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MALARIA SITUATION IN NORTH-EASTERN REGION OF INDIA

Malaria is one of the major public health problems of the north-eastern (NE) states of India. The disease is unevenly distributed over the region showing distinct epidemiological paradigms attributable to eco-geographic, ethnic and socio-cultural diversity. Malaria is found all over the north-eastern region except for areas above 5000 ft from MSL[1,2]. Stable malaria with preponderance of *Plasmodium falciparum* infection (60-80%) is the main characteristic of the disease pattern in the north-eastern region. Though the population of the NE region is 3.7% of the Indian population, this region contributed 8 to 12% of malaria positives, 10 to 20% of *P. falciparum* (PF) infections and 13 to 41% of deaths due to malaria in the country's average between 1991-1995. After the introduction of the National Malaria Eradication Programme (NMEP) in 1958, a dramatic reduction of malaria occurred in all malarious areas of the country which was, however, relatively less marked in the NE region[2]. This was evidenced by the retention of 50% area (9.29 NMEP units) in the NE region under the attack phase of NMEP compared to 11% in the rest of the country in 1968[1,3]. After 1965, a resurgence of malaria occurred in various parts of the country and the NE region was no exception. Large tracts of this region being hilly, forested, relatively inaccessible with poor communication and inadequate infrastructure, made control of malaria logistically difficult. The factor which further compounded the problem of malaria resurgence in the north-east was the development of chloroquine resistance in *P. falciparum* in Assam[4]. To appreciate the malaria situation in the NE region in a better way an attempt has been made in this article to provide a profile of malaria in the region briefly covering various elements of disease transmission.

Topography

The NE region of India, comprising 7 states *viz.* Arunachal Pradesh, Assam, Manipur, Mizoram, Meghalaya, Nagaland and Tripura, is situated between 22°04′ and 29°31′ N and 89°48′ and 97°25′ E covering an area of 2,55,128 km². The region has international borders on the north (with China), east (Myanmar) and south (Bangladesh). In the west it is contiguous with West Bengal. The NE region contributes 7.8% of the total land mass of the country. About 45% of the north-east is covered with tropical evergreen rain forest.

The region can be divided into 3 major geographical entities *viz.* the Himalayas, the Indo-Brahmaputra basin along with the Barak, Imphal and Tripura valleys (plains) and hill ranges bordering Myanmar and Bangladesh (north-eastern plateau). The northern Himalayan ranges are low and usually do not exceed 1850 m in height. The areas above 5000 ft MSL bordering China are free from malaria but the foothills and adjacent hills are highly malarious. The Indo-Brahmaputra basin (alluvial plain) is sandwiched between the Himalaya in the north and the hill ranges extending from Myanmar in the east to the Garo hills in the south. This region along with the Barak, Imphal and Tripura valleys has variable endemicity of malaria. The hill ranges

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along the Indo-Myanmar border, lying in the north-south direction, extend up to the Indo-Brahmaputra basin and are hyper-endemic for malaria. The hill ranges bordering Bangladesh in the south (lie east-west) which include the Naga, Mizo, North Cachar, Cachar, Karbi, Jaintia, Khasi and Garo hills have large areas with hyper- to holo-endemic malaria.

Climate

The climate of the region is conducive for prolonged malaria transmission. The south-west monsoon brings heavy rain fall to Assam and the adjoining states. Though the main rainy season is between June and September, rains occur more or less through out the year. The average number of rainy days is 200-250. The characteristic of rain fall in the NE region is its uneven precipitation. While Cherrapunji-Mowsynram region (Meghalaya) gets an annual rain fall of 11,500 mm, the Manipur valley in the same geographical zone receives a rain fall of 1000 mm. Most of the areas except the north-eastern plateau receive more than 2000 mm rain fall.

The region can be divided into three major isothermic zones. In the greater and lesser Himalayas, the temperature ranges between -20°C in winter to 15 to 20°C in summer. The northern part, except the greater and lesser Himalayas, along with the sub Himalayan areas lie within the 4°C January to 21°C July isotherms. The Indo-Brahamaputra basin lies between the 21°C January to 30°C July isotherms. The relative humidity of the region is more than 60% throughout the year.

Demography

The NE region has a population of 3,14,00,855 (1991 census). The decadal (1981-91) growth rate of the region was 39.7% which ranged from 23.6% in Assam to 56.9% in Nagaland. The population density in the north-east is 117/km^2. This also shows a wide variation of 10/km^2 in Arunachal Pradesh to 284/km^2 in Assam. This region is inhabited by many ethnic and cultural subgroups whose beliefs, culture, life-styles and occupational needs have direct bearing on the transmission of vector-borne disease. In the NE region, 25.2% of the total population is tribal with varying ethnicity. The tribals generally inhabit the forest and forest fringe areas. There is a large scale movement of people from outside and within the NE states for agriculture, project work and forest activities. Even within the same state sometimes the whole village shifts to another site in search of newer agricultural and forest land. Besides the permanently settled, there is a large floating population consisting of seasonal labourers from Orissa, Bihar and West Bengal. Studies have shown that of the 2,53,000 labourers engaged in 46 commissioned projects in the north-east, 70,900 (28%) were seasonal labourers who had immigrated from other parts of the country[5]. Large scale population movement, resulting in the introduction of newer strains of malaria parasite and dissemination of drug resistant strains is responsible for accelerated malaria transmission in the region.

The economy of the NE region is primarily agriculture based. In the plains mainly rice is grown by wet cultivation whereas in hilly forested areas the inhabitants practice shifting *(Jhum)* cultivation. It is estimated that 18.4% area in the north-east is under *Jhum* cultivation[6]. The climate in this region is suitable for growing tea and most of the highlands, plains and foothills are utilised for tea plantations. Most tea gardens are located in Assam, Arunachal Pradesh and Tripura[7]. Oil, coal and timber are the other important industries of this region.

Vectors of Malaria

Due to its peculiar climate, topography and terrain, the NE region is rich in flora and fauna. As such 130 species (37 anophelines and 93 culicines) of mosquitoes belonging to 12 genera have been recorded in this region[8]. Malaria in the NE region is primarily maintained by three major vector species *viz. Anopheles dirus, An. minimus* and *An. fluviatilis*[9]. In the past natural infection have been found in *An. philippinensis, An. annularis, An. maculatus* var. *willmorei (=An. willmorei)* and in *An. culicifacies*[10] in NE region, however, they are not considered of much importance.

An. dirus

An. dirus is regarded as the most important vector of malaria in the entire South-East Asia region. It is distributed in the wet forest areas in north-eastern India, western ghats in south-western peninsular India and the Andaman Islands. It is a complex of at least 7 sibling species provisionally designated as *dirus* A, B, C, D, E, F and *takasagoensis* with species 'D' reported to occur in north-east India[11]. In India, *An. dirus* was first incriminated in the Digboi area of Assam[12] and subsequently from different NE states[13-15]. It is basically a forest breeder and breeds mainly in temporary, shady/partly shady ground pools. Biting by *An. dirus* which occurs throughout the night is predominant between 2100 h and 0300 h. This mosquito feeds both indoors and outdoors and has a propensity to feed more on humans with >90% anthropophilic index. During the day females take shelter in the forests. It is a hygrophilic species, able to adapt to changing environmental conditions and demonstrates the phenomenon of "annual pulsation" wherein its "mother foci" in

the deep forests expand to the peripheral "secondary foci" during the rainy season and again retreat to the deep forests during the dry season[16]. This annual pulsation explains the high density of this species in the monsoon months (June-October) and extremely low density in the dry cool period (December-March). It has been reported that *An. dirus* is associated with the spread of chloroquine resistant *P. falciparum* strains[17].

An. minimus

It was once considered as the most important vector of malaria in the entire sub-Himalayan belt. Subsequent to the large scale application of DDT under the NMEP this species disappeared from its area of influence[9,13]. However, during the eighties *An. minimus* was again recorded in the NE region and incriminated as the vector in Assam[18,19], Arunachal Pradesh[20], Nagaland[21] and Mizoram[14]. It is a species of the hills and foothills occupying ecotone zones closer to the forests. It breeds mostly in slow running streams with grassy margins. *An. minimus* is prevalent throughout the year with higher densities between March and August. It is an endophilic, endophagic species with high anthropophilic habits. It usually feeds throughout the night with pronounced feeding between 2100 h and 0400 h. It prefers to rest indoors on the lower half of the walls and its distribution is usually patchy in the village with some houses being preferred for resting. *An. minimus* is highly susceptible to the residual insecticides[22].

An. fluviatilis

It is essentially a species of the hills and foothills but is also found in irrigated plain areas. Though recorded from most of the north-east states, it was earlier disregarded as a vector due to the non detection of natural infection. It is a complex of 3 sibling species provisionally designated as *fluviatilis* S, T and U[23]. Amongst these, species S is predominantly anthropophagic in contrast to T and U species[24] which are exclusively or primarily zoophagic. Deforestation in order to retrieve forest land, is possibly responsible for the establishment of *An. fluviatilis* in large tracts of the north-east. As a result most of the ecotone zones are under the influence of *An. minimus* as well as *An. fluviatilis* with the increased period of transmission and seasonal overlapping[16]. It is a clear water breeder normally found in streams, irrigational channels with grassy edges and perceptible flow of water. *An. fluviatilis* is basically a post monsoon species prevalent between November and July with peak densities in March to April. It prefers to rest indoors during the day. Though it bite throughout the night, feeding is mainly before midnight. It is susceptible to commonly used residual insecticides[18].

Epidemiological Profile of Malaria

Malaria endemicity in the NE region showed wide variations between 1961 and 1995 (Fig. 1). During this period the proportion of *P. falciparum* (Pf%) ranged from 16.8 to 70.6 and slide positive rate (SPR) from 0.96 to

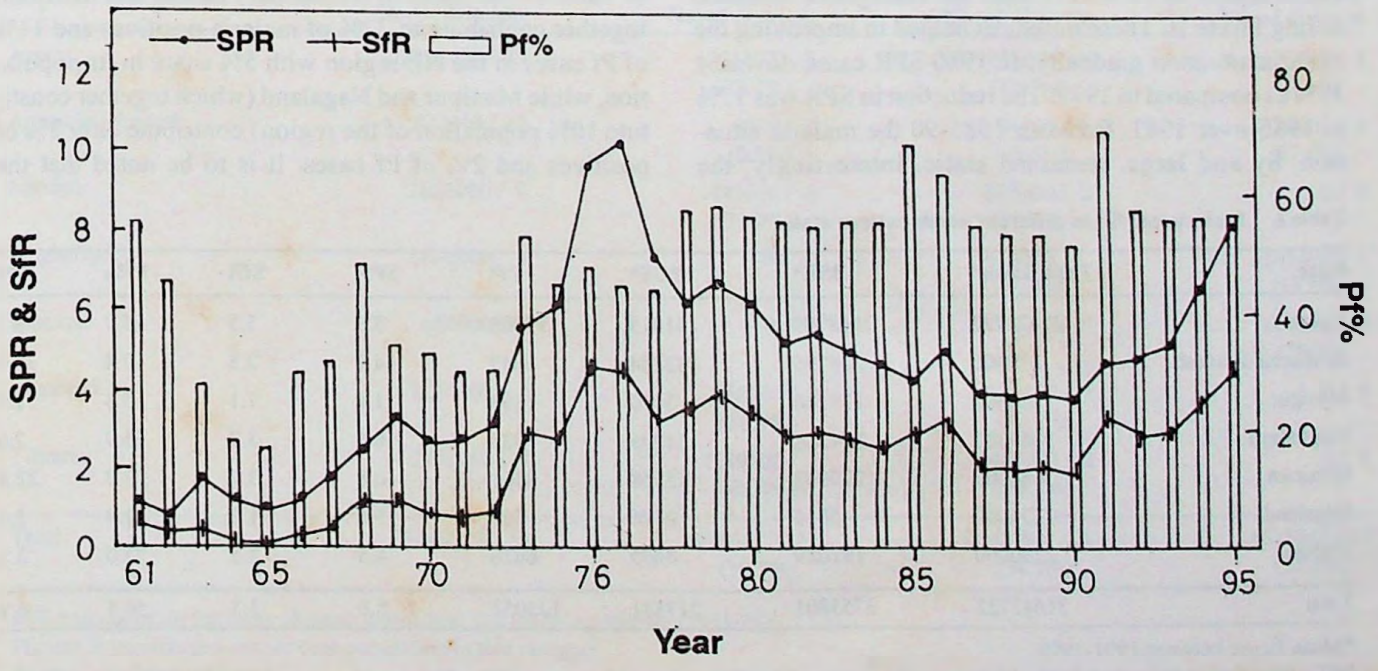


Fig. 1. Epidemiological situation in NE region of India (1961-95)
SPR : Slide positive rate; SfR : Slide falciparum rate; Pf % : *P. falciparum* percentage

10.2%. All indicators of malaria incidence showed the lowest values in 1965 and 1976 was the year of maximum incidence. The period between 1961 and 1995 can be divided into four distinct phases to understand the fluctuations in epidemiological situation of the region.

Phase I (1961-1965)

Surveillance to detect malaria cases was instituted in 1961 under the NMEP. During this phase malaria transmission was successfully curtailed resulting in a decline of SPR from 1.2 to 0.96, slide falciparum rate (SfR) from 0.64 to 0.16 and there were no deaths. DDT pressure resulted in geographical contraction of malaria in the NE region.

Phase II (1966-1976)

Achievements of the phase I began to fade due to the resurgence and geographical expansion of malaria. During this period, the hard core areas (forest/hill) resisted the efforts to control malaria. The incidence of malaria rose from 12,412 in 1966 to 2,25,506 cases in 1976 and malaria deaths occurred from 1971.

Phase III (1977-1990)

This phase was marked by the introduction of the modified plan of operations (MPO) and the *P. falciparum* containment programme (PfCP) under the NMEP as additional inputs in 1978 to contain the resurgence recorded during Phase II. These measures helped in improving the malaria situation gradually. In 1980 SPR came down by 39% as compared to 1977. The reduction in SPR was 17% in 1985 over 1981. Between 1985-90 the malaria situation, by and large, remained static. Interestingly, the decline in malaria during this period was mainly of *P. vivax* cases and Pf percentage actually showed a rising trend. Another feature of this phase was the occurrence of wide spread epidemics[5] in different parts of Assam and Tripura during 1986.

Phase IV (1991-1995)

This period can be called the phase of second resurgence marked by a rapid increase in malaria incidence as well as geographical expansion of the disease. Malaria and Pf incidence increased by 42 and 177% respectively in 1995 as compared to 1991. The maximum number of deaths also occurred during this phase (Fig. 2).

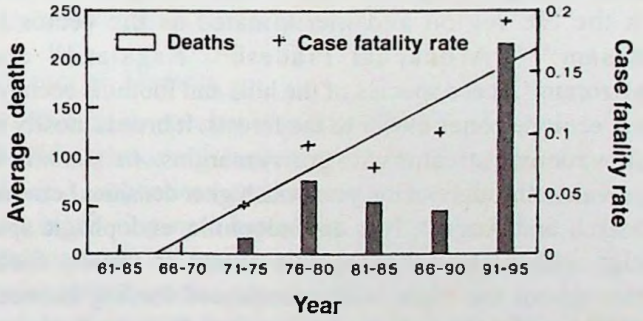


Fig. 2. Profile of deaths due to malaria in the NE region of India (1961-95)

The current epidemiological situation (1991-95) of malaria[25] in the different north-eastern states is presented in Table I. The states of Arunachal Pradesh and Mizoram together contribute to 22% of malaria positives and 11% of Pf cases in the NE region with 5% share in its population, while Manipur and Nagaland (which together constitute 10% population of the region) contribute only 3% of positives and 2% of Pf cases. It is to be noted that the

Table I. Malaria profile in different north-eastern states

State	Population*	BSE*	POS*	Pf*	SPR	SfR	Pf%	API
Assam	22428722	2668789	141013	92008	5.3	3.5	65.7	6.3
Arunachal Pradesh	819400	228795	32484	5657	14.2	2.5	17.4	39.6
Manipur	1826000	177146	3430	1898	1.9	1.1	55.3	1.9
Meghalaya	1860000	214288	14205	7938	6.6	3.7	55.9	7.6
Mizoram	684000	227943	15568	8361	6.8	3.7	53.7	22.8
Nagaland	1274000	45811	2576	564	5.6	1.2	21.9	2.0
Tripura	2750000	191029	8605	6626	4.5	3.5	77.0	3.1
Total	31642122	3753801	217881	123052	5.8	3.3	56.5	6.9

*Mean figure between 1991-1995

BSE : Blood slide examined; POS : Malaria positive cases; Pf : *Plasmodium falciparum*; SPR : Slide positive rate; SFR : Slide falciparum rate; Pf % : *Plasmodium falciparum* percentage; API : Annual parasite incidence

Source : Reference 25

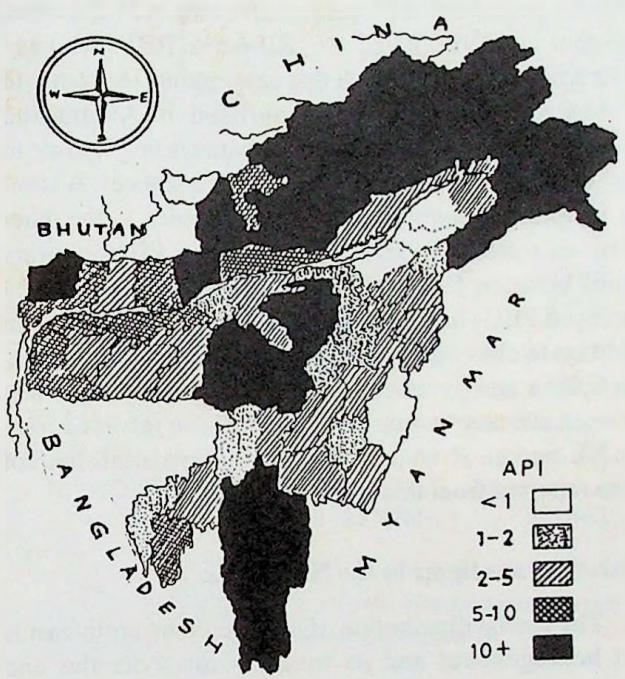


Fig. 3. Malaria endemicity pattern of NE region of India (1991-95)

latter two states are affected by insurgency and law and order problems resulting in operational deficiency. Malaria endemicity of various north-eastern districts is depicted in Fig 3. It is seen that 30% of the population of the NE region live in areas having annual parasite incidence (API) below 2, 55% population live in areas between 2-10 API and about 15% population live in areas recording API higher than 10 (Table II).

Assam

Assam is the largest state in NE region (71% population) and has the maximum number of positives (64.7%) and Pf (74.8%) cases. Of the 23 districts of Assam, four *viz.* Karbi Anglong, Kokrajhar, Darang and N.C. Hills, have the highest endemicity of malaria and contribute to 41% of total positives and 32% of Pf cases in the state average while contributing only to 12.3% of the population. The districts of upper Assam on south bank of Brahmaputra river including Dibrugarh, Sibsagar and Jorhat are the least endemic for malaria. These three districts together constitute 12% of state population but contribute only 0.43% of malaria positives and 0.49% of Pf cases.

Arunachal Pradesh

Geographically this is the largest state of the NE region with an area of 83,473 km^2 and the lowest population density. This state contributes 2.6% population in the NE region whereas it has 15% total positives and 5% Pf cases in the region. In general the hill and foothill areas of Arunachal Pradesh adjacent to Assam are highly endemic

Table II. Stratification of NE region according to annual parasite incidence (API)

State	Total population/ No. of districts	< 2 API	2–10 API	> 10 API
		Population/ No. of districts	Population/ No. of districts	Population/ No. of districts
Assam	22428722 / 23	6331872 / 7 (28.2%)	13169408 / 12 (58.7%)	2927442 / 4 (13.1%)
Arunachal Pradesh	819400 / 10	6600 / 1 (0.8%)	54200 / 1 (6.6%)	758600 / 8 (92.6%)
Manipur	1826000 / 8	1443000 / 6 (79.0%)	383000 / 2 (21.0%)	0 / 0
Meghalaya	1860000 / 3	0 / 0	1614200 / 2 (86.8%)	245800 / 1 (13.2%)
Mizoram	684000 / 4	0 / 0	0 / 0	684000 / 4 (100%)
Nagaland	1274000 / 7	646000 / 2 (50.7%)	628000 / 5 (49.3%)	0 / 0
Tripura	2750000 / 3	1289000 / 1 (46.9%)	1461000 / 2 (53.1%)	0 / 0
Total	31642122 / 58	9716472 / 17 (30.7%)	17309808 / 24 (54.7%)	4615842 / 17 (14.6%)

API calculated on the basis of mean population and malaria positives (1991-95)
Figures in parentheses are per cent population in that category
Source : Reference 25

for malaria with an API of >15. As per NMEP data, Arunachal Pradesh has a low Pf incidence. However, several studies have shown high (>60%) Pf incidence in different parts of the state[26, 27].

Meghalaya

There are only 3, predominantly tribal districts, *viz.* Garo Hills, Khasi Hills and Jaintia Hills (NMEP reporting districts) in this hilly state. The Garo Hills district has the highest Pf incidence (90%) in contrast to a very low (3.4%) Pf incidence in the Jaintia Hills.

Manipur

Of the 8 districts in the state, 3 are valley districts and 5 are hilly districts. Four districts *viz.* Churachandpur, Imphal, Bishenpur and Thouvel are highly endemic contributing together 85% of malaria cases and 90% of Pf cases.

Mizoram

There are 4 districts in this hilly, malaria endemic state. Two districts *viz.* Aizwal East and Aizwal West are relatively more endemic contributing 61.4% of positives and 75.5% of Pf incidence.

Nagaland

This hilly state has 7 districts, all of which are highly endemic for malaria. District Mokokchung has the highest SPR (8.2%) closely followed by Phek district (6.53%). In the remaining districts SPR varies between 3.5 and 5.8% and Pf proportion between 10.6 and 39%.

Tripura

Tripura, the second smallest state of India, is surrounded on three sides by Bangladesh and on one side by Assam and Mizoram. Of the 3 districts in the state, South Tripura is the most endemic contributing 62% and 58.6% of malaria positives and Pf cases of the state, respectively.

Drug Resistance Profile

Resistance to chloroquine in *P. falciparum* was first detected in 1973 from Manja PHC, Karbi Anglong district of Assam[4]. Regular monitoring of drug resistance, however, started from 1978 onwards under the Pf monitoring scheme of NMEP. A review of various *in vivo* chloroquine resistance studies carried out in Assam[28] between 1978-93, revealed that Pf was sensitive only in 34.2% cases, resistant in 47.9% (RI 35.6%, RII 6.5%, RIII 5.8%) and S/RI type in 17.9%. It is felt that chloroquine resistance to Pf has not yet been fully stabilised in Assam and chloroquine failure at the RI level is increasing leading to higher morbidity due to repeated recrudescences. A similar picture of chloroquine resistance is seen in the other north-east states. Studies carried out by Pf monitoring teams between 1978 to 1995 revealed that 47 of the 59 surveyed PHCs had resistance cases of all categories[25]. In addition to chloroquine, confirmed resistance to long acting sulpha and pyremethamine combination drugs[29] and reduced efficacy to quinine[30] has also been recorded from the NE region. *P. vivax* resistant to antimalarials has not been reported from this region.

Malaria Paradigms in the NE Region

The spatial distribution of malaria in the north-east is not homogeneous and its transmission dynamics and intensity is governed by a large number of stable and unstable, biotic and abiotic factors in different paradigms. A malaria paradigm is defined as a specific situation supporting a level of malaria endemicity which is dependent on local environmental and socio-economical activities[25]. Different paradigms of malaria in the north-east show wide variations and within the paradigms there sometimes exist sub-paradigms which govern the malaria situation to a considerable degree in the region. On the basis of the existing malaria situation the following paradigms of malaria can be identified in the NE region of India.

Tribal area malaria

These areas are predominantly hilly with deep forests/ disturbed forest fringes, rich in biodiversity, crisscrossed by hilly streams and characterised by a high concentration of tribals with low population density. In these areas malaria is stable-with prolonged transmission and high Pf preponderance. Resistance to chloroquine in Pf is usually widespread along with a focus of resistance to sulpha and pyremethamine combinations. *An. dirus, An. minimus* and *An. fluviatilis* alone or in combination are the major vectors which are refractory to control. Inadequate health infrastructure and lack of treatment facilities at the village level is an added disadvantage in these areas[31]. In this paradigm the adults develop sufficient immunity to malaria whereas the children in the absence of immunity suffer and die[32]. It has been reported that 7.4 million tribal population out of 27.1 million rural population in the north-east contribute 6% of total malaria and 11% of Pf

Table III. Prevalence of tribal population vs malaria incidence (1991-1995) in north-east India

% of tribal population	No. of districts	Population	BSE (ABER)	POS (SPR)	Pf (SfR)	% Population to total	% Malaria positives to total
0 - 5	6	6589726	800773 (12.2)	21450 (2.7)	17260 (2.2)	20.9	9.9
6 - 10	3	3372298	343780 (10.2)	7188 (2.1)	4855 (1.4)	10.8	3.3
11 - 25	8	10250707	1149007 (11.2)	75620 (6.6)	42507 (3.7)	32.7	35.2
> 25	41	11188124	1242302 (11.1)	110778 (8.9)	57034 (4.6)	35.7	53.1
Total NE region	58	31400855	3535862	215036	121656	100	100

BSE : Blood slide examined; ABER : Annual blood examination rate; POS : Malaria positive cases; SPR : Slide positive rate; SfR : Slide falciparum rate; Pf : *Plasmadium falciparum*
Source : Reference 25

cases[31]. Published data on malaria in the north-eastern states[25] reveal a similar picture on analysis (Table III). Predominantly tribal areas (areas with >25% of tribal population) contributing 35.7% of the population of north-east, have 53% malaria cases in the region whereas the predominantly non tribal areas (areas with <10% of tribal population) contribute only 13% of total cases though having almost equal population *ie.* 31.7%. The correlation between malaria incidence (API) and proportion of tribal population was, however, weak. Under tribal area malaria two sub-paradigms can be further identified.

Deep forest malaria : The forests in the NE region are tropical, evergreen monsoon type where the high humidity and temperature range favour vigorous growth of trees resulting in a thick shady canopy. *An. minimus* is, more or less, absent in these areas[33] and malaria is transmitted chiefly by *An. dirus*. The individuals involved in timber collection and tree felling stay for variable periods ranging from a few hours to a few nights, in the forest camps and face the risk of contracting malaria. Such people (usually labourers) after falling sick in forest camps return to their native villages for treatment and convalescence and setup a local transmission chain. *Jhum* cultivators are another vulnerable group of people in this sub-paradigm who often sleep in hilly forest areas in small thatched sheds, usually open from the sides, for variable periods both during the sowing and harvesting of crops and get exposed to infected *An. dirus* and the hazards of malaria.

Forest fringe malaria : Usually in the foothills and plains cultivation is done after clearing a small forest which disturbs the natural ecology of the area. Malaria in such forest fringe areas with disturbed ecology is maintained both by *An. minimus* and *An. dirus*. The transmission in these areas is intense and prolonged with moderate to high endemicity. This sub-paradigm also encompasses those areas where massive deforestation for retrieving cultivable land and timber has taken place. Usually in such areas malaria is endemic with wide fluctuations and is usually maintained by *An. minimus* and *An. fluviatilis* and possibly by *An. philippinensis/nivipes*.

Border area malaria

The north-east shares international borders with Bhutan, China, Myanmar and Bangladesh. These border areas are mostly hills and foothills with thick forest cover, poor communication and inadequate health infrastructure. The highly porous border allows frequent legal and illegal exchange and mixing of local populace from both sides. These factors facilitate the high malaria transmission in the border districts. Of the Indo-Chinese border districts, Tawang district (Arunachal Pradesh) is situated at a high altitude and is free from malaria. Besides, the northern parts of all other Indo-China border districts are also free from malaria and only their southern parts, contiguous with the foothill areas of Assam are malarious. Malaria in the Indo-Bhutan, Indo-Myanmar and Indo-Bangladesh border districts is hyper- to holo- endemic in nature. The

vulnerable population groups in this paradigm are the personnel of the security forces and Border Road Organisation. These are mixed population groups with varying levels of immunity against malaria. The military and paramilitary forces keep on moving from non-malarious to malarious areas and vice versa and in the process get exposed to local strains of malaria parasites causing enhanced transmission. The malaria epidemiological data of the international border districts of the NE region are shown in Table IV. The SPR and SfR in the border districts were significantly higher than in the non border districts.

Table IV. Malaria profile (1991-1995) in the international border districts of NE region

Category	BSE	Positive	Pf	SPR	SfR	Pf %
Indo-Bangladesh border	986744	47671	32175	4.8	3.3	67.5
Indo-Myanmar border	242788	20104	6828	8.3	2.9	34.0
Indo-China border	118561	16113	1436	13.6	1.2	8.9
Indo-Bhutan border	814009	74178	46662	9.1	5.7	62.9
Total border area	2162102	158066	87101	4.8	3.3	67.5
Total non-border area	1591699	59815	35951	3.8	2.3	60.1

BSE : Blood slide examined; Pf : *Plasmodium falciparum*;
SPR : Slide positive rate; SfR : Slide falciparum rate;
Pf %: *P. falciparum* percentage
Source : Reference 25

Organised sector malaria

The NE region has large mineral reserves, the exploration and extraction of which is done by organised sectors employing a large work force drawn from different parts of the country. Similarly the tea industry is a major organised sector of the economy in this area. In addition, many developmental projects such as power generation and road and rail line construction are being executed in the region. Malaria in all these sectors, could be clubbed under this paradigm. Being well organised, these segments have their own health delivery system. As far as malaria is concerned the NMEP has only a minimal presence in these sectors. The health institutions in these sectors, being primarily curative in nature so far as malaria is concerned, lack proper and systematic record maintenance and it is, therefore, difficult to assess the real epidemiological picture of malaria in this paradigm. In this paradigm 3 subparadigms can be identified.

Oil and coal sectors : These sectors are usually located in forest and forest fringe areas in the foothills and plains of the NE region. Generally workers engaged in drilling and exploration, *etc.* in the open areas are exposed to mosquito bites. The vulnerability of these sectors was identified by the Government of India as early as 1945 when the Nazira and Margarita coal fields pilot project for malaria control by DDT application was launched[3].

Tea sector : Tea industry is one of the most important sectors of the economy of the north-east. Most of the tea gardens are located in Assam, Arunachal Pradesh and Tripura in the foothill malarious areas. In Assam alone there are 848 tea gardens employing 5,41,661 labourers[7]. This community comprises a mixed population of various ethnic groups which had migrated from other parts of India many generations earlier. Malaria was a serious problem in these gardens affecting the production. Hence, even before the institution of any organised control elsewhere, various attempts were made to control malaria in the tea gardens[3, 34]. Regular data on the malaria morbidity in the tea gardens are lacking due to the absence of a reporting system and poor coordination between the tea garden management and the state health department. Nevertheless, recent studies indicated a very high malaria prevalence with Pf preponderance[35] and high degree of chloroquine resistance[36].

Developmental projects sector : Various developmental projects being undertaken in the NE region like power, roads, communication, irrigation, *etc.* invariably involve aggregation of labourers in the proximity of highly malarious forested areas. A wide variation in transmission dynamics is seen from project to project depending on the location of the project site.

The above discussion on the various well identified paradigms of malaria highlights the following important features of malaria transmission in the north-east.

(i) Most of the areas, except the high mountainous regions, in the north-east are endemic for malaria. However, deep forested and forest fringe areas with disturbed ecology in the hills and foothills, usually inhabited by tribals of various ethnicity are hard core malarious areas with high Pf preponderance and refractoriness to control. Malaria is usually stable with high asymptomatic carriers in these areas.

(ii) The stable nature of malaria endemicity in large areas of the north-east region is destabilised by the extension of human activities from outside which invariably results in increased transmission and malaria

outbreaks. Movement of people from the hard core areas to areas with low to moderate endemicity leads to enhanced transmission because of dissemination of different parasite strains.

(iii) The chief vectors of malaria in the NE region *ie. An. dirus* and *An. minimus* are hygrophilic and well adapted to the ecological conditions of the region. Their high anthropophilic habits makes malaria transmission possible even at low density levels.

Conclusions

It is evident that the malaria situation in the NE region is governed by a variety of specific ecological, epidemiological, geographical and social factors. Abundance of hills, foothills, forests, inaccessible tribal areas, poor communication and large scale population movement are some of the reasons for maintenance of high endemicity of malaria which is further compounded by the combination of specialist vactor species and increasing drug resistance. The geographical spread of malaria, which was contracted after the introduction of the NMEP in the sixties, resurged in the seventies and stabilised in the eighties, has reverted to expansion in terms of area and intensity in the nineties. Despite the control efforts by the government the malaria situation in the NE region has progressively deteriorated. This in retrospect can be attributed to a combination of factors–(i) failure to sustain residual insecticide spray coverage due to various technical, administrative and operational reasons; (ii) selection of exophilic and exophagic vector species under DDT pressure; (iii) selection of resistant malaria parasite strains under extensive antimalarial drug pressure; (iv) rapid developmental works causing tropical aggregation of labourers and; (v) insurgency related law and order problems seriously affecting control activities and resulting in movement of people from low to high endemic areas and vice versa. From the past experience it can be said that in order to tackle the malaria situation effectively in the north-eastern states newer control technologies (both for vector and parasite), sensitive to local situations, acceptable by the local population and in accordance with changing vector behaviour, need to be introduced. In this context insecticide treated bed nets have shown very promising results in the north-eastern conditions[37]. Similarly artimisinin derivatives have been found to be extremely effective in the treatment of malaria in this region[38]. Recently the Government of India has modified its control strategy and introduced a new Malaria Action Programme[39] for problematic areas in the country including the north-east. It is hoped that these tools and measures should be able to improve the malaria situation in north-east India. The improving malaria situation in some of the western Pacific countries (having malaria situation and problems similar to the NE region) is a reminder of the fact that the constraints of drug and insecticide resistance and population movement are not intractable obstacles to malaria control if the right strategies are applied in the right way, in the right place and at the right time[40].

References

1. Sharma, V.P. Reemergence of malaria in India. *Indian J Med Res 103* : 26, 1996.
2. Molinaeux, L. The epidemiology of human malaria as an explanation of its distribution including some implications for its control. In : *Malaria, Principles and Practice of Malariology* (Vol 2). Eds, W.H. Wernsodorfer and I. McGregor. Churchil Livingstone, London. 1988, p 913.
3. *Malaria and Its Control in India* (Vol 1). Directorate of National Malaria Eradication Programme (DGHS). Government of India, New Delhi, 1986, p 1.
4. Sehgal, P.N., Sharma, M.I.D., Sharma, S.L. and Gogoi, S. Resistance to chloroquine in falciparum malaria in Assam state. *J Commun Dis 5* : 175, 1975.
5. *Epidemiological Consideration for Planning Malaria Control in Southeast Asia Region* (Southeast Asia Series no. 17). Eds. A.V. Kondrashin and K.M. Rashid. WHO Regional Publication, SEARO, New Delhi. 1987, p 1.
6. Roy, B. and Irshad Ali, A.N.M. Shifting cultivation and forest in north-east India. In : *People of the Himalayas, Ecology, Culture, Development and Change*. Ed. K. Mahanta. Kamala-Raj Enterprises, Delhi. 1997, p 135.
7. *Statistical Hand-book of Assam 1993*. Directorate of Economics and Statistics, Government of Assam, Guwahati.
8. Malhotra, P.R. and Mahanta, H.C. Check list of mosquitoes of north-east India (Diptera : Culicidae). *Oriental Insects 28* : 125, 1994.
9. Rajagopal, R. Studies on persistent transmission of malaria in Burnihat, Meghalaya. *J Commun Dis 17* : 29, 1985.
10. Viswanathan, D.K., Das, S. and Oomen, A.V. Malaria carrying anopheles in Assam with special reference to the results of twelve months dissection. *J Mal Inst India 4* : 297, 1941.
11. Baimai, V. Population cytogenetics of the malaria vector *Anopheles leucosphyrus* group. *Southeast Asian J Trop Med Pub Health 19* : 667, 1988.
12. Clark, R.H.P. and Choudhury, M.A. Observations on *Anopheles leucosphyrus* in Digboi area of upper Assam. *J Mal Inst India 4* : 103, 1941.
13. Sen, A.K., John, V.M., Krishnan, K.S. and Rajagopal, R. Studies on malaria transmission in Tirap district, Arunachal Pradesh (NEFA). *J Commun Dis 5* : 98, 1973.

14. Das, S.C. and Baruah, I. Incrimination of *Anopheles minimus* Theobald and *Anopheles balabacensis* Baisas *(An. dirus)* as malaria vectors in Mizoram. *Indian J Malariol 22* : 53, 1985.

15. Dutta, P., Bhattacharyya, D.R. and Dutta, L.P. Incrimination of *Anopheles dirus* as a vector of malaria in Dibrugarh district, Assam. *Indian J Malariol 26* : 149, 1989.

16. Kalra, N.L. Forest malaria vectors in India : Ecological characteristics and epidemiological implications. In : *Forest Malaria in Southeast Asia* (Proceedings of an Informal Consultative Meeting). Eds. V.P. Sharma and A.V. Kondrashin. WHO/MRC, New Delhi, 1991, p 93.

17. The biology of malaria parasites. *WHO Tech Rep Ser 743* : 118, 1987.

18. Kareem, M.A., Singh, V.K., Bhatnagar, V.N., Krishnamurty, B.S., Das, M. and Sharma, G.K. A preliminary report on some entomological observations in malaria endemic areas of Kamrup district, Assam. *J Commun Dis 17* : 29, 1985.

19. Prakash, A., Mohapatra, P.K. and Srivastava, V.K. Vector incrimination in Tamulpur Primary Health Centre, district Nalbari, lower Assam during malaria outbreak, 1995. *Indian J Med Res 103* : 146, 1996.

20. Dutta, P. and Baruah, B.D. Incrimination of *Anopheles minimus* Theobald as vectors of malaria in Arunachal Pradesh. *Indian J Malariol 24* : 159, 1987.

21. Bhatnagar, V.N., Dwivedi, S.R., Mishra, B.G. and Das, M. Detection and incrimination of *Anopheles minimus* Theobald 1901 as malaria vector in foothill areas of Nagaland, India. *Indian J Malariol 19* : 129, 1982.

22. Prakash, A., Bhattacharyya, D.R., Mohapatra, P.K. and Mahanta, J. Current insecticide susceptibility status of *Anopheles minimus* Theobald in Assam. *J Commun Dis 28* : 143, 1996.

23. Subbarao, S.K., Nanda, N., Vasantha, K., Dua, V.K., Malhotra, M.S., Yadav, R.S. and Sharma, V.P. Population cytogenetic evidence for three sibling species in *Anopheles fluviatilis* (Diptera : Culicidae). *Ann Entomol Soc Am 87* : 116, 1994.

24. Nanda, N., Joshi, H., Subbarao, S.K., Yadav, R.S., Dua, V.K. and Sharma, V.P. *Anopheles fluviatilis* complex, host feeding pattern of species S, T and U. *J Am Mosq Control Assoc 12* : 147, 1996.

25. *Epidemiology and Control of Malaria in India.* Eds. R.S., Sharma, G.K., Sharma, and G.P.S., Dhillon. Directorate of National Malaria Eradication Programme (DGHS), Government of India, New Delhi, 1996, p 1.

26. Satyanarayana, S., Sharma, S.K., Chelleng, P.K., Dutta, P., Dutta, L. and Yadav, R.N.S. Chloroquine resistant *P. falciparum* malaria in Arunachal Pradesh. *Indian J Malariol 28* : 137, 1991.

27. Dutta, P. and Bhattacharyya, D.R. Malaria survey in some parts of Namsang circle of Tirap district, Arunachal Pradesh. *J Commun Dis 22* : 92, 1990.

28. Mohapatra, P.K., Prakash, A., Borgohain, B.K. and Mahanta, J. Chloroquine resistance profile of *Plasmodium falciparum* in Assam, India. *Third National Seminar on Malaria and Other Tropical Diseases*, Bangalore (Abstract no. 68), 1997.

29. Barkakaty, B.N., Chakravorty, N.K. and Narasimham, M.V.V.L. Efficacy of sulfalene and pyremethamine combination drugs alone and with quinine in treatment of *P. falciparum* cases in chloroquine resistant areas of north-east India. *J Commun Dis 22* : 178, 1990.

30. Barkakaty, B.N. and Narasimham, M.V.V.L. Efficacy of a low dose oral quinine therapy in *Plasmodium falciparum* cases of Assam, Meghalaya and Arunachal Pradesh in India. *J Commun Dis 23* : 248, 1991.

31. Pattanaik, S., Sharma, V.P., Kalra, N.L., Orlov, V.S. and Sharma, R.S. Malaria paradigms in India and control strategies. *Indian J Malariol 31* : 141, 1994.

32. Kondrashin, A.V., Jung, R.K. and Akiyama, J. Ecological aspects of forest malaria in Southeast Asia. In : *Forest Malaria in Southeast Asia* (Proceedings of an informal consultative meeting). Eds. V.P. Sharma and A.V. Kondrashin. WHO/MRC, New Delhi, 1991, p 1.

33. Narasimham, M.V.V.L. Perspectives of forest malaria in India. In : *Forest Malaria in Southeast Asia* (Proceedings of an Informal Consultative Meeting). Eds. V.P. Sharma and A.V. Kondrashin. WHO/MRC, New Delhi, 1991, p 81.

34. Gillroy, A.B. Increasing malaria during an eradication programme : A study on the tea estates in Assam, 1964-68. *Trans Roy Soc Trop Med Hyg 64* : 551, 1970.

35. Dev, V. and Phookan, S. Malaria prevalence in tea estates of Brahmaputra valley of Assam, India. *J Parasitic dis 20* : 189, 1996.

36. Gogoi, S.C., Dev, V., Choudhury, B. and Phookan, S. Susceptibility of *Plasmodium falciparum* to chloroquine in tea garden tribes of Assam, India. *Southeast Asian J Trop Med Pub Health 26* : 228, 1995.

37. Janakara, B.R., Wajiullah, Shahi, B., Dev, V., Curtis, C.S. and Sharma, V.P. Deltamethrin impregnated bed nets against *An. minimus* transmitted malaria in Assam, India. *J Trop Med Hyg 98* : 73, 1995.

38. Mohapatra, P.K., Khan, A.M., Prakash, A., Mahanta, J. and Srivastava, V.K. Effect of α / β of arteether on uncomplicated falciparum malaria cases in upper Assam. *Indian J Med Res 104* : 284, 1996.

39. *Operational Manual for Malaria Action Programme (MAP), 1995.* Directorate of National Malaria Eradication Programme (DGHS). Government of India, New Delhi, 1995, p 1.

40. Kondrashin, A.V. and Trigg, P.I. Control of malaria in the world. *Indian J Malariol 34* : 92, 1997.

This article has been contributed by Dr. P.K. Mohapatra and Dr. Anil Prakash, Sr. Research Officers, Dr. D.R. Bhattacharyya, Research Officer and Dr. J. Mahanta, Director, Regional Medical Research Centre, Dibrugarh.

ICMR NEWS

Dr. N.K. Ganguly, formerly Professor and Head, Department of Experimental Medicine and Biotechnology, Postgraduate Institute of Medical Education and Research, Chandigarh, has taken charge as the Director-General of the Indian Council of Medical Research on March 12, 1998. Recipient of several national and international awards, Dr. Ganguly has contributed extensively in areas of microbiology, immunology, experimental medicine, biotechnology, *etc* with over 500 research/review articles to his credit in several national and international journals. He has been associated in various capacities with several reputed science and technology agencies.

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The following meetings of various technical groups/ committees of the Council were held at New Delhi :

Meetings of the Project Review Committee (PRC)/ Expert Groups (EGs) held :

PRC on Oncology, Pathology and Environmental Health	February 23, 1998
EG on Anti-tobacco Education	February 26, 1998
EG on Evaluation of Pregnancy Test Kits	March 9, 1998

Meetings of the Task Forces (TFs) held :

TF on Mobile Unit approach to meet reproductive and child health (RCH) needs of women	February 23-24, 1998
TF on involvement of Practitioners in Indian systems of medicine in the delivery of RCH services	February 26-27, 1998
TF on district nutrition project	March 9, 1998

Participation of ICMR Scientists in Scientific Events :

Dr. P.R. Narayanan, Director, Tuberculosis Research Centre, Chennai, participated in a conference on Global Disease Elimination and Eradication as Public Health Strategies at Atlanta (February 23-25, 1998).

Dr. Padam Singh, Director, Institute for Research in Medical Statistics, New Delhi, participated in the XXXI session of the UN Commission on Population and Development at New York (February 23-27, 1998).

Dr. U. Sengupta, Director and Dr. B.K. Giridhar, Dy. Director (Sr. Grade), Central JALMA Institute for Leprosy, Agra, participated in a WHO meeting on the Future Role of Leprosy Training and/or Research Institutions at Addis Ababa (February 25-26, 1998).

Dr. H.N. Saiyed, Director, National Institute of Occupational Health, Ahmedabad, participated in the WHO regional consultation on Promotion of National Chemical Safety at Bangkok (March 4-6, 1998).

ICMR AIDED SYMPOSIA/SEMINARS/WORKSHOPS/COURSES/CONFERENCES

Symposium/Seminar/Workshop/ Course/Conference	Date & Place	Contact Address
National Workshop on Strategies for Sustainable Rural Development	March 26-27, 1998; (at Madurai)	Dr. Samuel Paul Raj, Head and Coordinator, School of Energy, Environment and Natural Resources, Madurai Kamraj University, Madurai-625021.
National Symposium on Affective Disorders : The Indian Scene	March 28-29, 1998; (at Chandigarh)	Dr. Ajit Avasthi, Organising Secretary of the Symposium, Department of Psychiatry, Postgraduate Institute of Medical Education & Research, Chandigarh-160012.
Seminar on Women in the Age of HIV/AIDS	April 22-25, 1998; (at Thiruvananthapuram)	Dr. Sabu Philip, Director, Institute for Interdisciplinary Research and Training, Thiruvananthapuram-695011.

COUNCIL'S TRAINING PROGRAMMES FOR 1998-99

Leprosy

At the Central JALMA Institute for Leprosy, Agra:

- Multidrug Therapy Orientation Course in Leprosy for Medical Officers (April 6-17, August 17-28, October 26-November 6; and December 7-18, 1998).

Virology

At the National Institute of Virology, Pune:

- Diploma in Medical Virology (July 1998-May 1999).

Reproductive Biology

At the Institute for Research in Reproduction, Mumbai:

- Workshop on Andrology for Clinicians (November 16-30, 1998)

Endocrinology

At the National Institute of Nutrition, Hyderabad:

- Annual Certificate Course on Endocrinological Techniques and their Applications (August 1-September 15, 1998).

Nutrition

At the National Institute of Nutrition, Hyderabad:

- M.Sc. in Applied Nutrition (June 1, 1998-February 28, 1999).
- Postgraduate Certificate Course in Nutrition (December 1, 1998-February 28, 1999).

Laboratory Animal Technology

At the National Centre for Laboratory Animal Science, National Institute of Nutrition, Hyderabad:

- Training Course for Laboratory Animal Technicians (June 16-July 31, 1998).

Occupational Health

At the National Institute of Occupational Health, Ahmedabad:

- Training Course on Environmental Hygiene Practice (November 16-20, 1998).

Biomedical Statistics

At the Institute for Research in Medical Statistics, Chennai:

- Basic Course in Statistics for Postgraduate Medical Students (July 1998).
- Basic Course in Statistics for Medical Officers (November 1998).

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