Thursday, 19 October 2017			
	Session 9	**Open**	**for guidance**
09:00 – 10:00	Proposed ERG on malaria mortality estimates /Presentation	Dr Abdisalan Noor	
10:00 – 11:00	Review revised recommendations for achieving universal coverage with long-lasting insecticidal nets in malaria control /Presentation	Dr Jan Kolaczinski	**For decision**
11:00	Meeting closure	Dr Ren Minghui	
11:00 – 11:30	*Coffee break*		
	Session 10	**Closed (MPAC members and GMP Secretariat only)**	**for decision**
11:30 – 16:00	Finalization of wording of recommendations (including lunch)	Dr Kevin Marsh	
16:00	*End of day*		

** Provisional Programme and may be subject to change*

Malaria Policy Advisory Committee Meeting
17–19 October 2017, Geneva, Switzerland
Background document for Session 9

Proposal for an Evidence Review Group on Methods for Quantifying Malaria Mortality

October 2017, Geneva, Switzerland

Introduction

WHO country estimates of mortality are used by various agencies to track the global progress against malaria; to determine which countries have the highest malaria burdens in order to prioritize resource allocation decisions; to understand national trends over time in order to assess the success of strategies; and to prioritize malaria in relation to other health conditions.

However, measuring malaria mortality is challenging, as weaknesses in most malaria endemic countries' civil, vital registration and routine health information systems do not allow for reliable analyses of causes of death. Various epidemiological and clinical factors have also made the measurement of malaria deaths a complex process. These include the similarity of the symptomatic manifestations of malaria to other infectious diseases, the development of immunity where infection does not always equate to disease, and the presence of important indirect morbid effects. In light of these challenges, disease modelling techniques that relate infection to clinical outcomes are used to compute estimates of malaria mortality.

WHO has produced estimates of malaria cases and deaths for every year since 2000. These estimates include lower and upper bounds, as well as a point estimate. According to WHO's latest estimates released in the *World Malaria Report 2016*, approximately 429 000 people (with an uncertainty range of 235 000 to 639 000) died of malaria in 2015 [1]. Other recent estimates include those by the Institute for Health Metrics and Evaluation (IHME), produced as part of the Global Burden of Disease (GBD) estimation. The latest IHME estimates suggest that 719 600 (with an uncertainty range of 594 600 to 863 000) died of malaria in 2016 [2]. Annex A provides details of the approaches utilized by WHO and GBD. Other notable methods for estimation include approaches by Korenromp *et al.* [3] and Ross *et al.* [4].

These methods have resulted in estimates with substantially different mean values for the same year and wide confidence intervals. Consequently, there has been a great deal of controversy and confusion both for countries and for the wider public in terms of the real progress made against malaria. Methodological issues raised include the use of static case fatality rate (CFR) measures that do not account for changes in malaria case management; the use of CFR data that are geographically very sparse to impute mortality rates of geographically highly disaggregated entities; the susceptibility of underlying mortality outcomes to overall incidence burden; and inappropriate age attribution of estimated malaria deaths.

WHO/HTM/GMP/MPAC/2017.19

For these reasons, WHO seeks to convene an Evidence Review Group (ERG) on malaria mortality to review existing data and methods and to provide advice on the best approaches for implementation.

Previous Malaria Burden Estimation ERG and recommendations

During its March 2012 meeting, MPAC approved the convening of an ERG on malaria burden estimation methodology in order to review both incidence and mortality estimation methods and to advise WHO on the best approaches. The ERG was tasked with addressing the following questions:

1. What approaches should WHO use to:
    (a) Estimate the number of malaria cases and deaths occurring in a country in order to prioritize countries for resource allocation decisions;
    (b) Understand trends over time in order to assess the success of global strategies;
    (c) Prioritize malaria in relation to other health conditions; and
2. What approaches should endemic countries use to:
    (a) Estimate the number of malaria cases and deaths nationally and subnationally;
    (b) Understand which populations are most affected;
    (c) Improve the quality of input data for estimating the burden of malaria cases and deaths?

The ERG met three times: in June 2012 and in January and July 2013. In its final meeting, the ERG made several recommendations to WHO and to the ERG members [5]. While many of these recommendations have since been acted upon, several key recommendations remain unfulfilled (Table 1).

TABLE 1
Recommendations from the Malaria Burden Estimation ERG 2012–2013 that require reconsideration or follow-up

Recommendation	Status
1. ERG members felt that changes over time in case management would not be reflected by a static CFR, but that identifying a valid CFR would be challenging.	CFR estimates used by WHO remain static.
2. Given that the malaria mortality research agenda is in its beginning stages, additional meetings of the MBE-ERG may be required in order to evaluate new methodologies. MPAC may decide that the Surveillance Monitoring and Evaluation Technical Expert Group (SME-TEG) should take over the functions of the current ERG, in which case many ERG members may transition to the TEG instead.	The SME-TEG was reconstituted following the reorganization of the GMP. Many members of the ERG are no longer part of the SME-TEG.
3. The ERG requests that Malcolm Molyneux reach out to 10 hospitals in endemic areas to determine whether they would be willing to share their data on the age distribution of severe malaria. The goal is to develop a list of hospitals in Africa that could serve as sentinel hospitals (like QEHC and Kilifi) for adult malaria mortality research. Results from analyses of hospital data should still be considered in light of being a biased sample of the general population. Community-level parasitaemia (such as from MAP or RTS,S sites) could be used to determine the level of incidental parasitaemia.	This work is pending, as Prof Molyneux became unavailable shortly after the meeting.
4. Over the next 9 months, the universe of available data to examine adult deaths from malaria should be assembled. This should include a literature search for hospital and other studies, and include the RTS,S trial data when made available. Tom Smith and WHO will spearhead this work.	Not yet done

5. The ERG recommends that Peter Byass send a sample of INDEPTH records (half with a classification of malaria and half without) to Malcolm Molyneux to determine whether, based on his field experience in hospital, he would code the deaths the same. This would serve as a validation of the InterVA methodology.	Not yet done
6. Ashwani Kumar and Nick White have agreed to produce a draft protocol for a study in India using hospital data on mortality and RDT results. They will circulate the draft to the ERG for comment.	The protocol was shared, but study results have yet to be received and reviewed.

Reason for establishing a second ERG

Since the last ERG meeting, several important events have taken place:

1. The GMP was reorganized and the Surveillance, Monitoring and Evaluation (SME) Unit was established. This Unit is now responsible for the World Malaria Report, including analysis of the burden of malaria. Following the formation of this Unit, the SME-TEG was reconstituted; however, several members of the first ERG are no longer members of the TEG either because of expiration of terms or for other reasons. Therefore, there is a need to restart the process of reviewing the evidence as recommended by the ERG 2012–2013.

2. Additional data on cause of death (from India and other countries) have become available and these require review for potential inclusion in the WHO mortality estimation approach.

3. With the scale-up of DHIS2, many malaria-endemic countries have improved their surveillance systems, and higher quality data on malaria deaths are being reported through the routine system. These data require review for use in burden estimation methods.

4. The CFR data used by WHO remain outdated and do not account for changes in malaria case management and it is impact of malaria mortality, as proposed by the ERG 2012–2013. A review of approaches that integrate changes in the coverage and quality of malaria case management in estimating CFR is require to better estimate malaria mortality.

5. The current CHERG estimates that WHO uses for estimating under-5 mortality in Africa assumes zero neonatal deaths due to malaria. This assumption needs to be reviewed and rectified.

6. The use of geospatial mortality modelling methods has been increasing, but little is known about the source and contribution of the various input parameters that yield the resulting geographic distribution of malaria deaths and how such methods could be best harnessed for future WHO estimations.

Expected output of the proposed ERG

The ERG on malaria mortality burden will address the following issues:

1. Re-review existing methods for mortality estimation with a focus on addressing issues related to temporal trends in CFR, age attribution of malaria mortality, and the role of geospatial approaches to modelling mortality estimation;

2. Re-visit the pending recommendations from the ERG 2012–2013 in light of any new data and develop proposals for best approaches to ensure they are fulfilled;

3. Re-focus on the indirect consequences of malaria infection and disease and their likely contribution to mortality (for example aneamia).

Annex: Methods for estimating malaria mortality

A1: WHO method

To estimate malaria cases and deaths, WHO uses different modelling and estimation methods for different groups of countries. To give one example: in high-burden countries of the WHO African Region where data reporting is not sufficiently complete, case estimates are derived from an estimate of the number of people living at high, low or no risk of malaria. Malaria incidence rates for each of these population groups are inferred from longitudinal studies of malaria incidence. Incidence rates are adjusted according to the percentage of the population living in urban settings and the expected impact of vector control programmes.

Meanwhile, under-5 deaths for the same group of countries are estimated using verbal autopsies. (A verbal autopsy is a method of finding out the cause of a death based on an interview with the next of kin or other caregivers.)

Deaths among those aged 5 and over are derived through mathematical modelling, based on under-5 death rates. In its malaria burden estimation, WHO works closely with a range of partners, including the UN Inter-agency Group on Child Mortality Estimation and the Child Health Epidemiology Reference Group (CHERG). Country-specific estimates are made available to partners and researchers following review by the relevant national authorities.

Category 1 methods

Category 1 methods were used for countries outside of Africa and for low-transmission countries in Africa.

Method 1(a). For countries in which vital registration was estimated to capture more than 50% of all deaths, and a high proportion of malaria cases were confirmed by parasite testing, reported malaria deaths were adjusted for completeness of death reporting.

Method 1b. For countries considered to be in the elimination programme phase as described in the *World Malaria Report 2015*, reported malaria deaths were adjusted for completeness of case reporting.

Method 1c. For other countries for which a Category 1 method was used, a CFR of 0.256% was applied to the estimated number of *P. falciparum* cases. This CFR represents the average taken from CFRs reported in the literature and from unpublished data from Indonesia, 2004–2009 (Dr Ric Price, Menzies School of Health Research, personal communication). A CFR of 0.0375% was applied to the estimated number of *P. vivax* cases. This figure represents the midpoint of the range of CFRs reported in a study by Douglas *et al.* [6].

Category 2 method

The Category 2 method was used for countries in Africa with a high proportion of deaths due to malaria. With this method, child malaria deaths were estimated using a verbal autopsy multicause model developed by the Maternal and Child Health Epidemiology Estimation Group to estimate causes of death in children aged 1–59 months. Mortality

estimates were derived for seven causes of post-neonatal death (pneumonia, diarrhoea, malaria, meningitis, injuries, pertussis and other disorders), four 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 mortality envelope of 1–59 months (excluding deaths from HIV/AIDS and measles) for corresponding years. Estimated prevalence of malaria parasiteswas used as a covariate in the model. The malaria mortality rate in children under 5 that was estimated using this method was then used to infer malaria-specific mortality in those over 5. This inference relied on the relationship between levels of malaria mortality in a series of age groups and the intensity of malaria transmission.

A2: IHME GBD 2016 method

The malaria mortality estimation component was a collaboration between the Institute for Health Metrics (IHME) and the Malaria Atlas Project (MAP) [2]. To account for the variability in the type and abundance of cause of death (CoD) and related data, three distinct approaches were developed to estimate malaria mortality due to (i) *P. falciparum* inside Africa; (ii) *P. falciparum* outside of Africa; and (iii) *P. vivax* in countries without falciparum malaria.

For the Outside of Africa and *P. vivax* models, data included vital registration, verbal autopsy and surveillance data from the CoD database. For the Africa models, only CoD data (mostly verbal autopsy) were georeferenced (e.g., find latitude and longitude) and used in the analysis. Systematic literature reviews for malaria were not conducted.

Outlier criteria excluded data points that were (i) implausibly high or low relative to global or regional patterns, (i) substantially conflicted with established age or temporal patterns, or (iii) significantly conflicted with other data sources from the same locations or locations with similar characteristics (e.g., local socio-demographic Index).

For most GBD causes, epidemiologic measures may be used as covariates in a traditional CODEm approach, if at all. To estimate the fatal burden of *P. falciparum* malaria in Africa, epidemiologic measures were used directly in the estimation process [7]. MAP generated updated spatiotemporal ‘cubes’ estimating clinical incidence (rates and case counts) for each 5x5 km pixel across Africa, by year, from 1980 to 2015, specified by three broad age-bins (0–5, 5–14 and 15+). MAP also generated an equivalent spatiotemporal prediction of access to effective antimalarial drugs (combining access to care, the fraction of malaria cases receiving different classes of antimalarials, and the estimated country-year-specific efficacy of each antimalarial class over time). This estimated treatment rate was combined with the incidence rate cube to derive a third cube estimating the incidence of untreated cases.

For each site-year for which malaria CoD fraction data were available, the researchers (i) estimated a site-year-specific malaria mortality rate as the product of cause-specific mortality fraction and all-cause mortality rate (with the latter drawn from national-level values); and (ii) divided the malaria-specific mortality rate by the site-year-specific estimate of untreated malaria incidence rate (drawn from the MAP cube) in order to estimate a site-year-specific CFR among untreated malaria cases. The site-year-specific CFR values derived were then used in a mixed-effects regression model to estimate pixel-year CFR for each 5x5

km grid cell. The covariates used in the model were the logarithm of country-year all-cause mortality, pixel-year nighttime lights, accessibility and fractional land cover classes, and study-specific age and sex, with the location of each study site as a national-level random effect. Data were weighted by sample size (i.e., the number of all-cause deaths observed in each study site-year).

Pixel-year predictions of CFR were then multiplied by the corresponding untreated incidence rate from the MAP cube to yield a pixel-year mortality rate estimate, which was then multiplied by pixel-year population to compute pixel-year malaria death counts. These were then aggregated to yield the required GBD national or subnational death estimates.

To disaggregate into GBD age-bins, a traditional national-level CODEm model was run separately with the following covariates: prevalence of *P. falciparum* in the 2–10 age group (*Pf*$PR_{2\text{-}10}$), *Pf* incidence rate, years of education, access to effective antimalarial drugs, and health system access. The resulting age-pattern predictions were used to split the country-year mortality estimates.

P. falciparum: Outside of Africa

In locations outside of Africa, a traditional CODEm approach was used, mirroring closely that used in GBD 2015. It must be noted that "outside of Africa" also included some countries on the African continent that had either very low incidence or relatively robust routine surveillance systems. These included Algeria, Egypt, Morocco, Comoros, Mauritius, Cape Verde, Sao Tome, Principe, Rwanda, Botswana, Namibia, Eritrea, Djibouti and South Africa. The model included the following covariates: prevalence of *P. falciparum* in the 2–10 age group (*Pf*$PR_{2\text{-}10}$), *Pf* incidence rate, years of education, access to effective antimalarial drugs, and health system access.

P. vivax: countries without *P. falciparum* transmission

For countries where the main/exclusive strain of malaria was *P. vivax*, deaths were estimated using a zero-inflated negative binomial mixed model where the outcome was study deaths. The model included the logarithm of mortality rate, age and sex as a fixed effect. Locations were included as random effects. The results from the *P. vivax*, Outside of Africa, and Africa models were collated and uploaded in CODEm and marked as best model.

References

1. World malaria report 2016. Geneva: World Health Organization; 2016 (http://www.who.int/malaria/publications/world-malaria-report-2016/report/en/).

2. GDB 2016 Causes of Death Collaborators. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. 2017;390(10100):1151–1210.

3. Korenromp E. Malaria incidence estimates at country level for the year 2004: proposed estimates and draft report. Geneva: World Health Organization; 2005 (http://www.who.int/malaria/publications/atoz/incidence_estimations2/en/).

4. Ross A, Maire N, Molineaux L, Smith T. An epidemiologic model of severe morbidity and mortality caused by Plasmodium falciparum. Am J Trop Med Hyg. 2006;75(2 Suppl):63–73.

5. Evidence Review Group: malaria burden estimation report on third meeting, 8–9 July 2013. Geneva: World Health Organization; 2013 (http://www.who.int/malaria/mpac/mpac_sep13_malaria_burden_estimate.pdf).

6. Douglas NM, Pontororing GJ, Lampah DA, Yeo TW, Kenangalem E, Poespoprodjo JR, et al. Mortality attributable to *Plasmodium vivax* malaria: a clinical audit from Papua, Indonesia. BMC Med. 2014;12(1):217.

7. Bhatt S, Weiss DJ, Cameron E, Bisanzio D, Mappin B, Dalrymple U, et al. The effect of malaria control on Plasmodium falciparum in Africa between 2000 and 2015. Nature. 2015;526:207–11.

Proposed WHO Evidence Review Group on methods for quantifying malaria mortality

Abdisalan M Noor Team Leader, Surveillance

Global Malaria Meeting, Geneva,
19 October 2017

Global **Malaria** Programme

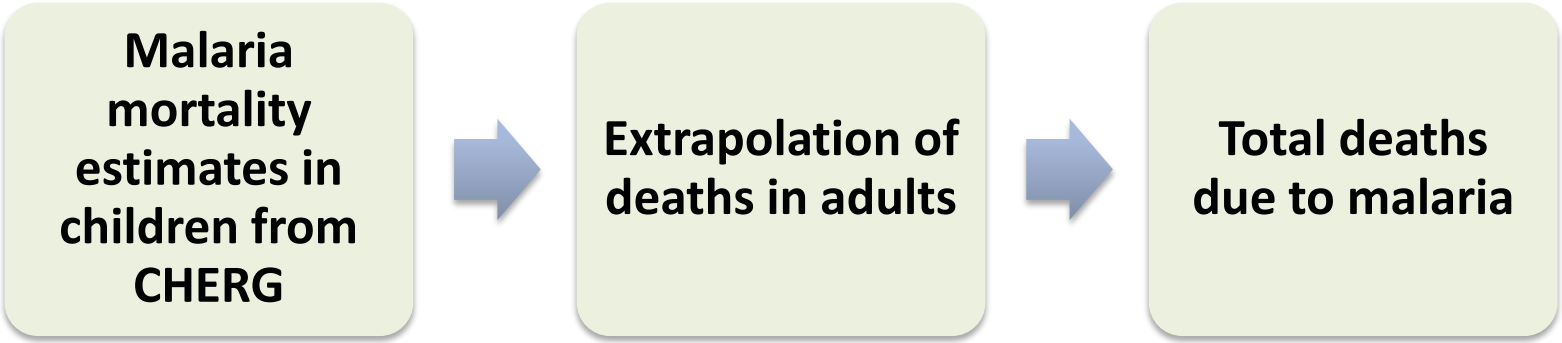
World Health Organization

Measuring malaria mortality

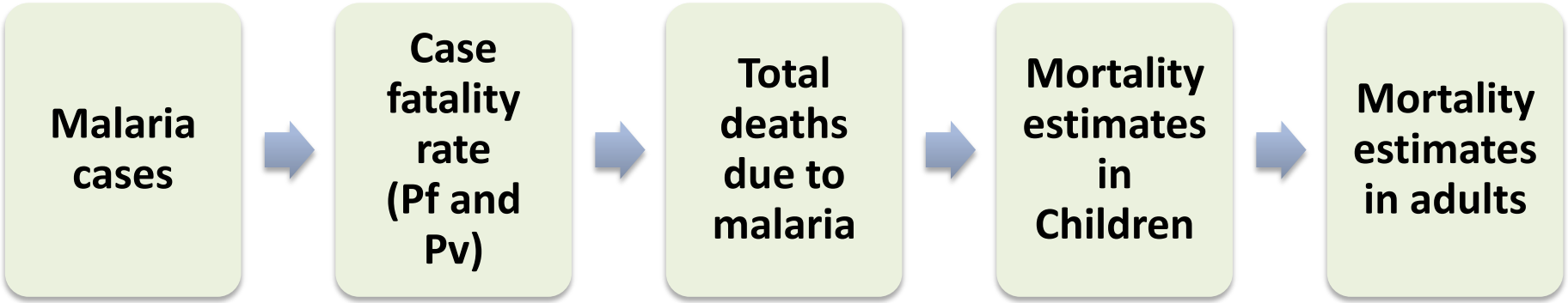
- **Weak national civil, vital registration and routine health information systems**
- **Uncertainty in clinical confirmation -** the similarity of the symptomatic manifestations of malaria to other infectious diseases, the development of immunity where infection does not always equate to disease, and the presence of important indirect morbid effects
- **Difficulties of model parametrization and uncertainty in model estimates**

Measuring malaria mortality – WHO Approach

1) Based on model estimates - SSA

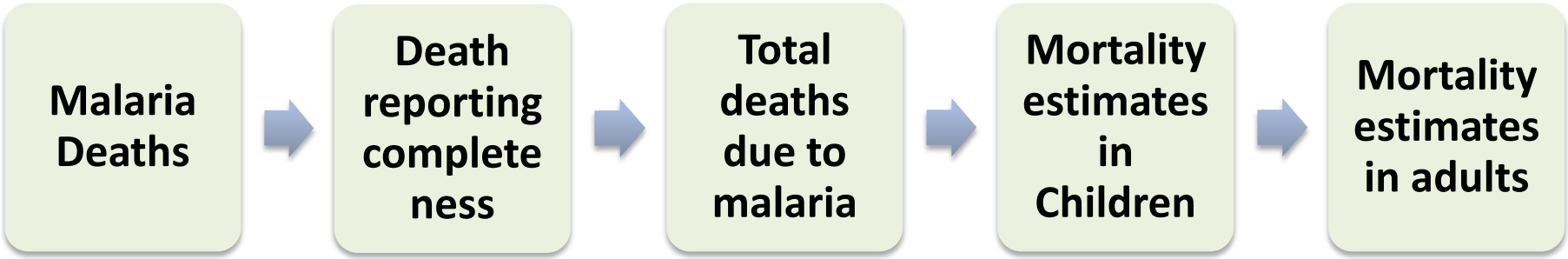


2) Based on estimates from reported cases – incomplete reporting outside Africa and some Southern Africa countries

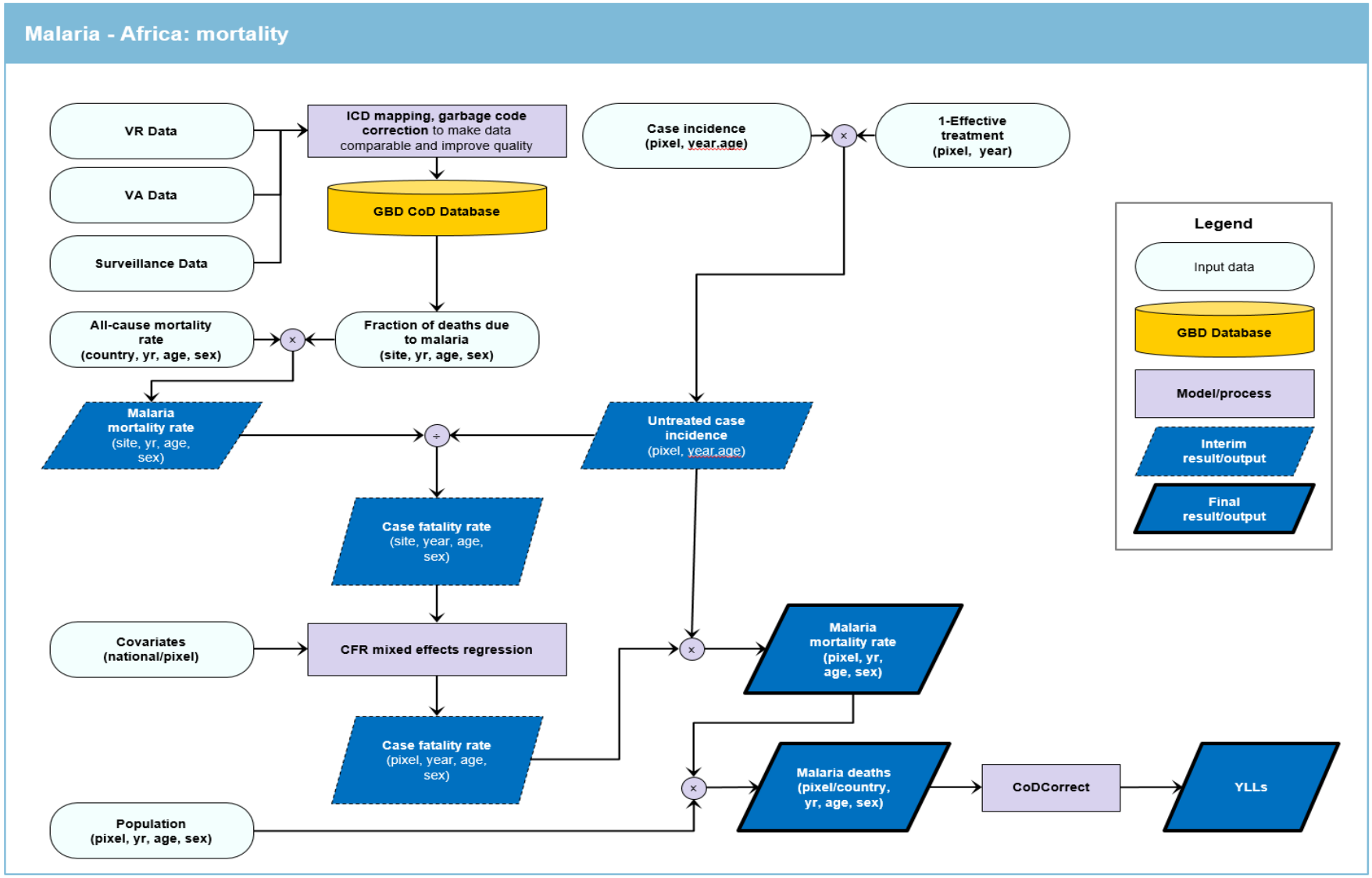


Measuring malaria mortality – WHO Approach

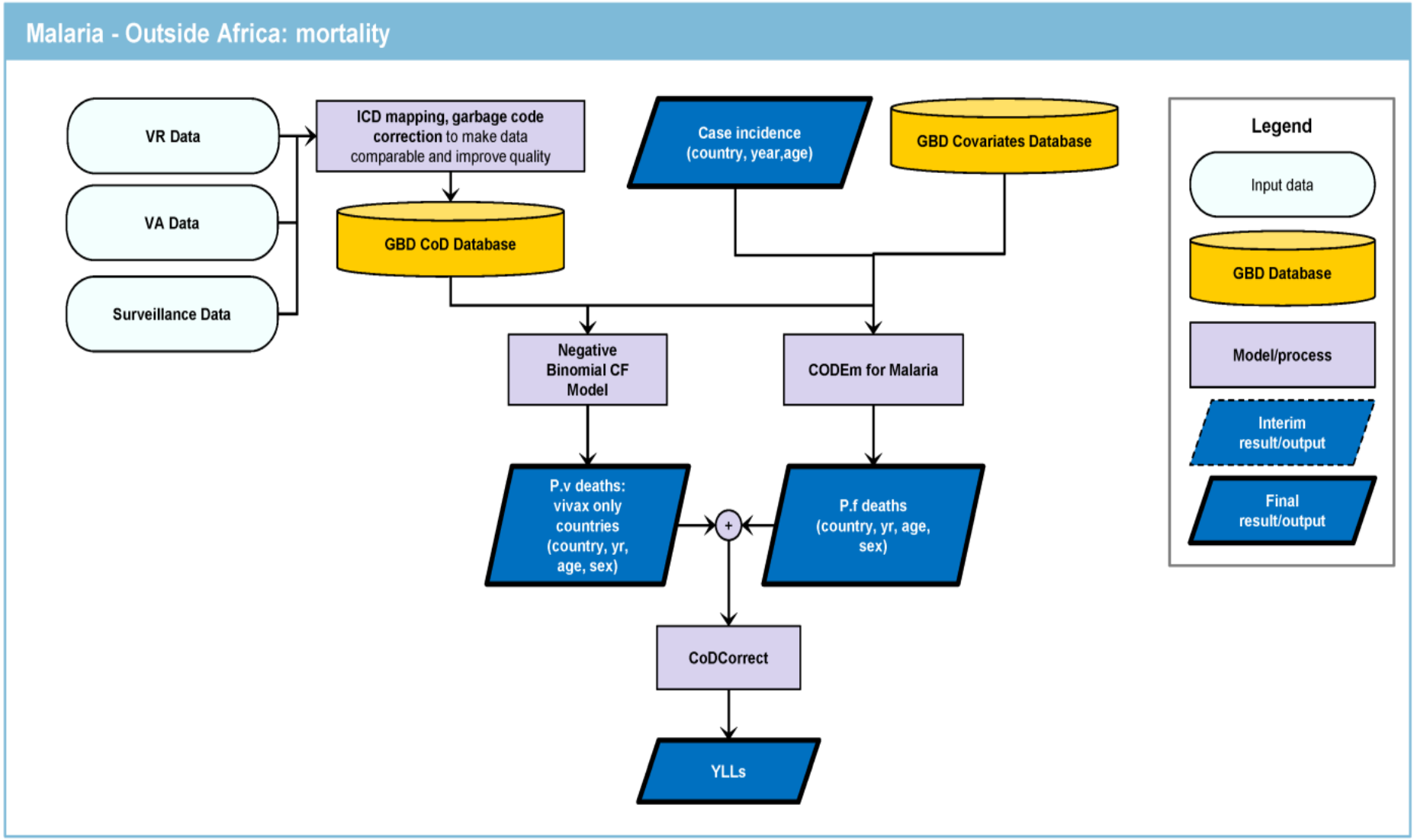
3) Based on reported malaria deaths – countries with good surveillance



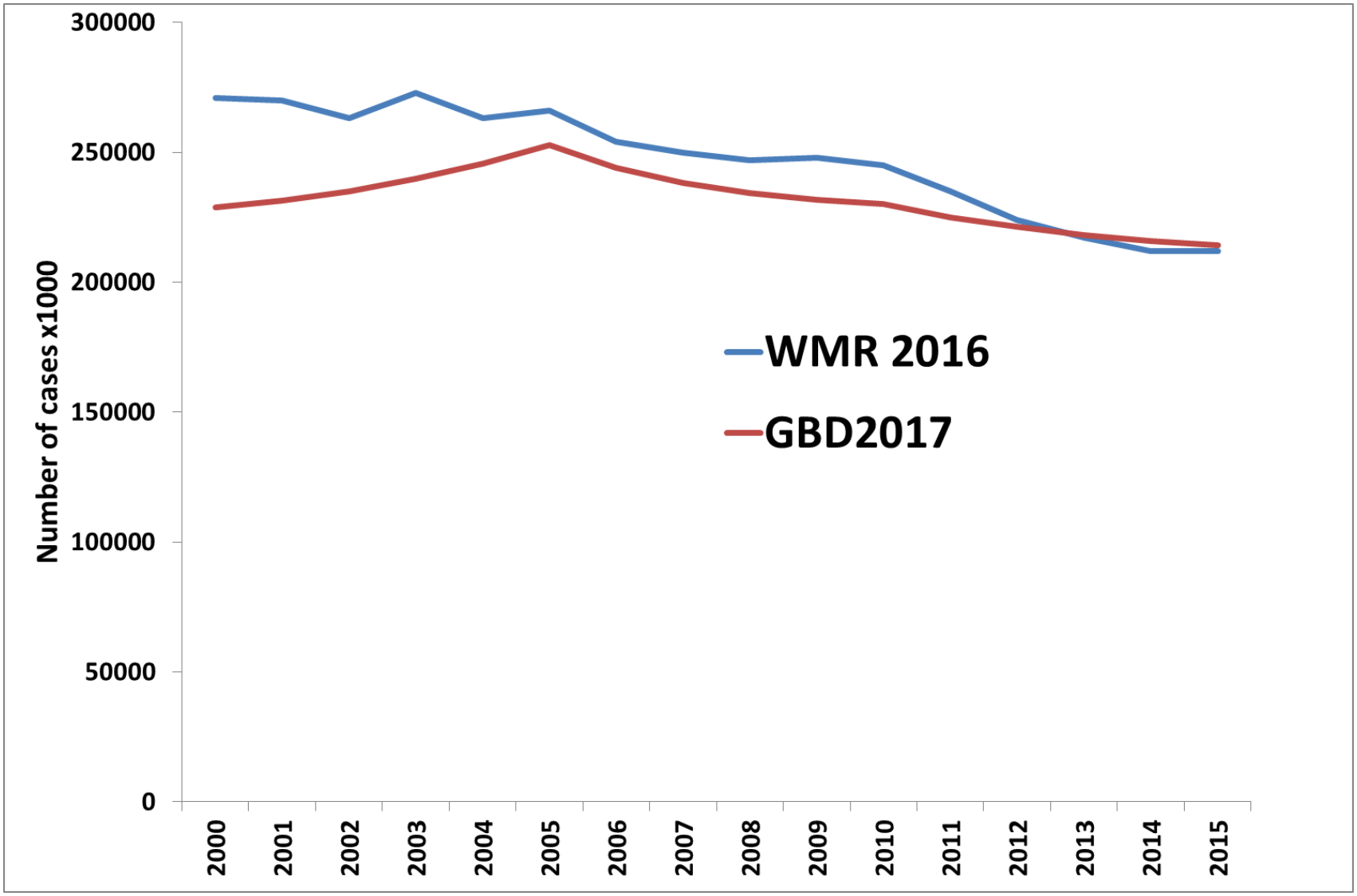
Measuring malaria mortality - GBD



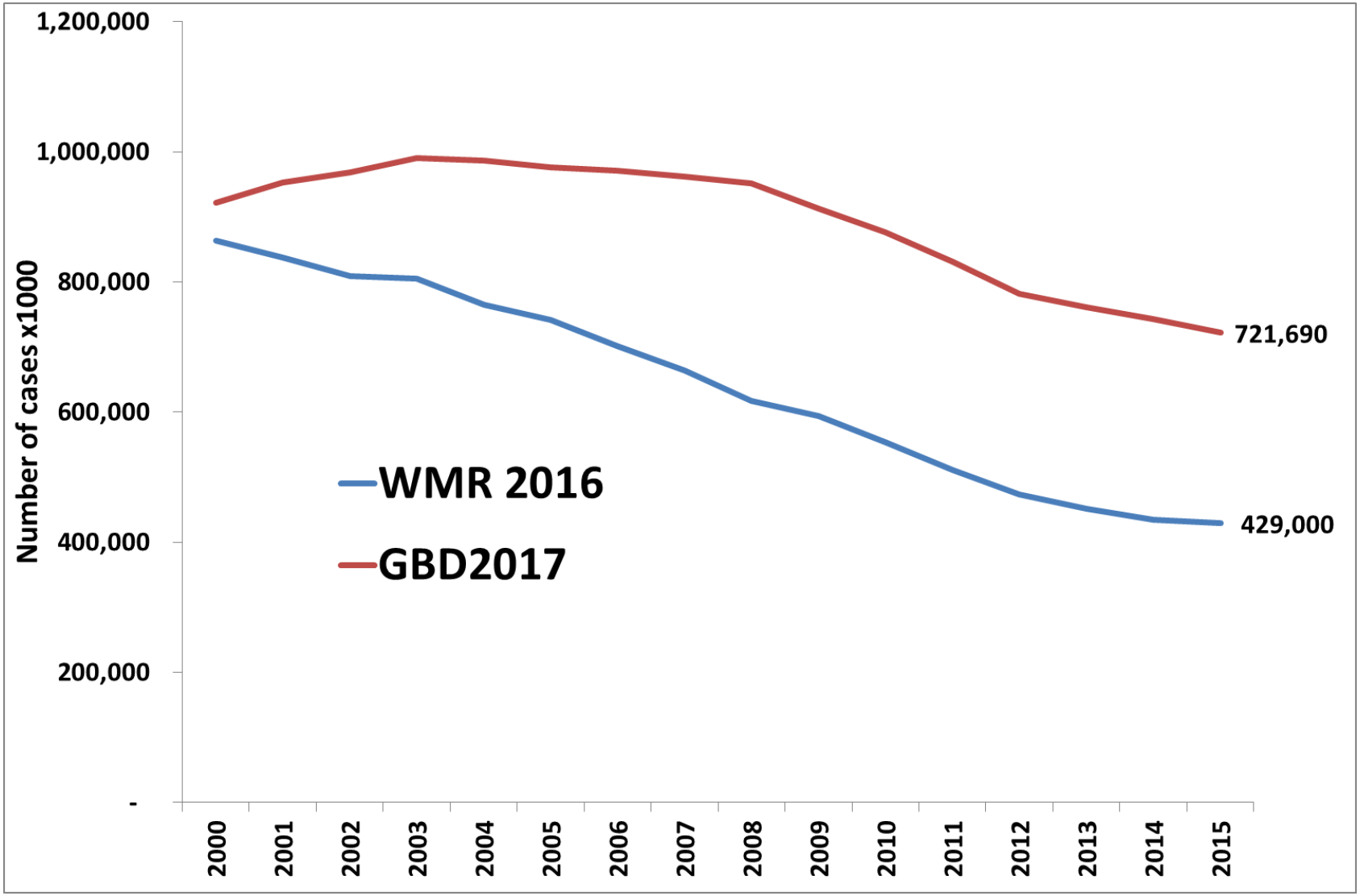
Measuring malaria mortality - GBD



GBD vs WMR – malaria cases



GBD vs WMR – malaria deaths



Sources of uncertainty

- Incomplete routine case and death data
- Static CFR
- Verbal autopsy
- Scale of analysis and problems of disaggregation
- Determination of the denominator (population at risk)

Previous Malaria Burden ERG

1. **What approaches should WHO use to:**
   a) Estimate the number of malaria cases and deaths occurring in a country in order to prioritize countries for resource allocation decisions;
   b) Understand trends over time in order to assess the success of global strategies;
   c) Prioritize malaria in relation to other health conditions; and
2. **What approaches should endemic countries use to:**
   a) Estimate the number of malaria cases and deaths nationally and sub-nationally;
   b) Understand which populations are most affected;
   c) Improve the quality of input data for estimating the burden of malaria cases and deaths?

Previous Malaria Burden ERG

Meetings:

- June 2012
- January 2013
- July 2013

- Dr Peter SMITH (Chair)
- Dr Salim ABDULLA*
- Dr John APONTE
- Professor Zulfiqar BHUTTA
- Professor Peter BYASS
- Professor Azra GHANI
- Professor Brian GREENWOOD*
- Dr Patrick KACHUR
- Dr Ashwani KUMAR
- Dr Seth OWUSU-AGYEI
- Dr Ana Carolina Santelli
- Dr Rick STEKETEE
- Dr Jane THOMASON
- Professor Nick WHITE*

Previous Malaria Burden ERG

Recommendation	Status
Changes over time in case management would not be reflected by a static CFR, but that identifying a valid CFR would be challenging.	CFR estimates used by WHO remain static.
Given that the malaria mortality research agenda is in its beginning stages, additional meetings of the MBE-ERG may be required in order to evaluate new methodologies via SME-TEG case many ERG members may transition to the TEG instead.	The SME-TEG was reconstituted following the reorganization of the GMP. Many members of the ERG are no longer part of the SME-TEG.
The ERG requests that Malcolm Molyneux reach out to 10 hospitals in endemic areas to determine whether they would be willing to share their data on the age distribution of severe malaria.	This work is pending, as Prof Molyneux became unavailable shortly after the meeting.
Over the next 9 months, the universe of available data to examine adult deaths from malaria should be assembled.	Not yet done
The ERG recommends that Peter Byass send a sample of INDEPTH records (half with a classification of malaria and half without) to Malcolm Molyneux to determine whether, based on his field experience in hospital, he would code the deaths the same. This would serve as a validation of the InterVA methodology.	Not yet done
Ashwani Kumar and Nick White have agreed to produce a draft protocol for a study in India using hospital data on mortality and RDT results. They will circulate the draft to the ERG for comment.	The protocol was shared, but study results have yet to be received and reviewed.

Reasons for new Malaria Burden ERG

- The GMP was reorganized and the Surveillance, Monitoring and Evaluation (SME) Unit was established. SME-TEG reconstituted.
- Additional data on cause of death (from India and other countries)
- With the scale-up of DHIS2, many malaria-endemic countries have improved their surveillance systems

Reasons for new Malaria Burden ERG

- The CFR data used by WHO remains outdated and do not account for changes in malaria case management and it is impact of malaria mortality, as proposed by the ERG 2012–2013.
- The current CHERG estimates that WHO uses for estimating under-5 mortality in Africa assumes zero neonatal deaths due to malaria.
- The use of geospatial mortality modelling methods has been increasing, but little is known about the source and contribution of the various input parameters
- Measuring the burden of anemia in malaria endemic countries

Purpose of new Malaria Burden ERG

- Re-review existing methods for mortality estimation with a focus on addressing issues related to temporal trends in CFR, age attribution of malaria mortality, and the role of geospatial approaches to modelling mortality estimation;
- Re-visit the pending recommendations from the ERG 2012–2013 in light of any new data and develop proposals for best approaches to ensure they are fulfilled;
- Re-focus on the indirect consequences of malaria infection and disease and their likely contribution to mortality (for example anaemia).

Addendum – morbidity burden estimation

1. Parasite to incidence

- Contribution from MAP
- Primarily for sub-Saharan Africa
- Model estimates are now beginning to be substantially lower that confirmed cases from the public health sector

2. Estimation from reported cases from the public health sector

- Confirmed cases + Presumed cases adjusted for slide positivity rate + cases in private sector + cases among those who don't seek treatment

3. Reported cases without any adjusted – mainly in elimination settings

ERG process

1. Preparation and selection of members– Q4 2017 to February 2018
2. ERG Meeting – Late Feb 2017
3. Presentation of ERG outcomes to SME-TEG – March 2018
4. Presentation of recommendations to MPAC – March 2018
5. Action on recommendations in preparation for WMR 2018

Revised recommendations for achieving universal coverage with long-lasting insecticidal nets in malaria control

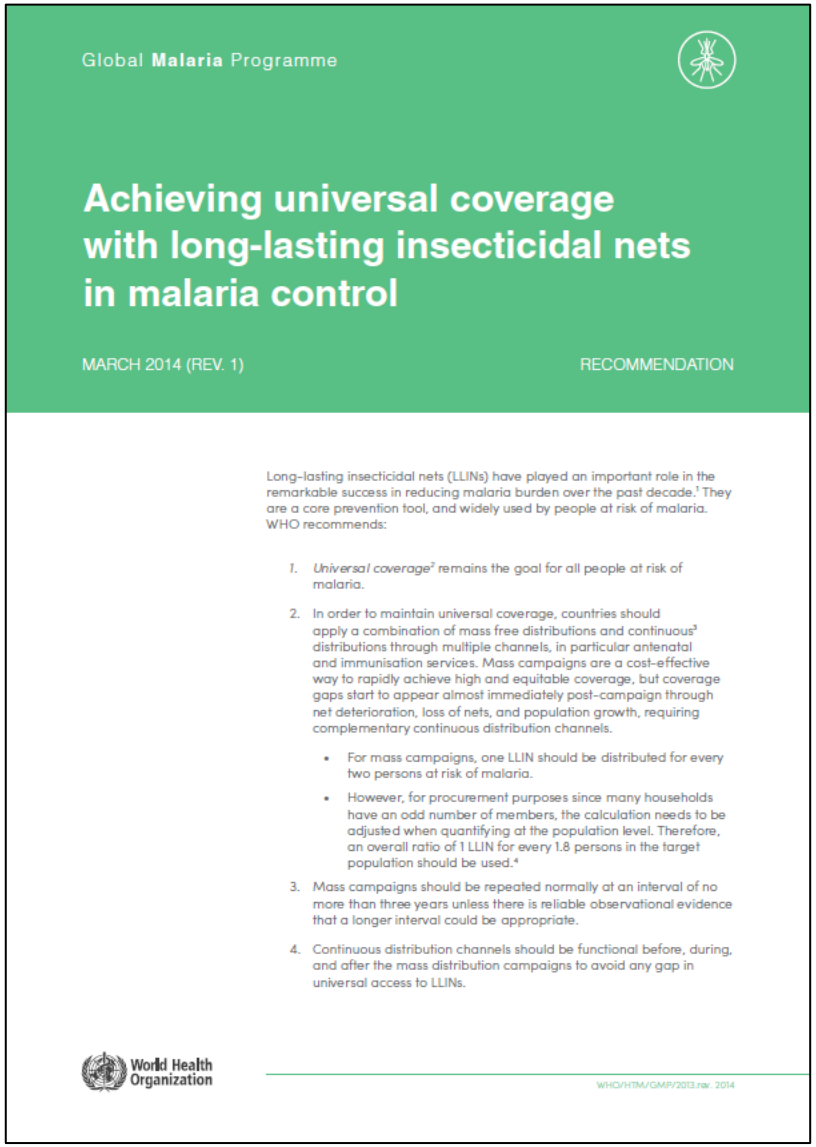
Malaria Policy Advisory Group Meeting

Geneva, Switzerland

19 October 2017

Global **Malaria** Programme

World Health Organization



Global **Malaria** Programme

Achieving universal coverage with long-lasting insecticidal nets in malaria control

MARCH 2014 (REV. 1)

RECOMMENDATION

Long-lasting insecticidal nets (LLINs) have played an important role in the remarkable success in reducing malaria burden over the past decade.[1] They are a core prevention tool, and widely used by people at risk of malaria. WHO recommends:

1. *Universal coverage*[2] remains the goal for all people at risk of malaria.
2. In order to maintain universal coverage, countries should apply a combination of mass free distributions and continuous[3] distributions through multiple channels, in particular antenatal and immunisation services. Mass campaigns are a cost-effective way to rapidly achieve high and equitable coverage, but coverage gaps start to appear almost immediately post-campaign through net deterioration, loss of nets, and population growth, requiring complementary continuous distribution channels.
   - For mass campaigns, one LLIN should be distributed for every two persons at risk of malaria.
   - However, for procurement purposes since many households have an odd number of members, the calculation needs to be adjusted when quantifying at the population level. Therefore, an overall ratio of 1 LLIN for every 1.8 persons in the target population should be used.[4]
3. Mass campaigns should be repeated normally at an interval of no more than three years unless there is reliable observational evidence that a longer interval could be appropriate.
4. Continuous distribution channels should be functional before, during, and after the mass distribution campaigns to avoid any gap in universal access to LLINs.

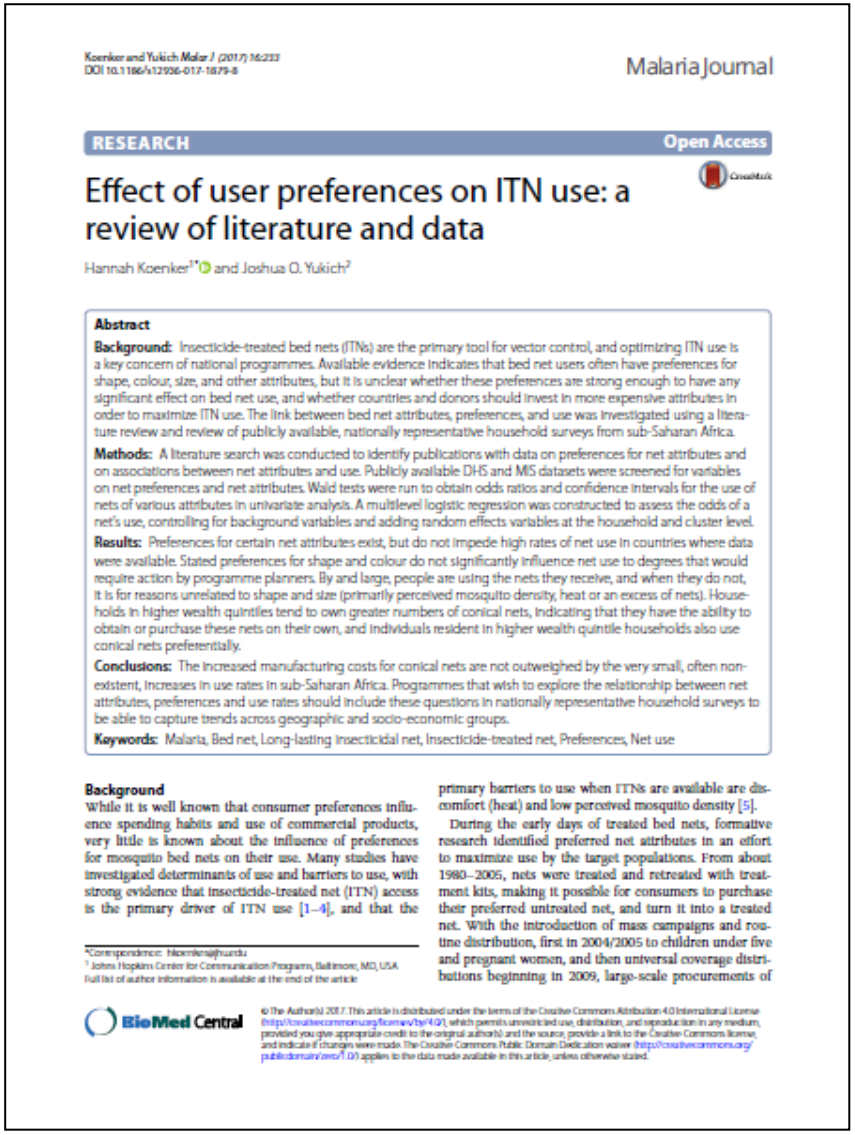
World Health Organization

WHO/HTM/GMP/2013.rev. 2014

Universal coverage: Defined as universal access to, and use of, LLINS.

Background

- Report on the effect of user preferences on ITN use was presented to VCTEG in March 2015
- WHO was requested by VCTEG to consider revision the universal coverage recommendations for LLINs to incorporate findings from this work
- Draft revisions review by VCTEG, AMP, GMP, and subsequently by MPAC
- Identified the need for broader revision of the document and discussions on some key points



Koenker and Yukich *Malar J* (2017) 16:233
DOI 10.1186/s12936-017-1879-8

Malaria Journal

RESEARCH Open Access

Effect of user preferences on ITN use: a review of literature and data

Hannah Koenker[1*] and Joshua O. Yukich[2]

Abstract

Background: Insecticide-treated bed nets (ITNs) are the primary tool for vector control, and optimizing ITN use is a key concern of national programmes. Available evidence indicates that bed net users often have preferences for shape, colour, size, and other attributes, but it is unclear whether these preferences are strong enough to have any significant effect on bed net use, and whether countries and donors should invest in more expensive attributes in order to maximize ITN use. The link between bed net attributes, preferences, and use was investigated using a literature review and review of publicly available, nationally representative household surveys from sub-Saharan Africa.

Methods: A literature search was conducted to identify publications with data on preferences for net attributes and on associations between net attributes and use. Publicly available DHS and MIS datasets were screened for variables on net preferences and net attributes. Wald tests were run to obtain odds ratios and confidence intervals for the use of nets of various attributes in univariate analysis. A multilevel logistic regression was constructed to assess the odds of a net's use, controlling for background variables and adding random effects variables at the household and cluster level.

Results: Preferences for certain net attributes exist, but do not impede high rates of net use in countries where data were available. Stated preferences for shape and colour do not significantly influence net use to degrees that would require action by programme planners. By and large, people are using the nets they receive, and when they do not, it is for reasons unrelated to shape and size (primarily perceived mosquito density, heat or an excess of nets). Households in higher wealth quintiles tend to own greater numbers of conical nets, indicating that they have the ability to obtain or purchase these nets on their own, and individuals resident in higher wealth quintile households also use conical nets preferentially.

Conclusions: The increased manufacturing costs for conical nets are not outweighed by the very small, often non-existent, increases in use rates in sub-Saharan Africa. Programmes that wish to explore the relationship between net attributes, preferences and use rates should include these questions in nationally representative household surveys to be able to capture trends across geographic and socio-economic groups.

Keywords: Malaria, Bed net, Long-lasting insecticidal net, Insecticide-treated net, Preferences, Net use

Background

While it is well known that consumer preferences influence spending habits and use of commercial products, very little is known about the influence of preferences for mosquito bed nets on their use. Many studies have investigated determinants of use and barriers to use, with strong evidence that insecticide-treated net (ITN) access is the primary driver of ITN use [1–4], and that the primary barriers to use when ITNs are available are discomfort (heat) and low perceived mosquito density [5].

During the early days of treated bed nets, formative research identified preferred net attributes in an effort to maximize use by the target populations. From about 1980–2005, nets were treated and retreated with treatment kits, making it possible for consumers to purchase their preferred untreated net, and turn it into a treated net. With the introduction of mass campaigns and routine distribution, first in 2004/2005 to children under five and pregnant women, and then universal coverage distributions beginning in 2009, large-scale procurements of

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Revised recommendations

Long-lasting insecticidal nets (LLINs) have played an important role in the remarkable success of reducing the global malaria burden over the past decade. They are a core prevention tool widely used by people at risk of malaria. Ensuring universal coverage of all people at risk of malaria with LLINs or IRS forms part of pillar 1 of the Global Technical Strategy (GTS) for Malaria 2016 – 2013. Universal coverage is defined as 100% access to, and use of, either of these interventions by populations at risk of malaria.

Revised recommendations

1. To maintain universal coverage, countries should apply a combination of mass free distributions through campaigns and continuous distributions through multiple channels, in particular through antenatal care (ANC) clinics and the expanded programme on immunization (EPI). Mass campaigns are the only proven cost-effective way to rapidly achieve high and equitable coverage. However, coverage gaps start to appear almost immediately post-campaign through net deterioration, loss of nets, and population growth. Thus, complementary continuous distribution channels are required.
    - For mass campaigns, one LLIN should be distributed for every two persons at risk of malaria.
    - However, for procurement purposes, since many households have an odd number of members, the calculation of LLINs required needs to be adjusted when quantifying at the population level. Therefore, in general, an overall ratio of 1 LLIN for every 1.8 persons in the target population should be used. This ratio can be adjusted as needed if there are data that support such adjustment.

Revised recommendations

2. The lifespans of LLINs vary widely between individual nets used within a single household or community, as well as between nets used in different settings. This makes it difficult to plan the rate or frequency at which replacement nets need to be procured and delivered. LLIN durability monitoring should therefore be conducted in line with available guidance, by all malaria programmes that have undertaken medium- to large-scale LLIN distributions. Where there is evidence that LLINs are not being adequately cared for or used, programmes should implement behaviour change interventions aimed at improving these behaviours.

3. Mass campaigns should normally be repeated at an interval of three years unless empirical evidence is available to justify the use of a longer or shorter interval. A shorter distribution interval may also be justified in cases where humanitarian emergencies increase the risk of an epidemic.

Revised recommendations

4. Continuous distribution through ANC and EPI channels should remain functional before, during, and after the mass distribution campaigns. School-based distribution should be discontinued during campaign years to avoid duplication of resources, unless there is empirical evidence to justify continuation of LLIN distribution through both schools and campaigns channels.
5. There should be a single national plan and policy, under the leadership of the national malaria control programme, for both continuous and campaign distribution strategies. This unified plan should include a comprehensive quantification and gap analysis for all public sector LLIN distribution channels. To the extent possible, the plan should also include major LLIN contributions by the private sector.

Revised recommendations

6. Each national malaria control programme should develop its own LLIN distribution strategy, based on analysing the local context of opportunities and constraints, and identifying a combination of distribution channels to achieve universal coverage and minimize gaps. In addition to mass campaigns, the distribution strategy could include:

   - ANC, EPI and child health clinics – these should be considered as high priority LLIN continuous distribution channels in countries where contact rates are high, as occurs in much of Africa south of the Sahara.
   - Schools, faith- and community-based networks, and agricultural and food-security support schemes – these can also be explored as a channel for LLIN distribution in countries where this approach is feasible and equitable.
   - Occupation-related distribution channels – in some settings, particularly in Asia where transmission ecology is often patchy, the risk of malaria may be strongly associated with specific occupations, such as plantation and farm workers and their families, miners, soldiers and forest workers. Opportunities for distribution through channels, such as private sector employers, workplace programmes and farmers' organisations, may be explored.

Revised recommendations

6. (Continued)
    - The private and commercial sectors can be important supplementary channels to free LLIN distribution through public sector channels. Access to LLINs can also be expanded by drawing on the private sector for the exchange of vouchers or coupons provided through public sector channels for a free LLIN at participating retail outlets. LLIN products distributed through the private sector should be regulated by the national registrar of pesticides to ensure quality following the specifications described by the WHO Pesticide Evaluation Scheme.
7. As programs explore a shift to different mixes of distribution methods, national malaria control programmes will need accurate tracking of LLIN coverage to district-level coverage, with triggering of sub-national responses if coverage falls below universal coverage. Tracking must differentiate the contributions of delivery channels to overall LLIN coverage.

Revised recommendations

8. Evidence available from Malaria Indicator Surveys (MIS) and Demographic and Health Surveys (DHS) in sub-Saharan Africa indicates that LLINs with different attributes (e.g., different shapes, colours and textiles) are used at similar rates regardless of the preferred net attributes indicated by intended end users. Furthermore, even if usage rates are higher in certain settings for LLINs with attributes that vary from the standard (which in most places are rectangular, white, large-sized, polyethylene or polyester LLINs), the increased use is unlikely to be sufficient to offset higher costs associated with procuring nets with non-standard attributes. Procurement of LLINs with attributes that are more costly (e.g. nets of conical shape) is therefore not recommended unless nationally-representative data clearly show that the use of LLINs with particular attributes increases significantly among at-risk populations.
9. Periodic “top-up campaigns” are not recommended.

Revised recommendations

10. In countries where untreated nets are widely available, national malaria control programmes should promote LLINs through changes to the market and techniques for treating untreated nets, including access to insecticide treatment kits.

11. Countries should generate data on defined standard indicators for coverage and access rates, to ascertain whether universal coverage has been achieved, as well as where programmatic modifications are required to improve performance toward achievement of targets. Currently the three basic survey indicators, as developed by the RBM Monitoring and Evaluation Reference Group (MERG) and adapted by WHO for the World Malaria Report, are:

    a) Proportion of households with at least one ITN/LLIN
    b) Proportion of population with access to an ITN/LLIN within their household
    c) Proportion of population reporting having slept last night under an ITN/LLIN (by age (<5 years; 5-14 years; 15+ years), gender and access to ITN)

These outcome indicators are usually measured in cross-sectional Demographic and Health Surveys, Multi Indicator Cluster Surveys and Malaria Indicator Surveys. Monitoring against process indicators is also likely to be necessary to guide malaria programme implementation.

Key discussion points (1 of 7)

It was felt that defining 'universal coverage' would be helpful

Long-lasting insecticidal nets (LLINs) have played an important role in the remarkable success of reducing the global malaria burden over the past decade. They are a core prevention tool widely used by people at risk of malaria. Ensuring universal coverage of all people at risk of malaria with LLINs or IRS forms part of pillar 1 of the Global Technical Strategy (GTS) for Malaria 2016 – 2013. Universal coverage is defined as 100% access to, and use of, either of these interventions by populations at risk of malaria.

Questions:

a) Is 100% coverage and use achievable and, if it were, would it be advisable to aim for this target?

b) What should countries do in situations where funds are insufficient to achieve 'universal coverage'?

Key discussion points (2 of 7)

Recommendation 2 on LLIN durability monitoring:

The lifespans of LLINs vary widely between individual nets used within a single household or community, as well as between nets used in different settings. This makes it difficult to plan the rate or frequency at which replacement nets need to be procured and delivered. LLIN durability monitoring should therefore be conducted in line with available guidance by all malaria programmes that have undertaken medium- to large-scale LLIN distributions. Where there is evidence that LLINs are not being adequately cared for or used, programmes should implement behaviour change interventions aimed at improving these behaviours.

Question: Durability monitoring has been actively advocated by GMP since 2011. However, what is the use of advising the programme managers to devote budgets for durability studies when the major donors are not following this recommendation in their procurement policies?

Key discussion points (3 of 7)

In recommendation 3, it would be good to provide further examples of where shorter LLIN replacement intervalls should be considered.

Mass campaigns should normally be repeated at an interval of three years unless empirical evidence is available to justify the use of a longer or shorter interval. A shorter distribution interval may also be justified in cases where humanitarian emergencies increase the risk of an epidemic.

Question: Should this include replacement of pyrethroid-only nets with, e.g. PBO nets, because of documented resistance?

Key discussion points (4 of 7)

On recommendation 6, bullet 2:

Each national malaria control programme should develop its own LLIN distribution strategy, based on analysing the local context of opportunities and constraints, and identifying a combination of distribution channels to achieve universal coverage and minimize gaps. In addition to mass campaigns, the distribution strategy could include:

- Schools, faith- and community-based networks, and agricultural and food-security support schemes – these can also be explored as a channel for LLIN distribution in countries where this approach is feasible and equitable.

Comment: Net use is lowest in teenagers and this is of increasing concern because of the mounting evidence of the deleterious effect of malaria early in pregnancy before first ANC attendance. Addressing this issue through distribution in schools or other means may warrant mentioning in the recommendations.

Key discussion points (5 of 7)

Comment: On all points mentioning continuous distribution through ANC and EPI (or any combination of targeted methods), the recommendations should be careful to avoid stating or creating the expectation that these channels could realistically sustain (or avoid gaps) in universal coverage. They may help off-set coverage declines, but are not universally targeted. In addition, there is limited experience where these continuous distribution channels operate well.

Discussion points (6 of 7)

Recommendation 8 on LLIN preference

Evidence available from Malaria Indicator Surveys (MIS) and Demographic and Health Surveys (DHS) in sub-Saharan Africa indicates that LLINs with different attributes (e.g., different shapes, colours and textiles) are used at similar rates regardless of the preferred net attributes indicated by intended end users. Furthermore, even if usage rates are higher in certain settings for LLINs with attributes that vary from the standard (which in most places are rectangular, white, large-sized, polyethylene or polyester LLINs), the increased use is unlikely to be sufficient to offset higher costs associated with procuring nets with non-standard attributes. Procurement of LLINs with attributes that are more costly (e.g. nets of conical shape) is therefore not recommended unless nationally-representative data clearly show that the use of LLINs with particular attributes increases significantly among at-risk populations.

Comment: This recommendation is based on behavioural studies done in Sub-Saharan Africa , which do not necessarily reflect the situation in all endemic areas in the world.

Discussion points (7 of 7)

On recommendation 9:

Periodic "top-up campaigns" are not recommended.

Comment: More information on top-up campaigns needed and why they are not recommended.

Footnote added: 'Top-up' campaigns take existing nets in households into account and each household is given only the additional number of nets needed to bring them up to the target number.

AMP The Alliance for Malaria Prevention

Expanding the ownership and use of mosquito nets

Statement on Accounting for Existing Nets

August 30, 2012

Quantifying the numbers of LLINs needed for national scale Universal Coverage campaigns is critically important to ensure that a sufficient number of nets are procured to meet the objectives of the campaign and to protect the whole population at risk from infection and reduce transmission of malaria. Recent field experience has documented that physically accounting for pre-existing LLINs through household registration of previously distributed nets is difficult, costly and may not yield accurate information on the location and availability of functional LLINs, especially where population coverage of nets is low. Through household registration, it is difficult to distinguish between households that are inaccurately identified as needing additional nets and those that genuinely have a net need. Results from Senegal and Nigeria indicate that only about 50% of the expected number of nets, calculated from the number of nets previously distributed and adjusted for assumed net loss over time, are actually identified in households visited by registration teams. Additionally, attempts to account for existing nets in quantifying the LLIN needs for a planned mass distribution campaign may underestimate the actual net need because nets that are functional but close to the end of their useful life at the time of household registration are counted against the household net need. Consequently, there is a significant risk that too few nets are procured to reach stated campaign objectives. Furthermore, since LLIN quantification estimates for campaigns are at the administrative area level (district, region, etc), it becomes operationally difficult to know how to allocate LLINs in campaigns to those households that truly need them.

Thus, it is the opinion of the Alliance for Malaria Prevention workstream of the Harmonization Working Group, that when universal coverage LLIN mass campaigns are carried out at any scale, programs should only consider taking existing nets into account (by not replacing existing LLINs in good condition with new LLINs) if the population coverage of LLINs is greater than 40% and the average (mean) age of existing LLINs is less than two years. In circumstances when the LLIN population coverage exceeds 40% and the mean age of existing LLINs is less than two years (at the time of the projected distribution) then a more careful cost analysis should be undertaken. This analysis should include the feasibility of identifying existing LLINs in households and assessing their condition accurately, as well as the additional costs of adding these activities to the net registration process.

Or potential additional wording: Physically accounting for pre-existing LLINs through household registration of previously distributed nets is difficult, costly and may not yield accurate information on the location and availability of functional LLINs. Accurate quantification is therefore not feasible.

Global **Malaria** Programme

Achieving and maintaining universal coverage with long-lasting insecticidal nets for malaria control

DECEMBER 2017

RECOMMENDATIONS

Long-lasting insecticidal nets (LLINs) have played an important role in reducing the global malaria burden since 2000.[1] They are a core prevention tool used widely by people at risk of malaria. Part of pillar 1 of the *Global Technical Strategy for Malaria 2016–2030* (GTS) is to ensure universal coverage for all people at risk of malaria using effective vector control with either LLINs or the other core prevention tool, indoor residual spraying (IRS).[2] Universal coverage for malaria vector control is defined as universal access to and use of appropriate interventions by populations at risk of malaria.

To achieve and maintain universal coverage with LLINs in line with the GTS, WHO recommends[3] the following based on current evidence.

Distribution mechanisms

1. To achieve and maintain universal LLIN coverage, countries should apply a combination of mass free net distribution through campaigns and continuous[4] distribution through multiple channels, in particular through antenatal care (ANC) clinics and the expanded programme on immunization (EPI). Mass campaigns are the only proven cost-effective way to rapidly achieve high and equitable coverage. Complementary continuous distribution channels are also required because coverage gaps can start to appear almost immediately post-campaign due to net deterioration, loss of nets, and population growth.

2. Mass campaigns should:

    a) Distribute one net for every two persons at risk of malaria. However, for procurement purposes, the calculation to determine the number of LLINs required needs to be adjusted at the population level since many households have an odd number of members. Therefore, in general, an overall ratio

World Health Organization

WHO/HTM/GMP/2017.20

of 1 LLIN for every 1.8 persons in the target population should be used. In places where the most recent population census was conducted more than 5 years prior, countries can consider including a buffer (e.g., adding 10% after the 1.8 ratio has been applied) or using data from previous LLIN campaigns to justify an alternative buffer amount.

b) Normally be repeated every 3 years, unless available empirical evidence justifies the use of a longer or shorter interval between campaigns. In addition to these data-driven decisions, a shorter distribution interval may also be justified during humanitarian emergencies, as the resulting increase in population movement may leave populations uncovered by vector control and potentially increase their risk of infection as well as the risk of epidemics.[5]

3. Continuous distribution through ANC and EPI channels should remain functional before, during and after mass distribution campaigns. School-based distribution should be discontinued in campaign years to avoid over-supply of LLINs. In areas where school-based distributions are operating at scale and achieve high coverage, these distributions may even be sufficient to replace mass distribution campaigns.

4. "Top-up" campaigns (i.e., LLIN distributions that take into account existing nets in households and provide each household only with the additional number of nets needed to bring it up to the target number) are not recommended. Substantial field experience has shown that accurate quantification for such campaigns is generally not feasible and the cost of accounting for existing nets outweighs the benefits.

Strategic planning

5. There should be a single national LLIN plan and policy that includes both continuous and campaign distribution strategies. This should be developed and implemented under the leadership of the national malaria control programme, and based on analysis of local opportunities and constraints, and identification of a combination of distribution channels with which to achieve universal coverage and minimize gaps. This unified plan should include a comprehensive net quantification and gap analysis for all public sector LLIN distribution channels. As much as possible, the plan should also include major LLIN contributions by the private sector.

   Therefore, in addition to mass campaigns, the distribution strategy could include:

   - ANC, EPI and other child health clinics: these should be considered as high-priority continuous LLIN distribution channels in countries where these services are used by a large proportion of the population at risk of malaria, as occurs in much of sub-Saharan Africa.

   - Schools, faith- and community-based networks, and agricultural and food-security support schemes: these can also be explored as channels for LLIN distribution in countries where such approaches are feasible and equitable. Investigating potential use of these distribution channels in complex emergencies is particularly important.

   - Occupation-related distribution channels: in some settings, particularly in Asia, the risk of malaria may be strongly associated with specific occupations (e.g., plantation and farm workers and their families,

miners, soldiers and forest workers). In these setting, opportunities for distribution through channels such as private sector employers, workplace programmes and farmers' organizations may be explored.

- Private or commercial sector channels: these can be important channels for supplementing free LLIN distribution through public sector channels. Access to LLINs can also be expanded by facilitating the exchange of vouchers or coupons provided through public sector channels for a free or subsidized LLIN at participating retail outlets. LLIN products distributed through the private sector should be regulated by the national registrar of pesticides in order to ensure product quality in line with WHO recommendations.

Other considerations

6. In sub-Saharan Africa, evidence from malaria indicator surveys and demographic and health surveys indicates that LLINs with different attributes (e.g., different shapes, colours and textiles) are used at similar rates, regardless of the intended end users' preferred net attributes.[6] Furthermore, even if usage rates in certain settings are higher for LLINs with attributes that deviate from the standard (which in most places are rectangular, white, large-sized, polyethylene or polyester LLINs), the increased use is unlikely to offset the higher costs associated with procuring nets with non-standard attributes. The procurement of LLINs with attributes that are more costly (e.g., nets of conical shape) is therefore not recommended for countries in sub-Saharan Africa, unless nationally representative data clearly show that the use of LLINs with particular attributes increases significantly among populations at risk of malaria. To build an evidence base to support the purchase of more costly nets, investigation into the preferences of specific population groups at risk of malaria may also be warranted if standard nets are unlikely to suit the lifestyle of these groups, such as may be the case for nomadic populations.

7. The lifespans of LLINs can vary widely among individual nets used within a single household or community, as well as among nets used in different settings. This makes it difficult to plan the rate or frequency at which replacement nets need to be procured and delivered. All malaria programmes that have undertaken medium- to large-scale LLIN distributions should conduct LLIN durability monitoring in line with available guidance.[7,8] Where there is evidence that LLINs are not being adequately cared for or used, programmes should design and implement behaviour change communication activities aimed at improving these behaviours.

8. In countries where untreated nets are widely available, national malaria control programmes should promote access to LLINs. Strategies for treating untreated nets can also be considered, for example, by supporting access to insecticide treatment kits.

Monitoring and evaluation

9. As national malaria control programmes implement different mixes of distribution methods, there will be a need to accurately track LLIN coverage at the district level. Subnational responses should be triggered if coverage falls below programmatic targets. Tracking must differentiate the contributions of various delivery channels to overall LLIN coverage.

10. Countries should generate data on defined standard indicators of coverage and access rates in order to ascertain whether universal coverage has been achieved and maintained. The data should also inform changes in implementation in order to improve performance and progress towards the achievement of programmatic targets. Currently the three basic survey indicators, as developed by the RBM Monitoring and Evaluation Reference Group (MERG)[9] and adapted by WHO for the World Malaria Report, are:

    a) proportion of households with at least one ITN/LLIN;

    b) proportion of population with access to an ITN/LLIN within their household;

    c) proportion of population reporting having slept last night under an ITN/LLIN (by age (<5 years; 5–14 years; 15+ years), gender and access to ITN).

    These outcome indicators are usually measured in cross-sectional demographic and health surveys, multi indicator cluster surveys and malaria indicator surveys. Monitoring against process indicators is also likely to be necessary to guide malaria programme implementation.

Endnotes

1. World malaria report 2016. Geneva: World Health Organization; 2016 (http://www.who.int/malaria/publications/world-malaria-report-2016/report/en/, accessed August 2017).

2. Global Technical Strategy for malaria 2016–2030. Geneva: World Health Organization; 2015 (http://www.who.int/malaria/areas/global_technical_strategy/en/, accessed August 2017).

3. These recommendations supersede the *WHO recommendations for achieving universal coverage with long-lasting insecticidal nets in malaria control* published in September 2013.

4. The term "continuous" is used to describe distribution systems that deliver nets continuously and without interruption over time, as opposed to "campaigns" that deliver a consignment of nets to a defined target population in a single time-limited operation. "Routine" LLIN systems deliver nets along with other routine health services.

5. Estimating population access to ITNs versus quantifying for procurement for mass campaigns. Geneva: World Health Organization; 2014 (www.who.int/malaria/publications/atoz/who-clarification-estimating-population-access-itn-mar2014.pdf, accessed August 2017).

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8. LLIN durability monitoring: toolkit and data repository. The President's Malaria Initiative (https://www.durabilitymonitoring.org/, accessed August 2017).

9. Household survey indicators for malaria control. Measure Evaluation Project; 2013 (http://www.rollbackmalaria.org/files/files/resources/tool_HouseholdSurveyIndicatorsForMalariaControl.pdf, accessed August 2017).