Malaria in India: Challenges and opportunities

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India contributes about 70% of malaria in the South East Asian Region of WHO. Although annually India reports about two million cases and 1000 deaths attributable to malaria, there is an increasing trend in the proportion of *Plasmodium falciparum* as the agent. There exists heterogeneity and variability in the risk of malaria transmission between and within the states of the country as many ecotypes/paradigms of malaria have been recognized. The pattern of clinical presentation of severe malaria has also changed and while multi-organ failure is more frequently observed in falciparum malaria, there are reports of vivax malaria presenting with severe manifestations. The high burden populations are ethnic tribes living in the forested pockets of the states like Orissa, Jharkhand, Madhya Pradesh, Chhattisgarh and the North Eastern states which contribute bulk of morbidity and mortality due to malaria in the country. Drug resistance, insecticide resistance, lack of knowledge of actual disease burden along with new paradigms of malaria pose a challenge for malaria control in the country. Considering the existing gaps in reported and estimated morbidity and mortality, need for estimation of true burden of malaria has been stressed. Administrative, financial, technical and operational challenges faced by the national programme have been elucidated. Approaches and priorities that may be helpful in tackling serious issues confronting malaria programme have been outlined.

1. Introduction

Malaria and six other diseases viz. diarrhea, HIV/AIDS, tuberculosis, measles, hepatitis B and pneumonia account for 85% of Global infectious disease burden (Murray and Lopez 1996, 1997). Malaria afflicts 36% of the world population i.e. 2020 million in 107 countries and territories situated in the tropical and subtropical regions. In the South East Asian Region of WHO, out of about 1.4 billion people living in 11 countries, 1.2 billion (85.7%) are exposed to the risk of malaria and most of whom live in India (Kondrachine 1992). Of the 2.5 million reported cases in the South East Asia, India alone contributes about 70% of the total cases. Currently, 80.5% of the 109 billion population of India lives in malaria risk areas. Of this, 4.2%, 32.5% and 43.8% live in areas of high, moderate and low risk to malaria respectively (*http://www.searo.who.int/*).

The Global Malaria Eradication Programme of WHO launched in the 1950s was a huge success in India as the incidence declined from estimated 75 million cases and 8,00,000 deaths in 1947 to just 49,151 cases (annual parasite incidence per thousand [API]: 0.13; slide positivity rate [SPR]: 0.38% and *Plasmodium falciparum* [Pf]: 34.9%) and no deaths in 1961 and malaria was thought to be on the verge of eradication (Sharma et al 1996). It was then, that a series of setbacks were witnessed leading to malaria resurgence in multiple foci in the country and reported cases increased to 13,22,398 by 1971 (API: 2.47; SPR: 3.27% and Pf:11.2%) and then to 64,67,215 in 1976 (API:11.25; SPR:11.6% and Pf: 11.7%) (Sharma *et al* 1996, *http://www.searo.who.int/*). The

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failure was attributed to the complacency, administrative, operational and technical problems like resistance in vectors to commonly used insecticide DDT and in parasites to chloroquine and overall low priority malaria enjoyed in the post control period. Thereafter with the implementation of modified plan of operation (MPO) in 1977, malaria cases declined and ranged between 2-3 million per annum in the subsequent years (Sharma 1999). However in 1996, due to outbreaks and epidemics 30,35,588 cases and 2803 deaths were reported. In 2006, the reported number of cases was 16,69,333 (API: 1.57; SPR: 1.63% and Pf:45.3%). In depth evaluation of MPO revealed that the incidence is grossly underestimated. WHO estimated 19500 to 20000 deaths per annum in India against reported figures of 209, 268, 353 and 406 deaths respectively from 1988-1991 (NMEP 1992). The vital statistics report for India, estimated 137,846 deaths in 1985 and 75,285 deaths in 1987 attributable to malaria. Hence the numbers reported by the National Vector Borne Disease Control Programme (NVBDCP) at best reflect a trend (figure 1). A notable feature is that *P. falciparum* has been showing steady increase in the post resurgence phase in 1970s and now account for 45% of the total reported cases. There was a gradual increase in the number of deaths as well. Table 1 depicts the journey of malaria control. The country has witnessed different phases of malaria situation in the country: from high prevalence of malaria to near eradication to resurgence in post DDT era to the use of artemisinin combination therapies (ACTs).

Currently, the states of Orissa, Jharkhand, West Bengal, North Eastern States, Chhattisgarh, Madhya Pradesh contribute bulk of malaria. Urban areas contribute about 15% of the total malaria cases reported in India and are primarily associated with construction activities and migrant population. Most of the malaria attributable mortality is reported from Orissa and other forested areas occupied by ethnic tribes in the country (Kumar *et al* 2007).

2. Malaria vectors and their control

There are six recognised primary vectors of malaria in India viz., *Anopheles culicifacies, An. stephensi, An. dirus, An. fluviatilis, An. minimus* and *An. Sundaicus* (table 1). Vectors of secondary importance are *An. annularis, An. varuna, An. jeyporiensis* and *An. philippinensis* (Rao 1984).

An. culicifacies is the vector of rural and peri-urban malaria in peninsular India. *An. stephensi* is responsible for malaria in urban and industrial areas while *An. fluviatilis*
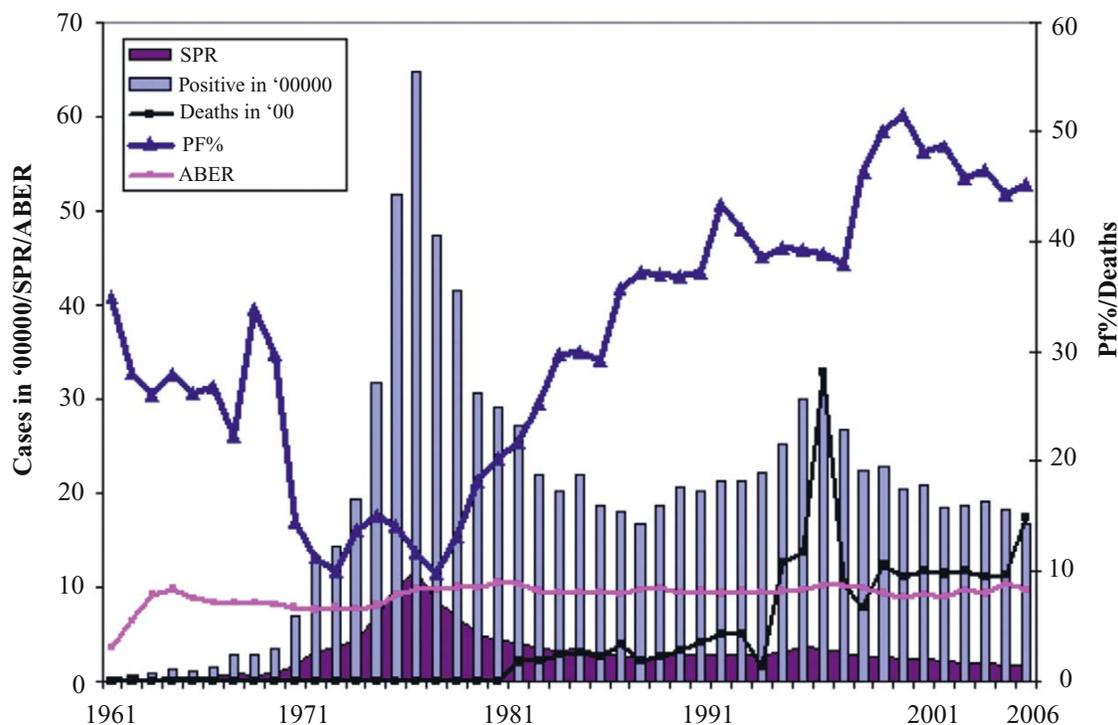

Figure 1. Malaria trend in India from 1961 to 2006. SPR, Slide Positive Rate; ABER , Annual Blood Examination rate; Pf% , Proportion of *P. falciparum* out of total positive cases (data source: NVBDCP).

Table 1. Journey of malaria control activities in India

Prior to 1940	No organized National Malaria Control Programme
1945	Insecticide properties of DDT identified
Prior to 1953	Estimated malaria cases in India - 75 million estimated Deaths due to malaria – 1 million
1953	Launching of National Malaria Control Programme
1958	Launching of National Malaria Eradication Programme
1966	Cases reduced to 0.1 million
Early 70's	Resurgence of malaria
1976	Malaria cases 6.46 million highest in post DDT era (one of the reasons for resurgence was insecticide resistance in malaria vectors)
1977	Modified Plan of Operations Implemented
1984 -1998	Annual reported incidence within 2-3 million cases
1994	Resurgence of malaria in some states
1997	World Bank Assisted Enhanced Malaria Control Project (EMCP)
2005	Global fund Assisted Intensified Malaria Control Project (IMCP) -100 million population in 94 districts of 10 states being covered from 2005-06
2006	World Bank Assisted Enhanced Vector Borne Diseases Control Project (EVBDCP) – 189 million population in 191 districts in 13 states
2006	ACT introduced in areas showing Chloroquine resistant falciparum malaria.
2008	ACT extended to high risk Pf districts covering about 80-90% Pf infection.

Table 2. Malaria vectors and their resistance status in India

Anopheline vectors	Reported status of vector resistance to insecticides

Primary vectors
  An. culicifacies
  An. stephensi
  An. dirus
  An. fluviatilis
  An. minimus
  An. sundaicus
Secondary vectors
  An. annularis
  An. varuna
  An. jeyporiensis
  An. philippinensis
	In An. culicifacies and *An. stephensi* – mono to multiple resistance to DDT, HCH and malathion widespread

is the vector of local importance in the forests and forest fringes in many states while *An. minimus* is the vector in the foothills of north eastern states. *An. sundaicus* is restricted to the Andaman and Nicobar Islands (Sharma 1998).

All the major vectors except *An. stephensi*, are species complexes (Sharma 1998). The members of a species complex can be identified by species specific paracentric inversions on polytene chromosomes, structural variations in mitotic chromosomes, electrophoretic variations in different enzyme systems and recently molecular tools (allele specific polymerase chain reaction [PCR] assay, PCR-restriction fragment length polymorphism [RFLP] assay) have been developed which unambiguously differentiate the members

of these species complexes (Dash *et al* 2007). The *An. culicifacies* complex responsible for 60-70% malaria cases occurring annually in India is a complex of 5 sibling species (provisionally designated as species A, B, C, D and E). These sibling species vary in their biological characteristics in terms of resting and feeding preferences, biting rhythms, responses to insecticides and malaria transmission potential. Similarly *An. fluviatilis,* another important vector of malaria in India has been established as a complex of 4 sibling species (S, T, U and V), of which species S is highly anthropophagic and an efficient vector of malaria (Nanda *et al* 2000). Mapping the geographic distribution of *An. culicifacies* and *An. fluviatilis* sibling species and studies of their biological characteristics have greatly helped in assessing the malariogenic potential of different parts of India and in planning situation specific, cost effective vector control operation (Subbarao 1998).

Vector control in India is based on indoor residual spraying (IRS) of insecticides in rural areas and anti larval operations in urban areas. DDT, HCH, Malathion and synthetic pyrethroids (SP) are used for IRS. Larval control is based on application of temephos, malariol, baytex and larvivorous fishes (NMEP 1985). Source reduction and use of biocides like *Bacillus thuringiensis israelensis* and *B. sphaericus* has been advocated in selected areas to avoid use of chemical larvicides since they are considered to be environment friendly (Kumar *et al* 1998).

In certain situations personal protection with insecticide treated nets (ITNs) or long lasting insecticide nets (LLINs)

is a practical proposition. Integrated vector management, which is a mix of selective use of IRS with DDT/Malathion/SP compounds coupled with ITNs/LLINs and complimented with other operationally feasible approaches like use of larvivorous fish and source reduction of vector breeding is being advocated by the NVBDCP.

3. Malaria case detection and treatment policy in India

In India, the key strategies for malaria control are, early case detection and prompt treatment (EDPT), active case detection and passive case detection through fever treatment depots and village link workers in the inaccessible and remote areas. Histidine rich protein-2 (HRP-2) based rapid diagnostic test (RDT) for the detection of *P. falciparum* (Beadle *et al* 1994) has been recently introduced in NVBDCP at a large scale in *P. falciparum* predominant areas for early diagnosis.

National Drug Policy provides guidelines for treatment of malaria in India. Chloroquine is the first line treatment for vivax malaria and for *P. falciparum* in low risk and chloroquine sensitive areas. In view of reports of treatment failure to chloroquine, ACT has been introduced in the high burden states for the treatment of *P. falciparum*. ACT, which is artesunate-sulphadoxine pyrimethamine, has been proposed for all districts with high Pf% which covers approximately 90% of falciparum infection in the country and will be implemented in phased manner during 2008-09 (*http://www.nvbdcp.gov.in/*).

4. Challenges and opportunities for malaria control in India

4.1 *Insecticide resistance in vectors*

The indoor application of residual insecticide DDT was introduced in 1950s and was deployed as main weapon for eradication of malaria with considerable success. Although the subsequent decades saw emergence of resistance in vectors in many parts of the world and also re-emergence of malaria, the reliance on insecticidal approach continued with the introduction of replacement insecticides such as HCH/Dieldrin, Malathion, Pirimiphos methyl, Fenitrothion, Carbamates (propoxure and bandiocarb) and synthetic pyrethroids (Deltamethrin, cyfluthrin and lambdacyhalothrin). The use of HCH was banned in India in 1997 due to environmental concerns and partly due to resistance, while DDT is still being used selectively for malaria and Kala Azar control. The usefulness of Malathion has been diminishing in the last two decades as suggested by many resistance studies. Emergence of resistance in

vectors to synthetic pyrethroids has also been documented (Singh *et al* 2002; Mittal *et al* 2002). Figure 2 shows insecticide resistance in different parts of the country. There are two pockets showing quadruple resistance; while as many areas in central part of India are showing triple resistance.

The insecticide resistance is generally restricted to particular target vector species within the geographical confines and appears after a prolonged use in health sector and/or exacerbated by the use of same class of insecticide in the agriculture. The best way to prolong the life of an insecticide in vector control programme is to devise rotation policy whereby use of unrelated compounds are rotated as has been done with considerable success in agriculture and Onchocerciasis Control Programme in Mexico (Richard *et al* 2001). In this programme, three insecticides were annually rotated which slowed down build up of resistance against pyrethroids. This strategy can be applied to both IRS and ITNs. In case of ITNs, carbamates can be rotated with synthetic pyrethroids or even the use of mixture of two unrelated compounds for impregnation has been shown to be promising (WHO 2006). Spraying of different insecticides in a mosaic fashion and their rotation in the adjoining areas has been shown to work and may be helpful in preventing resistance in vectors.

The key to the resistance management is the effective and continuous monitoring of resistance status in vectors using standardized bioassay techniques and materials provided by the WHO. This exercise must be an integral part of the IRS spray and ITN programmes. A list of alternative insecticides and approaches for vector control which can be substituted must be ready for introduction as soon as early signs of resistance are noticed. Another important aspect is the monitoring to ascertain whether reversal of susceptibility in vector population has taken place to an insecticide to which the vector had earlier become resistant.

The beneficial effect of ITNs on Entomologic Inoculation Rate, parasite prevalence and mortality in Africa and elsewhere is well documented (Alonso *et al* 1993). This intervention has following benefits if used judiciously.

- It creates a mechanical and lethal barrier between host and blood seeking vector.
- It is cost effective with fewer side effects compared to IRS. The insecticide which is polymerized on LLINs can withstand 20 washes and hence can remain effective for many years when compared to IRS or a simple impregnated net which has to be retreated with insecticide every 6 months.
- Nets work in most of the rural situations including the inaccessible areas inhabited by ethnic tribes and areas affected by insurgencies and wars.
- Nets can be carried by migrating populations during strife, famines or other natural calamities.
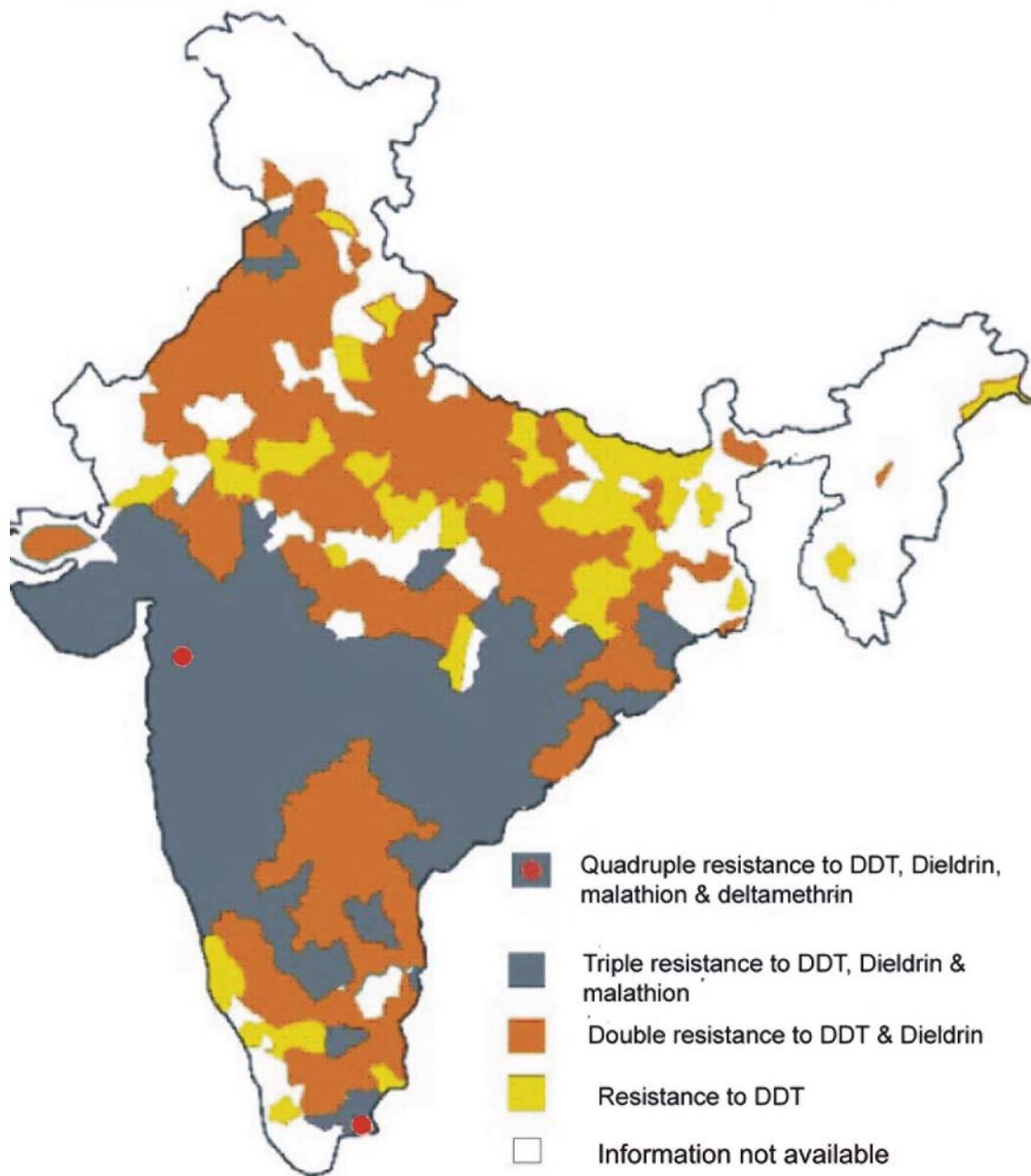
Figure 2. Resistance of *Anopheles culicifacies*, the principal vector of malaria in India to commonly used insecticides in India (Source: NVBDCP).

They can be used effectively in the refugee camps and also in large projects such as dams and other construction projects where labour aggregates from different regions and where the possibilities of explosive malaria outbreaks exist.

The limitation with the nets however, is that nets may be misused or not used by a proportion of population. But it has been shown in many studies that when compliance rate is around 80%, the mass effect of nets provides almost absolute protection quite similar to IRS (Curtis and Townson 1998).

Integrated vector management approach suggested by WHO promotes judicious mix of various vector control options (WHO 2004). It refers to a rational decision making process for the optimal use of resources for vector control.

4.2 *Drug resistance*

Chloroquine has been the mainstay of treatment of malaria for decades. This cost effective and safe drug has become ineffective for treatment of falciparum malaria in many parts of the world due to development of resistance by the parasite. In India, chloroquine resistance was reported for the first time in Assam in 1973 (Sehgal *et al* 1973) which was followed by several reports of chloroquine resistance especially from Orissa, North Eastern states, Madhya Pradesh and Gujarat (Misra *et al* 1996; Valecha *et al* 1996; Sharma 1999, 2000). In addition the drug is not gametocytocidal for *P. falciparum* and thus can not block transmission and can not prevent relapses in *P. vivax*. The second line drug sulphadoxine pyrimethamine combination is effective but development of resistance can be rapid since single step mutation confers resistance. It is not effective for treatment of vivax malaria and thus is not a good choice to treat clinically diagnosed cases in areas where both falciparum and vivax malaria co-exist. Quinine is effective but is reserved for treating complicated malaria. It produces many side effects with oral or parenteral use and needs monitoring and long duration of therapy if used alone. Mefloquine, although effective to treat multidrug resistant falciparum malaria, has a long duration of action which makes it vulnerable for development of resistance. Cross resistance between quinine and mefloquine is also reported. Artemisinin group of drugs are highly effective but due to short duration of action, recrudescence is a common phenomenon (WHO 2006). Dose schedules are empirical, safety in pregnancy is still being debated and there is also concern about neurological side effects. Primaquine, the only 8-aminoquinoline available for gametocytocidal action in *P. falciparum* and antirelapse activity in *P. vivax* is contra indicated in pregnancy and infants. There is at present no alternative therapy available. In the present scenario, WHO recommends the use of ACT which is highly effective and presents new prospects for deterring drug resistance (WHO 2006).

Another major recent development is the reduced sensitivity of *P. vivax* to chloroquine which is the drug of choice (Garg *et al* 1995; Dua *et al* 1996; Kshirsagar *et al* 2000; Singh 2000) and involvement of species in complicated malaria and multi-organ dysfunction (Kochar *et al* 2005).

Following action is necessary to tackle this problem.

- Complete treatment preferably after confirmation of diagnosis.
- Use of artemisinin based combination therapy for treatment of *P. falciparum*.
- Constitution of Country level task force for systematic drug resistance studies and monitoring
- Inter-country collaboration for monitoring of resistance along international borders and conver-

gence in anti malarial drug policy in these areas for resistance management.
- Creation of a network of researchers and institutions working on monitoring of drug resistance of existing antimalarials.
- Monitoring of resistance to chloroquine in *P. vivax*. This may be viewed as an emergency and steps may be taken to prolong the use of chloroquine in the treatment of vivax malaria.
- Antimalarial drug policies should also intimately address operational issues linked with chemotherapy such as quality of surveillance, diagnosis, compliance, health-seeking behaviour of the malaria affected communities.

Chemoprophylaxis policy for the tourists needs to be formulated. Specific recommendations for different endemic states of tourist attraction could be developed and hosted on the web sites of the national programme. The policy may be updated every 2 years based on epidemiological situation and review of malaria situation in the country.

4.3 *Lack of information on true disease burden*

The true burden of malaria in India is not known (Kumar *et al* 2007). A real picture of burden is important on two counts. Firstly it enables to set priorities right in the planning and resource allocation for malaria control and secondly it provides evidence that enables international donor agencies to assess financial need for operational research and disease control. According to the World Health Report-2001, malaria and other vector borne diseases were responsible for loss of 4.2 million disability adjusted life years (DALYs) in India (Peters 2001). According to a conservative estimate, malaria alone was found to be responsible for the loss of estimated 1.86 million DALYs in 1998 (Kumar *et al* 2007). Since India contributed to about 75% of malaria incidence and 50% mortality in the SEA region in that year, it is reasonable to assume that malaria may have caused loss of about 2.3-2.5 million DALYs in this region. The loss of DALYs could be averted if estimates of true burden were available and malaria control enjoyed the right kind of priority it deserves in the health agenda of the County with the necessary allocation of funds for its control.

Not much information on the burden of clinical, asymptomatic and complicated malaria is available in India and well planned studies are needed to provide evidence based information on these aspects as they have bearing on malaria treatment, transmission dynamics and management to prevent mortality. Besides, the quality of surveillance, diagnosis of disease and availability of antimalarials in remote and difficult areas of the country remains a challenge. Because of these and inadequate blood examination rate owing to poor active surveillance in many endemic states

of India, as shown by NVBDCP data, the actual burden of malaria is elusive (Kumar *et al* 2007). Although adverse health consequences on pregnant women and foetus are well known (Singh *et al* 1999, 2005; Melba 2002), planned studies are needed to generate adequate evidence for advocacy and policy for the protection of expectant mothers with suitable interventions such as Intermittent preventive Treatment in pregnancy and ITNs.

Overall, systematic studies on disease burden estimation can help in generating data necessary for creating political interest nationally, fund allocation from international agencies and prioritisation of resources within the country.

4.4 *Regular outbreaks in some urban, rural and large project areas*

An. stephensi, which is the principal malaria vector in urban areas, is expanding its distribution southward in Peninsular India along the west coast and is responsible for serious malaria outbreaks in Goa, Mangalore and recently indigenous cases of malaria have been reported in the Kasargod district of Kerala state which is by and large free of malaria. The vector is threatening to invade other towns of Kerala. The problem can be addressed by having rapid response teams and standard operating procedure in place (Kumar 1997).

4.5 *Lack of trained manpower and infrastructure at grass root level*

There are existing vacancies of malaria workers and Entomologists in large numbers in many states leading to diminishing skilled manpower for vector control. The Entomologists working for vector control is a vanishing tribe which enjoys lower priority and prestige within the control programme playing second fiddle to the medical fraternity and often work primarily as data and/or file managers. This interferes with their primary responsibility in the field which is guiding and monitoring vector control operations, impact assessment of interventions, resistance studies and population dynamics of vectors for appropriate targeting. This situation needs correction and also vacancies of Entomologist need to be filled up on priority basis followed by 'on job' training and re-orientation to upgrade skills. Training programmes at the national and sub-national level for entomologists, epidemiologists and physicians handling complicated cases should be given top priority. One of the key components of a successful anti malaria campaign is the community participation which can be elicited by information, education and communication (IEC) and Behavioural Change Communication. For this, regular training/orientation of Mass Media Officers, Field Extension and Health Educators attached to the programme is necessary followed by their effective deployment in the field.

Inadequate infrastructure and mobility are other key factors responsible for operational problems particularly in the remote and difficult areas.

4.6 *Diagnosis of malaria in remote areas*

Clinical misdiagnosis of malaria has been reported both in the public and private health sectors. Both under-and over-diagnosis of malaria has been observed in South East Asian countries (Amexo *et al* 2004). Hence it is necessary to use appropriate diagnostic tools to prevent unethical use of antimalarials in the malaria negative patients (WHO 2006). The development and commercial availability of Rapid diagnostic tests either for individual species (for *P. falciparum*) or in combination (P. *falciparum* + *P. vivax*) or for all the species has revolutionized malaria diagnosis recently (Palmer *et al* 1998; Valecha *et al* 2003). The standard test particularly HRP-2 based for *P. falciparum* has acceptably high sensitivity and specificity (Beadle *et al* 1994). With the reducing cost of these tests, RDTs are now being increasingly deployed in the control programmes in India. The major advantage is that RDT can be used for on-the-spot diagnosis and treatment of malaria and in many situations could be life saving as well as a useful tool for transmission control at the community level. Although RDT's for malaria diagnosis have been introduced in the National Policy, there use should be further encouraged as a part of the EDPT policy being followed in India. Besides routine diagnosis during both active and passive case detection, they can also play an important role in the special situations e.g. in spot detection and treatment of cases in migrant population/refugees, in large projects where labour congregates and during outbreaks of malaria.

4.7 *Counterfeit drugs*

Counterfeit antimalarials are a major threat to malaria control in the entire South East Asia including India threatening at the same time the lives of thousands of people and possibly leading to development of drug-resistant strains. Paul Newton and colleagues from Oxford University have reported that at least 12 different types of counterfeit antimalarials are in circulation in South East Asia (Newton *et al* 2006). It has been suggested that approx 30-50% of drugs are fakes.

The problem of counterfeit antimalarials is particularly serious in Myanmar and along Thai-Cambodia border and criminals involved are trans-nationals. Incidentally this is the area where multi-drug resistant strains of malaria

parasites are in circulation and if the latest and most effective antimalarial ACT becomes ineffective due to misuse, it will spell disaster for malaria control throughout the world. Eastern corridor of India is particularly vulnerable along Myanmar border. It has been suggested that more international subsidy should be provided to make these expensive drugs more affordable for the poor and also to step up regulatory checks and pharmacovigilance to check flourishing counterfeit drug trade. The situation in India can be controlled by formal pharmacovigilance studies and empowering Drug Controller General of India for regular monitoring.

4.8   *Population migration*

It is well known fact that malaria linked with migration of population is a complex phenomenon. Human populations move for economic activity e.g. labour work in projects, gem/metal mining, agriculture, etc.; under distress due to famines, floods, earthquakes, conflicts, etc.; tourism/recreation and culturally e.g. gypsies (Prothero 1977). The movement may lead to permanent change of residence known as migration or there may be temporary change of residence and followed by return to the original location which is termed as circulation. Both these phenomena can influence local malaria epidemiology i.e. transmission and its seasonal pattern.

In South East Asia, movements on forest fringes are responsible for 'forest malaria' (Sharma and Kondrachine 1991). From the South East Asia, the focus of mono to multi drug resistant falciparum malaria has spread into north-east India and from there towards the south and west and other parts of the subcontinent (Payne 1987).

From control perspective, migration malaria is the most challenging as migrants generally remain out of the ambit of organized health services, are hard to track and monitor and generally do not comply with control strategy of the country (Prothero 1977). The availability of spurious/fake drugs along the migration routes over the counter further complicates malaria scenario in migrants and with their free movements, they transmit drug resistant malaria. There is an urgent need to study population migration patterns in India and their implications on malaria control. It is therefore emphasised to engage sociologists along with entomologists and epidemiologists to deal with the peculiar situation and to formulate appropriate control strategy for migrant malaria.

4.9   *Impact of climate change on malaria*

Climate change poses a major, and largely unfamiliar, challenge to the efforts to manage human health. Taking into account the present malaria situation in different paradigms,

there is a need to identify areas vulnerable to climate change and its impact on the future scenario of malaria with global warming in 2050 and 2100, wherein a projection of rise in temperature and precipitation to the tune of 1.4 to 5.8⁰C and 7% respectively has been made by Inter-Governmental Panel on Climate Change (IPCC 2001). The projections are going to worsen the malaria situation in the country in various ways like a faster rate of development of mosquitoes, faster rate of digestion of blood meal, and an increased frequency of feeding. As a result, malaria will be seen in new areas.

To combat the consequences of climate change, we need to act in time by developing tools for early warning for seasonal forecasts, plan public health interventions and allocate resources and strengthen surveillance and EDPT. Adaptation strategies must be considered to reduce disease burden, injuries, disabilities and deaths.

5.   Discussion

Malaria, dengue and other vector borne diseases were estimated to account for 1.6% of India's total disease burden (WHO 1998). Overall, out of 4.2 million disability adjusted life years lost due to vector borne diseases, malaria alone was responsible for estimated 1.85 million years lost/annum in India (Peters *et al* 2001; Kumar *et al* 2007). Taking into account the clinical episodes, it has now been estimated with the help of epidemiological models, geographical and demographic data that *P. falciparum* estimates outside Africa especially in South East Asia are 200% higher than reported by the World Health Organization i.e. 118.94 million out of global estimates of 515 million cases (Snow *et al* 2005). In addition to this, the burden of *P. vivax* malaria in the world has been calculated at 71-80 million cases of which South East Asia and Western pacific countries contributed 42 million cases (Alilio *et al* 2004).

There is need to adopt strategic approach which would help in meeting Millennium Development Goals in halving the malaria morbidity and mortality by the year 2015. Such an approach must address political, economic, technical and administrative ground realities in India.

Further, there is felt need for paradigm shift from focus on *P. falciparum* to the neglected *P. vivax* malaria which is predominant parasite species in the country (55%). This has become necessary because of the ominous signs of decreasing sensitivity in *P. vivax* to chloroquine and recent reports of involvement of the species in complicated malaria and mortality (Garg *et al* 1995; Kshirsagar *et al* 2000).

Enough knowledge, experience and expertise in malaria control and research exist in India in spite of financial and operational constraints. Therefore, India needs better attention of international donor and funding agencies. As the Indian economy is booming, internal rather than external resource mobilization could be possible. While the Africa

focus by the donor agencies is quite justified, the neglect of South East Asia and highly populous and endemic countries like India would be detrimental to the Global reduction of morbidity and mortality due to malaria which is mandated in the Millennium Development Goals.

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