

# Development of a Standard Protocol for Estimating Malaria Disease Burden in SEA Region

*Report of an Informal Consultation  
New Delhi, India, 11-13 August, 2010*



**World Health  
Organization**  
Regional Office for South-East Asia

SEA-MAL-266  
Distribution: General

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Printed in India

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## Abbreviations

ABER	annual blood examination rate
API	annual parasite incidence
HMIS	health management information system
DALY	disability adjusted life year
DHS	directorates of health services/ demographic health surveys
DLHS	district level health surveys
ICMR	Indian Council for Medical Research
IDR	In-depth review
IRS	indoor residual spraying
ITN	insecticide-treated net
LLIN	long-lasting insecticidal net
MCCD	medical certification of cause of death
MERG	monitoring and evaluation reference group
MICS	multiple indicator cluster survey
NFHS	national family health survey
NGO	nongovernmental organization
NIMR	National Institute of Malaria Research
NIMS	National institute of Medical Statistics
NSSO	National Sample Survey Organization
NVBDCP	National Vector Borne Disease Control Programme
Pf	<i>Plasmodium falciparum</i>
PHC	primary health centre
RBD	registration of births and deaths
SEA	South-East Asia
SEARO	WHO Regional Office for South- East Asia
SPR	slide positivity rate
SRS	sample registration system
UCMS	University College of Medical Sciences
UNC	University of Northern Carolina
VA	verbal autopsy
WHO	World Health Organization



## Executive Summary

There is a wide gap between the reported incidence of malaria cases and malaria-attributable deaths and the actual burden of the disease in the South-East Asia Region (SEAR). The main reasons for this include deficiencies in malaria surveillance and case reporting as well as omission of relevant data from sectors which have no links with the national programme (e.g. private health sector). Various efforts to estimate the malaria disease burden by researchers have failed to deliver the consensus estimates on malaria morbidity and mortality due to procedural indeficiencies in methodology.

In order to bridge this information gap and maintain uniformity and comparability amongst the countries of SEAR and between the other WHO Regions, an informal consultation on development of a standard protocol for estimating malaria disease burden in the SEA Region, was held during 11-13 August, 2010 in New Delhi. The consultation was attended by eminent researchers, epidemiologists, malariologists, statisticians, officials from relevant government organizations and research institutions as well as international experts.

After taking stock of the situation, field experiences of various researchers from the National Institute of Malaria Research, India and international experts, finally, two methodologies were evolved and discussed at length by the group. The first methodology was based on a fever rate based model for morbidity estimation whereas the second methodology was based on adjustment of reported cases for reporting completeness and population covered by the programme. Finally, in order to maintain uniformity and comparability, the group approved the WHO methodology for estimation of morbidity and mortality using sub-national data and bottom-up approach.

The group suggested validation of the estimated figures of morbidity and mortality on the field and emphasized the need to conduct operational research in various areas to further improve morbidity and mortality estimates at country level as well as at the regional level.



## 1. Background

Malaria is a major public health problem in the WHO South-East Asia Region. Out of 11 countries in the Region, 10 are malaria endemic and about 1 271 million people (76% of the total population) are at risk of malaria. Out of the total population at risk, around 33% is at moderate to high risk of malaria, and 67% is at low risk. About 92% of the population at moderate to high risk live in Bangladesh, India, Indonesia, Myanmar and Thailand. However, the annual parasite-based diagnosed malaria cases and deaths in the Region are around 2.5 million and 3,500 respectively.

It is well recognized that there is a wide gap between the reported incidence of malaria cases and deaths and the actual burden of the disease in the Region. The main reasons for this include deficiencies in malaria surveillance and case reporting as well as omission of relevant data from sectors which have no links with the national programme (e.g. the private health sector). It is estimated that the true malaria incidence may be 10 – 20 times the reported figures. The issue of underreporting of malaria has been raised repeatedly in several forums. Most recently, the issue was raised at the Sixtieth session of the WHO Regional Committee for South-East Asia held in Thimphu, Bhutan. It is vital that improved estimates of the burden of malaria are obtained, not only for better planning, monitoring and evaluation of control programmes, but also to raise awareness of malaria in the Region where it receives relatively low priority.

There are several methods to assess the malaria burden. These include:

- Cross-sectional surveys of parasite prevalence
- Sero-epidemiological studies
- Estimation based on consumption of anti-malarial drugs
- Estimation based on epidemiological map, prevalence rate and adjustment for interventions
- Malariometric surveys

- Sentinel sites at various health care institutions
- Estimation based on surveillance statistics
- Estimation based on existing research data
- Mathematical modeling.

Each of the above methods has certain limitations. In order to establish the true picture of malaria disease burden in any country, which is continuously influenced by malaria control operations, a single method will not suffice. Therefore, the concerted deployment of various assessment methods, readily available ones as well as those in the process of research, should be adopted.

Although cross-sectional surveys and malariometric surveys may be the best ways to collect appropriate information for estimation of malaria burden especially morbidity, they are very cost-intensive and time consuming and hence, are not viable options to be conducted every year. Therefore, there is a need to develop a rapid and practical method for estimation of malaria morbidity and mortality, which can be applied uniformly to all countries in the Region and provide good estimates comparable with results obtained from periodic surveys.

In order to arrive at such a method of estimation of disease burden, WHO -SEARO had facilitated a consultative meeting in 2007 at New Delhi which focused mainly on India as it was the country contributing to the maximum malaria burden in the Region. During the meeting, many global, regional and local experts presented and deliberated on various methods of estimation of malaria disease burden. However, there was a significant variation noticed in the results presented by different experts. No progress could be made upon the methodology to be followed by each Member State. The estimated malaria incidence varied from 36 million to 160 million by employing various methods whereas the estimated malaria deaths ranged from 50 000 to 250 000 in the Region. In order to obtain satisfactory estimates, there is an urgent need to develop a base methodology which can be used in all Member States with some modifications as needed.

## **2. Objective of the consultation**

### **General objective**

To develop a common methodology for estimating malaria disease burden in the Member States of the Region.

### **Specific objectives**

- To review the available information on malaria morbidity and mortality from the Member States,
- To finalize a common methodology for estimation of malaria disease burden,
- To finalize the protocol for the methodology,
- To finalize the state-wise figures for malaria morbidity and mortality in India.

## **3. Proceedings of the consultation**

Dr J.P. Narain, Director, Department of Communicable Diseases, WHO-SEARO, during his opening address, welcomed the participants and remarked that malaria is major a public health problem in most countries of the Region. He mentioned that gross underreporting of malaria cases and deaths leads to poor visibility of the malaria problem. He emphasized the importance of surveillance, research and monitoring and evaluation in the malaria surveillance initiative. Dr. Narain mentioned that malaria is not only a health problem but also has social, economic and ecological impacts. He reiterated the need to finalize a generic protocol for estimating the disease burden.

Dr V.M. Katoch, Secretary, Department of Health Research and Director-General, Indian Council of Medical Research, mentioned the underreporting of malaria deaths in India, especially in tribal communities and appreciated WHO's initiative in organizing the consultation.

Dr Krongthong Thimasarn, Regional Adviser (Malaria), made a presentation on malaria disease burden estimation in the Region. She mentioned that India contributes to about 60% of malaria cases in the Region and that there has been a marginal increase in the reported number of malaria cases in the Region over the last three years. She highlighted that there is no formal disease burden estimation in many countries. Estimating malaria burden is important as low reporting leads to low visibility of the disease. The economic loss due to the disease also remains unknown. She informed that WHO-SEARO had established a Task Force to estimate the disease burden in India: for morbidity and mortality estimates.

Following self-introduction of participants, Dr A.C. Dhariwal, Director, National Vector Borne Disease Control Programme, was appointed as Chairperson, Dr Arvind Pandey, Director, National Institute of Medical Statistics, as Co-Chairperson and Dr Neena Valecha, Scientist F, National Institute of Malaria Research, and Dr Anup Anvikar, Scientist D, National Institute of Malaria Research, as rapporteurs.

## **4. Malaria in India**

### **4.1 Estimates of malaria burden in India**

Dr Ashwani Kumar, Officer-in Charge, National Institute of Malaria Research, presented the estimates of malaria burden in India based on a WHO-sponsored project. He presented different models based on fever rate for estimating malaria burden. He discussed the strengths and weaknesses of various models. He mentioned the National Family Health Survey and estimates of malaria burden based on that survey. The presentation also focused on a need to assess sensitivity and specificity of reported malaria cases at district level using appropriate sampling methodology, i.e., longitudinal stratified sampling frame either through re-examination of the blood smears or by conducting parallel surveillance covering all the paradigms in the country in a particular year.

## **4.2 Gaps and weaknesses of the formal reporting system of malaria in India**

Dr G.S. Sonal, Joint Director, National Vector borne Disease Control Programme, made a presentation on the existing malaria reporting system in India. The cases are reported from the village level to the sub-centre, to the primary health centre (PHC) and to the district. The district-wise data are compiled by the states and sent to the Directorate of the National Vector Borne Disease Control Programme (NVBDCP) in New Delhi. He mentioned various factors responsible for the gaps in reported figures and also measures which could be used to strengthen the malaria reporting system in the country. Dr Sonal reported that the present reporting system is based on malaria cases confirmed by microscopy and/or rapid diagnostic tests (RDTs). He discussed various factors responsible for under-reporting of malaria such as inadequate health facilities, shortage of health care personnel, poor access to healthcare, poor quality of slides/microscopy, constraints in data flow, etc. A large number of fever cases are not investigated for malaria and cause of death is often not reflected in mortality statistics. He also discussed the measures taken to improve the reporting system for instance, establishment of sentinel surveillance hospitals at district level to capture data of patients with severe malaria and deaths due to malaria, involvement of the private sector, NGOs, etc.

## **4.3 Malaria burden in forest and plain ecotypes of Orissa**

Dr S.K. Sharma, Officer-in Charge, National Institute of Malaria Research, presented glimpses of the malaria situation in Orissa state. He mentioned that the state has 4% of the total population of the country but contributes about 24% of all malaria reported cases. He presented a comparison of Slide Positivity Rate (SPR) and Annual Parasite Incidence (API) in Gurundia PHC of Sundargarh District as recorded by the National Institute of Malaria Research (NIMR) and NVBDCP. It was observed that the SPR elicited by NIMR was five times higher than the reported figure.

## **4.4 Malaria disease burden in Jharkhand**

Dr M.K. Das, Officer-in Charge, National Institute of Malaria Research, presented the malaria situation in Jharkhand state. It was shown that from

In his study the malaria deaths were almost three times the reported figures in two PHCs of Giridh District. Malaria cases were about 16 times the reported cases in a village of PHC Angara. Even though the sample size of these surveys might not be statistically significant it gave an idea of the gross under-reporting in the state.

#### **4.5 Malaria disease burden in Madhya Pradesh**

Dr Neeru Singh, Director, Regional Medical Research Centre for Tribals (ICMR), presented community-based longitudinal data (2006-2010) of one PHC consisting of 60 villages where both *P. falciparum* and *P. vivax* were prevalent. All malariometric indices, i.e., SPR, SFR, API and Pf% were very high as compared to the data recorded by NVBDCP. She also presented data on deaths due to cerebral malaria in the Government Medical College, a single hospital in Jabalpur District which was much higher than the total number of reported deaths in entire Jabalpur District. This showed gross under-reporting of malaria morbidity and deaths. It was suggested that data available from this area can be used for estimation.

#### **4.6 Changing malaria scenario in Karnataka**

Dr S.K. Ghosh, Officer-in Charge, National Institute of Malaria Research, discussed the overall improvement in the malaria situation in Karnataka state. At the same time, he referred to malaria cases in urban areas like Mangalore.

#### **4.7 Changing malaria scenario in Assam**

Dr Vas Dev, Officer-in Charge, National Institute of Malaria Research, presented data on the malaria scenario in Assam reporting declining malaria transmission trends in erstwhile high-risk areas owing to multiple interventions including induction of artemisinin-based combination therapy, insecticide impregnation of community-owned nets, provision of long-lasting insecticidal nets, releasing of larvivorous fish, increased awareness on treatment and prevention, and induction of accredited social health activists (ASHA) in healthcare services.

## **4.8 Evaluation of the malaria surveillance system in India**

Dr Naman Shah, MD PhD Candidate, University of North Carolina, USA, presented an evaluation of the malaria surveillance system in India. He also presented the findings of a case study conducted in Jalpaiguri district in West Bengal on the surveillance system. He explained that the purpose of various kinds of surveillance (active and passive), should be to enable quality case management but he observed that the Active Case Detection (ACD) scheme is not functioning well. He found in Jalpaiguri district that the excessive slide collection under ACD increases the work load of multipurpose workers (MPWs), the quality of slide collection is not good, there is delay in treatment (average 10-15 days), and the indices like Annual Blood Slide Examination Rate (ABER) and SPR are distorted. He suggested that ACD should be targeted to problem areas, particularly remote areas with poor access to passive case detection (PCD). He also informed that the national programme has already started making improvements in the case detection system in selected areas.

## **5. Malaria incidence and mortality**

### **5.1 Information on fever/malaria and utilization of public health services: NFHS (2005-06) and DLHS (2007-08)**

Dr Chander Shekhar, Reader, International Institute of Population Sciences, Deonar, briefed the participants about the two nationwide surveys, namely, the National Family Health Survey (NFHS) and the District Level Health Survey (DLHS). The surveys yield information like under-5 children who had fever during the last fortnight, beneficiaries of malaria control activities, usage of the public health system, epidemics of malaria, use of bed nets, fogging etc. It was felt that findings of such surveys could be used along with reported cases to derive the estimations.

### **5.2 Malaria mortality statistics**

Mr R.C. Sethi, Additional Registrar General, presented the three sources of data on malaria mortality in the country, viz. Special Survey on Causes of Death (2001-03), Medical Certification of Cause of Death (MCCD) and the

Annual Health Survey (AHS). The Special Survey on Causes of Death was conducted to make available bench-mark data on cause-specific mortality by age and sex. According to the survey, 3.1% of all deaths are due to malaria.

The civil registration system provides data on causes of death but the information is not medically authenticated in a majority of cases. To bridge the gap, a scheme of Medical Certification of Cause of Death was introduced in the early 1970s in India. The figures for malaria deaths could be extracted from this source.

Annual health surveys have been recently introduced in the country and comprise of clinical, anthropometric and biochemical components. Malaria has been given a separate code under acute illnesses which is being collected for all members of the household. Though the information collected is respondent-based, it can help in flagging the districts where malaria prevalence as well as mortality is high. Mr Sethi said that if proper suggestions are made more malaria-specific questions could be added to the questionnaire.

## **6. Practical approaches for malaria morbidity and mortality estimation**

### **6.1 Review of recent work on malaria burden estimation**

Dr Richard Cibulskis, Epidemiologist, Global Malaria Programme, HQ, discussed various approaches to estimate the malaria burden. These models take into consideration factors like reported cases of malaria, population infected within the community, population living at different levels of risk and reported deaths due to malaria. He discussed the pros and cons of these methods. He presented the method used by WHO that considers factors like reported confirmed and unconfirmed malaria cases, slide positivity rate, completeness of health-facility reports, proportion of fever cases using government facilities and proportion of fever cases not seeking any treatment. The method produces lower estimates than methods based on populations at risk, parasite prevalence or deaths. However, WHO

estimates correspond with fever incidence combined with SPR. The WHO method is dependent on accurate reporting by the countries.

## **6.2 Geo-statistical models for estimation of malaria**

Dr Arvind Pandey, Director, National Institute of Medical Statistics, and Dr H.K. Chaturvedi, Scientist 'E', National Institute of Medical Statistics, presented the geo-statistical and Bayesian models for estimation of malaria. The geo-statistical model involves spatial correlation of variables measured at various locations in two or three-dimensional space; e.g. rainfall, vegetation, soil texture, population density, economic wealth etc. The approach is being used in many disciplines including epidemiology. It could be used to estimate the burden of malaria for a given geographical region. If information/data are available for some sites, the model could be used to obtain an estimate for other sites. Within geo-statistical methods there could be various options to estimate disease burden such as Inverse Distance Weighting, nearest neighbour analysis and linear or nonlinear kriging (a technique involved in special interpolation). The Bayesian approach and its advantage of predicting the malaria risk based on prior distribution of malaria for a given population were discussed.

It was suggested that at the initial stage there is a need to use the model to estimate the disease burden at district level taking PHCs of the district at different locations. Further, it could be extended for the whole state in the second phase of modeling to obtain a precise estimate and geographical mapping of the disease.

## **6.3 Estimating burden of malaria through socio-economic route**

Prof. A. Indrayan, Professor and Head, Department of Biostatistics and Medical Informatics, University College of Medical Sciences, discussed the possibility of using social determinants to estimate the malaria burden since they affect malaria transmission in a given community. These could be micro-determinants like income, education, occupation, housing, sleeping habits, water storage, use of repellents or macro-determinants like poverty, economic crises, conflict and civil unrest, human activity such as agriculture and irrigation, deforestation, urbanization, health infrastructure, etc.

Though the social determinants may not directly impact the disease burden, they can help to develop improved estimates (correction factors) for data-deficient areas, when reliable social data are available.

#### **6.4 Estimation of malaria mortality in the SEA Region through empirical / field studies**

Dr Kamini Mendis, Coordinator, Case Management and Elimination, Global Malaria Programme, WHO-HQ, presented an estimation of malaria mortality in the SEA Region through empirical / field studies using uniform case fatality rate (CFR). She highlighted that findings of empirical studies suggest that malaria mortality is lowest in Sri Lanka with CFR around 0.01% and highest in Myanmar with CFR around 0.45%. Therefore, in the absence of any other credible method of estimation we can use CFR for the estimation of malaria mortality. The safest range of CFR for malaria mortality could be taken as 0.15% – 0.45%. These CFR limits may serve as lowest and highest limits for mortality.

### **7. Draft protocol for estimation of malaria disease burden**

Dr Rakesh Mani Rastogi, Technical Officer (Surveillance, Monitoring and Evaluation) presented the draft protocol which adapts a simple methodology for estimation of malaria morbidity and mortality. In the suggested methodology, most of the parameters are available through routine reporting whereas one parameter that is fever treatment seeking behaviour upon which estimates depend heavily is available through broad-based surveys like NFHS, DHS, MICS etc. In the first step of the methodology, the confirmed cases are adjusted against completeness of reporting while in the second step, the figures are further adjusted against utilization of government health facility or programme coverage areas to arrive at the estimates. Since DHS-like results are available for almost all countries of the Region, this methodology has an edge over other possible methods for maintaining uniformity and comparability.

## **Group work and closing session**

The participants were divided into two groups to discuss protocols for estimation of morbidity and mortality. The groups deliberated upon the pros and cons of various methods and made the following recommendations.

## **8. Recommendations**

The following recommendations were made:

- (1) The method applied by WHO's Global Malaria Programme for estimation of malaria morbidity could be used in the Region for uniformity. District-wise malaria case estimates could be developed on a regular basis using this method with the 2009 estimates to be delivered by December 2010.
- (2) The possibility of using the fever-rate based model for morbidity estimation was also discussed wherein there was a general agreement between the estimates from the two methods. Since no other country except India has data/survey for fever rates for all age groups, it was recommended that all Member States follow the WHO method to estimate morbidity. In India, estimates may be derived by both methods for some time for validation of the assumptions used in both methods.
- (3) Estimates may be developed using the bottom-up approach and sub-national level data. For India, the estimate may be developed from the district level onwards for capturing the eco-epidemiological variability of malaria endemicity in the country.
- (4) To improve the quality of malaria morbidity estimate for India, it was recommended that 1 to 2 malaria specific questions can be included in future Annual Health Surveys and DHS surveys.
- (5) For mortality estimates, the WHO-proposed method based on case fatality rate (CFR) can be used until evidence is generated allowing a standardized method relying on reported mortality data. There was consensus that there is a need to improve the CFR estimations, which can be done by:

- Validation of inpatient malaria mortality data and verbal autopsy as sources of information;
- Verification of the completeness of deaths and case reports.

It was also recommended that operational research including short- and long-term projects may be undertaken in the following areas:

- (1) Morbidity estimates;
  - Estimating SPR in different eco-epidemiological settings
  - Study on treatment-seeking behaviour
  - Malaria micro-stratification of the country.
- (2) Mortality estimates;
  - Improving estimates of CFR
  - Estimation of area-specific CFR
  - Estimates of cases not reporting to public health facilities.

Experiences from existing sentinel surveillance on malaria inpatients and deaths should be reviewed by mid-2011 to generate a strategy for achieving general reporting of malaria deaths efficiently and with quality

Dr R.K. Srivastava, Director-General of Health Services, India chaired the closing session where the above recommendations were presented. Dr Srivastava enquired whether the parameters required to calculate disease burden by the suggested method were available with NVBDCP and agreed, in principle, with the recommendations.

## **Annex 1**

# **Protocol for estimating malaria morbidity and mortality in WHO South-East Asia Region**

## **Methodology**

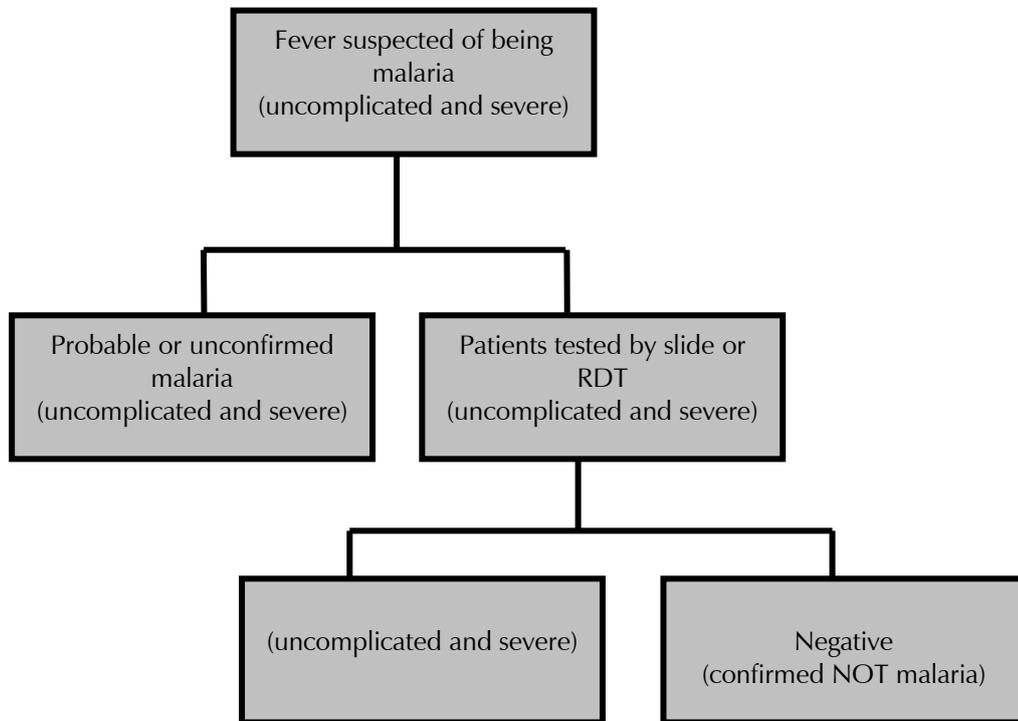
The proposed methodology for estimating malaria morbidity suggests adjusting the reported malaria cases for reporting completeness, the extent of health service utilization and the likelihood that cases are parasite-positive; where data permits.

The principal information being collected and available in the countries is the number of outpatients attending health facilities as recorded in the health management information system (HMIS) of a ministry of health, or by disease surveillance systems as follows:

- (1) The number of probable or unconfirmed cases recorded – these are cases that were treated as malaria but not tested or confirmed;
- (2) The number of cases confirmed by slide examination or RDT; and
- (3) The number of slide or RDT examinations undertaken.

The relationship between these numbers is summarized in Figure 1.

**Figure. 1** Relationship between suspected, unconfirmed and confirmed malaria



The following steps can be used to estimate the number of malaria cases in a country:-

- (1) Estimate the total number of parasite-positive cases that attended health facilities covered by the HMIS of a ministry of health. This can be calculated by adding the possible malaria positive cases in probable malaria cases to confirmed cases. The possible malaria cases in probable cases can be obtained by multiplying the probable malaria cases to slide positivity rate.
- (2) Adjust the revised confirmed cases missing HMIS reports; by dividing it by the health-facility reporting completeness fraction.
- (3) The estimated number of confirmed cases attending health facilities in the HMIS was then adjusted to take into account the propensity of fever cases to use health facilities not covered by

the HMIS (e.g. those going to the private sector), or not seeking treatment at all.

Upper and lower limits for the estimated number of cases,  $M$ , arising in any given year in a country /Region / State are given by:

$$M_{upper} = \frac{C + (s * U)}{r} \times \frac{1}{u}$$
$$M_{lower} = \frac{C + (s * U)}{r} \times \frac{(1 - n)}{u}$$

Whereas:-

$C$  = Reported number of confirmed malaria cases in a year.

If a country has information about microscopy quality check also, then first adjust the confirmed cases accordingly and use adjusted  $c$  in the formula.

$U$  = Reported number of probable or unconfirmed cases in a year – cases suspected of being malaria but not tested or confirmed.

$s$  = The proportion of slides examined that are positive for malaria parasites, often known as the slide positivity rate (SPR). In countries that are unable to undertake microscopic examination of all suspected cases,  $s$  was derived from a selection of facilities, or treatment outlets, that undertake case confirmation. The proportion of cases found to be positive,  $s$ , was applied to cases that were not confirmed.

$r$  = Completeness of health-facility reports. Typically this is the number of outpatient health-facility reports received divided by the number of facility reports expected. The expected number of reports is given by the number of health facilities multiplied by the number of reports expected to be submitted by each health facility in a year, which is 12 for a monthly reporting system. The quantity  $r$  has been reported by countries as lying within three possible ranges (less than 50%, 50%–80% and > 80%). In order to calculate an average reporting rate, it has been assumed that the reporting rate has a triangular distribution in the outer ranges and a uniform distribution in the middle with expected values in these ranges of 33%, 65% and 87% respectively.

$u$  = The proportion of the population with fever (or suspected malaria) that uses health facilities that are covered by the health-facility reporting system (under public sector / reporting NGOs etc.). This information should be derived from household survey information on whether or not children under 5 years, with fever in the previous two weeks, sought treatment in government health facilities. Use the most recent household survey like MICS, DHS or MIS etc. to get this information. Fever treatment rates for older age groups are assumed to be the same as those for children under 5 years. Household surveys undertaken in Indonesia (Susenas) and India (NSSO) suggest that this assumption is reasonable.

$n$  = The proportion of the population with fever (or suspected malaria) that does not seek treatment. Again, this information should be derived from household survey information on whether or not treatment for fever was sought, as described above.

**Uncertainty analysis:** An attempt should be made to quantify the uncertainty in each of the parameters and to use this information to construct a plausible range within which it is reasonably certain that the estimate of malaria cases lies. The underlying distribution assumed for each of the parameters is shown in Table 1. Pallisade@Risk software (version 5.7) can be used to sample from the distributions assumed for each parameter and each country. Latin Hypercube sampling can be performed 1000 times to yield a distribution for the estimated number malaria cases for a country, from which the mean value should be taken together with 5% and 95% uncertainty limits for the mean.

Table 1 *Distributions assumed for parameters in uncertainty analysis*

$r$  For each reported value of reporting completeness,  $r$  was assumed to be distributed as follows:

Reported Value	Distribution	Minimum	Most Likey	Maximum
80%	+ Triangular	80%	80%	100%
50–80%	Uniform	50%		80%
< 50%	Triangular	0%	50%	50%

*s* The uncertainty analysis aimed to reflect the variation of *s* within a country, so that when *s* was applied to cases that were not microscopically examined the slide positivity rate could take on a range of values that could reasonably be expected to occur across the country. Specifically, the national slide positivity rate, *s*, was assumed to be distributed normally with a mean  $\mu$  and standard deviation of 0.311 and 0.5547. Values of *s* were then truncated so that values lie between 0 and 1. This relationship was obtained from a least squares regression of the mean value of *s* against the standard deviation of *s* for each country for which sub-national values of *s* were available.

*u* and *n*: *u* and *n* were assumed to be distributed normally with mean and standard deviation derived directly from analysis of household surveys, taking into account the specified sampling design.

## Assumed distribution if parameter imputed

*r* The reporting rate was assumed to have uniform distribution with a range between 50% and 80%.

*s* If a country did not report a slide positivity rate, values of *s* from other countries in the relevant WHO Region were applied and assumed to occur with equal probability.

*u* and *n* If a relevant household survey was not available for a country, values of *u* and *n* from other countries in the relevant WHO Region were applied and assumed to occur with equal probability.

**Limitations:** Not all aspects of the uncertainty can be modeled accurately. Moreover, the assumptions regarding the distribution of some parameters may not always apply. Particular concerns regarding different parameters are summarized in **Table 2**.

In order to get an estimate close to the real situation, it is suggested to apply this method to get an estimate for the sub-national level first and the national level estimate should be built up by adding them especially in case of large countries like India and Indonesia. In estimating the malaria cases at sub-national level, there may be one problem when the representative value of *u* and *n* are not available from sub-national level as the rest of the information about the parameters used in the formula are readily available

up to health facility level. In those cases, we are left with no other option but to presume that the national level information for  $u$  and  $n$  will hold good at sub-national level also. Regarding getting the value for  $r$ ,  $C$  and  $U$ , it has been observed that the said information about completeness is available or can be made available at state/ province level through the district without much of a problem.

**Table 2: Potential problems and consequences of uncertainly in parameters used to estimate malaria cases**

Potential Problem	Consequence
<b>Reporting Completeness</b>	
Countries may not keep a complete and up-to-date list of all open health facilities, and reporting completeness may have been provided only for those facilities that are known to the malaria control programme.	Reporting completeness overestimated and malaria burden underestimated.
If health facility reports are aggregated at a district level then, in the absence of other information, when a district report is received it may be assumed that all health facilities in the district have reported. Similarly if reports are aggregated quarterly they may contain incomplete monthly information but be counted as complete. If accurate monitoring of the percentage of reports received is not kept, then reporting completeness may be overestimated.	Reporting completeness overestimated and malaria burden underestimated.
The analysis undertaken does not consider the type of institution failing to report. Failure of a hospital to report will generally have a greater influence on the reported number of malaria cases than a health post. In some countries malaria programmes have difficulty obtaining data from hospitals that use a separate reporting system. In other countries, missing reports may be mostly those from health posts and reporting completeness underestimated.	If hospitals are more likely to underreport, the reporting completeness will be overestimated. If health posts are more likely to underreport, reporting completeness will be underestimated.

Potential Problem	Consequence
<b>Utilization of Public Health Facilities</b>	
<p>DHS and MICS were used to estimate the proportion of malaria cases attending public health facilities, private health facilities, pharmacies or shops and those not seeking treatment at all. These proportions were derived from children under 5 who experienced fever in the two weeks before the survey. Care-seeking behaviour in children under 5 seemed to provide a reasonable approximation to care-seeking behaviour in other age groups in two countries where it could be checked, but may not apply elsewhere.</p>	<p>There is no comprehensive evidence to suggest that other age groups use health services more or less than children under 5 years in response to reported fever. Potential consequence unknown.</p>
<p>Case-seeking behaviour for self-reported fever may not necessarily reflect care-seeking behaviour for suspected or confirmed malaria.</p>	<p>There is no comprehensive evidence that fever differs significantly from true malaria. Potential consequence unknown.</p>
<p>Only 9 of the 69 household surveys analyzed were conducted in 2006. 85% of surveys were from 2000 or later, with the median age of survey being 5 years. Utilization of health services may therefore be under-or overestimated.</p>	<p>There is no comprehensive evidence that fever differs significantly from true malaria. Potential consequence unknown.</p>
<p>A single national estimate of the proportion of fever cases attending public health facilities was used. In some countries, the availability and accessibility of services may be greater in areas with less malaria. Conversely services may be less accurate.</p>	<p>Potential overestimation of the proportion of malaria cases attending public health facilities. Simultaneously the proportion of malaria cases using private health facilities may be overestimated. The combined effect of these tendencies is unknown.</p>
<p>The uncertainty analysis considered only sampling variation in the estimation of <math>u</math> and <math>n</math>. The potential effect of misclassification of treatment outlets as being covered by the HMIS or not was not explored.</p>	<p>Potential underestimation of the uncertainty regarding case estimates.</p>

Potential Problem	Consequence
<b>Slide Positivity Rate</b>	
Health facilities that undertake slide examination may only do so for selected patients, e.g. those admitted, or for adults.	If slide examination is reserved for more severe cases, the number of confirmed malaria cases may be overestimated. If slide examination is reserved for adults, the number of confirmed malaria cases may be underestimated. The combined effect of these tendencies is unknown.
A slide positivity rate derived from selected government facilities is applied to suspected malaria cases attending other facilities to estimate confirmed malaria cases. Health facilities not undertaking case confirmation may differ qualitatively from those undertaking slide examination (e.g. they may be in different parts of the country) and obtain a different SPR.	If facilities undertaking slide examination are located in more developed or urban areas, the true proportion of suspected cases that are confirmed may be underestimated. If slide examination is more likely to be undertaken in areas where malaria transmission is more intense, the proportion of all cases that are confirmed will be overestimated. The combined effect of these tendencies is unknown.
A SPR from public health facilities is applied to private facilities including shops and pharmacies, but the true rate may be different.	No evidence that slide positivity in the private sector differs from that in the public sector. Potential consequence unknown.
On average, a SPR of half of that found in public health facilities is applied to fever cases not attending facilities; the range of SPR used being from 0 to s.	Knowledge of infection rates in fever cases that do not seek treatment is insufficient. Potential consequence unknown.

## Estimation of malaria mortality

In all countries of the SEA Region where total malaria mortality comprises <5% deaths in children under 5 years, the number of malaria deaths is inferred by multiplying the estimated number of *P. falciparum* malaria cases in a country by a fixed case fatality rate. A case fatality rate of 0.3% for *P. falciparum* cases is applied to arrive at malaria mortality estimate. Since malaria case fatality rates in populations are not well documented, there is

no other choice but to go with empirical studies which suggest that in the SEA Region the malaria mortality rate ranges between 0.1% to 0.3% of *P.falciparum* cases.

Uncertainty limits for the number of deaths can be calculated by assuming a uniform distribution of case fatality rates ranging from 0.15% to 0.45%. The number of *P.falciparum* cases was assumed to have a uniform distribution with lower and upper limits given by the 5% and 95% uncertainty limits calculated in the estimation of total number of cases multiplied by the percentage of cases estimated to be *P.falciparum*. The following steps are needed to estimate malaria mortality:-

- (1) Multiply the upper and lower limits of the estimated number of malaria cases (including probable malaria cases) by Pf% (confirmed by microscopy or RDT) to arrive at lower and upper limits of estimated number of Pf cases.
- (2) Multiply estimated number of Pf cases with 0.3 to get the lower and upper limits of malaria deaths.
- (3) Take the average of lower and upper limits of malaria deaths to arrive at point estimate of the same.
- (4) 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. Example: Sri Lanka & Bhutan etc.

## Limitation

The same case fatality rates assigned to all Member States without regard to the availability and utilization of treatment for malaria, and in practice could vary from the rate used. At present, it is, however, not possible to identify a better method, which could be applied by all malaria-endemic countries

## Annex 2

# Agenda

### Day 1

Opening ceremony	
➤ CDS	
➤ MAL	
➤ NVBDC (Dr Dhariwal)	
Malaria situation in SEA Region	Dr Krongthong
Review of recent work on malaria disease burden estimation	Dr Cilbulskis
Presentation by NIMR field station Officials on Malaria Disease Burden in their respective areas (!0 presentations)	
Malaria related information collected in DHS/ DLHS surveys in India	Dr Chandra Shekhar
Estimation of malaria mortality in SEA Region through imperial / field studies	Dr Kamini Mendis
MCCD methodology for estimating malaria mortality	Mr Sethi
Model-based estimation for malaria morbidity in India	Prof Indrayan
Presentation on result received from Dr Prabhat Jha on APW on malaria mortality and it's implications towards the estimated malaria deaths during million death study in India, 2001-2003	Dr Cibulskis
Presentation of draft protocol	Dr Rastogi

### Day 2

- Group Work
- Morbidity
  - Mortality

**Day 3**

Group work (Continued)

Presentation of Group Work

Recommendations

Finalization of Protocol

Final State-wise Figure for malaria morbidity and  
Mortality for India

### Annex 3

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There is a huge gap between the reported incidence of malaria cases and malaria-attributable deaths and the actual burden of the disease in the South-East Asia Region. The main reasons for this include deficiencies in malaria surveillance and case reporting as well as omission of relevant data from sectors which have no links with the national programme (e.g. private health sector).

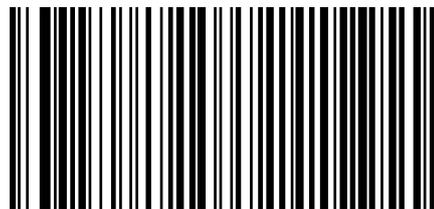
The estimation of burden of disease is essential for any programme for better planning and targeting the interventions to control and improve the disease condition. Therefore, there is a need to develop a rapid and practical method for estimation of malaria morbidity and mortality, which can be applied uniformly to all countries in the Region and provide good estimates comparable with results obtained from periodic surveys.



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