Epidemiology and Clinical Studies

3.1 Remote Sensing and Geographic Information System

3.1.1 Regional level mapping of malaria vectors using RS and GIS in northeastern states in India to develop strategic plan for malaria control

IRS-P6 LISS-III sensor data of two districts of Assam namely, Nagaon and Sonitpur were procured from National Remote Sensing Agency (NRSA), Hyderabad. Landsat TM of 19 December 1999, 28 November 2000 and 15 November 2001 covering two districts were downloaded from EROS Data Centre USGS website for the purpose of registration. IRS-P LISS-III images were geo-referenced with the help of Landsat TM data. Base layer for Nagaon district created, showing district boundary, road, rail and major drainage network. Preliminary visual interpretation of water bodies, wetlands, built-up areas, forest classes have been done for Nagaon district. It is noticed that Sonitpur district is covered by three IRS-P6 LISS-III scenes, the present Sonitpur district is carved out of the erstwhile Darrang district, hence new approved boundary was obtained and digitised. Besides this, blockwise malaria data have been procured and put on the GIS platform along with other census information. The work is in progress.

3.1.2 Micro level mapping of malaria vectors using GIS in bordering districts of Assam and Arunachal Pradesh in India to assist malaria control

Twelve satellite scenes of IRS-1D LISS-III were acquired from two districts of Assam namely, Kamrup and Sonitpur. Raw images were radio-metrically corrected using dark pixel removal technique and noise removal. Well-identified ground control points were taken to rectify the satellite images to provide latitude and longitude information using raster-based geometric corrections, the satellite images were geo-coded using geo-referenced Landsat TM data. Sub-pixel image-to-image accuracy was achieved through repeated attempts. Different images were joined together to get one single false colour composite (FCC). Histogram matching was performed to correct the radiometric difference of the mosaic images. Area of interest extracted from mosaiced FCC scene is shown in (Fig. 1). Digital image processing of satellite data was done through different algorithms and mathematical indices for unsupervised classi-fication and the images were classified into 250 cluster classes. These clusters were grouped under

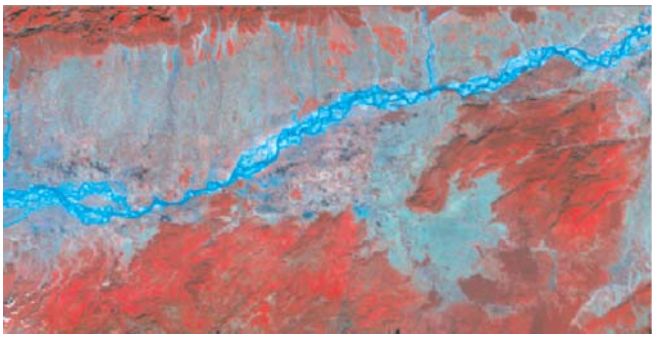


Fig. 1: **Mosaiced false colour composite**

different classes using visual interpretation of images. AOI generation of various classes for land cover classification namely, river, inland water bodies, tea gardens, vegetation, habitation, open land, etc. was done to get more accurate classified image. Normalised difference vegetation index (NDVI) technique was applied to further classify vegetation into different categories namely, dense forest, open forest, scrub land, grass, water bodies

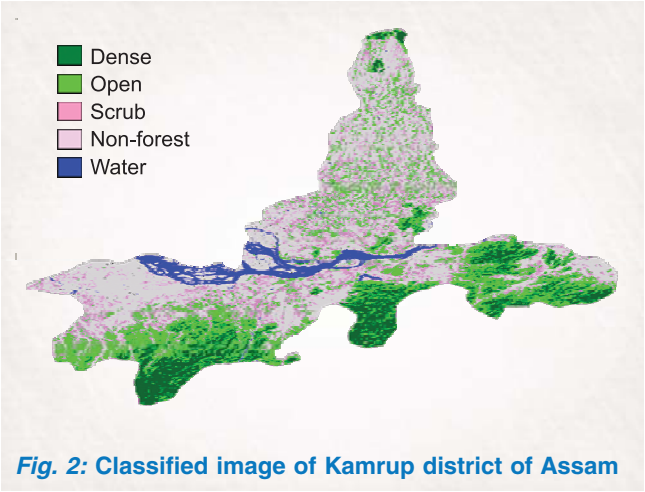


Fig. 2: **Classified image of Kamrup district of Assam**

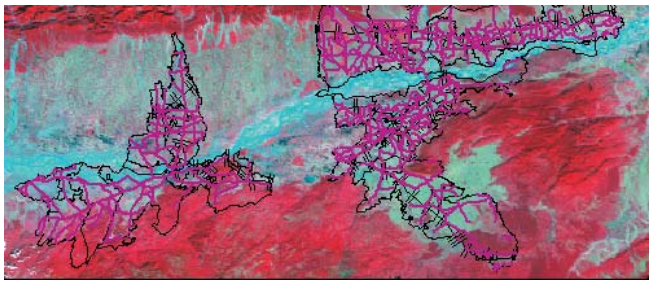


Fig. 3: **GIS layer's overlaid on satellite image**

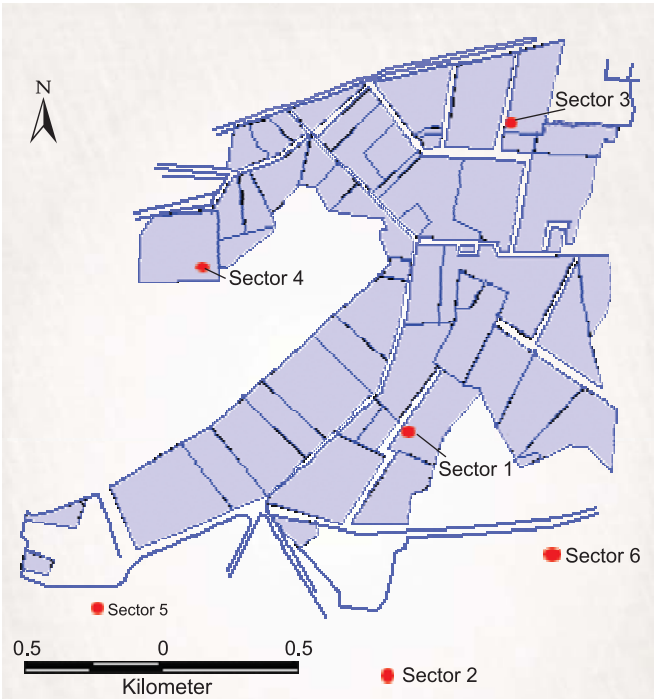


Fig. 4: **Showing different sectors of Jodhpur Cantonment area**

and non-forested areas (Fig. 2). Satellite images were again geometrically rectified with the shape file of the district coverage to get an exact overlay of GIS layers on the images (Fig. 3).

3.1.3 Application of GIS to map distribution of malaria vectors and to develop disease surveillance system in Jodhpur Cantonment area

The study was carried out in the cantonment area in Jodhpur district. This area has diversified population movements from all over India. Statewise contribution of the imported cases from different states, depicts highest contribution from Rajasthan followed by Madhya Pradesh and Uttar Pradesh states.

The area is divided into six sectors (Fig. 4). Indoor and outdoor density of adult mosquitoes was recorded from various GPS registered localities using manual aspirators (per man hour density) and CDC light-traps. Locations of major breeding sites and larval density of mosquitoes from different water bodies were recorded. Mosquitoes collected from each sector were identified into different species. The meteorological data (January 2004– December 2005), number of malaria cases among troops and family members reported in Army Hospital (July 2004 to March 2005), details of hygiene and chemicals used for mosquito control programme were analysed.

Malaria cases from the Army Cantonment Hospital for the past two years were taken into consideration in July 2004 and September 2005 showed highest number of malaria cases in respective years. It also shows the correlation between malaria cases and meteorological data. Relative humidity (RH) parameter was more correlated than any other parameters. When RH was high, malaria cases were more and with low RH, malaria cases were less.

The study on consumption of hygiene chemicals during 2004 and 2005 revealed highest consumption of Baytex 1000 Fenthion mainly during the months of July to August in both the years

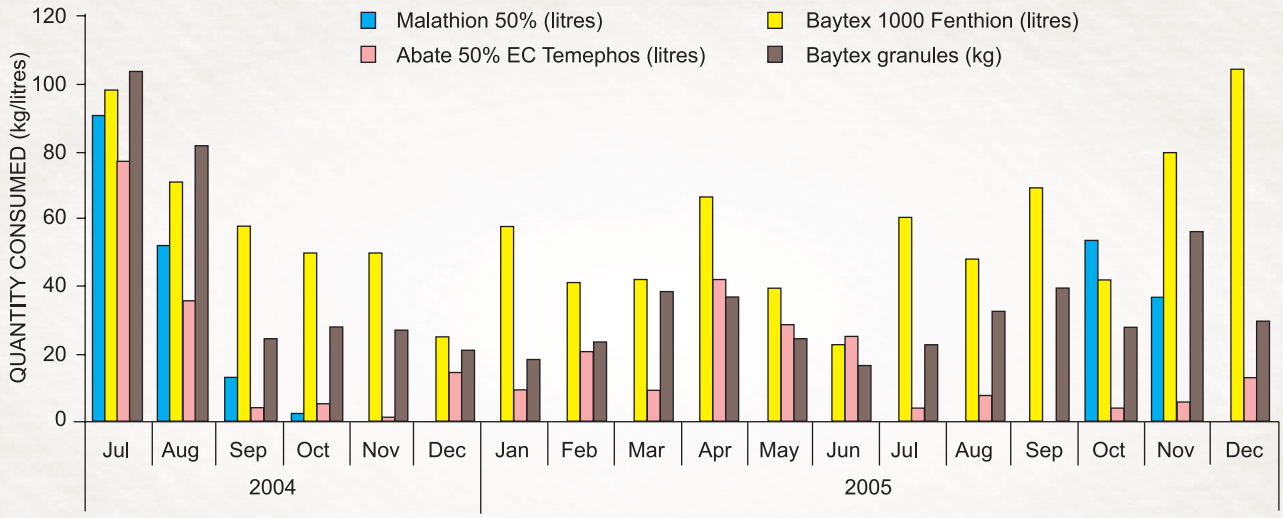


Fig. 5: **Consumption pattern of hygiene chemicals in Cantonment area, Jodhpur**

followed by Abate 50% EC Temephos. Malathion was stopped in between. Baytex granules have also been used in large quantity (Fig. 5). Baygon/ Propoxur was used in less quantity in the year 2004 but in 2005 it was used extensively, especially during July–September. Consumption of Odomos was found high in July and August in 2004 whereas in 2005 high consumption was seen during February– April.

Entomological findings

Indoor and outdoor entomological surveys were conducted in all the six sectors of the Cantonment area in the months of October 2004 and November 2005. Two anopheline mosquito species were collected from Sectors 1, 3 and 6 (Civilian area) during indoor collection. In outdoor collections, two specimens were collected from Sector 3 only.

Indoor and outdoor *Culex* mosquitoes were collected from all the sectors in both the surveys. High density of *Culex* was found indoors as compared to outdoors. Highest indoor density was found in Sector 3 followed by Sector 4, whereas outdoor density in October 2004 was highest in Sector 1 followed by Sector 3. In November 2005 *Culex* density was very low.

Larval density of *Anopheles* and *Culex* mosquitoes was estimated. High larval density of anophelines was observed in the year 2004 than 2005. Highest anopheline larval density was recorded in Sector 1 followed by Sector 6 (Civilian area) in October 2004 whereas in November 2005 highest larval density was recorded in Civilian area followed by Sector 3. *Culex* larval density was reported as high as 452 in Sector 5 followed by 115 in Sector 4 during November 2005. In October 2004 highest larval density was found in Sector 2. *Culex* larval density was higher in 2005 as compared to 2004 collection.

3.1.4 Implementation of GIS research in National Vector Borne Disease Control Programme

GIS-based information system for decision support of kala-azar control in Bihar

For the first time in India, an attempt has been made to design kala-azar control strategy at national level utilising GIS platform for Bihar state. It aimed at identifying high risk pockets and also the risk factors for the decision support of prompt and cost-effective control of kala-azar. There are 38 districts in Bihar, where 31 are endemic for kala-azar and nine are severely affected namely, Gopalgunj, Muzaffarpur, Saharsa, Saran, Vaishali, Araria, East Champaran and Madhepura. Despite implementation of various control strategies, the status of morbidity and mortality due to kala-azar in several districts

remained the same. For GIS platform geo-referenced digital maps of villages/tehsils/districts were used. A three tier database was constructed—districtwise, tehsilwise and village-wise. Attribute data such as villagewise population, schedule caste/schedule tribe population, medical facilities, primary health centres, etc. and data on kala-azar incidence/death for six years—from 2001 to 2006, were attached to the villages on the maps and were used for the analysis for decision support in formulation of control strategies. An example of Gopalgunj is given below.

Gopalgunj

Gopalgunj has about 8.3 thousand to 2.9 lakh population in its 14 tehsils. In the years 2001 to 2003 the kala-azar cases were 6, 19 and 52 respectively, confined to only Baikunthpur Tehsil/PHC of Gopalgunj district. This problem started from east of Gopalgunj and gradually built-up cases in

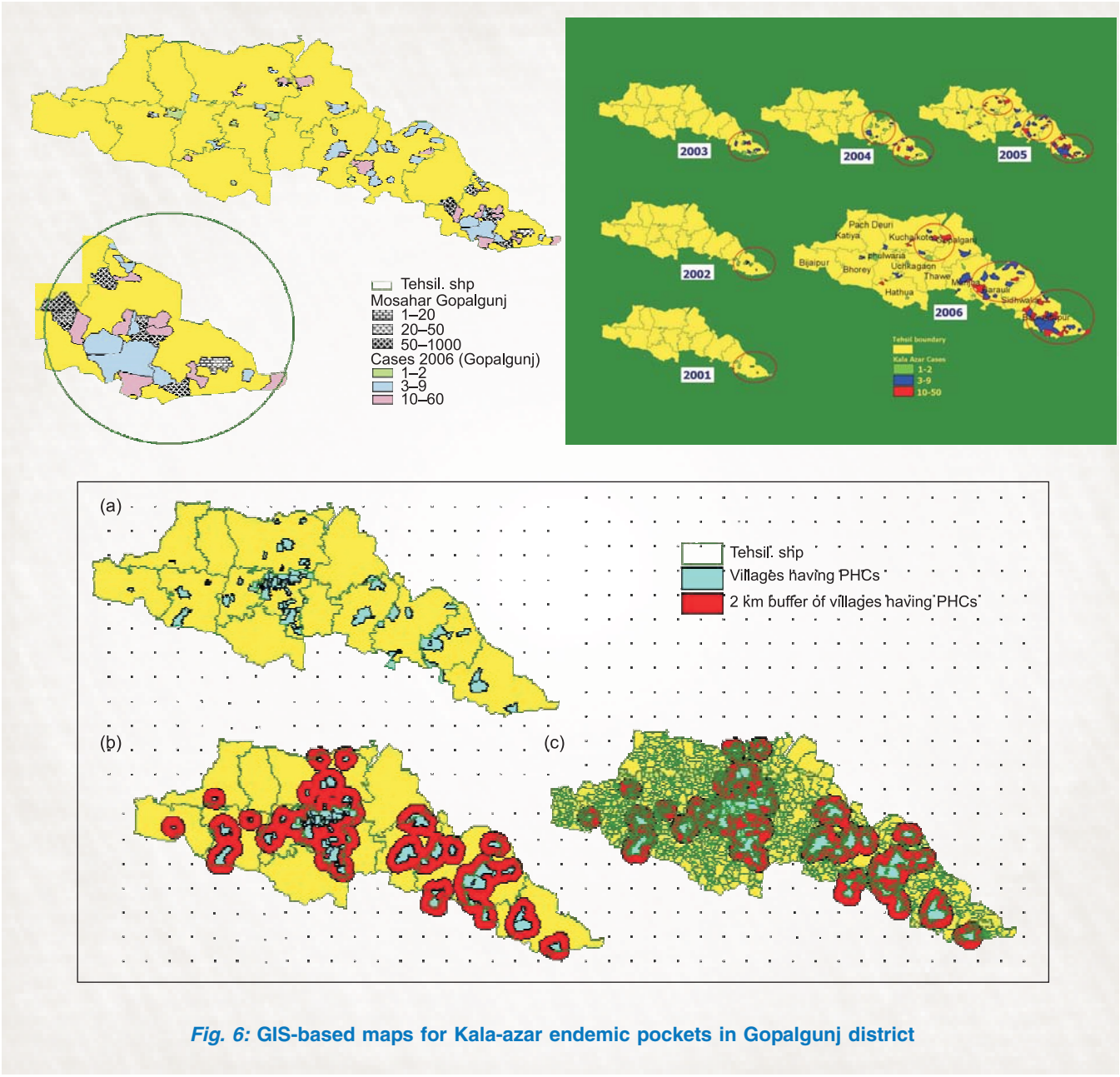


Fig. 6: **GIS-based maps for Kala-azar endemic pockets in Gopalgunj district**

western tehsils with time and in 2006, there was widespread incidence of kala-azar and the disease engulfed 50% of the tehsils and 23 villages having >10 cases. Overall, 8 tehsils of Gopalgunj namely, Baikunthpur Barauli, Gopalgunj, Hathua, Kuchaikot, Bhorey, Uchkagaon and Manjha have reported kala-azar cases from 2001 to 2006 and kala-azar control may be intensified in these villages.

Overlaying yearwise kala-azar cases over Musahar population, a tribe in Bihar, reveals a strong correlation of kala-azar cases with Musahar population. Fig. 6 shows such a correlation of Musahar population with kala-azar cases of 2006, the year of highest incidence. Villages where Primary Health Centres located in different tehsils of Gopalgunj were mapped and a buffer zone was created at 2 km and village boundaries were overlaid to show the accessibility for patients to closest PHC, and the areas where there is a need to establish new PHCs. Similar studies have been conducted for other kala-azar affected districts in Bihar and West Bengal.

GIS-based dengue information system for Delhi

In India, 21 states have reported dengue cases in 2006. A total of 10,935 cases and 171 deaths were reported from all over the country (provisional). The case fatality rate was 1.6%. Out of total cases, 31% were reported from Delhi and adjoining areas. Delhi also reported maximum number of deaths among all the states. A GIS-based Dengue Surveillance System was developed for monitoring and control of dengue in Delhi.

Delhi consists of about 139 million population spread over three localities namely, Municipal Corporation of Delhi (MCD), New Delhi Municipal Committee (NDMC) and Cantonment area. In MCD, there are 12 zones and 133 wards. NDMC consists of one zone and nine wards whereas in Cantonment area, there is only one ward in one zone. Digital map up to the level of street was used to create the GIS database. For all the three areas wardwise number of households, population, literacy rate, scheduled caste population, etc. as per 2001 census were attached. Streetwise reported dengue cases were mapped to identify clusters requiring intense attention for the control of disease (Fig. 7). A routine sample survey for breeding sites supporting breeding of dengue vector is carried out by the National Institute of Malaria Research. These data were overlaid to identify breeding source contributing more for proliferation of dengue vectors, to undertake situation-specific control measures. Based on GIS mapping, formulation of focused control strategy for dengue is in progress.

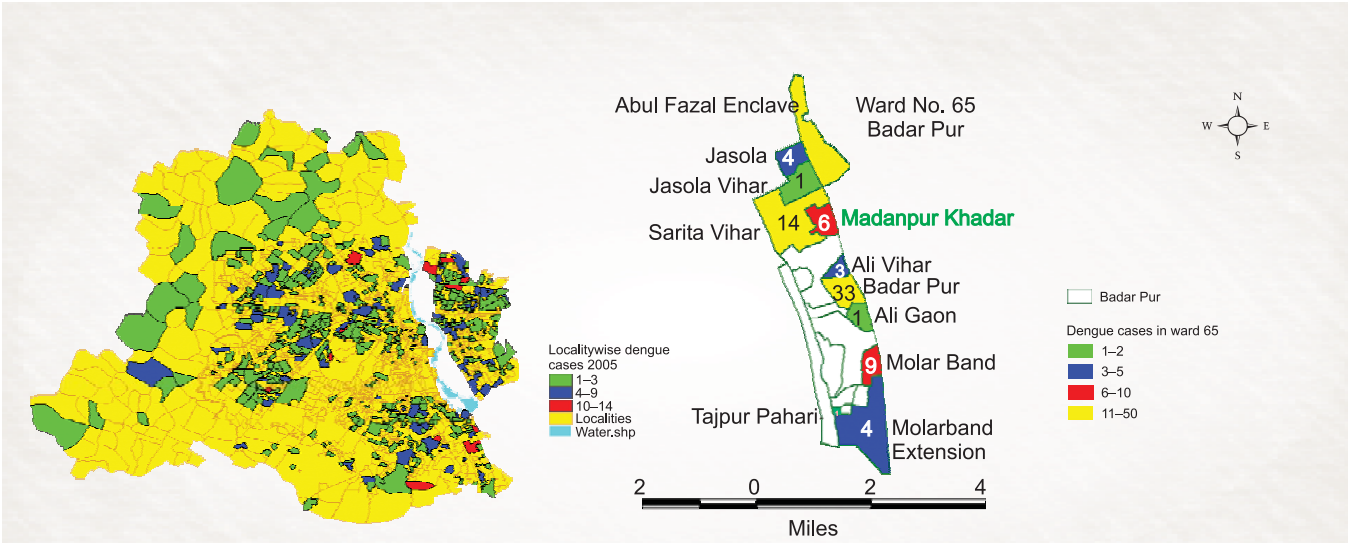


Fig. 7: **GIS map showing localitywise dengue cases in Delhi**

3.1.5 GIS-based analysis of current malaria scenario in India

In India, about 1.47 malaria cases were reported in the year 2006 with 46% *Pf* cases and 1263 deaths. In collaboration with National Vector Borne Disease Control Programme on API basis districts were categorised in four strata namely, having API <1.33, 1.34–5 and >5 and on *Pf* percent basis districts having < or >30%. GIS mapping of current malaria situation was carried out for decision support of formulating control strategy. GIS mapping revealed that in 2006, out of 208 districts 91 districts showed >5 API and 97 districts showed >30% *Pf* cases. Malaria incidence was correlated with drug resistance status.

In northeastern states, 9 and 20 districts showed 2–5 and >5 API respectively. In all, 24 districts had >30% *Pf* cases. In West Bengal and Jharkhand 9 districts showed API 2–5 and 13 showed >5 API. Also nine districts showed >30% *Pf* (Fig. 8). In Bihar no district was found to be having >5 API only one district had >30% *Pf*. The malaria in Orissa and Chhattisgarh is more with five districts in 2–5 API range and 19 in >5 API and overall 35 districts in 30% *Pf* zone. Similarly, for each state high risk districts were geographically identified to intensify the control activities in a focused way.

Districts falling on interstate borders with high malaria or *Pf*% were identified and it was proposed that same intervention should be followed in bordering districts to avoid increase in malaria cases due to infiltration of the population. Similar analysis has been done at block level for Madhya Pradesh (Fig. 8).

3.1.6 RS and GIS in mapping the malaria receptivity of Indira Sagar and Omkareshwar Dam project areas

The work on mapping of the receptivity of Indira Sagar and Omkareshwar Dam project areas is in progress. Digital map of villages of District Dhar was prepared, attached with attribute and malaria data. Trend analysis of epidemiological data from

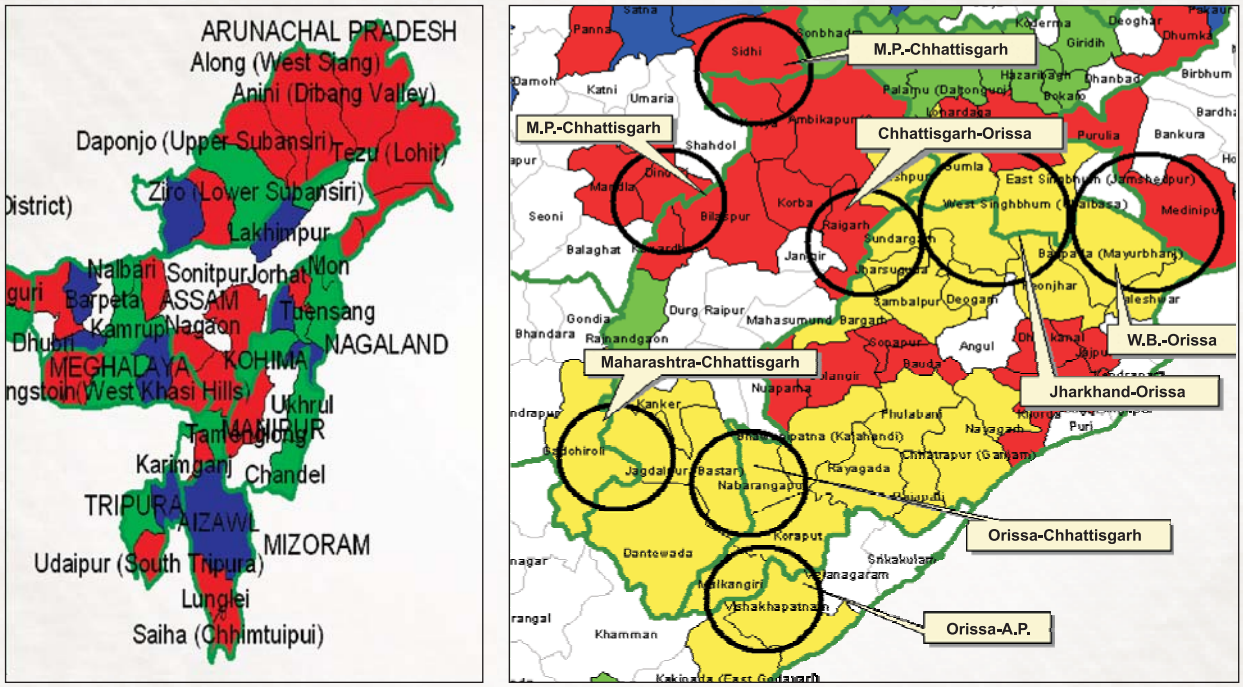


Fig. 8: GIS-based maps for malaria incidence classification

2002–05 has been done. The data on various entomological and parasitological parameters were being collected through periodic surveys regularly and are put in GIS-based frame work to view the impact of the construction of dams in space and time.

After completing each survey, meetings were held with the Vice-Chairman, NVDA and state authorities and survey highlights and actions required for developing mitigating measures—engineering, epidemiological and entomological to control the vector borne diseases were suggested and a review was also taken for the implementation of the previous recommendations.

3.1.7 Identification of epidemiological risk factors of malaria for development of strategic action plan for malaria control in problematic districts in Karnataka

In connection with our collaborative project on "Identification of epidemiological risk factors of malaria for development of strategic action plan for malaria control in problematic districts in Karnataka", a field visit was undertaken in Upper Krishna Project area of Raichur, Gulbarga, Bijapur and Bhagalkot districts during November (peak transmission month) 2006. Based on villagewise data of past three years, villages from highest and lowest malaria endemicity were selected for detailed survey. Altogether, 27 villages were surveyed for types of breeding habitats prevalent, man hour density (MHD) of adult vectors and fever cases. Malariogenic conditions around each village were also mapped.

Of the 25 villages surveyed under high malaria endemicity category, almost all had conducive malariogenic conditions. The problems were exacerbated by the vicinity of irrigation channel or seepage and the borrow pits in the vicinity of households and scattered households with poor economic conditions. The scattered breeding habitats and the hutments over vast area in jungle made the surveillance and intervention task bit difficult. The MHD of *An. culicifacies* was up to a maximum of seven even in the month of November. The villages, which were away from irrigation canal/ seepage water, etc. and were established enough were found to be of low endemicity.

Field visit was also undertaken in the month of April (low peak) 2007 in selected 10 villages. Highest MHD was 0.4 as compared to 7 in the month of November 2006. Data were also generated on socioeconomic attributes of 10 villages through questionnaires (293). Ground truth data in selected PHCs of Chitradurga and Tumkur districts were also collected. Satellite data of IRSP6 LISS IV for November 2006 were analysed and false colour composite (FCC) images at village-level were generated. The study is in progress to cover vast areas along the reservoir from Narayanpur to Almatti.

3.1.8 Identification of malaria risk factors in different ecosystems of Assam using remote sensing

Studies were initiated in Defence Research Laboratory, Tezpur sponsored project in Assam to identify ecological and environmental risk factors of malaria using satellite remote sensing at village-level for early warning of malaria outbreaks.

Most districts of the northeastern states are malaria endemic and many pockets are vulnerable to focal outbreaks. Epidemiological data of malaria for all the districts of Assam were procured from Govt. of Assam. Based on the incidence of malaria, Kamrup and Sonitpur districts were selected for detailed investigation. One PHC with highest malaria and the other with least malaria were selected from each district. Three to five villages from each category of PHCs were selected for detailed entomological, parasitological and ecological data generation.

Monthly meteorological data containing rainfall, temperature and relative humidity were collected from Indian Meteorological Department, Guwahati (Assam) in respect of Tezpur, Kamrup, Dhubri, Lakhimpur and Mohanbari (Dibrugarh) for the years 2003–05. The transmission windows of malaria were identified based on seasonal occurrence of cases and minimum temperature and RH required for ensuing transmission of *P. falciparum* malaria.

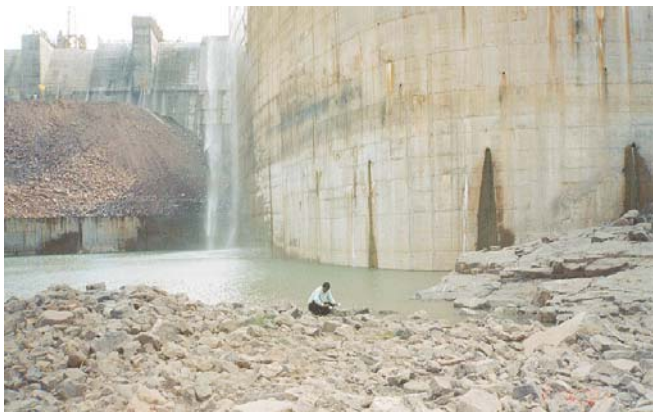
Field visits to the selected areas were made in November 2006. Data on entomological, parasitological and ecological aspects were generated.

The findings are as follows: (i) Rivers, ponds, drains, ditches/pits and canals were the main breeding habitats in the area surveyed. Maximum larval density was found in ponds while minimum in drains; (ii) Results of adult mosquito collection revealed that seven species of anophelines were collected from Kamrup and Sonitpur districts. In Kamrup district, the highest MHD of *An. minimus*, the major vector of malaria in northeast was nine in high risk village. In Sonitpur district also, the highest density (5) of *An. minimus* was found in high risk village; (iii) In Sonapur PHC (high risk area under Kamrup district), malaria positivity was found in all the four villages surveyed and SPR ranged from 15.3 to 42.1 with overall SPR as 34.87%. *P. falciparum* percentage was 64.7. In Upperhali PHC (low risk area under Kamrup district), of the two villages surveyed, malaria case was detected in only one and SPR was 4.2%; (iv) In Northjamaguri PHC (high risk area of Sonitpur district), of seven villages surveyed, malaria cases were found in four villages. SPR ranged from 20 to 100 with overall SPR as 52%. *Pf* percentage was 84.61. In Behguri PHC (low risk area), of the two villages surveyed, malaria cases were found in only one and SPR was 30.3%; (v) In Kamrup district, the highest peak of *P. falciparum* reaches in June/July while the lowest peak is in December to February. During January the temperature remains < 18°C. Based on minimum requited temperature (T) and RH, the transmission window (TW) is supposed to remain open for 11 months. In Sonitpur district, the incidence is lower than Kamrup district and the fluctuation of cases is similar to Kamrup district and transmission windows (TWs) are open for 10–11 months; and (vi) Retrospective analysis of *P. falciparum* and meteorological parameters to find out the suitable indicators responsible for malaria outbreaks is underway. Analysis of IRS 1D LISS III data did not reveal much landscape features at village-level to identify the ecological factors responsible for malaria endemicity. The work is in progress.

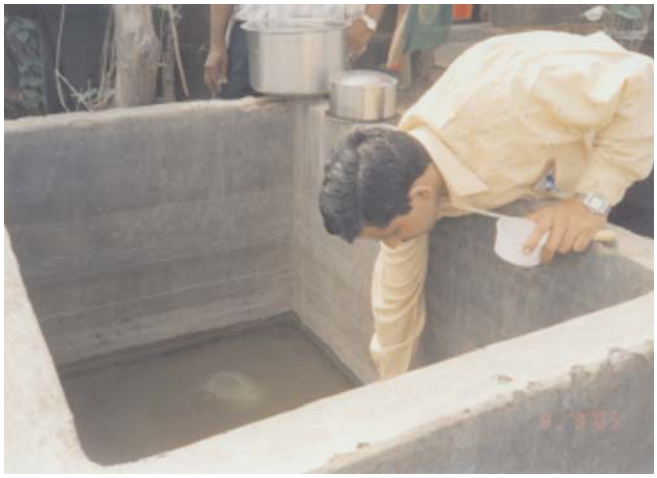
3.2 Health Impact Assessment

3.2.1 Health impact assessment of Indira Sagar Dam and resettlement and rehabilitation colonies in SSP Reservoir impoundment areas in Narmada Valley in Madhya Pradesh

During 2004–06, nine surveys (4 in pre-monsoon, 3 in post-monsoon and 2 in monsoon season) were carried out in seven districts—Khandwa, Badwani, Khargaon, Devash, Dhar, Harda and Jhabua of Indira Sagar, Omkeshwar and Sardar Sarovar Project areas. Mosquitogenic conditions created due to dam construction—seepage of the reservoir, pits and pools of down streams, new canals, pools created, curing tanks, etc. have been identified. Surrounding to these, a total of 33 villages, 18 rehabilitation and resettlement centres and 3 command area villages under seven districts



Mosquito larval collection at Dam site



Larval collection in storage tanks

have been surveyed for entomological and epidemiological data for all the vector borne diseases—malaria, dengue, JE and filariasis.

It is worth to mention that before the construction of dam, no malaria cases were recorded from these surveyed villages. In 2006 till September, 137 cases of chikungunya and 112 cases of typhoid were also recorded by NHDC Hospital, Narmada Nagar, Khandwa. Samples were also collected for dengue and JE but none was found positive.

Man hour density/per room density of malaria vectors *An. culicifacies* and *An. stephensi*, filaria vector *Cx. quinquefasciatus*, JE vector *Cx. vishnui* and dengue vector *Ae. aegypti* were calculated in all the three seasons. Impact of dam construction was observed in nine villages as the vector density was reported high in all the three seasons. To establish the transmission, other entomological parameters—biting habit, parity rate, gonotropic cycle, sporozoite rate, human blood index and presence of sibling species were also carried out. Breeding sites created due to dam construction were surveyed for larval breeding and species-specific breeding sites were identified for all the disease vectors. The susceptibility test for *An. culicifacies* was also carried out in all the three seasons and *An. culicifacies* was found resistant to DDT and susceptible to synthetic pyrethroids.

3.3 Epidemiology of Urban Malaria

3.3.1 Studies on the epidemiology of urban malaria in mega, medium and small cities of India

Delhi

A total of 22 localities were selected to carry out the entomological and epidemiological studies in consultation with officials of the Municipal Corporation of Delhi (Health Department). These 22 localities represent high, middle and poor income groups and also the commercial, recreation, industrial and transport areas. From November 2005 to June 2006, a total of 704 active slides were collected from these 22 localities. Out of these 704 slides, 20 were found positive for *P. vivax* and none was found positive for *P. falciparum*. Maximum number of cases were recorded from Okhla (Industrial area) and Trilokpuri (residential low income group area).

The morbidity and mortality data of malaria were also collected from about 25 agencies such as Government/private hospitals; private practitioners, clinics and nursing homes; cremation ground and diagnostic centres—malaria clinics, private and pathological laboratories.

Adult mosquito collection

Weekly hand catch collections were carried out in all the 22 localities from November 2005 to June 2006. Eight species of anopheline namely

Active fever surveillance in study population

Adult mosquito collection in rooms

An. stephensi, An. culicifacies, An. subpictus, An. annularis, An. aconitus, An. pulcherrimus, An. nigerrimus and *An. vagus* were collected from indoor resting places such as human dwellings, cattlesheds and mixed dwellings. Of these eight species, *An. stephensi* and *An. culicifacies* are well-known vectors of malaria. *An. culicifacies* was collected from Yamnua River belt—Sonia Vihar and peripheral areas of the city like Najafgarh and Mahipalpur. *An. stephensi* was collected from all the localities surveyed. Besides the anophelines, *Culex*, *Aedes, Mansonia* and *Armigeres* species were also collected. *Cx. quinquefasciatus* was the predominant species among all the mosquitoes collected during night as well as day-time collections. *Ae. aegypti* were also collected from the human dwellings. The total catch collection was also carried out in all the localities on monthly basis.

Identification of mosquito species

In bait collections (night collection), two *An. stephensi* were collected from Rohini area and three from Okhla industrial area. Three *An. culicifacies* were collected from Sonia Vihar. The biting time of both the species was recorded between 2200 and 2400 hrs.

Mosquito larval collection

Larval collection was carried out in all the 22 localities from 12 different breeding sites like overhead tanks, ground tanks, domestic containers, coolers, drains, ponds, pits, dump tyres, septic tanks, mud pots, fountain pools, riverbed pools, store drums, etc. The breeding of malaria vector species— *An. stephensi* was recorded from OHTs, ground tanks, domestic containers, fountains, pits and stone pools whereas the breeding of *An. culicifacies* was recorded from riverbed pools and pits only. The breeding of *Ae. aegypti* was recorded from drums, tyres, coolers, mud pots exclusively while in OHTs, ground tanks, domestic containers the breeding was also recorded in association with *An. stephensi*. Breeding of *Cx. quinquefasciatus* was recorded from almost all the breeding sites. The breeding of *An. stephensi* and *Ae. aegypti* in OHTs was recorded from November 2005 to May 2006 and maximum breeding was recorded during the months of November 2005 and March 2006, whereas ground tanks supported the breeding of both the species from November 2005 to June 2006 and the maximum breeding was recorded in the months of June and November. Maximum breeding of *An. culicifacies* was recorded from riverbed pools in the month of February and June. Some of the important breeding sites supporting the breeding of vector species are given below.

A detailed GPS survey has been carried out in east Delhi for the purpose of geo-referencing. Eighty-eight GPS waypoints located in different parts of eastern Delhi, mainly road intersections, have been randomly selected as registration point. Map has been digitised in ArcGIS 8.1 and the selected locations have been identified in the map for registration. To register map existing latitude and longitude has replaced in real world coordinates. A base map showing locations of different colonies

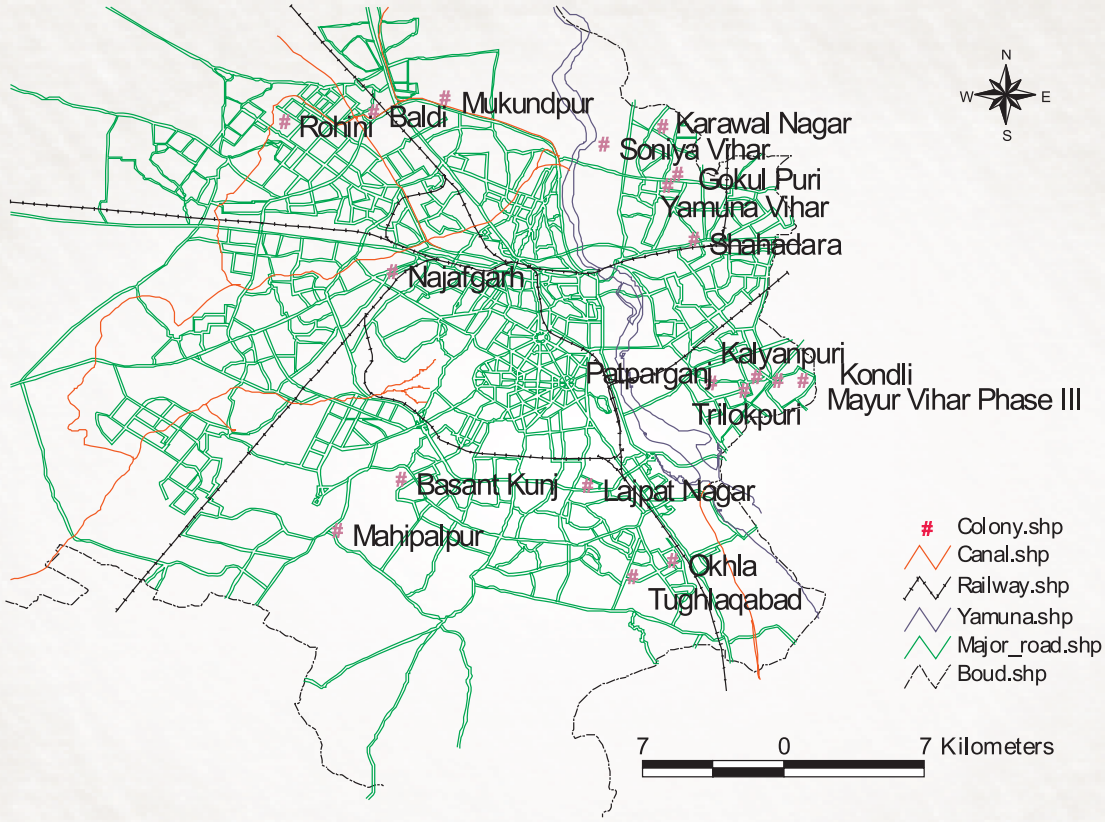


Fig. 9: **Map showing different colonies of Delhi under survey (GIS analysis)**

of Delhi under survey has been prepared for GIS analysis (Fig. 9).

Ajmer (Rajasthan)

Epidemiological survey

A total of 825 blood slides were collected in surveys carried out during November 2005, January and June 2006 from inhabitants of 20 localities representing high, middle and poor income groups and also from inhabitants residing in commercial, recreation, industrial and transport areas. Out of these, seven slides were found positive for *P. vivax* and one for *P. falciparum*.

Entomological survey

Adult collection

Hand catch collections were carried out in all the 20 localities during November 2005, January and June 2006. A total of five species of anophelines—*An. stephensi*, *An. culicifacies*, *An. subpictus*, *An. annularis* and *An. pulcherrimus* were collected from indoor resting places (human dwellings, cattlesheds

Mosquito collection on cattle bait

Domestic mosquito breeding habitats

and mixed dwellings). Out of these five species, *An. stephensi* was the most dominant species and collected in all the three surveys carried out, whereas *An. culicifacies* was collected in the months of November 2005 and June 2006 only. *An. stephensi* was collected from all the 20 localities surveyed, whereas *An. culicifacies* was collected from nine localities.

Larval collection

Larval collection was carried out in all the 20 localities from 15 different breeding sites like OHTs (cement and sintex), ground tanks, drains, drain pits, coolers, matkas, side pits, tankas, mud pots, fountains in marriage homes, fountain pools, tanks at ice cream factory, drum wells, etc. *An. stephensi* was found breeding in OHTs, ground tanks, matkas and fountains, whereas *An. culicifacies* was found breeding in fountain pools and tankas. *Ae. aegypti* was found exclusively in coolers, mud pots and drums, but in association with *An. stephensi* in OHTs, ground tanks and in matkas. The maximum breeding of vector species was recorded in ground tanks 63% during November 2005, 27.5% during January and 56.4% during June 2006 followed by OHTs. It is noteworthy to mention that *Ae. aegypti* has not been recorded for more than one decade.

Larval collection in water storage tanks

Vishakhapatnam (Andhra Pradesh)

Vishakhapatnam district is one of the northeastern districts of Andhra Pradesh situated within the geographic coordinates of 17° north latitude and 83° east longitude. The district is bounded by

Active surveillance in study villages

Domestic mosquito breeding habitats

Vizianagaram district on the north, East Godavari district in the south, Koraput of Orissa in the west and Bay of Bengal in the east. The total population of the district is around 3.28 million. Rural population of the district is approximately 60%. The scheduled castes and scheduled tribes population in the district is 7.8 and 14.3%, respectively. The field work in Vishakhapatnam has been initiated recently and analysis of data is in progress.

3.4 Clinical Trials

Assessment of therapeutic efficacy of antimalarial drugs against uncomplicated *P. falciparum* malaria

Antimalarial drug resistance is a major obstacle in the fight against malaria. A systematic surveillance system with periodic updating is essential for containment of drug resistance. The treatment policies can be updated only if the information on extent of the problem is known from various parts of the country. Since India is a vast country with several eco-epidemiological subtypes of malaria, it is necessary to evaluate efficacy of first and second line antimalarial drugs at several sites so as to devise alternative strategies for treatment as per need. India is also contemplating a partial change in its drug policy including a consideration for use of combination therapy in drug resistance areas. Therefore, while the studies on the occurrence of resistance to first line drugs should be continued, there is a need to evaluate efficacy of these proposed new regimens. Thus, in view of urgent need to update and rationalise treatment policies, which can be done only after updating the information on drug efficacy and safety with existing

drugs used in the country, these studies were initiated with the following objectives: (a) assessment of therapeutic efficacy of chloroquine (CQ) or sulphadoxine-pyrimethamine (SP) or combination therapy in uncomplicated *P. falciparum* malaria in endemic districts of Orissa, Jharkhand and Indo-Bhutan border districts in Assam; and (b) to validate the *in vivo* drug resistance data using molecular markers and therapeutic concentration of drugs.

Assam

District Udalguri was selected as a study site. Fifty-three patients were enrolled, out of which 51 completed the study. Efficacy of combination therapy (AS+SP) was evaluated. The regimen was found to be very effective with high cure rates, adequate clinical and parasitological response (ACPR 94.1%), rapid parasite clearance time and was well tolerated.

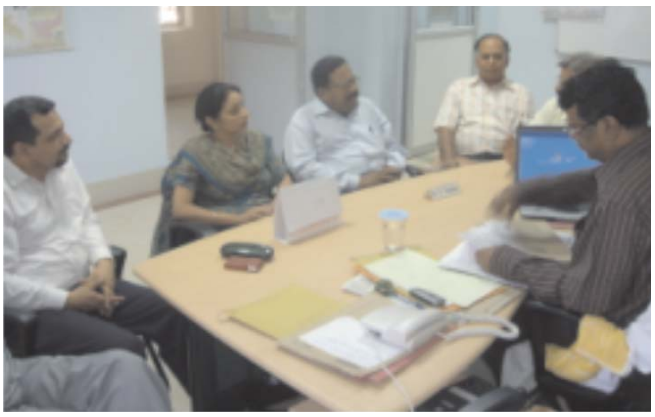
Orissa

The study has been completed in Keonjhar district. ACT (AS+SP) was found to be highly effective at this site also with cure rates of 98.5%. The results were similar to those observed in Assam. The town was already under the second line drug SP treatment. However, in adjoining PHC, Banspal, where chloroquine was the first line drug, the cure rates with CQ were only 21%.

Jharkhand

Tathaitangar PHC, Jaldega sub-centre in District Simdega and Angara PHC in District Ranchi were selected for the study. Orientation workshop was held at District Simdega on 7 July 2006 just before initiation of the study. Therapeutic efficacy of chloroquine was studied and results are discussed.

The studies were conduced according to WHO protocol for therapeutic efficacy. The procedural steps in brief are as follows: (i) Enrolment of subjects using pre-determined criteria by active/ passive surveillance; (ii) Collection of peripheral smears and samples for molecular biology; (iii) Follow-up for 28 days for clinical and parasitological cure; (iv) Rescue medication for treatment failures;



Investigations meeting with state health officials

(v) Survival analysis of data using specifically designed software; and (vi) Genotyping of blood spots on Day 0 and Day of recrudescence by MSP-1, MSP-2 and GLURP—Nested PCR with family-specific assay.

District Simdega

Fifty-one cases completed the follow-up and although total failure rates with CQ (25 mg/kg body weight over 3 days) were 34.2%, the early failures were low (7.8%) (Tables 1 a & b). Since the failure was much above the cut-off level for change of policy, the drug policy has been revised by the national programme.

District Ranchi

In Angara PHC, 68 patients were enrolled out of which 63 completed the study. High failure rates were observed with CQ (25 mg/kg over 3 days) at this site also, leading to change in drug policy (Tables 2 a & b).

TABLE 1a

Baseline characteristics of patients in Tathaitangar PHC, District Simdega

Drug: CQ		Dose: 25 mg/kg × 3 days
No. of cases enrolled	:	51
Male/Female	:	(19/32)
Age (Range)	:	0.5 months–40 yr
Parasitaemia/µl on D0 (Range)	:	1000–99, 440

TABLE 1b

Therapeutic response to chloroquine

Classification	No. of patients	Prevalence
ETF	4	0.078
LCF	10	0.196
LPF	4	0.078
ACPR	33	0.647
Total analysis	51	
With	0	
Loss	0	0
Total	51	

TABLE 2a

Baseline characteristics of patients in Angara PHC, District Ranchi

Drug: CQ		Dose: 25 mg/kg × 3 days
No. of cases enrolled	:	68
Male/Female	:	(37/31)
Age (Range)	:	2.5–50 yr
Parasitaemia/µl on D0 (Range)	:	1000–82,400

TABLE 2b

Therapeutic response

Classification	No. of patients	Prevalence
ETF	2	0.032
LCF	12	0.190
LPF	4	0.063
ACPR	45	0.714
Total analysis	63	
With	1	
Loss	4	0.074
Total	68	

3.4.2 A Phase II, double-blind, parallel-group, randomised, dose-ranging study assessing the antimalarial activity and safety of RBx 11160 administered for 7 days in patients with acute uncomplicated *P. falciparum* malaria

RBx 11160 (Arterolane) a new peroxide, is a synthetic trioxolane that is easy to synthesise, inexpensive, achiral and orally rapidly acting with high antimalarial activity. It is a potential new antimalarial agent with demonstrable activity in pre clinical models and a substantial safety margin between an effective dose for malaria and the toxic dose. Mechanism of action of the drug: reductive activation by haeme, released as a result of haemoglobin digestion; irreversible redox reaction produces carbon-centred free radicals, leading to alkylation of haeme and proteins (enzymes) and one enzyme is the sarcoplasmic endoplasmic reticulum ATPase PfATP6.

Studies carried out indicate that RBx 11160 is safe and does not produce any clinically significant effect on behavioural parameters and cardiovascular systems. The present study was designed to assess the clinical safety and efficacy of three dose levels of RBx 11160 (50, 100 or 200 mg), administered for 7 days in patients with acute uncomplicated *P. falciparum* malaria. The primary objective was to compare three (50, 100 and 200 mg) RBx 11160 dose levels administered orally for seven consecutive days on time to 90% parasite clearance (PC90) in patients with acute uncomplicated *P. falciparum* malaria and to identify the most appropriate dose of RBx 11160 for further investigation. The trial was conducted according to good clinical practices (GCP) guidelines.

Male or female patients aged 13 to 65 years, with no clinical evidence of severe malnutrition and presence of acute uncomplicated falciparum malaria with asexual parasitaemia between 1000 and 100,000 asexual parasites/µl blood were included. Patients with mixed infection, severe malaria, antimalarial treatment during two weeks prior to screening, history of hypersensitivity or allergic reactions to artemisinin, electrocardiogram

Monitoring and auditing according to GCP-ICH guidelines at IGH Hospital, Rourkela

(ECG) abnormalities with clinical significance, lactating or pregnant woman, evidence of other clinically significant diseases were not included.

The multicentric study has been completed on 80 patients in Rourkela field unit (Table 3) in collaboration with Ispat General Hospital, Orissa. All the three doses resulted in parasite clearance in all the patients by Day 7 and drug was well tolerated. The mean parasite clearance time for all dose ranges was 37 h. About 94% (74/79) patients cleared parasites by 72 h. High recrudescence was observed during 28 day follow-up. Further studies are planned in combination with long acting antimalarial. RBx 11160 (Arterolane) is an effective synthetic alternative to Artemisinin and further studies in combination with long acting partner drug are important. The study was conducted in two parts as shown below.

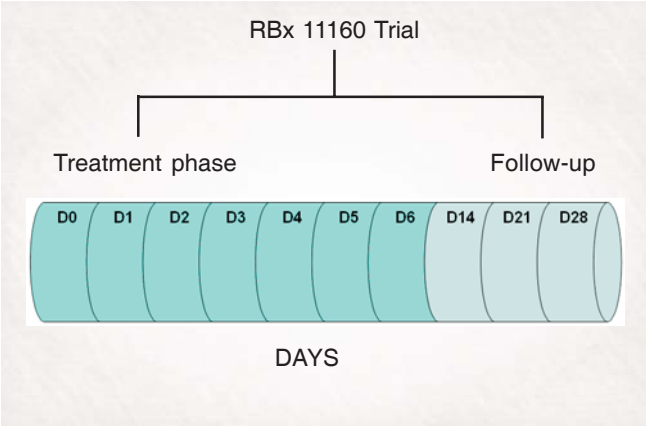
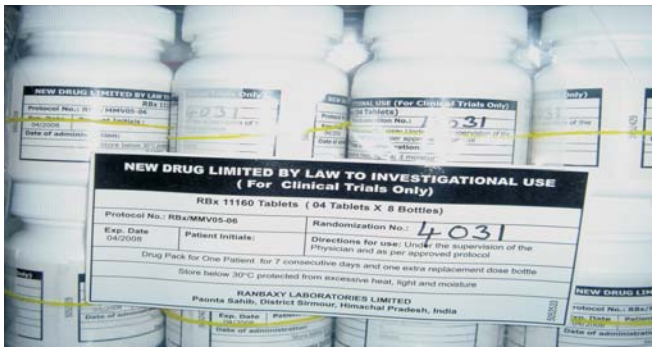


TABLE 3

Final global enrolment status

Study centre	No. of patients enrolled
Bangkok, Thailand	90
Rourkela, India	80
Bagamoyo, Tanzania	43
Kivunge, Zanzibar	17
Total	230



Drug storage

3.4.3 A Phase III, randomised, non-inferiority trial, to assess the efficacy and safety of Dihydroartemisinin + Piperaquine (DHA + PPQ, Artekin) in comparison with Artesunate + Mefloquine (AS + MQ) in patients affected by acute, uncomplicated *P. falciparum* malaria

Artekin™ was developed in China and is registered in China and Cambodia. It has been evaluated

extensively in clinical trials in Thailand, Vietnam, Cambodia and China. Efficacy has been high and tolerability was uniformly excellent in all the trials in these multidrug-resistant areas. Artekin™ is a second generation Artemisinin-based combination therapy (ACT) with similar efficacy to that of Coartem (Artemether + Lumefantrine) or Artesunate + Mefloquine but with a simpler dosing scheme that will aid better compliance. Moreover, its good safety profile and affordable cost make it ideal for resource constrained countries. Most of the clinical trials evaluating Artekin™ have been conducted without the sponsorship of a pharmaceutical company. In addition, the formulation of DHA+PPQ used in some trials through compliant with Chinese GMPs, was not compliant with the GMP standards laid by the European or US Health Authorities. For the later reasons Sigma-Tau has used the information/data generated from previous trials to support the design of a new phase III development strategy using Artekin product according to GMP and European regulatory standards as Euartekin. DHA – PPQ is highly effective and tolerated by all the age groups. DHA is active metabolite of Artemisinin. Piperaquine related to CQ and has similar mechanism of action and is long acting. The dose regimen includes 3 day therapy (2.1 mg/kg DHA & 16.8 mg/kg piperaquine). Reported side-effects are vomiting, dizziness and nausea. The primary objective of the study was to measure the Day 63, PCR corrected cure rates of Artekin and AS+MQ and demonstrate that the cure rate of Artekin is non-inferior to that of AS+MQ (non-inferiority margin = 5%).

The study was conducted at three sites—Goa, in collaboration with Goa Medical College & Hospital; Mangalore, in collaboration with Wenlock District Hospital, Mangalore; and Guwahati, in collaboration with Down Town Hospital. Investigator meetings were held before starting the study. This was a phase III, randomised, open label, two arms study to include 1050 patients (700 DHA+PPQ; 350 AS+MQ) at all the sites in India and other countries. In order to ensure concealment of treatment allocation and avoid other biases the randomisation was under blind conditions and treatment allocation was concealed until the final recruitment of the

Investigators meeting at Goa

Rajiv Gandhi Memorial Medical College and Hospital, Goa

patients. The primary endpoint was the PCR-corrected ACPR at D63. Patients classified as failures by clinical and parasitological criteria were considered ACPR if the PCR analysis showed a new infection rather than a recrudescence.

Males and females aged >18 years having microscopically confirmed, monoinfection of *P. falciparum* (asexual forms parasitaemia >1000/µl <100,000/µl or mixed infection), history of fever or presence of fever (temperature at >37.5°C) were included. Known hypersensitivity to the study drugs, severe malaria, presence of intercurrent illness, pregnant or lactating women were excluded. A total of 154 cases of *P. falciparum* were enrolled at all the sites

TABLE 4

Enrolment status at study sites in India

Characteristics	Guwahati	Mangalore	Goa
Number enrolled	69	57	28
Screen failures	1	3	0
No. finally enrolled	68	54	28
No. of patients completed the study	65	30	27
No. of SAE	0	0	0
Parasite clearance time	1 to 3 days	1 to 3 days	1 to 3 days
Adverse reaction	3	3	Nil
Recrudescence	Nil	3	Nil

(Table 4). Artekin is an effective and well-tolerated combination regimen.

3.4.4 Multicentre, open-label, randomised clinical trial of efficacy and tolerability of the fixed-dose artesunate/amodiaquine (AS/AQ) combination therapy and amodiaquine (AQ) monotherapy for treatment of uncom plicated falciparum malaria in India

At present, only one ACT (Artemether Lumefantrine–Coartem®) is available as a fixed dose drug in which both compounds are co-administered. Co-packaging of the combination partner drugs in a blister pack is highly recommended in order to make them user-friendly, and to increase adherence to the complete therapy. DND*i* in association with UNICEF/UNDP/World Bank/WHO (TDR) is developing a new fixed-dose combination of Artesunate and Amodiaquine that will allow a simple treatment of just three days, with a single daily administration of two tablets.

Since WHO has decreed that artemisinin-based combinations to be used in malaria endemic countries, the testing of AS/AQ is relevant for informing drug policy makers. Comparing AS/AQ with chloroquine, the current first line drug, would not be an optimal choice because chloroquine will have to be replaced in future. The present study with AS/AQ and AQ will allow gathering of data on amodiaquine for the first time in India.

The primary objective of the study was to measure

Community Welfare Society Hospital, Rourkela

Investigators meeting at Ranchi

the clinical and parasitological efficacy of the fixed-dose Artesunate/Amodiaquine combination therapy among children and adult patients suffering from uncomplicated falciparum malaria, by determining the proportion of patients having negative peripheral smear for malaria without relapse before 28 days (cure rate). The study has been initiated at Ranchi and Rourkela in collaboration with Community Welfare Society Hospital, Rourkela. Investigator meeting was held at Ranchi.

Inclusion criteria were: (i) children and adults from 6 months to 60 years of age; both gender; for children (aged 6 months), body weight 5 kg; (ii) presenting with uncomplicated falciparum malaria; (iii) axillary temperature >37.5°C (99.5°F); (iv) positive *P. falciparum* parasitaemia (1000–100,000 asexual parasites/µl); and (v) written informed consent (participant or parent/guardian). The exclusion criteria were: (i) any other concomitant condition that could explain the fever episode (upper respiratory tract infection or ENT infection for example); (ii) any concomitant infection by *P. vivax*; (iii) any chronic ailment; (iv) pregnancy; (v) Hb < 7 g/dl; (vi) ALT/AST > 2.5 ULN; and (vii) S.

TABLE 5
Enrolment status at study sites in India

Parameters	Ranchi		Rourkela	
	A (AS+AQ)	B (AQ)	A (AS+AQ)	B (AQ)
No. of patients enrolled	10	4	14	8
No. of patients finally enrolled	10	4	14	8
No. of patients completed the study	6	4	9	4
No. of SAE	0	0	1	0
Parasite clearance time	1–2 days	1–8 days*	1–3 days	1–2 days
Adverse reaction	0	0	0	0
Recrudescence	0	0	0	1

* One patient

creatinine >1.2 ULN. Thirty-six cases of *P. falciparum* were enrolled till date at both the sites (Table 5).

3.5 Monitoring and Evaluation of Disease Control Programme

3.5.1 Monitoring and supervision of spray operation in kala-azar affected Districts of Bihar state

In Bihar state, two visits in three districts namely Madhuvani, Darbhanga and Arwal from 19 to 28 May and from 18 to 26 June 2006 and two visits in District Madhepura from 21 to 28 February and from 17 to 22 March 2007 were made to supervise the DDT (50%) spray operation activities. In the above three districts, spray operations were ongoing in two PHCs in each district and four villages in each PHC. In district Madhuvani, the spray was started from 8 May 2006, in Darbhanga from 24 May 2006, but no spray was started in District Arwal during May 2006. The spray operations were affected due to non-payment of wages to spray teams. The spray reports revealed that in the above two districts advance planning of spray operations was made but no advance information regarding spray operations to the villagers was given. Recruitment of spray workers and preparations for spray suspension was found satisfactory. Out of 35 stirrup pumps checked, 4 pumps were found defective. Nozzle discharge rate was found satisfactory in rest of the pumps. Training/knowledge of spray workers was not satisfactory. Refusal varied from 5 to 15% due to untimely instructions to the villagers. Spray coverage in houses ranged from 45 to 85% and in rooms it varied from 65 to 92%. It was suggested that DMO should organise meetings with villagers to develop awareness and willingness towards spray operations. IEC programme should be made effective to check refusal rate and the staff deputed to check and supervise spray operations should visit the village for full coverage of spray.

During 2007, two visits in District Madhepura were made to supervise spray operations in all the PHCs. Two villages in each PHC were checked and the proforma of checklist for monitoring and supervision of IRS activities for kala-azar control was duly filled up. The observations recorded were that funds were not released for payment of wages to the spray workers at district level, refusals in Musahar and high communities were recorded, percent coverage of spray in the houses varied from 76.2 to 95.5% and in rooms it ranged from 74.3 to 91.9% which revealed high refusal rate by the community. It was suggested that bed rooms should not be spared for DDT spray at any cost, Medical Officer/Incharge of the concerned PHC should invariably check spray squad, monitoring and supervisory team framed by the district officials should check the spray activities in the villages to achieve cent percent coverage.

3.5.2 Assessment of malaria treatment practices in public and private health sectors

The early diagnosis and prompt treatment of cases of malaria is a key component of the global malaria

control strategy and the National Vector Borne Disease Control Programme in India executes this through the primary health care system. A large proportion of suspected cases of malaria are being treated outside the public health system. Antimalarial drugs are available over the counters and they are used injudiciously and sometimes in inappropriate doses. Exact information on the malaria treatment practices in private sector is lacking. The knowledge about the compliance with prescribed drug policy at different levels across the public health facilities is also not available. The study was planned at Delhi, Gujarat and Orissa to ascertain the allopathic treatment practices of malaria through a questionnaire survey among public and private health sectors at various levels of health system in the urban and rural areas.

The objectives of the study were: (i) to evaluate allopathic treatment practices for malaria in public and private health sectors; (ii) to assess and compare the awareness for National Drug Policy in public (teaching & non-teaching sectors) versus private sectors; and (iii) to assess the proportion of clinicians using rational treatment for the disease.

Questionnaire for the study has been designed. Meetings with social scientists and statisticians were held for finalising the questionnaire, and for estimation of sample size. A pilot study was carried

TABLE 6

General information and response of training

	Type of practice (%)	
	Government (n = 115)	Private (n = 70)
Awareness about malaria training course for doctors		
Yes	64	46.4
No	36	53.6
Report of malaria cases to concerned authorities		
Yes	43.2	27.9
No	56.8	72.1

TABLE 7

Diagnosis of malaria patients

	Type of practice (%)	
	Government (n = 115)	Private (n = 70)
Availability of diagnostic facility		
Yes	93	79.7
No	7.1	20.3
Treatment according to report of peripheral smear		
Yes	70.2	75.0
No	29.8	25.0
Awareness of RDT		
Yes	67.5	61.8

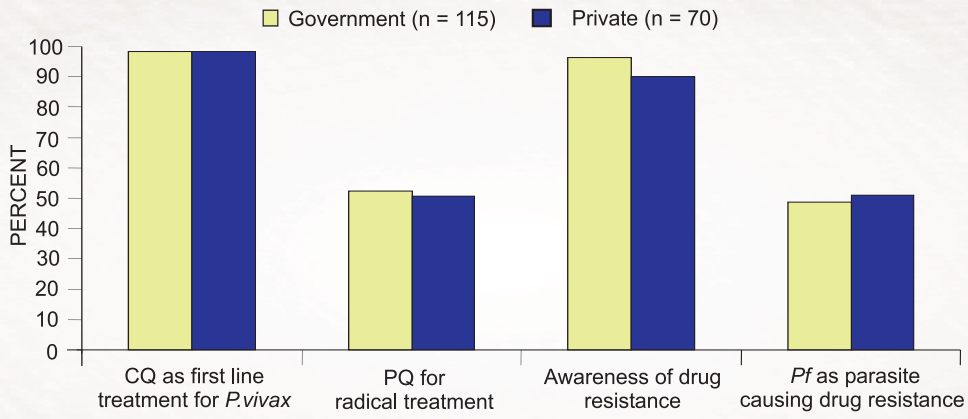


Fig. 10: **Awareness of treatment and drug assistance**

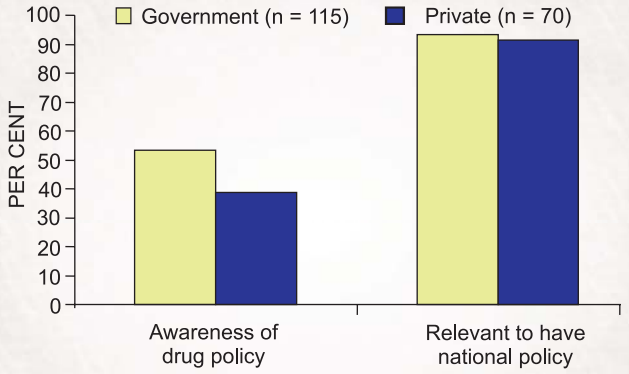


Fig. 11: **Awareness of drug policy**

out on 100 practitioners and based on the findings a sample size of 500 practitioners from each study site has been calculated. Questionnaires were completed from a total of six hundred fifty respondents. Of these, 200 were from Delhi, 400 from Gujarat and 50 were from Orissa.

The results of analysis available from 200 respondents of Delhi are as follows: 64% of the public health sector is aware about the malaria course conducted for training doctors (Table 6). Only 43% of the public health sector and 27% of private sector doctors report malaria cases to the concerned authorities (Table 6). A total of 93% of the public sector reported about the availability of diagnostic facility but only 70% treat according to the report of peripheral smear (Table 7). About 68 and 62% respectively from public and private health sectors are aware of the rapid diagnostic tests (Table 7). Except for three respondents, all the others reported chloroquine as the first line treatment for *P. vivax* (Fig.10). Use of primaquine for radical treatment was reported only by 50% from public and private health sectors (Fig.10). About 94% of the respondents are aware about the drug resistance but only 50% reported *Pf* as the parasite causing drug resistance (Fig.10). Awareness about drug policy for malaria was reported only by 53 and 39% respectively from public and private health sectors though 93 and 91% respectively felt that it is relevant to have national drug policy (Fig.11).

3.5.3 Studies on drug use practice and pre-packaged blister pack drugs

Blister packs for the radical treatment of adult patients (15 yr and above) who constitute nearly 60% of all the cases of malaria have been introduced for the first time in the national programme to improve acceptance of antimalarial drugs and compliance of the full course of radical treatment. The advantage of these blister packs is that less number of tablets has to be consumed for each dose. However, exact information on malaria treatment practices in public sector and compliance with prescribed drug policy at different levels across the public health facilities/sector is lacking in Jharkhand state. It is proposed to evaluate drug use practice and use of pre-packaged blister pack drugs through a combined review and observational study at various levels of health infrastructure.

The objectives of the study were: (i) to evaluate drug use practices at various levels of health infrastructure with emphasis on districts with change in drug policy in Jharkhand state; (ii) to study the knowledge and skills of paramedical personnel in the use of blister packs (including ACT) and its acceptance by paramedical personnel and in the community; and (iii) to study the compliance for blister pack, its impact on malaria epidemiology and the serious adverse events if any with the usage of blister packs.

The study is a questionnaire-based survey. The survey will involve primary health centres with first and second line of treatment, district health facilities and registered medical practitioners. The study will be done in two districts of Jharkhand state which are highly endemic for malaria. The primary health centres with first and second line of treatment and district health facilities will be selected from the study sites. The questionnaires will be completed by personal interaction with DMOs, SPOs, MO PHCs and other clinicians. Special emphasis will be given to knowledge of drug policy, drug resistance and usage of blister packs including ACT.

A workshop was held at NIMR involving experts from Jharkhand and Delhi states before initiation of the study. Field visit was undertaken to initiate

the study. Discussions were held with the District Malaria Officer, Simdega, Jharkhand for the proposed work. Data was collected on number of PHCs in Simdega district, supply of blister pack drugs, etc. The pilot study has been initiated in the Simdega district.

3.5.4 Institutional assessment of the NVBDCP Directorate and the assessment of the capacity building of the states

Successful implementation of the National Vector Borne Disease Control Programme requires enhanced capacities and capabilities both at the central level as well as in disease endemic states. Assessment is required of the current capacity of the Directorate of NVBDCP and its counterparts in the states and districts for improving programme performance to reduce the burden of malaria and other vector borne diseases.

An assessment of the functioning of 17 selected states including two municipal corporations was undertaken by the National Institute of Malaria Research (NIMR) during the period from November 2005 to November 2006. Of these, the states and municipal corporations assessed during September to November 2006 are Gujarat, Andhra Pradesh, Karnataka, Bihar, West Bengal, Rajasthan and the municipal corporations of Lucknow and Navi Mumbai. Institutional assessment of the Directorate of NVBDCP and four states namely Karnataka, Bihar, West Bengal and Rajasthan was assigned to the Indian Institute of Health Management Research (IIHMR), Jaipur.

The institutional assessment included overall functioning of the NVBDCP Directorate and state health organisations, role and functional integration of state and district level societies, review of ability of decentralised health system and capacity of district level organisations to prepare microaction plan and to manage financial resources. Assessment was also made of the linkages of health system with NGOs and private sectors/faith-based organisations, and the requirements for motivation, training and monitoring. Outcome of this exercise

Workshop in progress

is likely to benefit the NVBDCP in improving its overall performance taking advantages of the health sector reforms as well as intersectoral cooperation and community support at various levels.

The investigation was conducted by holding deliberations at national level with the programme planners, senior programme managers, policy makers and NGO executives. In the states, assessment was made by examining available documents, reports, office orders and circulars issued by the ministries, health directorates of the states, NVBDCP Directorate, published research papers, reports and field records of various functionaries at the district and lower levels.

During the assessment it was recognised that the programme had achieved many commendable achievements. There are committed individuals who are waking in the face of formidable field conditions and numerous other practical constraints. The states and its institutions have capacity to

implement the proposed NVBDCP but certain gaps have been identified by critical review during assessment which can be removed by cautious efforts. Study has been completed and the detailed report has been submitted to the NVBDCP.

3.5.5 Monitoring of implementation of programme activities in high risk districts

The Directorate of NVBDCP has identified districts with high burden of malaria in 17 states—Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Orissa, Rajasthan and West Bengal in the country for intensive monitoring for its effective control. Of these, monitoring of 21 districts in six states—Assam, Bihar, Goa, Karnataka, Madhya Pradesh and Orissa has been coordinated at NIMR, Delhi.

For monitoring each district, during each visit, two PHCs were selected and visited every month for a period of six months to evaluate parameters of programme activities. The various parameters evaluated are, study of epidemiological parameters for situational analysis such as trends of malaria incidence and deaths, identification of any high risk population and outbreaks, assessment of early diagnosis and prompt treatment, assessment of functioning of the PHC laboratory and record keeping, assessment of vector control methods undertaken and their impact, staff position and capacity building activities, status and functioning of district malaria control society, intersectoral co-ordination, availability of insecticides and antimalarials and IEC activities undertaken. Reports of the monitoring activities of these high risk visited districts have been prepared and submitted to the NVBDCP.

3.6 Vaccine Trial

3.6.1 Development of a site for malaria vaccine trials

This is a collaborative project with International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi and is being funded by the Department of Biotechnology, Govt. of India under Jai Vigyan Mission for vaccine development. The studies are being carried out to understand the epidemiology of malaria in Sundargarh district, Orissa that will facilitate the field trials for *P. falciparum* malaria vaccines through collection of clinical, entomological and molecular epidemiological/immunological indicators from the study site. The longitudinal and epidemiological studies were conducted in two sets of villages in the forest and plain areas characterised by hyper- and meso-endemic malaria situations, respectively. There are 35 study villages (Forest 23, Plain 12) with a total population of 15,847. These villages are grouped under Gurundia and Birkera primary health centres (PHCs) for the purpose of delivery of health services. Out of 35 study villages, 23 villages with a population of 8099 are situated in deep forests close to perennial streams and had persistent malaria transmission. The remaining 12 villages with a total population of 7748 are located in plain deforested areas with low levels of malaria transmission. All the twelve plain area villages come under Birkera PHC. Almost all (98%) of the residents of these 35 villages are tribals, predominantly of the Munda and Oram ethnic group. The average distance of all the study villages from the nearest PHC is 5–10 km. All the study villages are well-connected by roads and are located at a distance of 25 to 60 km from National Institute of Malaria Research field unit, Rourkela. The following longitudinal and cross-sectional studies were conducted as per protocol from the study area.

Detection of malaria cases was carried out through weekly active surveillance as well as passive surveillance in all the study villages of Phase I. The surveillance was carried out through village volunteers trained for this purpose. Data collected through weekly surveillance were subject to the analysis for malaria transmission pattern in two ecotypes, age distribution of malaria incidence and attack rate due to *P. falciparum*, proportion of *P. falciparum*/*P. vivax*/*P. malariae* and seasonal variations in the above parameters.

A longitudinal data on the above parameters from

the study site since August 2000 is available at NIMR field unit, Rourkela. Malaria is persistent throughout the year in both the areas but peak transmission was observed during post-monsoon months—September, October and November. The proportion of *P. falciparum, P. vivax* and *P. malariae* species in forest area was 89, 10 and 1 respectively, whereas it was 87.5, 12.5 and nil respectively in plain area. The malaria incidence rate of *P. falciparum* (only first episode per individual per year) during 2006–07 in forest and plain area was 18.7 and 0.5%, respectively. The highest incidence rate of 74% was recorded in the 1–5 yr age group and it was inversely proportional to increasing age, whereas in the plain area, no age-related correlation was found (Fig. 12). The average attack rate due to *P. falciparum* malaria in the total population was found to be 0.2 and 0.005 episodes per person per year in the forest and plain area, respectively. Three cross-sectional surveys were carried out during March, June and November representing intermediate, low and high malaria transmission seasons, respectively. About 40% of the study population was screened for malaria parasites. Blood samples were also collected for parasite genotyping and host immune response. Cross-sectional malaria prevalence data were analysed to obtain information on malaria prevalence in the study population, age distribution of parasite rate, spleen rate, asymptomatic cases, gametocyte carriers and seasonal variations in these parameters.

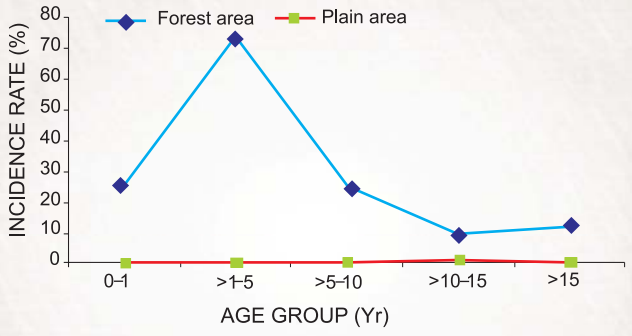


Fig. 12: **Malaria incidence rate in different age groups in forest and plain area of Sundargarh district during 2006–07**

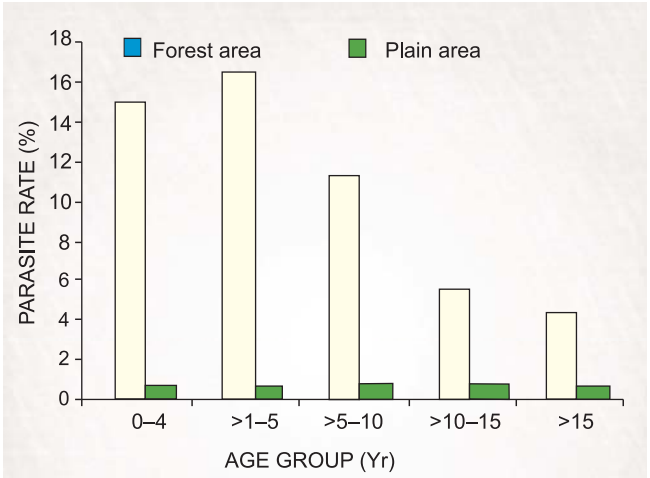


Fig.13: **Parasite rate in different age groups in forest and plain areas in Sundargarh district as recorded through cross-sectional prevalence surveys during 2006**

The average parasite rate in the forest and plain areas was 9.0 and 0.2, respectively. The highest parasite rate in the forest area during these surveys in 0–1 yr age group was found with a gradual decline as the age progresses, whereas in the plain area parasite rate was low and all the age groups were equally affected (Fig. 13). Out of total parasite positive cases found in the forest area during the cross-sectional surveys, 39% of the cases were asymptomatic and 6.4% were found to be gameto-

TABLE 8

Percent composition of anopheline species in the forest and plain areas of Sundargarh district during 2006–07

Species	Forest area		Plain area	
	Total No.	(%)	Total No.	(%)
An. culicifacies	1324	(39.2)	1913	(41.8)
An. fluviatilis	148	(4.4)	0	
An. annularis	317	(9.4)	540	(11.8)
An. subpictus	757	(22.4)	840	(18.3)
An. vagus	505	(15.0)	535	(11.8)
An. pallidus	187	(5.5)	308	(6.7)
An. aconitus	27	(0.8)	344	(7.5)
An. nigerrimus	32	(1.0)	48	(1.0)
An. splendidus	45	(1.3)	15	(0.3)
An. barbirostris	29	(0.9)	28	(0.6)
An. theobaldi	1	(0.03)	0	
An. tessellatus	1	(0.03)	4	(0.09)
An. ramsayi	1	(0.03)	2	(0.04)
Total	3374		4577	

cyte carriers. The average spleen rate in children and adults in the forest area was 52.7 and 12.8%, respectively, whereas in plain area it was 8.1 and 1.5%, respectively.

Entomological surveys were carried out in two indicator villages each in the forest and plain areas. Adult mosquito densities were monitored at monthly intervals by manual catching, using suction tube method. A total of 13 anopheline species from forest area and 11 species from plain area were recorded (Table 8). *An. culicifacies* was the most predominant species and accounted for 39 and 42% of the total anophelines in the forest and plain areas, respectively. *An. fluviatilis* was restricted to only forest area and its prevalence rate was 4.4%. The human blood index (HBI) of *An. culicifacies* and *An. fluviatilis* was 0.003 and 0.90, respectively thereby showing that the latter species is responsible for maximum transmission, whereas the former plays only complimentary role during spring and monsoon seasons. The entomological inoculation rate (EIR) in the forest area ranges between 0.02 and 0.61 infective bites per person per night during different seasons, thereby showing that transmission load in the forest ecotype is very high throughout the year, whereas it is low and seasonal in the plain area.

The existing epidemiological data from the study population will provide baseline information about the target population to be included in the field trial for malaria vaccines expected to be undertaken during 2008.

❑

Contribution of NIMR in Nobel Peace Prize, 2007 to IPCC

"The awarding of the Nobel peace prize to the Intergovernmental Panel on Climate Change (jointly with former US Vice-President Al Gore) is a remarkable testament to the dedication and commitment of the thousands of experts and participants who have produced the Panel's rigorous and comprehensive assessments of climate change research" (Press Release, IPCC October 12, Geneva).

"This is an honour that goes to all the scientists and authors who have contributed to the work of the IPCC, which alone has resulted in enormous prestige for this organization and the remarkable effectiveness of the message that it contains" – says Mr. Rajendra Pachauri, the Chairman of the IPCC.

"It is the most significant recognition that the IPCC has received for providing policymakers with objective and balanced information about the causes and impacts of climate change and possible response measures"– says Renate Christ, the Secretary of the IPCC.

"Hundreds of authors from all regions of the planet have devoted an incredible amount of time and labour to writing and reviewing the reports. None of them has been paid for their time".

Dr. R.C. Dhiman, Deputy Director (Senior Grade), scientist of National Institute of Malaria Research (Formerly, Malaria Research Centre) of Indian Council of Medical Research, Delhi also contributed in IPCC by serving as Reviewer in IPCC Working Group II, Fourth Assessment Report (Page 911 of Appendix III of Climate Change 2007: Impacts, Adaptation and Vulnerability).