where data are collected, how frequently, who is responsible, which collection tools are used, and when and how data are reported.

> *Not everything that can be counted counts, and not everything that counts can be counted.*
>
> —Albert Einstein

Data for malaria indicators can come from several source, the main ones are: (1) routine data collected through disease surveillance and monitoring at facilities and reported through HIS and (2) population-based surveys. Facility surveillance systems track the incidence of malaria cases, symptoms presented, case diagnoses, and treatments provided. Survey data yield national- and subnational-level information on technical SME strategies, such as the effectiveness of ITN distribution programs and the knowledge people show about the causes of malaria and ways to prevent it. Survey data are often trusted more than routine data because of rigorous sampling methods that establish set denominators. Survey data also include community-based information, which cannot be captured through routine systems; however, surveys are expensive and occur every few years, and the survey timing can affect coverage rates.

NMPs should ensure that their indicators are clearly defined and linked to program activities, and they may want to take advantage of predefined indicators developed by RBM or the Global Fund.

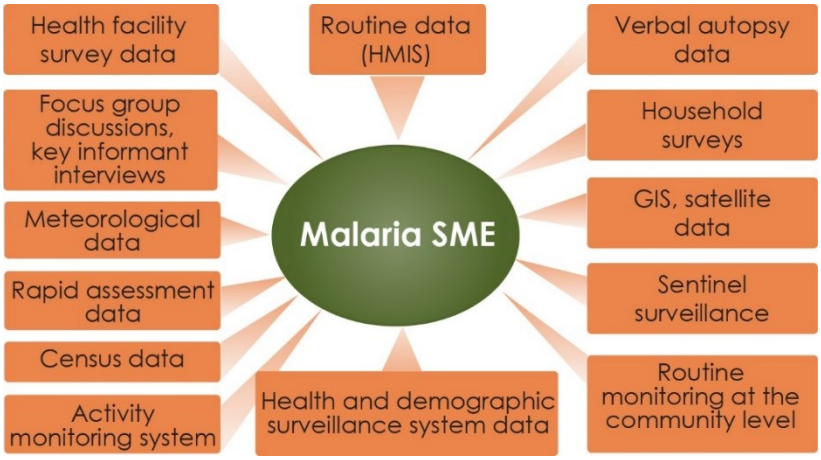
Chapter 8. Data Sources

This chapter describes the various data sources used to collect malaria indicators, including how each one is used and the benefits and limitations of each source.

8.1 Introduction to Data Sources

NMPs collect data from numerous national and secondary sources to guide program management decisions, track activities, and show results (Figure 26).

Figure 26. Potential data sources for malaria indicators



Data sources are classified as either routine or nonroutine. **Routine data** are collected continuously in healthcare facilities and from community workers. **Nonroutine data** are collected periodically through censuses, direct observations, focus groups, key informant interviews, special program reporting systems, surveys, rapid assessments, and research and special studies.

Routine data are collected continuously though processing and reporting and are collected more frequently than annually.

Routine data are reported weekly or monthly, according to set guidelines, and are then aggregated monthly or reported quarterly through various levels of the health system, until the national level receives the data for analysis. Examples of routine data collection sources are administrative systems, routine health information systems (RHIS), sentinel surveillance, and vital registration systems.

Nonroutine data are collected on a periodic basis, usually less frequently than annually.

Some data can be collected through routine and nonroutine processes, such as GIS and remote sensing and satellite imagery.

Routine and nonroutine data can be either quantitative or qualitative. **Quantitative data** measure program progress in numbers for statistical analysis. **Qualitative data** are descriptive observations that reveal information that cannot be measured in numbers. Qualitative data are collected through focus groups and key informant interviews. Direct observations, program reporting systems, and research studies are sources of both quantitative and qualitative data.

Qualitative data can reveal characteristics that cannot be accounted for in numbers and put the statistical analysis into context with factors that affect the outcomes. For example, an NMP distributes bed nets during a universal coverage campaign and tracks the number of bed nets distributed. These quantitative data document a program indicator, the number of households that have bed nets available. A follow-up survey asks how many people in the household used the bed nets in the previous two nights. These two indicators alone, however, do not prove that the campaign was successful. To do that, the NMP needs to ensure that the bed nets are being used. One way to do this is to conduct individual qualitative interviews to find out whether households have reasons for not using the bed nets. The quantitative number of bed nets distributed provides routine data on program indicators that are available in an RHIS. The qualitative information is collected through surveys that ask participants for their observations and thoughts on the household use of bed nets. The qualitative information adds depth to the numbers recorded in the RHIS. The NMP can use the enhanced information to make evidence-based decision on the success of the awareness campaign and make improvements in future campaigns.

Combining quantitative and qualitative data adds context to program outcomes by connecting data from different sources to help establish causality. Caution is needed, however, when quantitative and qualitative data are linked. Data should not be linked without a plausible connection. For example, entomological data on the number of mosquitoes in an area and contextual data on the number of motor vehicle accidents in the same area, both quantitative data, should not be linked, although qualitative data may indicate that rainfall affected both outcomes.

8.2 Health Management Information System

An HMIS is used to collect and store data collected during malaria control activities. Countries can use multiple HMIS to capture data. Well-known HMIS are RHIS, sentinel surveillance systems, and integrated disease surveillance and response (IDSR) systems.

Routine Health Information System

An **RHIS** is "a system that provides information at regular intervals of a year or less through routine mechanisms designed to meet predictable information needs." (Hotchkiss, Diana, & Foreit, 2012, p. 3)

Each country establishes its own RHIS to collect, aggregate, report, and analyze data from the national health system. A multilevel RHIS is integrated with a country's health system as an affordable source of data and storage. An RHIS functions differently at each level of the health system. Data collected at the health facility or community level can be compiled and aggregated for transmission periodically to the district or provincial level. At the national level, the RHIS analyzes data received and evaluates them to make them available for decision making and generate feedback to other levels of the system. After the data are processed, the information derived provides health system stakeholders and users with a basis for making informed evidence-based decisions; supports planning, managing, and evaluating programs and health services; and encourages research into health trends.

Many countries have adopted the open-source software, District Health Information Software, version 2 (DHIS2), to host their RHIS to collect and manage data at various system levels, but the software offers

limited analysis capability. RHIS tools, both paper and electronic, vary by country program. These tools include consultation and hospitalization registers, malaria case surveillance forms, and outpatient department cards. Reporting tools include aggregated monthly and quarterly report forms, forms to track notifiable diseases and monthly communicable surveillance, and records on inventory of materials, resources, and supplies. Staff records are also stored in the RHIS.

Various factors can affect a country's RHIS performance. Solid data collection, adequate technology, and standardized indicators are essential, but a well-performing RHIS also requires trained, motivated staff at all levels. Environmental factors, such as the health system structure and the management of roles and responsibilities, also affect RHIS performance.

RHIS data, usually available at the facility, district, and national levels, are collected continuously and reported frequently; however, data are limited to health facility reports on only the users who seek and receive care, not the entire population that is at risk. The quality and completeness of the reporting varies and has the potential for double-counting encounters. RHIS data often only capture information on government facilities, and thus do not always include information on private sector service delivery.

Sentinel Surveillance

Sentinel surveillance is the ongoing, systematic collection, analysis, interpretation, and reporting of health data for decision making undertaken in a limited number of health facilities.

Sentinel surveillance collects data at a limited number of health facilities, communities, or sites to detect trends and monitor the efficacy of antimalarial medicines. Data are collected continuously for analysis and interpretation and reported rapidly. Sentinel surveillance provides timely, on-the-spot information to track rapidly developing situations and outcomes, such as morbidity or mortality, and identify disease outbreaks. It is more likely to produce current high-quality data than the RHIS because it is easier to improve data collection and collation in a few facilities than in an entire system.

Sentinel surveillance is used less frequently because it is costly and requires frequent supervision, but it delivers information fast when rapid response is needed. It also pinpoints program problems in a specific area, allowing for rapid program adjustments. For example, malaria has many variations in parasite species and seasonal coverage. Sentinel surveillance can provide entomological and parasitological data to guide program responses, such as selecting effective antimalarial drugs to treat infections or adjusting IRS treatment schedules. It also allows flexibility to add malaria indicators for more specific monitoring, such as pinpointing causes of a facility's increased mortality rate.

Sentinel surveillance sites do not represent all health facilities, and the patients are not an accurate sampling of the community. Data are not generalizable, and recordkeeping can be burdensome for facility staff. Changes in health services at sentinel surveillance sites may also bias trend data.

A site location protocol for sentinel surveillance sites depends on the disease prevalence distribution, climate variance, geographic accessibility and area of intervention, and health facility capacity to serve as a site. The number of sites is determined by funding and population density and distribution.

Integrated Disease Surveillance and Response System

An IDSR is used to detect and predict epidemics, serve as an early warning system, and provide monitoring and objective assessment of intervention programs. An IDSR is designed to improve epidemiological surveillance and response for specific diseases such as arboviruses, measles etc. Every country has an IDSR with a list of priority diseases, conditions, and events that kick off specific, timely public health actions. This list includes epidemic-prone diseases, diseases targeted for eradication and elimination, diseases of international concern, and other major diseases of public health concern. As the malaria burden in a country decreases, the IDSR adds malaria to the priority disease list for close monitoring.

An IDSR helps a country share resources among disease control programs, such as integrated laboratory facilities and staff, to provide timely, complete, high-quality data. NMPs can benefit from an IDSR by using surveillance activities from one disease to strengthen malaria control activities through networks and common resources. This requires a strong network and efficient communication system that provides quick feedback and rapid response, usually beyond regular laboratory capacity.

8.3 Surveys

Surveys are an important data source for information that is unavailable from other sources. They yield an unbiased representation of the population through probability sampling. This is significantly different from data collected in most RHIS, which collect data only from individuals who seek care in the national health system.

There are two main types of surveys used to collect malaria data: (1) **national population-based surveys,** such as the DHS, MICS, and MIS; and (2) **health facility surveys**. Both types can use quantitative and qualitative data.

Quantitative surveys collect the same information from every respondent and report it in a standardized way to complement existing data from secondary sources. Qualitative surveys capture opinions, beliefs, behaviors, and sociodemographic, economic, and biologic information to reveal the knowledge and attitudes of a population and put the quantitative data into perspective.

National Population-Based Surveys

National population-based surveys measure household characteristics and behaviors and yield national or regional estimates. National population-based surveys, such as the DHS, MICS, and MIS, are usually cross-sectional and collect data from a large sample of respondents on a wide range of outcome indicators. They use well-tested data collection instruments for trend analyses to compare changes over time. They are less expensive than longitudinal studies that follow the same individuals over time. Population surveys are typically representative of the general population and, unlike facility surveys, they are not affected by selection bias. They also have established systems for data quality control.

The data from most national-level surveys can be accessed online. For example, data from the USAID-sponsored DHS are available at https://www.dhsprogram.com/, data from the UNICEF MICS are available at http://mics.unicef.org/, and data from the MIS, under the sponsorship of the RBM Partnership, are available at http://www.malariasurveys.org/. An online course on measuring malaria through household

surveys is available through the Global Health Learning Center at https://www.globalhealthlearning.org/course/measuring-malaria-through-household-surveys.

Population surveys have some limitations. They are expensive and time consuming, and the information collected is quickly outdated. They are expensive to conduct and analyze because of the large sample sizes, and it is difficult to detect small or short-term changes. They are representative of only the large geographic sample population because it is impractical to draw representative samples at the district level. Sampling errors, which are used to construct confidence intervals to indicate a probability that the true estimate of coverage is within these intervals, tend to be larger at the district level, making it difficult to compare different districts or measure district-level changes in coverage over time. Population surveys also are limited because they are periodic, conducted about every three to five years. Population surveys are not suitable for some types of information, such as retrospective attitudes and measurements because recall bias is often a concern.

The DHS, MICS, and MIS collect malaria data based on the RBM guidelines for core population coverage indicators used in primary malaria control and prevention strategies. Most national population-based surveys use three questionnaires: the household questionnaire, biomarker questionnaire, and the woman's questionnaire. The household questionnaire takes an inventory of all ITNs in a household, including the type, treatment status of household members, and a listing of household members who used the nets the night before the survey. The biomarker questionnaire asks questions on anemia and parasite prevalence among children under five. The woman's questionnaire covers current pregnancy status, ANC, IPTp therapy received during a pregnancy in the past two years, and the number of live children under five. It also asks about the woman's birthing history over the last five years and about the health of each of her children under five.

Most NMPs appreciate the data generated by the MIS because it is shorter than a DHS or MICS, which allows for more frequent monitoring. The MIS collects data during the height of malaria transmission season at the end of the rainy season through four to six weeks after the rains end. This peak transmission time frame is logistically challenging, but it fills in gaps in malaria information and collects only the data needed to calculate the household survey indicators for malaria control. The MIS also allows for more country specific questions to be included such as questions regarding malaria social and behavior change communication.

The MIS collects data on three main malaria control interventions: ownership and use of ITNs; IPTp coverage; and case management, including care-seeking, diagnostics, and treatment for children. It also measures parasite prevalence among children under five years of age, diagnoses with RDTs and/or microscopy and anemia prevalence among children under five. While this is most commonly collected in MIS surveys, malaria parasitemia has also been added to some DHS and MICS surveys.

Health Facility Surveys

Facility surveys are a nonroutine data source that collect quantitative data from facilities such as clinics, health centers, and hospitals. They are often cross-sectional and use a simple random sample and standardized questionnaires. The surveyors are usually trained health workers. Health facility surveys help clarify the links between households and care providers, show patterns of use and barriers to care-seeking, and assess the relationships between care providers and the government. They also identify gaps between community health needs and available services. This type of survey has been used to measure variations in physicians'

approaches to the diagnosis and treatment of patients with similar health problems, which has advantages over medical record reviews, analysis of claims data, and standardized patient questionnaires.

Facility surveys have several advantages. They cover both public and private health facilities and collect more detailed information than is typically available in the RHIS. They can be tailored to specific programs or timed to coincide with program implementation. The data collected can be linked to household survey data to demonstrate whether changes in the service delivery environment are leading to improved health outcomes. Facility surveys typically collect information on equipment, resources, and supplies, reflecting the quality of a facility.

Facility surveys also have some limitations. The survey sampling design and analysis may be complex, particularly to link the facility survey to behavioral data collected in a household survey. For example, a facility survey within a household survey can show availability of facilities in a particular community and the quality of the care obtained. It is important to note, however, that linking a facility survey with household data will not account for people who do not use the community health facilities where they live, particularly in urban areas. Facility surveys are expensive and time consuming, and they may not be sustainable because the data are less connected to ongoing program decision making. Facility survey information is rapidly outdated, and unless the survey is repeated, the data are not available regularly. Client-provider observations collected during routine supervisory visits may be a better option. Facility surveys also have sample size constraints. If the facility survey is representative at the national level, rather than at the subnational level, the sampling involves getting a representative sample of hospitals, health centers, and dispensaries. Some services, such as IPTp, may have a small client volume, which means that the survey team may need to spend longer at each health facility to conduct a sufficient number of provider-client observations.

8.4 Vital and Civil Registration Systems

Vital registration systems provide information on live births, deaths, fetal deaths, marriage, divorce, adoption, legitimization of birth, recognition of parenthood, annulment of marriage, or legal separation, as defined by the UN (Yé, et al., 2012). Vital registration systems are an excellent source of information on mortality and provide a resource to help calculate a population at risk or a target population. On the other hand, vital registration systems do not capture most births and deaths that occur due to coverage, which is typically low in most malaria-endemic countries in SSA.

Vital registration systems may include cause of death collected through hospitals for deaths that occurred in these facilities or through the verbal autopsy (VA) method for deaths that occurred outside the healthcare system, often at the community level. VA is an indirect, community-based vital registration tool used to establish cause of death through less formal household surveys, national census, and surveillance. In VA interviews, respondents are asked about the circumstances and events leading to death, including signs, symptoms, and duration. Trained physicians then use this information to ascertain probable causes of death (Herrera, et al., 2017; WHO, 2012). The cause of death attribution is based on WHO ICD 10 codes. The methods can estimate malaria mortality with some degree of sensitivity and specificity. The validity of VA methods to identify malaria-specific mortality in children is influenced by malaria prevalence, which differs from one area to another. VA tools for mortality need to be improved to provide optimum sensitivity and specificity, especially because a malaria diagnosis can be confused with other infections.

Despite the concerns about low sensitivity and specificity, VA may offer an alternative option for assessing malaria mortality deaths in most malaria-endemic countries, where health facility use is low, and most deaths occur outside the health system. Validated VA procedures to assess the impact of the malaria disease burden are emerging and proving to be valuable for monitoring and policymaking. A disadvantage of VA is that individuals who collect the data can vary in their interpretation of the international physician codes that categorize causes of death (Herrera, et al., 2017).

8.5 Health and Demographic Surveillance Systems

Health and demographic surveillance systems (HDSS) collect information from a geographically defined population over time. Unlike surveys, these systems collect information as frequently as every three months up to once a year in all or part of a district. HDSS help assess demographic events, such as births, deaths, and migration; provide measurements for risk sets and outcomes for evaluating interventions; track information on cause of death; maintain up-to-date sampling frames for identifying target populations for appraisal, intervention, and monitoring; and monitor project costs for decision making (INDEPTH Network, 2012).

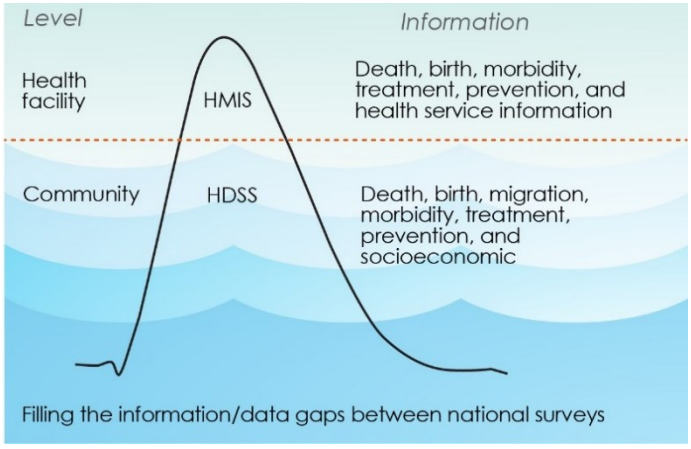
Examples of specific HDSS contributions in malaria M&E:

- Policy review of malaria treatment in Burkina Faso (Nouna and Oubritenga) and Mozambique (Manhica)
- ITN study informing national ITN programs in Tanzania (Ifakara), Ghana (Navrongo), and Burkina Faso (Nouna and Oubritenga)
- Resource allocation for the Tanzania Essential Health Intervention project
- Malaria vaccine testing (RTS,S with GlaxoSmithKline) in Burkina Faso (Nanoro), Ghana (Kintampo), and Mozambique (Manhica)

After an initial baseline or census is conducted on the defined population, fieldworkers periodically visit all compounds in the district and update information on key demographic events, such as births, deaths, marriages, migration, and pregnancies. In addition, HDSS can collect other health-related information, such as education and VA information.

HDSS complement other well-known sources of information, such as national censuses and the DHS, which cover long intervals, generally 10 years for a national census and three to five years for the DHS. HDSS are an ideal platform for evaluating community-level health interventions for shorter periods between the larger surveys. In addition, because the HDSS population is always updated, it provides a sampling frame for other studies, such as household panel surveys and cohort studies, and studies on livelihood and morbidity. HDSS add significant value to an HMIS. To illustrate, the system is like a hippo wading in water—part of it is visible (the HMIS) and the other part is below water (the HDSS) (see Figure 27). The HMIS shows only what occurs in health facilities, which is a small proportion of what is happening in the observed population, and the HDSS shows what is taking place within the community.

Figure 27. Added value of HDSS



Source: Yé, Wamukoya, Ezeh, Emina, & Sankoh, 2012

HDSS have many strengths. They monitor vital events in the study area and help assess specific intervention progress and impact. Unlike HMIS, HDSS can define the overall study population and, therefore, get an accurate denominator for data analysis. Linking the HDSS and HMIS increases the understanding of what is occurring in a community as a whole and in specific facilities. In addition, HDSS can serve as sentinel sites or operational research sites. These sentinel sites have multidisciplinary teams and provide an ideal environment for training.

Connecting HDSS worldwide

Since 1998, the INDEPTH Network has linked health research centers worldwide that are observing HDSS sites to monitor health trends and population developments (Sankoh & Byass, 2012).

Running HDSS sites is not without challenges. The maintenance cost is high. Another challenge is that over time, communities can lose enthusiasm for being studied. When the population is studied so intensely, the study itself can begin to act as an intervention and change behaviors. HDSS also have limited coverage; they study small areas, which are not representative of the national population.

Although it is possible to link HDSS data to HMIS data, this is rarely done in practice. The data are not easily accessible, and the data sets are vast and difficult to manage, and working with them requires specialized training. HDSS are set up to address specific research questions, not necessarily for general malaria SME.

8.6 Data for Malaria Control Strategies

NMPs use various malaria control strategies to measure progress in eliminating the disease. The data to track control efforts on three key strategies come from various sources, but a few of them are presented below.

ITN data sources: ITN data sources generally come from routine monitoring of the supply chain—from the manufacturers to inventory received to the facilities that distribute and use the materials—and household quantitative and qualitative surveys. Large-scale population surveys give a national overview of the ITN strategy. Outcomes on ITN strategies include indicator results on household coverage of ITNs and ITN use. These data generally come from large-scale population surveys and the more frequent routine data collection on commodities distributed.

IRS data sources: The effectiveness of an IRS program is measured with data on the coverage in a program area to demonstrate progress on indicator objectives, assess program performance compared to objectives, and support decision making. The most frequent sources for IRS data are program data and activity reports.

IPTp data sources: IPTp can be measured using program and RHIS data with surveys that provide national-level estimates and coverage. RHIS data provide facility performance in providing IPTp using ANC first attendance as a denominator, while surveys use women who had a live birth as the denominator.

8.7 Operational Research

Operational research identifies service delivery problems and tests new programmatic solutions to provide program managers and policy decision makers with the information they need to improve and expand existing services. Operational research is based on five basic steps: (1) identify the problem and its diagnosis, (2) select a strategy, (3) conduct experiments and evaluate results, (4) disseminate information, and (5) encourage data use.

For example, PMI relies on operational research to address new emerging questions and discuss unforeseen obstacles. PMI operational research has investigated measuring the impact of interventions, improving intervention uptake and scale-up, preserving intervention effectiveness in the face of vector resistance, and incorporating, withdrawing, or combining cost-effective interventions. PMI works with local institutions to implement and strengthen national programs to design and conduct operational research.

8.8 Summary

Data collection sources are either routine or nonroutine. Routine data are reported weekly or monthly, according to set guidelines, and then aggregated monthly or reported quarterly through various levels of the health system, and the national level receives the data for analysis. Examples of routine data collection sources are administrative systems, RHIS, sentinel surveillance, and vital registration systems. Non-routine data are collected periodically, and examples include censuses, direct observations, focus groups, key informant interviews, and surveys, such as the DHS, MICS, and MIS. Some sources such as GIS, remote sensing, and satellite imagery can be both routine and nonroutine. In addition, routine and nonroutine data can be either quantitative or qualitative. Quantitative data measure program progress in numbers for statistical analysis. Qualitative data are descriptive observations that reveal information that cannot be measured in numbers. Combining quantitative and qualitative data adds context to program outcomes by connecting data from different sources to help establish causality.

Countries use multiple HMIS to capture data, such as IDSR, RHIS, and sentinel surveillance systems. An IDSR is used to detect and predict epidemics, serve as an early warning system, and provide monitoring and objective assessment of intervention programs. Every country has an IDSR with a list of priority diseases, conditions, and events that kick off specific, timely public health actions. An RHIS functions differently at each level of the health system. Data collected at the health facility or community level can be compiled and aggregated for transmission periodically to the district or provincial level. At the national level, an RHIS analyzes data received and evaluates them to make them available for decision making and generate feedback to other levels of the system. Many countries have adopted DHIS2 to host their RHIS to collect and manage

data. Sentinel surveillance collects data from a limited number of communities, health facilities, or sites to detect trends and monitor the efficacy of antimalarial medicines. Data are continuously collected for analysis and interpretation for rapid reporting. Sentinel surveillance sites do not represent all health facilities, and the patients are not an accurate sampling of the community.

Surveys are an important data source for information that is unavailable from other sources. They yield an unbiased representation of the population through probability sampling, which is significantly different from data collected in most RHIS. Surveys are generally categorized as cross-sectional, which are national population surveys, such as the DHS, MICS, and MIS, and longitudinal, which are HDSS that track a geographically defined population over time.

Vital registration systems provide information on mortality and serve as a resource to help calculate a population at risk or a target population. They do not capture most births and deaths that occur outside of facilities in low-and middle-income countries. VA can be used to establish cause of death through less formal household surveys, national censuses, and surveillance. The collection methods are rudimentary, but they can be repeated and are moderately reliable for estimating malaria mortality.

HDSS collect information from a geographically defined population over time. Unlike surveys, these systems collect information as frequently as every three months up to once a year in all or part of a district. HDSS help assess demographic events, such as births, deaths, and migration; provide measurements for risk sets and outcomes for evaluating interventions; track information on cause of death; maintain up-to-date sampling frames for identifying target populations for appraisal, intervention, and monitoring; and monitor project costs for decision making. HDSS are an ideal platform for evaluating community-level health interventions for shorter periods between the larger surveys.

Operational research identifies service delivery problems and tests new programmatic solutions to these problems to provide program managers and policy decision makers with the information they need to improve and expand existing services.

Chapter 9. Malaria Surveillance

This chapter briefly describes basic malaria surveillance concepts, the process for conducting surveillance, and specific surveillance needs based on malaria transmission settings. Note that this chapter is not intended to duplicate the guidance provided in WHO's *Malaria Surveillance, Monitoring & Evaluation: A Reference Manual.* For further information, please refer to that document at https://www.who.int/malaria/publications/atoz/9789241565578/en/.

9.1 Basic Concepts

Definition of Malaria Surveillance

As a key element in epidemiology, surveillance systematically collects relevant data, consolidates the information, and delivers it quickly to guide decisions toward action to control, eliminate or prevent the disease from reintroduction.

Malaria surveillance provides timely, malaria-specific data and information at all levels in countries for action. The WHO malaria SME manual describes surveillance as an intervention that encompasses tracking of disease (malaria) through systematic collection, analysis, and interpretation, and programmatic responses and taking action in response to data received. As recommended by the GTS, malaria surveillance should be adapted to the transmission context because the data and action requirements are different for each transmission setting. Figure 28 shows the WHO malaria SME operational guidance by transmission setting.

Figure 28. WHO/GTS SME operational guidance for malaria surveillance by transmission setting

		High	Moderate	Low	Very low	Zero	Maintaining zero
		≥ 35% *Pf*PR or ~450 per 1,000 API	10–35% *Pf*PR or 250–450 per 1,000 API	1–10% *Pf*PR or 100–250 per 1,000 API	> 0 but <1% *Pf*PR or 100 per 1,000 API	No transmission	
Pillar 3 of the GTS 2016–2030 **Transform malaria surveillance into a core intervention**	Case detection	Passive case detection			Passive and active case detection		
	Recording	Outpatient and inpatient registers			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 use: health facilities	Data analyzed monthly		Weekly		Data analyzed in real time	
	Data use: intermediate levels	Data analyzed monthly		Weekly		Data analyzed weekly	
	Data use: national	Data analyzed monthly or quarterly		Weekly		Data analyzed weekly	
	Response time	Monthly or quarterly		Weekly		Case investigation within 24–48 hrs, focus investigation with 1 week	
	Feedback frequency to upper and lower levels	Annually or quarterly		Monthly		Every two weeks	
	Surveillance system monitoring	Every two years		Annually		Annually or more frequently	

*Pf*PR=*Plasmodium falciparum* parasite rate, API=annual parasitic incidence

Source: WHO, 2018c, p. 13

Objectives of Malaria Surveillance

Per the GTS recommendations, malaria surveillance is now incorporated into control and elimination operations by using current information for policy and program evidence-based decision making and to inform program implementation. The objectives of malaria surveillance are multifold—

Plan: To provide an evidence-based framework that organizes actions and tracks progress

Contribute: To use early detection and fast response to improve health outcomes and allow the healthcare community to move resources to places where they are needed most

Alert: To detect abnormal trends that can indicate epidemics and use this evidence to take preventive action

Describe: To describe the possible magnitude of increase in cases by analyzing trends and patterns in diseases and reporting the evidence to stakeholders who can use the information to take action

Evaluate: To measure the effectiveness of interventions and pinpoint areas that need strengthening

Hypothesize: To analyze available information and interpret it to form a working hypothesis that can be tested through research and refined during actions

Research: To identify disease elements that need answers through scientific research

Case Definition

Malaria surveillance detection follows established criteria, a standard case definition to ensure that every case is diagnosed in the same way. Malaria case definitions may vary slightly by countries, but the definitions recommended by the WHO/GMP Malaria Terminology (WHO, 2016) are as follows:

- *Suspected:* Illness suspected by a health worker to be due to malaria, generally on the basis of the presence of fever with or without other symptoms, but no confirmation of diagnosis was made
- *Presumed:* A suspected case of malaria that is not confirmed by a diagnostic test. Reserved for uncommon situations where a diagnostic test cannot be performed immediately
- *Confirmed:* A malaria case (or infection) in which the parasite has been detected with a diagnostic test, i.e. microscopy, a rapid diagnostic test, or a molecular diagnostic test
- *Severe:* Acute malaria (parasite has been detected with a diagnostic test, i.e. microscopy, a rapid diagnostic test or a molecular diagnostic test) with signs of severe illness and/or evidence of vital organ dysfunction
- *Malaria death:* A case of death confirmed by a positive microscopy or RDT or a molecular diagnostic test due to malaria

Case Detection

Malaria surveillance can be passive or active. With passive surveillance, data are collected from existing routine systems that have in-place systematic notifications. Malaria cases are captured when patients seek care at their own discretion in health facilities or from a community worker. With active surveillance, routine data are collected regularly from selected facilities or households, either in response to one or more confirmed cases or within high-risk groups as a precaution. New malaria cases are closely monitored and reported through routine systems.

Case Investigation and Classification

Case investigation is performed to determine the origin of the infection, local or imported, and document related factors. Detailed information on the history of the index case is collected from the service delivery point where it was reported or at the household to initiate the investigation. Case investigation is conducted most often in very low transmission settings, as part of reactive case detection, a response to one or more confirmed cases. Information collected will help classify the case as imported, introduced, indigenous, induced, recrudescent, or relapsing. Further details are available in the WHO manual.

Response

Every epidemic investigation and case investigation must end with a response. Programs often set levels of thresholds for actions. An alert threshold suggests the need for further investigation, and an epidemic threshold triggers a specific response through lab confirmation or the implementation of an urgent investigation. Thresholds are set according to transmission settings and the human and financial resources available for response. NMPs set response activities, such as resource mobilization, multisectoral communications, and other interventions. Programs are also responsible for maintaining adequate stocks of case notification and investigation forms, equipment, medicines, and diagnostic tests.

9.2 Malaria Surveillance Priorities in High- and Moderate-Burden Settings

High-burden settings are defined as having a *Plasmodium falciparum* parasite rate (*Pf*PR) of more than 35 percent or an annual parasitic incidence (API) of 450 per 1,000. Moderate-burden settings are defined as having a *Pf*PR of 10–35 percent or an API of 250–450 per 1,000. In high and moderate transmission settings (Table 3), malaria surveillance focuses on reducing the malaria burden. The objective is to collect data on malaria epidemiology to provide information for planning, implementing, and monitoring and evaluating malaria control interventions. Surveillance is mostly done through RHIS, IDSR, program reporting, and sentinel surveillance sites. Data on individual cases and deaths are recorded on outpatient department and inpatient registers, and the aggregated data are reported monthly and analyzed. In addition to routine data, household surveys, such as the DHS, MICS, and MIS, provide data on the prevalence of parasitemia and intervention coverage at the population level. Information on key indicators for high transmission settings are available in the WHO malaria SME manual (WHO, 2018c, Table 14 and Annex 17).

Table 3. Profile in a burden-reduction setting

Profile of malaria control in a burden-reduction setting	
Parasite prevalence/API	• High: *Pf*PR >=35%, API=450 per 1,000 • Moderate: *Pf*PR 10–35%, API=250–450 per 1,000
Incidence	• Most cases occur in children under five • Limited temporal variation • Limited geographical variation
Deaths	• Most malaria deaths occur in children under five
Fevers	• High proportion due to malaria
Health facility attendance	• High proportion due to malaria
Parasite	• Most cases due to *P. falciparum*
Vectors	• Efficient and stable anopheline activities
Health systems	• Weak, poor accessibility of services • Low ratios of staff to patients • Frequent stockouts of supplies (RDT, microscopy)

Analyzing Data

Program objectives for malaria surveillance in high and moderate settings are to decrease malaria mortality and reduce malaria cases. A strong malaria surveillance system generates high-quality data (see Chapter 11 for further details on data quality) and information on malaria incidence and mortality to inform planning and implementation of control interventions. Data analysis in this setting requires observing trends in aggregated data. Trends observed at the national level will require a closer look at the subnational level. Unpacking aggregated data at different levels identifies what is really happening to confirm whether a trend is valid. It also discloses issues that need to be addressed and inform action.

Can SME solve this mystery from Burkina Faso?

Since 2010, malaria continues to be a major health problem in Burkina Faso, a country with high to moderate malaria transmission. Malaria prevalence has decreased, from 76.1 percent (DHS 2010) to 61.4 percent (MIS 2014). According to the WHO *World Malaria Report 2018*, malaria deaths in Burkina Faso have decreased, from 9,024 in 2010 to 4,144 in 2017, but malaria incidence has increased, from 804,539 in 2010 to 10,225,459 in 2017, despite scale-up in key interventions. RHIS data also show that malaria incidence is increasing, from 309 per 1,000 cases in 2011 to 607 per 1,000 cases in 2017. These mixed results are puzzling NMP staff, particularly because they are implementing a suite of proven key control and prevention interventions throughout the country. What is happening in Burkina Faso and what malaria SME tools are needed to solve this mystery? Unpacking the data at the subnational level is needed to better understand the reason behind this pattern. A first impression is that the interventions are not working, but from an SME perspective, we must ask if the data are good enough to pick up changes in trends for malaria cases.

9.3 Malaria Surveillance Priorities in Low-Burden Settings

Low-burden settings are defined as having a *Pf*PR of 1–10 percent or an API of 100–250 per 1,000 (Table 4). These settings are classified in two groups: (1) areas that are transitioning moderate transmission to low transmission and (2) areas that show seasonal environmental changes that cause vectors to be inefficient. Surveillance objectives focus on collecting information to monitor for changes that might indicate an abnormal increase in malaria cases and preparing an adequate response. Low-burden settings are also potential candidates for elimination; therefore, the program goal is to reduce malaria incidence to very low. Passive case detections are still recommended but with the potential for reactive case detection if needed.

Data collected at the health facility level identify trends, indicate population groups with the highest incidence, and pinpoint the source of infection. Control activities center on those focal areas. NMPs and policies at the subnational level are guided by SME data on rates of incidence, mortality, and patient attendance; diagnostic results; and the quality of health facility reporting. Key indicators for low transmission settings are available in the WHO malaria SME manual (WHO, 2018c, Table 14 and Annex 17).

Table 4. Profile in a low-burden setting

Profile of malaria control in a low-burden setting	
Parasite prevalence/API	• *Pf*PR=1–10% (children ages 2–9) • API=100–250 per 1,000
Incidence	• Usually uniform in age groups • Most cases occur in specific populations with higher exposure • Significant proportion of imported cases
Case distribution	• Seasonal malaria, high risk of epidemics • More focal within districts
Deaths	• Few (most cases in populations with higher exposure)
Fevers	• Small proportion due to malaria
Health facility attendance	• Low proportion due to malaria
Parasite	• Higher proportion of *P. vivax*
Vectors	• Unstable seasonal anopheline activities
Health systems	• Usually stronger than high- and moderate-burden settings • Better availability of supplies (RDT, microscopy)

Analyzing Data

Surveillance in low-burden settings considers country heterogeneity, and analysis is disaggregated accordingly, based on a clearly defined threshold that can trigger an alert for further investigation. Surveillance data are compared to the thresholds over time. When the number of cases reaches the thresholds, further investigation is conducted to confirm the epidemic and prepare an adequate response. WHO recommends several approaches for calculating alert and epidemic thresholds, including constant malaria case count, percentiles over the median or third quartile, the mean number of malaria cases +2 standard deviations (mean+2SD), the cumulative sum (C-SUM), and the weekly slope or doubling of cases during three consecutive weeks (7–9). Countries can decide on the approach based on the settings.

How to calculate a threshold

Incidence records provide the number of monthly cases over the past three years. The threshold is calculated based on the month with the most cases. The threshold is calculated by taking the fifth highest number of monthly cases over the last 36 months.

Example: 85th percentile

Calculate the fifth highest number of cases that occurred within the last 3 years (36 months x 15%=5)

*Low transmission defined generally as 10 percent, but malaria control strategies may vary based on parasite prevalence between less than 5 percent and less than 10 percent.

1. Plot the monthly number of confirmed malaria cases in the current year and calculate the 85th percentile.
2. Compare values to the 85th percentile to determine low or high cases.
3. Monitor trends over time.

Example: The subnational level should update information in the table below.

Malaria Incidence rate	Diagnostic effort
Proportional malaria incidence	Quality of diagnosis and reporting
General patient attendance	Percentage of cases of *P. falciparum,* if multiple species are present

If the number of cases exceeds the 85th percentile, and if a trend analysis shows an increase in the malaria incidence, district-level staff are notified to begin an investigation.

At the health facility level, the investigation focuses on monitoring trends in the number of cases and tracking the number of suspected, tested, and treated cases. Facility information is plotted weekly and reported to the subnational level, but unusual changes are investigated immediately. District-level staff conduct a monthly data review and intensify the analysis.

Keeping an eye on the prize: Senegal

Senegal is on its way to elimination, with a national malaria parasite prevalence rate of 0.9 percent (DHS 2016). Malaria incidence varies across the country, with less than 5 percent in the northern part of the country, 5 percent–15 percent in coastal areas, and 25 percent in the southern region. According to the WHO *World Malaria Report 2018,* reported deaths have decreased, from 553 in 2010 to no deaths between 2015 and 2017. Senegal's current strategy is twofold, to carry out elimination measures in the north and ensure malaria control in the south with a path to elimination. The country's general objectives from the latest national strategic plan are to reduce malaria incidence and malaria mortality at least 75 percent compared to 2014 and stop local transmission in northern districts.

9.4 Malaria Surveillance in Very Low-Burden Settings

Very low-burden settings are defined as having a *Pf*PR of more than 0 but less than 1 percent or an API of less than 100 per 1,000 (Table 5). In this setting, the objective is to interrupt local transmission of malaria. A surveillance system in these areas is used to detect all malaria infections, with or without symptoms, and to ensure an immediate response and early cure to prevent secondary cases. The surveillance system must cover an entire country or region, and additional attention could be needed in areas with an ongoing or recent history of transmission. Every malaria case reported through a passive surveillance system is important and requires immediate actions to cover the following: confirm all malaria cases in public- and private-sector health facilities; investigate individual cases to determine whether the infection was acquired locally or imported; and identify the foci, investigate to document the characteristics of transmitted cases, and intensify response and surveillance activities in the focus area. More information on key indicators for very low transmission settings is available in the WHO malaria SME manual (WHO, 2018c, Table 14 and Annex 17).

Table 5. Profile in a very low-burden setting

Profile of malaria control in a very low-burden setting	
Parasite prevalence/API	• *Pf*PR =>0 but <1% • API=<100 per 1,000
Incidence	• Cases sporadic • Imported cases common
Case distribution	• Focal distribution • High risk of epidemics
Deaths	• Very few (in populations with higher exposure)
Fevers	• Small proportion due to malaria (except in specific populations)
Health facility attendance	• Very low proportion due to malaria
Parasite	• Mostly *P. vivax,* but can be *P. falciparum* depending on the settings (Africa or outside Africa)
Vectors	• Vector activities controlled and inefficient (most cases are imported)
Health systems	• Strong • Availability of supplies (RDT, microscopy) and resources to investigate every case

Analyzing Data

High-quality data are required on all individuals with a suspected case of malaria, confirmed through a parasitological test. Every case and focus area is investigated fully, and results are reported immediately and completely. Records are kept for all tests and investigations to guide program implementation.

9.5 Achieving Elimination

Elimination status is achieved when the incidence of locally acquired malaria in a geographic zone is zero as a result of deliberate efforts to prevent reestablishment of transmission. An elimination surveillance operation diligently records data and assesses key indicators that are focused on impact and quantity and quality of surveillance.

Surveillance is the key to success in achieving and maintaining elimination status. Thorough and diligent data collection and recording is essential to provide the information necessary for initiating a rapid response to new cases of malaria. This intense, strict surveillance requires national support for legislation and resources for additional staff, up-to-date laboratories for diagnostics, and treatment centers. All staff need training on recognition of malaria symptoms, diagnostic testing procedures, appropriate treatments, and accurate data recording. Successful continued elimination also requires private sector involvement to ensure that all facilities participate in the surveillance and continue funding support. More information on key indicators for elimination settings is available in the WHO malaria SME manual (WHO, 2018c, Table 14 and Annex 17).

Reaching success. Almost … Zanzibar

The island of Zanzibar has been on the brink of malaria elimination for years, with few reported malaria deaths (two in 2015, one in 2016, and one in 2017) and 1,400–3,500 confirmed malaria cases yearly since 2013, according to the *World Malaria Report 2018*. For many years, malaria was Zanzibar's number one public health problem. Malaria in Zanzibar was characterized by perennial stable transmission, with seasonal peaks during and immediately after the rainy seasons.

Over the past decade, the island of Zanzibar has experienced a rapid decrease in its malaria burden. Malaria prevalence on the island dropped from as high as 70 percent to less than 1 percent. The accelerated decrease is attributable to the large scale-up of malaria control, prevention, and surveillance activities.

The Zanzibar Malaria Elimination Programme has an active malaria surveillance system for case investigation and classification, called the Malaria Early Epidemic Detection System. Since 2008, this system has collected weekly health facility data using mobile phone technology. Malaria surveillance efforts to detect, investigate, and track every case within 48 hours will be the key to achieving elimination in Zanzibar (Zanzibar Malaria Elimination Programme, n.d.).

9.6 Monitoring Key Risk Factors

Malaria is a multifaceted disease that thrives on environmental opportunities for vector breeding and parasite transmission, such as temperature, rainfall, and vegetation coverage. These opportunities are compounded by gaps in the effectiveness of healthcare systems and initiatives, demographics, political stability, and economics. Knowing how all these factors work together to influence conditions for vector and parasite breeding and transmission can determine the success of establishing comprehensive malaria surveillance, which should go beyond recording the number of malaria cases and deaths. A strong malaria surveillance system, regardless of the transmission setting, requires observing risk factors that affect vector breeding, transmission risk, and effective diagnostics and treatment.

Environmental Factors

Numerous environmental factors influence the vector life cycle; the possible variations of combining temperature, rainfall, and wind are numerous, and the outcomes range from favorable for vector breeding and transmission to almost zero.

Ambient temperature, the measure of heat in a volume of air, is registered at 2 p.m. for maximum temperature and at 6 a.m. for minimum temperature. Maximum and minimum temperatures affect vector survival in the larvae and adult stages, the parasite development in the vector, and the frequency of blood meals. A high mean temperature between 20 and 30 Celsius improves vector breeding.

Rainfall creates vector breeding sites by increasing water surface, whether in large lakes or small puddles. Relative humidity, the ratio of air to water vapor, affects surface water dissipation and adult vector survival. A relative humidity of 10 percent is very low, and a relative humidity of 90 percent is very high. Higher humidity increases mosquito survival, wind direction and speed distribute the vector, and vegetation coverage affects the vector habitat.

Topography—slopes, valleys, wetlands, and wallows—affect water source formation. Soil type also affects the availability of surface water for mosquito breeding sites.

Anthropogenic Factors

Another factor in surveillance is anthropogenic, or influenced by human activity, which also affects vector and parasite breeding. Land use, such as irrigation schemes, mining, and farming, can create or increase surface water for breeding sites. Water sources, such as wells and boreholes, can provide breeding sites, even in the dry season. Urbanization affects vector survival by creating breeding sites in trash and puddles on pavement, but it also reduces transmission by making access to treatment easier. The type of habitat—crowded housing or open villages—also affects vector contact with humans.

9.7 Assessing Performance of a Malaria Surveillance System

A malaria surveillance system should be assessed periodically to ensure that the system is following NMP priorities. An assessment can also be used to document system effectiveness as well as the linkage of the surveillance system with other existing HIS. Outcomes from the assessment can provide opportunities for introducing new surveillance methods or techniques to strengthen the system. Four components of a system are monitored and evaluated in an assessment: structure, core functions, support functions, and quality outputs. More details on what should be assessed in each component are found in the WHO malaria SME manual. There are several tools for assessing system performance, such as MEASURE Evaluation's Performance of Routine Information System Management Series (PRISM) tool (https://www.measureevaluation.org/resources/tools/health-information-systems/prism).

9.8 Summary

This chapter describes basic malaria surveillance concepts; the process for conducting surveillance through case detection, investigation, and response; and various transmission settings. Malaria surveillance is the

continuous and systematic collection, analysis, and interpretation of malaria data, and the use of those data in planning interventions.

Malaria surveillance can be passive or active, using a well-defined case definition and diagnostic approach. Passive surveillance collects data from existing routine systems that have in-place systematic notifications. Malaria cases are detected when patients seek care at their own discretion in fixed health facilities or mobile health services, or from a community worker. Active surveillance collects data from selected facilities or households and closely monitors new malaria cases through either proactive or reactive data collection.

Malaria surveillance is tailored to respond to specific requirements for different transmission settings—high and moderate, low or very low. The transmission setting is determined through a profile that includes the *P. falciparum* prevalence, API, and type of parasite and vectors.

Malaria surveillance for high and moderate settings focuses on reducing malaria burden. Information is generated on malaria incidence and mortality using aggregated data from RHIS, IDSR, parallel malaria reporting, and sentinel surveillance. National and subnational data in burden reduction areas are summarized monthly to assess the efficacy of malaria control interventions and identify trends that require urgent response.

Malaria surveillance in low-burden settings focuses on unusual increases in malaria cases to prepare a response. These systems generate information on malaria incidence in two different groups: areas that are transitioning from moderate transmission to low transmission, and areas that show seasonal environmental changes that cause vectors to be inefficient. The focus is to reduce malaria incidence to very low using passive and reactive case detection.

The objective of surveillance systems in a very low-transmission setting is to interrupt local transmission of malaria by detecting all infections, with or without symptoms, and responding immediately to quickly treat cases and prevent secondary cases. Every malaria case is important in this setting and triggers case and foci investigations.

Elimination status is achieved when the incidence of locally acquired malaria in a geographic zone is zero as a result of deliberate efforts to prevent the reestablishment of transmission. Thorough and diligent data collection and recording is essential to provide the information necessary for initiating a rapid response to new malaria cases.

Surveillance must take into consideration numerous factors. Environmental opportunities for vector breeding and parasite transmission are temperature, rainfall, and vegetation coverage. These opportunities are compounded by gaps in the effectiveness of healthcare systems and initiatives, demographics, political stability, and economics. Human activity affects vector and parasite breeding. Land use, such as irrigation schemes, mining, and farming, increase surface water for breeding sites. Water sources, such as wells and boreholes, can provide breeding sites.

Assessing a malaria surveillance system ensures that the system is following NMP priorities; systems should be assessed periodically. Components to assess include the structure, core functions, support functions, and quality of the system.

10 Chapter 10. Evaluation Methods for National Malaria Programs

This chapter discusses the basic concepts of SME of NMPs, evaluation design, data sources, establishment of the causal link through analysis, implementation of the evaluation, and challenges and considerations when evaluating an NMP. In addition, the chapter explains the complex considerations in designing an evaluation, defining the criteria used to infer causality, distinguishing between internal and external validity, and selecting the best evaluation method to determine the effectiveness of an intervention.

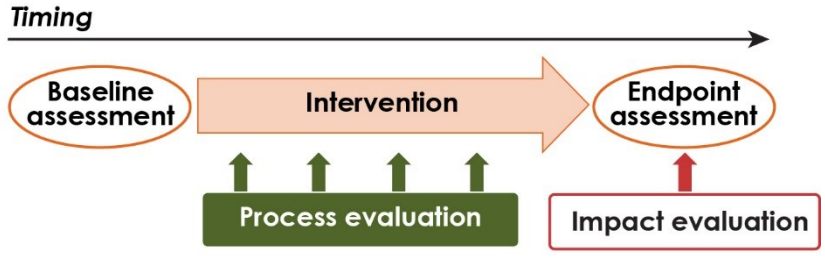
10.1 Background

The malaria community at global, national, and regional levels is interested in knowing how well malaria interventions have been implemented and how effective they were in reducing the malaria burden. NMP process evaluations provide crucial information for strategic planning and policy decision making. These evaluations provide an understanding of whether the program is accomplishing what it is intended to do—is it working and how well? NMP impact evaluations establish the causal links between interventions and changes in outcomes, and they help determine how to allocate and adapt interventions to improve performance. Evaluations can also help NMPs identify best practices, test alternatives to existing programs, and transfer knowledge to other contexts. Furthermore, evaluations deliver accountability by providing evidence and results for publicly funded programs. Before conducting an NMP evaluation, the evaluation questions should be clearly defined to provide focus and guide the planning process, which includes determining the type of evaluation, design, and data needed to answer the question.

10.2 Concepts

Monitoring is an ongoing tracking of progress, and evaluation is the periodic assessment of objectives and whether they have been achieved. Evaluation of NMPs is the process of objectively and systematically assessing the quality of implementation, relevance, effectiveness, and impact that the program has had on the country's malaria-related mortality and morbidity. There are two main types of evaluations of NMPs: process evaluations and impact evaluations (Figure 29).

Figure 29. Linkage between process evaluation and impact evaluation



Process Evaluation

Process or formative evaluations assess the degree to which the NMP has implemented its national malaria strategic plan (NMSP) and determine the reasons why the NMSP has or has not been implemented. A process evaluation examines the NMP's inputs, processes, and outputs. Examples of program inputs include

finances, resources, governance, and leadership. Using these inputs, the NMP processes include activities and malaria interventions deployed. The outputs of these processes may include treatment and interventions delivered, use of services, and supervision.

A process evaluation can document the implementation process and assess how the program has operated compared to the operations design (e.g., has it met its targets). It also assesses operational efficacy and efficiency. It helps to demonstrate how an outcome or impact was achieved. Using this information, a process evaluation can help describe the following: the malaria interventions in place; availability, accessibility, and adequacy of services; and service quality and use.

Impact Evaluation

Impact or summative evaluations assess the degree to which the NMP has had an effect on malaria transmission, malaria-related mortality, and malaria morbidity. These evaluations tie a program's outputs and outcomes with intended impact. They also evaluate whether the NMP has met its objectives and achieved its goals. Impact evaluations assess the changes in impact indicators, which may be attributed to a particular set of interventions deployed by the NMP.

Evaluation Questions

Evaluations of NMPs help answer specific questions about the process and impact of the program. Each type of evaluation will have its own set of questions. These questions guide the evaluation design, methods, indicators, and analysis (Table 6).

Table 6. Evaluation questions by type of evaluation

Evaluation type	Evaluation questions
Process	• How was the NMSP developed? Was it based on evidence? • How was the targeting of malaria control interventions? Was it appropriate? Equitable? • Were there any barriers to implementing the NMSP? Enough resources? Enabling environment? • How was the program managed? • Was the NMP activity implemented as planned? • Was the quality of the implementation optimal? • Did the NMP achieve its expected outputs?
Impact	• Did the NMP achieve the goals outlined in the NMSP? • Are the observed changes in impact indicators attributed to the NMP?

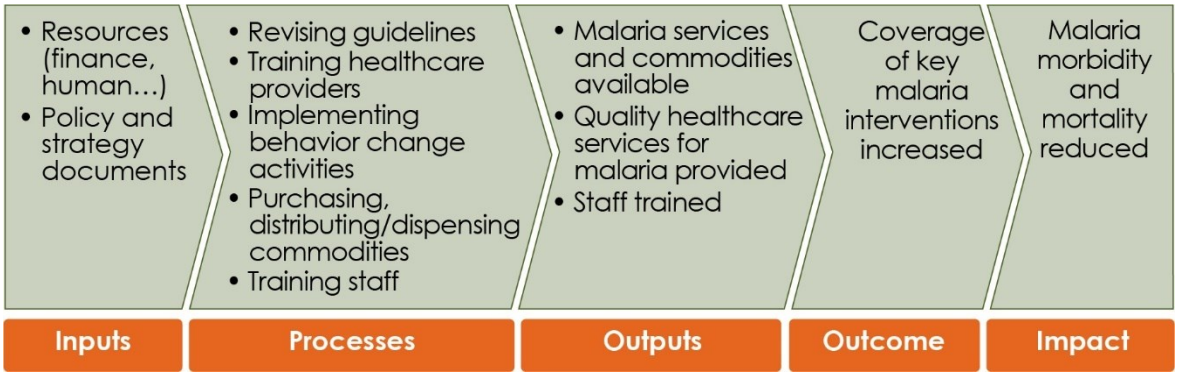
Evaluation Framework

After defining the evaluation questions for the NMP, the next step is to develop the evaluation framework or theory of change and indicator list to be used in the evaluation. The theory of change describes the linkage between a program's inputs, processes, outputs, outcomes, and its intended impact (e.g., reduced malaria-related mortality). Figure 30 outlines a simple theory of change for an NMP impact evaluation.

At the input stage, the evaluation will examine the funding, HIS, governance, and policies. At the process stage, the evaluation will examine how interventions are being delivered and how cases are tested and treated. At the output stage, the evaluation will examine the number of interventions delivered, use of services, and

number of community health workers trained. The outcome stage examines the uptake of malaria control interventions, diagnostic and treatment coverage. Each stage is linked to each other, and ultimately linked with the impact, which includes any changes in malaria-attributable mortality, malaria case incidence, and malaria transmission.

Figure 30. Theory of change



Causality

The ideal way to evaluate the effect of an NMP is through the comparison of outcomes in a population with and without the NMP. The outcome in the absence of the program is considered the counterfactual. The use of a counterfactual facilitates attribution of changes in outcome because the only difference between comparison groups would be the intervention or program being evaluated. The use of a counterfactual is not always possible in a national program context, however. In absence of a clear counterfactual, to establish a causal link between interventions and health outcomes, the Bradford Hill criteria recommends that a set of criteria should be met (Hill, 1965). The Bradford Hill criteria are one of the most used frameworks for making causal inferences in epidemiologic studies. It consists of nine key criteria (strength of association, consistency, specificity, temporality, biological gradient, plausibility, coherence, analogy, and experiment) and one additional criterion (reversibility). To establish a causal effect, an impact evaluation must show a plausible relationship. An association is plausible, and thus more likely to be causal, if it is consistent with other knowledge and specific to a disease and area. A strong association between cause and effect is more likely to establish a causal relationship, compared to a weak association between cause and effect. Consistency can be demonstrated by repeating the same results as several other studies. Table 7 provides additional details on these criteria.

Table 7. Bradford Hill criteria for causality

Criteria	Description
Strength of association	A strong association between possible cause and effect, measured by the size of relative risk, is more likely to be causal than a weak association. For example, children who use LLINs are three times less likely to get malaria, compared to children who do not use LLINs.
Consistency	Reproducibility: study designs used in different settings give the same result, which minimizes the likelihood that all studies are making the same mistake. For example, the use of LLINs has been shown to reduce malaria incidence consistently in different settings.

Criteria	Description
Specificity	Causation is likely if there is a specific population at a specific site and disease with no other likely explanation. The more specific an association between a factor and an effect is, the bigger the probability of a causal relationship. In the malaria context, malaria prevalence can be reduced only if there is good coverage of malaria interventions.
Temporality	There is a temporal relationship between the cause and effect. For example, malaria prevalence decreased after scale-up of LLINs in a specific population.
Biological gradient	Greater exposure should generally lead to a change in incidence (positive or negative) of the effect. For example, increase in coverage of LLIN use leads to the reduction of malaria prevalence.
Plausibility	An association is plausible and more likely to be causal if it is consistent with other knowledge, a plausible mechanism between cause and effect. For example, the use of LLINs reduces vector-human contact, which can reduce malaria incidence.
Coherence	Coherence between epidemiological and laboratory findings increases the likelihood of an effect. For example, antimalarial resistance has been shown to decrease treatment efficacy, similar to resistance found in other treatments.
Analogy	The use of analogies or similarities between the observed association and any other associations. For example, SMC has been shown to decrease parasitemia, similar to the reduction in disease burden seen from other mass drug administrations.
Experiment	Occasionally it is possible to appeal to experimental evidence.
Reversibility	Removing the possible cause results in a reduced disease risk, which strengthens the likelihood of the association being causal. In the case of malaria, removing LLINs used and other malaria interventions will result in an increase of malaria incidence.

Validity

The estimation of a counterfactual and use of the Bradford Hill criteria strengthen the validity of the evaluation. The evaluation may be internally or externally valid. Internal validity refers to the ability to attribute the observed effects between intervention and appropriate control/comparison groups to an intervention or program inclusive of confounding variables. With the use of an appropriate sample and random assignment to control/comparison group, we are able to estimate the "true" impact of the program. External validity refers to the ability to generalize study findings to other eligible populations or locations. For example, the findings of an externally valid study conducted on the effects of SMC on children under five in a Sahel country should be seen among children under five in another Sahel country.

10.3 Evaluation Designs

Evaluation design is the set of procedures used to select appropriate comparison groups to identify a valid counterfactual and answer evaluation questions. Driven by the priority evaluation questions of the NMP, the design should also address selection bias, spillover effects between groups, contamination of one group by another, heterogeneous impacts, and other factors.

Types of Designs

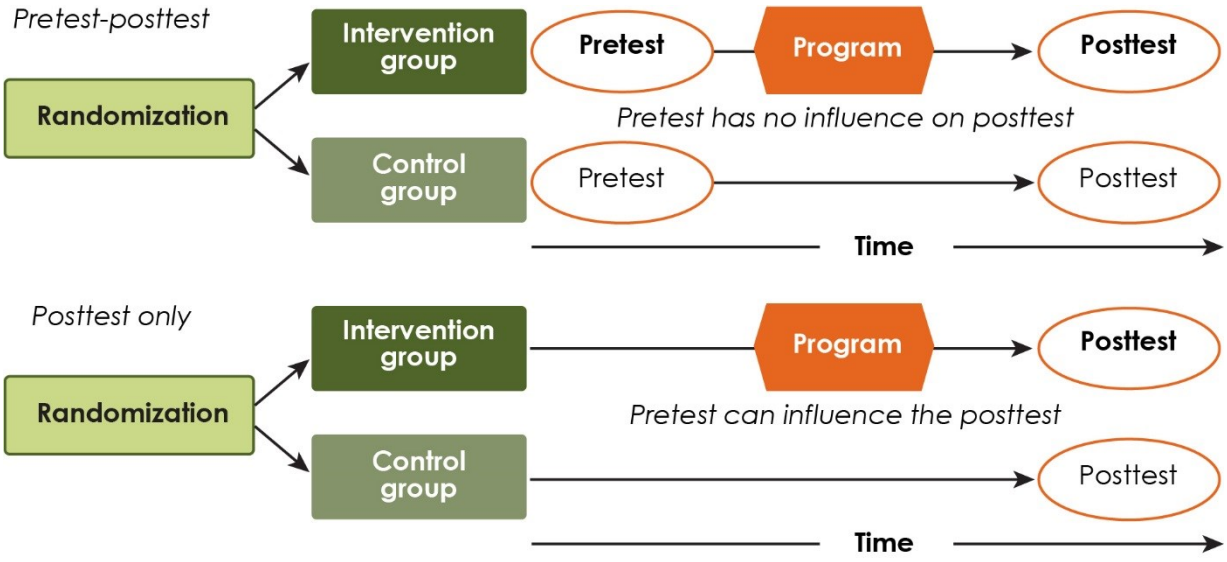
The three main overarching evaluation designs are experimental, quasi-experimental, and nonexperimental (Khandker, Koolwal, & Samad, 2009).

Experimental

Experimental design consists of random assignment of a unit of observation (individuals or households) to a treatment/intervention group or control group to measure the effects of an intervention. The two groups are assumed to be similar in all ways except that one receives the intervention and the other does not. The random assignment helps achieve similarity between the two groups and is necessary to demonstrate causality. For example, we want to assess the effectiveness of a specific malaria intervention in a required sample of X number of individuals. The individuals will be assigned randomly to intervention and control groups through a draw. Each individual receives an identification code on a piece of paper, which we fold and put in a basket. We draw from the basket the first individual, who will be assigned to the intervention group, and draw a second one, who will be assigned to the control group. We repeat this process until the basket is empty. Because we used a random process to assign individuals to groups, there is no bias involved, and the two groups of individuals should be similar.

Both groups will undergo a pretest prior to the intervention or program deployment and a posttest after the deployment (Figure 31). The pretest can be dropped if we think it is likely to affect the posttest, such as a case in which participants remember the questions and their responses from the pretest. The experimental design is considered the gold standard for inferring causality; however, it can be challenging in the context of a complex program evaluation. Figure 31 illustrates the experimental design process.

Figure 31. Illustration of an experimental design with pretest and without pretest



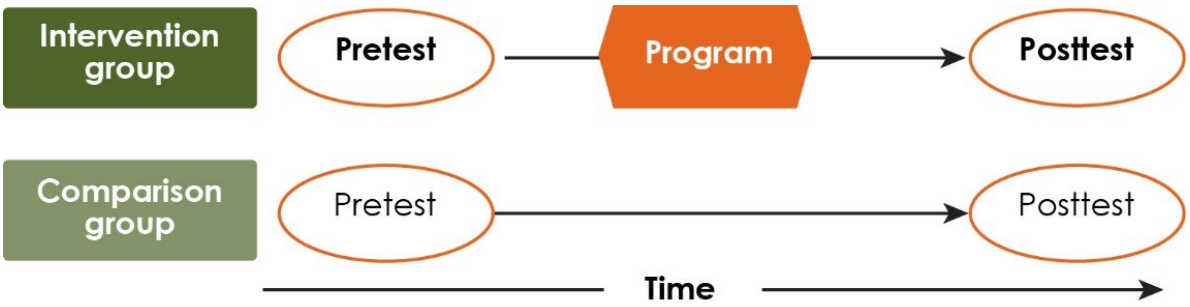
Quasi-Experimental

Quasi-experimental design consists of nonrandomized assignment of intervention and control groups. These designs take advantage of the natural differences in exposure to an intervention or program to estimate effects. For example, some parts of a community may be exposed to an intervention before other parts of the

community (Figure 32). Quasi-experimental designs are not as good at demonstrating causality, but they may require less resources than an experimental design. They offer a mid-point between experimental and nonexperimental designs. Even though this design is not randomized and subject to confounded effect estimates, rigorous analytical methods and careful design help alleviate these biases and account for internal validity issues compared to observational studies.

The advantages of this design include more assurance that outcomes are likely the result of the program and better estimated effects of the program than nonexperimental designs. Disadvantages of this design include the need to identify comparable groups, more required resources, and a lengthier process. An example of a quasi-experimental design is the stepped-wedge design. This design may be used in evaluating the impact of a malaria control intervention rollout. Malaria control interventions may be rolled out sequentially across a population (e.g., by clusters) over time, until eventually the entire population is covered by the intervention. In other words, different areas receive the intervention at different times. This design is considered more pragmatic and equitable because everyone receives the intervention during the course of the evaluation study period, unless the intervention isn't proven effective yet.

Figure 32. Illustration of a quasi-experimental design



Nonexperimental

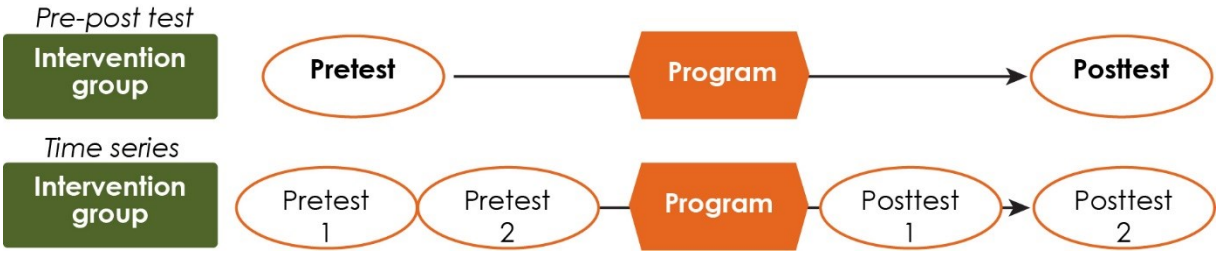
Nonexperimental design does not have a group for comparison (Figure 33). In many instances, we want to observe changes in coverage or impact, but we are not necessarily interested in linking those changes to a specific program. An example is measuring changes in ITN use among children under five in a country over a period of five years. Using two rounds of nationally representative surveys such as the DHS or MIS, we can estimate the change between baseline and endline to provide an overall picture of the achievement and remaining gaps to orient program efforts.

Nonexperimental design is not suitable for determining the effectiveness of interventions; however, it is commonly used for program evaluation. It is also known as outcome monitoring. In some instances, it is the only option available or needed for evaluating certain types of programs, which are at national scale. For example, a national mass media campaign to promote ITN use may use radio and television, which have widespread reach. In such a case, it is not possible to have a comparison group that has not been exposed to the intervention.

When used for program evaluation, pretest/posttest nonexperimental study designs may present some limitations because there is only one measurement before and one measurement after the intervention. Two measurements do not constitute a trend. Having multiple data points (at least two) before and after program

scale-up can provide additional strength to the design, because they help evaluators understand the trends before and after the program scale-up.

Figure 33. Illustration of a nonexperimental design

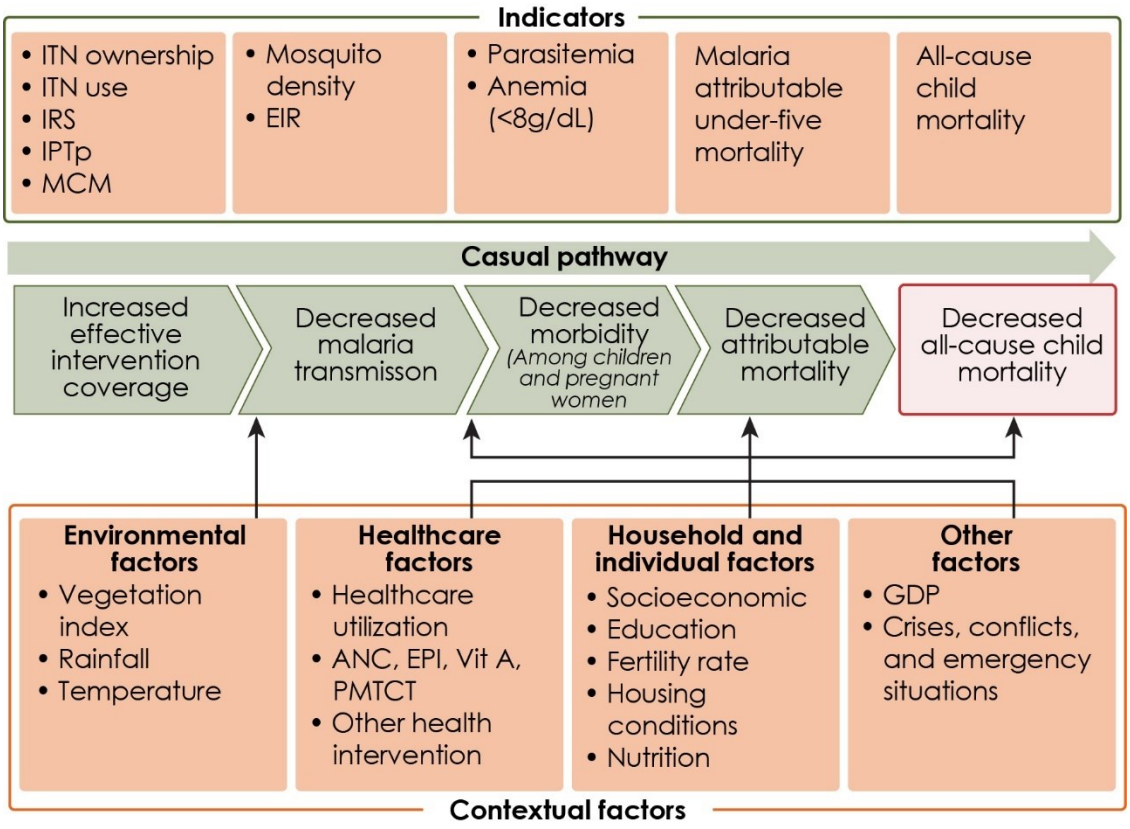


Plausibility argument

Constructing a plausibility argument and documenting contextual factors may strengthen the nonexperimental design. A plausibility argument is constructed by describing trends in intervention coverage, intermediary outcomes, impact outcomes, and contextual factors. These trends may then be linked using temporal, spatial, age-pattern, and "dose-response" associations. A plausibility argument framework illustrates the complex impact of malaria control (Figure 34) (Yé, et al., 2017). The middle horizontal bar represents the causal pathway, beginning with an outcome of the NMP, "Increased effective intervention coverage." The causal pathway leads to the overall impact goal of "Decreased all-cause child mortality." The top bar represents indicators that should be examined for each stage. For example, under "Decreased morbidity," the indicators are parasitemia and anemia. The bottom row represents contextual factors that should be accounted for in each stage when evaluating NMP impact. Due to the limited measurement of malaria-associated mortality at the national level, a proxy measure can be all-cause under-five mortality. Because all-cause under-five mortality is affected by a variety of factors other than malaria, it is necessary to document the trends of contextual factors, such as climate, health interventions, and socioeconomic characteristics. Each of the contextual factors listed may affect the overall impact.

A plausibility argument can accommodate a complex intervention and use data from different sources for a national-scale program evaluation. This design requires several data points for intervention and outcomes. The design often uses data from different sources, such as HMIS, surveys, sentinel surveillance, and climate observations; however, data collection methods may not be consistent over time.

Figure 34. Plausibility framework



EIR=entomological inoculation rate, EPI= extended program for immunization, GDP=gross domestic product, MCM=malaria case management

Source: Yé, et al., 2017

Summary of the Different Designs

To determine causal impact of an intervention, an experimental design is necessary. Experimental designs are usually used to test a program for unknown effectiveness. They require a control group. Experimental design can be expensive compared to nonexperimental design, which is the most common type of evaluation design for programs. Non-experimental designs may be used to determine the levels of outcome variables (e.g., the level of ITN use in a country) or to measure changes in levels of outcome variables over time. They are also used to evaluate the effects of full coverage programs, which are intended to reach everyone in the target audience. It is not possible to make causal attributions with this type of study design. Time series designs can strengthen the rigor of nonexperimental or quasi-experimental designs. Quasi-experimental designs are in between the other two types of designs in terms of their strength and associated costs. Their rigor can be strengthened using time series designs, various analytic methods, or using mixed methods (see plausibility discussion).

There are trade-offs between how strong a design and sampling are and whether their findings can be generalized to other situations. Because of the planning and controlled situations that are required to implement an experimental design, it is difficult to generalize the findings of these evaluations to other situations.

10.4 Key Indicators for Malaria Program Evaluation

Indicators used for NMP evaluation will depend on the evaluation question, data sources, and data availability. Examples of key indicators for process evaluations include the proportion of population at risk with access to an ITN in their household, proportion of population at risk that slept under an ITN the previous night, and proportion of pregnant women who received three or more doses of IPTp. Case management indicators include proportion of patients with suspected malaria that received a parasitological test and proportion of confirmed malaria cases that received the first-line antimalarial treatment according to national policy. Key impact indicators include malaria case incidence (number and rate per 1,000 people), malaria test positivity rate, proportion of admissions for malaria, malaria mortality (number and rate per 100,000 people per year), proportion of inpatient deaths due to malaria, and all-cause under-five mortality. These impact indicators depend on the transmission setting, with all-cause child mortality being the primary impact indicator in high-transmission settings and confirmed malaria case incidence being the primary impact indicator in moderate- to low-transmission settings (Evaluation Task Force of RBM's Monitoring and Evaluation Reference Group, 2019).

10.5 Data Sources for Malaria Program Evaluation

Data for NMP evaluation can come from multiple sources, as described in more detail in Chapter 8. These data sources may include national censuses, national population-based surveys (e.g., DHS, MIS, MICS), routine health information, sentinel surveillance sites, NMP-specific data, special studies, and other nonhealth data that can provide information to better understand the context. Regardless of the data source, the choice to use a particular source should be informed by the evaluation questions, which will help determine the relevance of the data source. Data sources should also undergo a quality review process before using them for the evaluation. To reduce cost and time, it is advisable to capitalize on existing data; however, in some instances, collecting additional data might be helpful and provide better insight for the evaluation. Both quantitative and qualitative data are useful for NMP evaluation.

Quantitative data measure characteristics or values numerically and allow for statistical analysis. Examples of quantitative data include the number of bed nets distributed, the number of malaria cases, or the number of antimalarial distributed. Quantitative data are the most commonly used for evaluation because of their objectivity. Qualitative data are descriptive or empirical and focus on aspects that cannot be measured numerically and can help explain complex phenomena or why an event is occurring. Examples of qualitative data include knowledge of pregnant women about the causes of malaria, observations of malaria treatment in health facilities, community perspectives on IRS, or complex contextual factors such as gender or social norms. Evaluations may employ mixed methods and use both types of data. Learn more about qualitative methods in evaluation at https://www.measureevaluation.org/resources/training/capacity-building-resources/qualitative-methods-in-evaluation-of-public-health-programs-a-curriculum-on-intermediate-concepts-and-practices/qualitative-methods-in-evaluation-of-public-health-programs-a-curriculum-on-intermediate-concepts-and-practices.

10.6 Contextual Factors

Evaluating malaria programs is a complex process with many factors to consider when interpreting the results. Contextual factors include the country's health system, sociocultural and socioeconomic (micro and macro) factors, environmental factors, epidemiological factors, and climate. These factors may influence the deployment of malaria control interventions, their use, and their implementation. Examples of contextual factors are described in Table 8.

Table 8. Contextual factors to consider when evaluating NMPs

Contextual factor	Description and examples
Health system	• Government expenditure on health • Health commodity quality • Population access to health facilities • Availability of commodities • Other nonmalaria interventions
Sociocultural and socioeconomic (micro/macro)	• Economic growth • Household income • Parental education • Migration • Conflicts • Non-health interventions • Gender and equity
Environmental	• Altitude • Vegetation
Epidemiological	• Other diseases • Highly endemic neighboring countries • Malnutrition • Insecticide resistance
Climate	• Total and frequency of rainfall • Extreme weather events

10.7 Establishing the Causal Link

Testing the Hypothesis

When evaluating an NMP, there must be a hypothesis about the effects of the program. The hypothesis may either be true or false. To test this hypothesis, an assumption has to be made regarding a parameter, such as the NMP's impact on malaria mortality. In this case, the NMP not having an effect is considered the null hypothesis, which is the default position, stating that there is no relationship between the two things being measured. The alternative hypothesis states that the NMP does have an effect on malaria mortality. During an evaluation of an NMP, the null hypothesis is tested through a four-step approach: (1) establishing the null and alternative hypotheses, (2) choosing the contrast criterion, (3) estimating the parameter of interest and calculating the p-value, and (4) making a decision and reaching a conclusion.

After establishing the null and alternative hypotheses, the significance level of the data analysis must be identified. The significance level is represented by the p-value or probability value, which is the probability of finding an impact estimate as extreme as found in the data, assuming that the null hypothesis is actually true.

The p-value is typically 0.05 to determine whether the null hypothesis will be rejected. P-values below 0.05 reject the null hypothesis of no effect.

Types of Analysis

After the evaluation questions, type of evaluation, study design, indicators and data sources, and hypothesis have been identified, the next step is to establish the causal link. These factors determine the type of analysis to be used. Rigorous statistical methods used to analyze experimental designs with randomized assignment method and, quasi-experimental designs include difference-in-difference (DID), regression discontinuity, and propensity score matching. For nonexperimental studies, a trends analysis may be used.

DID analysis compares changes before and after or pre- and post-program for those in the program and control groups (Gertler, et al., 2011). For comparison, the DID analysis requires program and control groups and at least two time points (baseline and follow-up). The DID analysis is often paired with the stepped-wedge design, with the assumption that the two groups would experience the same outcome effects without the program. This is called the Equal Trends or Parallel Assumption. The DID analysis and design combination are modestly robust but require understanding and consideration of factors that affect the study population, such as other concurrent programs being deployed, other disease epidemics, and other contextual factors that may affect observed outcomes. The availability of baseline data and pre-baseline data help better estimate program effects.

Regression discontinuity analysis addresses potential confounders by controlling for differences between groups at baseline (Gertler, et al., 2011). This analysis is typically used as an impact evaluation method for programs with a clearly defined eligibility threshold for certain programs or interventions. The analysis measures the difference in post-intervention outcomes between those near the threshold. For example, malaria programs use a household wealth index threshold to determine ITN distribution. Households with income below a certain wealth index are eligible for free ITNs, and those with income above the threshold are not. This threshold represents a discontinuity in the population and generates two separate and distinct groups. Households closer to the threshold are more similar to each other, compared to households further from the threshold. Regression discontinuity analysis is useful when thresholds like this are employed and provides an unbiased estimate of program impact. Furthermore, there is no exclusion of households or individuals from the intervention.

Propensity score matching analysis uses observational data between groups that received an intervention and those that did not and are matched, to estimate the impact attributed to the intervention (Yé & Duah, 2019). More specifically, the propensity score is generated through the probability of treatment assignment based on the observed baseline characteristics or covariates. Propensity score matching is conducted in two phases. The first phase generates the propensity score through a regression model that predicts the conditional probability of receiving the intervention for each individual or household based on certain observed characteristics. The propensity score is then used as the basis to match individuals or households that received the intervention with those that did not, or vice versa, based on the common support. The next phase includes another regression to model the outcome based exclusively on the intervention, using only those that were matched. Essentially, the analysis compares the average outcomes between a treatment group and a statistically matched group based on available observed characteristics. Propensity score matching is

best applied when there are large sample sizes, the intervention is common, but the outcome is uncommon, and investigators can assume that no further unmeasured confounding variables exist that predict the propensity of receiving the intervention or are strongly correlated with the outcome of interest.

10.8 Implementing the Evaluation

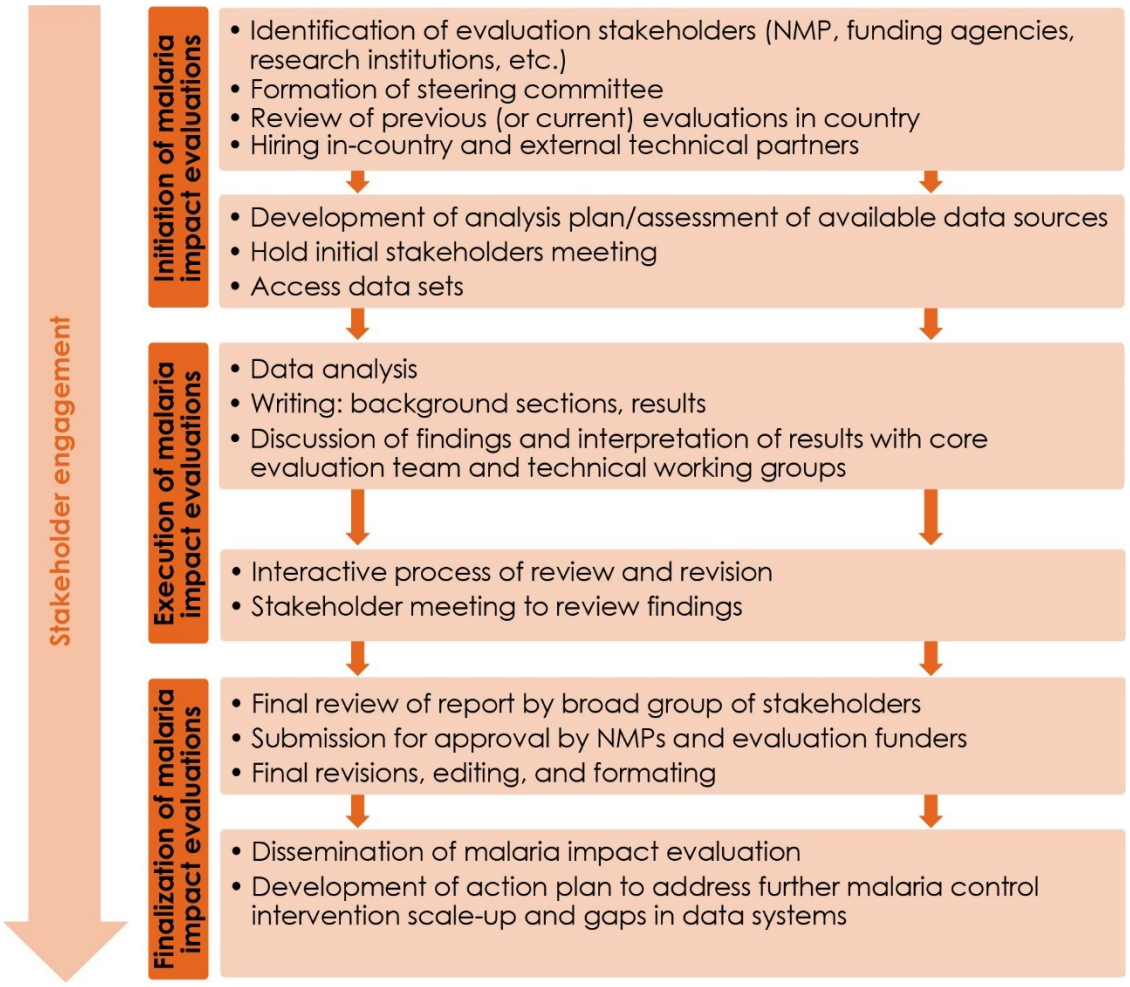
Implementing an evaluation of malaria programs first requires engaging stakeholders. Stakeholders include staff in the national and subnational program in government institutions, policymakers, funding partners, research organizations, academic institutes, advocacy groups, and others who may benefit from the program. Engaging stakeholders should be prevalent and consistent throughout the evaluation process, from the planning stages to the dissemination of results. This engagement is crucial for developing community ownership of the evaluation process and fostering use of the results to further improve the program and outcomes. It is important for the evaluation process that there is transparency and that stakeholders understand all aspects of the evaluation, such as the purpose, objectives, design, methods, roles and responsibilities, and results dissemination method (Hershey, et al., 2017).

Conducting a stakeholder analysis will identify the partners to engage in the actual evaluation. A useful stakeholder engagement tool, developed by MEASURE Evaluation, can be found at https://www.measureevaluation.org/resources/publications/ms-11-46-e. Key partners will include members of the NMP, Ministry of Health, and those involved with the NMSP development process. Other key partners include those with both evaluation and malaria experience who may help advise the evaluation process or benefit from it. Achieving agreement among key stakeholders for the evaluation and ensuring that it fits the political and operational context are crucial for stakeholder buy-in for the evaluation process.

Early engagement of stakeholders and transparency build the foundation for the dissemination and use of evaluation results. Stakeholders should be given the opportunity to review and discuss the findings with the evaluation team, and it should be noted early on that the evaluation results will be disseminated regardless of whether the findings are positive or negative (e.g., results show poor implementation, lack of governance).

Evaluation results may be used by the various stakeholders involved to provide an evidence basis for the development of the subsequent NMSP. The results should be leveraged to inform strategies for increasing the program's effectiveness. This increased efficiency may be accomplished through action plans addressing issues identified in the evaluation, informed selection of interventions, and identification of populations at risk. The results may be disseminated through presentations at meetings or action planning workshops. They may also be disseminated through the development of policy briefs, factsheets, bulletins, and publications in peer-reviewed journals. Hershey et al. (2017) provides an excellent overview of conducting an impact evaluation divided into three phases—initiation, execution, and finalization—with stakeholder engagement throughout each phase (Figure 35).

Figure 35. Framework for conducting malaria impact evaluations



Source: Hershey, et al., 2017

10.9 Challenges and Considerations in Evaluating Malaria Programs

The evaluation of malaria programs is complex with many challenges. These challenges include evaluating interventions at a national scale, different areas having different responses to the same interventions, limited data for tracking morbidity and mortality at various scales, limited individual-level data, and defining intervention maturity to affect outcome.

With significant scale-up of interventions, evaluating these interventions at a national scale presents a significant challenge in attributing changes in malaria outcomes to these interventions. Frameworks using multiple data sources and attention to contextual factors, with subnational analysis, may help in plausible attribution of implemented malaria control interventions (Yé, et al., 2017).

In addition to evaluating at a national scale, different regions of the country may respond differently to the implemented interventions. For example, an effective ITN campaign in one region may not be as effective in another region due to outdoor biting mosquitoes or changes in vector behavior. This should be considered when conducting evaluations.

Highly endemic countries have made significant improvements in their HIS, but the availability and quality of data are still lacking. This poses a challenge to assessing the impact on morbidity and mortality. Countries often rely on population-based household surveys, but these surveys are conducted only periodically, every two to three years. Other sources of morbidity and mortality data include the RHIS, but this system usually captures cases in the public health system only. Individual patient data from clinics are aggregated at the facility level and reported upward to the district-level. These data may be analyzed and further aggregated with other facility-level data and reported upward to the regional level.

The challenge of defining an intervention's maturity is that it takes time for an intervention to affect outcomes. For example, implementing intermittent preventative treatment in women will not immediately impact malaria outcomes. Time will be needed for the intervention to be implemented and for the community to be aware of the intervention and use.

10.10 Evaluation Examples

Examples of evaluations conducted are available on the PMI website at https://www.pmi.gov/resource-library/pmi-publications/evaluation. This site includes impact evaluations of malaria control intervention scale-up on all-cause child mortality in children under five conducted in several sub-Saharan countries.

10.11 Summary

NMP evaluations are invaluable for demonstrating how well malaria interventions are being implemented and how effective they are in reducing malaria burden, and for providing useful information for strategic planning and policy decision making. This chapter describes key concepts in program evaluation and highlights different types of designs used—experimental, quasi-experimental, and nonexperimental—and when to use them. It also provides how-to guidance on choosing key indicators, using essential data sources, and considering contextual factors when conducting an NMP evaluation.

Steps to establish the causal link include testing the hypothesis and deciding which type of analysis to use. Analytical methods for NMP evaluations vary, from rigorous statistical methods to moderate trend analysis. Common analysis methods include randomized assignment, DID, regression discontinuity, and propensity score matching.

This chapter also covers implementing an evaluation and includes a framework (Figure 35) highlighting the various stages of implementation. Finally, challenges, considerations, and examples are shared.

11 Chapter 11. Data Quality, Data Management, and Data Analysis

Earlier chapters have discussed various components of SME in NMPs. This chapter discusses data quality in a data management system, the effects of data quality on an NMP, and ways to ensure good data quality at all system levels. It also summarizes key elements of a data quality assessment (DQA).

11.1 Data Quality

Data quality can make or break a malaria SME system. Like a lens through which to view the world, it can provide a clear picture of a program or a distorted view that shows inaccurate program performance.

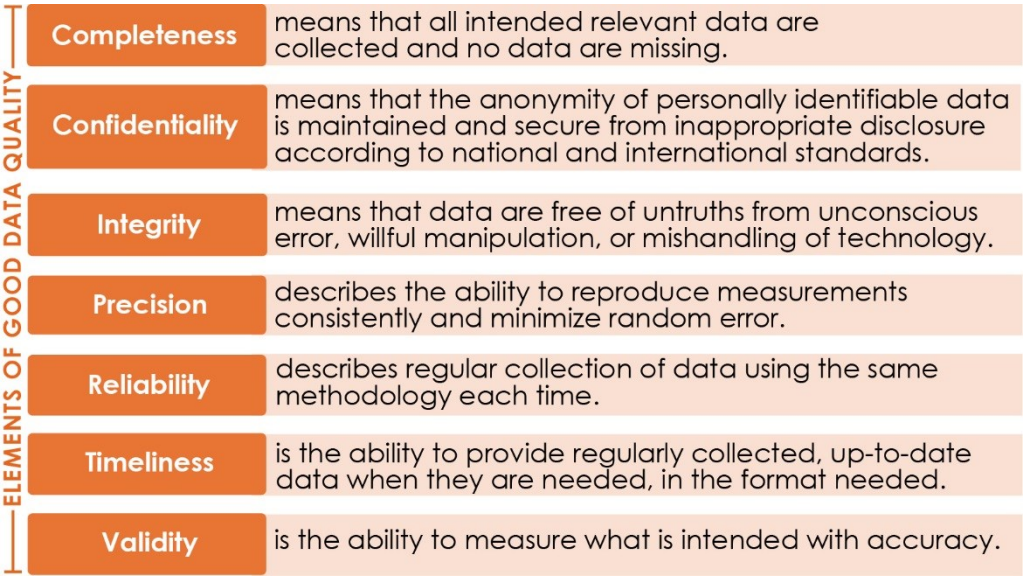
How is your data quality?

- Does your organization have problems with incomplete or missing data?
- Does your system have data delays at various levels your system?
- Do you trust your data?

Data quality affects every part of an NMP. It influences the effectiveness of the data management system and the confidence that stakeholders have in the program. Poor data quality can lead decision makers to make inaccurate program management choices, which later require additional resources to correct misjudgments, or missed opportunities to identify program strengths and weaknesses. Strategies to strengthen and improve data quality are essential for a successful NMP.

Ensuring good data quality includes taking the following seven dimensions into consideration: completeness, confidentiality, integrity, precision, reliability, timeliness, and validity (Figure 36).

Figure 36. Elements of good data quality



Completeness means that all data needed to measure program indicators are collected and entered in the data management system. A strong data review mechanism helps ensure that no data are missing and that all service delivery points and the full program population are represented. Program records should clearly list all program areas, healthcare facilities, and population demographics. If data are missing, especially in large areas, it may be necessary to reexamine the sampling frame or perform supervisory checks on staff capacity for data collection to determine whether further training is needed.

Confidentiality means that all personally identifiable information is analyzed, stored, and maintained in strictly secured conditions according to national and international data standards. Procedures are in place to guard against inappropriate disclosure of personally identifiable data in paper or electronic form. To maximize data confidentiality, personal information is identified by a number or deleted if not needed for analysis. If kept, it is separated from the main database and password protected. Paper forms are stored in locked cabinets in a secured area.

Integrity means that data are free of errors resulting from willful manipulation or unconscious mistakes. Data are accurate and consistent over the entire life cycle, from collection to entry, storage, dissemination, and use. Data integrity can be willfully or unconsciously compromised at any point, such as data lost if a fragile data management system fails or is intentionally manipulated for personal or political reasons.

Several strategies for quality control assurance can increase data integrity and maintain objectivity and independence. Examples are not involving data collectors in the program being assessed, using more than one collector and reporter to limit individual mistakes or manipulation, and introducing cross-checks. Adding cross-checks also increases opportunities to catch errors. Special effort is needed to remove incentives that could lead to data manipulation, such as monetary rewards for meeting targets and rewards for collecting the most data forms per month.

Precision is measured by the margin of error or confidence interval. A DQA can account for the degree of precision needed. Several strategies can increase precision and minimize random errors. Criteria for precision should be established before data collection begins, and program applications need to be adjusted to meet those criteria. For example, to improve an accurate estimate of the number of children under five in a specific population, oversample data collection. To ensure that data collection staff have the capacity to maintain adequate precision, refine data collection instruments and instructions and clarify reporting schedules and requirements. For example, an error log and highlighting feature can show data points that fall below the specified level of precision.

Reliability indicates that the data collection system is stable and consistently measures relevant indicators. The system can produce the same findings and results repeatedly over time. Reliability, however, does not mean that the data are valid; it means only that the system works reliably. For example, if two scales both register a weight each time they are used, regardless of that weight, they are reliable. If, however, one shows the wrong weight, it is not valid, although it was reliable in showing a consistent measurement.

Reliability can be strengthened by documenting all procedures, clarifying instructions to data collectors, and maintaining error logs during data processing. Indicator reference sheets should provide clear instructions and definitions for data collection, cleaning, analysis, and reporting. Documented procedures help ensure that data

are collected regularly and managed consistently, but these protocols can easily be overlooked. Staff training and frequent reminders increase awareness. One simple way to ensure reliability is to use the same collection tool for collating and reporting to reduce transcription errors.

Timeliness means that routine data collected in the community and at health facilities are reported soon after collection. Periodic surveys can leave a gap between collection and reporting, and the most recent data may not be available when needed. Data that are not current and reporting that is irregular have limited use for program managers and stakeholders.

Timeliness can be improved with several strategies. One is to establish a realistic schedule that includes deadlines for data collection, collation, analysis, and reporting to meet program management needs. Data collectors and collators need to be aware of data reporting deadlines. All data collection forms and collation reporting forms should have clear instructions for reporting deadlines. Reports should include the date when the data are reported, which can expose late reporting problems that need to be remedied.

Validity means indicator measurements are accurate and well founded. Valid data answer these questions: Do the data clearly, directly, and adequately represent the result intended to be measured? Do the data adequately represent performance? For example, data collected to measure an indicator based on the number of malaria cases diagnosed with RDT or microscopy should not include the number of all suspected cases of malaria.

Several strategies can increase validity. Carefully written indicators specify the measurement needed, and indicator reference sheets include clear definitions, with no ambiguities. Data collection and collation tools should have clear instructions.

Implementing Data Quality in an NMP

Some advanced SME data collection systems can be complex. Field personnel and managers can find the many requirements confusing, which can easily result in data errors. Money and time spent on training, supervision, and familiarization with all processes and procedures relevant to SME data collection are a good investment.

Data collection, consistency, reliability, and validity are especially important in public health. With consistent, quality-controlled procedures and tools in place, the data management system should be able to produce repeatable results.

Data collection methodologies should take into account the particular situation in which data will be collected, such as specific program needs and local culture. A thorough knowledge of the population in the study area helps accurately represent the population during sample selection. Enumeration—the calculation of the number of subjects in the sample area—must accurately represent the program population being studied. Oversampling is better than misrepresentative sampling or undersampling.

Care and effort are needed to plan and document procedures and definitions before data collection begins. Consistent procedures for data collection, maintenance, analysis, processing, and reporting require that definitions and indicators remain stable across time, personnel, reporting schedules, and analytical methods. Documenting the procedures for the data life cycle makes it easier to detect errors and find solutions.

Quality controls help ensure that data are reliable, free of significant error and bias, and available for periodic review. DQAs and routine random checks between entered data and source data can reveal gaps in procedures and errors made during data collection and transcription. An electronic data collection system that uses smart phones or tablets can check for null, inconsistent, or unallowable values and minimize threats to reliability by eliminating transcription. This real-time check also minimizes returns to respondents for clarification. Errors can be tracked to their original source, all the way to the original collection point. All data collections encounter errors, but the procedures for detecting and correcting these errors can improve data quality.

Standardized data collection tools used at facilities and in the community and the collation forms for reporting can minimize subjective judgement for data based on human observation. For example, in malaria diagnostics, more than one microscopist should read blood slides to determine parasite prevalence, and a third person is needed to confirm when the first two do not agree.

Data Quality Guidelines

Established, clearly defined data quality guidelines ensure trustworthy information. Several quality control measures can reduce double entry errors, consistency issues, and range errors.

Double entry means that two independent people enter the same information. The two entries are then compared to ensure that the information matches 100 percent. Any entries that do not match should be compared to the original collection documents. Information flagged as incomplete, conflicting, or nonfeasible data can be returned through the data flow path until the error or omission is corrected.

Consistency and validation refer to conflicting information between questions on variables. If the data processing software is configured for maximum consistency, all related questions and variables must have at least 99 percent consistency.

Range error refers to values outside of acceptable ranges. All responses or values should be 100 percent within the acceptable range. For example, if a variable in the sample population is based on women 15–49 years of age, then any age value outside this range is unacceptable. This check should be done at both the field supervision and data entry levels.

Figures 37 and 38 list the various target levels for range error checks on routine and nonroutine data quality.

Figure 37. Nonroutine data quality targets

Set quality target: non-routine data		
Aspect	Execution	Error tolerance
Consistency/validation	99%	95%–100%
Error (range check)	100%	95%–100%
Double entry	100%	100%

Figure 38. Routine data quality targets

Set quality target: routine data		
Aspect	Execution	Error tolerance
Completeness	100%	85%–100%
Promptitude	100%	85%–100%
Accuracy	100%	90%–100%

Data Quality Assessment

A DQA is a review of a program's SME system to ensure acceptable data quality. A DQA examines four aspects of the data collection process: (1) design, (2) organizational structure, (3) implementation practices, and (4) follow-up verification of reported data. A DQA asks these questions: Are systems and practices in place to collect, aggregate, and analyze the appropriate information? Are these systems and practices being followed? Are reported data for key indicators being verified? Are spot-checks conducted to find nonsampling errors? Figure 39 illustrates the verification process in a DQA. The national total circled in green encompasses the totals added from Regions 1, 2 and 3, and the Region 1 total circled in red combines totals from service delivery points 1 and 2.

Figure 39. Verification process in a DQA

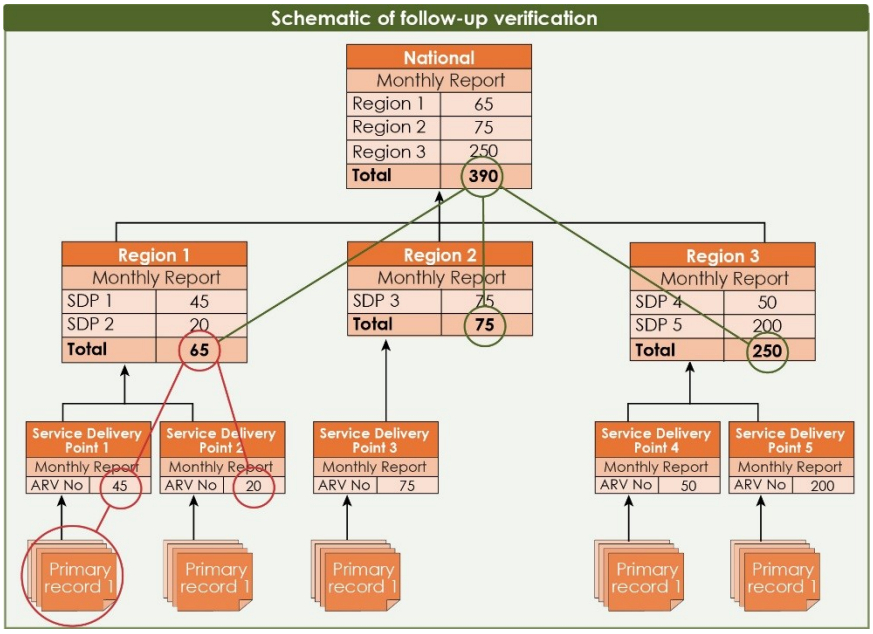


Table 9 lists questions used in a DQA.

Table 9. DQA questions

Functional area		Question
SME structures, functions, and capabilities	1	Are key SME and data management staff identified and assigned clear responsibilities?
	2	Have key SME and data management staff received the required training?
Indicator definitions and reporting guidelines	3	Do operational indicator definitions meet relevant standards that are followed systematically by all service points?
	4	Has the program clearly documented what is reported, who receives the information, and how and when reporting is required?

Functional area	Question	
Data collection and reporting forms	5	Are standard data collection and reporting forms used systematically?
	6	Are data recorded in detail and with sufficient precision to measure relevant indicators?
	7	Are source documents retained, and are they made available according to a written policy?
Data management processes	8	Are steps clearly defined for documenting data collection, aggregation, and manipulation?
	9	Are data quality mechanisms in place to address challenges?
	10	Are procedures clearly defined and followed to identify and reconcile discrepancies in reports?
	11	Are procedures clearly defined and followed for periodically verifying source data?
SME capacity and system feedback	12	Do SME staff understand their roles and how data collection and analysis fit into the overall program quality?
	13	Do SME staff understand the program management plan and SME plan?
	14	Do SME staff have the required skills in data collection, aggregation, analysis, interpretation, and reporting?
	15	Are feedback mechanisms in place to improve data and system quality?

Practical tips for a DQA

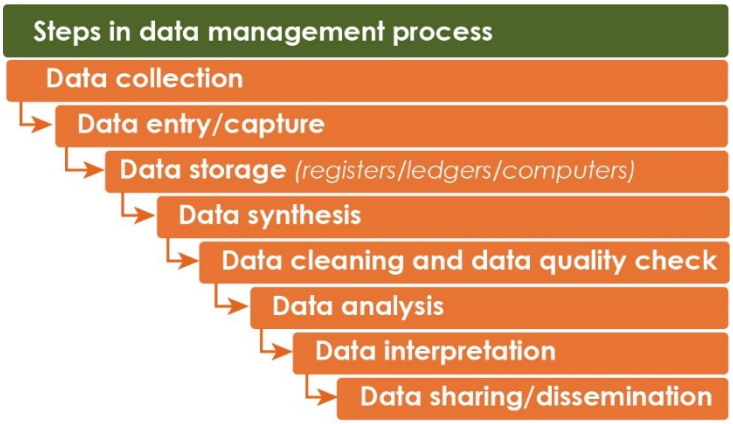
- Build assessment into normal work processes.
- Use software checks and edits of data on computer systems.
- Get feedback from data users.
- Compare the data with data from other sources.
- Obtain verification by independent parties.
- Design the SME system for data quality.
- Ensure that all dimensions of data quality are incorporated into the SME design.
- Ensure that all processes and data management operations are implemented and fully documented.

For more information on how to conduct a DQA, see the *Data Quality Audit Tool—Guidelines for Implementation* at https://www.measureevaluation.org/resources/publications/ms-08-29.

11.2 Data Management

Data management encompasses the full spectrum of activities involved in handling data—collection, entry, storage, synthesis, cleaning, quality check, analysis, interpretation, and dissemination. It also includes policy development, data ownership and custodianship, documentation, metadata compilation, maintenance, standardization, harmonization, audit, security, and access. Data management is an important component in SME, and it requires constant attention and diligence. Figure 40 illustrates the steps in data management.

Figure 40. Steps in the data management process



Data Flow

Data flow is the process of moving data from the point of collection—the data source—to the point where they will be processed into formats that stakeholders—the end points—can use them. Elements of data flow are data source points, data storage points, data processes, and data end points, as illustrated in Figures 41, 42, and 43. These points indicate who is responsible, how data flow through the various points, and how the information will be transmitted.

Figure 41. Health management information system data flow

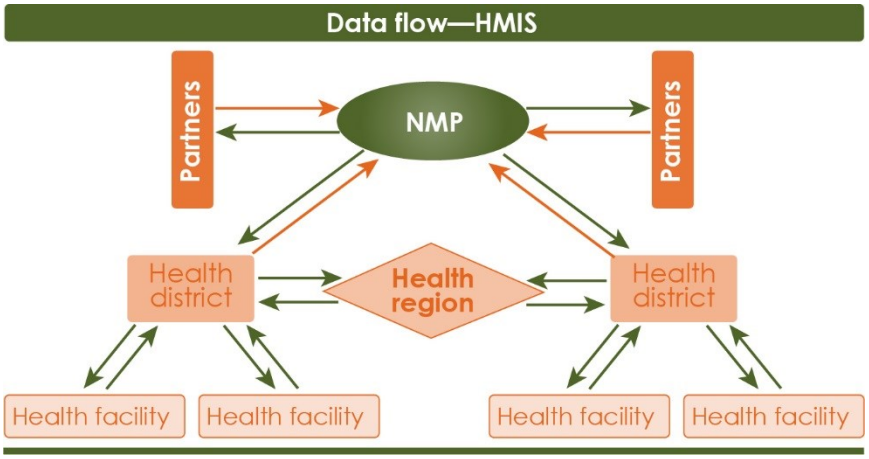


Figure 42. Example of program data flow and management processes

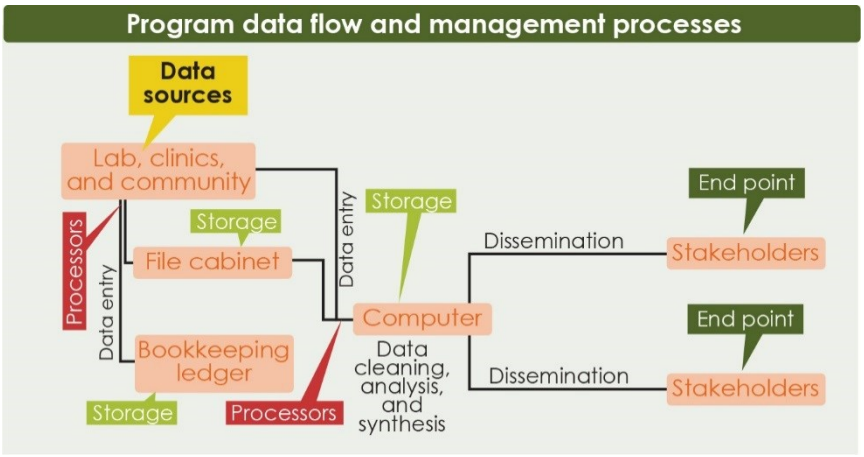
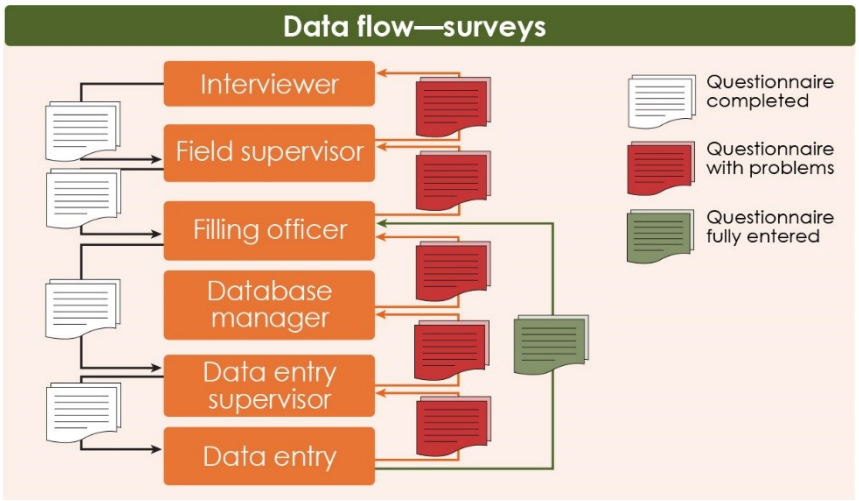


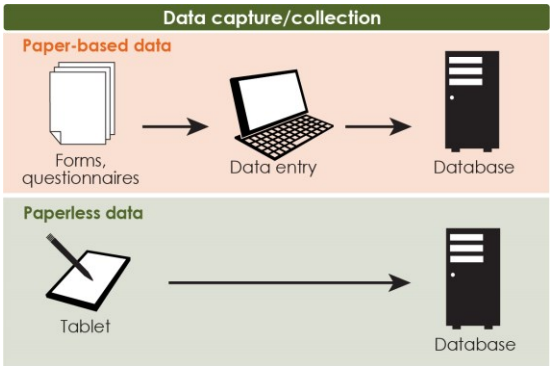
Figure 43. Example of a data flow diagram



Data Capture

Data capture (Figure 44) should be planned carefully, including the collection tools and hardware, database and processing software programs, database structure, and data entry. Software for data capture includes CSPro, Microsoft Access and Excel, and Epi Info, a free set of software tools for public health practitioners and researchers. The software needs to check for plausible values or missing information. Electronic data are usually collected on smart phones or tablets and then uploaded into an HMIS database. Countries are increasingly using DHIS2 software to house these large databases.

Figure 44. Example of data collection and capture



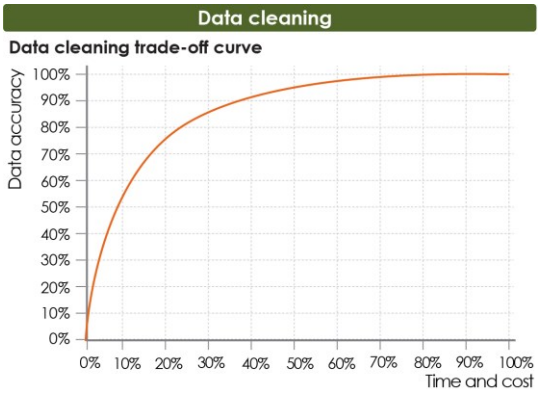
Data Sources and Storage

SME data sources are places where data are obtained, which are often specified in terms of organization, publication, or information systems. These data sources should be feasible within the available resources and inspire confidence in the quality of information gathered. Flow diagrams need to clearly indicate source locations and outline the timing of data collection. Electronic data storage uses password-protected databases in management and analysis programs, such as Epi Info, SAS, SPSS, Microsoft Access, or Microsoft Excel, that are backed up regularly. Paper forms with data are stored in secure rooms that are accessible to only personnel who need to manage the data.

Data Cleaning

Data cleaning checks for completeness; consistency, which can be checked by comparing variables; plausibility to determine whether data values fall within an acceptable range; and occurrence of duplicate entries or outliers, found through analysis on basic frequencies and means. Figure 45 shows a data cleaning trade-off curve that illustrates the time and cost expended to clean data compared to improved accuracy—a clearly diminishing return on investment. As more time is spent past a certain level, improvements in data accuracy taper off.

Figure 45. Data cleaning trade-off curve



Data Security

Data security maintains confidentiality of data sources and data integrity. Password-protected electronic data should protect personally identifiable information. Unique identifiers should be removed from the data set, and the final analytical data should be anonymous. Paper documents should be kept in a locked location. Some studies allow ethical reviews with unique identifiers, but the analyst should not be able to identify individuals. Regular data backups should be stored offsite to guard data integrity.

Other Aspects of Data Management

Data ownership means that the individual or organization that holds the legal rights to the data retains the rights to the data. Data ownership should be decided before collection to avoid confusion and conflict.

Data retention refers to the length of time that data should be kept available. Documents based on the data may require lengthy retention, which could have implications on data storage arrangements.

Data sharing refers to data dissemination in a format that the data user needs and limitations on data that should not be shared. Data sharing guidelines should outline how results will be disseminated and clearly stipulate when and which data should and should not be shared.

11.3 Data Analysis

Analysis turns raw data—a mass of numbers—into useful information. It also determines how the information is organized. Data analysis answers questions raised at a program site or during research and prepares information for comparison of targets or theories with achievements and performance. Although the terms "data" and "information" are often used interchangeably, there is a distinction. **Data** refers to raw, unprocessed numbers, measurements, or text. **Information** refers to data after they are processed, organized, structured, or presented in a specific context.

Although statistical software packages make analysis easier, the first steps in analysis are taken by the people who collect the data and enter them electronically into a database. These are the points that determine the quality of the data and their usefulness later during analysis. No matter how many data pieces are collected, if they are not trustworthy, they are not useful.

Data analysis organizes the collected data and manipulates them to reflect answers on specific indicators. For example, to determine whether a program is meeting its objectives, an analysis compares performance on indicators with the targets set for the objective.

Several indicators are common among NMPs. This text focuses on those indicators and the statistical calculations used to interpret SME results. Figure 46 shows examples of indicator comparisons used to measure progress.

Figure 46. Examples of indicator comparisons

Examples of indicator comparisons

Compare actual performance against targets

Indicator	Progress (6/12/16)	Target (1/30/17)
Number of persons trained on case management	15	100

Compare current performance to prior (completed periods)

Indicator	2016	2017
Number of LLINs distributed	50,000	167,000

Compare performance between sites or groups

Indicator	District A	District B
Number of fever cases tested for malaria by clinics	3,500	8,000

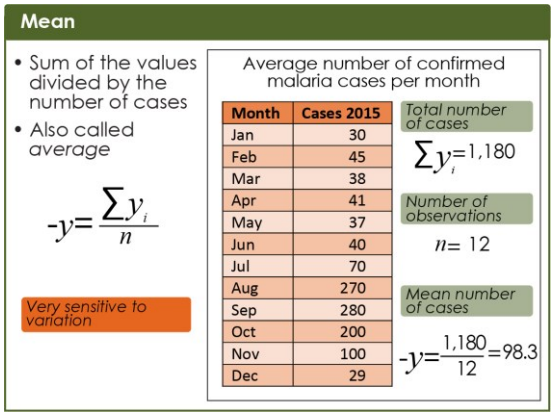
Common Measurements in Malaria Data Analysis

Malaria data analysis uses some common measurements for routine data: central tendency, variation, and ratios.

Measures of central tendency are mean, median, and mode.

Mean is the most commonly used measure to show the central values in a data set. Mean is the center point in an observation cluster, taking into consideration the magnitude of every value, which makes it sensitive to extreme values. Mean is used when data are distributed symmetrically. If a data set contains some data with extreme values, extremely low or high compared to most other values in the data set, the mean may not be the most accurate method to assess the observation cluster point. Figure 47 shows an example of how mean is used.

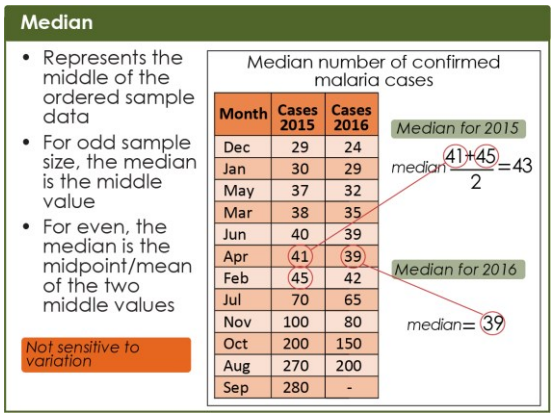
Figure 47. Uses of mean in data analyses



Median is the middle value in a data set when data points are arranged from least to greatest value. Median is another measurement of central tendency, but with less sensitivity to extreme values than the mean because it considers the ordering and relative magnitude of the values. Median is used when data are skewed and not symmetric, and it does not show a trend in variation differences. In a list of values ranked from smallest to largest, half of the values are greater than or equal to the median and the other half are less than or equal to it. With an even number of values, the median is the average of the two mid-point values.

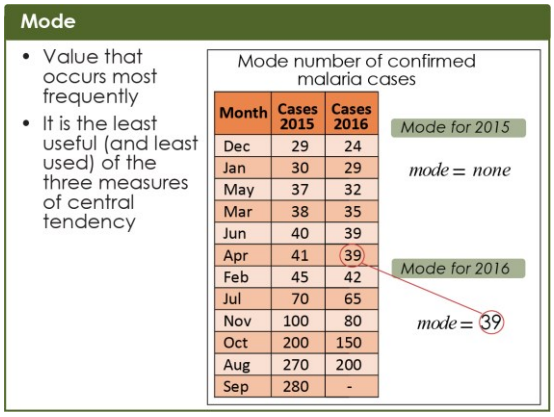
Figure 48 shows two lists of cases, 2015 and 2016. The 2015 list has an even number of cases, with the median calculated by adding the two mid-point values, 41 and 45, for a total of 86. That total is divided by 2, the number of values, to calculate the median, 43. The 2016 list has an odd number of cases, so the median is the middle value in the list. Before the median is calculated, the numbers in the list must be ranked in order.

Figure 48. Example of median calculation



Mode is the value in a list that occurs most frequently. If no values are repeated, there can be no mode. Mode is the least useful measure of central tendency, and therefore it is used the least. Figure 49 shows an example of mode calculated for the monthly cases of malaria in 2015 and 2016. Because 2015 does not have a repeated value, it has no mode. The mode in 2016 is 39 because that value is repeated.

Figure 49. Example of mode calculation



Measures of variance include range, variance, and standard deviation. **Range** is the difference between the highest and lowest values in the distribution. **Variance s^2** is the sum of the squared deviations from the mean divided by the number of observations minus 1. **Standard deviation** is calculated as the square root of the variance. Figure 50 shows an example calculation for variance and standard deviation.

Figure 50. Calculation of variance and standard deviation

$$s^2 = \frac{\sum (y_i - \bar{y})^2}{n-1}$$

Ratios are a form of comparison between two numbers, typically as percentages, proportions, and rates. Ratios are expressed as "a to b," "a" per "b," and "a:b."

Percentage is a proportion of the nominator, or part of the whole, multiplied by the denominator, or 100, used to compare data across facilities, regions, and countries. For example, if a clinic has 12 female clients and 8 male clients, which are the numerators, the denominator is 20, the total number of clients. The proportion of male clients is eight-twentieths or two-fifths. To state this as a percentage, convert the fraction to a decimal, 0.4, and then multiply by 100, which equals 40 percent. In this example, the denominator includes all clients, both male and female. It is important to distinguish the nature of the denominator, and state the distinction to avoid wrong assumptions. In this example, the definition needs to answer these questions: What is the whole? Does this mean all clients or just certain clients, such as all pregnant clients or all clients with a fever?

Proportion is a ratio in which all individuals in the numerator are not necessarily included in the denominator. For example, three staff members per clinic is a ratio expressed numerically as 3:1. It is not the same as saying 1 to 3 or 1:3. The order of the numbers matters. Continuing the example of the clinic with 12 female clients and 8 male clients, the denominator is total clients, 20, and the ratio of male clients is 8 to 20, or 8:20. The ratio of the number of clients at the clinic is 20 to 1, or 20:1.

Rate in public health is a measure of the number of cases that occur in a given period, divided by the population at risk during that time period. The comparison is often expressed as the number of occurrences per 1,000, 10,000 or 100,000 population. Rate is a probability statement, most often used in public health to describe infrequently occurring events, such as maternal mortality, because it is easier to express "8 per 100,000" rather than ".00008 percent." The under-five mortality rate is the probability, expressed as a rate per 1,000 live births, of a child born in a specified year dying before reaching age five at the current age-specific mortality rates.

Annual parasite incidence is a rate often used in the analysis of malaria data to describe the number of microscopically confirmed malaria cases detected during one year per unit population. It is calculated by dividing the confirmed number of malaria cases that occurred in one year by the total number of people under surveillance, which can be the entire population at risk or the number of people in the program area.

11.4 Summary

Data quality affects every part of an NMP. It influences the effectiveness of the data management system and the confidence that stakeholders have in the program.

Strategies to strengthen and improve data quality are essential for a successful NMP. Ensuring good data quality includes taking the following seven dimensions into consideration: completeness, confidentiality, integrity, precision, reliability, timeliness, and validity.

Data collection, consistency, reliability, and validity are especially important in public health. Consistent, quality-controlled procedures and tools enable the data management system to produce repeatable results. Methodologies that consider the particular situation and a thorough knowledge of the population ensure an accurate sample of the population.

Documented procedures and definitions need to be in place before data collection begins to ensure consistent data collection, maintenance, analysis, processing, and reporting across time, personnel, reporting schedules, and analytical methods.

Quality assurance controls help ensure that data are reliable, free of significant error and bias, and available for periodic review. DQAs and routine random checks between entered data and source data can reveal gaps in procedures and errors made during data collection and transcription. A DQA examines four aspects of the data collection process: (1) design, (2) organizational structure, (3) implementation practices, and (4) follow-up verification of reported data. A DQA asks these questions: Are systems and practices in place to collect, aggregate, and analyze the appropriate information? Are these systems and practices being followed? Are reported data for key indicators being verified? Are spot-checks conducted to find nonsampling errors?

Data management encompasses the full spectrum of activities involved in handling data—collection, entry, storage, synthesis, cleaning, quality check, analysis, interpretation, and dissemination. It also includes policy development, data ownership and custodianship, documentation, metadata compilation, maintenance, standardization, harmonization, audit, security, and access. Data management is an important component in SME, and it requires constant attention and diligence

Data analysis turns raw data—a mass of numbers—into useful information. It covers organization and prepares information for comparison of targets or theories with achievements and performance. The terms "data" and "information" are not interchangeable. Data refer to raw, unprocessed numbers, measurements, or text. Information refers to data after they are processed, organized, structured, or presented in a specific context.

12 Chapter 12. Data Presentation, Interpretation, and Use

Data presentation, interpretation, and use are integral parts of malaria SME. Findings, when disseminated, provide information to partners, government, stakeholders, and counterparts on program achievements and trends in healthcare. Providing information informs policy development, promotes successful concepts and processes, elicits feedback, and validates local findings with broader trends.

The way this information is shared is essential. Choosing the best approach to present data, interpret them correctly, and disseminate them clearly will drive data use for NMPs. This chapter summarizes effective ways to present SME results to encourage data use.

12.1 Effective Information Presentation

Data users influence how SME information is presented, but all the methods for publishing information have a common challenge—match the message delivery to the needs of the audience.

Methods for presenting SME information

- Academic journals
- Briefings
- Broadcast and print media
- Conferences
- Formal reports
- Magazines and newsletters
- Posters
- Social media and blogs
- Videotapes and podcasts

The audience and the type of information determine the delivery format. The scientific and research communities want statistics and analytic details, which are best delivered as a written report. A formal report can run up to 100 pages and include detailed tables and charts. Policymakers and funding partners want direct, concise summaries, delivered as a PowerPoint presentation with bulleted lists.

The following sections describe some of the more effective ways to present malaria SME findings.

Written Report or Slide Deck?

Most SME results are disseminated as either a written report or a slide deck. Formal SME written reports usually follow a content order: introduction, background, methods, findings, conclusions, recommendations, and appendices. The introduction describes the SME program and the condition it seeks to improve. The background describes when and where data were collected and puts the program in perspective with the national malaria burden. The methods section explains key indicators used to measure performance, how data were collected, and how the findings were calculated. The conclusion interprets the analyses and findings and relates the results to a national malaria strategy or malaria control effort. The recommendations, based on the interpretation, suggest actions to mitigate risks or extend activities according to program goals and objectives.

The purpose of a slide deck presentation is to provide a simple structure for sharing information. Slides have fewer details than formal written reports, and they usually last no more than 15 to 20 minutes and cover three main findings. In no more than 20 slides, or about one slide per minute, a presentation includes only key points, following the KISS rule: *Keep It Short and Simple*, and the 6 x 6 rule: *six words per line, six lines per slide.* A slide at the beginning of the presentation states the objective, outlines the presentation contents, and provides clear explanations of all technical terms and abbreviations. The writing leaves out extra words, uses simple phrases in the active voice, and delivers the important points. Slides need type large enough for the audience

to see, 32 to 44 points for titles and nothing smaller than 28 points for text and bullet points. The presentation should have a consistent look throughout, using the same font, color, and capitalization format.

Basic Presentation Graphics

Detailed tables and graphics are best used in written reports for academic interest, and lengthy tables should be included as appendices. PowerPoint charts, graphs, and maps are snapshot summaries used to condense information and show trends; these visual tools need to be simple and easily read from a distance. Other graphics, such as photos and text boxes, can add interest and a human element, but these graphic techniques should be used sparingly, or they lose their effectiveness. Following are descriptions of graphic elements to provide guidance on choosing the best way to illustrate different kinds of malaria SME information.

Tips on creating presentation graphics

- Text should be readable, in a simple *sans serif* font no smaller than 28 points.
- Use a simple format and consistent color scheme. Use a light background with dark text.
- Beware of animations and special effects. Use them sparingly. They can be distracting at best and non-functioning at worst.
- Keep text short and simple, leave out extra words. Limit to 20 slides, six lines each, and about six words per line.
- Choose graphics as illustrations. Match graphics to the audience's capability to understand the information.
- Slides are visual cues to the oral presentation.

Visual Impact with Data Summaries

Tables, charts, and graphs have specific uses, such as bar charts, histograms, line graphs, and pie charts.

Charts and Graphs

Bar charts are best for comparing means or percentages of different groups. They should be used for comparing categories that are mutually exclusive only. In malaria SME, bar charts are often used to compare countries, diseases, or interventions. Bar charts compare data across categories of variables, such as fever, cough, and diarrhea, or durations, such as per week, per month, and per year. The columns can be arranged alphabetically, numerically, or the order in which the data were received. A bar chart has no high end or low end, and the order of the columns does not change the results. Most bar charts show vertical bars, but they can also be horizontal. Figure 51 provides an example of malaria data represented in a horizontal bar chart, and Figure 52 provides an example of malaria data represented in a vertical bar chart.

Figure 51. Horizontal bar chart for malaria SME data

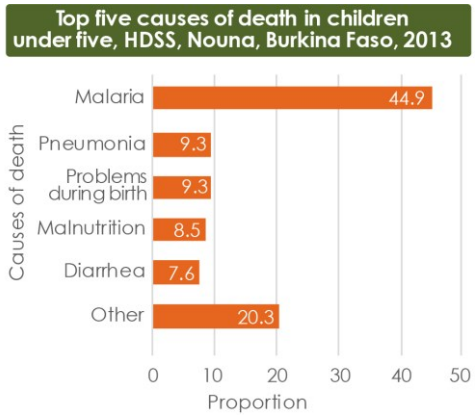


Figure 52. Vertical bar chart for malaria SME data

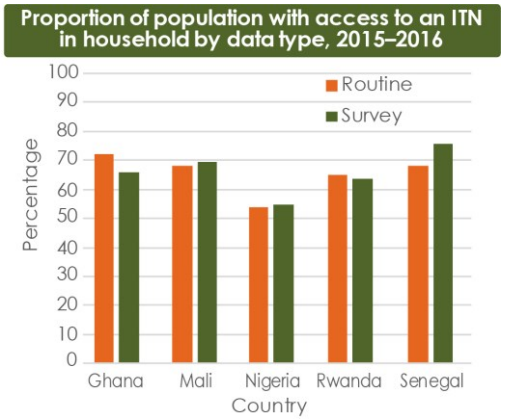
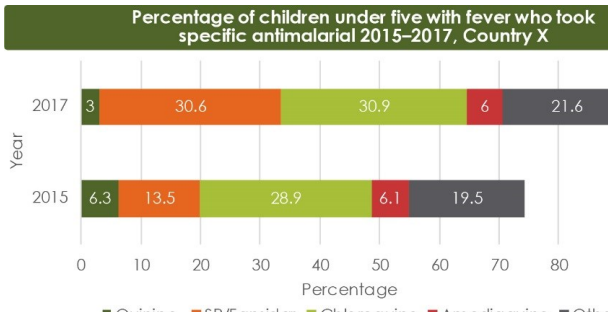


Figure 51 compares the top five causes of death in children under five in an HDSS in Nouna, Burkina Faso. This horizontal bar chart shows that almost half of the childhood deaths (44.9%) are caused from malaria in this region.

Figure 52 compares ITN access using routine and survey data in five SSA countries in 2015 and 2016. Details on these data sources are described in Chapter 8.

A bar chart has no high end or low end, and the order of the columns does not change the results. A stacked bar chart (Figure 53) is often used to compare multiple values to represent durations or portions of an incomplete whole, such as the type of antimalarial medication taken by children with fever in 2017 compared to 2015. This example shows two types of information. First, there was an increase in antimalarial use in 2017 in children under five in Country X compared to 2015. Second, the type of antimalarial used is shown, presenting a slightly increased use of chloroquine and other and a twofold increase in SP/Fansidar.

Figure 53. Stacked bar chart for malaria SME data



Histograms show the distribution of a sample within one dimension. Histograms are ideal for illustrating sample distributions on dimensions measured with discrete intervals. Unlike horizontal and vertical bar charts, the x-axis is not divided into mutually exclusive categories. In malaria SME, histograms (Figure 54) are used to represent the relative frequency of continuous data, similar to relative frequency tables. Histograms may look similar to bar charts—both have columns and are plotted on a graph—but their purposes are different. A histogram shows the quantitative distribution of numerical data in one group, such as age, height, or weight. It is an estimate of the probability distribution of the number of data points in a range of values. These groupings are sometimes called bins. The bin label can be a single value (6 months, 1 year, 5 years) or a range of values (0–6 months, 6–18 months, 2–5 years). The bars in a histogram touch, and the order of the information is important because the data elements are grouped numbers that form a continuous range from left to right, low to high.

Figure 54. Histogram for malaria SME data

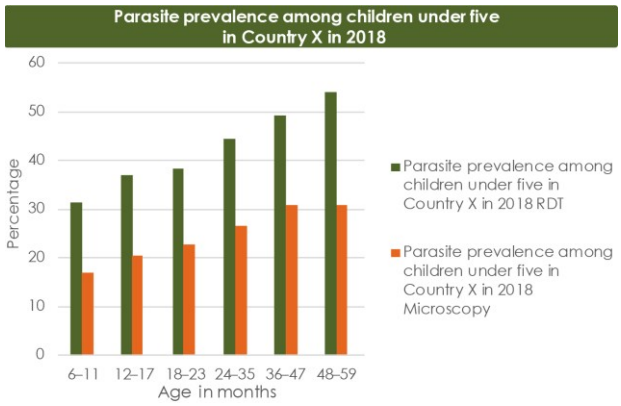
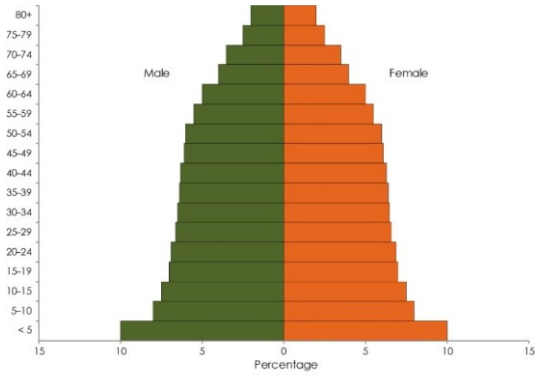


Figure 54 shows the parasite prevalence among children under five in Country X during 2018. The graph shows that RDTs are twice as likely to be used to diagnose malaria in Country X as microscopy, regardless of the child's age.

Population pyramids (Figure 55), a type of histogram, are used to illustrate descriptive population data. Two histograms side-by-side illustrate a population distribution by gender and age for a geographic area, typically a country. For example, a population pyramid might show males on the left and females on the right, and the bins might be five-year age categories. Population pyramids can hint at population growth patterns, such as the number of women of reproductive age used to predict increased birth rates or the number of elderly men to reflect the results of a traumatic disaster, such as a war.

Figure 55. Population pyramid for Country X, 2018



Line graphs are best for illustrating trends over time and are particularly useful when there are many data points. In malaria SME, line graphs often show malaria data points over the course of time.

Figure 56 provides a glance at Uganda's NMP from 2000 to 2011, showing when certain interventions (ITN, IPTp) began and how mortality and anemia in children were affected.

Pie charts are used to show proportional shares in a whole, usually as percentages. A pie chart (Figure 57) displays the contribution of each value to a total, such as one quarter out of an entire year. The values of the slices always add up to 100. All values should be labeled, either as a number or a percentage, and identified on the chart, and *n*, the number of cases, should be included to provide context. Limit pie charts to four or six segments; the smallest segments can be grouped under "other" to make the graphic simpler. The color scheme should be distinctive but not jarring, with only enough contrast to make the slices distinguishable, and the color scheme should match the overall presentation theme.

Figure 57 shows a pie chart representing the percentage of malaria cases in Region A by district. The chart shows that District 4 has the most cases (43%), and District 1 has the fewest cases (9%).

Figure 56. Line graph showing results from PMI's impact evaluation of NMPs in Uganda

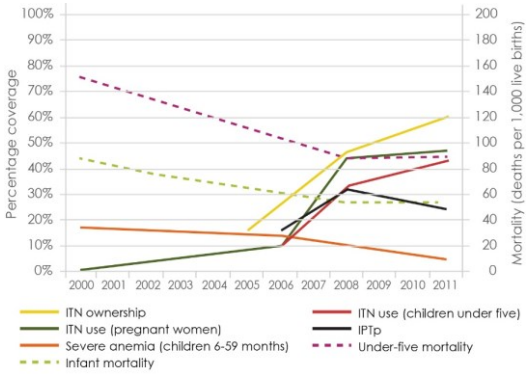
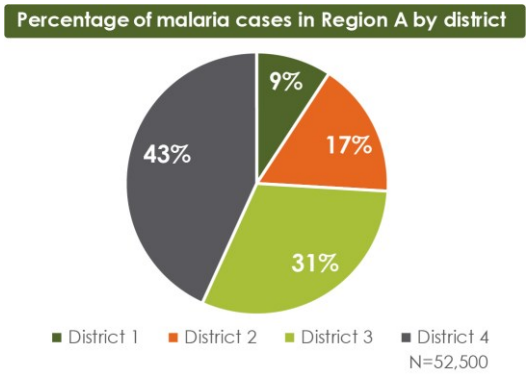


Figure 57. Pie chart for malaria SME data



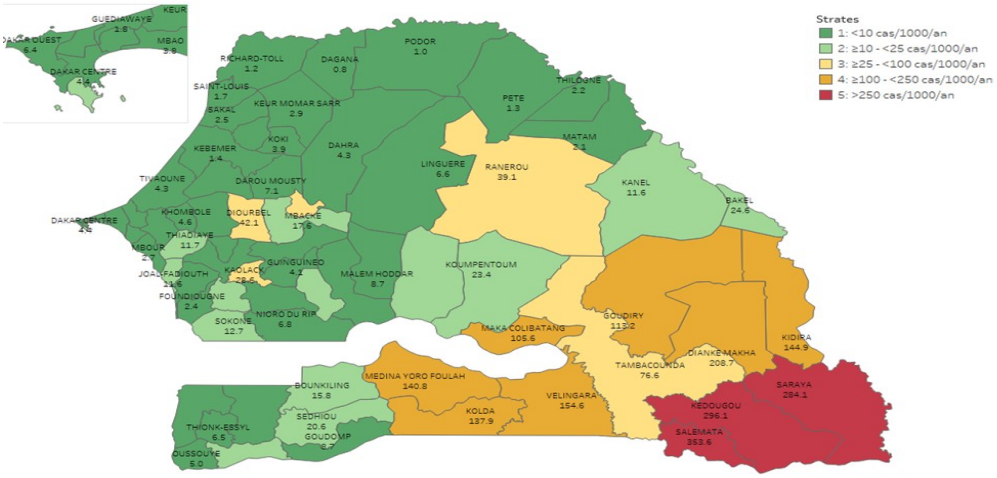
Tips on creating charts and graphs

- Label x- and y-axes on graphs and state measurements, such as months and years, percentages, or numbers in hundreds, thousands, or millions.
- Use a maximum of three to four lines in line charts. Make the trend lines thick enough to be easily visible. Remove superfluous gridlines to avoid distractions and clutter.
- Use a figure note to spell out abbreviations.
- Use a figure note below the graph to cite the data source and date that data were collected or accessed.
- Use the figure caption for a brief descriptive title and do not embed the title in the graphic. If more detail is needed, put it in a figure note below the graph.
- Use two-dimensional graphs to avoid distortion.
- Place a legend to the side or below the graph.

Maps

Maps are particularly persuasive and easy to understand. They quickly show comparisons by political or geographic boundaries or by thematic data classification on specific variables, such as a wealth quintiles, population density, fertility rate, and voter registration. They are more compelling than words because they clearly present geographic differences. In smaller surveillance settings, maps can show trends, such as malaria incidence stratified by district in Senegal in 2016 (Figure 58) or detection of drug-resistant parasites. With user-friendly computer programs and applications that do not require special data or systems, it is relatively simple to create maps for spatial interpretations and visualization of distribution comparisons.

Figure 58. Malaria incidence stratified by district in Senegal, 2016



Source: Senegal National Malaria Control Program

Tables

Tables lack visual appeal, but they are useful for summarizing information and showing side-by-side comparisons over a time range or among variables. Two types of tables are used frequently to summarize SME information: frequency distribution tables and relative frequency tables.

Frequency distribution tables show the number of times specific types of data occur for a whole category; they are a tally of the frequency that the parts occur in the whole. For example, Table 10 shows a frequency distribution table with the number of malaria cases confirmed with a blood test in Burkina Faso between 2011 and 2017. Note that a footnote defines a confirmed blood test to include RDTs and microscopy. The data source is the World Malaria Report, 2018.

Table 10. Frequency distribution table for malaria cases confirmed by a blood test in Burkina Faso, 2010–2016

Year	Number of malaria cases confirmed by blood test* in Burkina Faso
2011	428,113
2012	3,858,046
2013	3,769,051
2014	5,428,655
2015	7,015,446
2016	9,779,154
2017	10,225,459

*Blood test by rapid diagnostic test or microscopy to confirm presence of malaria parasite

Source: World Malaria Report, 2018

Relative frequency tables show a percentage of a part of the whole. Table 11 is an example of a relative frequency table that shows the number of confirmed cases of malaria in Burkina Faso from 2011 to 2017 and the percentage of these confirmed cases each year. It is computed by dividing the number of values in an interval (1 year) by the total number of values in the table (X number of cases), and then multiplying by 100. Relative frequency is one way to show trends in program efforts.

Table 11. Relative frequency table of malaria cases confirmed by blood test in Burkina Faso and the percentage of confirmed cases by year

Year	Number malaria cases confirmed by blood test* in Burkina Faso (n)	Relative frequency (%)
2011	428,113	1.1
2012	3,858,046	9.5
2013	3,769,051	9.3
2014	5,428,655	13.4
2015	7,015,446	17.3
2016	9,779,154	24.1
2017	10,225,459	25.2
TOTAL	40,503,924	100.0

*Blood test by rapid diagnostic test or microscopy to confirm presence of malaria parasite

Source: World Malaria Report, 2018

Caution is needed when using frequency tables to show trends because the numbers in the table may not tell the complete story. Using the same example above, it looks like testing rates are improving in Burkina Faso each year, which may be a sign of an improved malaria surveillance system. The table does not show the presumed or suspected cases compared to the confirmed cases, nor does it provide program targets, so more information is needed. It is likely that more cases of malaria occurred in 2011, but they were not reported. In any case, this relative frequency table shows a trend in the right direction for Burkina Faso.

Tips on creating tables

- Use a table note below the table to spell out all abbreviations used.
- Use a table note to cite the source and date that data were collected or accessed.
- Keep tables to no more than five columns and six rows. Use additional tables on the next slide if more columns or rows are needed. Remember, a slide is a visual cue; it is not intended to present the detailed information.
- Avoid running tables into slide border areas; maintain enough white space for easy reading.
- Use the table caption for the table title. Do not include the title in the body of the table. Avoid long table titles; use a table note if further explanation is necessary.
- Use a table if exact numbers are necessary; use a graph or chart to convey an idea of perspective in context. For example, how big is this problem compared to other countries or how much of the budget is represented by this program?

12.2 Data Interpretation

First, it is important to distinguish between "data" and "information." Data means the values of the units being studied. Information results after the data are analyzed and put into context of the study. The terms "analysis" and "interpretation" have different meanings. Analysis, which varies in complexity, summarizes data and converts them to useful information to guide decisions. Interpretation adds meaning to the information by making connections and comparisons.

Data interpretation answers these questions:

- Does the indicator meet the target?
- What is the programmatic relevance of the finding?
- What are the potential reasons for the finding?
- How do the results compare to other programs, groups, or trends?
- Should other data be reviewed (triangulated) to understand the finding?
- Is further analysis needed?

As discussed in Chapter 11, data analysis uses mathematical and statistical calculations to summarize values into numbers and percentages. Interpretation applies the analysis results to link indicators with program activities and indicator results with progress toward program goals and objectives. For example, a policymaker who is not familiar with malaria may have trouble making sense of data that show that the parasite prevalence rate in Zambia is 10.2 percent. This number is more meaningful in a larger context that shows how the rate has changed over time or whether it is higher or lower than neighboring countries. Linking a finding to a specific indicator, program, or policy also makes survey results applicable and relevant.

Following is an example that shows how a district malaria SME officer can use data in the national RHIS to see whether facilities in the district are meeting their coverage target, which is for 80 percent of women to receive IPTp.

The first step is to choose the data needed from standard ANC registers, shown in Table 12.

Table 12. Categories of data available in ANC registers

Code	Variable
1.	New ANC clients
2.	Group pretest counseled
3.	Individual pretest counseled
4.	Accepted HIV test
5A.	HIV test result—Positive
5B.	HIV test result—Negative
5C.	HIV test result—Indeterminate
6A.	Posttest counseled—Positive
6B.	Posttest counseled—Negative
8A.	ARV therapy received—Current NVP
9.	IPTp-2
10.	IPTp-3

The district malaria SME officer chooses three categories: Code 1, new ANC clients, which refers to the number of pregnant women who have come to the clinic for the first time for ANC; Code 9, IPTp-2, which refers to the number of pregnant women who have received two doses of SP; and Code 10, which refers to the number of pregnant women who have received three doses of SP (Table 13).

Table 13. ANC register information on the number of clients receiving IPTp

Number of ANC clients receiving IPTp

Code	Variable	Facility 1	Facility 2	Facility 3	Facility 4	Facility 5
1.	New ANC clients	744	2,708	105	1,077	908
9.	IPTp-2	536	1,435	39	969	862
10.	IPTp-3	372	542	38	452	780

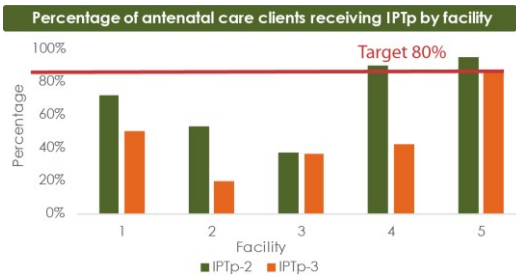
After analyzing the data (Table 14), the district malaria SME officer can see that Facility 5 is providing the best IPTp coverage for pregnant women, at 95 percent for IPTp-2 and 86 percent for IPTp-3, both of which exceed the national targets of 80 percent. This is calculated by dividing the number of ANC clients who received IPTp-2 (n=862) at Facility 5 by the total new ANC clients at Facility 5 (n=908): 862/908=95 percent.

Table 14. ANC information on the percentage of clients receiving IPTp

Indicator	Facility 1	Facility 2	Facility 3	Facility 4	Facility 5
Percentage of new ANC clients who received IPTp-2 in the past year	72%	53%	37%	90%	**95%**
Percentage of new ANC clients who received IPTp-3 in the past year	50%	20%	36%	42%	**86%**

The district malaria SME officer also wants to know about the other four health facilities. Are any other facilities meeting the target of 80 percent? In Figure 59, the bar chart shows that Facility 4 has met the target for IPTp-2 but needs to improve efforts for IPTp-3. Only Facility 5 has met the target of 80 percent for both IPTp-2 and IPTp-3.

Figure 59. Percentage of ANC clients receiving IPTp by facility



Next, the district malaria SME officer wants to know why the other facilities are below the target. The answers can suggest ways the facilities can improve their IPTp coverage by adopting strategies from Facilities 4 and 5. The district malaria SME officer may also ask which facility is performing better or worse than expected, and what the trend over time is for these facilities.

12.3 Data Dissemination and Tracking Information Use

The purpose of gathering data is for use in guiding policy and program decisions. Program activity data add perspective to the delivery of healthcare services, so can prompt actions to improve health outcomes. Getting the right information to the people who need it, when they need it, in the format they can use requires tailoring the information to the audience. A plan for effective dissemination takes into account audience needs, delivery methods, available resources, and goals.

Dissemination Plan Components

A dissemination plan considers the following: audience, information content, delivery medium, timing and resources, and feedback method.

Print materials are the most common way to disseminate the results of a large evaluation. Detailed tables and graphics convey extensive information, with descriptive text to explain the methodology used. Dissemination, however, needs to go beyond the limited audience that receives the detailed printed reports. To reach staff, program decision makers, national and subnational administrative levels, stakeholders, and funding partners, the information needs to be presented in several ways. The more ways the information is made available, the more likely it is to be used.

Dissemination materials beyond formal printed reports are most useful if they summarize major points of interest to the audience, highlight key ideas and conclusions, and make recommendations. It is tempting to present all the findings from a study but doing so may bury the core message and overload the audience with information. The delivery should make a distinction between "findings," which are objective scientific results, and "messages," which interpret the findings and provide commentary that puts the information into context. Slide presentations are more effective if they present less information and are focused on three to five points.

Matching the media to the audience increases the chances that the information will be used. Policymakers do not have time to read long documents, and appropriate formats for this audience are short summaries in a PowerPoint presentation or a policy brief that frames the data for policymaking. As online technologies become more widely available in SSA, new ways are emerging to disseminate information electronically.

Blogs, newsletters, podcasts, and social media can spread information and evoke feedback. Translating materials into local languages reaches additional audiences, improves comprehension, and demonstrates respect for the culture.

A plan for dissemination should be developed at the same time data collection is being planned. A dissemination planning matrix can help organize the goals and tasks (Figure 60). Dissemination should not be an afterthought.

Figure 60. Example of a dissemination planning matrix

Activity	Target audience	Tools	Person responsible	Timing
Present results to community members	Community members	Oral presentation with interactive exercises	Alice	June 2018
Present results at partner meetings	Partner organizations	PowerPoint presentation, full report (printed, electronic)	Jane	September 2018
Present results at health conferences	Scientific community	Poster	John	November 2018
Publish results in peer-reviewed journals	Scientific community	Article	John	December 2018
Alert media about the above activities	General population	Interview news segment	Alice	December 2018

A dissemination plan has the following components:

Program overview: Summarize program goals, objectives, and activities, and the reason for the current evaluation.

Dissemination goals: Develop short- and long-term goals that include effecting national and subnational policy changes, sharing best practices and lessons learned, influencing culture changes, or reaching facility and community staff for improved healthcare outcomes.

Target audiences: Include potential data users, stakeholders, national and district decision makers, funding partners, and health facility staff. Identify audiences by consulting credible sources and involving stakeholders. Make priority lists for timing and key messages.

Key messages: Tailor the message to match the needs of the target audience.

Delivery medium: Tailor the delivery format to the target audience—written report, slide presentation, in-service workshop, community meeting, or social media. Tailor the information level to fit users' needs and understanding.

Dissemination activities, tools, and responsibilities: Organize activities and timing to reach as many outlets as possible, including face-to-face meetings and briefings. Assign responsibilities for tasks and activities and set timelines.

Timing and budget: Assess data users' needs for timing and the resources available for dissemination activities. Both time and budget are frequently underestimated. Prepare plans for travel, design and printing, translation, presentation equipment, and space rental. Allow time for document editing and design, presentation rehearsal, and social media preparation.

Evaluation: Review dissemination efforts using measurable criteria for activities.

To ensure that the results are understood and the information is used, dissemination should be combined with capacity building by helping users understand the context and terminology used. Teach users to read tables and charts and demonstrate ways to use data for decision making.

Dissemination Concerns

Several challenges can hamper the dissemination of evaluation results: data literacy of the audience, data delivery to the right audience, and timing.

Data literacy is the ability to understand complex statistical methods and ramifications of interpretation. Low data literacy can make it difficult to match materials to audience capabilities. Targeting audiences with the right level of data literacy or investing in training can increase data use.

Data delivery tailored to who needs the information, how much, and how much detail requires a knowledge of potential data users. District and local managers who can use the information to improve programs and data quality are often overlooked. Seeing results and hearing recommendations can underscore why data are collected.

Timing dissemination to meet users' needs can be difficult because of the time required to compile and analyze study results. Dissemination events should precede the national planning cycle. This puts the information in the hands of decision makers as they set program priorities. Extending dissemination can be challenging, but it is important to keep the information visible to promote its continued use.

Data Use Tracking and Mapping

Data use can be tracked several ways. The flowchart in Figure 61 illustrates an ideal two-way data use path from service delivery points to higher-level program supervisors and stakeholders. In reality, the flow often breaks down, and local service providers fail to receive feedback that can be used for improvements.

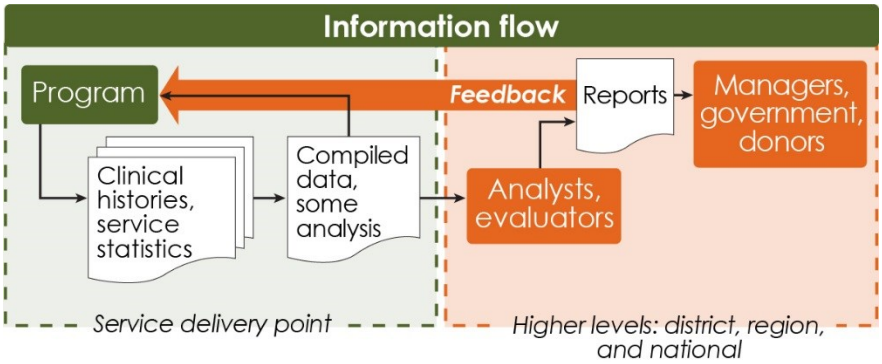
Data use questions

- Are facilities or districts using the data to assess their coverage targets?
- Are interventions being developed to address problem areas identified by service statistics?
- Are the interventions improving program service statistics?
- Are decision makers using the information to reach targeted populations?

Tracking information use is neither easy nor cheap. Data pass through many levels, sometimes simultaneously (Figure 61). Here is the typical path: (1) Healthcare delivery points generate data taken from individual client clinical histories and service records. (2) Program managers receive the compiled local-level data and transmit them to regional directors and higher administrative levels. (3) Analysts at the higher levels prepare reports for programs that generated the data.

(4) Facilities use the information to compare with previous performance and other facilities. (5) Higher administrative levels give service providers feedback for program improvements.

Figure 61. Data flow chart—the ideal



An information use map illustrates roles in the HIS (see the MEASURE Evaluation information use map tool at https://www.measureevaluation.org/resources/publications/ms-11-46-c for more details). These maps can be international, regional, national, or local to define data flow for indicator data, identify challenges, and illustrate relationships among SME processes. Vast amounts of money and effort are devoted to collecting and reporting data and storing them in health system databases to maximize the knowledge gained through healthcare initiatives. Unfortunately, the data flow path often breaks down when providing feedback and sharing lessons learned and insights.

For example, to illustrate the breakdown of data flow in Country X, local health facilities reported on the number of people tested for malaria, and labs reported the test results. A local health information unit statistician aggregated the data and sent a quarterly report to the ministry of health, which in turn sent a quarterly report to the national epidemiology center and an annual report to the prime minister. Unfortunately, local facilities never saw these reports, and they could not compare their performance to other facilities or see their efforts compared to national trends and goals. They had no way to know they were not on track, and therefore they did not make an effort to improve results. After national-level feedback, these information gaps quickly became apparent when local processes were visualized in an information use map, which showed that data were reported but not used for local improvements. The mapping showed where information could be shared. As a result, local facilities made mid-course improvements and increased malaria testing.

12.4 Summary

The effective presentation of data has several elements. First, know the audience. Second, prepare presentations using appropriate media. Slide presentations provide visual cues to the information delivered orally. Slide presentations should maintain a consistent format and limit the number of elements on a page and their complexity.

Graphics should put information into visual context with the main presentation message and match the capability of the audience to understand the information. Charts, graphs, and tables need to be simple, and all graphic components should be labeled.

Data are numbers. Analysis is the process of summarizing data and converting them to information. Information is an interpretation of the analysis. Interpretation applies the information to a particular program or situation.

A dissemination plan considers the audience, information content, delivery medium, timing and resources, and feedback method.

13 Chapter 13. Malaria SME Ethics

As good malaria SME practices improve HIS, the role that ethics play in data collection, processing, and dissemination becomes ever more vital. Applying solid ethics principles to the process is not only good research practice, but it also protects data, patients, program managers, researchers, and survey participants. As more data become electronic, efforts to instill ethics must bring together expertise in legal and ethical norms, information systems security, data management, healthcare delivery, and community contexts. The ability to collect and analyze healthcare data electronically comes with an equally enormous challenge—to do it ethically.

Even defining ethics is challenging. In its application to malaria SME, rational ethics is the difference in the *ability* to do something and the *right* to do something. It is a dichotomy: "Just because we *can* doesn't mean we *should*." Ethics are not laws or hard, fast rules; ethics standards govern making priority choices and considering the consequences and beneficial justification.

This chapter defines ethics, applies research ethics principles to malaria SME, and discusses how ethics are applied to digital health information today.

13.1 Ethics Defined

For this discussion of data collection, management, and use in malaria SME, ethics can be defined as the moral principles that govern choices and behavior while conducting a program activity or research. It is an interdisciplinary understanding of the ethical considerations involved in collecting, linking, transmitting, sharing, storing, processing, analyzing, and using hardcopy and electronic health data. Professionals working in malaria SME must apply ethical considerations to HIS to ensure patient confidentiality, protect individuals from harm, provide choices, and offer transparency on how data are obtained, processed, used, and shared (Bryman, 2012). Implementing ethical principles early in HIS can help countries harness the power of electronic data for the good of the population and minimize potential harm.

The consideration of ethics in healthcare has a long history, but examples in this century have codified some of the principles. Long before electronic data for healthcare came into existence, the world became aware of the horrors that resulted from unethical health research, and several prominent documents emerged to give guidance, notably the Nuremberg Code of Medical Ethics (1945), the Declaration of Helsinki (1964, revised seven times, most recently in 2013), and the Belmont Report (1978) (The Nuremberg Code, 1947; World Medical Association, 2013; National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1978).

Two of the most notable examples of unethical health research were (1) the Nazi medical experiments, 1933–1945, in which inmates in concentration camps were forced to participate, without consent or knowledge of the consequences, in various experiments to help the German military; and (2) the Tuskegee syphilis study, 1932–1972, in which 600 African-American men in Alabama (399 with syphilis, 201 uninfected) were enrolled in a study but not informed about the correct duration of the study or the consequences. Participants were told the study would last six months, but it lasted 40 years. Infected participants were not informed about their status nor treated with penicillin (United States Holocaust Memorial Museum, n.d.; CDC, n.d.b).

13.2 Principles of Research Ethics

Research ethics are built on four foundational principles: autonomy, nonmaleficence, beneficence, and justice. The following sections discuss how these principles affect malaria program activities (Thomas, Sage, Dillenberg, & Guillory, 2002).

Principles of healthcare systems ethics

Autonomy—Respect all people and treat them with courtesy. Seek informed consent. Provide full and truthful information about the program. Provide an opportunity for the individual to choose to participate, free of coercion and undue influence.

Non-maleficence—Do no harm. Assess the risks for participants and malaria SME program benefits. Protect privacy and provide data security. Report results truthfully and completely, without plagiarism or errors.

Beneficence—Act for the benefit of others. Evaluate the worth of the program evaluation compared to the welfare of participants.

Justice—Ensure that all procedures are reasonable and well-considered, non-exploitative, and administered fairly. Select participants fairly without exploiting them.

Applying Ethics Principles

Informed Consent

The consent process has three elements: information, comprehension, and voluntariness. Informed consent requires that program participants be given truthful and complete information about the research and opportunities to ask questions and choose whether to participate. The standards for informed consent should be established ahead of time and explained to the participant. Consent information generally includes research procedures, purpose, potential risks and benefits, treatment and alternative procedures, and a statement offering the subject an opportunity to ask questions and the option to withdraw at any time. Additional information sometimes includes how subjects are selected and the identity of the organization or researcher (Bryman, 2012; Saunders, Lewis, & Thornhill, 2012).

The participant's comprehension depends on the way information is conveyed. For example, information that is presented too fast and in a disorganized way gives the participant too little time to consider it and ask questions, which adversely affects the individual's ability to make an informed choice. Language and literacy must also be considered. Consent forms must be in a language that the participant understands, and a translator must clearly explain the study objectives and expectations, so that the participant fully understands.

Voluntariness requires that the participant be given an opportunity, without influence or coercion, to decline to participate or to withdraw later. Coercion is an overt threat of harm to obtain compliance. Undue influence occurs if an excessive reward is offered, inappropriate, or unwarranted. Inducements such as monetary or food incentives that ordinarily would be acceptable may be considered undue influences if the participant is especially vulnerable.

Assessment of Risks and Benefits

An assessment of risks and benefits relates to the principle of beneficence. All aspects of research must be justified based on a favorable risk-to-benefit assessment. Risks and benefits must be communicated to all researchers and research participants. If risks are foreseen in the research study, alternative ways to obtain benefits should be systematically considered if necessary.

Ethical Selection of Participants

Justice in participant selection requires fairness. Potentially beneficial treatment should be offered to all participants equally, without regard to social status or conditions. Social justice requires distinguishing candidate participants that should or should not participate based on appropriateness and the ability to bear the burdens imposed by the research. For example, social justice can be imposing an order of selection preference, such as adults before children, or an exclusion, such as institutionalized, mentally infirm individuals or prisoners.

Ethical Writing for Malaria SME

Writing to present malaria SME results also requires an ethical approach. The writing should observe the laws and regulations on copyright and ownership, and guard the confidentiality of individuals. It should respect individuals and their cultural variations and diversity. The writing should protect and promote the public good through impartial evaluation, seek truth, and communicate findings accurately. The writing should be based on an evaluation of NMP activities through rigorous assessments that ensure accuracy and quality. These cautions are possible with good data system management, storage, and retention.

Ethical writing also requires authors to know the harm and consequences that result from fabrication, falsification, and plagiarism. The Office of Research Integrity in the U.S. Department of Health and Human Services (n.d.) defines these terms as:

"Fabrication is making up data or results and recording or reporting them." This could be making up fake data, manipulating research methods, or changing results to benefit the researcher or project.

"Falsification is manipulating research materials, equipment, or processes, or changing or omitting data or results such that the research is not accurately represented in the research records."

"Plagiarism is the appropriation of another person's ideas, processes, results, or words without giving appropriate credit."

Research writers can avoid plagiarism by using direct quotes in quotation marks or summarizing the idea in a paraphrase. A citation is used to indicate a source after a quotation or paraphrased summary of the idea. A reference is the information that guides a reader to the source, usually in a reference list or footnote.

Researchers should avoid sneaky publication practices and withholding data and guard against poor data quality and data-gathering procedures.

Ethical Approval Process

Ethical review bodies are established to ensure moral responsibility. Determining whether ethics are being upheld in NMP evaluations is not solely the responsibility of review bodies; it is the responsibility of every member of the malaria SME unit.

Fundamental elements to consider in the ethical approval process:

- Scientific nature of the methods and how the study will be conducted
- Recruitment of participants
- Community considerations
- Care and protection of participants
- Informed consent
- Privacy issues

Institutional review boards (IRBs) provide program oversight. The IRB should provide an independent review of program protocols to prepare for a country's national review board. Review and approval of program protocols should be based on ethical principles. IRB members may need to take a course in research ethics that covers social and scientific value, scientific validity, fair selection of participants, procedures for informed consent, respect for program participants, good clinical and laboratory practices, and in-place efforts to minimize risks and maximize benefits. The purpose of an IRB is to protect the interests of every person and institution involved in the research.

Ethics review boards are usually composed of at least five people with a balance of scientific training, research expertise, and nonscientific qualifications. A diversity of gender, age, and ethnic and cultural backgrounds is preferred. External consultants with unique skillsets may be accessed when needed. For example, a digital health expert may be considered to review a study using digital tools.

The process for a large malaria SME program planned in multiple countries or across a large region may require more than one IRB approval. IRB approval is often required at the institution in which the study was conceptualized and then again in each country in which program activities will be implemented. This process takes time, which should be factored into the beginning of the program.

13.3 Ethics in Digital Health Information

Traditional healthcare in SSA is transitioning to technology-assisted service delivery, and digital data ethics are becoming increasingly important. Digital data ethics examine the relationship between three elements: public health ethics, information systems security, and clinical/research ethics (Wambugu, Thomas, Johnson, & Villella, 2017).

Figure 62. Interdisciplinary fields of electronic health data

Source: Wambugu, Thomas, Johnson, & Villella, 2017

Before digital health records debuted in the early 2000s, most records were on paper. Healthcare providers maintained patient files, information was recorded on paper registers, and forms were stored where space was available. The information was vulnerable; it could easily be lost or destroyed by the vagaries of nature and it was bulky to store. Purging outdated records was an

arduous task. Sharing health information was limited to how fast physical records could be transferred (Harman, Flite, & Bond, 2012). Transitioning record systems mixes digital and paper systems—filing cabinets and databases, paper forms and electronic tablets and phones, computers and servers.

The extra steps required for malaria control SME data transcription and data entry have introduced additional challenges. The areas of data ownership and sharing add a new layer of complexity. Information technology and legal systems are struggling to establish procedures that apply in a broader context.

No one doubts the benefits of information technology in malaria control SME, but many have well-founded ethical concerns about program development and activities in countries. Data ethics, including security and confidentiality, are difficult to safeguard because regulations are inadequate or nonexistent, financial resources are inadequate, and the capacity is severely limited to manage strong ethical practices. Data are vulnerable to loss or compromise from cyber criminals, and without adequate safeguards against tampering, patients' trust in the system could be eroded.

Transitioning to digital data information

MEASURE Evaluation studied mobile smart phone users in Kenya and Tanzania to study behavior among health workers in low- and middle-income countries that could affect data confidentiality, privacy, quality, and security (Wambugu & Villella, 2016). The results showed that preexisting public health ethics barely cover digital data, and users showed limited awareness of digital data ethics.

The study made it clear that data quality and security can be compromised by ethical gaps in technology, user behavior, and organizational setup. It found that digital data ground rules are under development, but they lack governance structures and standards or mature practices for handling personal and sensitive data. The study made numerous recommendations for setting up digital health data systems in developing countries.

International treaties and national laws on consent, privacy and confidentiality, ownership and authorship, data governance and custodianship, and data sharing are being developed, but the efforts are young and immature. One relevant tool is USAID's "Considerations for Using Data Responsibly at USAID," a recent guide for responsible data practices, https://www.usaid.gov/sites/default/files/documents/15396/USAID-UsingDataResponsibly.pdf. It states in part that, "In countries, high-profile privacy incidents have eroded public trust in the ability of governments and private companies to keep data secure."

Meanwhile, an ethical approach to data usage, sharing, and repurposing is needed to guide data accessibility and protect privacy and confidentiality, especially as countries adopt the use of DHIS2 software.

Under the names e-health, m-health, and health informatics, countries are developing strategies to use health information technology for increased access to healthcare, improved service quality, and decreased health system costs. These strategies are particularly important in malaria control activities and surveillance because they affect funding, detecting, and eliminating the disease. The overarching goal for ethical conduct is to balance the rights of individuals with a greater community health structure. These strategies must combine legal, technological, medical, and societal perspectives.

A wide range of information systems comes under the umbrella of digital health and malaria control SME—HMIS for aggregated health data, electronic medical records for facility-level patient data, mobile apps for

community health workers providing front-line healthcare, logistics management information systems for ensuring delivery of essential drugs, and laboratory information systems for tracking samples and test results. Digital health data are often combined with other types of data in the broader socioeconomic environment, expanding the number and types of information systems encompassed in digital health.

Examples of when ethics principles were not taken into consideration in malaria SME

- Taking photos of health facility registers during a site visit. Health facility registers contain contact information, such as names, addresses, and phone numbers, that can identify a patient. To protect autonomy, photos of HMIS data, such as health registers and patient health cards, should not reveal contact information that can identify a patient.
- Removing health registers from health facilities at any time for data analysis, training, or other purposes. Health facility registers are private property of the facility and should never be removed from the facility for any purpose.
- Sharing passwords for open-source software, such as DHIS2. Clear guidance and protocols about electronic health data and storage should be put in place and enforced to protect patient privacy. Passwords should not be shared.
- Publishing a report by a research collaborator before the NMP had a chance to review the findings. Discussing research findings, coming to consensus, and creating a dissemination plan with stakeholders are essential steps that must come before publishing.
- Providing free ITNs to children to entice them or their parents to take part in a malaria survey. Bribing a population with free interventions or commodities to get information from them is unethical.

13.4 Summary

Ethics are important to protect human rights and quality of life. Malaria control SME personnel have a moral responsibility to protect program participants from harm. Ethics standards establish values that are essential for collaborative work, such as trust, accountability, mutual respect, and fairness.

Ethical conduct means simply doing the right thing, but in reality, it means more. It involves every team member acting in the right spirit, out of an abiding respect and concern for human beings. It involves guarding privacy and observing confidentiality, respecting an individual's culture and diversity, and providing choices to research subjects.

Research ethics principles are important in HIS to establish guidance on obtaining informed consent; collecting, aggregating, reporting, processing, and analyzing data; managing data systems and security; and presenting results without fabricating, falsifying, or misrepresenting results. These principles promote accurate data collection, dissemination of truthful results, and avoidance of errors of omission or commission. USAID's tool discusses how to use data responsibly, highlighting important concerns and providing actionable advice to help those who use data in development programs maximize utility while managing risk.

Ethics in digital data require efforts to bring together expertise in legal and ethical norms, information systems security, data management, healthcare delivery, and community contexts. They are an interdisciplinary understanding of the ethical considerations involved in collecting, linking, transmitting, sharing, storing, processing, analyzing, and using hardcopy and electronic health data. Every member of the malaria SME unit must behave ethically, cause no harm to program participants, safeguard individual privacy, and inform participants thoroughly and honestly about the program and seek their consent.

Ethics questions to consider when developing and evaluating a malaria SME program

Data storage

- Are data system management principles in place?
- Who has ultimate responsibility for data maintenance and security?
- Who is responsible for providing documentation and metadata? Does the documentation cover moving data from one storage place to another or copying and replicating them in other places?
- How is access to data managed? How well informed and trained are the data gatekeepers?
- What are the risks associated with the use of a data repository, such as the cloud or a third party? Who has authority to access, manage, and release these data?
- Are processes in place to track data use?
- Is data destruction, as a requirement of ethics applications, a relevant approach to digital data?

Data use

- What processes are used to make personally identifiable information anonymous? What potential harm could result from stripping identifiable information from the data?
- What are the ethical and legal responsibilities for researchers using repurposed data?
- Do the benefits outweigh the potential risks or unintended consequences of repurposing data?
- Do researchers assess the applicability of data previously collected and understand how they were collected? Do researchers have a responsibility to assess whether the secondary use of the data aligns with the intent of the original collection?
- Do researchers using data gathered for another program have a responsibility to ensure that access to the data and their use do not pose risks to the original participants?

Surveys

- Does the consent form clearly describe the purpose of the research and how the data will be used? Do participants understand the consent? Is the consent form in a language that is understood by participants? Has the consent form been explained clearly in a language understood by participants?
- Are participants given the opportunity to ask questions and opt out at any time? Are incentives or coercion used to promote participation?
- Are participants informed that some questions ask personally identifying information? Are participants aware that, although every effort will be made to keep their personally identifiable information confidential, some small risk remains that the information could inadvertently be identified?
- Does any mechanism, regulatory framework, or administrative structure protect the participants' privacy in this program? Is personally identifiable information protected under a privacy law?
- To what extent are the data gathered in this context considered personal and private, or public and available for research?
- Are participants aware that data collected for one program may be repurposed in future research projects?
- Does the consent for the original data include or preclude a new use of the data? Are participants asked to sign a consent that is for one use only or does the consent extend to repurposed uses? Does the consent extend to linking these data to other data, including personal data like names and addresses or age and gender?
- Does consent need to be renegotiated if the data are used by someone other than the researcher or organization that collected them?

14 Chapter 14. Perspectives, Reflections, and Emerging Issues in Malaria SME

This compendium is an effort to bring together, in one handy reference, all the basic concepts of SME as they are applied to NMPs.

14.1 The Evolution of SME

At the beginning of the century, initiatives were created that catalyzed global investments in malaria. The RBM Partnership was established in 1999, followed by the Abuja Summit in April 2000, in which endemic countries in Africa committed to halving malaria mortality by 2010. At the UN Millennium Summit in 2000, the global community and international development partners committed to a set of goals and objectives, which included reductions in malaria mortality by 2015. The scope and specificity of this global commitment required a consistent means to monitor the progress toward, and achievement of, collectively identified goals. To guide this effort, RBM worked with global development partners and endemic country programs to develop strategic plans and identify a series of indicators for tracking progress toward the Abuja Summit and Millennium Development Goals.

The focus in the early days was providing broad access to prevention and treatment interventions to all populations at risk of malaria. Due to this focus on population-level access and use of services, the primary means of monitoring progress was through large population-based surveys. Under the leadership of RBM, the global malaria community established a consistent set of goals, objectives, and indicators, and developed a set of tools to monitor progress. These indicators formed the basis for the monitoring of global progress in malaria control as well as the malaria-related components of the Millennium Development Goals. After an initial 10–15 years of scaling up interventions such as bed nets at a population level, malaria prevalence began to drop, and interventions needed to be layered on with more targeted approaches.

14.2 The Changing Landscape of SME

Over the past 10 years, the landscape for malaria control has evolved, and consequently the SME landscape has also evolved. A decade ago, most highly endemic countries in Africa were focused on scaling up universal access to ITN and malaria diagnosis and treatment services. A few interventions, such as IRS, were more focalized, primarily because the cost of these interventions prohibited wide-scale implementation. As noted above, most of the national program targets were focused on population-level coverage of key interventions. To measure progress against these population-level indicators (coverage of ITNs, access to treatment, etc.), the global community implemented large-scale population-based surveys (DHS, MIS, MICS). These surveys were able to collect data for indicators whose denominators were either the population as a whole or some demographic subset, such as children under five or pregnant women.

In terms of impact measurement, population-based surveys provide reliable and validated sources of data on morbidity and mortality indicators in the form of parasite prevalence and all-cause child mortality. These indicators, although robust, are less sensitive in the short term and are difficult to directly link to specific interventions. As advances in malaria control have reduced the burden of malaria, such broad indicators are of less use for measuring the impact of targeted interventions. Over time, indicators such as incidence rate and test positivity rate, derived from routine surveillance platforms, have become increasingly important as impact measures. National programs, with support from global partners, have invested in improving

surveillance systems. In the years to come, the focus will continue to shift away from mortality to reductions in transmission and eventually toward elimination, and these surveillance systems will become the primary means of measuring the impact of malaria control and elimination efforts.

The geographic focus of impact measurement has also shifted. As countries have made progress in malaria control, many countries have been able to reduce transmission in some areas of the country while still working on reducing burden in higher transmission zones. This has led to a layered approach to malaria control that requires more targeted interventions, such as IRS, SMC, or MDA, in some areas. The recently rolled out High Burden, High Impact initiative of the WHO focuses on country stratification and matching control interventions to specific settings and populations.

14.3 Looking to the Future

The Role of New Diagnostic Tools and Technologies

To measure the burden of malaria, differential diagnosis, which separates a true case of malaria from the myriad other causes of fever, is critical. Microscopy has always been considered the gold standard in this domain because it allows the physical identification not just of the parasite itself, but also of the specific species (or mix of species) and the density of the infection in an individual. However, microscopy requires specialized tools and skills that are not easily deployed in the field, thereby limiting its utility for large-scale diagnosis through surveys or surveillance activities. RDTs have been a game changer for surveillance because they are an inexpensive point-of-care tool that can be easily used in low-resource settings, especially at the community and household levels. The expansion of mass diagnosis allowed for rapid assessments of prevalence across countries, but it had varying impacts on measures of incidence.

New diagnostic tools have the potential to push the envelope even further. Highly sensitive RDTs will allow the detection of very low level, asymptomatic infections, which will be critical for identifying remaining foci in the path to elimination. In the laboratory, other antigen-based techniques can be used on large samples to identify patterns of histidine-rich protein 2: a protein used in RDTs that tests for *P. falciparum,* the deletion of which may affect the accuracy of current RDTs (WHO, 2018e). PCR is another tool used in research that has yielded a lot of information on the patterns of distribution of different *Plasmodium* species, multiplicity of infection in patients, and genetic diversity of the individual infection. These laboratory-derived data may not be of critical importance clinically, but they provide a wealth of information on how well a program is doing in reducing transmission.

The Cultivation and Use of Data for Evidence

Although the ability to detect a case of malaria has evolved, the systems for collecting and aggregating these data are still improving. Most endemic countries have rolled out enhanced HMIS systems through the DHIS2 platform or other software, but these systems are not always fully functional at the community level. In the coming years, the focus of technical assistance should be on digitalization of data and transmission from community to facility and up the health system. These enhancements will improve the accuracy and reliability of the data and make them available on a more timely basis to program managers at all levels of the system. Another area of emphasis should be the inclusion of private sector data into the national system. In many endemic countries, the majority of malaria cases are still treated in the formal or informal private sector.

Inclusion of these cases will improve a country's ability to offer appropriate care and to provide a more detailed picture of transmission dynamics. Within the health facility, data system enhancements should focus on the links between clinical data, lab results, and information on stock availability, to ensure that testing is done, treatments correspond to test results, and commodities are readily available. After these systems are fully functional, a next step would be to introduce tools to better visualize and interpret the data to help answer key programmatic questions.

NMP managers are benefiting not only from improved measurement of epidemiologic data, but also from their access to a range of information from other sources, which can help enhance their understanding of program dynamics. Data from nonhealth sources can add depth and nuance to the analysis of epidemiologic trends, which in turn helps target interventions more specifically. Some of the nonhealth data that are important in the malaria context include information from entomological monitoring, climate and rainfall data, information on housing structures and land use activities, and population dynamics, such as patterns of migration.

This new focus on multiple sources of data can improve program implementation in many ways. For example, many countries now have access to ITNs with different types of insecticidal mechanisms. Program managers can make use of data on information on mosquito bionomics and insecticide resistance, community patterns of bed net use, epidemiologic data, and information on ITN costs to target different types of bed nets to different parts of a country for mass distribution. Another use case for data is in the area of SMC. Modeled data on climate and rainfall patterns as well as demographics can help identify areas that are eligible for SMC, where additional benefits might be obtained from extending SMC to older children compared to adding additional cycles to the existing program. In areas targeting elimination, transmission remains focused in pockets based on geography and the risk profiles of population (occupation, housing style, etc.). Detailed data on population dynamics and the genetic profiles of the parasite can help identify emerging patterns in the spread of resistance, identify residual foci, and track down imported cases.

14.4 Final Word: SME Is the ONLY Way We Achieve Elimination.

Our ultimate goal as a malaria community is to eliminate malaria in humans. We have effective interventions to detect and cure existing infections and prevent the onward transmission of disease. These interventions need to be targeted effectively, monitored throughout implementation to ensure that they are being deployed appropriately, and evaluated for impact. These steps all require robust systems with a coherent plan and approach to collect, report, analyze, and use data for decision making and with knowledgeable, well-trained staff. The WHO criteria for the certification of elimination status state:

> *WHO grants this certification when a country has proven, beyond a reasonable doubt, that the chain of local transmission of all human malaria parasites has been interrupted nationwide for at least the past 3 consecutive years, and that a fully functional surveillance and response system that can prevent re-establishment of indigenous transmission is in place.*
>
> https://www.who.int/malaria/areas/elimination/certification/en/

It is clear that the only way a country will be able to reach elimination status is to develop the M&E systems necessary to document the successful impact of the NMP. Fully functional surveillance systems are also

necessary to monitor disease-free status, both in the three-year lead-up to certification and in the years that follow. Viewed through this lens, surveillance becomes not just the "third pillar" of malaria control and elimination, but also, arguably, the most important one.

References

African Union. (2014). African Union Convention on Cyber Security and Personal Data Protection. Retrieved from https://au.int/sites/default/files/treaties/29560-treaty-0048_-_african_union_convention_on_cyber_security_and_personal_data_protection_e.pdf

Australian Agency for International Development. (2005). *AusGuideline: 3.3. The logical framework approach.* Canberra, Australia: The Commonwealth of Australia. Retrieved from https://sswm.info/sites/default/files/reference_attachments/AUSAID%202005%20The%20Logical%20Framework%20Approach.pdf

Behrens, R.,H., Neave, P.,E., & Jones, C. O. H. (2015). Imported malaria among people who travel to visit friends and relatives: Is current UK policy effective or does it need a strategic change? *Malaria Journal, 14,* 149. Retrieved from https://malariajournal.biomedcentral.com/articles/10.1186/s12936-015-0666-7

Bellinger, G., Castro, D., & Mills, A. (2004). *Data, information, knowledge, and wisdom.* Retrieved from https://homepages.dcc.ufmg.br/~amendes/SistemasInformacaoTP/TextosBasicos/Data-Information-Knowledge.pdf

Bryman, A. (2012). Chapter 6: Ethics and politics in social research. In *Social Research Methods* (4th Edition) (pp. 130–155). Oxford, UK: Oxford University Press.

Cohn, S. (2006). *Privacy and confidentiality in the nationwide health information network.* Washington, DC: National Committee on Vital and Health Statistics. Retrieved from https://www.ncvhs.hhs.gov/recommendations-reports-presentations/june-22-2006-letter-to-the-secretary-recommendations-regarding-privacy-and-confidentiality-in-the-nationwide-health-information-network/

Cox, F. (2010). History of the discovery of the malaria parasites and their vectors. *Parasites & Vectors, 3,* 5. Retrieved from http://www.parasitesandvectors.com/content/3/1/5

Detinova, T. S. (1962). *Age-grouping methods in Diptera of medical importance.* Geneva, Switzerland: World Health Organization.

Evaluation Task Force of Roll back Malaria's Monitoring and Evaluation Reference Group. (2019). *Framework for evaluating national malaria programs in moderate- and low-transmission settings.* Chapel Hill, NC, USA: MEASURE Evaluation, University of North Carolina. Retrieved from https://www.measureevaluation.org/resources/publications/tr-19-334

Galactionova, K., Tediosi, F., de Savigny, D., Smith, T., & Tanner, M. (2015). Effective coverage and systems effectiveness for malaria case management in Sub-Saharan African countries. *PLoS One,* 10(5), e0127818. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4441512/

Gejibo, S.H. (2015). *Towards a secure framework for mHealth.* Bergen, Norway: University of Bergen.

Gertler, P. J., Martinez, S., Premand, P., Rawlings, L. B., & Vermeersch, C. M. J. (2011). *Impact evaluation in practice.* Washington, DC: World Bank. Retrieved from https://siteresources.worldbank.org/EXTHDOFFICE/Resources/5485726-1295455628620/Impact_Evaluation_in_Practice.pdf

Ghana Ministry of Health. (2009a). *Anti-malaria drug policy for Ghana.* Accra, Ghana: Ghana Ministry of Health. Retrieved from https://www.ghanahealthservice.org/downloads/GHS_Antimalaria_drug_policy.pdf

Ghana Ministry of Health. (2009b). *National malaria control monitoring and evaluation plan 2008-2015.* Accra, Ghana: Ghana Ministry of Health. Retrieved from https://www.ghanahealthservice.org/downloads/M%20&%20E%20PLAN.pdf

Global Health Learning Center. (n.d.). Measuring malaria through household surveys. Retrieved from https://www.globalhealthlearning.org/course/measuring-malaria-through-household-surveys

Harman, L. B., Flite, C. A., & Bond, K. (2012). Electronic health records: Privacy, confidentiality, and security. *Virtual Mentor, 14*(9), 712–719. Retrieved from https://journalofethics.ama-assn.org/article/electronic-health-records-privacy-confidentiality-and-security/2012-09

Hay, S., Guerra, C. A., Tatem, A. J., Atkinson, P. M., & Snow, R. W. (2005). Urbanization, malaria transmission, and disease burden in Africa. *Nat Rev Microbiol, 3*(1), 81-90. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/15608702

Healthcare Information and Management Systems Society. (n.d.). Health informatics defined. Retrieved from https://www.himss.org/health-informatics-defined

Herrera, S., Enuameh, Y., Adjei, G., Ae-Ngibise, K.,A., Asante, K. P., Sankoh O., Owusu-Agyei, S., & Yé, Y. (2017). A systematic review and synthesis of the strengths and limitation of measuring malaria mortality through verbal autopsy. *Malar J, 16,* 421. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/29058621

Hershey, C. L., Bhattarai, A., Florey, L. S., McElroy, P. D., Nielsen, C. F., Yé, Y., . . . Salgado, S. R. (2017). Implementing impact evaluations of malaria control interventions: Process, lessons learned, and recommendations. *American Journal of Tropical Medicine and Hygiene, 97,* 20–31. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/28990921

Hill, A.,B. (1965). The environment and disease: Association or causation? *Proceedings of the Royal Society of Medicine, 58,* 295–300. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1898525/

Hotchkiss, D., Diana, M., & Foreit, K. (2012). *How can routine health information systems improve health systems in low-resource settings? Assessing the evidence base.* MEASURE Evaluation Special Report. Chapel Hill, NC, USA: MEASURE Evaluation, University of North Carolina. Retrieved from https://www.measureevaluation.org/resources/publications/sr-11-65

Innovative Vector Control Consortium. (n.d.). Insecticide resistance management (IRM). Retrieved from https://www.ivcc.com/research-development/irm/

INDEPTH Network. (2012). *Population and health in developing countries: Population, health, and survival in INDEPTH Sites.* Ottawa, Canada: International Development Research Centre. Retrieved from

https://www.idrc.ca/en/book/population-and-health-developing-countries-population-health-and-survival-indepth-sites

Kenya Ministry of Health, National Malaria Control Programme. (2019a). *Kenya malaria strategy 2019–2023*. Nairobi, Kenya: Ministry of Health.

Kenya Ministry of Health, National Malaria Control Programme. (2019b). *Kenya malaria monitoring and evaluation plan 2019–2023*. Nairobi, Kenya: Ministry of Health.

Khandker, S. R., Koolwal, G. B., & Samad, H. A. (2009). *Handbook on impact evaluation: Quantitative methods and practices*. Washington, DC, USA: World Bank. Retrieved from http://documents.worldbank.org/curated/en/650951468335456749/Handbook-on-impact-evaluation-quantitative-methods-and-practices

Macdonald, G. (1957). *The epidemiology and control of malaria*. London, UK: Oxford University Press.

Martens, W. (1997). *Health impacts of climate change and ozone depletion: An eco-epidemiological modelling approach*. PhD thesis. Maastricht, Netherlands: Maastricht University. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1533278/

MEASURE Evaluation. (2011). *Tools for data demand and use in the health sector: Stakeholder engagement tool*. Chapel Hill, NC, USA: MEASURE Evaluation, University of North Carolina. Retrieved from https://www.measureevaluation.org/resources/publications/ms-11-46-e

Nájera, J., González-Silva, M., & Alonso, P. L. (2011). Lessons for the future from the Global Malaria Eradication Programme (1955–1969). *PLoS Medicine, 8*(1), e1000412. Retrieved from http://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1000412

National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. (1978). *The Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects of Research* Washington, DC, USA: United States Government Printing Office. Retrieved from https://videocast.nih.gov/pdf/ohrp_belmont_report.pdf

National Malaria Elimination Centre, Ministry of Health. (2017). *Zambia National Malaria Elimination Strategic Plan, 2017–2021: Moving from accelerated burden reduction to malaria elimination in Zambia*. Lusaka, Zambia: Ministry of Health. Retrieved from http://www.makingmalariahistory.org/wp-content/uploads/2017/06/NMESP_2017-21_email-version.pdf

The Nuremberg Code. (1947). In Mitscherlich, A., & Mielke, F. (Eds.), *Doctors of infamy: The story of the Nazi medical crimes* (pp. xxiii-xxv). New York, NY, USA: Schuman.

Office of Research Integrity, U.S. Department of Health and Human Services. (n.d.). Definition of research misconduct. Retrieved from https://ori.hhs.gov/definition-misconduct

Okogun, G. R. A., Anosike, J. C., Okere, A. N., & Nwoke, B. E. B. (2005). Ecology of mosquitos of Midwestern Nigeria. *Journal of Vector Borne Diseases, 42,* 1–8. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.663.3466&rep=rep1&type=pdf

Roll Back Malaria (RBM) Partnership. (2008). *The global malaria action plan for a malaria-free world.* Geneva, Switzerland: RBM Partnership. Retrieved from http://www.unhcr.org/4afac5629.pdf

Roll Back Malaria (RBM) Partnership. (2015). *Action and investment to defeat malaria 2016-2030.* Geneva, Switzerland: RBM Partnership. Retrieved from https://endmalaria.org/sites/default/files/RBM_AIM_Report_0.pdf

Sankoh, O., & Byass, P. (2012). The INDEPTH Network: Filling some international gaps in epidemiology. *International Journal of Epidemiology, 41*(3):579–588. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/22798690

Saunders, M., Lewis, P., & Thornhill, A. (2012). Chapter 6: Negotiating access and research ethics. In *Research Methods for Business Students* (6th Edition). London, UK: Pearson.

Snow, R. (2014). Sixty years trying to define the malaria burden in Africa; have we made any progress? *BMC Medicine, 12,* 227. Retrieved from https://bmcmedicine.biomedcentral.com/articles/10.1186/s12916-014-0227-x

Tanner, M., & de Savigny, D. (2008). Malaria eradication back on the table. *Bulletin of the World Health Organization, 86*(2), 82. Retrieved from http://www.who.int/bulletin/volumes/86/2/07-050633/en/

Thomas, J. C., Sage, M., Dillenberg, J., & Guillory, V. J. (2002). A code of ethics for public health. *American Journal of Public Health, 92*(7), 1057–1059. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1447186/

United Nations Development Group (UNDG). (2017). *Data privacy, ethics and protection guidance note on big data for achievement of the 2030 agenda.* Geneva, Switzerland: UNDG. Retrieved from https://undg.org/wp-content/uploads/2017/11/UNDG_BigData_final_web.pdf

United Nations Development Programme. (n.d.). Human development reports. Retrieved from http://hdr.undp.org/en/content/human-development-index-hdi

United States Agency for International Development (USAID). (2010). *Performance monitoring and evaluation tips: Building a results framework* (2nd edition, number 13). Washington, DC, USA: USAID. Retrieved from https://www.ndi.org/sites/default/files/Performance%20Monitoring%20and%20Evaluation%20Tips%20Building%20a%20Results%20Framework.pdf

United States Agency for International Development (USAID) & FHI 360. (2019). Considerations for using data responsibly at USAID. Washington, DC, USA: USAID. Retrieved from https://www.usaid.gov/sites/default/files/documents/15396/USAID-UsingDataResponsibly.pdf

United States Centers for Disease Control and Prevention. (n.d.a). Identifying the components of a logic model. Retrieved from https://www.cdc.gov/std/program/pupestd/components%20of%20a%20logic%20model.pdf

United States Centers for Disease Control and Prevention. (n.d.b). The Tuskegee timeline. Retrieved from https://www.cdc.gov/tuskegee/timeline.htm

United States Centers for Disease Control and Prevention. (2012). Human factors and malaria. Retrieved from https://www.cdc.gov/malaria/about/biology/human_factors.html

United States Centers for Disease Control and Prevention. (2018). Anopheles mosquitoes. Retrieved from https://www.cdc.gov/malaria/about/biology/mosquitoes/index.html

United States Holocaust Memorial Museum. (n.d.). Nazi medical experiments. Retrieved from https://encyclopedia.ushmm.org/content/en/article/nazi-medical-experiments

University of California San Francisco. (2011, August 30). Progress fighting malaria: A timeline. Retrieved from https://www.ucsf.edu/news/2011/08/10525/progress-fighting-malaria-timeline

Voices for Malaria-Free Future. (n.d.). Malaria: What is the economic impact of malaria? Retrieved from https://www.malariafreefuture.org/malaria#economic_impact

Wambugu, S., Thomas, J., Johnson, D., & Villella, C. (2017). *Data ethics: Harnessing the power of digital health information systems*. Chapel Hill, NC, USA: MEASURE Evaluation, University of North Carolina.

Wambugu, S., & Villella, C. (2016). *mHealth for health information systems in low- and middle-income countries: Challenges and opportunities in data quality, privacy, and security*. Chapel Hill, NC, USA: MEASURE Evaluation, University of North Carolina. Retrieved from https://www.measureevaluation.org/resources/publications/tr-16-140

World Health Organization. (n.d.). eHealth at WHO. Geneva, Switzerland: WHO. Retrieved from http://www.who.int/ehealth/about/en/

World Health Organization (WHO). (2012). *Verbal autopsy standards: The 2012 WHO verbal autopsy instrument release candidate 1*. Geneva, Switzerland: WHO, Health Metrics Network, and INDEPTH Network. Retrieved from https://www.who.int/healthinfo/statistics/WHO_VA_2012_RC1_Instrument.pdf?ua=1

World Health Organization (WHO). (2015a). *Global technical strategy for malaria, 2016–2030*. Geneva, Switzerland: WHO. Retrieved from http://www.who.int/malaria/publications/atoz/9789241564991/en/

World Health Organization (WHO). (2015b). *Guidelines for the treatment of malaria. Third edition*. Geneva, Switzerland: WHO. Retrieved from http://www.who.int/malaria/publications/atoz/9789241549127/en/

World Health Organization (WHO). (2015c). *World malaria report 2015*. Geneva, Switzerland: WHO. Retrieved from https://www.who.int/malaria/publications/world-malaria-report-2018/en/

World Health Organization (WHO). (2016). *WHO malaria terminiology*. Geneva, Switzerland: WHO.

World Health Organization (WHO). (2017). *A framework for malaria elimination*. Geneva, Switzerland: WHO. Retrieved from https://www.who.int/malaria/publications/atoz/9789241511988/en/

World Health Organization (WHO) & Roll Back Malaria Partnership to End Malaria. (2018a). *High burden to high impact: A targeted malaria response*. Geneva, Switzerland: WHO. Retrieved from https://www.who.int/malaria/publications/atoz/high-impact-response/en/

World Health Organization (2018b). Immunization, vaccines and biologicals, Malaria Vaccine Implementation Programme (MVIP). Retrieved from https://www.who.int/immunization/diseases/malaria/malaria_vaccine_implementation_programme/en/

World Health Organization (WHO). (2018c). *Malaria surveillance, monitoring & evaluation: A reference manual.* Geneva, Switzerland: WHO. Retrieved from https://www.who.int/malaria/publications/atoz/9789241565578/en/

World Health Organization (WHO). (2018d). *World malaria report 2018*. Geneva, Switzerland: WHO. Retrieved from https://www.who.int/malaria/publications/world-malaria-report-2018/en/

World Health Organization (WHO). (2018e). *Protocol for estimating the prevalence of pfhrp2/pfhrp3 gene deletions among symptomatic falciparum patients with false-negative RDT results.* Geneva, Switzerland: WHO. Retrieved from https://www.who.int/malaria/publications/atoz/hrp2-deletion-protocol/en/

World Medical Association. (2013). World Medical Association declaration of Helsinki: Ethical principles for medical research involving human subjects. *JAMA, 310*(20), 2191–4. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/24141714

Yé, Y. (2008). Environmental Factors and Malaria Transmission Risk Modelling the Risk in a Holoendemic Area of Burkina Faso. Retrieved from https://www.taylorfrancis.com/books/9781351159005

Yé, Y., & Duah, D. (2019). The President's Malaria Initiative contributed to reducing malaria burden in sub-Saharan Africa between 2004 and 2014: Evidence from generalized estimating equation analysis. *PLoS One, 14,* e0217103. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6534374/

Yé, Y., Eisele, T. P., Eckert, E., Korenromp, E., Shah, J.A., Hershey, C. L., . . . Bhattarai, A. (2017). Framework for evaluating the health impact of the scale-up of malaria control interventions on all-cause child mortality in sub-Saharan Africa. *American Journal of Tropical Medical Hygiene, 97,* 9–19. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/28990923

Yé, Y., Louis, V. R., Simboro, S., & Sauerborn, R. (2007). Effect of meteorological factors on clinical malaria risk among children: an assessment using village-based meteorological stations and community-based parasitological survey. *BMC Public Health, 7,* 101. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1913509/

Yé, Y., Wamukoya, M., Ezeh, A., Emina, J. B., & Sankoh, O. (2012). Health and demographic surveillance systems: A step towards full civil registration and vital statistics system in sub-Saharan Africa? *BMC Public Health, 12,* 741. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/22950896

Zanzibar Malaria Elimination Programme. (n.d.). Country profile. Retrieved from http://zamep.go.tz/country-profile/

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