A methodology for malaria programme impact evaluation

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Abstract

This document describes a methodology for continual assessment of the impact of malaria interventions, and the efficiency of the malaria programme. The methodology is designed to be implemented recurrently on a cycle of 2–5 years, with the involvement of stakeholders, including National Malaria Control Programmes, development partners and other organizations active in the programme. Their participation should inform the impact and efficiency assessment, so that it is linked to subsequent decision making defining the nature and scope of malaria control interventions.

The methodology is designed in a modular way, providing some flexibility with regard to which elements are implemented at any given time. Some modules require technical capabilities usually not available in a regular M&E team, and will require contributions from other national and/or international partners.

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Acronyms

ACT	Artemisinin-Based Combination Therapy
API	Annual Parasite Incidence
ASL	Above Sea Level
BMGF	Bill and Melinda Gates foundation
CHW	Community Health Worker
DALY	Disability Adjusted Life-Years
DHS	Demographic and Health Surveys
DPT3	Diphtheria, Pertussis and Tetanus vaccination
EIR	Entomological Inoculation Rate
GDP	Gross Domestic Product
HDSS	Demographic Surveillance System
HMIS	Health Management Information System
iCCM	Integrated Community Case Management
IEC	Information, Education and Communication
IMNCI	Integrated Management of New-born and Childhood Illness
IPTc	Intermittent Preventive Treatment in Children
IPTi	Intermittent Preventive Treatment in Infants
IPTp	Intermittent Preventive Treatment in Pregnancy
IRS	Indoor Residual Spraying
ITN	Insecticide Treated Net
LCU	Local Currency Unit
LLIN	Long Lasting Insecticide Treated Net
MIC	Multiple Indicator Cluster Survey
MIS	Malaria Indicator Surveys
MoH	Ministry of Health
NASA	National Aeronautics and Space Administration
NMCP	National Malaria Control Programme
NFM	New Funding Model
NGO	Non-Governmental Organization
NHA	National Health Accounts
NSP	National Strategic Plan
OR	Operational Research
PMI	President's Malaria Initiative
RBM	Roll Back Malaria
RBM-MERG	RBM Monitoring and Evaluation Reference Group
RDT	Rapid Diagnostic Test
RoI	Return on Investment
SMC	Seasonal Malaria Chemoprevention
Swiss TPH	Swiss Tropical and Public Health Institute
USAID	United States Agency for International Development
WHO	World Health Organization

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1 Methodology

1.1 Overview of modules

The methodology is designed in a modular way so that it is possible to conduct an evaluation consisting of only a sub-set of the full set of analyses. This full set I includes plausibility analyses of both programme performance and of the public health impact it has achieved; model-based analysis of past impact (sections 1.4.8) and prediction of future impacts (sections 1.4.9 & 1.4.10); and economic analysis of the costs already incurred (section 1.4.11), the health return on that investment; the economic and social returns on that investment (section 1.4.12), as well as projections of future costs of the programme as currently configured, and of alternative strategies (section 1.4.13). The analyses of costing and public health impact can be combined to provide cost effectiveness analysis of these potential intervention strategies.

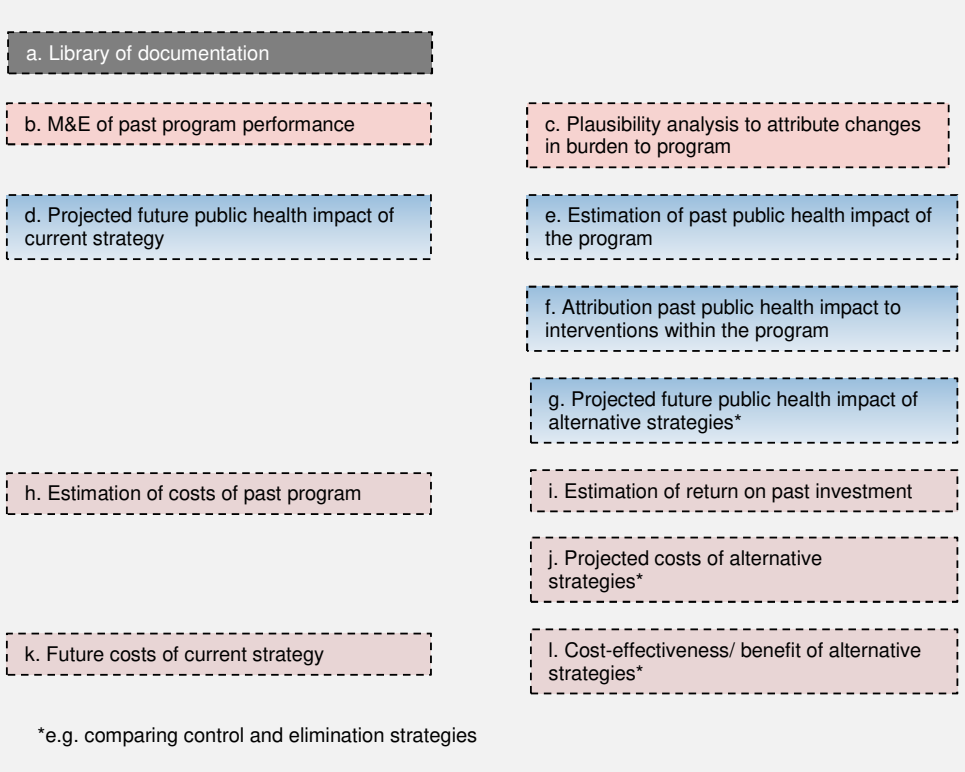

Figure 1. Modules included in the full methodology

The individual modules (Figure 1) comprise:

a) Assembling libraries of relevant documents (section 1.2.7); and of datasets (section 1.3.1);

b) Descriptive analyses of contextual factors, outputs and outcomes of the programme. This includes assessment of data quality of the national malaria surveillance (i.e. including HMIS) and vital statistics (section 1.3.2) as well as of the intervention coverages and public health impact that have been achieved by the programme as a whole over the period since the beginning of the programme (section 1.4.3).

c) Plausibility analysis to attribute changes in burden to the programme (sections 1.4.4). Assessment

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of levels and trends in infection, malaria burden and intervention coverage, using available surveillance, survey, programmatic and other data at national level and disaggregated by region and malaria transmission strata.

d) Model-based projection of the public health impact of continuing the current strategy (section 1.4.9)

e) Model-based estimation of the contribution of the programme to the public health impact achieved since the beginning of the programme, complementary to the plausibility analysis (section 1.4.7).

f) Extension of these models to attribute the contributions of distinct interventions to the impact achieved since the beginning of the programme (section 1.4.8).

g) Model-based projection of the public health impact of alternative strategies (section 1.4.10) considering in particular strategies aiming at sub-national or national elimination.

h) Cost of the programme since the beginning of the programme (section 1.4.11).

i) Estimation of health return on past investments, i.e. retrospective analysis of cost per case/death/DALY averted (section 1.4.12).

j) Projected cost of continuing the programme as currently planned (section 1.4.11).

k) Projected cost of alternative future strategies, in particular those aiming at sub-national or national elimination (section.1.4.13).

l) Project the cost-effectiveness / benefit of different future candidate intervention strategies, in particular strategies aiming at national- or sub-national level elimination (section 1.4.13).

The methodology is designed to be easily implemented recurrently, when required by the programme. Different modules can be included on each occasion as required. The methodology itself does not involve any primary data collection, but its implementation will indicate where there are data gaps, requiring community or health facility surveys. A different exercise, complementary to this methodology, is undertaking primary data collection from health facilities.

In addition to documenting the agreed approach to prepare for its implementation, the project entails:

- Reviewing existing processes and the sufficiency of previous impact and efficiency evaluations
- Identification and mapping of key stakeholders and partners
- Documentation of what has already been carried out to develop the methodology including identification of possible new approaches.

1.2 Documentation and specifications required for the first application of the methodology

1.2.1 Specification of health outcome measures

The metrics and standard units and metrics to measure both malaria burden and intervention coverage will include at least those recommended by the Global Technical Strategy for Malaria 2016–30, as appears below (a detailed description in Appendix B):

OUTCOME

- Proportion of population at risk who slept under an insecticide-treated net the previous night
- Proportion of population at risk protected by indoor residual spraying within the past 12 months
- Proportion of patients with suspected malaria who receive a parasitological test
- Proportion of patients with confirmed malaria who receive first-line antimalarial treatment according

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to national policy

IMPACT

- Parasite prevalence: proportion of the population with evidence of infection with malaria parasites
- Malaria case incidence: number of confirmed malaria cases per 1,000 persons per year
- Malaria mortality rate: number of malaria deaths per 100,000 persons per year

The epidemiological analyses will consider levels of prevalence, incidence of clinical malaria, and malaria mortality separately for children <5 years of age, and for older people. The economic analyses (e.g. cost-effectiveness analysis) will consider incidence of clinical malaria, malaria specific mortality, and disability adjusted life-years (DALYs) averted over the period of the evaluation.

Additional outcomes, such as trends in severe malaria and malaria admissions, and in-patient deaths may be included.

1.2.2 Definition of the baseline prevalence and coverage

The current levels of malaria endemicity are due to the past and continuous impact of malaria control interventions. Without these interventions malaria prevalence would return to its baseline which represents the intrinsic potential for malaria transmission. For the purpose of this exercise the situation at the beginning of the programme, evaluated through a community survey such as DHS survey will be treated as baseline. This baseline should be conducted before the implementation of the control measures that will be analysed.

1.2.3 Definition of the temporal scope of the analyses

The plausibility analyses will consider the period from the beginning of the programme until the most recent survey. The same time period will be considered for the retrospective assessment of the impact of the past interventions. One, two and five, and ten year time horizons starting from the current year, will be considered for the prospective analyses of impact.

1.2.4 Definition of the spatial resolution of the analyses

Running the analysis at a global such as national level would ignore all the heterogeneities in the country in terms of prevalence and intervention coverage. On the other hand, if the scale of the analysis is too high it might become operationally irrelevant and accurate data would not be available at this resolution in any case.

Analyses will, where possible be carried out at the operational level (e.g. district). This may entail using smoothing methods to obtain estimates of prevalence and intervention coverage at high spatial resolution, which can be aggregated at the specified unit level for calibration purposes. The analysis will therefore require geospatial information including shape-files of administrative boundaries at the specified unit level.

1.2.5 Specification of Intervention mixes

The evaluation will consider strategies consisting of mixes of the existing interventions in use within the programme (see example Table 1).

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Table 1. Interventions considered

Interventions	Details
Vector Control	LLINs, IRS, larviciding
Case Management	Scale-up of ACTs Introduction of RDTs Scale up of rectal and IV artesunate
Malaria surveillance	Passive case detection, Pro-active case detection, Reactive case detection
Community Empowerment and Mobilization	
Monitoring and Evaluation	
Programme Management	

1.2.6 Specification of the modeling tool

The potential effects of scale-up of different malaria control interventions on the trend of malaria morbidity and mortality can be assessed using the *OpenMalaria* platform.

OpenMalaria is a suite of micro-simulation models developed by Swiss TPH that provides a general platform for modelling impacts on transmission and disease of different curative and preventive intervention strategies against *Plasmodium falciparum* (and *P. vivax*). The models can be used to consider different deployment options, and detailed product profiles and to answer many different questions for product development, policy and intervention planning, including analyses of health systems, pharmacodynamics, and vector control interventions (see http://github.com/SwissTPH/openmalaria/wiki/References). The development of *OpenMalaria* has, since 2006, mainly been supported by the Bill and Melinda Gates foundation (BMGF), and the Swiss TPH modelling team are part of the BMGF supported Malaria Modeling Consortium. Emulations of OpenMalaria are used in the malaria module in the Spectrum - OneHealth interface that can be used to specify and calibrate models of malaria epidemiology.

1.2.7 Specification of scope of economic analyses

Prospective estimates of programme expenditures as well as estimation of return on investment (RoI) on past investment on malaria control and elimination rely on modelling to inform resource requirements for the programme and the scale of benefits that could be achieved under alternative control and elimination programme implementations. These analyses are aligned in scope (in terms of perspective adopted, list of interventions and their respective coverage (observed or assumed), population, time horizon etc.) with the modelling analysis plan.

The evaluation can be conducted from a broad provider perspective; it will consider resource use by the national government (NMCP, Ministry of Health and other related government ministries, local NGO's etc.) and development partners. Only direct costs of the programme are considered, these include direct expenditures related to malaria prevention or treatment (i.e. cost of drugs or cost of transportation to and from healthcare facility). The analysis will produce incremental costs of the programme, and, where relevant, will consider both financial and economic costs. Latter define costs "in terms of the alternative uses that have been for-gone by using a resource in a particular way". These include, in addition to the financial costs, a valuation of resources that do not have financial transactions (i.e. donated goods and services or capital goods, health care resources diverted from other uses or shared with other health programmes, and inputs whose prices are distorted; Drummond et al. 2005). The usefulness of full economic cost is in that it enables comparison of intervention efficiency in the long-term, where all resources can (hypothetically) be redeployed in alternative uses. Therefore, average costs are useful for cost-effectiveness analyses for long-term planning decisions.

For retrospective analysis, costs will be evaluated over the period when the programme started to date. Average annual cost of the programme will be estimated for a pre-determined year. For prospective analysis, supporting malaria elimination assessment, timeframe will be specified by the NMCP. Costs will

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be reported in constant the pre-determined year LCU and USD.

1.2.8 Document Library

A comprehensive library will be assembled of existing documents on malaria intervention costs and impacts, and of malaria surveys in the country.

1.2.9 Data availability

The available data sources will be listed; including data already collected by routine processes as well as by those efforts on impact assessment (Appendix A). This documentation will elaborate on agencies and individuals responsible for data collection, analysis and reporting, as well as mechanisms and processes used to assure data access and data quality. Memoranda of understanding will be provided for signature by participating agencies.

1.2.10 Design of templates

Templates will be designed for tables, figures, and required documentation. These will include those for description and visualization of input different data, and calculation of derived indices (e.g. transmission measures, access, effective coverage of case management). Graphics will be required for representation of geographical data and trends in time.

1.3 Tasks required only the first time the methodology is implemented

1.3.1 Assembly of data library

The corresponding data library will be assembled. With participation of local stakeholders, the required data (Appendix A) will be collated, documented and organized for its immediate use. This protocol does not entail any primary data collection.

1.3.2 Assessment of data quality

The data sources potentially contributing to the answers of detailed questions on impact will be assessed in multiple data quality dimensions such as completeness, internal consistency and consistency with other sources. The data quality assessment will consider both the national level and the relevant sub-national levels. For this purpose tables will be produced identifying:

- Number and percentage of districts with a completeness rate less than 75% for each indicator estimated based in data proceeding from the routine health management and information system or the sentinel surveillance
- Number and percentage of districts with results higher/lower than 3 standard deviations compared to the mean for each indicator estimated based in data proceeding from the routine health management and information system or the sentinel surveillance
- Results for indicators obtained from similar or related data (e.g. ITN distributed *vs* coverage of ITN, insecticide procured *vs* households sprayed)

1.4 Tasks required each time the methodology is implemented

1.4.1 Building the Impact Assessment team

The impact assessment requires a committed and qualified team. Partnership between international specialists and local experts is essential to ensure both cultural and institutional sensitivity, as well as perspective and credibility in the analysis and presentation of the results. The team will need to assess (and if necessary, build) skills and capacity in data collection, (including costing data) analysis, and interpretation, as well as in complementary areas, such as qualitative research.

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1.4.2 Updating of libraries of data, document sources, and review of data quality

This will include adding relevant documents (including any malaria programme review reports) and any additional data collection, and assessment of any substantive changes in data quality (See Appendix A).

1.4.3 Descriptive analyses of contextual factors, outputs and outcomes

This approach follows the conceptual framework of the RBM Monitoring and Evaluation Reference Group (RBM-MERG) for key factors affecting the impact of malaria control programmes (RBM-MERG, 2014), to assess simultaneously changes in:

- Health outcomes (see section 1.2.1)
- Coverage of malaria control interventions
- Transmission intensity
- Environmental contextual factors
- Socioeconomic and non-malaria contextual factors

According to this conceptual framework (adapted in Figure 2), the impact of malaria control interventions (upper half) on the morbidity and mortality is affected by external factors (below), so the latter should be included in the impact assessment. This framework includes all-cause child mortality (ACCM) as the ultimate indicator of malaria programme impact, however in settings with low transmission intensity (childhood prevalence lower than 25%) given the reduced contribution of malaria to mortality (as in the country) the ACCM is unlikely to be very informative (RBM-MERG, 2014, Rowe et al., 2007). We thus propose that mortality attributable to malaria should be the choice as impact indicator.

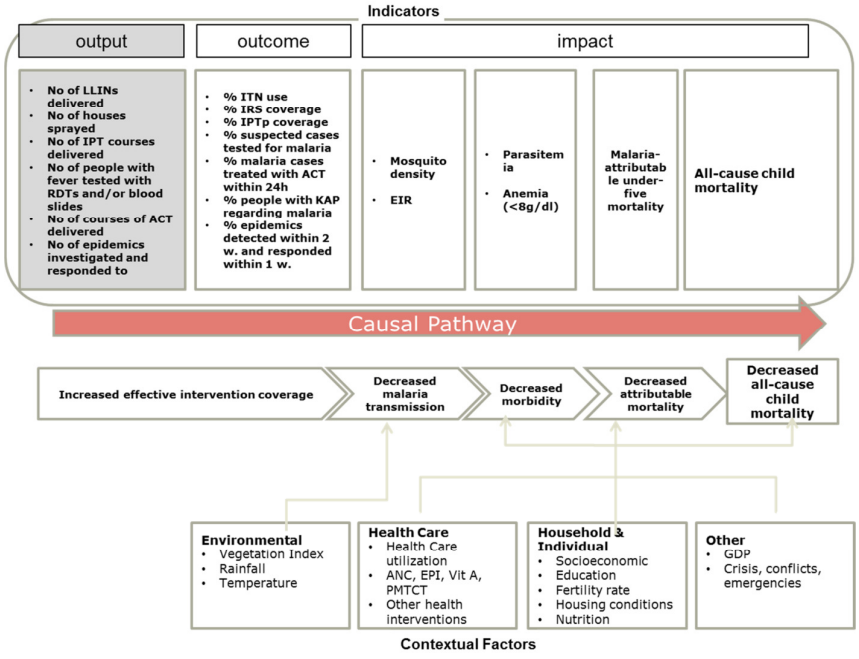

Figure 2. Conceptual framework for key factors in assessing the impact of malaria programmes (adapted)

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A description of the malaria control programme covering the following topics:

1. Basic country information

Including maps showing administrative boundaries, a geographical profile of the country and seasons. Basic country information should also describe the GDP sector composition, as well as general development indicators.

The document should include a description of population distribution across age and population groups (e.g., pastoralist populations, refugees), regions and population strata (altitude; see background chapter), as well as migration flows inside and across the country's borders.

2. Description of the health care system, including community-based component

It should include a description of the health care system, including the number of facilities at each level of care, and the ratio of health worker to population for each type of health care worker, as well the changes if any over the evaluation period. The ratio of community health worker (CHW) to population as well as the role of CHWs should be described. Changes regarding access to health care, either from public or private providers over the evaluation period should be described.

3. Malaria epidemiologic profile

It should include a breakdown of the country into malaria risk zones, including a map showing changes over the evaluation period. The profile should include a description of the species of malaria parasites and mosquito vectors in the country. Also the trends of the number of malaria cases, all-cause and malaria-specific deaths (by age groups of under 5 and above 5 years), differentiating lab confirmed and clinical cases, based in both facility-based data and community-based surveys. This description should identify if cases are clustered by geographical areas or any other criteria.

4. Malaria control interventions and policies (strategies)

The formation, structure and partnerships of the Malaria Programme should be described. Also the malaria control strategy (goals, targets and activities), including the milestones and achievements of main interventions included in the National Strategic plan.

5. Funding and commodity inputs

Including:

- Total expenditure on health for malaria
- Total expenditure on malaria as a percentage of total health expenditure
- Total government expenditure on health for malaria
- Per-capita total expenditure on health for malaria
- Total expenditure on health for malaria as a percentage of GDP
- Government expenditure on health for malaria as a percentage of GDP
- Government per-capita total health expenditure
- Government total expenditure on health as a percentage of total government expenditure
- Per-capita national expenditure on health for malaria
    - ITNs, ACTs, RDTs, Insecticide (structures sprayed) procured or distributed over the evaluation period
- Key events in the country

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This section should include background information on political events as civil disturbance and migration; environmental and climate events as floods, droughts and natural disasters; and major disease outbreaks.

A set of tables and graphs will be produced as follows:

1. Has there been a change in outcomes and behaviours, positive or negative, over the period since the beginning of the programme?
    - Proportion of all ages and children aged under 5 years population at risk who slept under an insecticide-treated net the previous night, by region, altitude and epidemiological stratum
    - Proportion of all ages and children aged under 5 years population at risk protected by indoor residual spraying within the past 12 months, by region, altitude and epidemiological stratum
    - Proportion of all ages and children aged under 5 years patients with suspected malaria who receive a parasitological test, by region, altitude and epidemiological stratum
    - Proportion of all ages and children aged under 5 years patients with confirmed malaria who receive first-line antimalarial treatment according to national policy, by region, altitude and epidemiological stratum

2. What have been the changes in the relevant health outcomes (section 1.2.1) over the period since the beginning of the programme?
    - Recorded incidence of malaria from the HMIS, expressed as the annual incidence per 1000 persons at risk among all ages and separately for children aged under 5 years by region, altitude and epidemiological stratum
    - Prevalence of *P. falciparum* by region, altitude and epidemiological stratum among all ages and children aged < 5 years
    - Prevalence of severe anaemia by region, altitude and epidemiological stratum among all ages and children aged < 5 years
    - Recorded incidence of severe malaria from the HMIS, expressed as the annual incidence per 100,000 persons at risk among all ages and separately for children aged under 5 years by region, altitude and epidemiological stratum
    - Number of recorded malaria deaths by age groups (all ages and under 5 years) per 100'000 persons at risk by year, region, altitude and epidemiological stratum.

3. Has there been a change in the intensity of transmission over the period since the beginning of the programme?
    - Entomological Inoculation Rate (EIR) by epidemiological stratum will be compared over time if available
4. What have been the changes in the contextual factors (section 1.2.1) over the period since the beginning of the programme?
    - Monthly mean temperature and humidity by epidemiological stratum
    - Immunization coverage (measles, DPT3)
    - Coverage of micronutrient supplementation interventions (Vitamin A, iron, zinc).
    - Per capita expenditure on health and on malaria (see above, funding and commodity inputs)
    - GDP per capita, percentage of population living below poverty line and the Gini coefficient

The analysis will include: time series plots of the outcomes with specific attention to dates/years of scale-up of key interventions, and maps of the geographic distribution of malaria incidence and prevalence.

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1.4.4 Standardised plausibility to attribute past impact

The data descriptions in section 1.4.3 will be used to develop a plausibility argument, with the approach based on the standard guidance currently available, mainly RBM-MERG (2014). This entails hypothesizing alternative causal pathways explaining the changes in health outcomes. The plausibility of the hypothesis that changes in disease burden reflect mainly programmatic efforts will be contrasted with at least one hypothesis attributing changes in part or in whole, to factors external to malaria programmes. Specifically, this will involve consulting to identify possible explanations for trends, using regression or correlation approaches to evaluate the relationships between considering both the factors listed in Figure 3, especially:

- Were there sufficient quality data (please refer to 3.2.2) to detect the effect of increase in service coverage and quality on disease burden? Are there significant sources of bias?
- Can the observed trends be linked to an improvement in the programme such as the scaling-up of malaria control interventions and health system strengthening efforts, positive changes in policy etc. or conversely to a deterioration in the programme performance?
- Do alternative explanations (e.g. climate change, global warming, change in case definitions) contributing to explain the observed trends?

In addition, the interpretation will consider the coherence of patterns of change across outcomes and which management recommendations might lead to improvements in the contributions of the Global Fund to outcomes and impact, in particular:

- What was the contribution of various sources of funding in scale up of resources, increase of coverage of key intervention services, improvement of service quality and outcome? What kind of competing explanations and hypotheses of changes in outcomes and impacts, positive and negative?
- The extent of geographical heterogeneity in the outcomes: are trends local or national? Are there specific geographical areas or subpopulations in which the burden of disease is especially high and that warrant increased attention including greater investment of financial resources and/or reallocation of resources to focus on more effective, higher impact interventions?
- Potential areas of investment needed to improve evidence about impact (trends in disease burden) in future

Other specific analyses may be required in the context of the country, that go beyond standard M&E plausibility analyses adapted to African countries, in particular to address additional evaluation questions that are detailed in consultation with the country's malaria programme's stakeholders (e.g. impact by malaria transmission strata). This might be the case for instance if transmission is generally low, with a large contribution of *P. vivax*. There may be a need to focus more on morbidity and mortality rates for older children and adolescents because of relative low levels of acquired immunity, and analyses will be carried out for 5–9 year and 10–14 year old age groups if disaggregated data are available.

A particular focus in the interpretation will be in situations where there have been increases in recorded case incidence. However based in the conceptual framework of key factors affecting the impact of malaria programmes (see 3.3.3), only a subset of hypothesis are related to a deterioration of the programme, as shown in Figure 3. Some reasons for increases in reported case numbers may require programme adjustments while others do not. Where such increases are found an analysis will be conducted to identify the cause and appropriate responses.

Where the data available are inadequate for this analysis, this will be documented. In particular, it will be important to document the adequacy of data on age-specificity in HMIS data, especially clinical incidence in individuals of more than 5 years of age, and on the quality of commodities, especially ACT.

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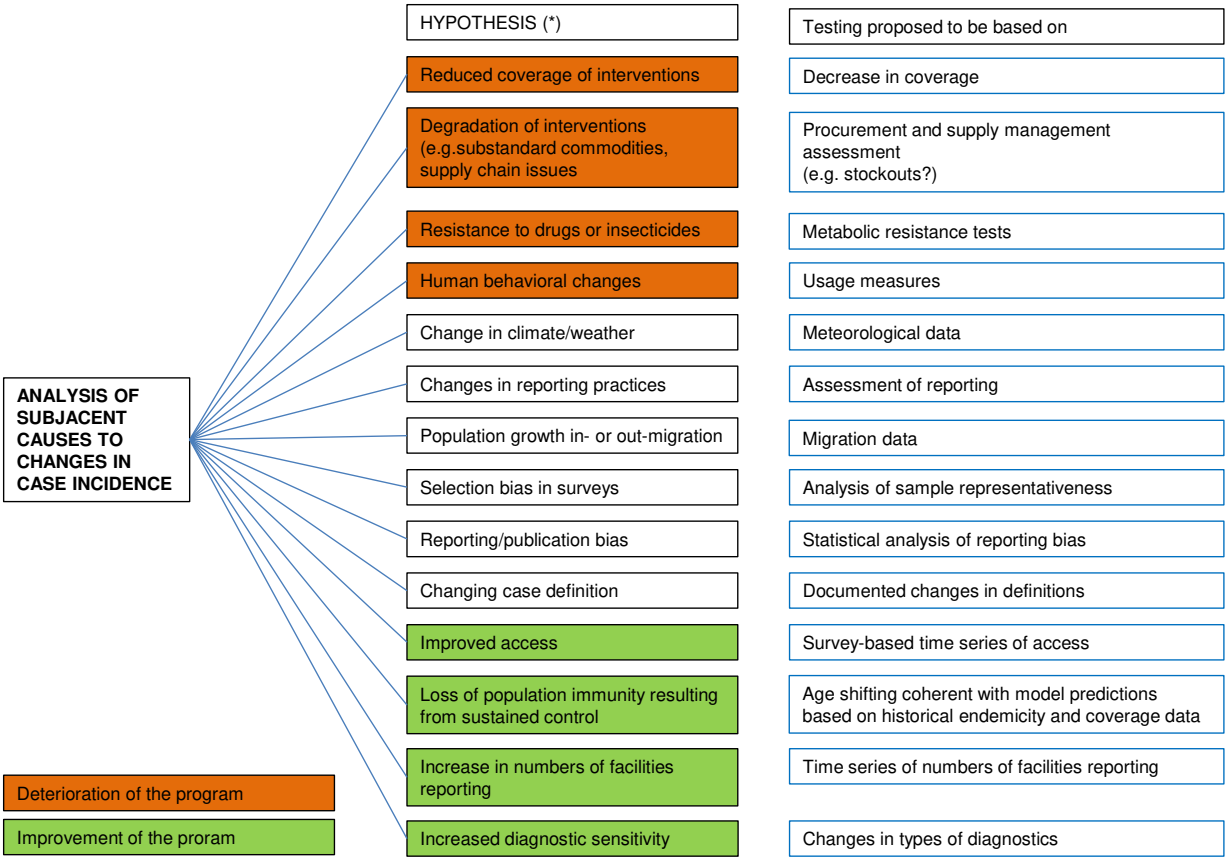

Figure 3. Analysis for identifying subjacent causes of changes in case incidence

1.4.5 Calibration of simulation models

Modelling can be used to complement analysis of data collected in a particular location. However, modelling still requires data to accurately represent the actual context of malaria in this particular setting. The calibration will be built on the data collated as described in section 1.4.2 (see Appendix A for more details). Where possible these data will be geo-located and disaggregated over time. If available the last survey done before the scale up of the interventions (and concurrent HMIS data) will be used for estimating the baseline and if available, a survey conducted in the last year preceding the impact evaluation will be used to represent the current situation.

Where possible this calibration will use local data. Values from research literature may be used where local values are unavailable (e.g. for certain entomological parameters, or for universal constants describing malaria infections).

A list of data required for calibrating the models is in Appendix A. The general strategy for calibration of the most important elements of the models will broadly be as follows:

Creation of high resolution maps

Geo-located data that were collated will be used to produce high resolution maps of predictions of incidence and prevalence based on data from HMIS or other similar sources and from community surveys (including Malaria Indicator Surveys (MIS) and Demographic and Health Surveys (DHS) if available). ITN usage and access to health facilities in the country and over time will also be mapped when applicable. Geospatial models will be applied using data collected at cluster levels to predict at high resolution while

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using covariates from remote sensing data. This highly technical step requires experts in geospatial modelling and could be subcontracted.

Estimation of parameter values and distributions at district level

High resolution maps provide high granularity but are not practical in real-world. Operations are often deployed at a higher geographical level and these estimates will in any case be more accurate in predicting at a higher level. Operationally, it is more appropriate to aggregate those estimates at district level. Utilizing the shape-files for each district together with predicted maps, yearly maps of distribution of malaria and interventions will be produced when applicable, accounting for variability within districts.

Parameterization of baseline transmission

The parameterization will use both the maps of predicted case-incidence and of predicted prevalence. The maps of predicted prevalence and incidence at baseline will be utilized to provide estimates of baseline transmission. Mathematical models (following the general approach of Yukich et al. (2012) will be used to combine the prevalence and incidence at district level to obtain estimated distributions for transmission rates, the required input parameter for transmission models such as *OpenMalaria.* Uncertainty and within-district heterogeneity in both prevalence, incidence, and access to care will be captured by discretizing each variable, computing the transmission for each combination, and population-weighting each combination to produce a distribution for transmission rate in each district.

Parameterization of seasonality in malaria transmission

Malaria transmission highly depends on seasonality and this is also the assumption in the model. As direct estimates are difficult to obtain, seasonality in malaria cases in the HMIS data will be used as a proxy. The method from Yukich et al. (2012) will be used to characterize seasonality based on data from health facilities. Vector abundance data may be used as an alternative if this is more available than temporal patterns of case incidence. For either of these sources of data, seasonality can be directly extracted with monthly values or indirectly using time series analyses (for districts with inadequate data).

Parameterization of effective coverage of case management

Rates of treatment of malaria obtained from HMIS data will be compared with population-based estimates (from MIS or DHS) to obtain to population prevalence data to estimate the reporting rates of fevers. Estimates of effective coverage, defined as a case of malaria appropriately receiving a treatment and clearing the infection, need to consider metrics on treatment seeking behaviour including the proportion of individuals seeking care and the type of facilities they go to, compliance of the health services to the national guidelines in terms of diagnosis and treatment, as well as adherence of the patient to treatment drug quality and cure rates (Galactionova et al. (2015). Data on each of these will be collated either in country or through literature review and in case of lack of available data assumptions will be made by extrapolating from other setting and consulting expert's opinion.

Parameterization of vector behaviour and resistance

Vector behaviour and resistance data are required to parameterize the models for each important Anopheles vector with different biting and resting behaviour, and sometimes independent levels of resistance to insecticides. In case these data are not available, sensitivity analyses can compare scenarios with different vector biting and resting behaviours, and resistance to insecticide will be assessed.

Parameterization of Intervention effects

For each intervention, model parameterization requires data on multiple components in particular for the effects of vector control interventions, including LLIN/IRS effects, on vector survival (accounting for insecticide resistance as appropriate) and coverage in terms of usage need to be defined. Intervention

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coverage estimates: i.e. LLIN ownership/usage, IRS coverage and treatment coverage will be extracted from community-based surveys such as MIS. Commodity distribution data such as the number of LLINs and ACTs distributed or the amount of insecticide used for IRS, as well as the number of RDTs used will complement this information. Relationships between indicators may be analysed to provide validation and better estimates of interventions coverage.

Parameterization of intervention coverage over time

If predicted maps of ITN usage and access to treatment are produced over time for each district (depends on the availability of raw data), the trend of intervention coverage will be modelled with a spline parameterized with a few number of parameters. The intervention history of each district will therefore be summarized by these parameters and the overall range of these parameters will represent the boundaries to be used for the simulations. Indeed, for each parameter, a certain number of levels of this parameter will be chosen between these boundaries to be run during the simulations.

1.4.6 General strategy for simulations

A scenario is defined as a sequence of events and circumstances that characterize a particular setting. Scenarios are run through the model to represent in silico what would happen given the values of the parameters that were utilized. An experiment consists of many scenarios where parameters have multiple levels and multiple combinations of these levels are simulated. A full factorial experiment, assessing each level of each parameter against one another will be run to encapsulate the ranges of settings in the country. Given the number of settings that needs to be simulated for the country, it will not be possible to simulate each of them but instead grids of simulations will be run and a look-out table will be produced to read predictions for a specific setting. In any case, a large number of simulations will be run (>50 000). The main model outcomes relevant for this methodology will be prevalence and incidence of malaria. However, other variables such as transmission and deaths could also be considered. The simulations will therefore provide predictions of prevalence and incidence of malaria for different scenarios. Indeed, scenarios could represent both different epidemiological profiles as well as different intervention strategies.

Using weighted estimates to represent the country settings

Each pixel of the map of the country can be characterized with parameters from the model including prevalence, intervention coverage, and access to treatment. As a result, each pixel will be attributed a weight vector that translate the different simulations from the run experiment into the specific settings of the pixel. Also each pixel will be attributed a weight according to its population size. Consequently, after aggregation each district will be attributed a weight vector which length is the number of simulations in the experiment. This weight vector corresponding to the input of the model will be applied to the output of the model to provide estimates of the predictions per district.

Aggregation and summary of results

The model will provide predictions of prevalence and incidence over time for each district. The results will be summarized geographically and temporally to present the impact of the interventions nationally as well as per strata. The impact of the programme will be estimates by comparing scenarios of different of different strategies (described below). Impact of the intervention will be assessed at specific time points as well as cumulative over time. The predictions will include levels of uncertainty composed of the model uncertainty as well as the geographical variability. Uncertainty in parameters can also be included in case of uncertainty in data collated.

1.4.7 Model-based estimation of past public health impact of the programme

The calibrated transmission models (e.g *OpenMalaria*) will be run to simulate the impact, from baseline up to the current time, of the scale-up of different malaria control interventions on national level trends in prevalence and incidence. These modelled trends of malaria prevalence will be compared to the available data (as in the example shown in Figure **4**), used to validate the parameterization of the models, and

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compared with the attribution of the programme effects from the plausibility analysis. To the extent that time and resources are available model estimates of malaria indicators and intervention coverage in space and time will be compared with local research datasets identified in the documentation library (e.g. HDSS), and malaria seasonality estimated from reported cases will be compared with seasonality in rainfall from remote sensing data.

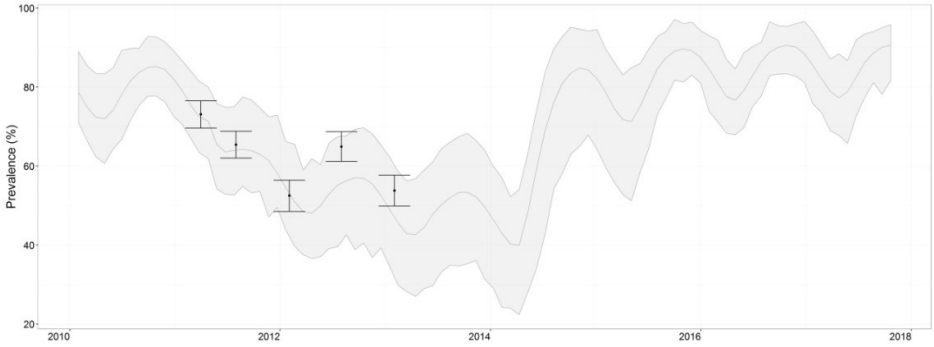

Figure 4: Illustration of a hypothetical trend of simulated malaria prevalence (grey shaded areas) compared to hypothetical prevalence data observed in community surveys (black error bars).

1.4.8 Model-based attribution of past public health impact to specific interventions

As different interventions are complementary to each other and part of the comprehensive control package, the estimation of the contribution to the impact made by different components of the programme is not straightforward. Further simulations will be used to estimate the contribution of each malaria control intervention to past changes in health outcomes. The contribution of each of the malaria control interventions will be evaluated by simulating the counterfactual trends in infection and disease that would have been observe had single interventions (or no interventions) been implemented. Summary statistics will be computed for predicted indicators corresponding to each of the health outcomes of interest (section 1.2.1). The predictions for single interventions will be compared with those for no intervention and for the true historical pattern of intervention, to assess the contribution of each of the interventions. This analysis will be analogous to the continent-wide analysis of Bhatt *et al.* (see Figure 5). The conclusions will be compared with those of the plausibility analysis (section 1.4.3).

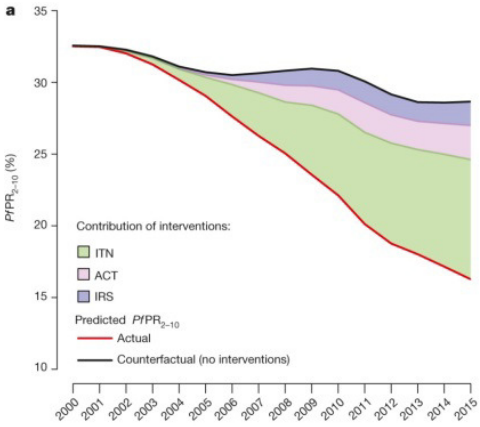

Figure 5: Estimated relative contributions of interventions to $PfPR_{2-10}$ reductions across Africa Source: Bhatt et al., 2015 (baseline year 2000)

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1.4.9 Prediction of the future public health impact of current strategy

A series of simulations will be carried out to project the future effects of the malaria programme based on malaria case management (including community services) and distribution of other preventive services at coverage levels and implementation currently estimated for each district. These simulations correspond to the status quo scenario. In addition, simulations will be carried assuming scale-up to National Strategy Plan (NSP) targets (the NSP scenario). In each case the public health impact will be computed for different time horizons.

1.4.10 Prediction of the future public health impact of alternative strategies

A series of scenarios for future interventions will be simulated to estimate the likely impact of alternative strategies being considered by the programme, in particular strategies aiming at national elimination. Each strategy being considered will be specified in terms of the anticipated coverage levels of case management (including community-based services) and/or vector control over time for each district. In each case the public health impact will be computed for different time horizons.

Each simulated intervention strategy will be compared to the status quo scenario. Additionally, the different interventions strategies proposed, will also be assessed against one another. Each scenario entailing changes relative to the current coverage will thus be compared with the status quo and with NSP targets with each intervention considered singly and in combination. The simulations will thus give rise to projected trajectories for each outcome and scenario (see schematic in Figure 6). The choice of the different scenarios to be simulated will be cover intensified coverage of the current strategy as well as additional elimination interventions as outlined in the National Malaria Elimination Plan if available.

As with the analysis of past interventions, the projections of the impact that is likely to be achieved from different candidate intervention strategies in the future can be extended to make summary predictions of expected impact for each intervention (as for the Kenyan example in Figure 6**: Illustration of Hypothetical trend of simulated malaria burden for scenarios with different interventions**: No further interventions deployed (blue); the current strategy continues (green); interventions coverage reach NSP targets (orange); an optimal intervention strategy is implemented (red)

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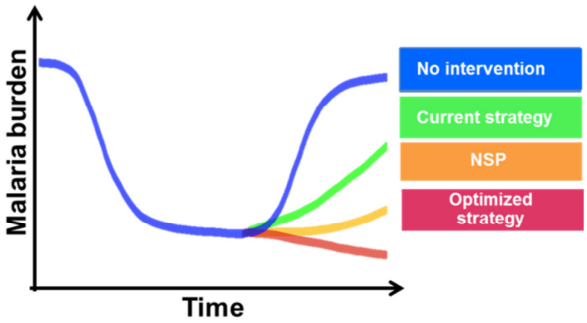

Figure 6: Illustration of Hypothetical trend of simulated malaria burden for scenarios with different interventions: No further interventions deployed (blue); the current strategy continues (green); interventions coverage reach NSP targets (orange); an optimal intervention strategy is implemented (red)

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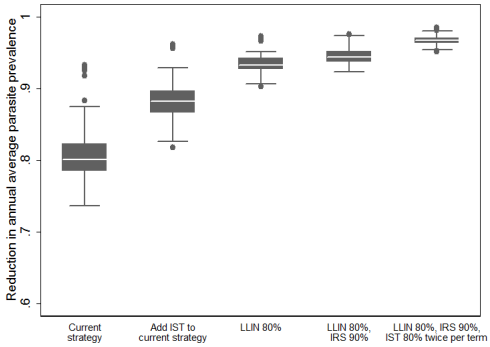

Figure 7: Predicted impact of different combinations of interventions in highlands of western Kenya. Source: Stuckey et al., 2012

1.4.11 Estimating malaria expenditures

The primary objective of the costing study is to assess resource (financial, economic, and physical) requirements to deliver malaria services implemented or planned for implementation by the NMCP. The general steps involved in implementing a costing study are similar regardless of the time frame chosen, thus the methodology presented below applies to all current, retrospective, and prospective costing analyses.

Malaria interventions

In the first step of the costing study a detailed mapping of the programme based on NMCP strategic documents and advice of programme officers is produced. It describes the programme and interventions delivered. The description covers:

- Stage implementation (planned or currently delivered)
- Target population and extent of coverage of target population
- Scope of the intervention (local, regional, and national)
- Mode (i.e. fixed facilities, campaign, etc.) and level of delivery (i.e. national, regional, etc.)
- Persons/agencies responsible for the development/implementation of the intervention

Costing approach

Micro-costing approach will be used to estimate the cost of malaria interventions. It is defined as a valuation technique which entails a detailed identification and measurement of inputs required for delivery of a given health care intervention; these are then converted into value terms to produce a cost estimate.

Cost estimation based on micro-costing methodology includes the following steps:

- Identifying activities involved in delivering the service or intervention
- Identifying types of inputs (or ingredients) such as health personnel, equipment, materials and supplies needed to undertake a specific activity
- Identifying discrete unit by which each ingredient is counted
- Assigning a monetary value to each ingredient unit
- Estimating quantities of each of the units required to complete the specific activity
- Multiplying unit costs by the quantities required to obtain ingredient cost estimates
- Adding ingredient cost estimates together to get a total activity cost estimate

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Data collection

Disaggregated data used to populate the National Health Accounts (NHA) malaria sub-account will be used, where possible, to estimate the cost of NMCP. Expenditure and resource use data will be extracted from the NHA tool (i.e. costing spread-sheets) used by the country to collect and aggregate malaria related expenditures, as well as survey sheets filled out by the programme and partners and programme executed budgets etc. to inform unit costs and resource assumptions for this study. Costing might require additional data collection to assess individual line-items for key activities; the latter would rely on a limited sample of providers at each service level and one that is informed by distribution of malaria interventions including priority areas (i.e. need to over-sample areas with low/ high transmission, or remote rural areas). Details on programme components and possible data sources that could be used to assess their respective economic value are detailed in the Appendix B.

Estimate expenditures

To facilitate interpretation and analysis, malaria related expenditures should be listed by source (i.e. government, partner, or household), intervention (i.e. prevention, treatment and prophylaxis, diagnosis, IEC, and programme management), type of input (capital or recurrent; fixed or variable), and type of costs (financial, economic). When estimating cost of malaria elimination strategy an additional stratification to distinguish between phases of elimination is suggested; namely, costs should be evaluated, and reported separately for control, elimination, and prevention of re-introduction phases.

Where possible, expenditures should be further classified into consumables, personnel, equipment and infrastructure, other operationally relevant expenditure categories. See Table 2 for an example of definitions used in the literature. These expenditure categories will be aligned with budget categories adopted by the country.

Table 2. Categories of programme expenditure

Expenditure category	Activities, cost line items
Consumables	Health commodities, including drugs, diagnostics, and insecticides Procurement, handling, and storage costs for health commodities Communications materials such as flyers and posters Administrative materials
Personnel	Salaries and benefits Training of malaria-specific staff and general health workforce on malaria-related issues Allowances and performance incentives
Equipment and infrastructure	Health-related equipment such as microscopes and other laboratory machinery Vehicle purchase and maintenance Administrative equipment such as computers Construction and maintenance of malaria-related building such as an insectary
Travel	Fuel Travel allowances such as for lodging and meals Other travel expenses such as airfare
Other	Meetings to related to planning and implementation of malaria-related activities Technical assistance provided by local or international experts

Source: Salbot et al. 2010

For intervention specific expenditure categories cost line items, their quantities and prices would be identified for each activity based on assumptions on future resource needs as outlined by the specific implementation scenario. Cost line items will include, for instance, entries for each labour unit (i.e. head of NMCP or nurse, etc.), type of commodity (i.e. ITN, LLIN, ACT, RDT, microscopy, etc.) and other key programme inputs.

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Shared inputs (i.e. overall management of the NMCP, capital costs etc.) are allocated to malaria related interventions based on percentage allocation informed with expert opinion (i.e. programme manager, MoH).

Sensitivity analysis

Assumptions made with respect to resource use and cost data could have important implications for the estimated cost of the programme. The impact of these assumptions on prediction will be assessed by means of sensitivity analysis. Key cost drivers identified during the costing study are to be varied either singly or jointly over a comprehensive range; the latter could be informed with estimates from the literature (i.e. costing studies of malaria programmes implemented in the region) or expert opinion.

1.4.12 Estimating return on past investment in malaria control

Estimating malaria investment

The value of past investment in malaria control and prevention will be obtained directly from the country NHA malaria sub-accounts. From tables detailing health expenditure by type of financing agent and type of function totals summarizing expenditures by country agencies and development partners will be extracted. These expenditures refer to financial obligations incurred for goods and services consumed and provided, and not to actual cash payments by the programme or partners (actuarial accrual). Implicitly the focus on financial transactions understates the full scope of resources used to deliver the services by the programme; it omits the opportunity cost of using existing in country capacity to deliver malaria services, the value of volunteer labour and in-kind transfers made by communities. Expenditure estimates from the NHA are subject to limitations imposed by the NHA approach including the difficulty and potential inconsistencies in mapping expenditure data from national and international agencies into standardized categories, reliance on expert opinion to attribute expenditure aggregates to disease categories and services, omission of expenditures related to malaria sequalae, etc.

These limitations could be mitigated to some extent by re-estimating malaria expenditures following micro-costing mythologies detailed above. This would entail mapping country stake-holders that contributed to control efforts in the past. Close collaboration with malaria stake-holders will be required to identify retrospectively key resource categories, level of resource use, and attribution of expenditures across interventions deployed.

Estimating benefits of investment in malaria control

Benefits of the programme will be expressed in terms of natural units (i.e. number of malaria episodes or DALY's averted, change in population at risk of malaria etc.) as well as specific programme targets (i.e. change in coverage of ITN's etc.). The methodology to assess these is detailed in sections 1.4.3 - 1.4.8.

Additionally, estimates of direct treatment health savings enabled by the programme will be estimated. These refer to expenditures averted due to reduction in malaria burden and include cost of treatment for episodes that would have occurred had the level of investment and scale of malaria services remained at the baseline level. Calculating treatment cost savings relies on estimates of disease averted attributable to the programme and is subject to country patterns in health-seeking for malaria. These could be best isolated with a modelling framework; in the absence of which, approximations based on scaled change in burden of the disease could be used. Estimates yielded with plausibility attribution are likely biased, attributing to the programme the impact of other factors affecting malaria epidemiology such as environmental change, economic, and social development.

The public health impact of the programme could also be expressed in terms of its monetary value. The key approaches to assign a monetary value to health outcomes include human capital, revealed preferences, and stated preferences (willingness to pay; WTP; Drummond at al 2005). In the prior, healthy life years gained by interventions implemented are quantified with market wage rates; it yields estimates of

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programme benefits in terms of the present value of future earnings. The latter two methodologies require surveying individual preferences: first one on health risks associated with a job versus wage rates at which individuals would be willing to accept that job, and second on contingency of a market existing for a given health benefit and maximum amount individuals would be willing to pay for it using vignette of benefits and alternative payoffs.

The scope of benefits is evaluated within a discreet window selected by the programme. By design it will to some degree include the impact of control efforts implemented prior to evaluation start year (i.e. due to long-lasting protective effect of LLIN's and to a lesser extent IRS) and at the same time understate the impact of interventions implemented over the evaluation period (i.e. the longer term benefits of reduced transmission (stickiness)).

Estimating return on investment in malaria control

Both costs and benefits will be assessed over 2005-2015 year period. Return on investment is then calculated as a ratio of total benefits enabled by malaria investment to programme costs incurred over the period. Similar calculation can be made when evaluating future investment on malaria control.

1.4.13 Evaluating malaria elimination strategy

NMCP formulated elimination scenarios will be first compared to status-quo (current implementation of malaria control) and then to each other. For the prior average cost-effectiveness ratio (ACER) will be estimated by relating the incremental costs of the elimination strategy net of any treatment health savings to its incremental health impact over sustained control. Treatment health savings are estimated as the difference in disease burden under a given elimination scenario and that estimated for the baseline; if positive – elimination strategy yields a health benefit (averts more disease compared to the comparator scenario), if negative – the new intervention yields a health loss (results in access burden compared to comparator scenario). Comparison of alternate elimination scenarios is based on incremental cost-effectiveness ratios (ICERs); these ratios illustrate the additional cost per an additional unit of health benefit relative to the next most effective option. Differences in effectiveness and costs of elimination alternatives are evaluated on the cost-effectiveness plane to establish their relative dominance. The analysis narrows the set of interventions to be considered for implementation by excluding strategies that are less effective and more costly relative to other available alternatives. A positive ICER implies a given intervention is both more effective and more costly than the next option; a negative ICER on the other hand suggests that the intervention is not only more effective but also less costly than the next option.

The general guidance for countries on deciding on whether or not to pursue elimination suggests the decision is best informed by a comprehensive cost–benefit analysis that compares the potential net benefits of elimination with those of continued controlled low-endemic malaria. The benefits incorporate reduced public and private expenditure, increased productivity, and educational attainment. Given gaps in evidence base on benefits of malaria elimination a conservative approach of focusing only on marginal costs and potential for cost-savings of the strategy is recommended here. If elimination is cost saving, and financial benefits alone exceed costs, NMCP and partners should be comfortable pursuing an elimination programme without quantifying additional benefits. If elimination is not cost saving, then gathering the evidence needed to calculate potential additional benefits becomes a priority.

Estimating costs of elimination strategy

To calculate costs of an elimination strategy, costing data are needed for the three phases encompassed by the strategy: the baseline of controlled low-endemic malaria, the interruption of transmission (or elimination phase), and the post -elimination (or prevention-of-reintroduction phase). Costs associated with sustained control and each of the phases of elimination will be assessed by costing specific elimination scenarios as defined by NMCP strategy. This would entail defining the scope of implementation for each intervention included in the strategy (population targeted, coverage rates, geography etc.), outlining the key

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activities involved in delivering each of the services, and then producing for each activity detailed lists of resources, quantities required, and respective unit prices. If multiple alternate elimination scenarios are considered, these can be costed analogously. The estimation follows methodological guidance provided under section 1.4.11.

Cost projections cover both short term and longer term horizons.

Estimating the probability that elimination strategy is cost saving

First the cumulative cost of the control programme is compared to that of elimination strategy at baseline. Then to assess the robustness of the comparison minimum-to-maximum sensitivity analyses on all major assumptions for both controlled low-endemic malaria and elimination are to be implemented by varying yearly costs by intervention category, time to elimination, cost of prevention of reintroduction, discount rate, and period of analysis to the smallest and largest values deemed realistic . Probabilistic analysis examining the 95% certainty intervals from Monte Carlo simulations using triangular distributions for all assumptions will be implemented. For these simulations, potential permutations of costs for controlled low-endemic malaria, elimination, and prevention-of-reintroduction phases will be calculated repeatedly by randomly drawing values from distributions around each assumption. For each run of sensitivity analysis, costs will then be compared. The probability that elimination strategy is cost saving compared to control is assessed across all sensitivity runs.

Estimating benefits of malaria elimination

While there is substantial evidence supporting sizable gains in moving from no malaria control activities to large control activities, it is unclear how large these gains may be and where the economic gains may be found when moving from a state of controlled low endemic malaria to malaria elimination (i.e. very low burden to no burden). It has been shown that most of the benefits associated with malaria elimination would already be realized in the sustained low endemicity phase; including the bulk of productivity gains and gains related to educational attainment. The argument for pursuing elimination focuses on the global and regional public good of removing the threat of a deadly epidemic-prone disease (Barrett (2003); Feachem et al. (2010)). Other economic benefits propagated by elimination include sustained gains in human capital, which in turn alter favourably investment decisions of individuals, foreign investors, and firms resulting in higher productivity for the country and the region following elimination (Sabot et al. (2010); Gallup and Sachs (2001)). These additional benefits of elimination are difficult to quantify, where it has been attempted the gains, have been shown to be modest (Modrek et al. (2012)).

For this reason estimation of benefits of malaria elimination strategy focuses on direct public health impact, treatment health savings, and other direct savings identified by the programme (i.e. changes programme expenditures due to changes in volume of services provided).

To support advocacy for control and elimination estimates of programme health benefits can be converted to economic gains. Most conservatively, these economic benefits can be calculated following the methodology adopted by the Roll Back Malaria. This entails multiplying the number of years of life saved by the programme by the present value of a 1-year increase in life expectancy; the latter is calculated by multiplying country GDP with a region-specific coefficient of economic returns to life expectancy as calculated by the Lancet Commission on Investing in Health. Alternatively, the economic benefits of reductions in malaria related mortality can be calculated by estimating and then multiplying the number of work years of life saved (i.e. incremental change of elimination over control strategy) by the monetary value of economic output per person of working age. The latter is calculated as real gross domestic products (GDP) divided by the working-age population of the country. To incorporate the forecast of future productivity growth, estimated GDP per person of working age is scaled with the ratio of per cent change in real GDP over per cent change in working population. The economic benefits are reported net of costs associated with malaria interventions i.e. as a net benefit. Finally to account for societal time-preferences, net benefits of malaria interventions are expressed in their value today by applying discounting.

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Appendix A. Required data for Plausibility Analyses and Modelling Impact

Data type	Sources	Available from	Operational definition	Level of aggregation	Purposes within this exercise
Recorded case incidence	Health Management Information Systems (HMIS) Reports from sentinel sites.	NMCP/MoH	INCIDENCE: (1000 * Number of confirmed malaria cases)/ Population at risk of malaria) Numerator: The number of suspected malaria cases confirmed by either microscopy or RDT. The number should include both outpatient and inpatient cases. The number should include cases detected passively (attending health facilities or seen by community health workers) or actively (sought in the community); a breakdown of cases detected passively and actively will be provided where possible. Denominator: The number of people living in areas where malaria transmission occurs (defined at the district level)	Facility, monthly if possible. Aggregated at District-level possibly by month and year If possible gender information and age categories (e.g. <1, 1–4, 5–14, >14). Minimally <5 and all age data distinguished.	estimating treatment rates; parameterising seasonality; model validation; plausibility analysis of trends in case incidence
Malaria-specific mortality	As above	NMCP/MoH	MALARIA MORTALITY RATE: (100 000 * Number of inpatient malaria deaths) / Population at risk of malaria Numerator: Cases in which the underlying cause of death is malaria. All recorded malaria deaths should have had a parasite-based test for malaria (microscopy and/or RDT) and a diagnosis based on the test result. Data on malaria deaths recorded from hospitals and other facilities with beds should be included. These are a subset of all malaria deaths. Denominator: The number of people living in areas where malaria transmission occurs.	As above	plausibility analysis of trends in mortality; parameterizing models of access to care for severe disease.
Malaria prevalence	Baseline and subsequent community surveys MIS/DHS,	NMCP/MoH	Proportion of a specified population with malaria infection at one time as per WHO malaria terminology (WHO 2016)	Enumeration Area	Plausibility analyses and model parameterisation
All cause child mortality	DHS	Open access	5q0: mortality risk for children under 5 years of age obtained from life tables estimated from birth histories.	By year	Plausibility analysis

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Intervention coverage measured in the community	DHS	DHS, NMCP/MoH	• Proportion of population at risk who slept under an insecticide-treated net the previous night • Proportion of population at risk protected by indoor residual spraying within the past 12 months • Proportion of patients with suspected malaria who receive a parasitological test • Proportion of patients with confirmed malaria who receive first-line antimalarial treatment according to national policy	Enumeration Area	Plausibility analyses and model parameterisation
Population	Census, WorldPop	Census bureau, WorldPop	Population size	enumeration area, pixel, or district	Plausibility analyses and model parameterisation
Vector bionomics (survival, host preferences, endophily, endophagy etc..)	Research literature	publications		As available	Parameterising models of vector control
Estimates of intervention effectiveness	Reports, Research literature	NMCP/MoH, implementation partners, publications	Susceptibility to insecticides, Efficacy of anti-malarials, Longevity of LLINs under field conditions	As available	Parameterising models of vector control
Environmental data		high resolution data are available at global level (NASA etc)	Remote sensed temperature, rainfall, topography, NDVI, landcover	High resolution	Model parameterisation
Quantities of commodities distributed	Additional sources if available (including operational studies) Detailed micro-planning data, ANC, EPI, PMTCT.	NMCP/MoH, implementation partners and academics	Commodities distributed (LLINs, IRS, treatments, RDTs) and volumes of insecticide for IRS(ACT & RDT) in health facilities and private sector. IPTp coverage.	By month, year, or quarter if possible. By district if possible.	Plausibility analyses, parameterising models of intervention coverage and economic evaluation
Shape-files of districts		NMCP/MoH/academic partners	All available, including the most recent	district	All analyses
Stocks, cost of commodities, storage, transportation	Central medical stores records	MoH	see Appendix B	Central or regional, by time as available	Economic evaluation
Stocks, cost of commodities, storage, labour	Health facility records, health facility surveys	MoH	see Appendix B	Facility, by time as available	Economic evaluation

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Appendix B. Costing data

Level of costs	Activities	Cost components	Sources of data
Start-up costs	Start-up	Planning meetings Training of programme staff Development of infrastructure Development of information and communication materials	Budgets and expenditure reports
Programme costs	Overall programme management; planning; surveillance, monitoring and evaluation	Planning meetings Surveillance, monitoring and supervision Development of behavior change communication Number of IEC material development meetings Number of days of IEC meetings Number of participants Per diem per participant Travel allowance Printing per leaflet or poster Radio/TV spot design TV/Radio AD airing charges Programme management staff Training of health staff No of/and duration of training Number of trainers Number of participants per training Per diem for trainers Travel Allowance for participants Per diem per participant Accommodation costs for trainers and participants	NMCP budgets and expenditure reports
Supply chain costs	Procurement	Demand forecasting and quantification Cost of commodities Cost of tendering/contracting out to different companies In-country handling charges (clearance fees) Volume package for transport of commodities Storage cost per m^3 per month No of months of storage Volume package of storage per m^3 Staff wage per month & percentage of staff time spent on procurement, storage and order processing Distribution costs	NMCP financial records; donors and other partners involved in procurement of commodities. Government purchase contracts and supply records Central medical stores records
Service delivery costs	Case management	Cost of diagnostics Costs of drugs per treatment Cost of building space and equipment used No of days of treatment Proportion of diagnostic tests conducted Proportion of microscopy conducted Wastage rates Cost of referral of patient Inpatient cost Average length of stay Labour costs Training of health staff	Health facility records Central medical stores for drugs and commodities price lists
	IPTp or IPTi/IPTc and SMC	Cost of drugs Wastage rate Numbers of patients provided with preventive treatment Labour costs Training of health staff	Health facility records
	ITNs/LLINs	Cost of ITNS/LLINs Distribution costs of ITNs/LLINs Numbers of ITNs/LLINs distributed Cost of labour Cost of IEC materials and BCC activities	NMCP records Implementing partners records
	IRS	Cost of insecticide spray Number of spray rounds in year Number people living in sprayed house Effective spray rate kg of active ingredient per m^2 Cost of labour	NMCP records Local authorities financial records

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