# MALARIA SITUATION IN THE GREATER MEKONG SUBREGION

Abstract. The epidemiology of malaria in the Greater Mekong Subregion is complex and rapidly evolving. Malaria control and elimination efforts face a daunting array of challenges including multidrug-resistant parasites. This review presents secondary data collected by the national malaria control programs in the six countries between 1998 and 2010 and examines trends over the last decade. This data has a number of limitations: it is derived exclusively from public sector health facilities; falciparum-specific and then pan-specific rapid diagnostic tests were introduced during the period under review; and, recently there has been a massive increase in case detection capability as a result of increased funding. It therefore requires cautious interpretation. A series of maps are presented showing trends in incidence, mortality and proportion of cases caused by Plasmodium falciparum over the last decade. A brief overview of institutional and implementation arrangements, historical background, demographics and key issues affecting malaria epidemiology is provided for each country. National malaria statistics for 2010 are presented and their robustness discussed in terms of the public sector's share of cases and other influencing factors such as inter-country variations in risk stratification, changes in diagnostic approach and immigration. Targets are presented for malaria control and where appropriate for elimination. Each country's artemisinin resistance status is described. The epidemiological trends presented reflect the improvement in the malaria situation, however the true malaria burden is as yet unknown. There is a need for continuing strengthening and updating of surveillance and response systems.

**Keywords:** malaria, incidence, mortality rate, risk group, multidrug resistance, surveillance, control program, GMS

## INTRODUCTION

The epidemiology of malaria in the Greater Mekong Subregion (GMS) is highly complex. All four species of human plasmodia occur and cases of *Plasmodium knowlesi* (a zoonosis associated with macaques but sometimes transmitted to humans in deep forested areas) have also been documented in Viet Nam, Cambodia, Thailand and Myanmar (Cox-Singh *et al*, 2008; Van den Eede *et al*, 2009; Jongwutiwes *et al*, 2011; Lee *et al*, 2011; Sermwittayawong *et al*, 2012). The vast majority of malaria cases are caused by *Plasmodium falciparum* and *Plasmodium vivax*. The epidemiology of the disease varies greatly between and within countries and from one population group, or individual, or situation to another. In many cases the different situations and contexts require different malaria control strategies, adapted to suit specific risk groups and vector behaviors, and adjusted to take into consideration local infrastructure and health service coverage. In addition malaria control strategies must be sufficiently reactive and innovative to deal with the rapidly evolving environmental conditions resulting from the large number of economic development projects currently underway (Schapira and Boutsika, 2012) (see Chapter 1).

During the last decade there has been an overall improvement in the malaria situation (Delacollette *et al*, 2009) in the GMS. However, the burden of disease remains unacceptably high and in Myanmar the situation is particularly serious (although it accounts for only about 18% of the population in the GMS, in 2010 it accounted for 74% of malaria attributed deaths and more than 76% of confirmed malaria cases). Furthermore, the risk of a significant resurgence of malaria remains very real in populations residing in areas that have become free of malaria but where primary vectors persist (WHO and Myanmar MOH, 2007).

The relative importance of vivax malaria is increasing region-wide (Maguire and Baird, 2010; WHO, 2010; MOH Cambodia - CNM, 2011) especially in areas where control efforts are having a significant impact of falciparum malaria (which is more amenable to control on account of the fact that it does not have difficulty to treat liver stages like vivax malaria).

Malaria control and elimination efforts in the Region still face a daunting array of challenges relating to both technical and programmatic issues, to political and economic constraints, to security problems, to environmental changes, to the rapidly evolving partner landscape, to the progressive disinterest among policy makers responsible for allocating funds for malaria elimination and to the lack of engagement by communities in elimination efforts (see Chapter 1) (The Lancet Series, 2010). Furthermore, the long overdue emphasis on improving the quality of malaria diagnostic and treatment services in the private sector has placed a considerable extra burden on national malaria programs and on the various partners involved. Multidrug-resistant *P. falciparum* and the presence of inappropriate, substandard and fake drugs (the latter intentionally lacking active ingredient) add considerably to the frontline difficulties associated with efforts to effectively eliminate the disease or at least to maintain the gains made so far (see Chapter 5 and section on substandard and counterfeit medicines in Chapter 1).

In the GMS intense malaria transmission is largely restricted to forested areas (see Chapter 3) (Dysoley *et al*, 2008; Sanh *et al*, 2008). The most efficient vectors, members of the *Anopheles dirus* species complex, cannot survive without dense shade and high humidity. Deforestation therefore generally leads to substantially reduced malaria transmission. The next most efficient vector, which is probably the most important in terms of transmission, is *Anopheles minimus (senso lato)*. This species is also primarily forest-based but can survive in less densely shaded forest, forest fringes and in the bamboo thickets that commonly persist post-deforestation. The establishment of oil palm and rubber plantations following deforestation can also provide suitable habitats for vectors resulting in resurgence in malaria transmission. Secondary vectors such as *Anopheles maculatus* and *Anopheles aconitus* occur in areas of open farmland and in flooded rice fields and sporadic secondary transmission can take place in these areas as a result of imported cases. Wherever transmission occurs on a regular basis it tends to be perennial with seasonal peaks associated with rainfall or sometimes linked to internal or cross-border population movements (MoH Vietnam, unpublished data, 2011).

There are five broad categories of people affected by malaria in the Region: ethnic minority groups; forest fringe inhabitants; rubber plantation workers; temporary migrants and seasonal workers; and new forest settlers.

The epidemiology of the disease varies considerably from one group to another (Box 1).

## Box 1

## Key malaria risk groups in the GMS

**Ethnic minority groups (EMGs).** Traditional forest inhabitants belong to over 50 different ethnic groups. Most have their own distinct language and often only a small proportion of group members (predominantly men) speak the national language, making communication of health messages extremely problematic. Poverty in these communities is often extreme.

Minority groups tend to be concentrated in remote areas (commonly along borders) where access to healthcare services (both public and private sector) is often limited. Many groups have large communal villages that are left all but empty for much of the year as families spend months away tending their crops in small farms scattered through the nearby forest. In addition, individuals (usually young men) may spend short periods away from their homes or forest farms, hunting or collecting forest products. Access to healthcare is often made even more difficult as a result.

All age groups tend to be exposed seasonally to long periods of sometimes intense transmission. Adults are usually partially immune but children and pregnant women are extremely vulnerable. Mortality data does not exist but the numbers of malaria related deaths in many of these communities are undoubtedly high. Peak transmission season surveys conducted in 38 villages in Ratanakiri (Cambodia) in September 2001 revealed mean falciparum prevalence rates of 28% overall (range 7-51%) and 41% in children (range 2-81%) (Sochantha *et al*, 2006). These higher rates are comparable with those found in holoendemic parts of East Africa. Similar malaria hotspots are found in Viet Nam, Lao PDR and Myanmar.

The micro-epidemiology of malaria in areas of intense transmission is not well un-

derstood: It is not clear exactly where within a community most transmission occurs. It could be in the village (either inside the house, outside the house or at springs on the outskirts of the village) or it could be at the forest farms.

**Forest fringe inhabitants.** Many people live in rice growing communities close to the forest. Villagers (predominantly young men) make frequent overnight visits to the forest to hunt and to collect construction wood and other products. These visits frequently result in malaria. Cases returning to the village can infect anopheles mosquitoes breeding in and around the rice fields and although these species are less efficient vectors than the ones found in the forest, limited local transmission can occur. All age groups are therefore at risk but the majority of cases are found in adult males.

**Rubber plantation workers.** Rubber plantations can provide suitable habitats for *An. dirus* (Garros *et al*, 2008). Rubber tappers work at night and very early in the morning when it is cool in order to prevent the latex they collect from coagulating and thereby maximize yield. This greatly increases their potential for contact with vector mosquitoes. Typically in the GMS latex is collected for ten months of the year from late April to February when the trees are in full leaf. The workforce is therefore permanent and in large plantations can be sizeable. Typically whole families are involved and are housed in company owned settlements in or close to the trees. The men tend to start work first leaving women to tend to their children before joining them in the plantation soon after dawn. All age groups are therefore at risk of malaria but exposure is highest amongst adult males.

**Temporary migrants and seasonal workers.** People involved in forest-based activities are at high risk of contracting malaria. Key risk groups include workers involved in timber extraction (including illegal loggers and sandal wood collectors and groups digging out timber stumps for the production of carved ornaments), soldiers (who often travel with their families), workers involved in infrastructure development projects (such as building roads and dams), workers involved in agricultural development projects (establishing rubber, cashew and coffee plantations), gem and gold miners and increasingly tourists. Seasonal workers harvesting coffee and fruit from orchards or cassava and rice close to the forest are also at high risk. While the temporary migrants described above are mostly men, the seasonal workers include many women. In each case, workers may come from villages near the forest but many also come from other regions when seasonal demand for labor in those areas is low. Often they have little or no immunity to malaria. When ill, most attend health facilities close to the forest where they work, but many also seek treatment when they return to their homes.

**New forest settlers.** Families who, for economic or political reasons, relocate to forested areas to establish farms are initially at high risk of contracting malaria. Their immunity is usually low. Malaria transmission typically diminishes year by year with continued development and deforestation of settled areas.

As forested areas shrink and are replaced by farms and large plantations and as populations become increasingly stable the patterns of transmission are changing.

The lack of strong health systems and in particular the importance of the private sector in providing malaria treatment continues to be a major issue. In many countries the 'for-profit' private sector plays a key role in the delivery of malaria treatment especially in remote areas. Often there is a lack of any form of parasitological diagnosis so treatment is based on what is available and what a patient can afford. This more often than not is artemisinin-based monotherapy that contributes toward the development of resistance. Greater engagement with the private sector will be a key to the success of national malaria control efforts in many countries, as universal coverage targets are not attainable without private sector involvement. Valuable lessons have been learned from a major malaria-specific private sector engagement initiative in Cambodia – the 'Malarine Project' - which began providing heavily subsidized ACTs and RDTs in 2000 and subsequently scaled-up under Global Fund support (GFATM, 2010b; MOH Cambodia-CNM, 2011; Yeung *et al*, 2011).

Mobile populations are proving particularly difficult to target with effective interventions for a number of reasons: many actively avoid contact with authorities either because they are illegal immigrants, or are breaking national rules relating to internal migration, or are involved in illegal activities of some sort. Added to this, many are driven only by the need to make money and so getting accurate information for health action from them is a sensitive and complex multi-sector task (see Chapter 4).

Outdoor transmission is a key feature of the epidemiology of malaria in the GMS, limiting the effectiveness of key interventions for vector control and personal protection and hampering further progress with malaria control and elimination efforts. In an effort to address this problem, the Roll Back Malaria Vector Control Working Group has proposed a comprehensive stratification of outdoor malaria risk groups with each group linked to a list of possible interventions. Although the fine details have yet to be decided, intervention packages are likely to include a wide variety of tools (including RDTs, ACT, LLINs, long-lasting insecticide treated hammock nets and hammocks, other long-lasting insecticide treated materials, insect repellents and multilingual communication materials) and approaches (village malaria workers, mobile malaria staff, LLIN loan schemes for temporary workers, chemoprophylaxis and kits for stand-by diagnosis and treatment) tailored to the specific needs of each risk group (RBM, 2012) (see Chapter 7).

## MATERIALS AND METHODS

The secondary data used in this review originate from the national malaria control pro-

grams (NMCPs) in the six GMS countries, and were obtained via the WHO's Western Pacific and South-East Asia Regional Offices to which the WHO Member States report health data annually. Those data are consolidated at regional level and are ultimately incorporated into the World Malaria Report each year. All six NMCPs produce estimates for several indicators including the number of malaria cases suspected, tested and confirmed, the proportion of confirmed malaria cases caused by P. falciparum and the number of deaths attributed to malaria. Confirmed malaria cases are defined as cases with a parasite-based diagnosis, whether it be the result of microscopy, rapid diagnostic test, or some other reliable method (WHO, 2011). Data and information provided in this chapter cover the period from 1998 to 2010 (with detailed comparison of selected indicators from 2002 and 2010) and so need to be interpreted with caution taking into consideration the introduction of first falciparumspecific and then pan-specific RDTs (Pan-specific RDTs are capable of detecting both falciparum and other malaria species) (both with increasing sensitivity and specificity over time) (WHO WPRO, 2012) and the very significant increase in case detection capability as a result of the massive increase in funding for malaria during the last decade (GFATM, 2006, 2007, 2010a,b,c,d; 2012a,b; WHO, 2011) (see also Chapter 7).

Official malaria figures do not accurately reflect the true disease burden as they are largely derived from passive case detection at public health facilities. The routine malaria information collected from the health information system (HIS) and/or by malaria specific vertical information channels has several limitations. Its accuracy (completeness) depends on various factors affecting patients' healthcare-seeking practices such as the coverage and performance of public healthcare services, financial barriers to access (such as transportation costs, lost earnings for carers and the fact that the public sector does not provide credit the way the private sector does) legal barriers for unrecorded migrant workers and social barriers for remote ethnic minority groups concerned about racial discrimination. In addition, numerous cases are diagnosed and treated by community based volunteer networks (such as the Village Malaria Worker Project in Cambodia which accounted for 45% of all cases treated in the public sector in 2010). Initially malaria volunteers were generally posted as an interim strategy in remote places with no formal health care facilities within reasonable walking distance (WHO, 2007). They are now however increasingly engaged in additional tasks such as active surveillance, individual case follow-up and directly observed treatment associated with elimination and are now used in less remote and less endemic communities than before (MOH, Cambodia-CNM, 2011). Patients managed by VMWs are not yet usually recorded in the routine HIS although national experts managing procurement, supply chains and national reporting systems do take such data into account for general planning and evaluation (MOH Cambodia, 2012 unpublished data).

Patients treated outside the public sector (for example by private practitioners, traditional healers, shop-keepers, faith-based organizations and self-treated cases) and asymptomatic cases mostly remain undetected or unreported in the official figures despite recent efforts by national programs to engage more with accredited private providers towards better service delivery and reporting (Yeung *et al*, 2011). For instance, a study on the health information system in Viet Nam found that national malaria figures greatly underestimate the malaria burden, largely because private health facilities, where coverage in some communities is double that of public health facilities, are not accounted for (Erhart *et al*, 2004). Another study in Viet Nam acknowledged the fact that in Binh Phuoc Province in 2011, between 13-23% of patients are either self medicated or seeking care from informal private providers (Anh NQ and Hung LX, unpublished data, 2011). Similarly, 20-41% of individuals in Cambodia (depending on the location) seek their first malaria treatment in the nearest public health facility (Incardona *et al*, 2007; MOH, Cambodia-CNM, 2009 and 2011). Results from a survey in Lao PDR showed that about 53% of respondents self-medicated for malaria (MOH Lao PDR-CMPE, 2010).

It should also be noted that the routine surveillance data used in this analysis does not distinguish between locally acquired and imported cases and so may be misleading to some extent, especially where imported cases have been reported in areas free from transmission (such as Ha Noi Province in Viet Nam where 16 cases were reported in 2012 (MOH NIMPE Viet Nam, unpublished data) or in less endemic areas where large numbers of cases are imported (such as Yunnan Province in China).

Despite their known limitations, routine health information systems are recognized and supported by WHO as useful instruments (albeit in need of further strengthening) for providing country information on major disease trends and detection of epidemics over space and time (Cibulskis *et al*, 2007, 2011; WHO, 2011).

This analysis aggregates the number of malaria cases and deaths at the regional level to produce estimates on malaria morbidity and mortality for the GMS. The sub-national areas are provinces for Cambodia, Lao PDR, Thailand and Viet Nam; they are states, divisions and townships for Myanmar; and prefectures and counties for Yunnan Province in China. However, comparisons of the number of cases and deaths between countries or sub-national areas do not account for differences in collection and reporting methods, sources of data (such as the various combinations of active and passive case detection used by some countries, performance of services and the respective importance of the private sector in health commodity delivery), or the varied definitions of data items between countries. Therefore, any interpretation of the data presented here should take into account these limitations.

## RESULTS

## Cambodia

Malaria remains an important public health issue in Cambodia and the NMCP receives strong political support (Moeun Chhean Nariddh, 2011). Cambodia's national malaria control effort is led by the National Center for Parasitology, Entomology, and Malaria Control (CNM). Management of implementation is largely decentralized through Provincial Health Departments and through Malaria Supervisors at provincial level or sometimes at 'Operational District' level. Numerous international partners are involved in supporting Cambodia's malaria control effort to the extent that inter-agency coordination has become a critical issue.

Following the rise of the Khmer Rouge regime in 1975, two decades of civil war led to the near total destruction of Cambodia's health infrastructure. A gradual process of reconstruction started in the mid 1990s and over the last decade Cambodia's development has been dramatic.

In 2010 the country had an estimated population of 14.1 million with about 3.2 million people (24%) residing in malaria endemic areas (Table 1). Among 386,420 suspected cases, 135,731 were tested and 46,101 were parasitologically confirmed (further updated to 58,621 following receipt of late reports) mainly by RDTs. Of these confirmed malaria cases, 63% were caused by P. falciparum. One hundred fifty-one malaria related deaths were reported amongst hospital inpatients. An additional 47,222 patients were confirmed by public sector supported community-based diagnostic and treatment services (the 'Village Malaria Workers') bringing the estimated total number of cases confirmed in the public sector to just below 106,000 in 2010. This figure does not include data from Cambodia's substantial private sector (this includes official health care facilities and pharmacies as well as unofficial drug shops and mobile drug sellers) that is the first choice for 59-80% of people with fever seeking treatment (ACTwatch, 2009; MOH Cambodia-CNM, 2009, 2010; Yeung et al, 2011). Results from a recent survey suggest that only 22% of people with malaria symptoms are parasitologically tested - 56% of them in the public sector (MOH Cambodia-CNM, 2011). The increasing proportion of non-malaria fever cases can be expected to lead to a greater proportion of people wrongly treated with anti-malarials in future (Kasper et al, 2012). The reported figures therefore underestimate the true burden of disease to some extent. Nevertheless, they do give the most robust and consistent measure available of progress over time (Figs 1 and 2).

National statistics reported to WHO indicate that between 2002 and 2010 the number of probable and confirmed cases and the number of malaria related deaths fell by 52% (from 100,194 to 47,910) and 67% (from 457 to 151), respectively (WHO, 2011).

al malaria statistics in the Greater Mekong Subregion, 2010.
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Country	Population (UN estimates)	Population at risk (million) <sup>a</sup>	Suspected malaria cases	Patients tested for malaria	Confirmed malaria cases <sup>b</sup>	falciparum malaria cases	vivax cases	Pf/Pv ratio (%) <sup>c</sup>	Malaria deaths	Malaria incidence rate (per 1,000)	Malaria mortality rate (per 100,000)	% of patients seeking care outside public health facilities <sup>d</sup>
Cambodia China-Yunnan Lao PDR Myanmar Thailand Viet Nam Total	14,138,255 45,966,000 6,200,894 47,963,012 69,122,234 87,848,445 87,848,445 271,238,840	3.2 35.5 2.6 33.1 2.1 15.5	386,420 1,233,966 2,138,654 2,803,918	135,731 520,830 280,365 1,005,252 2,138,654 2,767,136 6,847,968	46,101 2,277 2,277 14,654 420,808 44,124 17,515 555,479	8,213 631 14,341 390,518 18,604 12,763 445,070	4,794 1,638 304 29,944 25,838 4,466 6,802	63 28 70 74 74	151 3 24 788 80 21 1,067	3.26 0.05 3.68 8.77 0.64 0.20 2.04	1.07 0.01 0.39 1.64 0.12 0.02 0.02	59-80 <5 60-80 60 13-23
<sup>a</sup> Population livii bData are from been diagnose	ng or residing HIS and/or νε d by VMWs.	in areas with ertical malaria	ongoing mal	aria transmi stem. In Ca	ission exclue mbodia and	ding 'receptiv Lao PDR, a	/e areas' ( n addition	where e al 47,22	spidemics 2 and 39,	could occur 182 malaria	r). a cases, ree	spectively, have

cP. falciparum/P. vivax ratio is generally taken from blood smears only (microscopy).

dEstimated percentage is based on recent local surveys. It includes self treatment, traditional healers, formal and informal private providers, VMWs, etc.

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Comparing annual parasite incidence by province in 2010 with that in 2002, and taking into account the limitations described above, it is clear that progress has been made towards pre-elimination targets (WHO, 2007). By 2010 incidence of confirmed malaria in all provinces had fallen below 10 per 1,000, and in half it had fallen below 1 per 1,000, demonstrating progress towards elimination (Fig 4). During the same period malaria mortality also declined significantly in all provinces with only one province, Rattanakiri, showing a malaria mortality rate above 10 per 100,000 in 2010. Four provinces reported zero malaria death in 2010 (Fig 5).

Impact level targets for 2015 include: annual probable and confirmed malaria deaths reported in public health facilities down to less than 1 per 100,000 population; and, annual probable and confirmed malaria cases reported in public health facilities down to less than 2 per 1,000 population. By 2020 the country aims to move towards elimination of malaria with an initial focus on *P. falciparum* ensuring zero malaria deaths. 2025 is the target date for elimination of all malaria species (MOH Cambodia-CNM, 2011).

The Thailand-Cambodia border has long been associated with the development of antimalarial drug resistance, first to chloroquine, sulphadoxine-pyrimethamine and mefloquine and since 2006 to artemisinin (see Chapter 5).

#### China (Yunnan Province)

Malaria remains an important public health issue in China. China's national malaria control effort is led by the National Institute of Parasitic Diseases (NIPD) in Shanghai, part of the China's Center for Disease Control (China- CDC). Implementation is through provincial, prefecture, city and county CDCs, township hospitals and village doctors. Technical support is provided by CDCs at different levels (see further details in Chapter 7).

Following China's sweeping economic reforms of the 1990s severe financial constraints developed and the NMCP went into decline. By the early 2000's malaria control efforts had become piecemeal and the national reporting system had been seriously undermined. Following the outbreak of Severe Acute Respiratory Syndrome (SARS) in 2002-2003 major improvements were made to disease surveillance including the development of a webbased geographical information system that incorporates a comprehensive malaria specific module (Zhou, unpublished report). Also since 2003, support from The Global Fund for AIDS, TB and Malaria (GFATM) and renewed national political commitment have resulted in major improvements in implementation of malaria control activities (Zhou, unpublished report).

Vivax malaria is endemic in central regions where several provinces are prone to largescale epidemics, and both vivax and falciparum malaria are present in Hainan and Yunnan Provinces (Lin *et al*, 2009) (Hainan is an island province and here falciparum malaria is on



Fig 1–Trends in incidence of confirmed malaria cases by Mekong country, 1998-2010.



Fig 2–Trends in the malaria mortality rate by Mekong country, 1998-2010.

the point of elimination). As this review relates only to the GMS this profile deals only with Yunnan.

Yunnan Province shares a border of 4,000 km with Myanmar, Lao PDR and Viet Nam. Malaria occurs mainly in these border areas, and in the catchment area of the Yuanjiang River. In 2010 Yunnan had an estimated population of 42.4 million; 35.5 million of these people are currently classified as residing in malaria endemic areas (84% of the population). However this proportion is considered an overestimate firstly because it is based on a county level stratification that includes large urban populations and secondly because many of the cases considered in the stratification are actually imported (especially from Myanmar). Two thousand six hundred forty-three cases of malaria were reported in 2010 and 2,277 (86%) of these were parasitologically confirmed. Of these confirmed malaria cases, 28% were caused by *P. falciparum*. Three malaria related deaths were reported amongst hospital inpatients in 2010 and all of these were likely to have been the result of infections contracted outside China (substantially delaying access to treatment and increasing risk). Since the HIS in China distinguishes between local and imported cases, it should be easy to identify countries which are recording indigenous cases only.

In 2009, 63% of Yunnan's malaria cases (1,832/ 2,987) were imported from Myanmar and more than 95% of these are believed to have come from the five highly endemic 'Special Regions' just across the border (where estimated incidence in 2009 reached 134/1,000) (China's round 10 application to GFATM, 2010, unpublished document) ('Special Regions' are self-administered regions). Each year an estimated 1.6 million Chinese nationals cross the border to work in Myanmar. An estimated 100,000 of these spend long periods away. Minimizing the number of cases imported from this area is crucial to China's malaria elimination effort (Li H *et al*, unpublished data, 2009).

The malaria statistics for Yunnan presented above are based mainly on data from public sector health facilities and from village doctors (private sector medical practitioners supported by the public sector). However they also include data from private sector providers who are required by law to report all malaria cases to the public sector. The reported figures therefore provide a realistic estimate of the true burden of disease and give a reasonably robust measure of progress over time (Figs 1 and 2).

National statistics reported to WHO indicate that between 2002 and 2010 the number of probable and confirmed cases and the number of malaria related deaths fell by 95% (from 172,200 to 7,855) and 55% (from 42 to 19), respectively (Figs 4 and 5) (WHO, 2011) and despite increased case detection rates associated with the programmatic improvements described in Chapter 7.

Yunnan's impact level targets for 2015 include, all 19 'class A' counties in border areas achieve annual incidence of reported malaria below 0.1 cases per 1,000 population and no further local transmission by 2017 (County Class A: local infections are detected in 3 consecutive years and the incidence rate is equal or higher than 0.1/1,000); and, no local transmission of malaria in the 55 'Class B' counties; MOH China-NIPD China, 2010) (County Class B: local infections are detected in 3 consecutive years and the incidence rate is lower than 0.1/1,000 at least in one of the 3 years). China aims to have eliminated malaria transmission in other provinces by 2015. However, the recent withdrawal of GFATM grants for China may put these targets in jeopardy.

There is no evidence of transmission of artemisinin resistant falciparum malaria in Yunnan at present but there is suspicion of resistance on the border with Myanmar and this is currently under investigation (see Chapter 5).

## Lao PDR

Malaria remains an important public health issue in Lao PDR and as elsewhere in the Region the NMCP receives strong political support. Lao PDR's national malaria control effort is led by the Ministry of Health's Center for Malaria, Parasitology, and Entomology (CMPE). Management of implementation is largely decentralized through Provincial Health Departments. Several international partners are involved in supporting Lao PDR's malaria control effort including USAID/President's Malaria Initiative, Health Poverty Action, the Pasteur Institute Lao PDR, Population Services International and several national non-governmental organizations.

In 2010 Lao PDR had an estimated population of 6.2 million with about 2.6 million people residing in malaria endemic areas (42% of the population). In 2010, 280,365 patients were tested for malaria in public health care facilities and 14,654 were parasitologically confirmed (MOH Lao PDR-CMPE, 2010). Of these confirmed malaria cases, 98% were reported to be caused by P. falciparum, but this is an overestimate as it was based largely on results from the P. falciparum specific RDTs used at the time. It has to be noted that in addition to those patients tested in public health care facilities, 39,182 and 20,562 patients were tested by village malaria workers and accredited private providers, respectively. In 2010, 24 malaria related deaths were reported amongst hospital inpatients. These NMCP figures are based primarily on data from public sector health services, including data from community-based diagnostic and treatment services which rolled-out between 2006 and 2008 (Figs 1 and 2). However, data from Lao PDR's growing private sector (focusing on pharmacies and clinics in malaria hot spots) has been progressively included, initially covering 4 provinces in 2009 and then expanded to cover 8 provinces in 2010. The reported figures therefore need to be interpreted with this expansion in mind as it currently underestimates the true burden of disease to some extent (MOH Lao PDR-CMPE, 2010).

National statistics reported to WHO indicate that between 2002 and 2010 the number of probable and confirmed cases and the number of malaria related deaths fell by 73% (from 85,192 to 23,047) and 88% (from 195 to 24), respectively (Figs 4 and 5) (WHO, 2011).

In 2010, the highest incidence rates of confirmed malaria in Lao PDR were recorded in the southern provinces of Attapeu, Sekong, Savannakhet and Saravane.

The most at-risk groups are miners and forest and agricultural workers. Migrant workers (both registered and unregistered) from neighboring countries employed on development projects in Lao PDR are also at high risk but cases from these groups are not routinely captured in the H/MIS. An assessment of an outbreak in Attapeu Province in 2011 showed migrant workers accounted for about 70% of confirmed malaria cases (CMPE, unpublished report, 2011).

Impact level targets for 2015 include: annual malaria deaths (as reported by hospitals) down to 0.2 per 100,000 population; and, annual parasite incidence down to 2 per 1,000 population. The country aims to progressively roll-out malaria pre-elimination and elimination in selected provinces. A timeline has not yet been formalized (MOH Lao PDR-CMPE, 2010).

There is no evidence of local transmission of artemisinin resistant falciparum malaria in Lao PDR at present. Monitoring is continuing in 3 sentinel sites (see Chapter 5).

## Myanmar

Myanmar has by far the greatest burden of malaria in the GMS. In 2010 the country had an estimated population of 48 million with about 33.1 million people residing in malaria endemic areas (69% of the population) (Table 1). One million five thousand two hundred fifty-two of 1,233,966 suspected malaria cases were tested in 2010 and 420,808 of these were parasitologically confirmed either by microscopy (103,285) or by RDTs (317,523). Of these confirmed malaria cases, 70% were caused by *P. falciparum*. Seven hundred eighty-eight malaria related deaths were reported amongst hospital inpatients. These figures from the Ministry of Health are based entirely upon data from public sector health services. The figures do not include data from the formal and informal private sector. During surveys completed in 2012, 67% and 82% of interviewees in containment tiers 1 and 2, respectively said that the public sector would be their first choice for treatment seeking in the event of fever although of those who had had fever recently 65% and 48%, respectively had actually sought treatment from the public sector (Malaria Consortium, 2012, unpublished report). Although large, the reported figures therefore greatly underestimate the true burden of disease. Nevertheless they provide the most consistent measure of progress over time.

National statistics reported to WHO indicate that between 2002 and 2010 the number of probable and confirmed cases and the number of malaria related deaths fell by 10% (from 722,058 to 649,522) and 70% (2,634 to 788), respectively (WHO, 2011). These figures (Figs 1 and 2) need to be considered in light of improved data management in general and case finding in particular as a result of greatly increased availability and use of RDTs (GFATM, 2010c).

Townships with the highest malaria incidence (API greater than 10/1,000) in 2010 were located in the following areas: Rakhine State on the west coast, Chin State which borders Bangladesh, Kachin and Northern Shan States on the border with China, and Tanintharyi Division which borders Thailand (Fig 4). The highest mortality rates (greater than 10/100,000) in 2010 were recorded in 6 townships namely Hpakan, Moemeik, Hkamti, Tanai, Nogmung and Kanpetlet (Fig 5). There are several townships from which information is currently unavailable due to armed conflict.

The majority (60%) of people get infected in forest or forest fringe areas (WHO and Myanmar Ministry of Health, 2007). Population groups at high risk of malaria are internal migrants, people who resettle in malaria endemic areas, subsistence farmers in forests and on the forest fringes, forest workers (loggers, gem miners, etc) and particularly non-immune migrants working in forest areas.

Impact level targets for 2015 are: proportion of all deaths due to malaria down to 5%; number of malaria confirmed admissions down to 25,000 (4% of all hospital admissions); number of confirmed malaria cases reported by health workers in facilities and outreach down to 770,616; and, slide/RDT positivity rate down to 30% (GFATM, 2012a).

The Thailand-Myanmar border has long been associated with the development of antimalarial drug resistance, first to chloroquine, sulphadoxine-pyrimethamine and mefloquine and since 2006 to artemisinin and recently, several areas of concern for artemisinin resistance have been identified within Myanmar (see Chapter 5).

### Thailand

Malaria remains an important public health issue in some parts of Thailand particularly in areas bordering Myanmar and Cambodia and in conflict areas in the south. Tourism is a key concern (around 15 million tourists visit Thailand every year) and partly as a result of this the NMCP continues to receive political support, although increasingly this is competing with the new priority given to non-communicable diseases. Thailand's national malaria control effort is led by the Ministry of Public Health's Bureau of Vector Borne Disease (BVBD). Management of implementation is largely decentralized through the Offices of Disease Prevention and Control and Provincial Public Health Offices. These sometimes create policies and strategies that conflict with those of the national program. Several national and international research institutions and implementing partners are involved in supporting Thailand's malaria control and elimination effort (WHO, 2012b). Almost 60% of peer-review publications in the GMS originate from Thailand (see Chapter 6).

In 2010 the country had an estimated population of 69.1 million with about 2.1 million people (3%) living in malaria endemic areas in 2,753 villages (Table 1). Among 2,138,654 patients tested for malaria mainly by microscopy, 44,124 were parasitologically confirmed. Forty-one percent of cases were caused by *P. falciparum*. This proportion has declined steadily from 80% in 1965. Eighty malaria related deaths were reported amongst hospital inpatients (but these figures have not been audited by the NMCP and the connection between the NMCP and the hospital clinicians is not strong) (Figs 1 and 2).

Thailand remains the primary destination for migrant labor from neighboring countries (Asian Migration Centre, 2005) (see Chapter 4). Much of the population movement in and

out of Thailand is across the border with Myanmar, which extends for about 2,000 km. Along this border malaria remains the leading infectious disease (contrary to national figures where it ranks almost bottom) and most cases and deaths are related to cross-border movements with most infections acquired in Myanmar.

The treatment of malaria is regulated in the private sector: pharmacies need authorization from the Ministry of Public Health to procure ACT and over-the-counter sales are not permitted. Despite this there is still a dynamic informal private sector. In addition a number of non-governmental organizations run facilities in some border areas for patients from outside Thailand. They also manage, in coordination with official health services, unregistered migrants reluctant to reveal themselves to government health workers and therefore unable to access the highly subsidized health services delivered in government-run facilities (GFATM, 2010c).

For these reasons MOPH figures are thought to under-estimate the true burden of disease especially in border areas since most patients in these areas are not captured in official records. Nevertheless the MOPH figures do give a robust measure of progress over time. Significant efforts are currently being made to strengthen the national surveillance system through the progressive incorporation of data generated from non-governmental organizations (GFATM, 2010c).

National statistics reported to WHO indicate that between 2002 and 2010 the number of probable and confirmed cases and the number of malaria related deaths fell by 27% (from 44,555 to 32,480) and 78% (from 361 to 80), respectively (Figs 4 and 5) (WHO, 2011). Regular re-stratification of malaria risk has revealed a steady decline in the number of endemic villages. The number of villages with recorded local transmission has dropped from 4,908 in 2000 to 2,753 in 2010 (MOPH-BVBD unpublished data, 2010).

In 2010 the highest stratum of malaria burden (API greater than 10 per 1,000) is only documented in Tak Province on the border with Myanmar. Several provinces show an API between 10 per 1,000 and more than 1 per 1,000 situated on the borders with Myanmar, Malaysia (Narathiwat Province) and on the border with Cambodia (Trat Province) (Fig 4).

Impact level targets include: reduce annual parasite incidence from 0.4 per 1,000 (baseline 2010) to 0.2 per 1,000 population in 2016 and malaria mortality rate from 0.14 per 100,000 (baseline 2010) to 0.05 per 100,000 population in 2016. The country also aims to increase the proportion of districts achieving interruption of malaria transmission (no indigenous cases of malaria for three years) to 60% by 2016 and 80% by 2020 (MOPH-BVBD, 2011).

The Thailand-Cambodia and Thailand-Myanmar borders have long been associated with the development of antimalarial drug resistance, first to chloroquine, sulphadoxine-

pyrimethamine and mefloquine and since 2006 to artemisinin (see Chapter 5).

### Viet Nam

Malaria remains an important public health issue in Viet Nam and the NMCP receives strong political support with malaria recently reaffirmed by the MOH as one of the country's five priority communicable diseases. Viet Nam's national malaria control effort is led by the National Institute for Malariology, Parasitology and Entomology (NIMPE) in Hanoi and two regional level IMPEs. Implementation is managed by provincial centers for malaria control in more endemic provinces and by departments for malaria control within provincial centers for preventive medicine elsewhere. Endemic districts have a malaria focal point and health centers in endemic communes have specialized staff responsible for malaria control. NMCP partners include a number of national community groups including the Women's Union and the Youth Union.

In 2010 Viet Nam had an estimated population of 87.8 million with about 15.5 million people living in malaria endemic areas (18% of the population). Out of 2,803,918 suspected patients, 2,767,136 were tested and 17,515 confirmed as malaria. Of these confirmed malaria cases, 74% were caused by *P. falciparum*. Twenty-one malaria related deaths were reported amongst hospital inpatients. These NMCP figures are based on data from public sector health services. They do not include data from the private sector. A survey conducted in the Binh Phuoc Province in 2011 suggested that around 13% of resident patients and 23% of migrants were accessing initial health care from the private sector (Anh NA and Hung LX, unpublished data, 2011). The role of the private sector is increasing considerably over time and so this percentage is likely to rise further. The reported malaria statistics may therefore underestimate the true burden of disease. Nevertheless, as elsewhere they do give the most robust measure available of progress over time (Figs 1 and 2). The NMCP has recently introduced a new malaria information system (MIS) that is being piloted in 3 provinces.

The burden of malaria in Viet Nam has also decreased drastically with improvements in socio-economic conditions coupled with increased government investments in vertically driven malaria control operations all the way to the community level. National statistics reported to WHO indicate that between 2002 and 2010 malaria incidence (based on probable and confirmed cases) and the number of malaria related deaths fell by 64% and 58%, respectively (Figs 4 and 5) (WHO, 2011).

A large proportion of Viet Nam's malaria cases occur in forested mountainous areas (Erhart *et al*, 2004, 2005). The southern province of Binh Phuoc bordering Cambodia has the highest malaria incidence accounting for over 18% of all cases (MOH Vietnam-NIMPE, 2012, unpublished data).

Impact level targets for 2020 include: less than 0.15 malaria cases per 1,000 population; less than 0.02 malaria deaths per 100,000 population. The country's malaria elimination related targets for 2020 are: no hyper-endemic provinces; 40 provinces with no local transmission; 15 provinces in elimination mode and 8 provinces in pre-elimination mode (MOH Vietnam-NIMPE, 2010).

Resistance to antimalarials has long been a problem in Viet Nam. Resistance to artemisinin was first confirmed in Binh Phuoc Province in 2010 (see Chapter 5). A containment plan was quickly developed but as yet has only received very limited funding from the domestic budget (MOH Viet Nam NIMEP, 2012, unpublished data).

## DISCUSSION

This chapter highlights significant progress made in the GMS in malaria control from 2002 up to now based on official epidemiological data reported annually to WHO by WHO Member States (Figs 1-5). In spite of clear limitations described in the methodology section, there is a consensus among experts that the epidemiological trends presented above reflect the improvement in the malaria situation in the GMS with data consistently reported from public health facilities in most countries (Fig 3). The completeness of this data is heavily dependent on the coverage of primary health care services in remote locations, on the ease with which migrant populations can access these services and on the treatment seeking practices of people in endemic areas. Due to the lack of information from outside the public sector and to some extent due to the lack of information on malaria species resulting from diagnostic limitations in most countries, the true malaria burden is as yet unknown.

The proportion of malaria cases caused by *P. falciparum* infections provides a proxy measure of the early success of malaria control programs and in the GMS this proportion has been declining markedly and is now less than 50% in an increasing number of provinces (Fig 6). This is clearly recorded in Thailand through the routine surveillance system but is also documented in other countries and locations thanks to several local and national surveys (MOH Cambodia-CNM, 2011; MOPH Thailand-BVBD, 2011). A number of cytogenetic studies in the region indicate a much higher proportion of non-falciparum and mixed infections than RDTs and microscopy would suggest (Moon *et al*, 2009; Kim *et al*, 2010; Steenkeste *et al*, 2010) but nevertheless the trends relating to proportion of cases caused by falciparum are valid.

If national information systems are to remain the basis for measuring malaria trends over space and time then there is a continuing need to strengthen the surveillance and response system as an intervention *per se* preferably integrated with other disease systems to increase

cost-effectiveness and using or strengthening existing modern diagnostic and communication technologies (WHO, 2012a). With modern communication technologies from SMS (short message service) to more sophisticated web-based systems, any disease including malaria can be mapped almost on a real time basis at the most peripheral level and national level so that appropriate actions can be taken quickly according to pre-established guidelines and operational procedures (Meankaew et al, 2010; MC, MOH-CNM and WHO, 2011). While quasi real-time mapping is certainly useful for locating and further confirming or inferring areas of transmission in an increasingly focal and sporadic transmission environment, it has not yet been possible to set up and consolidate nationally-driven mapping system engaging geographers and communicable diseases specialists to map disease events to the most peripheral level (usually village) using and consolidating existing databases. Most national programs do not yet have the technologies and skills or do not collaborate sufficiently with other programs or sectors or academies to perform such essential tasks while progressing towards malaria elimination. More collaboration is also needed between national programs and clinicians to review how clinicians conclude malaria as the primary cause of death. A death auditing exercise might help clarifying and improving diagnostic procedures and proper reporting. Most data are still paper-based with numerous time consuming administrative layers delaying intelligence on malaria and as a result delaying response to any events.



Fig 3–Trends in the incidence of malaria-attributed deaths and confirmed malaria cases (either by microscopy or rapid tests) in the Greater Mekong Subregion, 1998-2010.



reporting including the lack of travel information by using API only.





Fig 6–Proportion of falciparum infections among confirmed malaria cases (generally by microscopy) by administrative level II or III in the Greater Mekong Subregion in 2010. Ultimately, the success of innovative real time tools will depend to a large degree on the kind of action that can be mounted in response to the alerts that they generate (MC, MOH-CNM and WHO, 2011).

All maps (Figs 4-6) in the current monograph reflect the situation of essential malaria parameters down to the administrative level above cluster of districts and villages. There is a need to connect the database with geographical parameters in a more dynamic way providing useful information for action at both peripheral and national level (API less than 1/1,000). An increasing number of districts and villages in the GMS have reached the pre-elimination level (API less than 1/1,000), a WHO proposed transitional milestone towards elimination (WHO, 2007). In these villages as well as in villages where elimination has been achieved, all suspected cases must be laboratory tested and if possible PCR confirmed with proper travel history forms completed and entered into a database (Meankaew et al, 2010; Proux et al, 2012). Avoiding multiple databases managed by different departments from different sources is essential in order to consolidate a single national recording database computerizing information from all available sources including recognized private providers. Some countries like China are progressing towards such integrated and consolidated systems (MOH China – NIPD, 2010). Thailand is progressing as well but has to harmonize and consolidate several sophisticated technologies and systems and multiple sources of data to ensure the final consolidated database reflects the actual situation to be ultimately useful for decision makers in the MOPH and for non-health sectors (WHO, 2012b).

The WHO Mekong Malaria Program along with partners has facilitated the finalization of the regional M&E Surveillance Framework aiming at defining and harmonizing suitable regional indicators for the GMS context (see Chapter 7). That framework includes impact and outcome indicators routinely generated by the Health Information System as well as essential indicators for the program to measure progress made towards implementation of targeted interventions as well as programmatic performance (WHO-MEASURE Evaluation, 2006). The GFATM, which is providing substantial funding for malaria programs in the GMS is also looking to better document the impact of its investment (GFATM, 2012a,b), and encouraging more investment in operational research (GFATM-TDR, 2008).

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