Annex 1 – Data sources and methods

Sections 1–8

Section 1: Introduction

Figure 1.1 The map shows the estimated incidence of malaria cases per 1000 population in 2013. See notes for Figures 8.3–8.5 for estimation of malaria cases per 1000 population.

Figure 1.2 The map shows the proportion of a country’s population that lives on less than US$ 2 per day, as estimated by the World Bank.¹

Section 2: Financing for malaria programmes

Figures 2.1 and 2.2 International financing data were obtained from three sources. The Global Fund supplied information on disbursements for malaria control to WHO up to 2013. Information on funding from the United States Agency for International Development (USAID) was obtained from ForeignAssistance.gov.² Malaria funding for the United States Centers for Disease Control was obtained from Congressional Justifications and Operating Plans (1).³ For other development agencies, information on disbursements was available up to and including 2012, through the Organisation for Economic Co-operation and Development (OECD) Development Co-operation Directorate database on official development assistance (ODA).⁴ Contributions from the Department for International Development (DFID), United Kingdom of Great Britain and Northern Ireland (UK) were assumed to have increased in 2013 in line with 2010–2012 disbursements. For other agencies, funding for 2013 was assumed to have remained at 2012 levels.

Domestic financing data were obtained from national malaria control programmes (NMCPs). Data included government total malaria budget and expenditures, broken down by programme components including malaria commodities, programme supervision and management, training, and behavioural change interventions. Where domestic financing data were not available, data from previous years were used. Domestic financing data do not include the cost of the time that health workers spend testing, treating and tracking malaria patients; capital costs (e.g. infrastructure or vehicles); and household spending on malaria prevention and treatment.

Figures 2.3 and 2.4 The potential for increasing global (domestic and international) malaria investments between 2014 and 2020 was explored through two financing scenarios:

- Global investments from endemic and donor countries increase at the projected rate of total government expenditures estimated by the International Monetary Fund (IMF) for 2014–2020.⁵ In the case of multilateral donors such as the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund), the average growth rate of government expenditures for all the countries contributing to the Global Fund over the 2014–2020 period was used.⁶ For the European Union (EU), which is a Global Fund contributor, the average government expenditure growth rate of EU countries contributing to the Global Fund’s budget in 2011–2013 was used.
- Data on net ODA from countries that participated in funding malaria control and elimination activities between 2010 and 2013 were used to calculate a donor investment effort for 2012,⁷ as the percentage of the donor country’s gross national income (GNI) allocated to ODA. The 2012 global average donor investment effort was then compared to the 0.7% target of GNI for ODA by 2015 (2, 3), and the necessary rate of increase was calculated for the 2012 global investment effort to reach the 2015 target of 0.7%. The rate of increase was then applied to international investments in malaria control until 2015. It was assumed that, after 2015, investments in malaria control and elimination would match the rate of increase of total government expenditures estimated by the IMF for 2016–2020. This second scenario also assumed that governments of endemic countries increase the priority they give to malaria funding. Levels of investment priority for malaria were estimated using the domestic investment priority index (DIPI), calculated as (government spending on malaria/government revenue) x (total population/population at risk). Countries were then classified into quartiles depending on their DIPI. Countries in the lowest quartile, Q1 (i.e. with DIPI ≤25th percentile), were assumed to increase their investment in malaria to reach the level of priority of countries in Q2. Similarly, countries in Q2 were assumed to increase their investments to the level of the next quartile (Q3). Countries in Q3 or Q4 were assumed to increase their investments in malaria control and elimination at the same rate of growth as their total government expenditures (as under scenario 2). For countries with insufficient data available for calculating the DIPI, it was assumed that spending increased at the same rate as government expenditures for countries for which there were no IMF data, it was assumed that domestic funding remained constant.

Section 3: Vector control for malaria

Tables 3.1 and 3.2 Policies regarding vector control interventions were reported to WHO by NMCPs.

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¹ http://data.worldbank.org/products/wdi
² http://www.foreignassistance.gov/web/default.aspx
³ http://www.cdc.gov/fmo/topic/Budget%20Information/
⁴ http://stats.oecd.org/index.aspx?datasetcode=CRS1#
⁵ http://www.imf.org/external/pubs/ft/weo/2014/02/weodata/weoselgr.asp
⁶ http://www.theglobalfund.org/en/partners/governments/
Countries and populations at risk

The main analysis covered 40 of the 47 (8) malaria endemic countries or areas of sub-Saharan Africa. The islands of Mayotte (for which no ITN delivery or distribution data were available) and Cabo Verde (which does not distribute ITNs) were excluded, as were the low-transmission countries of Namibia, Sao Tome and Principe, South Africa and Swaziland, for which ITNs make up a small proportion of vector control. Analyses were limited to populations categorized by NMCPs as being at risk.

Estimating national net crops through time

As outlined in Flaxman et al. (4), national ITN systems were represented using a discrete time stock-and-flow model. Nets delivered to a country by manufacturers were modelled as first entering a "country stock" compartment (i.e. stored in-country but not yet distributed to households). Nets were then available from this stock for distribution to households by the NMCP or other distribution channels. To accommodate uncertainty in net distribution, we specified the number of nets distributed in a given year as a range, with all available country stock (i.e. the maximum nets that could be delivered) as one extreme and the NMCP-reported value (i.e. the assumed minimum distribution level) as the other. New nets reaching households joined older nets remaining from earlier time-steps to constitute the total household net crop, with the duration of net retention by households governed by a loss function. Rather than fitting the loss function to a small external dataset, as was done by Flaxman et al., the loss function was fitted directly to the distribution and net crop data within the stock-and-flow model itself. Loss functions were fitted on a country-by-country basis, allowed to vary through time, and defined separately for conventional ITNs and LLINs. The fitted loss functions were compared to existing assumptions about rates of net loss from households. The stock-and-flow model was fitted using Bayesian inference and Markov chain Monte Carlo (MCMC) methods, providing time-series estimates of national household net crop for conventional ITNs and LLINs in each country, together with evaluation of under-distribution, all with posterior credible intervals.

Estimating national ITN access and use indicators from net crop

Rates of ITN access within households depend not only on the total number of ITNs in a country (i.e. net crop), but also on how those nets are distributed between households. One aspect that is known to strongly influence the relationship between net crop and the distribution of household ownership of nets is the size of households found in different countries, which varies greatly across sub-Saharan Africa. Many recent national surveys report the number of ITNs observed in each surveyed household. These data make it possible not only to estimate net crop, but also to generate a histogram that summarizes the net ownership pattern (i.e. the proportion of households with zero nets, one net, two nets and so on). In this way, the size of the net crop can be linked to distribution patterns among households, taking into account household size, making it possible to generate ownership distributions for each household size stratum. The bivariate histogram of net crop to distribution of nets among households by household size allowed for calculation of the proportion of households with at least one ITN. Also, because the number of both ITNs and people in every household can be triangulated, this histogram allowed for the direct calculation of two additional indicators: the proportion of households with at least one ITN for every two people, and the proportion of the population with access to an ITN within their household.

For the final ITN indicator – the proportion of the population who slept under an ITN the previous night – the relationship between ITN use and each of the three access indicators was explored for 74 of the 93 national surveys for which sufficient data were available. The proportion of the population with access to an ITN within their household displayed the largest correlation (adjusted $R^2 = 0.96$). This relationship was fitted using a simple Bayesian regression model, which was used to predict a time series of ITN use for every country.
Estimating ITN requirements to achieve universal access

The two-stage modelling framework represented the pathway from ITN delivery from manufacturers through to resulting levels of net access and use in households. It also accounted for two potential factors that may reduce access levels (i.e. the efficiency of allocation of nets to households during distribution, and the loss of nets from households over time), and allowed these to be quantified through time for each country. Using this architecture, it was possible to simulate delivery of any volume of ITNs to a given country over a given future time period, to predict the levels of access and use that would result, and to examine the impact of different amounts of allocation efficiency and net loss. The model was used to estimate the levels of access likely to be achieved by 2016 under a broad spectrum of LLIN delivery levels across the 4-year period. These simulations were run under two scenarios: the first being “business-as-usual”, where current levels were maintained for allocation efficiency and net loss (~a 2-year median retention time), and the second using maximized allocation efficiency and a 3-year median retention time.

Figure 3.3 The number of ITNs available in households was derived from the ITN coverage model described above. The number of ITNs (LLINs and conventional ITNs) distributed within countries were reported by NMCPs to WHO. The number of LLINs delivered to malaria endemic countries was reported by the seven World Health Organization Pesticide Evaluation Scheme (WHOPES)-approved manufacturers.

Figure 3.4 Estimates of the number of ITNs needed for different levels of access to nets in the population were derived from the ITN coverage model described above.

Figure 3.5 A total of 50 household surveys from 31 countries, conducted between 2000 and 2013, were analysed to establish a relationship between the proportion of different subpopulations sleeping under ITNs (children aged under 5 years, children aged 5–19 years and pregnant women) and the total population sleeping under an ITN. The results of the linear regression were then applied to estimates of the proportion of the total population sleeping under an ITN, produced by the model described above.

Figure 3.6 The proportion of households using ITNs below, at or above the standard capacity of two persons per net was calculated by comparing the number of persons with access to an ITN in each household to the number of persons who slept under an ITN as recorded in household surveys. Households in which the number of persons sleeping under an ITN was the same or greater than the number of persons who could have slept under an available ITN were categorized as using ITNs at or above capacity. Households in which the number of persons sleeping under an ITN was less than the number of persons who could have slept under an ITN were categorized as using ITNs below standard capacity.

Figure 3.7 The number of persons protected by indoor residual spraying (IRS) and the population at risk of malaria was reported by NMCPs to WHO.

Figure 3.8 See notes for Figures 3.1, 3.2 and 3.7 for derivation of the population at risk with access to an ITN in their household, and the proportion benefitting from IRS. Analysis of household-survey data indicates that about half of the people in IRS-sprayed households are also protected by ITNs (9). Therefore, the proportion of the population protected by either ITNs or IRS was estimated by adding half the proportion of the population protected by IRS to the proportion with access to an ITN. The coverage estimate is for June 30, 2013.

Figures 3.9 and 3.10 Insecticide resistance monitoring results were collected from NMCP reports to WHO, the African Network for Vector Resistance, the MAP, the PMI and the published literature. In these studies, confirmed resistance was defined as mosquito mortality of <90% on bioassay test.

Section 4: Preventive therapies for malaria

Table 4.1 Policies regarding preventive therapies were reported by NMCPs to WHO. The number of countries where seasonal malaria chemoprevention, intermittent preventive treatment in pregnancy (IPTp) and intermittent preventive treatment in infants (IPTi) are appropriate was based on criteria described in published WHO guidance for these interventions (10).

Figure 4.1 The number of pregnant women who attended an antenatal care clinic at least once and who received one, two or three doses of IPTp was derived from NMCP reports to WHO. The number of pregnant women receiving IPTp beyond their first trimester was calculated using the population at risk of malaria and the crude birth rate adjusted for still births and spontaneous abortions after the first trimester, published by the United Nations (UN) Development Programme (8):

\[
\text{Estimated number of pregnant women receiving IPTp beyond first trimester} = \frac{\text{2013 population at risk (country-specific)} \times \text{crude birth rate (country-specific)} \times 1.023 \times 1.004}{1000}
\]

For countries that reported on at least one of the IPTp data elements for 2013, having no visible bar for a data element denotes missing data. The Central African Republic, Gabon, Namibia, Nigeria and Somalia did not report on any IPTp data elements for 2013.

Figure 4.2 The proportion of pregnant women in the population receiving IPTp was derived from both NMCP-reported data and household survey data.

- Using NMCP reports and expected number of pregnancies in the population, as described above, the median value of the proportion of pregnant women who were receiving one dose of IPTp was calculated for each year, among reporting countries, from 2000 to 2013.

- For the estimates based on household survey data, the proportion of pregnant women receiving one, two or three or more doses of IPTp was calculated by approximate year of pregnancy, as determined by child-birth date in the household member roster. Most household surveys collected information on pregnancies during the 3–5 years before the survey date. IPTp indicators recommended by WHO and the Roll Back Malaria (RBM) Partnership Monitoring and Evaluation Reference Group (MERG) were reported by household survey year; the indicators include births within
2 years of the survey date, in an attempt to reduce recall bias regarding pregnancies that occurred more than 2 years before the survey. Calculating receipt of IPTp by year of pregnancy for all years covered by the survey increases the amount of information available to assess trends across countries. The observations for all surveys with data for a given year were combined and reweighted, based on type of survey, survey sampling design and country-year population estimates. The country-year point estimates were recalculated using the new weights. The median and interquartile range were then calculated among countries that had point estimates each year from 2000 to 2013.

Since few surveys with 2013 data were available, the estimates from 2013 household survey data for the first, second and third dose of IPTp shown in Figure 4.2 are projections from 6-year linear trend analyses. The NMCP data-derived estimates for first-dose IPTp (also shown in Figure 4.2) were not a projection; they provide the most recent and comprehensive estimates of IPTp coverage across countries implementing IPTp in Africa.

Section 5: Malaria diagnostic testing

Table 5.1 Policies regarding diagnostic testing were reported by NMCPs to WHO.

Figure 5.1 The proportion of suspected malaria cases receiving a malaria diagnostic test in public facilities was calculated from NMCP reports to WHO. The number of malaria diagnostic tests performed included the number of rapid diagnostic tests (RDTs) and microscopic slide examinations. Few countries reported the number of suspected malaria cases as an independent value. For countries reporting the total number of malaria cases as presumed malaria cases (i.e. cases classified as malaria without undergoing malaria parasitological testing) and confirmed malaria cases, the number of suspected cases was calculated by adding the number of negative diagnostic tests to the number of presumed and confirmed cases. Using this method for countries that reported only confirmed malaria cases for the total number of malaria cases, the number of suspected cases was equal to the number of cases tested. Such data are not informative when determining the proportion of suspected cases tested; therefore, countries were excluded from the regional calculation for those years in which they reported only confirmed cases for total malaria cases.

Figure 5.2 The proportion of children aged under 5 years with fever who received a finger or heel stick, and where they were brought for care, were calculated from available household survey data for 2000–2014 (the most recent surveys from 29 countries). Places of care that were included in the public sector health management information system were categorized as public facilities, and included public clinics and hospitals. Private facilities included private clinics, pharmacies and shops.

Figures 5.3, 5.4 and 5.5 Manufacturers reporting the number of RDT sales included 41 manufacturers that participate in RDT product testing by WHO, the Foundation for Innovative New Diagnostics (FINN), the United States Centers for Disease Control and Prevention (CDC) and the Special Programme for Research and Training in Tropical Diseases (TDR). The number of RDTs reported by manufacturers represents total sales to the public and private sector worldwide. The number of RDTs and artemisinin-based combination therapies (ACTs) distributed within countries by national programmes are reported by NMCPs to WHO, as are the number of microscopic examinations of blood slides performed for malaria parasites and number of RDTs performed.

Figure 5.6 Results of RDT product testing conducting by WHO, FIND, CDC and TDR were taken from *Malara* rapid diagnostic test performance: Results of WHO product testing of malaria RDTs: Round 5 (11). The panel detection score used to quantify RDT performance is an index that measures test positivity as well as inter-test and inter-lot consistency. The score is the frequency with which all RDTs tested on a sample in the evaluation panel are positive (two RDTs from each of two lots positive against 2000–5000 parasite/μl sample, and one RDT from each lot positive for 2000–5000 parasite/μl sample). Therefore, for a sample at 200 parasites/μl, four of four tests have to be positive for that sample to be considered detected by RDT; for a sample at 2000–5000 parasites/μl two of two tests have to be positive for that sample to be considered detected by RDT.

Section 6: Malaria treatment

Table 6.1 Policies regarding malaria treatment were reported by NMCPs to WHO.

Figure 6.1 The proportion of children with uncomplicated malaria (defined as fever in the 2 weeks preceding the survey and parasite infection measured by an RDT at the time of the survey) receiving an ACT was estimated for all countries in sub-Saharan Africa in 2003–2012, using a three-step modelling approach:

1. **Fitting a model to predict whether a child with fever has a malaria infection:** For 37 countries with a demographic and health survey (DHS) or malaria indicator survey (MIS), the malaria parasite infection status of a child was assessed from an RDT given at the time of the survey. It was assumed that a positive RDT provides a reasonable measure of a 2-week prevalence of infection (12–14). A logistic regression model was created to predict malaria parasite infection amongst febrile children in surveys in which RDT testing was not performed. Covariates in the model included the child’s age and sex, household wealth quintile, ITN ownership, facility type where treatment was sought (public or other), urban or rural status, and malaria transmission intensity, as measured by the *Plasmodium falciparum* parasite rate (PPR) of children aged 2–10 years (PPR2–10).

2. **Predicting the infection status of children in surveys in which RDTs were not used:** Coefficients estimated from the logistic regression model in Step 1 were used to obtain predictions of infection status among all children with a fever from DHS and multiple indicator cluster surveys (MICS) in which RDT testing had not been performed (66 surveys). The national survey-weighted proportion of febrile children with a malaria parasite infection (RDT measured or imputed) aged under 5 years who received an ACT was then calculated for all surveys.

3. **Estimating the proportion of children with malaria that received an ACT:** ACT distribution data reported by NMCPs were used to calculate a predicted ACT “availability” per person at risk for *P. falciparum* malaria in each country. A linear model was then created to predict the proportion of children with malaria receiving an ACT, using ACT availability per capita in the current and previous year as a covariate. Additional covariates,
obtained from the World Bank dataset, included national ITN coverage (by year), measles vaccination coverage, GNI and the proportion of births with a skilled birth attendant. The model was run in a Bayesian framework using MCMC methods, and included uncorrelated random effects for each country and correlated (autoregressive) random effects for each year. For non-survey years, the proportion of children who received ACT for each country and year (2003–2012) was imputed based on the relationship between ACT coverage and ACT availability across countries.

Publicly available sources of population-based survey data were considered if they included a module assessing fever treatment for children aged under 5 years, categorized by type of antimalarial received. For the period 2003–2012, 16 MIS, 55 DHS and 20 MICS were included. Estimates of mean PPR2–10, as well as the total population at risk of malaria, were ascertained from the MAP for 2010. Population growth rates were derived from the UN Population Prospects database.

**Figure 6.2** The proportion of children aged under 5 years brought for care, and where they were brought for care, were calculated from the most recent household survey undertaken for each country in sub-Saharan Africa (a total of 29 surveys). Public sector places of care included hospitals, health centres and health posts. The formal private sector included private clinics and doctors. The informal private sector included pharmacies, drug stores, shops and traditional healers. Community included care provided by community health workers.

**Figures 6.3 and 6.4** Data on ACT sales were provided by eight manufacturers eligible for procurement by WHO/United Nations Children’s Fund (UNICEF). ACT sales were categorized as either to the public sector or to the private sector, and products were grouped according to type of ACT and product presentation (i.e. co-formulated and co-blistered). Data on ACTs distributed within countries through the public sector were taken from NMCP reports to WHO.

**Figure 6.5** The availability of ACTs in public sector health facilities was measured as the ratio of distributed ACTs reported by NMCPs to the estimated number of presumed and confirmed malaria cases attending public sector health facilities. For countries outside Africa and countries in Africa with consistent reporting, the estimated number of presumed and confirmed cases in the public sector was derived from NMCP reports, corrected for reporting completeness. For countries in Africa with inconsistent reporting, the estimated number of presumed and confirmed cases in the public sector was derived from the estimated number of confirmed malaria cases (see Section 8.3); the proportion of suspected cases tested; and the slide positivity rate (SPR), where:

\[
\text{estimated presumpt} = 1 - \left( \frac{\% \text{ suspected cases}}{\text{estimated confirmed cases}} \times \text{SPR} \right)
\]

The proportion of children aged under 5 years with fever who received ACT among those who received any antimalarial treatment was calculated from available household survey data for countries in sub-Saharan Africa for 2005–2013. Definitions of public sector and private places of care were as described in the diagnostic testing section. Places of care that were included in the public sector health management information system were categorized as public facilities, and they included public clinics and hospitals. Private facilities included private clinics, pharmacies and shops. For recent surveys for which the dataset was not available but a written report had been released, the proportion of ACTs among any antimalarial treatment given was imputed based on the relationship between the indicator for all febrile children and for those children in the public and private sector in other household surveys.

**Figure 6.6** The estimated proportion of confirmed malaria cases and non-malaria cases receiving or not receiving ACTs at public health facilities in the WHO African Region for each year were derived from data reported by national programmes. The ratio of distributed ACTs to the estimated number of presumed and confirmed malaria cases was calculated as described for Figure 6.5 and used for the proportion of cases receiving ACTs. The proportion of suspected malaria cases tested was calculated as for Figure 5.1. The malaria test positivity rate was calculated from the number of malaria diagnostic tests performed and the number of tests positive for malaria. The distributed ACTs were apportioned evenly to presumed and confirmed cases. The proportion of confirmed cases among presumed and confirmed cases was derived from the proportion of suspected cases tested and the malaria test positivity rate. Non-malaria cases included suspected malaria cases that were tested negative, and presumed cases that would have been negative had they been tested.

**Section 7: Gaps in intervention coverage**

**Figure 7.1** Data on intervention coverage were derived from nationally representative household survey data from MICS, MIS and DHS conducted in 2011–2013. In total, 21 surveys included data about households without nets; 20 surveys included data on pregnant women who did not receive IPTp; and 23 surveys included data on febrile children aged under 5 years who did not seek treatment and did not receive an ACT, 20 of which also included data on febrile children who did not receive a diagnostic test. For each survey, the proportions of households or children aged under 5 years not covered by a given intervention were calculated over the entire population and within various subpopulations, taking into account the sampling design. The median de facto household population size within each survey was calculated for inclusion in the final analysis. The quartile estimates and interquartile ranges were calculated across all of the country-level proportions.

**Figure 7.2** The proportions of the subpopulations not covered by a given intervention within each survey were assembled and used to fit linear regression models for each service, to predict the overall lack of coverage. The choices of subpopulations were based on published literature reviews that identified the factors most likely to influence coverage estimates. For the household-level analysis, the subpopulations included levels of wealth, presence (or lack) of at least one pregnant woman or child aged under 5 years, education level of the
household head, type of residence and relative household size. For the child-level analyses, the subpopulations included levels of household wealth, type of residence, education level of the mother, age of the child, gender of the child and relative household size. Model selection was based on the optimal R², Akaike information criterion and Bayesian information criterion scores for all possible predictor combinations. The decomposition of the R² goodness-of-fit estimator for linear models has been suggested as a method to describe the relative contribution of predictors across the entire distribution of a continuous outcome (15). In this analysis, the decompositions of the goodness-of-fit estimators for each linear model, presented as Owen decomposition values, describe the degree to which different factors contributed to the observed lack of coverage across the surveys. This does not necessarily imply a causal relationship, and the contributions of the individual factors do not necessarily reflect their level of statistical significance in any given country.

Figure 7.3 The country-specific differences in coverage between levels of endemicity were examined by calculating the absolute difference between the intermediate-to-high malaria risk coverage estimates and the no-to-low malaria risk coverage estimates. The malaria endemicity level was determined by extracting the raster values from the data layers of MAP’s forthcoming 2000–2013 time series of PPR at all available survey cluster locations, and classifying those within each cluster as having no-to-low risk or intermediate-to-high risk of malaria. The cluster-level extraction data from PPR raster values were provided by the MAP. The household-level analysis used cluster-level classifications based on PPRs for the year 2000 to take into account the impact of ITNs on the parasite rate. In the other analyses, endemicity classifications were based on the PPRs for the survey year.

Section 8: Trends in infections, cases and deaths

Figures 8.1 and 8.2 The main source of information on reported numbers of malaria cases and deaths are the disease surveillance systems operated by ministries of health. Data from such systems have three strengths: (i) case reports are recorded continuously over time and can thus reflect changes in the implementation of interventions or other factors; (ii) routine case and death reports are often available for all geographical units of a country; and (iii) the data reflect the burden that malaria places on the health system. Changes in the numbers of cases and deaths reported by countries do not, however, necessarily reflect changes in the incidence of disease in the general population, for several reasons. First, not all health facilities report each month; hence, variations in case numbers may reflect fluctuations in the number of health facilities reporting rather than a change in underlying disease incidence. Second, routine reporting systems often do not include patients attending private clinics or morbidity treated at home, so disease trends in health facilities may not reflect trends in the entire community. Finally, not all malaria cases reported are confirmed by microscopy or RDT; hence, some of the cases reported as malaria may actually be other febrile illnesses (16, 17).

When reviewing data supplied by ministries of health in malaria endemic countries, the following strategy was used to minimize the influence of these sources of error and bias:

- **Focusing on confirmed cases (by microscopy or RDT) to ensure that malaria (not other febrile illnesses) was tracked.** For high-burden countries in the WHO African Region, where there is little confirmation of cases, the numbers of malaria admissions (in-patient cases) and deaths were reviewed, because the predictive value of malaria diagnosis for an admitted patient is considered to be higher than that of an outpatient diagnosis. In such countries, the analysis may be heavily influenced by trends in cases of severe malaria rather than trends in all cases.

- **Monitoring the number of laboratory tests undertaken.** It is useful to measure the annual blood examination rate (ABER), to ensure that potential differences in diagnostic effort or completeness of reporting are taken into account. To discern decreases in malaria incidence, the ABER should ideally remain constant or be increased. In addition, it is useful to monitor the percentage of suspected malaria cases that are examined with a parasite-based test. Some authorities recommend that the ABER should be >10%, to ensure that all febrile cases are examined; however, the observed rate depends partly on how the population at risk is estimated, and trends may still be valid if the rate is <10%. A value of 10% may not be sufficient to detect all febrile cases. In Solomon Islands, a highly endemic country, the ABER exceeds 60%, with an SPR of 25%, achieved solely through passive case detection.

- **Monitoring trends in the SPR or RDT positivity rate.** This rate should be less severely distorted by variations in the ABER than trends in the number of confirmed cases.

- **Monitoring malaria admissions and deaths.** For high-burden African countries, when reviewing the number of malaria admissions or deaths, it is also informative to examine the number of admissions from all causes, which should remain constant or be increased. If the total number of admissions fluctuates, then it may be preferable to examine the percentage of admissions or deaths due to malaria, because this proportion is less sensitive to variation in reporting rates than the number of malaria admissions or deaths.

- **Monitoring the number of cases detected in the surveillance system in relation to the total number of cases estimated to occur in a country.** Trends derived from countries with high case detection rates are more likely to reflect trends in the broader community. When examining trends in the number of deaths, it is useful to compare the total number of deaths occurring in health facilities with the total number of deaths estimated to occur in the country.

- **Examining the consistency of trends.** Unusual variation in the number of cases or deaths that cannot be explained by climate or other factors, or inconsistency between trends in cases and in deaths, can suggest deficiencies in reporting systems.

- **Monitoring changes in the proportion of cases due to *P. falciparum* or the proportion of cases occurring in children aged under 5 years.** Decreases in the incidence of *P. falciparum* malaria may precede decreases in *P. vivax* malaria, and there may be a gradual shift in the proportion of cases occurring in children aged under 5 years; however, unusual fluctuations in these proportions may point to changes in health-facility reporting or to errors in recording.
These procedures help to rule out data-related factors (e.g. incomplete reporting or changes in diagnostic practice) as explanations for a change in the incidence of disease. The aim is to ensure that trends in health-facility data reflect changes in the wider community, which is more likely in situations where changes in disease incidence are large; coverage with public health services is high; and interventions promoting change, such as use of ITNs, are delivered throughout the community rather than being restricted to health facilities.

Where data reported by NMCPs were sufficiently complete and consistent to reliably assess trends between 2000 and 2013, a country was classified as being on track to achieve, by 2015, a decrease in case incidence of >75%, 50–75% or <50%, or to experience an increase in case incidence by 2015, using 2000 as the baseline. A 75% reduction in malaria case incidence is equivalent to a 5% reduction per year between 2000 and 2015. Thus, to achieve a reduction of 75% by 2015, countries need to have reduced the incidence of malaria by at least 65% between 2000 and 2013. Countries that reduced malaria incidence rates by 43–65% between 2000 and 2013 are projected to achieve reductions in malaria case incidence of 50–75% in 2015.

### Table 8.1

The criteria used to classify countries according to programme phase were updated in 2012 to facilitate tracking of progress over time (18). The updated criteria are based on an evaluation of three main components: the malaria epidemiological situation, case-management practices and the state of the surveillance system (as shown in Table A.1). The evaluation concentrates on the situation in those districts of the country reporting the highest annual parasite index (API). Other components – for example, the stated programme goal, vector control and malaria prevention practices, and health systems and financing – are also important for tracking progress towards elimination; however, they are less specific and are therefore not included as classification criteria.

#### Table A.1 Criteria for classifying countries according to malaria programme phase

<table>
<thead>
<tr>
<th>Malaria situation in areas with most intense transmission</th>
<th>Pre-elimination</th>
<th>Elimination</th>
<th>Prevention of reintroduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test positivity rate &lt;5% among suspected malaria patients throughout the year</td>
<td>Yes</td>
<td>Yes</td>
<td>(1) Recently endemic country with zero local transmission for at least 3 years or (2) country on the register or supplementary list that has ongoing local transmission</td>
</tr>
<tr>
<td>API in the district with the highest number of cases/1000 population/year (ACD and PCD), b averaged over the past 2 years</td>
<td>&lt;5 (i.e. fewer than 5 cases/1000 population)</td>
<td>&lt;1 (i.e. fewer than 1 case/1000 population)</td>
<td></td>
</tr>
<tr>
<td>Total number of reported malaria cases nationwide</td>
<td>A manageable number (e.g. &lt; 1000 cases, local and imported) nationwide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All cases detected in the private sector are microscopically confirmed</td>
<td>National policy being rolled out</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>All cases detected in the public sector are microscopically confirmed</td>
<td>National policy being rolled out</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Nationwide microscopy quality assurance system covers public and private sector</td>
<td>Initiated</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Radical treatment with primaquine for P. vivax</td>
<td>National policy being updated</td>
<td>National policy fully implemented</td>
<td></td>
</tr>
<tr>
<td>Treatment with ACT plus single-dose primaquine for P. falciparum</td>
<td>National policy being updated</td>
<td>National policy fully implemented</td>
<td></td>
</tr>
<tr>
<td>Surveillance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaria is a notifiable disease nationwide (&lt;24–48 hours)</td>
<td>Laws and systems being put in place</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Centralized register on cases, foci and vectors</td>
<td>Initiated</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Malaria elimination database</td>
<td>Initiated</td>
<td>Yes</td>
<td>Certification process (optional)</td>
</tr>
<tr>
<td>Active case detection in groups at high risk or with poor access to services (proactive case detection)</td>
<td>Initiated</td>
<td>Yes</td>
<td>In residual and cleared-up foci, among high-risk population groups</td>
</tr>
<tr>
<td>Case and foci investigation and classification (including reactive case detection and entomological investigation)</td>
<td>Initiated</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

**ABER**: annual blood examination rate; **ACD**: active case detection; **API**: annual parasite index; **PCD**: passive case detection.

**Figures 8.3–8.5**

Maps of *P. falciparum* infection prevalence (PPR<sub>2005</sub>) and associated national-level estimates of average PPR<sub>2005</sub> for countries in sub-Saharan Africa were derived from a geostatistical modelling framework developed by the MAP. The model drew on three categories of data:

- Geopositioned community-based survey measurements of PPR were identified through periodic literature searches for published data sources, direct communication with malaria specialists for unpublished data sources, and national household surveys. Surveys were primarily conducted in children aged under 5 years, although those based on any defined age range of individuals were included. Most surveys were conducted using microscopy or RDTs to identify infected individuals. After checks for consistency, completeness and duplication, a final assembly was defined for subsequent modelling consisting of 28 361 spatio-temporally unique observations at time points between 1995 and 2014.
- Input data layers were also assembled, to represent levels of intervention coverage. For ITNs, national-level trends in ITN use were taken from the coverage model described...
earlier (see Section 3). This was used in conjunction with a geostatistical model to generate a continuous space-time “cube” predicting the proportion of individuals sleeping under an ITN the previous night for every 5 × 5 km pixel, and expressed as an annual mean. For IRS, annual reports from NMCPs were assembled, detailing the proportion of the population at risk targeted for coverage each year (note: this does not necessarily represent the proportion ultimately receiving and protected by the intervention). For ACTs, national household survey data were assembled from 93 surveys on the proportion of children with fever accessing an ACT; this was used as a proxy for access to effective antimalarial drugs in clinical malaria cases across the population as a whole. To estimate this coverage in country-years for which no survey was available, an empirical model was built that related coverage levels to the number of ACT courses distributed per capita in each country each year. The latter variable was available from NMCP reported data, and was largely complete for the period 2000–2013.

- A suite of 20 environmental and sociodemographic geospatial input layers were also developed and used as covariates in the PfPR model. Existing approaches to constructing and selecting covariates for this purpose are crucial, but have often been subjective and ad hoc (e.g. a huge variety of covariates are used in modelling with little quantitative justification). To address this, we undertook an exhaustive covariate construction and selection process. First, a literature review was conducted to establish a comprehensive list of variables that have been used as covariates in malaria mapping. Second, a large library of covariate data was assembled to reflect this list, including the construction of dynamic versions where possible. Third, the resulting set of 33 base covariates was leveraged to create more than 50 million possible covariate terms via factorial combinations of different spatial and temporal aggregations, transformations and pairwise interactions. Fourth, the expanded set of covariates was tested via successive selection criteria to yield an optimum covariate subset that maximized out-of-sample predictive accuracy. The final subset included predominantly dynamic covariates; it substantially out-performed earlier sets used in global malaria risk maps from the MAP.

These data sources were then used in a space–time Bayesian geostatistical model that was a more sophisticated version of an earlier approach constructed by the MAP (19). The new model included mechanisms to adjust the PfPR survey data by the age range of individuals observed, the season of each survey and the type of diagnostic used. The impact of interventions was modelled by fitting flexible functional forms to capture the separate effects of ITNs, IRS and ACTs on declining PfPR as a function of coverage reached, and the starting (pre-intervention) PfPR in the year 2000. The model was used to predict a spatio-temporal cube of age-specific PfPR at 5 × 5 km resolution across Africa for each year from 2000 to 2013. Detailed maps of year-specific human population density from the WorldPop project10 were used, in conjunction with the PfPR cube, to calculate population-weighted mean PfPR,11 for each country and each year. The average number of contemporaneous infections in each country and year was calculated by multiplying the annual mean all-age PfPR by the population in each pixel, then summing across all pixels in each country.

### Tables 8.2 and 8.3, and Figures 8.6–8.8

The methods for producing estimates of malaria cases and deaths in 2000–2013 either adjusted the number of reported cases to take into account the proportion of cases that were not captured by a surveillance system or, for countries with insufficient surveillance data, produced estimates using a modelled relationship between malaria transmission, case incidence or mortality, and intervention vector control coverage, as outlined below.

#### Cases

The number of malaria cases was estimated by one of two methods:

- For countries outside the WHO African Region and low-transmission countries in Africa: estimates of the number of cases were made by adjusting the number of reported malaria cases for completeness of reporting, the likelihood that cases are parasite-positive and the extent of health-service use. The procedure, which is described in the World malaria report 2008 (16, 20), combines data reported by NMCPs (reported cases, reporting completeness, likelihood that cases are parasite-positive) with those obtained from nationally representative household surveys on health-service use. If data from more than one household survey were available for a country, estimates of health-service use for intervening years were imputed by linear regression. If only one household survey was available, then health-service use was assumed to remain constant over time; analyses summarized in the World malaria report 2008 indicated that the percentage of fever cases seeking treatment in public sector facilities varies little over time in countries with multiple surveys. Such a procedure results in an estimate with wide uncertainty intervals around the point estimate.

- For countries in the WHO African Region: for some African countries, the quality of surveillance data did not permit a convincing estimate to be made from the number of reported cases. For these countries, an estimate of the number of malaria cases was derived from an estimate of the number of people living at high, low or no risk of malaria. Malaria incidence rates for these populations were inferred from longitudinal studies of malaria incidence recorded in the published literature. Incidence rates were adjusted downwards for populations living in urban settings, and for the expected impact of ITN and IRS programmes. The procedure was initially developed by the RBM MERG in 2004 (21) and also described in the World malaria report 2008.

### Deaths

The number of malaria deaths was estimated by one of two methods:

- For countries outside the WHO African Region and for low-transmission countries in Africa:11 the number of deaths was estimated by multiplying the estimated number of P. falciparum malaria cases by a fixed case fatality rate for each country, as described in the World malaria report 2008. This method was used for all countries outside the WHO African Region and for countries within the WHO African Region where estimates of case incidence were derived from routine reporting systems and where malaria causes less than 5% of all deaths in children.

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10 http://www.worldpop.org.uk/
11 Botswana, Cabo Verde, Eritrea, Madagascar, Namibia, South Africa, Swaziland and Zimbabwe
aged under 5 years, as described in the Global Burden of Disease 2004 update (22). A case fatality rate of 0.45% was applied to the estimated number of P. falciparum cases for countries in the WHO African Region, and a case fatality rate of 0.3% for P. falciparum cases in other regions. In situations where the fraction of all deaths due to malaria is small, the use of a case fatality rate in conjunction with estimates of case incidence was considered to provide a better guide to the levels of malaria mortality than attempts to estimate the fraction of deaths due to malaria.

- For countries in the WHO African Region: child malaria deaths were estimated using a verbal autopsy multi-cause model developed by the WHO Child Health Epidemiology Reference Group to estimate causes of death for children aged 1–59 months in countries with less than 80% of vital registration coverage (23-25). A total of 128 data points from 95 verbal autopsy studies and 37 countries that met the inclusion criteria were included. Among them, 47 data points were either new or updated from the previous estimates of malaria deaths published in the World malaria report 2012. Mortality estimates were derived for seven causes of post-neonatal death (pneumonia, diarrhoea, malaria, meningitis, injuries, pertussis and other disorders), causes arising in the neonatal period (prematurity, birth asphyxia and trauma, sepsis, and other conditions of the neonate) and other causes (e.g. malnutrition). Deaths due to measles, unknown causes and HIV/AIDS were estimated separately. The resulting cause-specific estimates were adjusted country by country to fit the estimated 1–59 month mortality envelopes (excluding HIV and measles deaths) for corresponding years. Estimates were then further adjusted for intervention coverage; that is, pneumonia and meningitis estimates were adjusted for the use of Haemophilus influenzae type b vaccine, and malaria estimates were adjusted for the use of ITNs.

The bootstrap method was employed to estimate uncertainty intervals by re-sampling from the study-level data to in turn estimate the distribution of the predicted percentage of deaths due to each cause. Deaths in those above the age of 5 years were inferred from a relationship between levels of malaria mortality in different age groups and the intensity of malaria transmission (26); thus, the estimated malaria mortality rate in children aged under 5 years was used to infer malaria-specific mortality in older age groups.

Malaria incidence and mortality rates were estimated using “total population at risk for malaria” as a denominator. Projections to 2015 were based on a linear extrapolation of the trend in incidence and mortality rates from 2000 to 2013.

Table 8.4, Figures 8.9 and 8.10 The number of cases averted and lives saved between 2001 and 2012 was estimated by calculating the number of cases and deaths that would have occurred if incidence and mortality rates had remained at 2000 levels until 2013 (i.e. had there been no progress). The calculated number of cases and deaths was compared with the estimated number of cases and deaths presented above. The lower numbers of cases and deaths in 2013 compared to 2000 may be due in part to factors other than the expansion of malaria programmes. Some progress is likely to be related to increased urbanization and overall economic development, which lead to improvements in housing and nutrition.

Regional profiles

Figure A. Incidence rates are derived from reports of confirmed malaria cases in 2013 (by microscopy or RDT) from ministries of health to WHO, and from the number of people living at risk for malaria in each geographical unit as reported by NMCPs. Incidence rates are corrected for reporting completeness by dividing by the proportion of health-facility reports received in 2013 by the number expected. If subnational data on population or malaria cases were lacking, an administrative unit was labelled “no data” on the map. In some cases, the subnational data provided by the NMCP did not correspond to a mapping area known to WHO, either because of modifications to administrative boundaries, or the use of names not verifiable by WHO. The maps for countries in sub-Saharan Africa display a combination of: cases per 1000 per year, and parasite prevalence in areas with >10 cases per 1000 population per year. To obtain a measure of combined parasite prevalence for both P. falciparum and P. vivax, the sum of the two independent parasite rates (19, 27) was calculated at each point (~5 km2). Data on environmental suitability for malaria transmission were used to identify areas that would be free of malaria.

Figure B. Sources of data for the financial contributions are as described for Figure 3.1.

Figure C. Sources of data for international and domestic contributions are as described in the notes for Figure 3.1. Funding per capita at risk was calculated by giving populations at low risk for malaria (i.e. those living in areas with fewer than one case reported per 1000 per year) half the weight of populations at high risk (i.e. those living in areas with one or more cases reported per 1000 per year). This procedure was followed to ensure that countries with populations at low risk for malaria could be included in the analysis, and also to take into account the greater need for malaria programmes and funds in countries with larger proportions of their population at high risk for malaria.

Figure D. For the WHO African Region and for Djibouti, Somalia and the Sudan in the WHO Eastern Mediterranean Region, the proportion of the population with access to an ITN is derived from a model that takes into account household survey data, ITNs distributed by NMCPs, and ITNs delivered by manufacturers (see methods for Figures 3.1 and 3.2). For other countries, the proportion of the population protected with ITNs is estimated from the number of ITNs delivered by NMCPs in the past 3 years divided by the population at high risk. It is assumed that each net delivered can cover on average 1.8 people, that conventional nets are re-treated regularly, and that nets have a lifespan of 3 years. The denominator is the population living at high risk for malaria, since it is assumed that, in countries with lower levels of transmission, ITNs will be preferentially targeted to populations at higher risk. IRS coverage is calculated as the total number of people protected with IRS, divided by the population at high risk. There are limited data on the extent to which these interventions overlap, so the two bars...
simply represent the percentage of populations protected by the respective interventions individually.

**Figure E.** Few countries have information systems that record treatments given to individual patients. It is therefore necessary to use aggregate information on numbers of treatment courses delivered to public health facilities, and relate this information to the number of malaria cases among patients attending such facilities. For countries in the WHO African Region, the number of treatment courses available is calculated as the total number of ACT courses distributed by a ministry of health, divided by the estimated number of presumed cases recorded as malaria (without a diagnostic test having been performed) plus confirmed *P. falciparum* malaria cases at public health facilities. In other WHO regions, the number of treatment courses available is shown as a percentage of confirmed malaria cases plus presumed malaria cases reported in the public sector, correcting for reporting completeness. The bars for any antimalarial treatment show the number of all treatment courses supplied in relation to all malaria cases of any plasmodium species, including the ACT to treat *P. falciparum*.

**Figure F.** The percentage of confirmed cases in which *P. falciparum* or a mixed infection was detected was calculated as the total number of *P. falciparum* and mixed infections between 2009 and 2013, divided by the number of confirmed malaria cases over that period. For countries in the elimination phase, only locally acquired *P. falciparum* cases and mixed infections were considered.

**Figure G.** Analysis of changes in malaria incidence rates focuses on confirmed cases (by microscopy or RDT) reported by ministries of health, to ensure that malaria (not other febrile illnesses) is tracked. For countries in the WHO African Region, the figure shows percentage reductions in the rate of hospital admissions and deaths (except for Algeria, Botswana, Cabo Verde, Namibia, Sao Tome and Principe, South Africa, Swaziland and Zimbabwe) and in the rate of reported malaria deaths. Although the diagnosis of admitted patients is not always confirmed with a diagnostic test, the predictive value of diagnosis undertaken for an admitted patient is considered to be higher than for outpatient diagnosis. See notes for Figures 8.1 and 8.2 for more details of analysis undertaken.

**Country profiles**

**I. Epidemiological profile**

**Maps:** The procedures used for the map of confirmed cases per 1000 population divided by parasite prevalence were the same as those used for Figure A of the regional profiles. For the map showing the proportion of cases due to *P. falciparum*, the total number of cases due to *P. falciparum* was divided by the total number of confirmed malaria cases. If no data were available for a subnational geographical area, or there were too few cases to calculate a reliable proportion, the area was highlighted as such. For areas where parasite prevalence was used, the total number of infections due to *P. falciparum* was divided by the total of *P. falciparum* and *P. vivax* infections. Data on environmental suitability for malaria transmission were used to identify areas that would be free of malaria.

**Population:** The total population of each country was taken from the 2012 revision of the World population prospects. The country population was subdivided into three levels of malaria endemicity, as reported by the NMCP: (i) areas of high transmission, where the reported incidence of confirmed malaria due to all species was >1 per 1000 population per year in 2013; (ii) areas of low transmission, where the reported malaria case incidence from all species was ≤1 per 1000 population per year in 2013, but >0 (transmission in these areas is generally highly seasonal, with or without epidemic peaks); and (iii) malaria free areas, where there is no continuing local mosquito-borne malaria transmission, and all reported malaria cases are imported. An area is designated ”malaria free” when no cases have occurred for several years. Areas may be naturally malaria free because of factors that are unfavourable for malaria transmission (e.g. altitude or other environmental factors), or they may become malaria free as a result of effective control efforts. In practice, malaria free areas can be accurately designated by NMCPs only after the local epidemiological situation and the results of entomological and biomarker investigations have been taken into account.

In cases where an NMCP did not provide the number of people living in high- and low-risk areas, the numbers were inferred from subnational case incidence data provided by the programme. The population at risk is the total population living in areas where malaria is endemic (low and high transmission), excluding the population living in malaria free areas. The population at risk is used as the denominator in calculating the coverage of malaria interventions, and is therefore used in assessing current and future needs for malaria control interventions, taking into account the population already covered. For countries in the pre-elimination and elimination stages, ”population at risk” is defined by the countries, based on the resident populations in foci where active malaria transmission occurs.

**Parasites and vectors:** The species of mosquito responsible for malaria transmission in a country, and the species of *Plasmodium* involved, are listed according to information provided by WHO regional offices. The proportion of malaria cases due to *P. falciparum* was estimated from the number of *P. falciparum* and mixed infections detected by microscopy, divided by the total number of malaria cases confirmed by microscopy in 2013.

**II. Intervention policies and strategies**

**Intervention policy:** The policies and strategies adopted by each country were reported by NMCPs to WHO. They vary according to the epidemiological setting, socioeconomic factors and the capacity of the NMCP or the country’s health system. Adoption of policies does not necessarily imply immediate implementation, nor does it indicate full, continuous implementation nationwide.

**Antimalarial treatment policy:** Antimalarial treatment policies were reported by NMCPs to WHO.

**Therapeutic efficacy tests:** Data on therapeutic efficacy were extracted from the WHO global database on antimalarial drug efficacy. The data originated from three main sources: published data, unpublished data and regular monitoring data from surveillance studies conducted according to the WHO standard protocol. The percentage of treatment failures is the total number of failures (early treatment failures + late clinical failures + late parasitological failures), divided by the total number of patients who completed the study follow-up. The number of studies included in the analysis

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12 http://esa.un.org/unpd/wpp/unpp/panel_population.htm
and the years during which the studies were conducted are shown for each antimalarial medicine. The minimum, median and maximum describe the range of treatment failures observed in the studies for each antimalarial medicine.

III. Financing

Sources of financing: The data shown are those reported by NMCPs. The government contribution is usually the declared government expenditure for the year. In cases where government expenditure was not reported by the programme, the government budget was used. External contributions are those allocated to the programme by external agencies; however, such contributions may or may not be disbursed. Additional information about contributions from specific donor agencies, as reported by these agencies, is given in Annex 2. All countries were asked to convert their local currencies to US$ for reporting on sources of financing.

Expenditure by intervention in 2013: The pie chart shows the proportion of malaria funding from all sources that was spent on ITNs, insecticides and spraying materials, IRS, diagnosis, antimalarial medicines, monitoring and evaluation, human resources, technical assistance and management. There are differences in the completeness of data between countries, and the activities for which expenditures are reported do not necessarily include all items of expenditure. For example, government expenditures usually only include expenditures specific to malaria control, and do not take into account costs related to health facility staff, infrastructure and so on.

IV. Coverage

ITN and IRS coverage: Indicators are shown according to data availability:

- With access to an ITN (survey) – the proportion of all individuals that could be covered by available ITNs in each household, assuming each ITN can be shared by two people. The indicator is calculated from nationally representative household surveys such as DHS, MICS and MIS.
- All ages who slept under an ITN (survey) – the proportion of all individuals who spent the previous night in surveyed households who slept under an ITN, as measured in a nationally representative household survey such as DHS, MICS or MIS.
- With access to an ITN (model) – For high-transmission countries in the WHO African Region, a model was used to estimate the proportion of the population with access to an ITN within their household for years in which household survey results were not available. The methods used to estimate the indicator were the same as those described for Figures 3.1 and 3.2.
- At high risk protected by ITNs – For countries in WHO regions other than the African Region, nationally representative household surveys are not undertaken sufficiently frequently to allow an assessment of levels and trends in ITN coverage. Therefore, the number of ITNs distributed by NMCPs is used. The proportion of the population potentially protected with ITNs is calculated as:

\[
\text{Number of ITNs distributed} \times (\text{number of LLINs distributed in the past 3 years} + \text{number of conventional ITNs distributed or retreated in the past year}) \div \text{population at high risk for malaria}
\]

LLINs are considered to have an average useful lifespan of 3 years and conventional ITNs 1 year; also, each net is assumed to protect two people. The ratio of 1.8 is used in the formula to allow for only one person sleeping under some ITNs in households with an odd number of inhabitants. The population at high risk is used as the denominator since it is assumed that populations at high risk will be preferentially targeted to receive an ITN. For countries in the elimination phase, those residing in foci are considered to be the population at risk.

- At high risk protected by IRS – calculated as the number of people living in a household where IRS has been applied during the preceding 12 months, divided by the population at risk (the sum of populations living in low- and high-transmission areas). For areas outside Africa, the population at high risk is used as the denominator. The percentage of people protected by IRS is a measure of the extent to which IRS is implemented and the extent to which the population at risk benefits from IRS nationwide. The data show neither the quality of spraying nor the geographical distribution of IRS coverage in a country.

Cases tested and cases treated in the public sector

Suspected cases tested – the number of suspected cases examined by microscopy or by RDT, divided by the total number of suspected malaria cases. For countries that do not report the number of suspected cases independently, the number of suspected malaria cases is derived from the number of presumed and confirmed cases, the number tested and the number of positive tests. This indicator reflects the extent to which a programme can provide diagnostic services to patients attending public health facilities. It does not consider patients attending privately run health facilities, and therefore does not reflect the experience of all patients seeking treatment. In many situations, health facilities in the private sector are less likely to provide a diagnostic test than those in the public sector. The indicator may also be biased if those health facilities that provide a diagnostic test (e.g. hospitals) are more likely than other facilities to submit monthly reports.

Under 5 with fever with finger/heel stick (survey) – the proportion of children aged under 5 years with fever in the past weeks who had a finger or heel stick, as measured in a nationally representative household survey such as DHS, MICS or MIS.

Antimalarial medicines distributed versus cases – Few countries have information systems that are able to record the treatments given to individual patients. Instead, data on the numbers of antimalarial medicines distributed by the country’s ministry of health are used to calculate proxy indicators of access to treatment. Three indicators are shown:

- Antimalarials distributed versus all malaria cases – the number of first-line treatment courses distributed, divided by the
estimated number of malaria cases attending public sector health facilities.

- **ACTs distributed versus *P. falciparum* malaria cases** – the number of ACT treatment courses distributed, divided by the estimated number of *P. falciparum* malaria cases attending public sector health facilities.

- **Primaquine distributed versus *P. vivax* malaria cases** – the number of primaquine treatment courses distributed, divided by the estimated number of *P. vivax* malaria cases attending public sector health facilities.

For high-transmission countries in the WHO African Region, the estimated number of malaria cases attending public sector health facilities is used as a denominator. For other countries, the denominator is the number of confirmed cases plus the number of presumed cases, adjusted for reporting completeness. These indicators can provide information on whether the NMCP delivers sufficient antimalarial medicines to treat all malaria patients who seek treatment in the public sector. It is not a direct measure of the proportion of patients with malaria cases that have received treatment.

- **ACTs as percentage of all antimalarials received (survey)** – children aged under 5 years with fever in the past 2 weeks who received ACTs as a proportion of children aged under 5 years with fever who received any antimalarial.

**Cases tracked**

- **Reporting completeness** – calculated as the total number of health facility reports received by a ministry of health during a year, divided by the total number of facility reports that were expected in that year. The expected number of facility reports is the number of health facilities multiplied by the frequency of reporting; that is, if 100 facilities are expected to report each month, 1200 reports would be expected during a year.

- **Percentage fever cases <5 seeking treatment at public health facility (survey)** – the proportion of children aged under 5 years with fever in the past 2 weeks who sought treatment at a public health facility, derived from a nationally representative household survey such as DHS, MICS or MIS (for programmes in the control phase only).

- **Cases investigated** – the proportion of reported confirmed malaria cases that are investigated for additional information on the characteristics of the case; most importantly, whether the case was imported or locally acquired (for programmes in the pre-elimination and elimination phase only).

- **Foci investigated** – the proportion of foci of malaria transmission that are investigated for additional information on the characteristics of malaria, including evidence of local malaria transmission and entomological information such as vector breeding sites within the transmission focus (for programmes in the pre-elimination and elimination phase only).

**V. Impact**

**Test positivity**

- **SPR** – the number of microscopically positive cases divided by the total number of slides examined.

**RDT positivity rate** – the number of positive RDT tests divided by the total number of RDT tests carried out. The RDT positivity rate and SPR are derived from the number of parasitologically positive cases per 100 cases examined by RDT or microscopy. They measure the prevalence of malaria parasites among people who seek care and are examined in health facilities. Trends in these indicators may be less distorted by variations in the ABER than trends in the number of confirmed cases.

- **Parasite prevalence (survey)** – the proportion of people tested for malaria parasites in a survey (most often children aged under 5 years) who have malaria parasites (programmes in control phase only).

- **Confirmed malaria cases per 1000 and ABER**

- **ABER (microscopy and RDT)** – the number of parasitological tests (by microscopy or RDT) undertaken per 100 population at risk per year. The numbers of parasitological tests were derived from reports by NMCPs to WHO. The ABER provides information on the extent of diagnostic testing in a population. It can be useful to take into account when interpreting trends in confirmed cases. To discern changes in malaria incidence, the ABER should ideally remain constant (see notes for Figures 8.1 and 8.2). There is no set threshold or target for ABER; rather, it is the trend in ABER in relation to reported case incidence that is most informative.

- **Cases (all species)** – the total number of confirmed malaria cases (by microscopy or RDT) divided by the population at risk. The numbers of confirmed cases were derived from reports by NMCPs to WHO. The indicator is useful in assessing changes in the incidence of malaria over time, provided that there has been consistency in patient attendance at facilities, diagnostic testing and case reporting over time.

- **Cases (*P. vivax*)** – the total number of confirmed *P. vivax* malaria cases (by microscopy or RDT) divided by the population at risk. The numbers of confirmed *P. vivax* cases were derived from reports by NMCPs to WHO (the numbers exclude mixed infections). For countries in the pre-elimination or elimination phases, the total number of indigenous cases (acquired within the country) and imported cases were also plotted.

- **Malaria admissions and deaths (for countries in the control phase)**

Numbers for malaria admissions and deaths for countries in the control phase were derived from reports by NMCPs to WHO.

- **Admissions (all species)** – the number of patients admitted for malaria with malaria as the primary discharge diagnosis, divided by the population at risk.

- **Admissions (*P. vivax*)** – the number of patients admitted for malaria with *P. vivax* malaria as the primary discharge diagnosis, divided by the population at risk.

- **Deaths (all species)** – the number of patients dying in health facilities with malaria as the primary cause of death, divided by the population at risk.

- **Deaths (*P. vivax*)** – the number of patients dying in health facilities with *P. vivax* malaria as the primary cause of death, divided by the population at risk.
References


