EPIDEMIOLOGY

Malaria Clinics

At MRC, 2 Nanak Enclave: A total of 1993 patients attended the malaria clinic located at 2, Nanak Enclave during January to December, of which 70 were found positive for malaria. Among these, 58 were positive for *P. vivax*. Age-wise distribution of *P. vivax* cases is as follows: 1–4 yrs – 1; 4–9 yrs – 1; 9–14 yrs – 5; and >14 yrs – 51, while 12 *P. falciparum* cases were in the following age groups, 4–9 yrs – 1; 9–14 yrs – 1; and >14 yrs – 10. Slide positivity rate (SPR) for the year varied between 0.79 and 5.56 in different months with an average SPR of 3.51. Case history of *P. falciparum* cases revealed that majority were imported in nature, majority of these patients were natives of Jharkhand and Bihar who visited their relatives in Delhi for seeking employment. The month-wise distribution of these cases are given in Table 7.

Table 7. Data from Malaria Clinic, MRC, Nanak Enclave, Delhi

Month	BSE	Total (+)ve	*Pv*	*Pf*	SPR	SfR
Jan	72	4	3	1	5.56	1.39
Feb	91	1	0	1	1.1	1.1
Mar	145	2	2	0	1.38	0
Apr	127	1	1	0	0.79	0
May	108	8	8	0	7.41	0
Jun	98	5	5	0	5.1	0
Jul	408	17	11	6	4.17	1.47
Aug	271	9	7	2	3.32	0.74
Sep	196	7	7	0	3.57	0
Oct	221	11	10	1	4.97	0.45
Nov	147	2	2	0	1.36	0
Dec	108	3	2	1	1.85	0
Total	1993	70	58	12	3.51	0.6

From the clinic, blood samples were collected from volunteers for the following:

Parasite Bank: Eighteen *P. vivax* blood isolates were deposited at the parasite bank for further studies.

Host-parasite interaction : Forty blood isolates of *P. vivax* and four blood isolates of *P. falciparum* were used for artificial feeding experiments. Among these the

mosquitoes fed on 28 *P. vivax* blood isolates were found positive for both gut and gland infections, while mosquito infectivity could not be obtained when fed on any of *P. falciparum* isolates.

Genetic diversity: Twenty-three *P. vivax* blood isolates were used for MSP3α and duffy binding protein diversity studies.

At MRC, 22 Sham Nath Marg: A total of 210 patients or referred cases from hospitals attended the malaria clinic for blood examination and treatment of malaria during January to December. Out of 38 patients found positive for malaria, 20 were diagnosed as *P. vivax* and 18 as *P. falciparum* cases.

Clinical Studies on Malaria

A study was undertaken with the objective of studying the clinical profile in malaria and to study the level of drug resistance *in vivo* in view of increasing resistant strains of *P. falciparum* and *P. vivax*. Patients with proven infection with *P. falciparum* and *P. vivax* willing to attend the clinic for 28 days follow-up were included in the study (34 *Pv* + 4 *Pf*). Thirteen per cent of them were children. The parasite density ranged from 160 to 52,800 and 400 to 88,320 among 34 *P. vivax* and 4 *P. falciparum* patients, respectively. History of travel to endemic areas (Bihar and U.P.) was found in 50% of the cases. Fever and headache were the main presenting symptoms. All patients were treated with chloroquine dosage and 28 days follow-up was done to assess the drug response. All the 34 *P. vivax* patients had parasite clearance by two days and did not report with recrudescence. Out of 4 *P. falciparum* patients, 3 had adequate clinical response, and one had late treatment failure.

Tolerability and Efficacy of Artesunate plus Chloroquine or Sulphapyrimethamine Combinations vs Single Agent Chloroquine or Sulphapyrimethamine for the Treatment of Uncomplicated *P. falciparum* Malaria

Combination therapy is based on the synergistic or additive potential of two or more blood schizontocidal drugs with independent modes of action and different biochemical targets in the parasite. The objective of combining antimalarial drugs is to improve efficacy and delay the development and subsequent selection of drug resistant parasites, thus prolonging the useful therapeutic life of drugs in the combination. The advantages of artemisinin-based combination therapy (ACT) relate to the unique properties and mode of action of the artemisinin component, which include rapid reduction of the parasite biomass, rapid resolution of clinical symptoms, effective action against multidrug-resistant *P. falciparum* and reduction of gametocyte carriage rates (which may reduce transmission of resistant alleles specially in the areas with low or moderate malaria transmission). Therefore, studies have been planned to evaluate the role of combination therapy in malaria in Indian scenario.

A study was conducted on microscopically confirmed patients of uncomplicated *P. falciparum* malaria in Mandla, Madhya Pradesh, where resistance to first/second line drugs has been reported. Subjects fulfilling inclusion criteria were enrolled. Safety and tolerability of combination therapy was first established in 12 patients by recording detailed physical, haematological and biochemical parameters before and after the treatment. Subsequently, the patients were enrolled randomly by open design in different treatment groups (monotherapy or combination therapy). Clinical and parasitological parameters were evaluated during 28 day follow-up period. The number of adult patients enrolled and treatment given up to December 2001 are given in Table 8.

Table 8. Number of adult patients enrolled and treated

Group	No. of patients	Drug	Dose (mg)	Treatment schedule
A1	10	Sulphapyrimethamine	1500+75	Day 0
A2	16	Sulphapyrimethamine +	1500+75 +	Day 0
		Artesunate	100 (twice a day)	Day 0, 1 and 2
B1	10	Chloroquine	600+600+300	Day 0, 1 and 2
B2	10	Chloroquine +	600+600+300+	Day 0, 1 and 2
		Artesunate	100 (twice a day)	Day 0, 1 and 2

None of the patients had early parasitological or clinical failure. No major adverse effects were observed in any of the groups. The follow-up and analysis of results is in progress.

Role of Asymptomatic Carriers in the Transmission of Malaria

Parasitological surveys for the detection of asymptomatic carriers of malaria were conducted in District Sundergarh of Orissa. Surveys were carried out in March, June and September 2001. Asymptomatic carriers constituted 40-50% of the total examined in different study areas. Gametocyte density was more in symptomatic cases as compared to that of in asymptomatic carriers. Blood samples drawn from asymptomatic gametocyte carriers were fed to *An. stephensi* in different batches. Two out of 20 samples from asymptomatic carriers showed development of malaria parasites in the vector. On the other hand out of 11samples from symptomatic cases, three showed development of parasites in the mosquitoes. The results showed that the role of asymptomatic gametocyte carriers has to be established in the transmission of malaria. There is an urgent need to develop a test which is simple and could screen large number of samples within a short time. Hence, a peptide for detection of gametocyte antibodies has been prepared and is in the process of standardization.

Spatio-temporal Dynamics of Malaria in Mewat (Funded under ICMR Task Force Project on GIS and RS)

Ground verification with respect to classification of Landsat satellite image of August 1998 was done in the month of August and it was found that the areas falling in Class Bare 1 were highly water-logged during this year also and the malaria incidence and mosquito nuisance in these areas were very high (Fig. 14).

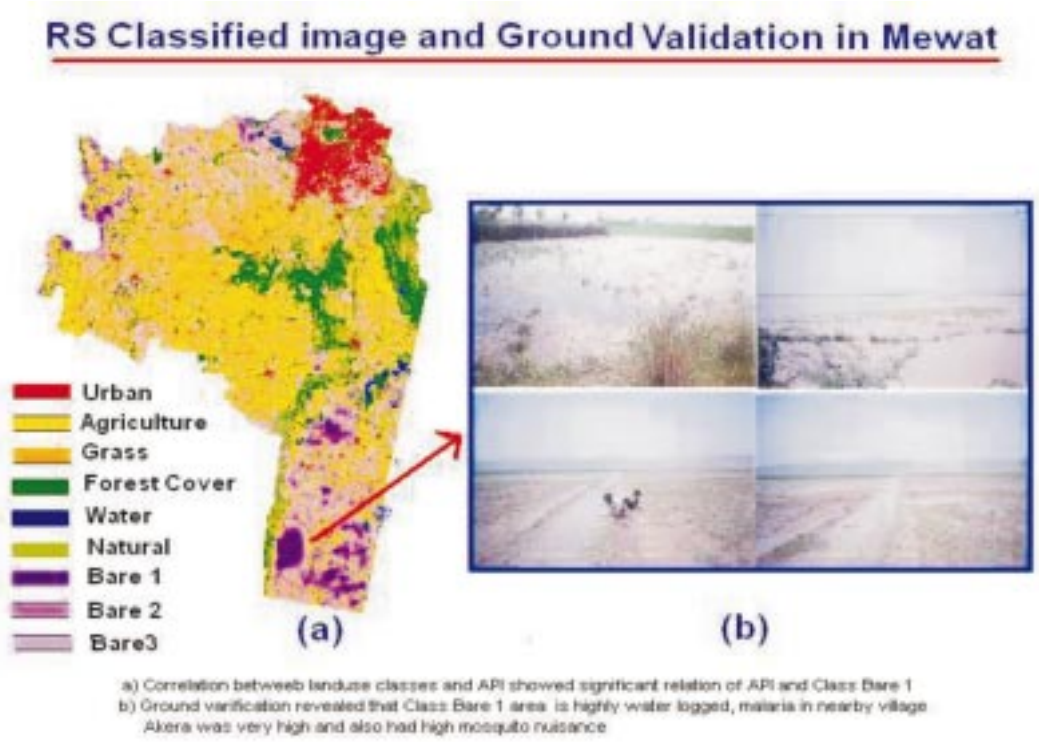


Fig. 14: Ground validation revealed that Class Bare 1 areas are highly water-logged, malaria incidence and mosquito nuisance is very high in nearby villages

A 3D model of Mewat was developed using spot heights and slope map generated by Haryana Remote Sensing Application Centre (HARSAC), Hissar (Fig. 15). Broadly, the area comprised of Nuh, Nagina and Punhana blocks is sandwiched in two ranges of hills. Road network and the village boundaries were draped to identify route for ground verification. The topological features developed by GIS were found to be correct.

Draping of natural drainage network on 3D model and estimation of drainage density could identify the areas potential for water-logging. Drainage density showed a negative correlation with section-wise average API, which shows that the villages where drainage density is high, malaria is low (Fig. 16). Southern and western parts of Mewat area has a slope towards Kotla lake. In addition, the area is drained by Landoha, Ujjina, Nuh and Kotla drains. These drains fill the Ujjina natural depression

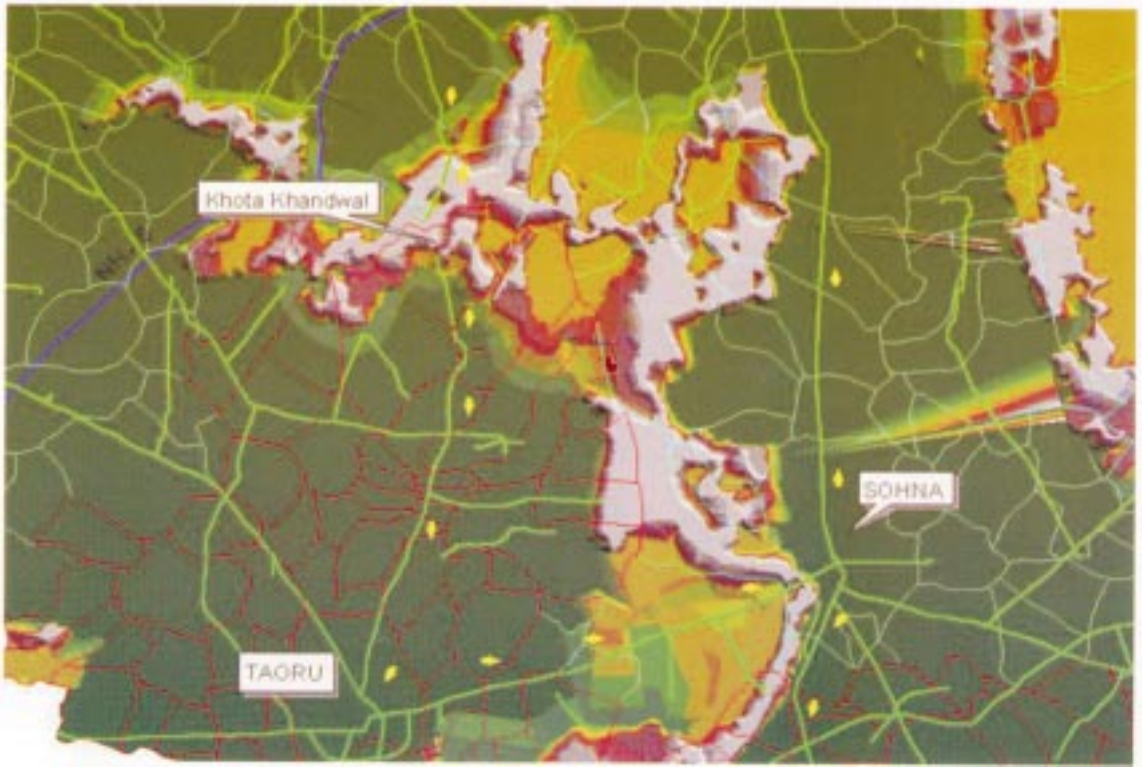


Fig. 15: A 3D model developed using contours and spot heights shows undulations in Mewat region

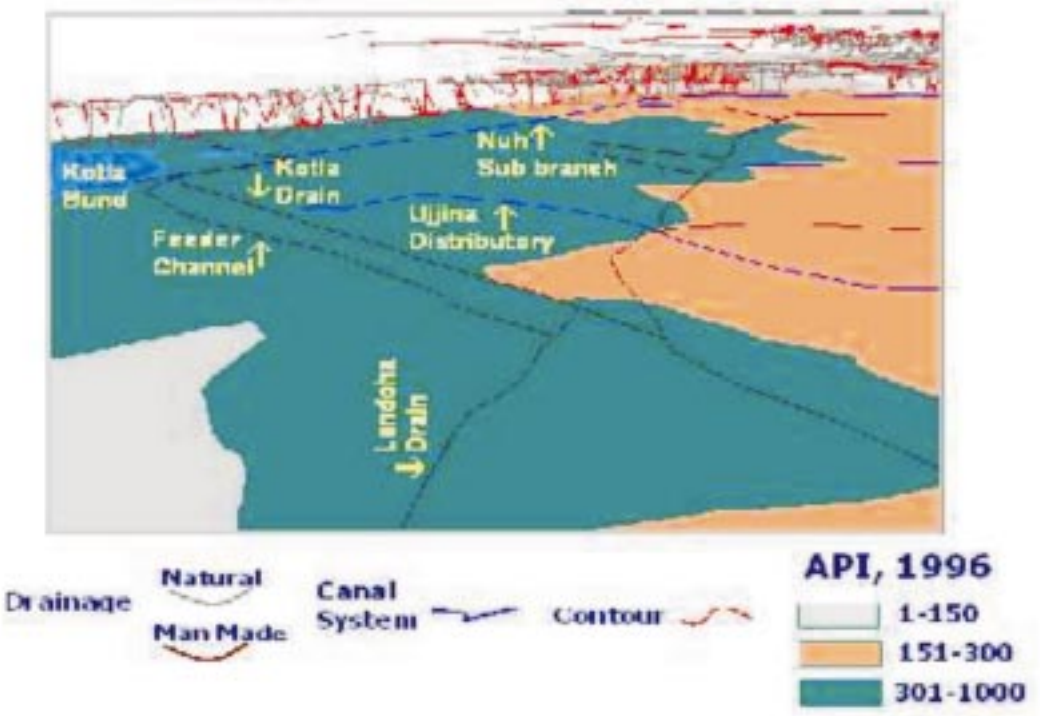


Fig. 16: Drainage and canal system draped on contours of Mewat shows malaria incidence is low in northern area where the drainage density is high

turned lake. Flow direction and water accumulation points were mapped using hydrological modelling features of GIS software. Overlying settlement map of Mewat region showed villages in low-lying areas. Canal network map was also prepared which showed that the part of Mewat region is covered with a network of surface irrigation through network of distributories/ minors originating from Gurgaon canal. Geographical reconnaisance (GR) revealed that extensive seepages originating from distributories etc. find their way to the Kotla lake but before entering, these raise the sub-soil water within 3 m, as a result most of the Mewat region is water-logged.

On the basis of ecological features five malaria paradigms have been identified in Mewat—mining, irrigation command area, flood prone area, catchment area (Kotla and Ujjina lake and surrounding area) and urban area. Villages falling in each paradigm have been identified. Section-wise malaria data for each paradigm have been extracted. Sections with persistent high malaria were identified. The paradigm maps will help in identifying risk factors.

GIS-based Malaria Information Management System for Urban Malaria Scheme in India

GIS based malaria information management system developed for Dindigul town, District Dindigul, Tamil Nadu was updated to cater the ubiquitous needs of Urban Malaria Scheme in India. The system can help in: (i) identifying high receptive areas in time and space domain; (ii) identifying risk factors for high receptivity; and (iii) monitoring and evaluating control measures.

Four proformae for recording information on different epidemiological and entomological parameters (to be used) were developed to update GIS database. This was done in consultation with state and district health officers. The Proforma 1 is for collection of information on key containers, positive breeding sites, larval density, etc. in each street for each habitat. Adult density may be recorded in the Proforma 2, antilarval activities in the Proforma 3. The Proforma 4 is for recording parasitological information. The basic objective was to develop the model to assist planning and implementation of a suitable control measure.

Delineation of Breeding Habitats and Landscape Features Suitable for *An. culicifacies* Abundance in Tumkur district, Karnataka Using Satellite Data (Funded under ICMR Task Force Project on GIS and RS)

In continuation of entomological and landscape ecological data collected and reported earlier in July 2000, entomological data on adult *An. culicifacies* density; prevalence and larval density in breeding habitats in 30 villages (10 each in high, moderate and non-malarious areas) were collected in January 2001 (non-transmission season of

malaria) and in May 2001 (peak season of malaria). Satellite data (IRS LISS III and PAN data) of respective areas in respect of April 2000 (data of July was not available) and December 2000 were analyzed for delineation of breeding habitats, land use features and correlation of land use features with mosquito density. A buffer zone of 1.5 km radius around each village was created and supervised classification of land use features was done. Vegetaion index in entire Tumkur district for April 2000 period was also generated.

It was found that with IRS PAN data, delineation of streams, ponds and tanks was possible but irrigation wells particularly covered under canopy of coconut plantation were not identifiable. Landuse features of three categories of PHCs were compared vis-a-vis breeding potential and man hour density of *An. culicifacies.* The preliminary findings indicate that coconut/arecanut plantation, agricultural land, type and extent of water bodies, less barren area are some of the landscape features supporting *An. culicifacies* abundance in high malarious area.

Meteorological Variables and Malaria: An Analysis for Developing Model of Malaria Transmission (A Project on 'Impact of Climate Change on Human Health— Malaria and Dengue' co-sponsored by Govt. of India and U.K. w.e.f. 1.9.2001 at National Physical Laboratory, New Delhi. MRC is also a participating institute)

In continuation of earlier work in respect of Surat district, Banaskantha (Gujarat) and Bikaner district (Rajasthan) were selected in consultation with NAMP for analysis of meteorological parameters and incidence of malaria from predictive value point of view. Based on optimum conditions required for transmission (Temp. 24ºC and RH 55%) the threshold time of transmission was determined. Month-wise time series analysis of data on temperature, rainfall, *P. vivax* and *P. falciparum* cases for a period of seven years including the period of outbreak of malaria was done. It was found that in Banaskantha district from 1985 to 1987 (drought years), *P. falciparum* cases were only 131 in 1987, while in high rainfall years, .i.e. 1988 –1991, there was an increase in *P. falciparum* cases reaching up to 23201 in 1990 (Figs. 17). The impact of rainfall on malaria incidence was also analysed for Bikaner and Surat districts (Fig. 18). In order to see the impact of rainfall at the threshold of transmission period in a particular year, it was found that high (unusual) rainfall at the beginning of transmission season may be helpful in prediction of malaria in ensuing month.

Testing of Coded Serological Samples for Analysis and Stratification of Three Sites

A total of 760 samples were collected from three different sites of the country during February. The samples were coded and subjected to analysis.

Fig.17: **Impact of meteorological data on incidence of malaria in Banaskantha**

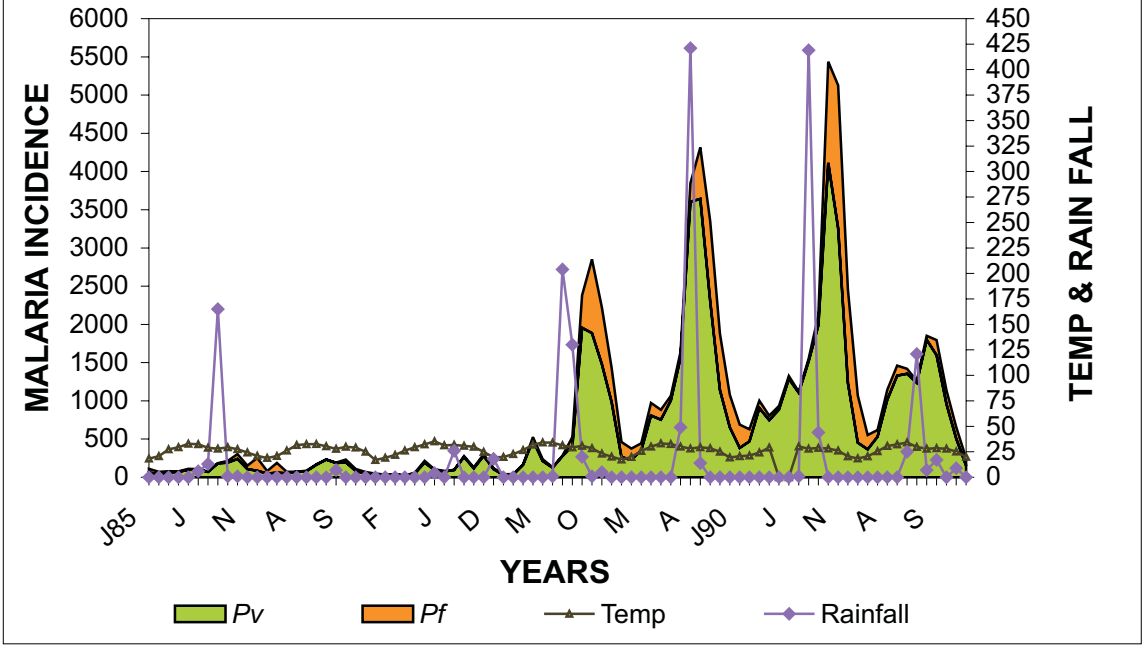
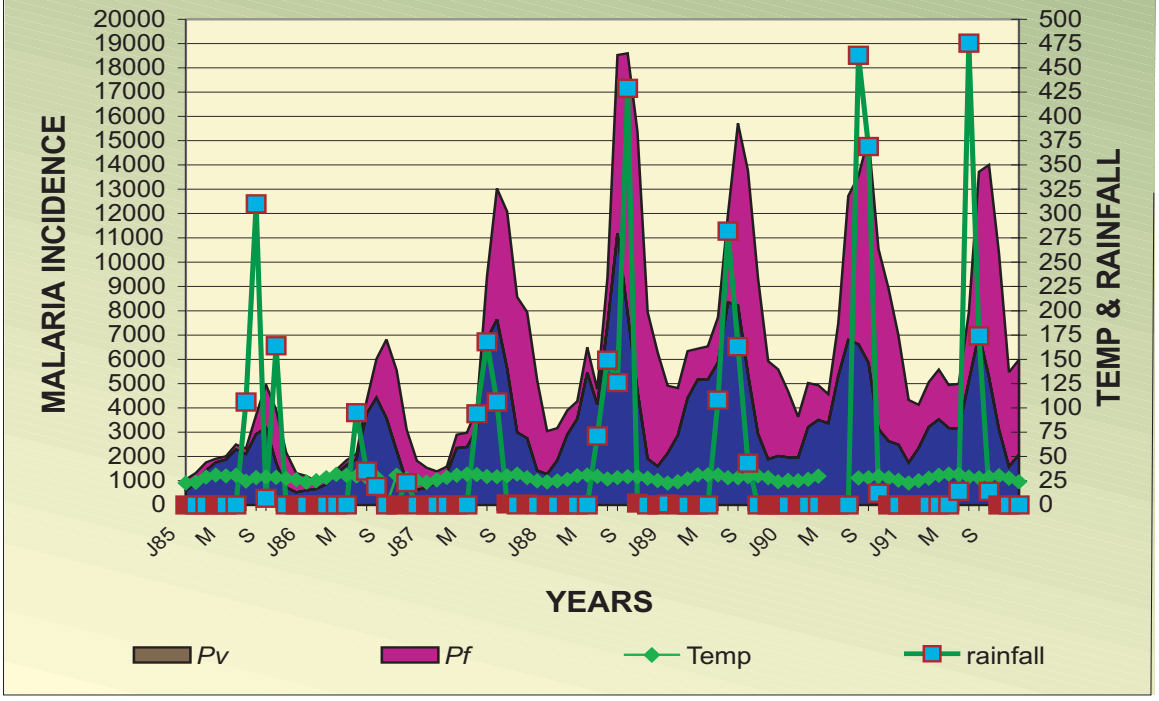


Fig.18 **: Impact of meteorological data on incidence of malaria in Surat**



Site A comprised of three villages in District Shahjahanpur where 306 finger prick blood samples were collected from these villages and no malaria positive case was recorded at the time of sample collection. PHC data from 1997 to 2000 indicated low or no transmission. The samples were divided into three age groups as shown in Table 9. ELISA O.D. obtained from AR1 peptide ELISA were taken into consideration.

Table 9. Analysis of blind samples

Area	Malaria status	Mean O.D.±S.D.		
		1–4 yrs	5–14 yrs	>15 yrs
Site A	Medium	0.47 ± 0.25 (17)	0.45 ± 0.27 (105)	0.37 ± 0.27 (153)
Site B	High	0.85 ± 0.36 (44)	0.86 ± 0.35 (106)	0.83 ± 0.32 (161)
Site C	Low	0.17 ± 0.07 (8)	0.27 ± 0.19 (60)	0.28 ± 0.16 (71)

Figures in parentheses indicate number of samples tested.

Site B comprised Rourkela area which had a history of high malaria transmission as reflected from the PHC data. ELISA O.D. of all the age groups from all study villages indicated high malaria incidence. From six villages of Kuarmunda PHC, 299 samples were collected, including 49 from malaria positive cases. API during the year 2000 in these villages was high and ranged from 23.2–105.4. ELISA O.D. confirmed the parasitological data that malaria transmission is high in this site.

Site C comprised of one village named 'Purum' of Kamasamudram PHC, Kolar district, near Bangalore, and 139 samples were collected. None was found pos-itive for malaria parasite. PHC data for the past three years showed 'zero' API indicating no malaria transmission. ELISA O.D. were less than 0.3 confirming a low transmission.

To confirm serological data with equivalent transmission index (ETI), a micro-software programme has been developed. ETI has been derived from known ELISA O.D. and known reliable API by the formula 270.55 x AR1 ELISA O.D.+7.4 (Table 10).

These three sites were stratified serologically using AR1 ELISA O.D. and ETI values according to which site C had the lowest transmission, site B had the highest and site A had moderate transmission. There is a great need of an alternative surveillance system which can determine low or non-endemic areas since low transmission is difficult to assess microscopically which is simple to determine by serology.

Table 10. Coded blind samples for serological tests

Code No.	Sample size	Mean O.D.±S.D.		API (2000)	ETI
		R1	*Pf*		
R	45	1.2 ±0.273	0.81 ± 0.28	74	334.76
BR	50	0.727 ±0.604	0.77 ± 0.59	48.5	204.08
KB	48	0.76 ± 0.13	0.90 ± 0.14	23.2	213.01
KJ	38	1.0 ± 0.25	1.2 ±0.208	77.5	277.95
RK	65	0.83 ± 0.14	0.76 ± 0.11	28.1	231.95
KG	53	0.85 ± 0.18	0.79 ± 0.14	105.4	237.36
C	104	0.54 ± 0.20	0.49 ± 0.13	0	153.50
PR	139	0.26 ± 0.12	0.24 ± 0.10	0	80.44

Code C: Site A (Shahjahanpur area); Codes R, BR, KB, KJ, RK, KG: Site B (Rourkela area); Code PR: Site C (Bangalore area).

Development of a Field Site for Malaria Vaccine Trial (A Collaborative Project with International Centre for Genetic Engineering and Biotechnology, New Delhi— Funded by Department of Biotechnology, Govt. of India)

There are 13 study villages with a total population of 4,221 under Gurundia and Birkera PHCs of Sundergarh district, out of which eight villages with a population of 2,058 are located in deep forests and five villages with a total population of 2,163 are located in a plain area. The study villages are predominantly inhabited by ethnic tribals — Oram, Munda and Khadia etc.

Parasitological Surveys

The longitudinal and cross-sectional parasitological surveys were conducted in all the study villages. The SPR, SfR, *Pf* per cent and annual parasite incidence (API) in the forest villages were 38.1, 30.8, 80.9 and 323.1 respectively, whereas in the plain area villages these were 20.7,13.4, 64.5 and 43.0 respectively. The malaria incidence was more in the younger age groups up to 15 years and the highest incidence was in the 0–5 years age group in the forest area but in the plain area no malaria case was found in the 0–5 years age group and the malaria cases were evenly distributed among the age groups of 5–10, 10–15 and >15 years.

Out of the total malaria cases in the forest area, the prevalence of *P. falaciparum*, *P. vivax and P. malariae* accounted for 82, 16 and 2 per cent respectively but in the plain area, the prevalence of *Pf* and *Pv* were 68 and 32 per cent respectively. The spleen rate in children living in the forest area villages was above 75 per cent throughout the year and in adults it was above 40% whereas, in the plain area the spleen rate in children and adults ranged from 40–82 and 9–14% respectively.

Entomological Surveys

An. culicifacies was widely prevalent in both the areas, whereas *An. fluviatilis* was not found in the plain area. Results of all night mosquito landing collections on human baits showed that *An. fluviatilis* preferred to bite humans and the man landing rate in the forest area was 13.5 bites per person per night. The man landing rate of *An. culicifacies* in the forest and plain areas was 0.3 and 0.5 bites per person per night respectively. The sporozoite rate of *An. culicifacies* and *An. fluviatilis* was found to be 0.70 and 2.82 respectively and entomological inoculation rate (EIR) for these species was calculated as 0.002 and 0.38 infective bites per person per night in the forest area villages, whereas, it was nil in the plain area.

Multiplicity of Infection

Multiplicity of infection is an important marker to get information about the intensity of malaria transmission as well as development of host-immune responses. Forty-nine field collected blood spots from *P. falciparum* positive patients from forested villages were genotyped using MSP 1 (block 2) and MSP 2 (central variable region) by PCR asay. Primers used were gene specific in primary PCR and family specific in the nested PCR condition. Multiplicity of infection among isolates ranged from 1.1 to 3.28. Number of alleles observed were 22 in MSP 1 and 24 in MSP 2. A high proportion of isolates (65–100%) had multiple infectivity with different genotypes of MSP 1 and MSP 2.

Sequence Diversity

The sequence diversity in three malaria vaccine candidates namely MSP 1_{19} (C- terminal 19KD fragment of MSP 1) EBA 175-RII and TRAP was determined in *P. falciparum* isolates collected from forested villages.

Primers were designed covering part of block 16 and entire block 17 of MSP 1 complete N-terminal portion of TRAP and for EBA-175 region F2. Sequencing of 10 field isolates for MSP 1 has shown polymorphism only at 5 amino acid positions. Out of which four were reported earlier by other workers. Rest of the sequence was conserved in all the 10 field isolates. Sequencing of TRAP N- terminal region in field isolates showed polymorphism at 25 sites, and three were reported for the first time.

Sequencing of EBA-F2 region in 16 field isolates has shown polymorphism at 19 amino acid positions. Only five of these polymorphisms were reported between different strains. Study further revealed that a few selected amino acids are targeted for change. This selection may be to maintain non-synonymous polymorphism in EBA region II, thus not affecting the functional aspects. However, important motifs are found to be conserved in all the three vaccine candidates studied.

Immunological Profile

Immunological studies were carried out to study antibody profiles for three antigens (MSP 1, EBA-175 and TRAP). The antibody levels were higher in individuals from forest areas than those residing in the plain area. However, age-wise increase in antibody level was observed both in forest and plain areas.

GIS Database: Village boundaries of plain area villages Balupatra, Chikatmati, Sarala, Mahaliapalli and Mallikpalli were digitized showing landscape features such as highways, village roads, walk ways, rivers, canals, branch canals, water bodies, houses, schools, shops, club, churches, industries, open space, rice fields, etc.

Data Architecture: A three tier GIS database has been generated. First level, village-wise data, which include census information and malaria data. Second is house-wise data, where data of individual house pertaining to house number, number of rooms in the house, type of house – kuchcha or pucca/human dwelling or mixed dwelling, name of the head man, number of persons in the house, their names, age, sex, religion, tribe, income, etc., number of animals in the house and malaria history. Houses have been depicted by square blocks on the village boundary. Third level is 'Personal' level data, person's name, age, sex, marital status, education level, occupation, malaria history up to four malaria episodes have been included. Persons in the houses have been shown by dots. Number of dots in a house (shown by boxes) show number of persons (Fig. 19).

Fig. 19: GIS-based information system consisting of three tier information on village, house and personal level

Out of five plain area villages house-wise data of three villages have been obtained and put in the GIS database. In forest villages data, there were some discrepancies, that are being sorted out.

Functionality of the System

(1) Information of any village/house or person can be retrieved at the click of the mouse within village boundary/ house/ dots respectively on the map.

(2) Using zoom-in facility one can blow up houses and can see number of persons, by assigning different colour to positive and negative cases both for houses or persons, one can see the house-wise malaria spread or in houses how many persons are sick to evaluate the disease scenario (Fig. 19).

(3) Buffer zones can be created around major breeding sites to see the impact.

(4) Malaria epidemiology can be studied both in space and time where change in malaria situation in any village can be correlated to any specific breeding site or the activity in that area to take situation specific control measure.

(5) Per cent composition of any parameter can be easily mapped to review the situation. For example, if one needs to know the per cent parasite composition—*Pv* and *Pf*, instantly situation of the entire area/houses can be known.

Depending upon the requirement database can be tailor-made and so the analysis algorithm to achieve the desired result.

Evidence-based Situation Analysis of Malaria in five Pilot Districts Under Roll Back Malaria (RBM) Initiative [Funded from WHO Country Budget for Biennium 2000-2001]

State of Goa

The population of Goa State is 1.2 million distributed in an area of 3702 km^2. It is divided into two districts (north Goa and south Goa), which are subdivided into eleven tehsils and its capital is Panaji. For malaria control purposes whole Goa comprises of one district, 19 PHCs, 172 subcentres, 360 census villages, 32 malaria clinics. The average population of the PHC is 53,000 and that of sub-centre is 6,800. In urban areas, there are four urban health centres with attached four NFCP units. There are 30 and 90 government and private hospitals respectively, besides there are a large number of private practitioners.

The malaria control programme is an ongoing programme in the state and is being implemented as per the guidelines of the National Anti Malaria Programme (NAMP). Of the two districts, north district is problematic where urban health centre (UHC)

Panaji, PHCs Aldona, Candolim and Corlim are harbouring high malaria endemicity. Margaon is the only UHC in south district showing alarming increase of malaria incidence. Collection, analysis of the data and the maintenance of the information system are inadequate and village/locality-wise data are not available. Case detection is through PCD only. All fever cases are given presumptive treatment and radical treatment is provided to the confirmed malaria cases. Prevention practices include larviciding, use of fish in wells, source reduction, environmental management supported by legislative measures.

Though malaria is restricted to urban areas, urban malaria scheme (UMS) has not yet been implemented. National filaria control (NFC) unit established earlier is deployed for surveillance, GR and control activities without adequate guidelines, scientific and technical support. A post of District Malaria Officer is to be created in both the north and south districts. The municipal committees unlike in other parts of India do not have the responsibility to control the mosquitoes and mosquito-borne diseases. Building byelaws of Goa state are unique in the country but need to be enforced in an effective manner with strong political support. There are several technical, administrative and scientific posts which are vacant for several years resulting deployment of untrained staff and eventually failure of surveillance and preventive measures leading to periodic local and focal outbreaks of malaria associated with developmental activities.

Parasitological survey revealed that *Pf* is the predominant species. The slide positive rate (SPR) and slide falciparum rate (SfR) were 69.8 and 69.8 in ward no. 1 as against 5.4 and 2.7 in ward no. 12, respectively in Panaji City. Monitoring of chloroquine resistance revealed 22.2% early treatment failure (ETF) and 16.6% late treatment failure (LTF) of malaria cases.

Entomological survey revealed the presence of 13 anopheline species in the selected PHC and of these *An. stephensi* is the vector of malaria and breeds profusely in curing tanks at construction sites. The transmission is high at these sites among labourers who live within the construction complex. The man mosquito contact was 10 per bait per night with biting peak between 0100 and 0300 hours. Man hour density (MHD) of *An. stephensi* ranged from 8–10 in model construction site, Panaji. Larval susceptibility test revealed that the larvae of *An. stephensi* are still susceptible to baytex and abate, however, adult mosquitoes were resistant to DDT but susceptible to synthetic pyrethroids. *An. culicifacies* was not encountered in adequate number, therefore, susceptibility tests were not carried out.

Knowledge, aptitude, behaviour and practice (KABP) studies revealed that about 58% people are getting their blood smears examined at malaria clinic run by the Directorate of Health Services, while 46% preferred to get examined their blood smears in hospitals or diagnostic laboratories. Private practitioners are also willing

to participate in the programme provided that the basic facilities for collection of blood smears and results of blood examination are made available to them. Interactive workshops at central and peripheral level were organized for advocacy.

In Goa state, the Public Developmental Authority (PDA), Municipal Committee, University, Medical College, NGOs, Airport Authority of India, Port Authority of India were identified as potential partners under Roll back malaria (RBM) initiative.

District Tumkur, Karnataka

In continuation of earlier work on situation analysis of malaria, second field survey was conducted in the District Tumkur, during August–September 2001 and following field activities were undertaken.

Parasitological studies were carried out by conducting fever survey in six villages of Mathighatta PHC under Taluka C.N. Hally. The adjacent Taluka Hospital at Sira was also visited. Examination of blood smears revealed overall SPR as 24.44, ranging between 8.62 and 60. It may be pointed out that majority of malaria cases were of *P. falciparum* (*Pf* 92.31%), consisting mostly ring stages. Point prevalence study in a primary school revealed that a large number of students were infected with *P. falciparum* showing lack of typical clinical symptoms of malaria. Hence the existence of asymptomatic malaria cases can not be ruled out in this area.

The team visited two PHCs of Taluka C.N. Hally—C.N. Hally and Mathigatta, and PHC Sira (Taluka Sira). Blood smears collected from patients who reported at PHC hospital in the months of August and September 2001 were cross-checked for malaria parasites. It was observed that quality of blood smear and staining was very poor. Examination of blood smears revealed discrepancy in results particularly false negativity of *P. falciparum* cases by the PHC technicians. It was observed that technicians were capable of identifying *P. falciparum* gametocytes only, while ring stage of *P. falciparum* parasite were invariably missed. Out of 300 confirmed negative slides, 12 were found positive for *P. falciparum* rings only. Altogether *P. falciparum* rings were found to be missed in 23 slides. In order to find out the susceptibility status of *P. falciparum* against chloroquine, 7-day *in vivo* drug sensitivity test was conducted in 19 *P. falciparum* cases. The results of *in vivo* test suggested that chloroquine is highly effective and should be used as a first line of treatment.

It may be mentioned that majority of patients are invariably treated either with sulphadoxine-pyrimethamine combination or E-mal (α and β artether) as a first line of treatment, as evidenced by discussion with private medical practitioners, community, chemists and pharmacists. Various medical stores were visited to know the common antimalarial drugs availability, which revealed that antimalarials other than chloroquine were being used by the patients either by prescription of general

practitioners or by self-medication. The E-mal and ablaquine (chloroquine + bulaquine) were the most commonly used drugs available with medical stores.

Entomological survey was also carried out by conducting indoor resting collection of mosquitoes in few villages of PHCs Mathighatta, C.N. Hally and Dasudi. Six anopheline species—*An. culicifacies*, *An. fluviatilis*, *An. subpictus*, *An. annularis*, *An. pallidus* and *An. vagus* were encountered. Of these, *An. culicifacies* and *An. fluviatilis* are the established vectors of malaria.

Further 33 ovaries of *An. culicifacies* were collected to find out the sibling species composition. Out of twenty-five specimens that could be identified, 22 were species A and three were species B. Beside adult collection larval breeding survey was also conducted in limited mosquito breeding sites—tanks, ponds and wells. Majority of these water habitats were found to be positive for anopheline breeding. It was suggested that in all perennial water bodies larvivorous fishes should be introduced on priority basis.

Two workshops were organized to identify partners to be involved in malaria surveillance, early detection and prompt treatment (EDPT). One workshop was held at district headquarters, Tumkur on 3 September 2001, another at Taluka C.N. Hally of District Tumkur on 7 September 2001. Representatives of various non-government organizations, government and private sectors and community attended the workshops. The target sectors were Health Department, Non-government Voluntary Organizations (NGOs), Private Health Care Providers, Non-health Government Sectors, Education Departments and Community Representatives—MP, MLA, Village Panchayat Head, etc. The objectives of these workshops were to interact with different groups and to get their opinion for their active partnership in formulating malaria action plan.

Based on the findings of two field visits a final project report was prepared and handed over to the authorities of the National Anti Malaria Programme, State Health Department, WHO-SEARO, New Delhi and ICMR.

District Keonjhar, Orissa

The situation analysis of malaria in District Keonjhar, Orissa was carriedout through intensive surveys during September 2001. The studies revealed that all 13 PHCs are highly endemic for malaria. Factors like hilly forested terrain with predominantly tribal population, reservoirs of malaria parasites, presence of highly anthropophagic malaria vector, *An. fluviatilis* and highly inadequate indoor residual spray with DDT contribute for almost perennial transmission of *P. falciparum* malaria. Percentage of *P. falciparum* is consistently over 90% for the past several years with 10 to 30 deaths due to malaria but since last three years the number of malaria deaths had increased

to over 70 each year (108 in 2000). ABER is above 19% since last ten years. Slide positivity rate is above 10% since 1986. Highest API was recorded in 1991, 1992 and 1996 (about 47). Presumptive radical treatment (PRT) is being practiced. District Malaria Officer works under Chief District Medical Officer (CDMO). Most of the posts are filled up except AMO and MPHWs. The provision of adequate financial assistance through EMCP with World Bank assistance is existing. However, due to cumbersome procedure of release, adequate funds are not available in time to DMO.

Procurement and distribution of drugs and laboratory supplies are satisfactory but same is not true for insecticides. Required quantities of insecticides are not projected as per technical requirement due to inadequate operational cost. Problems have also been faced for warehousing of insecticide. Transport is not adequate. Supervisory and monitoring staff is required. Accessibility to remote villages is difficult resulting in poor surveillance and difficulty in referral of severe cases. There are a large number of private practitioners, but they do not follow the national drug policy. *In vivo* study of therapeutic efficacy of antimalarials in two PHCs revealed that *P. falciparum* is susceptible to chloroquine. *An. fluviatilis* species S was incriminated and found to be the principal vector of malaria. Susceptibility status of vectors is not being monitored regularly. Investigations revealed that *An. fluviatilis* is highly susceptible to DDT, malathion and deltamethrin. However, *An. culicifacies* was found to be resistant to DDT. Deltamethrin treated mosquito nets are being used in one PHC under EMCP.

KABP studies revealed the awareness about malaria transmission and its proper treatment was much less in tribal population as compared to non-tribals. Many of the tribals go to spiritual healers and use primitive traditional methods of personal protection. Tribal population are also reluctant to get their blood examined at the onset of fever and they do not get their houses sprayed with insecticide. They need to be given proper health education pertaining to the above mentioned points

Two workshops were conducted at district and PHC level. Interactions with officers belonging to health, non-health departments and NGOs revealed that there is ample scope of establishing partnerships and link with them to combat malaria under RBM initiative. The response from non-health departments, private sectors and other organizations was very encouraging and they offered their services in various malaria control activities to be undertaken under RBM initiative.

District Aizawl, Mizoram

A field visit was undertaken in Aizawl, Mizoram in September 2001 to collect evidence-based research data for situation of malaria in Aizawl (West), Mizoram.

Parasitological survey was carried out in seven villages of Kolasib, Sairang and Lengpui PHCs. In addition, blood slides were collected from OPD at Kolasib. Of

827 slides collected, only 19 were positive (8 *P. vivax* and 11 *P. falciparum*) giving SPR 2.29, SfR 1.3 and *Pf* % 57.8. Of 11 *Pf* cases only five could be followed for seven days *in vivo* chloroquine sensitivity test. Of five subjects four were found fully susceptible, while one case showed parasitaemia on Day 3 but it was cleared on Day 5.

Entomological surveys for prevalent breeding habitats of anopheline mosquitoes and adult mosquito density in houses were carried out in all seven villages. Collection of landing mosquitoes on human baits and light-trap collection outdoors for four nights was also undertaken. Light-trap collection and night bait collection did not yield any anopheline mosquitoes. Only *An. vagus* and *An. barbirostris* were collected from indoor resting sites. Two *An. dirus* mosquitoes emerged from the larvae collected from water collection in rock crevices. Rice fields and other water bodies yielded *An. vagus* and *An. barbirostris. An. minimus* was not encountered.

Health seeking behaviour of communitiy was also assessed through questionnaires in Rengtakawn, Meidum, Lengpui and Sairang villages. Preliminary findings indicate that community is well aware of the use of mosquito nets, they go to the health centres when fallen sick but do not comply to complete treatment.

In order to create awareness, sensitization of the different sectors and communities and to seek their participation in malaria control two workshops were organized—one at Aizawl (for district level) and another at Kolasib (for community level workers). The workshop at Aizawl was inaugurated by the Hon'ble Mininster of Health, Govt. of Mizoram and was attended by 23 participants including four NGOs and Medical Officers. District Commissioner, Aizawl agreed to coordinate different sectors for malaria control as per the need of local health department. The workshop at Kolasib was attended by 38 participants including, D.C., Medical Officers, YMA, MHIP, MUP, teachers, pastors, journalists, village council chiefs, etc. There has been headway in forming district (recently constituted) level committee of different sectors for malaria control.

District Jodhpur, Rajasthan

District Jodhpur in the western region of Rajasthan was one of the five pilot districts selected for implementation of RBM initiative. An initial survey was carried out in November 2000 to collect data/information on infrastructure of Health Care System, resources and retarding factors for effective malaria control. Later, a study was carried out in September 2001 to ascertain the factual validity of some key factors (mainly operational).

Out of 10 Community Health Centres (CHCs) in the district, two CHCs with high and low API were selected on the basis of last five years epidemiological data provided

by NAMP for evidence-based situation analysis. Further in each of the selected CHCs, two villages with low and high API were selected for the studies and to understand the health seeking behaviour of malaria patients and to study KABP among local community a survey was carried out in villages using a structured questionnaire. Data and information collected on different aspects pertaining to malaria control programme were analyzed and suitable suggestions were made.

Epidemiological data of the district for the past 10 years (1991–2000) revealed API in the range of 0.3–6.2, SPR 0.3–6.3 and *Pf* per cent 6–65, respectively. Of the total 512 subcentres in the nine CHC areas, high risk areas of the district were stratified based on API and *Pf* % data of three years (1997–1999). A total of 46 subcentres were having API between 2 and 5, 16 between 5 and 10 and 11 above 10. *P. falciparum* rate was above 30% in 42 subcentres.

For entomological studies seven villages were selected in two CHCs. Two malaria vectors, *An. stephensi* and *An. culicifacies* were prevalent in both CHCs. Density of adult *An. culicifacies* was maximum in stone quarry areas of CHC Banar. Anopheline breeding habitats (per cent positive) were also maximum in stone quarry areas. *An. stephensi*, the major vector of malaria was found breeding extensively in underground water storage tanks which can be made mosquito proof by simple engineering methods—wire mesh. In District Jodhpur selective indoor residual spray is being done with DDT. In the present survey, prevalent vector species namely *An. stephensi* and *An. culicifacies* were found resistant to DDT in two high risk PHCs, Banar and Fidusar.

Two advocacy workshops on intersectoral coordination among potential partners for control of malaria under RBM initiative were organized. Participants were invited from different sectors of Government, non-Government organizations and private sectors. Students and community leaders also participated in the district level workshops. A total of 40 participants attended the workshop. The participants were appraised of the concept of RBM initiative for malaria control. They were briefed about the objectives of RBM and their role as individuals and as a part of their organizations in the management of malaria through partnership.

The study revealed that most of the private medical practitioners do not follow radical treatment of malaria (with primaquine) to interrupt further transmission of malaria in the community. Therefore, NGOs involved in health activities, private medical practitioners, nursing homes and other health providers should be made aware of the national drug policy and treatment of malaria cases and specially of complicated cases. These agencies should be sensitized to extend cooperation to Government Health Services. Paramedical staff with these private agencies may also be given adequate technical training to support health system.

One of the main reasons for persistence of malaria in few areas could be due to inadequate surveillance and treatment mainly because of inaccessibility and tough

terrain. In such a situation, malaria patients visiting the nearby private practitioner (mostly quacks) are administered suppressive treatment by intramuscular injection of chloroquine (40–80 mg base) resulting in administration of subcurative doses.

From the KABP study done, it was observed that the people have fairly good knowledge about malaria, its treatment and control etc. People in general are aware of personal protectoin measures, but most of them are not actually using these methods due to economic reason or variation in the attitude. Therefore, is advisable to motivate the community through IEC activities.

Highlight of the Research Activities Carried Out by MRC Field Stations under the Integrated Vector Control of Malaria Project

Nadiad (Gujarat): Urban malaria projects in Surat and Ahmedabad were completed, and technology transferred. In collaboration with WHO, new insecticides are under field evaluation. Field evaluation of nets treated with bifenthrin and a new formulation of deltamethrin was undertaken. A study of epidemiological efficacy of malathion indoor residual spraying was initiated. Work on the health impact assessment of Sardar Sarovar project was initiated. Epidemic containment support in earthquake-affected areas was provided.

Jabalpur (Madhya Pradesh): Investigations on malaria outbreak in Betul district was carried out. Field work on clinical trial of chloroquine + azithromycin was completed. Paracheck diagnostic test kit was evaluated in the field. Tolerability and efficacy of artesunate + chloroquine or sulphapyremethamine combination vs. single agent chloroquine or sulphapyremethamine for uncomplicated falciparum malaria were evaluated. Study on anopheline ecology and malaria prevalence in villages near Bargi Dam was done. Follow-up investigation on malaria outbreak in the villages of Narayanganj PHC, Mandla was carried out. Evaluation of the impact of DDT indoor residual spraying was conducted in four villages of Chhindwara district.

Hardwar (Uttaranchal): Work on new antimalarial drug development (reaction product of sulphadoxine) was carried out. One of the compounds from a plant showed good antiparasitic activity against *Trypanosoma brucei brucei* (WHO results), besides having antimalarial activities. Concentrations of allethrin released by mats in air were found higher in room with air cooler than in those with open windows without cooler. Follow-up work of the impact of bioenvironmental control methods in industrial complexes was continued. Parasitological and entomological surveys were carried out in Laksar PHC of District Hardwar. A project on evaluation of the impact of malathion indoor residual spraying being used in malaria control was also completed.

Sonapur (Assam): Clinical trial of combination therapy of chloroquine + azithro-

mycin against *P. falciparum* was completed. Multidrug resistance study on *Pf* malaria in Sonapur was carried out.

Chennai (Tamil Nadu): Role of ecological variants of *Anopheles stephensi* in malaria transmission was studied. Association of rainwater harvesting devices and vector breeding was studied. Field evaluation of hilmilin, an insect growth regulator, against culicines was undertaken. Health education and training programmes were also undertaken. Malaria clinic was run for prompt diagnosis and early treatment.

Rourkela (Orissa): Longitudinal and cross-sectional parasitological and entomological studies were conducted to develop suitable sites for malaria vaccine trials. Epidemiological studies were conducted to understand the role of *An. culicifacies* and *An. fluviatilis* sibling species in malaria transmission dynamics and to characterize parasite population and immune response in a tribal population. Studies on host feeding preferences and susceptibility status of malaria vector species were carried out. Gametocytocidal efficacy of compound 80/53 in uncomplicated *P. falciparum* cases was evaluated. The prevalence of haemoglobinopathies in different tribal communities was studied.

Haldwani (Uttaranchal): Malariogenic stratification to identify malaria risk factors was carried out in two PHCs in Terai/Bhabar areas. Larvicidal evaluation of *Bacillus thuringiensis* var. *israelensis* was carried out.

Car Nicobar (A&N Islands): Epidemiological investigation of malaria in creek and non-creek areas was carried out. Malaria prevalence among Jarawas, a primitive tribe was studied.

Panaji (Goa): Three indigenous mosquito pathogenic *Bacilli* were isolated, characterized and tested. A malaria outbreak in Sanguem PHC was investigated. Ecology and bionomics of *An. stephensi* in urban ecosystem were studied. Rapid diagnostic kits were tested for NAMP. A field trial of *Bti* was carried out. Transfer of bioenvironmental control technology to Mormugao Port Authorities continued in contract research mode.

Bangalore (Karnataka): Bioenvironmental control strategy was extended in Mangalore city by intersectoral participation and NGO support. Follow-up of this strategy in Kolar and Hassan districts was carried out and the Govt. of Karnataka has drafted a plan to implement this strategy in the whole state. Work on development of mosquito control plan in Bangalore city has been started. An evidence-based malaria situation analysis in District Tumkur under RBM initiative was carried out. A study on the remote sensing for delineation of breeding habitats of *An. culicifacies* was also carried out. Evaluation of the impact of DDT indoor residual spraying was done in District Mandya.

Shahjahanpur (U.P.): Geographical reconnaissance of larval habitats in Shahjahanpur was continued. Field evaluation of the larvicidal efficacy of *Bti* was carried out.

Shankargarh (U.P.): Diagnostic and treatment services were continued through malaria clinic as a passive surveillance agency to monitor disease prevalence in the area.