High-risk areas of malaria and prioritizing interventions in Assam

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Malaria is a major public health illness in Assam that contributes >5% of the reported cases in the country annually. Both Plasmodium falciparum and P. vivax occur in abundance, but P. falciparum (the killer parasite) accounts for >60% of the cases. Transmission of the malaria pathogen is persistent, and is maintained mostly by Anopheles minimus; other vectors are An. dirus and An. fluviatilis. There is an imperative need for better reporting system for evidence-based targetting of interventions, and to save operational costs. We propose that control programmes targetted at the population groups at high-risk (estimated to be ~40% of the total population of the state that accounts for >60% of cases) can be potentially highly effective in reducing transmission of the causative parasite. We call for greater coordination/political commitment for organized control operations along border areas by the respective state governments to thwart the development and spread of multi-drug resistant malaria, and thus save lives. Concerted efforts should be made for strengthening the health infrastructure at the periphery for better case management to avert and possibly delay the emergence of drug-resistant malaria, and help ensure equitable growth and development of communities at stake. The present article is an attempt to stratify malaria endemic districts, and delimit the borders for prioritizing intervention strategies for effective control of the disease in the north-eastern region of India.

Keywords: *Anopheles minimus*, Assam, high-risk areas, malaria, transmission and control.

THE state of Assam (24°44′ to 27°45′N lat.; 89°41′ to 96°02′E long.) is strategically placed, bounded by the hill states of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura, and shares an international border with Bhutan to the north and Bangladesh to the south (Figure 1). It is the most populous (27.85 million) and second largest state (78,523 km^2) in northeastern India, and is considered a gateway for economic activities. Malaria is a major public health illness. Assam alone, with only 2.6% of the country's population, contributes >5% of the total malaria cases in the country. The region is highly receptive to malaria transmission due to excessive and prolonged rainfall (2–3 m) promoting vector breeding and longevity due to high humidity (60–90%) and warmer climates (22–33°C) for most of the year. Both *Plasmodium falciparum* and *P. vivax* occur in abundance, but *P. falciparum* (the killer parasite) accounts for >60% of cases. The comparative epidemiological data on malaria incidence for the preceding years 2000–03 as reported by the state health services are presented in Figure 2. Disease outbreaks characterized by enhanced morbidity are annual events that take heavy toll on human lives amidst public chaos and panic. Transmission of the malaria pathogen is

Figure 1. Map of Assam showing district boundaries with bordering states, and international border with Bhutan and Bangladesh (source: www.mapsofindia.com). Numbers against the respective district indicate the malaria cases per thousand population.

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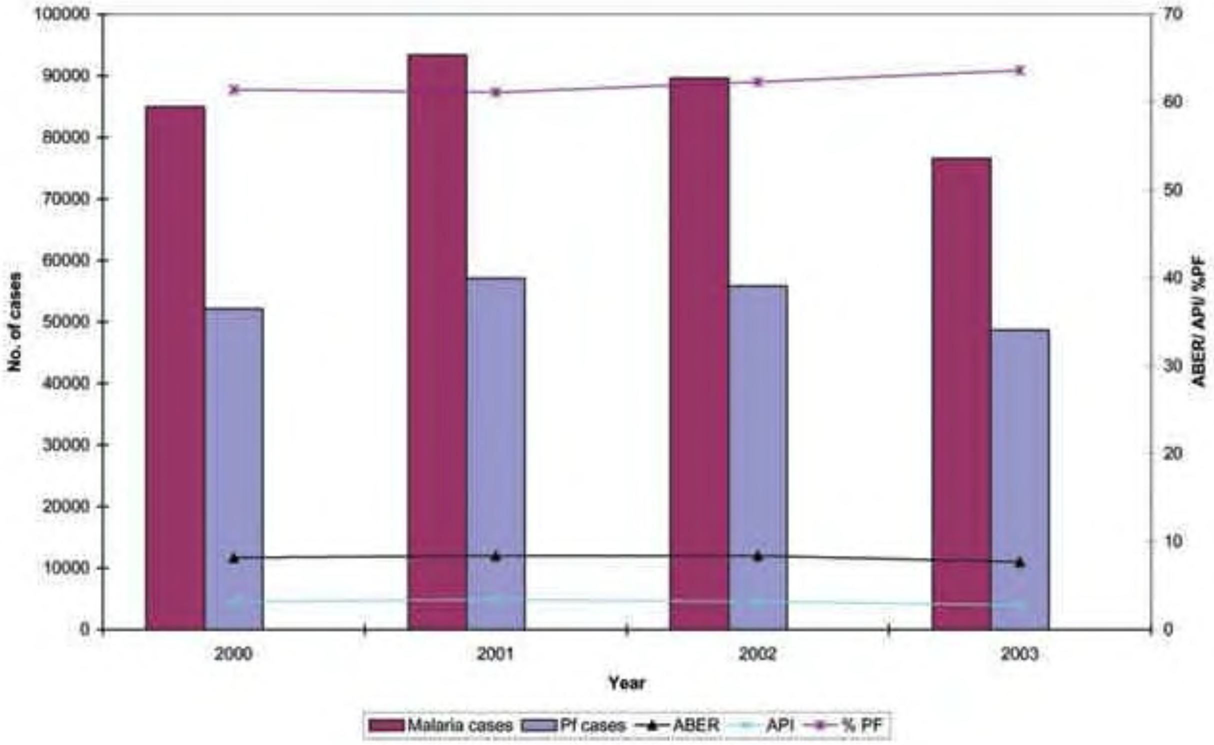

Figure 2. Comparative epidemiological data on malaria incidences in Assam state for the years 2000–03 (Source: State Health Directorate). ABER denotes % of population checked for malaria parasite in their peripheral blood smear; API is equal to number of confirmed cases of malaria/1000 population/year; % Pf marks the proportion of positive blood-smears with *P. falciparum* parasite infection.

persistent and is estimated to be low to moderate, maintained mostly by *Anopheles minimus*; other vectors are *An. dirus* and *An. fluviatilis*[1,2]. For optimizing vector control operations, spatial distribution of malaria is an important consideration for designing situation-specific intervention strategies that are aimed at reducing transmission[3,4]. The objective of the present report was to stratify the malaria-endemic districts and delimit the borders for prioritizing intervention strategies for effective control of the disease, and to contain the spread of malaria.

The state can be broadly divided into three physiographic units, namely the Brahmaputra valley in the north, the Barak valley in the south and the hill regions that lie between the two valleys. Of the total of 23 districts in the state, 21 either share an interstate border or an international border or both (Figure 1). All districts report malaria cases, but the disease is unevenly distributed across the landscape associated with varying intensity of transmission and population groups those at risk (Table 1). Based on the annual parasite incidence (API), defined as number of confirmed cases per thousand of population, ten districts reported less than two cases. For all other districts (44% of total population), API was ≥ 2, a criterion which is considered to be a sensitive malariometric indicator for residual spray interventions against vector populations[5]. Amongst districts (altitude < 200 m amsl), the hill districts of Karbi Anglong and N. C. Hills (altitude 200–600 m amsl) were worst affected, reporting API > 12. These were also the districts having more than one interstate border and higher concentration of tribal aborigines (> 50%), but population densities were the least (< 100 km^2)[6].

Comparatively districts of lower Assam, particularly Kokrajhar, Darrang, Goalpara and Hailakandi were more malaria prone with API in the range of 4–11, than upper Assam where the districts of Dibrugarh, Sibsagar and Jorhat were affected the least reporting the lowest API (0.02–0.1). The latter were also ones with the highest proportion of literates (> 70%) against the state average of 64%. As many as 122 block level Primary Health Care Centres (PHCs) of the existing total of 156 have been identified as high-risk, given by the guidelines of malaria action plan (MAP) of the national control programme[7]. Among these, 89 PHCs are located in border areas, and 50 are tribal-dominated (source: State Health Directorate of Assam). Varying segments of population groups of these PHCs at the district level are estimated to be living in high-risk areas for malaria infection (Table 1). These are largely the population groups (mostly tribal) located along border/remote, inaccessible areas, which are prone to outbreaks of the disease reporting enhanced morbidity and mortality. As much as > 80% of the population of two hill districts of Karbi Anglong and N. C. Hills, and that of Hailakandi were estimated to be at high-risk for malaria, and for ten districts, it ranged from 50 to 80%. For the remaining districts, it was <50% of the population that was at risk except Dibrugarh, which was risk free.

Table 1. Comparative epidemiological situation of malaria-endemic districts of Assam based on data for the year 2003 (source: State Health Directorate)

District	Population in millions (% of population at risk)	No. of blood smears examined (% of population checked)	No. and percentage of blood-smears: + ve for malaria parasite (SPR)	No. and percentage of blood-smears: + ve for *P. falciparum* (SFR)	Per cent of malaria cases positive for *P. falciparum*	No. of malaria cases/ 1000 population (API)	No. of deaths: Confirmed	No. of deaths: Suspected
Barpeta	1.61 (8)	89409 (5.5)	1632 (1.82)	646 (0.72)	40	1	0	0
Bongaigaon	0.97 (58)	69602 (7.1)	2118 (3.04)	1881 (2.70)	89	2	0	0
Cachar	1.57 (50)	88829 (5.6)	3956 (4.45)	3941 (4.43)	99	3	1	0
Darrang	1.62 (55)	116436 (7.1)	12203 (10.48)	1297 (1.11)	11	7	1	6
Dhemaji	0.61 (56)	33322 (5.4)	964 (2.89)	98 (0.29)	10	2	4	0
Dhubri	1.63 (60)	109493 (6.7)	1552 (1.41)	1444 (1.31)	93	1	1	0
Dibrugarh	1.57 (0)	119797 (7.6)	36 (0.03)	28 (0.02)	78	0.02	0	0
Goalpara	0.89 (76)	70053 (7.8)	3809 (5.43)	3047 (4.34)	80	4	0	0
Golaghat	1.05 (22)	85352 (8.1)	471 (0.55)	174 (0.20)	37	0.4	3	0
Hailakandi	0.68 (99)	75734 (10.9)	7568 (9.99)	7532 (9.94)	99	11	6	0
Jorhat	1.15 (19)	75468 (6.5)	136 (0.18)	88 (0.11)	65	0.1	0	0
Kamrup	2.56 (42)	172996 (6.7)	4237 (2.44)	3715 (2.14)	88	2	0	0
Karbi Anglong	0.80 (83)	168860 (20.9)	13484 (7.98)	11221 (6.64)	83	17	18	0
Karimganj	1.18 (9)	59011 (4.9)	803 (1.36)	728 (1.23)	91	1	0	0
Kokrajhar	0.79 (64)	66168 (8.3)	4841 (7.31)	3803 (5.74)	79	6	0	0
Lakhimpur	0.96 (57)	77004 (7.9)	3076 (3.99)	41 (0.05)	01	3	0	0
Morigaon	0.78 (8)	40927 (5.2)	352 (0.86)	226 (0.55)	64	0.4	0	0
Nagaon	2.10 (52)	209716 (9.9)	5002 (2.38)	3541 (1.68)	71	2	9	16
Nalbari	1.22 (35)	74606 (6.1)	1466 (1.96)	1222 (1.63)	83	1	0	16
N.C. Hills	0.20 (93)	24674 (12.3)	2551 (10.33)	2099 (8.50)	82	13	1	0
Sibsagar	1.10 (4)	67688 (6.1)	23 (0.03)	20 (0.02)	87	0.02	0	0
Sonitpur	1.87 (78)	163392 (8.7)	4784 (2.92)	1562 (0.95)	33	3	9	8
Tinsukia	1.24 (34)	76184 (6.1)	1506 (1.97)	410 (0.53)	27	1	0	0
Total	27.85 (41)	2133820 (7.7)	76570 (3.58)	48668 (2.28)	64	2.75	53	46

Of total blood smears checked for malaria parasite, the prevalence rates for those positive for malaria and those positive for *P. falciparum* (SFR) were 3.58 and 2.28% respectively, but were noted to be variable among districts (Table 1). For six districts, namely Darrang, Goalpara, Hailakandi, Karbi Anglong, Kokrajhar and N. C. Hills, the smear parasite rate (SPR) was > 5%, meeting one of the criteria for declaring high-risk zones. These were also the districts (except Darrang) reporting higher rate for *P. falciparum* infection and death. For other districts, SPR varied from 0.03 to 4.45%. *P. falciparum* was the major parasite (> 60%) in the state, but for districts of Barpeta, Darrang, Dhemaji, Lakhimpur, Sonitpur, Tinsukia and Golaghat, *P. vivax* outnumbered the *P. falciparum* cases. As many as ten districts reported deaths confirmed to be due to *P. falciparum* infection. Among these, Karbi Anglong, Nagaon, Sonitpur and Hailakandi contributed the bulk of death cases. Of the total deaths attributable to malarial infection, just as equal proportions were suspected based on clinical presentation of the diseased from whom blood smear could not be collected/examined.

While malaria inflicts all age groups of both sexes, certain localities in the given geographic area contribute significantly more cases than others[3]. Malaria incidences were reportedly higher in villages located nearer (<1 km) to the vector breeding habitat (seepage streams), and foothills[8]. Variation exists down to the household level, and it is the knowledge of location of such individuals/population groups at high-risk that can help malaria control measures to be targetted for desired level of transmission reduction[9]. It was observed that districts flanked with more than one interstate border, e.g. Karbi Anglong, N. C. Hills and Kokrajhar had many more cases compared with those having only one interstate and/or international border. These borders are highly porous, and most outbreaks of the disease reportedly occur in these bordering population groups owing to inter-mixing of population groups with varying levels of immunity against malaria[10]. High morbidity and mortality have been reported in personnel of the security forces deployed along these border areas. These are also the foothill/forest fringe areas where health infrastructure is weak and transmission of the disease is high under the combined influence of *An. minimus*, *An. dirus* and *An. fluviatilis*[11]. There are as many as seven interstate borders and two international borders that are shared by Assam (Figure 1). Among these, Arunachal Pradesh and of Meghalaya share a border with seven districts (19 PHCs) each, but per cent share contribution of malaria/*P. falciparum* cases varied (Figure 3). Bordering PHCs with Arunachal Pradesh contributed comparatively more cases of malaria but less of *P. falciparum* than those of Meghalaya. Nagaland shares a border with five districts (13 PHCs) and per cent

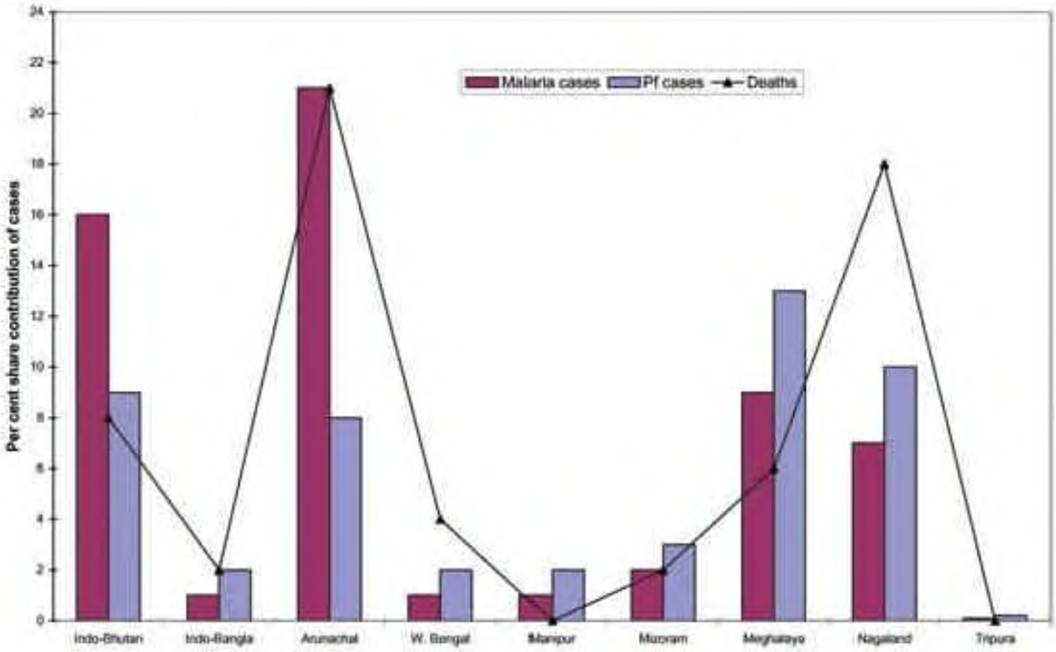

Figure 3. Comparative per cent share contribution of malaria cases and attributable deaths in inter-state and international bordering districts of Assam.

share contribution to cases was lower than Meghalaya. Bordering districts/PHCs with West Bengal (2/5), Manipur (2/5), Mizoram (3/5) and Tripura (1/1) were fewer, and contributed the least number of cases. Among the two international borders, Indo-Bhutan had as many six districts (12 PHCs) and contributed more cases and deaths compared with three districts (10 PHCs) sharing their borders with Bangladesh. Malaria is now establishing its foothold in bordering districts previously free of the disease, such as Lakhimpur, Jorhat and Tinsukia (districts of upper Assam) owing to deforestation and population migration/new settlements in the reserve forest areas, reporting increased morbidity and mortality[11,12]. Majority of malaria-attributable deaths (>60%) were recorded along these bordering population groups, and were significantly correlated with reported *P. falciparum* cases ($r = 0.7333$, $df = 7$, $P \leq 0.0311$).

It is evident that malaria remains endemic in the state despite the intervention strategies being in force ever since the establishment of the National Malaria Control Programme in 1953. The difficulty of accurately targetting the vulnerable pockets has probably amounted to persisting transmission of the disease in the region. Annual blood examination rate (% of population checked for malaria parasite) was reportedly well below the target of 10% for the state (Figure 2), which is suggestive of fragmented surveillance – a measure that is considered important to monitor the progress of disease interventions and early detection of outbreaks. This component of the control programme possibly has resulted in the build-up of infectious reservoir of the malaria pathogen that facilitated the emergence of multi-drug resistant strains[13–15].

Malaria burden is linked with poverty[16]. As much as 36% of the total population of Assam is estimated to be living below the poverty line, and the risk factors for malaria are much concentrated in these marginalized population groups[6,8]. Healthcare facilities tend to be located in urban areas; consequently treatment access is poorly addressed by the health systems in the periphery where it is needed most. Thus, the true number of malaria cases and deaths could indeed be much higher and the figures presented may only be taken as trends[17]. There might as well be misdiagnosis and/or misidentification of parasite species; spot surveys in many such pockets revealed more cases of *P. falciparum* than *P. vivax*[8]. There is an imperative need for better reporting system for evidence based targetting of interventions, and to save operational costs[18]. The non-random distribution of malaria cases appears to conform closely to 20/80, whereby approximately 20% of the host population contributes 80% of the cases[19]. As the rule implies, we propose that control programmes targetted at the population groups at high-risk (estimated to be ~ 40% of the total population of the state that accounts for > 60% of the cases) can be potentially highly effective in reducing transmission of the causative parasite. We call for greater coordination/political commitment for organized control operations along border areas by the respective state government to thwart the development and spread of multi-drug resistant malaria, and thus save lives. Until malaria vaccines become available, we have to rely on old, traditional interventions with emphasis on reducing man–mosquito contact. It is envisioned that effective control of malaria, particularly the drug-resistant varieties in such areas of low to moderate endemicity are quite feasible with the existing tools, provided these are accurately targetted in relation to clustering of malarial infection. These tools when combined with bioenvironmental approaches, e.g. use of insecticide-treated nets, improved diagnostics supplemented by geographical information data can yield rich dividends for effective malaria control[20,21]. Concerted efforts should be made for strengthening health infrastructure at the periphery for case management to avert and possibly delay the emergence of drug-resistant malaria, and help ensure equitable growth and development of communities at stake[22,23].

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ACKNOWLEDGEMENTS. We acknowledge the help and assistance of Suraj Anand, North Carolina State University, Raleigh, USA for statistical analyses, and thank Biman Patwary, Sonapur College, Dimoria block, and S. Phookan for data management, constructive discussions and literature search on the subject. Thanks are also due to Dr V. P. Sharma, and anonymous reviewers for valuable suggestions.

Received 21 April 2005; revised accepted 11 September 2005