Estimation of True Malaria Burden in India

Malaria imposes great socio-economic burden on humanity and with six other diseases like diarrhoea, HIV/AIDS, tuberculosis, measles, hepatitis B and pneumonia account for 85% of Global infectious disease burden. About 36% of the world population, i.e. 2020 million is exposed to the risk of contracting malaria in ~ 90 countries. World Health Organization estimates 300–500 million malaria cases annually and 90% of this burden is in Africa alone. In addition, the estimated annual mortality attributed to malaria ranges from 700,000 and 2.7 million globally and over 75% of them are African children and expectant mothers. Doubts have been expressed about reliability of these estimates as most of the hyper- and holoendemic countries, especially in Africa lack credible diagnostic facilities and reporting system.

In the south-east Asian Region of WHO, out of about 1.4 billion people living in 11 countries (land area 8,466,600 km^2, i.e. 6% of global area), 1.2 billion are exposed to the risk of malaria and most of whom live in India (Kondrachine 1992). However, the south-east Asia contributed only 2.5 million cases to the global burden of malaria. Of this, India alone contributed 76% of the total cases. Taking into account 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 that 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, 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 (Mendis *et al* 2001).

Malaria Scenario in India

Even a century after the discovery of malaria transmission through mosquitoes in India by Sir, Ronald Ross in 1897, malaria continues to be one of India's leading pubic health problems. In the 1930s, a treatise written by Sinton (1935) on 'what malaria costs India' recorded that the problem of the very existence in many parts of India was in fact the problem of malaria. In those days, it constituted one of the most important causes of economic misfortune, engendering poverty which lowered the physical and intellectual standards of the nation and hampered prosperity and economic progress in every way. In 1935, it was estimated that 100 million malaria cases and 1 million deaths occurred in India. Another estimate in 1947 suggests that 75 million cases (21.8% population) occurred in the post-independence population of 334 million with some

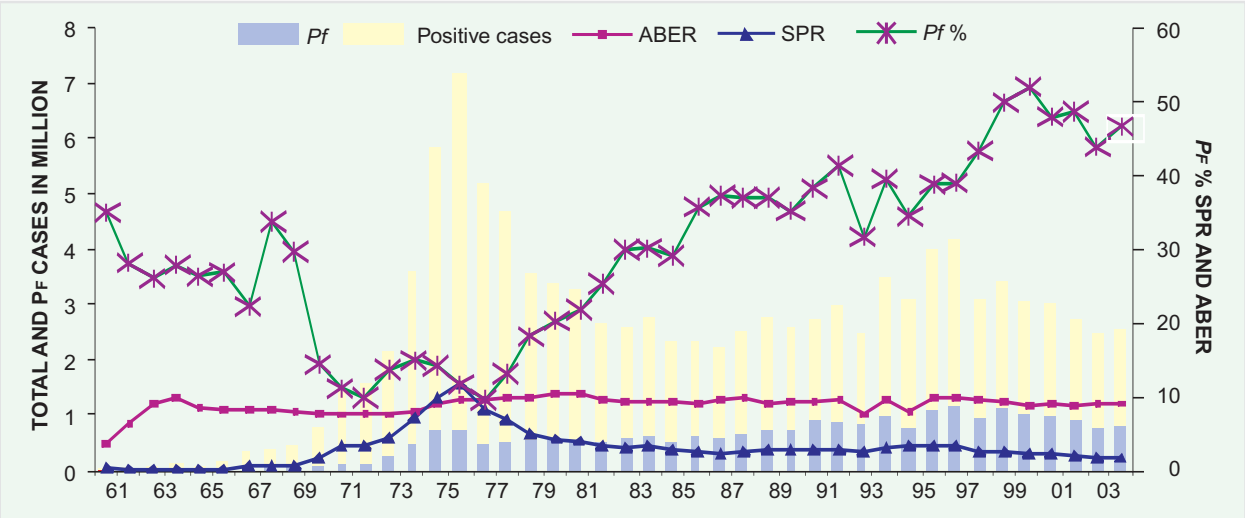

Fig. 3: Trends of malaria incidence in India from 1960 to 2005. Nearing eradication in 1960s (< 100,000 cases) to resurgence in the mid 1970s (~6.4 million cases) and stabilizing trend to around 2 million cases in the 1990s. *Plasmodium falciparum* proportion has steadily risen to around 50% in the recent years and the remaining incidence is of *P. vivax* and a small proportion of *P. malariae*. (Source: NVBDCP data)

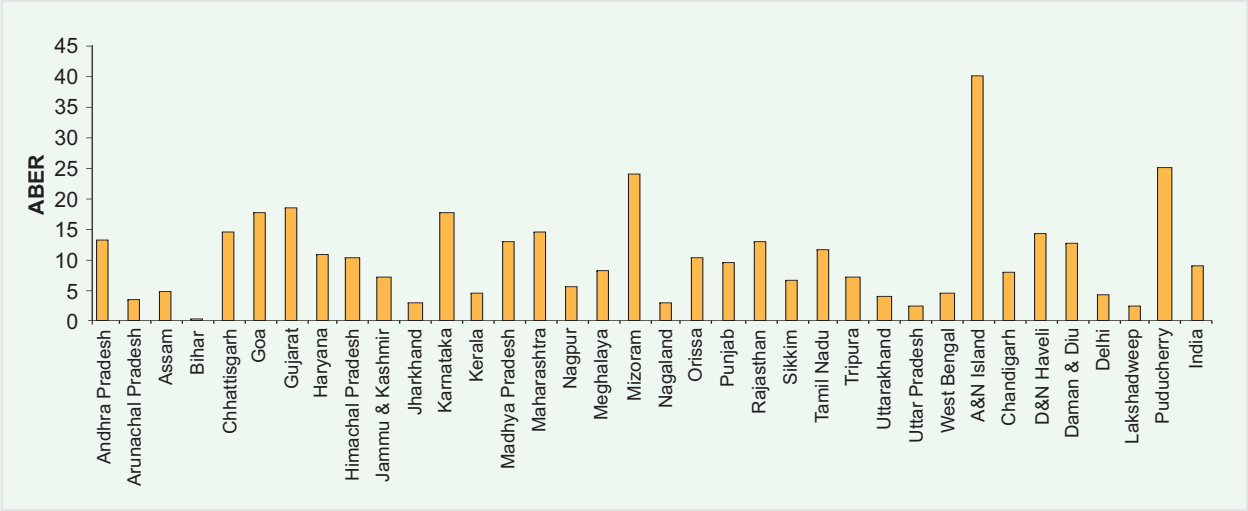

Fig. 4: Showing annual blood examination rates (ABER) for the detection of malaria in different states of India in 2004. About 10% is considered adequate to reflect true picture of malaria but there are some highly endemic states where ABER is much less than the prescribed norms. Even national average was 9% (Source: NVBDCP, India)

800,000 deaths. From this point, India achieved spectacular gains in malaria control during the 'Eradication Era' in the 1950s till the mid 1960s when reported cases were reduced to 64,000. In the post-resurgence phase, for many decades reported cases of malaria fluctuated between 1.5 and 3.0 million against the backdrop of rising population of India (Fig. 3).

There were a number of attempts to arrive at the true burden of malaria morbidity and mortality in India. Whereas, NMEP reported 5.2 and 2.9 million cases in 1975 and 1980 respectively, the Indian Drug Manufacturers Association estimated 12 million cases in 1975 and 20 million in 1980. From 1990s to date the reported malaria incidence in India has been around 1.5 to 2.6 million cases and 666–1000 deaths/annum, whereas estimated incidence by WHO was 15 million malaria cases with 19500 to 20000 deaths/annum (WHO SEARO website).

In 1990, it was estimated that out of a population of 843.7 million in India, 75 million, 240 million and 500 million people were respectively at high, moderate and low risk of contracting malaria. Situation has not changed much since then except for the population growth in each risk category (Sharma 1996). It is now well-accepted that the reported incidence of malaria at the national level on the basis of surveillance carried out in the primary health care system at best reflects a trend and not the true burden of malaria. Some studies carried out by the Malaria Research Centre (now NIMR) have also revealed a huge gap between reported and the true incidence of malaria. Sharma *et al* (1983) found that malaria incidence in PHC Kichha in District Nainital (erstwhile in U.P.) and Kharkhoda in District Sonepat (Haryana) was much high 95% (1784 cases) and 97% (7117 cases) higher than reported [76 and 183 cases respectively] (Table 2). Similarly, Malhotra *et al* (1985) detected 2623 cases as against 49 reported in Gadarpur PHC (Uttarakhand) showing once again a gap of 98%. Another study in PHC Bisra in District Sundargarh, Orissa state reported a slide positivity rate (SPR) of 33% by adopting weekly surveillance during 1988–89, whereas the SPR recorded by fortnightly surveillance during 1981–97 in Bisra PHC ranged between 9 and 18.5% (Yadav

Table 2. Some examples of incidence gap between routine surveillance system and longitudinal/point prevalence studies

Area	Pop	Surv	Cases	SPR	SFR	% Dif	Ref.
Kichha PHC,	97183	RS	76	4.7	NA	95	Sharma *et al*
Nainital	97183	LS	1784	22.1	NA		1983
Kharkhoda PHC,	91806	RS	183	12.6	5.5	97.4	Sharma *et al*
Sonepat	91806	LS	7117	43.2	30.46		1983
Gadarpur	6475	RS	492	5.27	1.61	98.1	Malhotra *et al*
UHC (U.P.)	6475	LS	623	58.66	34.58		1985
Bisra PHC,	6918	RS	825	7.6	3.8	68.0	Ghosh *et al*
Rourkela	NA	PP		26.3	15.8		1989

NA—Not available LS—Longitudinal studies; RS—Routine surveillance; PP—Point prevalence; Pop—Total population surveyed; Surv—Type of surveillance; Dif—Difference; Ref.—Publication reference

et al 1990). Yet another study in the mining areas of Orissa reported that at any given point of time about 13% population harboured malaria parasites and about 200 persons suffered from new malaria episodes per 1000 population per year (Haque 1998).

One of the reasons for under reporting is the low Annual blood examination rate which is reflection of inadequate disease surveillance by the states. The NVBDCP prescribes that annual blood examination rate for malaria should at least be 10% on a presumption that 10% of the population in a year will have fever at one point of time or the other. It is assumed that if all or most of the fever cases are examined for malaria, most of the incidence of malaria could be captured during fortnightly active surveillance. A look at the 2004 data (Fig. 4) show that the average ABER was 9% in India. In 14 out of 29 states, some of which were highly endemic to malaria, ABER ranged from 1 to 8% and in the remaining 15 states and union territories, ABER ranged from 10 to 40%.

Other reasons attributed to the gap besides inadequacies in surveillance are the quality of smear examination and underreporting of malaria cases. Underreporting of malaria due to misdiagnosis has been observed in Gujarat, where re-examination of blood smears in 9 primary health centers revealed that 6.7% of them had been misdiagnosed. As a result, 1262 malaria cases went undetected and unreported. Consequently, the annual parasite incidence (API) of malaria should have been 9.0 instead of 5.9 reported (Gautam *et al* 1992). How reliable was the clinical diagnosis alone for the treatment of malaria was shown in a hospital-based study. While there were 24% malaria cases on the basis of clinical judgement alone, the cases were actually 52% when microscopic diagnosis was done showing a gap of 28% (Gautam *et al* 1991). In a more recent study conducted in Ahmedabad metropolitan city in Gujarat state, it was estimated that there were on an average 25,465 malaria cases/annum as against 4119 cases reported and at least 22 malaria deaths/million population as against 0.3/million reported (Yadav *et al* 2003). This situation would have been further different if data of patients treated by all the private practitioners was available and computed to find out the true incidence in the city.

In three hospitals under the Steel Authority of India Limited in the mining areas in the interior forest of Sundargarh district in Orissa, a large number (52–68%) of outpatients with fever were treated for clinical malaria and a subsequent study showed that a third of all fever cases indeed had malaria (Yadav *et al* 1990). None of these cases were, however, captured in the PHC statistics due to lack of reporting system and even *P. malariae* parasites were not recorded due to misdiagnosis. It is a recognized fact that a large number of patients avail medical care at private institutions which do not keep or report disease statistics to health services.

Burden of malaria in different States of India

The annual parasite incidence (API) is a malariometric index to express malaria cases per thousand population. As per the NVBDCP incidence records, in most parts of of India the API was <2, whereas 2–5 API was in scattered regions, while regions with >5 API were scattered in the states like Rajasthan, Gujarat, Karnataka, Goa, southern Madhya Pradesh, Chhattisgarh, Jharkhand and Orissa, and in the northeastern states (Fig. 5).

The proportion of *P. vivax* and *P. falciparum* varies in different parts of India. Although most of the indo-gangetic plains and northern hilly states, northwestern India and southern Tamil Nadu state have <10% *P. falciparum* and the rest *are P. vivax* infections; in the forested areas inhabited by ethnic tribes, the situation is reverse and *P. falciparum* proportion is 30–90% and in the remaining areas it is between 10 and 30% (Fig. 6).

In India, maximum malaria is contributed by the Orissa state (Fig. 7). Although Orissa has a population of 36.7 million (3.5%), it contributed 25% of total 1.5 to 2 million reported annual malaria incidence, 39.5% of *P. falciparum* malaria and 30% of deaths due to malaria in India (Source: NVBDCP, India). Similarly, in the other states inhabited by ethnic tribes mainly in the forest ecosystems, meso- to hyper-endemic conditions of malaria exist with the preponderance of *P. falciparum* to the extent of 90% or even more.

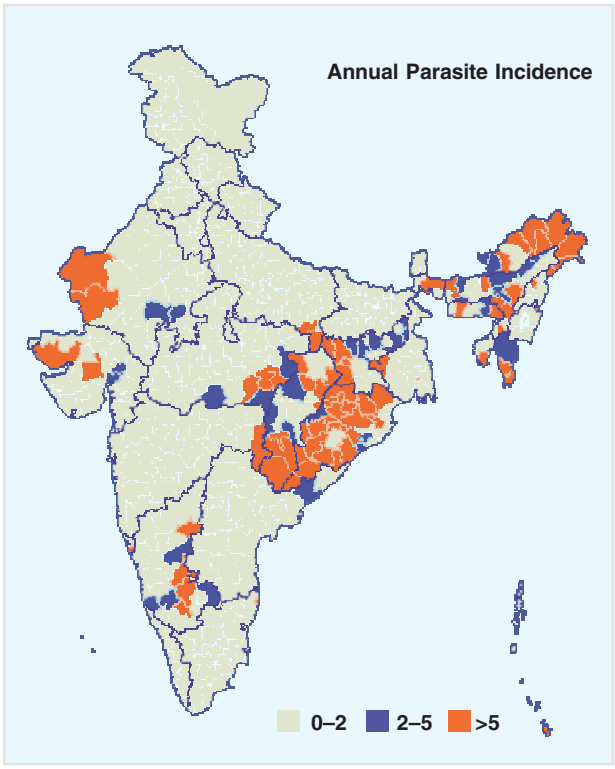

Fig. 5: Distribution of Malaria Incidence in India according to API in 2004 (Data Source: NVBDCP). Majority of India had less than 2 cases per 1000 population, 2–5 cases in some scattered regions and >5 cases where ethnic tribes live and stable malaria conditions prevail

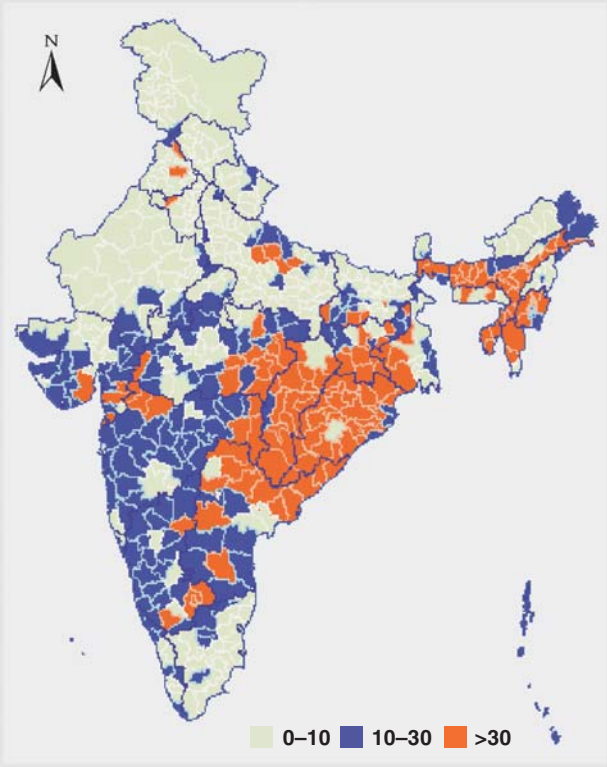

Fig. 6: *Plasmodium falciparum* proportion distribution in India. High proportion of *P. falciparum* up to 90% is seen in zones inhabited by ethnic tribes in forest ecosystems where stable malaria conditions occur

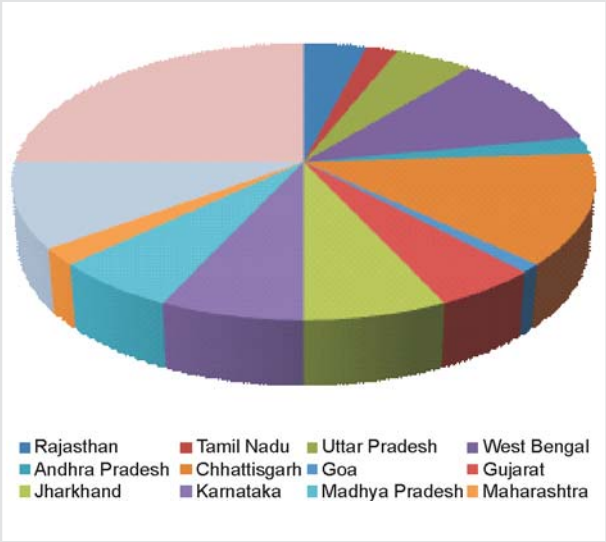

Fig. 7: Contribution of different states to malaria in India. Orissa, Chhattisgarh, West Bengal, Jharkhand and Karnataka contributed the most

Malaria Prevalence according to Age and Gender in India

Most of the point prevalence studies in India have been carried out for outbreak/epidemic investigations. There is very limited information on age and gender specific seasonal prevalence of malaria in different paradigms in the country. In the available studies, age and gender classification used is arbiterary (Das *et al* 1997; Dev and Sharma 1995; Prakash *et al* 1997; Dutta *et al* 1999; Shukla *et al* 1995; Dhiman *et al* 2001; Shrivastva *et al* 1995). The burden is generally higher in males than females in all age groups. These studies showed that children in the states like Assam, Arunachal Pradesh and Rajasthan had higher incidence of malaria than adults, whereas in the indo-gangetic plains the situation was reverse.

The Burden of Drug Resistant Malaria

In India, chloroquine resistance in *P. falciparum* was first reported from Manjha in Karbi Anglong district in 1973 (Sehgal *et al* 1973) and then from Nowgaon in 1974 in the northeastern state of Assam. More cases were then detected in next 3–4 years in Assam, Arunachal Pradesh, Mizoram and Nagaland. Although foci of resistance to chloroquine are present in the entire country, the problem is more pronounced in areas with intense *P. falciparum* transmission like northeastern states and Orissa; in areas where there is intermixing of population like project areas including construction sites, in big metros and along international borders (Fig. 8). In most of the studies, only late treatment failure to chloroquine has been observed probably because of semi immune nature of the population.

The problem of drug resistance has also been investigated using molecular markers. Molecular studies in 274 Indian *Pf* isolates have detected K76T mutations in all cases who did not respond to chloroquine and 96% of cases who were cured with chloroquine showing lack of co-relation between K76T mutation and clinical cure (Vinayak *et al* 2003). However, in this study, significant association of K76T mutation was observed with *in vitro* response to chloroquine in *P. falciparum*. Alleles of *Pfmdr1* gene showed strong association but incomplete correlation with CQ resistance (Bhattacharya *et al* 1997).

Although the available data on sulfadoxine pyrimethamine (SP) resistance is limited, it appears that the efficacy of this drug is within acceptable limits except in limited areas like Indo-Myanmar border in Arunachal Pradesh and some parts of Assam and West Bengal (NVBDCP 2002; Mohapatra *et al* 1997). In a study, out of 40 clinical isolates, 87.5% had Dihydrofolate reductase (DHFR) and 15% had Dihydropteroate synthase (DHPS) mutations (Biswas 2004). Parasites carrying double or single mutants also showed increased minimum inhibitory concentration (MIC) value for both pyrimethamine and sulfadoxine.

Only limited reports of chloroquine resistance in *P. vivax* malaria are available from India. Two cases from Mumbai did not respond to full dose of chloroquine (1500 mg) and peripheral smear continued to be positive despite adequate blood concentration of drug (Garg *et al* 1995). Similarly, there is another case report from Mathura (U.P.) of non-response to standard dose of chloroquine as confirmed by repeated blood examination (Dua *et al*.1996). Recently, 16% RI and 6.7%, RII resistance

Fig. 8: Areas shown in Grey (triangles and patches) where chloroquine resistance in *P. falciparum* has been confirmed qualifying for use of second line drug SP (Source: Data from NVBDCP, India)

in *P. vivax* was reported in a study conducted in 75 patients in Bihar (Singh 2000). In addition, multi-drug resistance has also been reported (Kshirsagar *et al* 2000). Contrary to these reports, a study in West Bengal and Orissa during 1998–2001, observed 100% cure rates by Day 7 in 480 vivax malaria patients (Nandy *et al* 2003). Incidentally, these areas, where *P. vivax* is still sensitive to chloroquine, have high drug pressure and chloroquine resistance in *P. falciparum.* Similar findings were confirmed in therapeutic efficacy studies with chloroquine in vivax malaria, in Gautam Budh Nagar (Uttar Pradesh) in the north, Navi Mumbai (Maharashtra) in the west and Chennai (Tamil Nadu) in south India in 287 patients in 2002. Curative efficacy of chloroquine was 100% in these patients of vivax malaria. Rapid parasite and fever clearance was observed in all cases and the drug was well tolerated (Valecha *et al* 2006). From the data available so far, it is evident that the problem of drug resistance in *P. vivax* is not of major concern, however, one needs to be vigilant as *P. vivax* produces relapsing type of infection and is a predominant species in India.

Based on the results of 28-day *in vivo* studies till 2001 and therapeutic studies from 2002 onward conducted by NVBDCP and research institutes including National Institute of Malaria Research, drug policy has been revised in 241 PHC'S of 71 districts in 20 states of India.

The Burden of Complicated Malaria

In India, reports suggest that mortality in complicated *P. falciparum* malaria in Vellore in southern state of Tamil Nadu was 7.9%, while in Jabalpur (Madhya Pradesh) and Rourkela (Orissa) it was 25.6 and 30% respectively (Herris *et al* 2001; Shukla *et al* 1995). In Jabalpur Medical College, 1783 patients were admitted with complicated *P. falciparum* infection of which 152 (8.5%) had cerebral malaria. Of these, 39 (25.6%) died and majority of them were in 16–40 years age group. Mortality was significantly higher in patients with hyper-parasitaemia and hypoglycemia. Delayed diagnosis and comatose condition were the main determinants of death. In a

tertiary care industrial hospital at Rourkela, a comparative analysis revealed that total number of patients admitted with complicated malaria significantly increased from 14.15% (62/431) in 1995–97 to 23.69% (236/996) in 2000–02. Similarly, cases of acute renal failures doubled from 22.5% (47/369) to 44.15% (117/265) and deaths in patients without renal involvement also increased from 12.7% (47/369) to 16.8% (119/731) [Unpublished data, courtesy Ispat General Hospital, Rourkela]. A general shift in the clinical profile in patients with complicated malaria has been observed and multiple organ dysfunction/failure is becoming common feature. For example in a tertiary care hospital in Cuttack only 10.9% (96/879) cases admitted were without complications, while 382 (43.5%) had either cerebral or renal or hepatic involvement, 298 (33.9%) had cerebral malaria with either renal or hepatic involvement and 103 (11.7%) had multi-organ failure and 138/783 (17.6%) died due to malaria.

Complications due to hitherto considered benign species *P. vivax* have been reported from Bikaner, India as from elsewhere in the recent years (Kochar *et al* 2005; Beg *et al* 2002; Valecha *et al* 1992; Patial *et al* 1998). It was observed that 72 of the 440 patients with microscopically and PCR confirmed mono infection of *P. vivax* had severe manifestations which included jaundice [33 (47%)], severe anemia [11 (15.7%)], respiratory distress with acidosis [8 (11.42%)], acute renal failure [7 (10%)], cerebral dysfunction with multiple convulsions [6 (8.6%)], abnormal bleeding [6 (8.6%)], shock (hypotension) [5 (7.1%)], pulmonary edema [3 (4.2%)] and hemoglobinuria [3 (4.2%)]. Many combinations of severe manifestations were observed in 35 of the 72 *P. vivax* cases followed. In 12 pregnant women with *P. vivax* infection, there were 2 abortions, 2 stillbirths and 4 pre-term deliveries.

The Burden of Malaria in Pregnancy in India

It is well-known that pregnant women constitute an important risk group for malaria infection particularly in hyper and holoendemic situations. The well known effects include effectiveness of placental barrier, parasite sequestration in placenta, suboptimal nutrition of the fetus, congenital malaria, intrauterine growth retardation, low birth weight, premature interruption of pregnancy, infant mortality and maternal death (Egwunyenga *et al* 1997; Melba 2002; Singh *et al* 2005; Singh *et al* 1999). Besides it may be the cause of cerebral malaria and severe anemia. In low transmission areas maternal mortality is about 1% while in Africa it could be between 84 and 2000 per 100,000 live births (0.00084–2%).

In the southeast Asia, malaria is a serious burden in pregnancy with spectrum of ill effects as shown by slide postivity rate (1.1–58%, n = 45–365), parasitaemia (1–70%, n = 55–365), cerebral malaria (7–76%, n = 45–365), anaemia (8.6–90%, n = 45–365), maternal mortality (7–66.6%, n = 45–365), placental malaria (18–29%, n = 256–365), abortions (2–11%, n = 45–365) and intrauterine fetal development impairment (2–31%, n = 45–322), stillbirth (2–13%, n = 45–365), pre-term (4.2–60%, n = 45–322) and low birth weight (5.4–89%, n = 55–365) (Singh *et al* 2005).

In the northwestern India in a hospital-based study in Bikaner, it was found that mortality rate in 45 pregnant women with *P. falciparum* infection was highly significant (37.8%) in comparison to non-pregnant women with *Pf* infection (14.81%) at p <0.001. Similarly, cerebral malaria (75.55%), severe anaemia (<5 g%) 20%, hepatic (13.3%) and renal failure (20%) were significantly more in pregnant women than non-pregnant females at 32.92, 4.11, 9.05 and 6.17%, respectively, (Kochar *et al* 2005).

From Central India, it has been reported that pregnant women (n = 365) suffer significantly more from both *P. vivax* (n = 121) and *P. falciparum* (n = 244) malaria than non-pregnant women (n = 150) (Singh *et al* 1999). The weight of neonates born to infected mothers was 300–350 g less on an average than neonates born to non-infected mothers(n = 1762). The weights continued to be significantly lower till the first six months affecting the growth of babies in infancy. It was found that rates of malaria infection reduced from first to third pregnancies. The mean parasitaemia in pregnant women suffering from *P. vivax* ($p<0.05$) or *P. falciparum* ($p<0.0001$) malaria was much higher than non-pregnant malaria infected women. Similarly, women with *P. falciparum* infection were significantly more anemic than the non-infected pregnant women ($p<0.0001$) or infected non-pregnant women ($p<0.001$). The pregnant women with *P. falciparum* malaria were significantly more anaemic than those suffering from *P. vivax* infection. Of the 244 pregnant women who had *P. falciparum* infection, 3 (1.22%) died, while in another 3 abortions were recorded and in two others still births were recorded. Only one still birth and abortion each were recorded in *P. vivax* infected women who were primigravidae. Among non-infected women, however, one abortion (in a primigravida) and one stillbirth (in a multigravida) were recorded.

Mortality Attributable to Malaria and Gaps

In India, malaria is one of the most important causes of direct or indirect infant, child and adult mortality. In pre-independent India, death toll due to malaria was estimated at one million during normal years and two million during epidemic years (Sinton 1935). Malaria mortality steeply declined after National Malaria Eradication Programme was launched in 1958. The National Programme reported 879, 666, 1057, 946 and 938 deaths due to complicated *P. falciparum* malaria from 1997 to 2001 showing a Specific Malaria Mortality Ratio (SMMR) of 0.30 to 0.48 in these years which was one of the lowest in the world. However, as per the WHO SEARO, 19500 to 20000 deaths occurred annually

Table 3. Estimates of deaths due to malaria in 15 states and Union Territories (UT) in India based on report of medically certified deaths in 1998[18]

State/UT	Proportion of deaths medically certified to total reported deaths (a)	No. of certified deaths attributable to malaria (b)	Total no. of estimated deaths due to malaria* (c) =b ×100/a
Puducherry	53.5	8	15
Nagaland	4	7	175
Manipur	32.7	10	31
Meghalaya	15.6	37	237
Haryana	10.5	80	762
Goa	89.9	87	97
Gujarat	4	95	2375
Arunachal Pradesh	69.5	119	171
Andhra Pradesh	6.6	165	2500
Delhi	58.5	212	362
Rajasthan	12.8	245	1914
Maharashtra	33.6	326	970
Karnataka	13.8	407	2949
Madhya Pradesh	4.9	890	18163
Orissa	9.4	1793	19074
Total	14.9	4481	49796

*Assuming malarial deaths were uniformly distributed in the entire sample of deaths due to all causes.

in India. Other than these sources, there are scanty reports on deaths due to malaria which are primarily based on outbreak or epidemic investigations. Age, gender and cause specific deaths are most extensively covered in the Govt. of India report on the basis of Medical Certification of Cause of Death (MCCD) (Anonymous 2001, 2002). The most recent available report is for 1998 during which there were 4481 certified malarial deaths reported from various categories of hospitals in rural and urban areas of India (Kochar *et al* 1998). Significantly, in this report only 14.9% of the total registered deaths were medically certified and to which specific cause of death was attributed. A simple conversion to 100% certification would mean that the deaths due to malaria could be 49,796 assuming that the malarial deaths were uniformly distributed in the remaining 85.1% sample (Table 3). During the same year, i.e. 1998 only 666 deaths were reported by the NVBDCP hence, these estimates were incomparable. It may further be noted that MCCD-1998 report contained death statistics from only 15 states and union territories out of total of 29 states and seven union territories. Certified death data from many malaria endemic states, such as Uttar Pradesh, Bihar, Assam, West Bengal and Tamil Nadu were not available. Had there been reporting of deaths from these states, the malarial deaths would have been much more than estimated 49,796. Hence, available data on deaths are incomplete and there appears to be a huge gap between reported and actual deaths due to malaria in India.

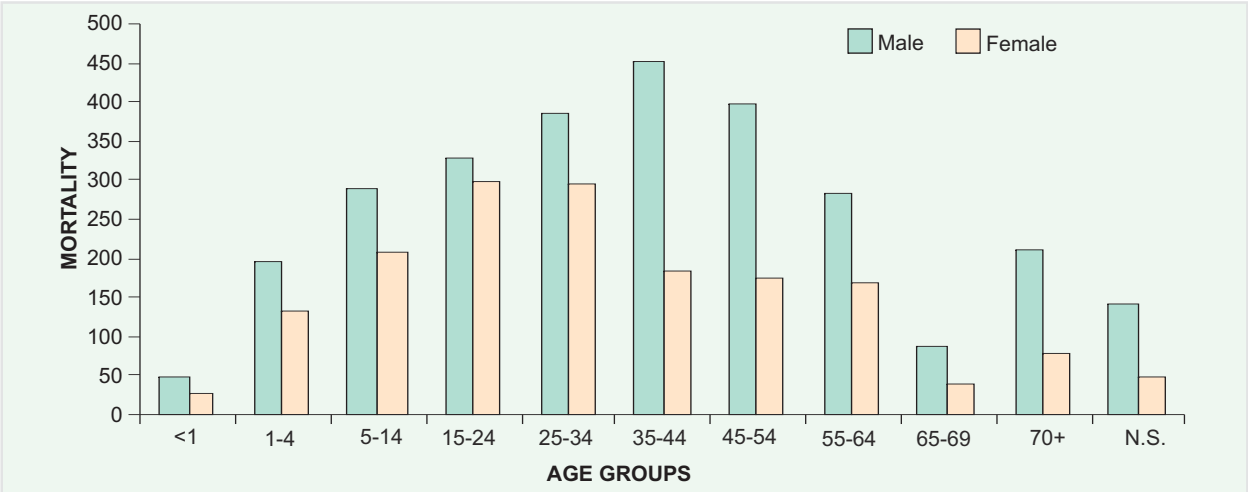

Fig. 9: Age and sex distribution of malaria mortality in India in 1998. The deaths are more in males than in females across all the ages while middle productive ages in general have much higher mortality than in children. N.S.= age not specified

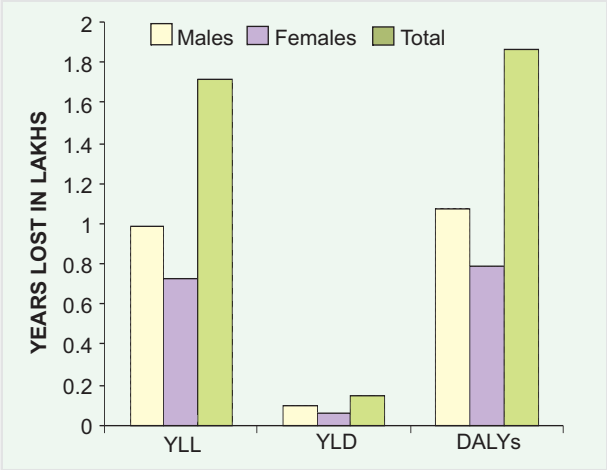

Fig. 10: Years of life lost (YLL), years lost due to disability (YLD) and disability adjusted life years lost (DALYs) due to malaria in both sexes in 1997 in India

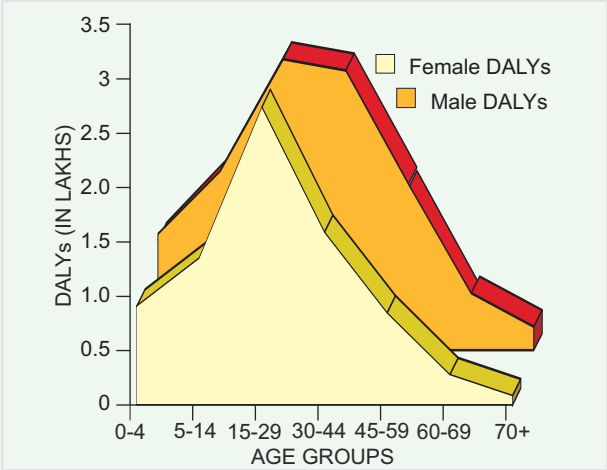

Fig. 11: DALYs lost according to age and sexes in India in 1997

Age and Sex-wise Distribution of Malaria Mortality

Age-sex distribution of malaria deaths shows that in general malaria mortality across all ages was comparatively higher in males than in females (Fig. 9). This mortality gap in genders widens after the age of 25 years (Anonymous 2002). Overall number of deaths in males were 2827 (63.1%) as compared to 1654 (36.9%) in females with a male: female ratio of 1:0.56. Unlike in Africa, where most of the deaths are reported in infants and children, it is seen that in India malarial deaths increased up to the age of 44 years in both the genders and then declined thereafter. Although the deaths in infants and children <14years of age accounted for 20.6%, in the higher ages (15–54 years), it accounted for 56.1% and the rest 23.3% were in >55 years of age. Hence, most of the burden of malarial mortality was borne by the economically productive ages.

The Burden of Malaria in terms of DALYs Lost in India—A Preliminary Estimate

In 1993, the Harvard School of Public Health in collaboration with World Bank and WHO assessed the Global Burden of Diseases (GBD) (Murray and Lopez 1997). The GBD study introduced a new metric–the disability adjusted life year (DALY)-to quantify the burden of the disease. One DALY means one lost year of healthy life on account of disease and is a common currency for disease morbidity and mortality expressed in time. This concept has gained importance in the past decade and WHO had undertaken GBD study of 135 major causes for the year 2002 and estimated DALYs for each cause in different regions and the countries (WHO 2004).

DALYs lost due to malaria in India for the year 1997 have been computed (Kumar *et al* 2007). The deaths due to malaria were estimated at 71,396 based on MCCD 1997 report (Anonymous 2001). Deaths were proportionately distributed according to age and gender based on MCCD data. From population Census of India 1991 report (Anonymous 1991), mid year population was calculated and assigned to different ages of both genders. Incidence of malaria was taken as per the WHO estimates of 15 million. Disability weights estimated in Global Burden of Disease Study 2000 for episodes (0.172 to 0.211), anaemia (0.012 to 0.013) and neurologic sequelae (0.581) were used. Duration of episode of malaria was taken as 7 days. DALYs were estimated using GBD template with age weighting and discounting. The total DALYs lost due to malaria were worked out to 1.86 million years. Among the females, DALYs lost were 0.786 million as against 1.074 million in the males (Fig. 10). The maximum DALYs lost (53.25%) were in the middle productive ages from 15 to 44 years followed by children <14 years of age (27.68%) and rest 19% in >45 years of age (Fig.11).

Health planners and administrators need estimates of true burden of malaria for allocation of much needed resources for interventions. The current reported incidence of around two million/annum in India at best reflects trend and given the gaps identified in various studies, the actual incidence is definitely far more than presently known. The reasons attributed to such a gap are deficiencies in coverage, collection and examination of blood smears and reporting system. Moreover, in India, the government health sector which provides free or highly subsidized health care caters to the needs of 20% population mainly in rural areas while the rest of the population seeks health care in private sector as their first point of contact where bulk of malaria is generally treated empirically Zwi *et al* 2001. The clinically treated cases never or rarely find place in the official statistics. This gap needs to be bridged to build burden estimates. Coupled with this, there is likelihood of sizable population acting as asymptomatic carriers of plasmodial infection, particularly in hard core malarious areas inhabited by ethnic tribes in India where meso- to hyper-endemic conditions exist. In such areas, inaccessibility and insurgency appear to be major causes of deficient routine surveillance services. In many such remote places, DDC (Drug

distribution centres) have been opened in India where malaria is symptomatically treated by trained community volunteers without accounting for the treated cases. Similar doubts have been expressed about the validity of estimates available for Africa because of inadequate detection and reporting and general inadequacies in the surveillance in malarious countries. The known and missing incidence of malaria in affected countries has been compared with the ears of hippopotamus which are visible above water while the bulk lies unseen underneath. This statement may also apply to many parts of India.

The true incidence of morbidity and mortality are of paramount importance in estimation of DALYs lost. In the absence of true burden estimates, we computed DALYs lost for India using WHO projections and mortality estimation on the basis of MCCD data. Although our DALYs estimates are conservative, they are much higher at 1.86 million years lost as compared to WHO estimates of 0.844 million years for the year 2002 (WHO 2004). India, therefore, must initiate burden estimation studies based on primary incidence and prevalence data to highlight the actual malaria burden in the country.

Malaria is well-known for its debilitating, demoralizing and impoverishing consequences and, therefore, estimation of its true burden and control is central to addressing these issues with the final aim of lifting the human resource above poverty line. The poor may find it hard to deal with persistent malaria problem, as coping with it is economically disastrous for the communities living on the edge. A good investment in malaria control not only makes public health sense but also economic sense in the present era of economic liberalization and surge in India. A firm malaria control is imperative for human resource development which in turn is imperative for equitable and sustained economic growth.

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Institute's references are listed in the Chapter "Research Articles published by NIMR scientists".